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Threatened Deer



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Threatened Deer

Proceedings of a Working Meeting of the Deer Specialist Group
of the Survival Service Commission

on

THE IUCN THREATENED DEER PROGRAMME

and

A DOSSIER ON THE PLANNING OF RESTORATION
PROGRAMMES FOR THREATENED MAMMALS WITH
SPECIAL REFERENCE TO DEER

held at

Longview, Washington State, U.S.A.

26 September – 1 October 1977

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Foreword

It gives me great pleasure to provide the foreword to this volume which comprises the proceedings of a working meeting of the Survival Service Commission's Deer Specialist Group, held in Longview, Washington State, USA, on September 26–October 1, 1977. This Group is one of more than 30 Specialist Groups that advise and assist in the execution of the Commission's programme.

Since 1949, the Survival Service Commission of IUCN has had international responsibility for

> the collection and dissemination of data on species and subspecies which are threatened with extinction throughout their world range; and the initiation and coordination of action to ensure the survival of these animals and plants, thereby maintaining the genetic diversity of the planet.

By 1966, a comprehensive system of data collection had been evolved through the compilation and publication of the Red Data Books, but it was recognized that these were a means rather than an end. Action Programmes were needed to ensure the Survival of these species and subspecies. As an initial step in this direction and following two years preparatory work, the Threatened Deer Programme was launched, in January 1974, as a pilot venture in the stimulation of sustained scientific and governmental involvement in threatened species. IUCN and its Survival Service Commission now have a whole series of comprehensive conservation programmes covering a wide range of species and ecosystems, but the Threatened Deer Programme was the first – the pioneer.

Within the past four years, eight major projects have been initiated under the Programme, three established national projects have been added to it and some dozen smaller survey projects on the status of individual species or regional surveys of deer have been undertaken. The World Wildlife Fund has financed more than half of these projects but, in spite of this help, the Programme has been, and continues to be, plagued by shortage of funds. It may be too early to draw long term conclusions on the results of the Programme, but clearly it has already been instrumental in achieving some significant successes in restoring populations of several threatened deer.

The proceedings are divided into two main parts. The first provides case

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histories on the Programme's major field projects. In keeping with the Group's special role of providing pilot studies in a more comprehensive approach to conservation, the second part provides a dossier on the planning of restoration programmes for threatened mammals, with special reference to deer. The object of the first half of the meeting was to assess the results of the Programme to date and to recommend such reorganization as was considered essential. The object of the second half, was to provide a summary of criteria and guidelines on threatened species restoration, supported by the case histories and other papers that, it is hoped, will prove of use to conservation organizations and others which are concerned with planning, developing and screening projects in this field.

The dossier summary will require continuing revision in the light of new research and the accumulation of experience. It was not widely circulated in draft, so it is hoped that this publication will provide the best means of obtaining comments and review from a cross-section of the conservation movement.

The meeting was held in Longview, because of its proximity to the principal, remaining habitat areas of the Columbian white-tailed deer (*Odocoileus virginianus leucurus*), the only deer still on the world threatened list in North America. The Washington Department of Game took part in some of the meeting's deliberations and kindly provided transport and other facilities at the meeting, including arrangement for the Group members to visit the Columbian white-tailed deer National Wildlife Refuge. This enabled them to refine some dossier criteria by their theoretical application to a threatened deer population in the field. A debt of gratitutde is owed to the Director of the Department, Mr. Ralph Larson, and his staff for their help.

In conclusion, on behalf of the Group, the Commission and the Union as a whole, I wish to record our sincere thanks to the United Nations Environment Programme, which made a substantial contribution to the cost of the meeting and this publication and, without whose help, neither meeting nor publication would have been possible.

Sir Peter Scott
Chairman, Survival
Service Commission
of IUCN

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Contents

Introductory papers		*Page*
Man and deer	: R.D. Taber	9
Geographical Location and Current Conservation Status of the Threatened Deer of the Worls	: I. McTaggart Cowan & C. W. Holloway	11

PART I: THE IUCN THREATENED DEER PROGRAMME

1. Species close to extinction in the wild

*Persian fallow deer (*Dama mesopotamica*) Status Report	: Dept. of Environment, Iran	23
The Manipur brow-antlered deer (*Cervus eldi eldi*) – A case history	: M.K. Ranjitsinh	26
The Argentinian Pampas Deer (*Ozotoceros bezoarticus celer*) or Venado	: J.E. Jackson	33
Summary of discussion		

2. Endangered, vulnerable and rare species under continuing pressure

*Preliminary report on the status of the Bawean deer (*Axis kuhli*)	: R. A. Blouch & S. Atmosoedirdjo	49
Himalayan musk deer (*Moschus moschiferus moschiferus*)	: M. Green	56
Some aspects of the ecology of the swamp deer or barasingha (*Cervus duvauceli duvauceli*) in Nepal	: D. Schaaf	65

* Additional papers, submitted after the meeting

Digitized by Google

		Page
Kashmir deer (*Cervus elaphus hanglu*) in Dachigam	: F. Kurt	87
The Chilean huemul (*Hippocamelus bisulcus*) project – A case history (1975–76)	: A. Povilitis	109
Summary of discussion		129
3. Species of which some populations, at least, are recovering or have recovered		
The status of the swamp deer (*Cervus duvauceli duvauceli*) in the Dudhwa National Park	: Arjan Singh	132
Decline and restoration success of the central Indian Barasinga (*Cervus duvauceli branderi*)	: H. Panwar	143
*The present status of the Bactrian deer (*Cervus elaphus bactrianus*) in the USSR	: A. Bannikov	159
Case histories – The Tule elk (*Cervus canadensis nannodes*)	: D. McCullough	173
*Status of Columbian white-tailed deer *Odocoileus virginianus leucurus*): Some quantitative uses of biogeographic data	: T. Gavin	185
Summary of discussion		203
4. Future direction and organization of the Threatened Deer Programme		
The IUCN Theatened Deer Programme – A review of its objectives, achievements, shortfalls and future requirements	: C. Holloway	206
Socio-ecological organization and aspects of management in South Asian deer	: F. Kurt	219
Summary of discussion		240
Elements for the Threatened Deer Programme 1978–82:		242

* Additional papers, submitted after the meeting

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PART II: A DOSSIER ON THE PLANNING OF RESTORATION PROGRAMMES FOR THREATENED UNGULATES WITH SPECIAL REFERENCE TO DEER

Introduction		247
Summary of criteria and guidelines		248
1. Basic considerations for restoration programmes		
Constraints of small populations	: F. Bunnell	264
Human constraints and conservation, the case of rural communities in the third world	: D. Pitt	288
Summary of discussion		296
2. Components of study programmes		
How to generate etho-ecological data in field studies of endangered ungulates	: V. Geist	297
Essential data required on population structure and dynamics in field studies of threatened herbivores	: D. McCullough	302
Field study techniques of special application to depleted populations	: R. Taber	318
Research toward conservation of threatened deer of the world	: I. McTaggart Cowan & C. Holloway	329 339
Summary of discussion		
3. Components of management programmes		
Criteria for the reintroduction of threatened species into parts of their former range	: H. Jungius	342
Captive breeding as a practical aid to preventing extinction, and providing animals for re-introduction	: G. Whitehead	353
*Threatened deer – disease implications, field work and management	: A. McDiarmid	364
The values of deer and other wildlife, both as secure and endangered populations	: G. Petrides	379

* Additional paper, submitted after the meeting

Digitized by Google

*The aesthetic value of wildlife with special reference to threatened forms	: A. Povilitis	388
Promotion of national conservation measures and support for the restoration of threatened species of mammals	: C. Holloway	392
Threatened species conservation vis-à-vis community welfare in developing countries	: H. Panwar	407
*Some aspects of Policy and Practice in management of endangered deer	: I. McTaggart Cowan	415
Summary of discussion		426
Other business		431
List of participants and authors of papers		433

* Additional papers, submitted after the meeting.

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Man and Deer

RICHARD D. TABER

Of all the major land-masses, only sub-saharan African is without deer. When humans first erupted from the African homeland into Europe and Asia as stone-age hunters, they encountered deer of several kinds – the fallow deer of the mideast river bottoms, the roe deer of the forest, the reindeer of the tundra, the red deer of many temperate habitats. These deer which converted lichens, grass and leaves to red meat, fat, hides, sinews and bone, were often a vital resource in human economy. And the conspicuous antlers, mysteriously grown and cast in harmony with the seasons, enhanced their spiritual aura. The Paleolithic cave painters celebrated the antlers with many-tined portrayals, and showed the shaman-hunter in his antlered mask.

During the glacial period the wapiti crossed the Bering land bridge to North America, joining the New World deer which had already spread through the temperate and tropic regions of north and South America. And hunting man, too, crossed from Siberia to spread, eventually, from the arctic slope to Tierra del Fuego, encountering and living upon the deer in many forms in many habitats.

As glaciers withdrew, the reindeer and its pursuers moved northward, tamed beasts to become domesticated ones before the dawn of agriculture. The forest moved northward, too, bringing the moose with the cold spruce forest and the red deer with the warmer oaks and beeches.

As agriculture arose, men opened the forests with fire and axe. The forest openings and edges responded with a surge of plants, all within reach and many nutritious food for deer. Man hunted deer, deer learned to be wary of man, and to hold their own despite continual hunting. With the rise of human warrior-classes first in the Middle East, and then more broadly in Europe and Asia, the deer received a measure of princely protection, to insure its survival for the princely chase. Over five hundred years ago the noble European huntsman discussed the male red deer, and its suitability as quarry:

> "... the first year that they be calved they be called a calf; the second year a bullock; and that year they go forth to rut; the third year a brocket; the fourth year a staggard, the fifth a stag; the sixth year a hart of ten and then first is he chaseable, ..."[1]

[1] Edward, Duke of York, 1406–1413. Publ. 1911 as *The master of Game*, Wm. A. and F. Baillie-Grohman (eds). Chatto & Windus, London. 302 pp.

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At about the same time, in the mountainous realm of Inca Peru, there were also clear ideas about the proper way to hunt the deer, through different ideas and different deer. Like all animals, deer were under the royal protection, to be rounded up in periodic hunts employing thousands of human beaters. Then the females and young were released again, along with the handsomest of the males.

The protection afforded the deer by the interest of the ruling classes was most effective when the rulers were supremely powerful. Where governmental power was weaker, human predation on deer increased. Robin Hood, hunting the King's deer, was an outlaw, a folk hero, or an early exponent of social protest, but he and his kind made life more difficult for the deer.

With the development of firearms, and their continual perfection, and their mass-production by the industrial system, deer everywhere became more vulnerable. Hungry families wanted meat. Hides could be sold. Medicines, magical or otherwise could be made of certain parts. The musk-deer contributed to perfume, the bezoar stone of the pampas deer was sure proof against poison, the new antlers of any deer, taken internally, made old men young (it was thought) throughout the Orient.

Increasing numbers of humans have expanded everywhere into deer habitats. The climax forests were, and still are, being converted to young forest, or grassland, or cultivated fields. Deer respond. Some, such as the caribou, decline under heavy hunting and change in winter habitat; others, such as the white-tailed deer, increase despite heavy hunting because changes in habitat are beneficial.

As European forests have changed from oak and beech to spruce and pine under intensive management, artificial food has helped the red, roe and fallow deer to survive and prosper. As North American hunters have changed from pioneers to sportsmen the regulation of hunting has permitted white-tailed and mule deer, wapiti, moose and caribou to increase to the capacity of their habitats.

Deer populations have been established in new locales – Hawaii, Australia, New Zealand – where success in terms of expanding populations has sometimes far exceeded the original intent.

But there are many deer, particularly in the tropics and sub-tropics, and in less developed countries, which are rapidly dwindling away under the twin pressures of hunting and habitat-change. These are the concern of the present volume.

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INTRODUCTORY PAPER

Geographical location and current conservation status of the threatened deer of the world

IAN McTAGGART COWAN AND COLIN W. HOLLOWAY

This paper was prepared at the request of the Deer Specialist Group of the Survival Service Commission of IUCN for the Group meeting in Longview, Washington State, in September 1977. Its purpose is to serve as an introduction to the published proceedings of the meeting by providing a summary review of the distribution and conservation status of all the species and subspecies of deer that are considered to be under some threat of extinction throughout their world range and which form the subject matter of the IUCN Threatened Deer Programme.

A similar review was published four years ago (Cowan & Holloway 1973). In the intervening period, however, our sources of information from many parts of the world have improved considerably. Three more species or subspecies have been added to the list of world threatened deer, namely the Himalayan musk deer (*Moschus moschiferus moschiferus*), the Calamian deer (*Axis calamianensis*) and the Cedros Island deer (*Odocoileus hemionus cerrosensis*); two subspecies of the pampas deer (*Ozotoceros bezoarticus*) have been deleted, as their status is better than was formerly believed; and there have been some significant changes in the status of other threatened deer; so that a revision of the original review is now essential.

1. DEFINITIONS

IUCN collects and disseminates information on vertebrate animals that are threatened with extinction throughout their world range through the compilation and publication of volumes of the Red Data Book. These species and subspecies are categorized according to assessment of their current proximity or vulnerability to extinction. **Threatened** is a collective term applied to all Red Data Book categories, which are defined as follows:

Endangered
Taxa in danger of extinction and whose survival is unlikely if the causal factors continue operating.

Included are taxa whose numbers have been reduced to a critical level or whose habitats have been so drastically reduced that they are deemed to be in

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immediate danger of extinction. Also included are taxa that are possibly already extinct.

Vulnerable
Taxa believed likely to move into the endangered category in the near future if the causal factors continue operating.

Included are taxa of which most or all the populations are **decreasing** because of over-exploitation, extensive destruction of habitat or other environmental disturbance; taxa with populations that have been seriously **depleted** and whose ultimate security is not yet assured; and taxa with populations that are still abundant but are **under threat** from serious adverse factors throughout their range.

Rare
Taxa with small world populations that are not at present endangered or vulnerable, but are at risk.

These taxa are usually localized within restricted geographical areas or habitats or are thinly scattered over a more extensive range.

Indeterminate
Taxa that are suspected of belonging to one of the first three categories but for which insufficient information is currently available.

In practice, endangered and vulnerable categories may include, temporarily, taxa whose populations are beginning to recover as a result of remedial action, but whose recovery is insufficient to justify their transfer to another category.

The present definitions are extremely subjective and there is an obvious need for more objective criteria, although better criteria alone will not effect substantial improvement in the system without corresponding improvement in the sources of scientific data.

2. THREATENED DEER OF THE WORLD IN DECEMBER 1977

An inventory of the 29 species and subspecies of deer that are regarded as under threat of extinction is provided below. The approximate geographical location of each taxon is shown by the corresponding numeral on the map (ref. Fig. 1). Systematics and nomenclature follow Whitehead (1972). The animals are listed in systematic order and information on distribution and status is taken from the last completed edition of the mammal volume of the Red Data Book (Goodwin & Holloway, 1972–76) and supplemented by additional references where indicated.

1. *Moschus moschiferus moschiferus* Linnaeus 1758 **Vulnerable**
Himalayan musk deer. Occurs in high altitude woodland and dwarf scrub in the Himalayas from northern Pakistan to the north Burmese border. Total numbers are unknown. Populations have been seriously depleted mainly by poaching for musk, a thick oily secretion obtained from the musk gland,

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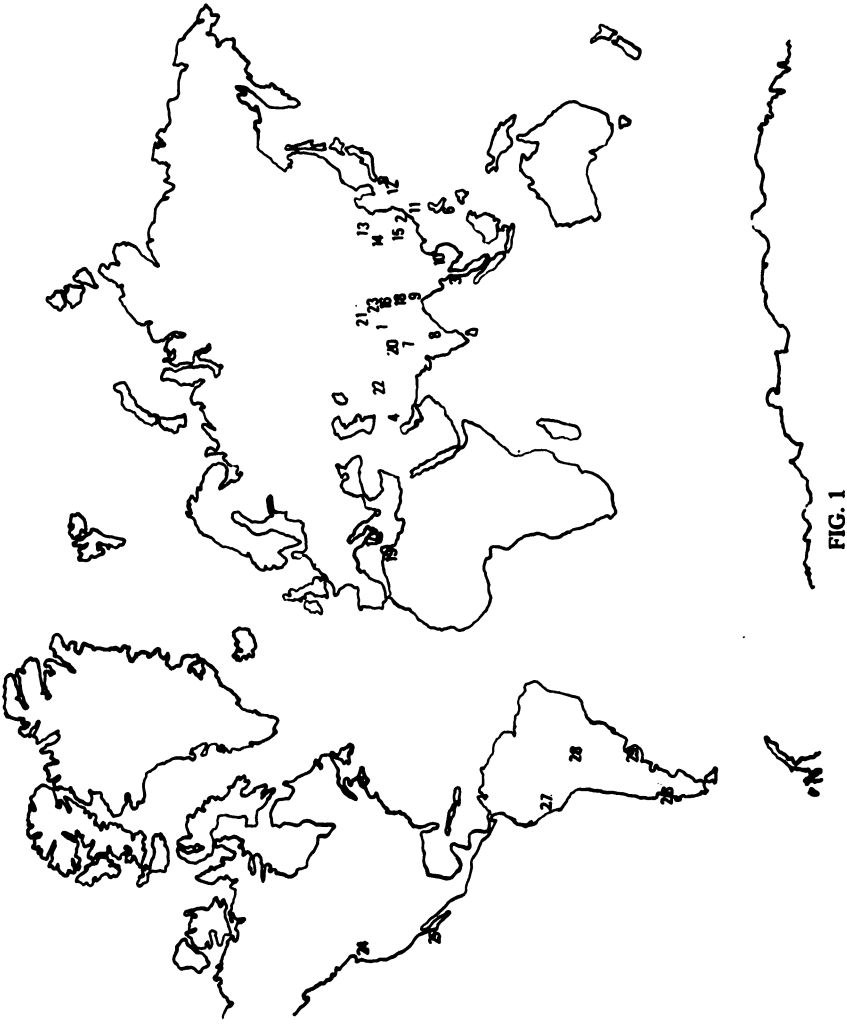


FIG. 1

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which is situated in the lower abdomen of the males. It is used in the oriental medicine trade and cosmetic industry and presently commands very high prices. Populations of the deer are believed to be continuing to decline, the animal has legal protection and trading in musk is banned over a large part of its range. It occurs in several national parks and reserves. A research project to provide the basis for management of the deer is expected to commence under the IUCN Threatened Deer Programme (TDP), in Nepal, in early 1978 (Green, these Proceedings, p. 60).

2. *Muntiacus crinifrons* (Sclater 1885) **Indeterminate**
Black muntjac. Has been recorded only from the state of Chekiang in the south-east of the People's Republic of China. In 1966, it was stated to occur in Szechwan, where its populations were small but stable, but to be almost certainly extinct in the Yangtze river mouth area. More recent information is lacking.

3. *Muntiacus feae* (Thomas & Doria 1889) **Endangered**
Fea's muntjac. Has a restricted distribution in mountainous evergreen forests in the border region of southern Burma and west Thailand. Its numbers and trend in populations are unknown. Forest clearance within its range is not presently regarded as a serious threat to the deer but hunting of muntjac for meat is practised and human populations in neighbouring areas are increasing. The species is protected by law, although enforcement over much of this region is virtually impossible, and it occurs in at least one Wildlife Reserve, in Thailand, where protection has been increased by inclusion of the area in the **Operation Tiger** scheme. It was the subject of a survey under the TDP in 1974/75, which suggested that its range in Thailand extended further south than was formerly believed (C.R. Miller 1975, pers. comm.).

4. *Dama mesopotamica* (Brooke 1875) **Endangered**
Persian fallow deer. In the wild, is probably now reduced to two areas of riparian forest thicket (principally of *Tamarix* and *Populus* spp.) along the Dez and Karkheh rivers in west Iran. Both areas have been declared wildlife refuges, but protective measures have not yet succeeded in eliminating stock-grazing and forest clearance. Periodic flooding of these areas is an additional hazard. Total populations are estimated at 40–65 animals and are stable or possibly declining slightly. The deer is totally protected by law. A captive breeding group of Persian fallow deer, established at Dasht-e-Naz (55 ha) in 1964–67, with six animals, has now increased to 50–55 animals, three of which were released onto an island in Lake Rezaiyeh in 1977. A further captive breeding group, probably comprising Persian/European fallow deer hybrids and numbering 30 animals, is maintained in a separate enclosure. The Iranian Persian fallow deer project was coopted into the TDP in 1975 (Iranian Dept. of Environment, these Proceedings, pp. 23–25).

5. *Axis kuhli* (Müller & Schlegel 1836) **Rare**
Bawean or Kuhl's deer. Confined to Bawean Island (220 sq. km), Indonesia, in the Java Sea. Total population currently estimated at 200–500 animals and probably increasing now that hunting has been reduced. The deer is

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legally protected. In the long term, the main threat to this woodland species is loss of habitat to cultivation and teak (*Tectona grandis*) plantations. The island's human population is increasing quite rapidly. A one-year study project, to determine future management practices and propose a suitable area as a reserve, was begun under the TDP in late 1977 (Blouch & Atmosoedirdjo, these Proceedings, pp. 49–55).

6. *Axis calamianensis* (Heude 1888) **Vulnerable**
Calamian deer. Occurs only on Busanga (900 sq. km), Culion (400 sq. km) and some intervening islets in the Calamian Islands, in the Philippines. Total population estimated at 900 animals and declining as a result of widespread, uncontrolled hunting. Natural forest (mixed *Dipterocarpus* spp.) is receding as a result of shifting cultivation and permanent agriculture but the deer appears to be a forest edge species and has readily adapted to agricultural clearings. It is totally protected insofar as the Calamian Islands form part of the Palawan Game Refuge but no enforcement is attempted. Over a quarter of the deer's range occurs within the recently established Yulo King Ranch, on Busanga Island; the owners have agreed to provide total protection for the deer and may sponsor an ecological study.

7. *Cervus duvauceli duvauceli* Cuvier 1823 **Endangered**
Swamp deer, northern race. Occurs in Nepal and northern India (from Uttar Pradesh to Assam); normally associated with high grass swamps and fairly flat grassland areas in moist deciduous forest. Total numbers are now estimated to be around 4,500 and are probably continuing to increase. Over 60% of the world population occurs in two protected areas: Sukla Phanta Reserve (Nepal) and Dudhwa National Park (India); current increases are largely the result of recent enlargement of the area of Dudhwa and improving protection. Most of the remaining populations occur in reserves. At present, the principal threats to the deer are human encroachment in its remaining habitats (through stock grazing, grass cutting and fuelwood collection), poaching and seasonal floods. Fieldwork for a detailed ecological study of the deer was completed, in Sukla Phanta, in June 1976, under the TDP, and a final report and management proposals will be submitted to HMG Nepal in the immediate future (Schaaf, these Proceedings, pp. 65–86 Singh, these Proceedings, p. 141).

8. *Cervus duvauceli branderi* (Pocock 1943) **Endangered**
Swamp deer, southern race or barasingha. Occurs only in the extended Kanha National Park area (940 sq. km), in Madhya Pradesh, India, where it is associated with a drier sal (*Shorea robusta*) forest grassland type than the northern race. Its numbers declined from around 3,000 in 1938 to 66 animals in 1969. Restoration measures from that date have included exclusion of stock grazing and forest exploitation, revision of grassland burning regimes, relocation of villages, anti-poaching, water development and withdrawal of tiger baiting sites in grasslands. Annual counts of deer populations are made and the census figure for barasingha in 1977 was 283 animals. The barasingha was the subject of the pilot field research project for the TDP in 1971–73 (Panwar, these Proceedings, pp. 143–158).

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9. *Cervus eldi eldi* M'Clelland 1842 **Endangered**
Manipur brow-antlered deer or sangai. Confined to the Keibul Lamjao National Park at the southern end of Logtak Lake, Manipur State, India. The Park area consists of three low hills and a surrounding morass of floating mounds of organic matter and vegetation (*phumdi*). The sangai is presently regarded as the most threatened deer in the world, the 1977 aerial census recorded 18 deer, only, in the Park. The State Government, with the aid of Central Government funds, has purchased land within the Park, increased Park staff, and constructed fences and cattle-proof trenches on selected boundaries to reduced human disturbance from poaching, stock grazing, grass cutting and burning, and fishing in the Park area. A dam has been constructed on the Manipur river that will maintain the water level of the lake at a constant height and will very probably alter the nutrient cycle and species composition of the Park's vegetation. Arrangements have now been made for a continuing research/conservation project on the deer and its habitat, in which two members of the Deer Group will be actively involved. There are a total of 49 sangai presently held in eight captive collections (Ranjitsinh, these Proceedings, p. 30; F. Kurt, *in prep.*)

10. *Cervus eldi siamensis* Lydekker 1915 **Endangered**
Thailand brow-antlered deer. Occurs in open plains and deciduous forests in parts of Laos, Cambodia, Vietnam and Hainan Island. Now considered to be extinct in the wild in Thailand (Pong Leng-Ee 1977, pers. comm.). Population size unknown but is considered to have been very seriously depleted by uncontrolled hunting and destruction of habitat. A 1974 Chinese publication states that the deer still occurs in nine counties of Hainan Island but herds are small and scattered (I. Orr, 1975, pers. comm.). The deer is totally protected throughout its range and occurs in three reserves in Cambodia, but the extent to which the law is enforced is unknown.

11. *Cervus nippon taiouanus* Blyth 1860 **Endangered**
Formosan sika. Almost certainly extinct in the wild. Formerly, it was widely distributed in the grasslands and open woodlands of Taiwan at altitudes below 300 m a.s.l. It was finally exterminated, probably in 1969, as a result of uncontrolled hunting and loss of habitat to cultivation. Several hundred deer of this race are farmed in Taiwan and a suitable re-introduction area, which is similar to its original habitat, has been identified and could form the basis for a re-introduction project, in the foreseeable future, under the TDP.

12. *Cervus nippon keramae* Kuroda 1924 **Endangered**
Ryukyu or Kerama sika. Confined to three unoccupied islets (Yakabi, Geruma and Aka) in the Kerama group of the Ryukyu Islands. It has been exterminated from other Keramas as a result of hunting, poor quality forage (which is also browsed by feral goats) and drought. The deer is totally protected by law. Population size and trend in numbers are unknown, although the deer and its habitat have been the subject of a study by the University of the Ryukyus in 1971–77 (Sadao Ikehara 1977, pers. comm.). Arrangements are being made for English translations of the University's research

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reports and to examine the scope for a cooperative study and conservation project under the TDP.

13. *Cervus nippon mandarinus* Milne-Edwards 1871 **Endangered**

14. *Cervus nippon grassianus* Heude 1884 **Endangered**

15. *Cervus nippon kopschi* Swinhoe 1873 **Endangered**
North China, Shansi, and South China sika, respectively; there is some doubt as to whether or not they are taxonomically distinct from the earlier-named *C. n. hortulorum.* They occur only in the People's Republic of China, in forest areas – the first two in Shansi Province and the third in the lower Yangtze Valley. There is no recent information on the status of their populations, but they were very seriously depleted by over-hunting and loss of forest habitat to agriculture in the past and might already be extinct in the wild. The North China sika is believed to be kept in deer farms and a group of South China sika were held in the Canton Zoo in the mid- 1960s.

16. *Cervus albirostris* Przewalski 1883 **Indeterminate**
Thorold's or white-lipped deer. Occurs in high altitude coniferous forest, rhododendron and alpine grasslands in eastern Tibet and neighbouring areas of the People's Republic of China (as far as the upper Yangtze and Nan Shan district). No recent information is available on its status. It has been seriously depleted by hunting for the antler trade but was reported, in 1973, to occur still at high altitudes in parts of Tibet, Szechwan and Chinghai, It is totally protected by law and is held in captive collections. A pair was presented to the Government of Sri Lanka in 1972.

17. *Cervus elaphus corsicanus* Erxleben 1777 **Endangered**
Corsican red deer. Considered to be extinct in Corsica and is now confined to three mountainous areas near the southern coast of Sardinia. Its habitat comprises Mediterranean *maquis,* broadleaf and coniferous woodland and meadows. The total population is estimated to be around 200 and probably stable. Numbers have been reduced by poaching and degradation of habitat. Most of the deer's range occurs in three regional natural reserves. The deer is only partially protected by law and shooting in the hunting season is still permitted outside the reserves.

A field study of the deer has been undertaken in 1973–77 by the Sardinian section of WWF in cooperation with the Forest Department, the Provincial Hunting Committee, private landowners and the Cagliari University (Schenk 1976; H. Schenk & R. Massoli-Novelli 1978, pers. comms.) The possibility of initiating a study and conservation project under the TDP is being investigated.

18. *Cervus elaphus wallichi* Cuvier 1823 **Endangered**
The shou. Probably extinct; it occurred in temperate forests in south-eastern Tibet and adjacent valleys of Bhutan. Inquiries in the People's Republic of China suggest that it became extinct as a result of uncontrolled hunting some years ago (N. Myers 1975, pers. comm.). Extensive searches, in 1973–74, by

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the Bhutanese Forest Service within its former range in Bhutan could find no trace of it. There are no captive animals in existence.

19. *Cervus elaphus barbarus* Bennett 1833 **Endangered**
Barbary deer. Confined to a restricted area of cork-oak and pine forest on the border of Algeria and Tunisia. Total population size, is considered to be in the region of 500 deer, which includes approximately 150 animals in captive breeding enclosures in each country. Numbers in enclosures are increasing, but the trend in wild populations is unknown (P. Hunkeler 1978, pers. comm.). The deer is totally protected by law throughout its range but there has been insufficient enforcement in the past. The scope for initiating a study and reintroduction project for the deer under the TDP is being investigated.

20. *Cervus elaphus hanglu* Wagner 1844 **Endangered**
Kashmir deer or hangul. Occurs only in moist temperate forest in the Vale of Kashmir and, at present, the only viable population known with certainty occurs in Dachigam Sanctuary (90 sq. km). Although totally protected by law, numbers have been reduced drastically within the past thirty years by poaching, loss of habitat to agriculture, and human disturbance, including grass cutting and burning, and livestock grazing within its summer and winter ranges, even within the Sanctuary. A research project for the deer was initiated under the TDP in 1975, which has been accompanied by an improvement in protection. The hangul population in the Sanctuary is presently estimated to be 250, based on a count in spring 1977; numbers are probably increasing. It is possible that small remnant groups of hangul occur in other areas of Kashmir and on the border with the State of Himachal Pradesh (Kurt, this volume, p. 88).

21. *Cervus elaphus yarkandensis* Blandford 1892 **Endangered**
Yarkand deer. Possibly extinct, but may still occur in riverain woodland in the Tarim river basin, Sinkiang district, Chinese Turkestan. It was known to be heavily hunted even prior to the 1920s and large areas of its habitat have almost certainly been lost to agriculture, but there is no recent information on its status.

22. *Cervus elaphus bactrianus* Lydekker 1900 **Endangered**
Bactrian or Bokharan deer. Occurs in riverain woodland in arid regions of the Tadzhik, Turkmen, and Uzbek SSRs of the USSR and an adjacent strip of northern Afghanistan. The total population has doubled since the mid-1960s as a result of relocation of animals into protected areas, in some cases into mountainous regions outside the deer's natural range. Numbers are currently estimated to be 1,100 and are increasing; most of the remaining populations are in reserves although the two populations and their habitats on the Afghanistan side of the border still lack protection. The Soviet study and conservation project for the Bactrian deer was included in the TDP in 1975 (Bannikov, this volume, pp. 159–172).

23. *Cervus canadensis macneilli* Lydekker 1909 **Indeterminate**
M'Neill's deer. Occurs in high altitude forest – rhododendron areas in parts of

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Sinkiang, in Chinese Turkestan, and the neighbouring border region of eastern Tibet. Populations were seriously depleted by over-hunting, principally for antlers for the oriental medicine trade, but it was reported, in the mid-1960s, that surviving populations were strictly protected by the authorities. There is no recent information on the status of this deer.

24. *Odocoileus virginianus leucurus* Douglas 1829 **Endangered**
Columbian white-tailed deer. Occurs in floodplain forests and meadows along the lower Columbia river in Washington and Oregon States, USA. Populations are currently estimated to number about 400 animals and the trend is relatively stable. In addition, there are at least three areas, near Roseburg, in south-east Oregon, which contain several hundred white-tailed deer whose systematic status requires investigation. The deer is totally protected by law and several refuges have been established for it. It has been the subject of a detailed ecological study and several additional research projects are about to be initiated. A Recovery Team has been appointed and has prepared a report on further action required to ensure the survival of this deer, which includes acquisition of more land for refuges and plans for relocation. This series of projects was incorporated into the TDP in 1977 (Fisher *et al.* 1977; Gavin, this volume, pp. 185–202).

25. *Odocoileus hemionus cerrosensis* Merriam 1898 **Endangered**
Cedros Island deer. Confined to an area of pine forest and *chaparral* in the southern sector of the island, which is situated off the western coast of Baja California. A recent survey undertaken by the Mexican Wildlife Service suggests that the present population may number around 50 animals and it is probably declining as a result of losses to poachers and feral dogs, and disturbance to the deer and its habitat caused by repeated bush fires. The deer is totally protected by law but protection is not enforced. A senior official of the Mexican Wildlife Service and a member of the Deer Group will visit the island in March 1978 to examine the feasibility of launching a study and conservation project under the TDP (A. Salas Cuevas 1977, pers. comm.).

26. *Hippocamelus bisulcus* (Molina, 1782) **Indeterminate**
Chilean huemul. Occurs in high altitude scrub, forest and grassland in the Andes of southern Chile and Argentina. Total numbers are unknown but considered to be declining as a result of poaching, disease and loss of habitat through fire, tree-felling and grazing of domestic stock. The deer is totally protected (although the law is inadequately enforced) and it occurs in a number of reserves. An ecological study of the deer under the TDP was conducted, 1975–76, at the northern extremity of its range in Chile, but further surveys are required in the southern parts of its range to assess its status and provide the basis for additional conservation measures (Povilitis, this volume, pp. 109–128).

27. *Hippocamelus antisensis* (d'Orbigny 1834) **Vulnerable**
Peruvian huemul or taruca. Occurs in high altitude forest, scrub, thickets and grasslands in the northern Andes in Peru, western Bolivia, north-eastern Chile and north-west Argentina; it is believed to be extremely rare if not already

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extinct in southern Ecuador. Total population size is unknown although believed to be declining because of poaching and loss of habitat to agriculture at lower altitudes, and competition with domestic stock at higher elevations. It is now considered to be rare over much of its range except in Peru, where it is still fairly well distributed and locally numerous. It is totally protected by law, although enforcement in the isolated areas in which it occurs is frequently lacking; it is also recorded in several national parks and reserves.

28. *Blastocerus dichotomus* (Illiger 1815) **Vulnerable**
Marsh deer. Occurs in seasonally flooded grasslands in swamps along rivers in south-east Peru, Bolivia, Brazil south of the Amazonian rain forest, Paraguay, north Argentina and, possibly, western Uruguay. Access to higher ground during periodic inundation of the grasslands is essential to the deer's survival. Total numbers are unknown but are almost certainly declining in most regions as a result of poaching, disease transmitted by domestic stock and loss of habitat to agricultural development. The deer is protected by law throughout its range and occurs in several national parks and reserves but enforcement of protection is frequently inadequate. It is the subject of an ecological study, which is not presently included in the TDP, in the Pantanal area of the Matto Gross, Brazil. This area probably contains the largest population of the deer anywhere in its range estimated to number 5,000 to 6,000 animals in 1977, based on an aerial survey. More detailed examination of the herds suggests that the years 1975–77 were reproductive failures, possibly as a result of brucellosis, which has been particularly severe among Pantanal cattle since the floods of 1974. An unknown number of deer have died from foot and mouth or other disease and from starvation during the floods (Schaller & Vasconcelos, 1977).

29. *Ozotoceros bezoarticus celer* Cabrera, 1943 **Endangered**
Argentine pampas deer. Currently occurs in only four localities in the Buenos Aires and San Luis Provinces of northern Argentina. Total numbers are estimated at around 200 animals (which includes 22 deer in a captive breeding group) and are believed to be stable as a result of improved protection measures initiated through a project under the TDP. The previous decline of populations was attributed to over-exploitation (although the deer is totally protected by law), loss of habitat to agricultural development, competition with domestic livestock and introduced wildlife, and disease transmitted by domestic stock. Present plans include the establishment of an estuarine reserve of 9,000 ha and continuing improvement of the captive breeding enclosure, which should ensure the production of surplus animals for reintroduction (Jackson, these Proceedings, pp. 41–44).

3. DECLINE AND RESTORATION OF POPULATIONS

Previous reviews of this subject have analysed existing data on world threatened deer to provide a basis for conservation strategy (Cowan & Holloway, 1973; Holloway, 1975). Although the list of species has been

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modified, the main conclusions from these analyses, which are summarized below, remain largely unchanged.

The numbers of naturally rare deer in the threatened lists are few; the majority of them formerly comprised much larger populations with far wider distributions than at present.

Most of the world threatened deer occur in relatively isolated areas of developing countries, especially in Asia, where human pressure on these remaining wilderness areas, to poach, graze stock, cut grass or collect fuel, is high and protection is often minimal because wildlife staff are few and untrained.

Deer provide numerous readily utilizable products (meat, hides and antlers) and many populations of the threatened species have suffered considerable reduction from over-exploitation. Many deer species are especially vulnerable to this source of depletion because of their large size, gregariousness, and accessibility during breeding and migration. All threatened deer have been affected to varying degrees by modification of their habitat. Losses of habitat to agriculture, especially, have been particularly severe for those species that occur in moist, lowland areas (swamps, riparian forest and flood plains) within fairly arid regions.

Cervid populations generally appear to have considerable resilience, however, and in spite of these pressures, only one species out of forty (Shomburgk's deer, *Cervus schomburgki,* last recorded in Thailand in 1932) and two subspecies out of nearly two hundred (the American wapiti, *Cervus canadensis canadensis,* and Merriam's wapiti *C. c. merriami* in North America) have definitely been exterminated within the past few hundred years (Whitehead, 1972). Two other subspecies of caribou (*Rangifer tarandus*) have become extinct during this period, but these are considered to have been evolutionary senile taxa, whose extinction was probably not directly attributable to human interference (Banfield, 1961).

What is of greater significance in the present context is that there are numerous examples, especially from North America but also from Europe and Asia, of depleted deer populations making a comparatively rapid recovery in response to protection. It must be recognized, however, that the status of many of the deer that are presently regarded as threatened throughout their world range is very precarious indeed. Excluding deer that occur only in the People's Republic of China and on which recent information is lacking, nearly half of the remaining species and subspecies have total populations that number less than 500 animals. Their habitats have often been modified substantially, they may carry parasites or disease transmitted by domestic stock, and depletion of their populations may have altered age structures and sex ratios or affected their behaviour to a degree where simple protection of the deer and its habitat is no longer sufficient to restore populations.

Formulation of the objectives of the IUCN Threatened Deer Programme has been based on a consideration of these factors. The aim of each component project is to identify the causes of the species decline as precisely as possible, to propose practical and realistic remedial measures, and to monitor and assist in the implementation of these measures through the maintenance

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of regular contact with the responsible authorities. The case histories of the initial projects that comprise the Programme, which were considered at the Longview meeting and are reproduced in this volume, give some indication of the successes, and the difficulties, of pursuing these objectives in practice.

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PART I: THE IUCN THREATENED DEER PROGRAMME

1. SPECIES CLOSE TO EXTINCTION IN THE WILD

Persian fallow deer (*Dama mesopotamica*) Status Report

DEPARTMENT OF THE ENVIRONMENT, IRAN

ABSTRACT

The captive Persian fallow deer population at Dasht-e-Naz Wildlife Refuge in north-central Iran is currently estimated at 50 to 55 animals. A sharp upswing in the productivity of this population has been recorded this year, 1977.

The first successful attempt to re-establish the Persian fallow deer in the wild from existing stock at Dasht-e-Naz was also achieved this year. A male and two females were flown to Ashk Island in north-western Iran. Early observations indicate that the deer are adapting favorably.

The population of Persian fallow deer returned to Iran from Germany in 1972 has reached 30 animals. At least some of these are believed to be hybrids (Persian and European fallow deer cross-breeds), so this entire population has been transfered to a new site. It is expected that it will eventually be relocated in south-western Iran in an area where Persian fallow deer probably existed in earlier times.

The current status of the remaining wild Persian fallow deer in two Wildlife Refuges in south-western Iran is not clearly understood. The population for both areas combined is estimated at 40 to 65 animals.

* * * * * * *

The future of the Persian fallow deer in Iran can be viewed with optimism based upon the favourable reproductive success to date of the captive population located at Dasht-e-Naz Wildlife Refuge in north-central Iran.

The current fallow deer population at Dasht-e-Naz is estimated to range between 50 and 55 animals. Actual counts revealed an adult sex ratio of 19 males to 21 females. The year's fawn crop was counted at 9 but expected to more closely approximate 15 in actuality.

The park fallow population increased by approximately 25% over the previous year's estimate.

In addition, the current population of the Persian fallow deer returned from Germany (von Opel Zoo near Frankfurt) to Dasht-e-Naz in 1972 has reached 30 animals. This comprises 8 males, 13 females and 9 fawns. These deer will hereafter be referred to as the "German" fallow to avoid confusion.

By the year 1977, therefore, the total fallow deer population existing at Dasht-e-Naz Wildlife Refuge had reached 80 to 85 animals equal to a stocking rate at the park of approximately 1.5 animals per hectare. This stocking rate

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being well in excess of the accepted stocking rate at the park of 1 animal per hectare was taken advantage of this year by removing the surplus animals and relocating them in two new locations in Iran.

The first successful attempt to re-establish the Persian fallow deer in the wild from existing stock at Dasht-e-Naz was accomplished this year following termination of the rutting season. Three animals, a male and two females, were captured in nets at the park and flown to Ashk Island in north-western Iran where they were subsequently released. The island, located in Lake Rezaiyeh is 2600 hectares in area and characterized by a grass – Artemisia – Pistacia plant community, completely undisturbed for the past ten years prior to the introduction of the fallow deer. As a result, the island is expected to provide excellent forage and shelter conditions for the deer and early observations of these test animals have indicated that they are indeed adapting favourably. Additional fallow deer will be relocated to the island from Dasht-e-Naz starting from 1978 subject to positive assessment of the island's suitability to maintain a deer population during the interim.

During the current year the "German" fallow deer were removed in total from Dasht-e-Naz and relocated to an enclosure located nearby. The enclosure will serve as a temporary site for these animals until a permanent site can be established sometime during the next year. It is expected that the animals will be relocated in south-western Iran at Dasht-e-Arjan National Park. This region characterized by oak and open grasslands represents an area where the Persian fallow deer likely existed in earlier times until finally becoming eradicated. With adequate protection it is expected that the Persian fallow deer can be re-established and once again thrive in this area.

The genetic character of the "German" fallow has become increasingly suspect and it is now fairly well assumed that at least a portion of the original animals returned to Iran from the von Opel Zoo were hybrids. European and Persian fallow deer were cross-bred at the von Opel Zoo but unfortunately the hybrids were not destroyed so some mixing is feared to have taken place. Without the benefit of positive proof to assess the genetic purity of these animals it was finally decided to remove these animals from Dasht-e-Naz and eliminate the potential risk of contaminating the known pure animals existing at the park.

Following the establishment of the "German" fallow deer in a permanent site the males will be replaced with several pure Persian males from the Dasht-e-Naz population for breeding purposes. Male offspring will continue to be removed each year until such time as the genetic character of the population approximates as near as possible that of a pure Persian population.

The current status of the Persian fallow deer located in the Dez and Karkheh Wildlife Refuges and adjoining Protected Regions in south-western Iran is not clearly understood. Efforts to accurately census these wild populations continue to be discouraged by the extremely dense and nearly impenetrable nature of the riverain vegetation characterizing the animal's habitat in these regions. At best a population index has been approximated from year to year based upon reported sightings of deer by local gameguards as well as from frequency and distribution of tracks, pellet groups and cast

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antlers. Population trends during the past few years indicate a slight increase in numbers of deer at Dez as opposed to Karkheh where the animals appear to have declined steadily. A current population for both areas combined is estimated to range between 40 and 65 animals.

The future status of the Persian fallow in Dez and particularly Karkheh is considered precarious and is expected to deteriorate unless stronger measures can be instigated to reduce the major limiting factors. Blatant violations by the local populace of the department's regulations against deforestation and grazing of domestic livestock within the refuges have been the major source of disturbance affecting the deer to date. In addition, periodic flooding in the Karkheh refuge has probably been responsible for the significant reduction of the fallow deer in this refuge.

It is expected that stronger enforcement measures in the future will benefit the fallow deer in the Dez and Karkheh Wildlife Refuges and serve to perpetuate the species in these regions.

The success of this year's fallow deer translocation projects and a sharp upswing in the productivity of the Dasht-e-Naz population significantly advances Iran's effort towards the salvation of this precious deer species.

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PART I: THE IUCN THREATENED DEER PROGRAMME
1. SPECIES CLOSE TO EXTINCTION IN THE WILD

The Manipur brow-antlered deer (*Cervus eldi eldi*) – A case history

M.K. RANJITSINH

ABSTRACT

The Manipur brow-antlered deer (*Cervus eldi eldi* Mcleland, 1842), always restricted in its distribution, is now confined to the Keibul Lamjao sanctuary, an area of 13¾ square miles. An aerial census in 1975 revealed 14 specimens, another in February 1977, 18. It is thus perhaps the most endangered mammal in the world. Though the sanctuary has been upgraded to a national park and greater efforts made to protect the animal and prevent grazing, poaching still occurs. The intricate aquatic ecosystem with its floating islands will also be affected by a hydroelectric project raising the water-table. More effective protection of the national park; research on the ecology of the deer and its habitat; continued financial assistance from the Central Government; acquisition of private holdings which almost bisect the already small sanctuary; total prevention of grazing; a management plan for the national park; and a second home for the "Sangai" – are amongst measures advocated to ensure its survival.

1. INTRODUCTION

The Manipur brow-antlered deer (*Cervus eldi eldi* Mcleland, 1842) locally called "sangai", has the dubious distinction of being perhaps the rarest and most localized mammal subspecies in the world. Zealously protected by the rulers of Manipur State in the past, the stag was relentlessly hunted by both local people and army personnel once the area came under British hegemony. By 1950, the Manipur sub-species of the brow-antlered deer was regarded as extinct till located once again in a small area called the Keibul Lamjao at the south-eastern corner of the Logtak Lake. An area of approximately 20 sq. miles was formed into a sanctuary in 1954, and was subsequently reduced to 10¾ sq. miles in 1959. The average rainfall is 130 cm, falling mostly from July to August.

In 1966, the sanctuary was officially gazetted and in 1968, a further 3 sq. miles were added. On 28 March 1977, the area was at long last declared a National Park and all agricultural and fishing rights within the area of the Park were extinguished. The Wildlife (Protection) Act, 1972, has been extended to the State of Manipur.

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Of the three sub-species of the Thamin, the sangai carries the smallest pair of antlers and has always been confined, even in historical times, to the vale of Manipur. At present, it is restricted to the Keibul Lamjao.

2. THE HABITAT

Apart from the three hills of Pabot, Toya and Chingjao, the remainder of the park is one vast morass of floating organic matter called the phum or phumdi. A passage of free water for boating up to Pabot Hill has been cleared. The phumdi is made up of decayed vegetation, and varies in thickness from 1 to 4 feet. It floats upon the water, the level of which varies with the season. During the driest months of February and March some of the phumdi, especially along the edge of the park, rests on the hard ground below. With the onset of the monsoon the major portion of the park gets covered with water and the animals seek refuge on the hills. Then in approximately three or four days the phumdi which had settled on the ground, sets itself free and once again floats on the top of the water. In 1966, there were heavy floods with the water level rising to an unprecedented height of 2531 feet above MSL. The phumdi got carried away with the current and with it went a certain number of the deer.

The reeds and grasses which grow on the phumdi and the ratio thereof, as listed in E.P. Gee's account (*J. Bombay Nat. Hist. Soc.*, 1960), are as below:

Local name	Scientific name	Percentage of the total
Tou	*Phragmites karka*	45%
Singut	(not yet identified)	25%
Kohimum	*Saccharum munja*	15%
Ishing Kombong	*Saccharum latifolium*	5%
Pulai	*Alpinia allughas*	5%
Singnang	*Saccharum procerum*	2%
Miscellaneous		3%

The Ishing Kombong (*Saccharum latifolium*) is the favourite food of the sangai and is relished even by the animals in captivity outside the park. The percentage which it occupied in the erstwhile sanctuary, if not 5% as per E.P. Gee's report, would certainly not be more than 10%. An adequate supply of the Ishing Kombong grass is essential for the conservation of the deer, and the matter becomes more significant when it is realised that it is also a favoured food of the encroaching domestic buffalo.

The phumdi becomes thicker and heavier with the passage of time with more vegetation being added to it each year. This process of annual increase is more evident in the phumdi at the edges of the park, where it has had the opportunity of settling on the ground for the longest period, and thereby of deriving sustenance from the soil below. If for two or three years consecutively there is no heavy flooding this borderline phumdi would not be forced to leave the ground to float. It will become a part of the hard ground as humus. Trampling by domestic buffalo during the dry season would also, I am sure,

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help in pressing the phumdi to the hard ground below and making it a permanent fixture thereupon. The ultimate result of these processes is that the phumdi at the border becomes hard ground, and the actual area of the floating phumdi and therefore the habitat of the sangai, decreases.

Water Hyacinth has made its appearance in the open water areas of the park, but such areas being very limited, the hyacinth has not yet assumed significant proportions.

The three hills within the park are not only very important observations points, but constitute a very significant factor in the eco-system. They are the only hard ground in the park to which the animals can go to. Though the sangai has adapted itself admirably to the phumdi habitat, the alacrity with which the captive sangai move over hard areas and hilly ground, and the fact that it used to inhabit other non-phumdi areas, are evidence enough that unlike the sitatunga, the sangai is not exclusively a marsh animal. The fact that they regularly visit the hills is proved by their droppings there. Other animals such as the hog deer also use these hills, which during the floods provide the only refuge for the larger mammals of the park and must surely be important to their breeding. All the three hills should be strictly protected from grazing and other exploitation. Simul and other indigenous trees like *Salix tetrasperma* may be planted, especially on the now barren Chingjao Hill, but no exotics should be introduced.

3. LIMITING FACTORS

Though the area of the National Park is larger, the real habitat of the Manipur deer does not exceed 6 sq. miles, and this too is under imminent danger of being divided into two halves. The total world population of the subspecies is now confined to this last tenuous habitat, and unless the encroachment and grazing are stopped this habitat will decrease still further. It is evident that the prime reason for the survival of this unique deer in this heavily populated area is the floating swamp which the deer with their elongated hooves are able to negotiate far better than man and cattle. If the swamp or the phumdi goes, the deer will vanish with it.

The cutting of grass in the dry season was an annual feature and was officially permitted. This has come to a stop with the establishment of the national park but care has to be taken that illegal cutting of grass is no longer allowed as this constitutes a major cause of disturbance.

The burning of the grass in the dry season was an annual occurrence. The maintenance of the grassland habitat and of the height of the grass at particular levels, may require burning from time to time. Edaphic factors would have to be investigated to determine whether burning of grass is essential for the welfare of the sangai and, if so, in which season and with what frequency should these fires be carried out. Of particular importance would be the effect of fire on the *Saccharum latifolium* which as stated above is a preferred fodder of the sangai.

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Grazing, mainly by buffaloes, was mot prevalent in the northern and southern part of the sanctuary and has caused degeneration of the habitat. The presence of domestic stock constitutes a grave potential danger in the diseases that they could convey and which could effectively wipe out the entire population of the sangai in Keibul Lamjao. It is hoped that with the establishment of the park a more effective control over grazing may come into effect, but it will require a firm hand on the part of the authorities to prevent the ingress of cattle.

Fishing in the open patches in the sanctuary was practised. Though this exploitation also would now be illegal it will not be easy to stamp it out completely.

Poaching did occur, especially in the north-eastern region. The main offenders are from the Muslim community whose population around the sanctuary has increased. Luckily the Hindu population is mostly vegetarian. However, the Muslim community possesses a large number of weapons, and crop-protection weapons are issued to the land-owners including those occupying land in the Thang-Brel-Maril, which almost divided the sanctuary into two parts. Most of the poaching occurs from March to May during the dry season.

The shortage of protective staff at Keibul Lamjao is one of the main reasons for the illegal habitat destruction, poaching and other disturbance discussed above.

A very significant new aspect which may have very important ecological ramifications on the Keibul Lamjao is the Logtak project. A coffer dam has been constructed on the Manipur river which would permanently raise the water of the Keibul Lamjao to the level of 2525 feet above MSL, and there would be no fluctuation in the water table as was the case previously. Prima-facie this would appear to benefit the park insofar as it will increase the area of water and thereby the area of the true habitat of the deer. It would also prevent the cattle and poachers from making any inroads into the heart of the park as they did during the peak dry season. On the other hand, the effect of the maintenance of the water at the constant level at 2525[1] above MSL on the hydrology and ecology of the marsh habitat, which indeed is one of the most complex ecosystems in the country, can only be ascertained through a detailed study. The nutrient cycle and species composition of the grasses would in all probability be affected; there would also be repercussions on the annual burning practices that have been followed in the past. As the rutting season of the deer is during the dry season when the water table is at the lowest and the larger portion of the phumdi morass is settled on the ground, the raising of the water table through this project could also have an effect upon the breeding of the deer. Finally, there could very well be other re-percussions upon the food chain and the growth of the phumdi. With more open water being made available, the water hyacinth might increase rapidly, before the much slower growing phumdi could cover these open patches, and have adverse effects upon the indigenous flora.

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4. THE STATUS OF THE DEER

In 1959, E.P. Gee carried out a sample survey of an area of a quarter square mile of the sanctuary and, from the deer which were driven out from what is in fact the best habitat, estimated the number at about 100. On my first visit to Keibul Lamjao in 1972, one stag was seen, but a drive over a portion of the sanctuary was unsuccessful. The floods of 1966 were said to have been responsible for a number of sangai being swept away. However, poaching and disturbance perhaps took the greatest toll. My estimate then was about 50 deer. By this time the real habitat of the deer was only 6 square miles.

In March 1975, at the height of the dry season when the phumdi had already been burnt and the cover very open, I was able to carry out an aerial survey from a helicopter, flying at an altitude of 100–300 feet over the entire sanctuary and the surrounding area for a duration of 45 minutes. We were able to see the same individuals and groups more than once, and there really was no likelihood of any sangai being left uncounted. Even the smaller and more elusive hog-deer (*Axis porcinus*) were counted. The total sangai population was 14 animals, 5 stags, 6 hinds and 3 fawns. The two largest groups were of 3 animals each. The next and last aerial census was carried out on 28th February 1977. The total population recorded was 18, 6 stags, 8 hinds and 4 fawns.

The present population of the brow-antlered deer in captivity is as follows:

1. Manipur Zoo	1 (stag)
2. Delhi Zoological Park	12 (5 M, 7 F)
3. Calcutta Zoo	14 (6 M, 8 F)
4. Ahmedabad Zoo	6 (1 M, 5 F)
5. Hyderabad Zoo	4 (1 M, 3 F)
6. Lucknow Zoo	2 (1 M, 1 F)
7. Mysore Zoo	8 (3 M, 5 F)
8. Kanpur Zoo	2 (1 M, 1 F)
	Total: 49

5. CONSERVATION MEASURES

As mentioned above th Keibul Lamjao sanctuary has been upgraded to a national park this year under the Wildlife (Protection) Act 1972, which is now applicable to the state of Manipur.

Under the Central Asssistance Scheme for the Development of National Parks, the union Government of India has released a total of 719,000 Rupees up to this year. The money has been spent on capital works, mainly towards the payment of compensation to farmers for the acquisition of their land within the park, construction of office and residential accommodation for the staff appointed, building of fencing along the 2,218 metres of the periphery of the park where it is most vulnerable, to act as a physical barrier against cattle grazing and illegal human entry. The money has also been spent for digging a cattle-proof trench along 870 metres of the boundary; for the construction of an enclosure for captive breeding of the deer in the Manipur

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zoo; for the purchase of 7 canoes for purposes of patrolling; and for the establishment of 4 new check-posts at strategic points in the park. Funds were also utilized for the census carried out by an army helicopter this year.

The State Government of Manipur has borne the recurring cost of the salaries of the staff amounting to about 50,000 Rs each year. My earlier proposal regarding the staff structure for the park has been adopted by and large, and a full time assistant conservator of forests has been placed in charge of the park with an assistant veterinary surgeon, a range officer, a field assistant, 3 foresters, 4 forests guards, 8 animal watchers and other staff.

With the establishment of the national park and with the appointment of additional staff and the provision of funds for conservation efforts, the prospect of the survival of the habitat and of the deer has notably improved. However, it will have to be ensured that the legal provisions against poaching, fishing, illegal encroachment, grazing and other detrimental factors do not remain merely on paper. Poaching is mostly done with the help of dogs and traps, and constant vigilance will have to be employed, especially in the dry season, to prevent these activities. Grazing takes place mostly from November to May. If the need for additional staff is felt at certain times of the year, recourse could be had to the help of the local home guards or police force. Arms licences of known poachers should be cancelled, and an inventory of all weapons of people residing along the periphery of the park should be maintained in accordance with the provisions of the Wildlife (Protection) Act 1972.

Regular prophylactic innoculation of the cattle residing in the surrounding territories is absolutely essential to ensure that no outbreak of bovine diseases threatens the wild ungulate population in the park.

As long as the entire wild population remains in this one habitat there will always be a danger of its extermination, even though its numbers multiply significantly in the future within the park. To prevent such an occurrence it is essential that a *second sanctuary* for the Sangai to be established in a suitable habitat – perhaps in the Khoidum Lamjao across the Manipur river; and secondly, for an effective captive breeding programme to be initiated. A large enclosure has been constructed outside the park area and in this have been put a wild-caught hind and 3 deer supplied from the Delhi Zoo. The experiment has not proved a success, mainly because of lack of proper care. The deer do very well in captivity and there is absolutely no reason why they should not thrive in captivity in Manipur. The captive breeding unit must be supplied either from the Delhi of Calcutta zoos. Exchange between zoos of captive "sangai" would be helpful in preventing in-breeding amongst the small existing zoo populations.

None the less the most crucial and difficult task is to establish an alternative home for the deer in the wild, since the swampland in the Manipur valley has all but gone with the possible exception of the Khoidum Lamjao mentioned above. Other possibilities such as another area adjacent to Logtak Lake or even one in the surrounding hill country to which the species is known to be capable of adapting itself, are complicated by the problem of safeguarding them from cattle ingress and from poaching.

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6. RESEARCH

Detailed investigation of baseline data, making of inventories and applied research on topics of crucial significance to the ecology of the deer and its habitat, are of prime importance. Very little has been done in this regard so far. Apart from the field visits and reports by E.P. Gee and myself, the Zoological Survey of India and the Botanical Survey of India have carried out studies of the deer in the erstwhile sanctuary. However, many questions remain unanswered. A proper investigation of the limiting factors of the sanctuary, especially those which have caused the decline of the deer, and are preventing their increase in numbers must be studied. Poaching and reduction of the habitat may not be the only factors though these are of course the most obvious. Investigations of the veterinary aspects should also be carried out and ecto-parasites collected. A detailed scientific study of the effects of the Logtak Project on the Keibul Lamjao ecosystem, with recommendations to ameliorate its deleterious effects if any, needs to be carried out urgently. The effects of annual burning of the habitat also need to be analysed.

In 1974 and 1975, the Zoological Survey of India carried out two surveys totalling 2½ months. However, no very significant new facts were brought to notice except that the examination of the faeces of the deer revealed that some of them have mucous and protozoan infection of *Emmeria wassilewskyi*. According to this report protozoan diseases were quite common amongst the cattle in the area.

The Botanical Survey of India have also carried out a survey of the Keibul Lamjao at the instance of the Government of India. In reality, biological aspects are perhaps the most important in the context of this national park, and further research in this field is called for, particularly the relationship between the water fluctuations and the growth of the "phumdi", and the ecology of the latter.

A proper management plan for the national park based upon investigations carried out is of prime importance.

Enumeration of the deer would have to be done every alternative year from the air to ascertain population trends. The Zoological and Botanical Surveys of India and if possible the University of Manipur should be associated with future research in the park on a continuing basis, and students from other parts of the country encouraged to take up applied research projects under their auspices.

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PART I: THE IUCN THREATENED DEER PROGRAMME

1. SPECIES CLOSE TO EXTINCTION IN THE WILD

The Argentinian Pampas Deer or Venado (*Ozotoceros bezoarticus celer*)

J.E. JACKSON

ABSTRACT

Known examples of the southernmost subspecies of the Pampas Deer, *Ozotoceros bezoarticus celer*, total some 200, living in four wild and one captive herd in Argentina. Recent history, past conservation attempts and reasons for the dramatic population crash are discussed, together with the conditions, problems and solutions tried at each existing site. Prospects for conserving and boosting stocks are potentially promising: in one habitat, a wardened estuarine reserve of 9000 ha will be established if funds and provincial backing are forthcoming; major improvements in the captive animals enclosure should result in a population increase and surplus individuals can be used for reintroduction schemes; at two places, anti-poaching vigilance afforded by landowners maintains stable populations which may be boosted by habitat modifications; at the coastal dune locality, continued poaching, road building, tourist development and deep-water port construction threaten to finally exterminate the few surviving deer.

1. GENERAL INTRODUCTION

1.1. Recent history, present status and reasons for decline

The Pampas Deer, *Ozotoceros bezoarticus*, once inhabited natural grassland throughout much of eastern Latin America lying below the Equator. Three subspecies are generally recognized (Cabrera, 1943).

(*a*) The northern form, *O.b. bezoarticus*, extends across most of eastern and central Brazil, reaching down to the borderlands of Uruguay.

(*b*) The natural range of *O.b. leucogaster* covers south-western Brazil, south-east and east Bolivia, Paraguay and the extreme north of Argentina.

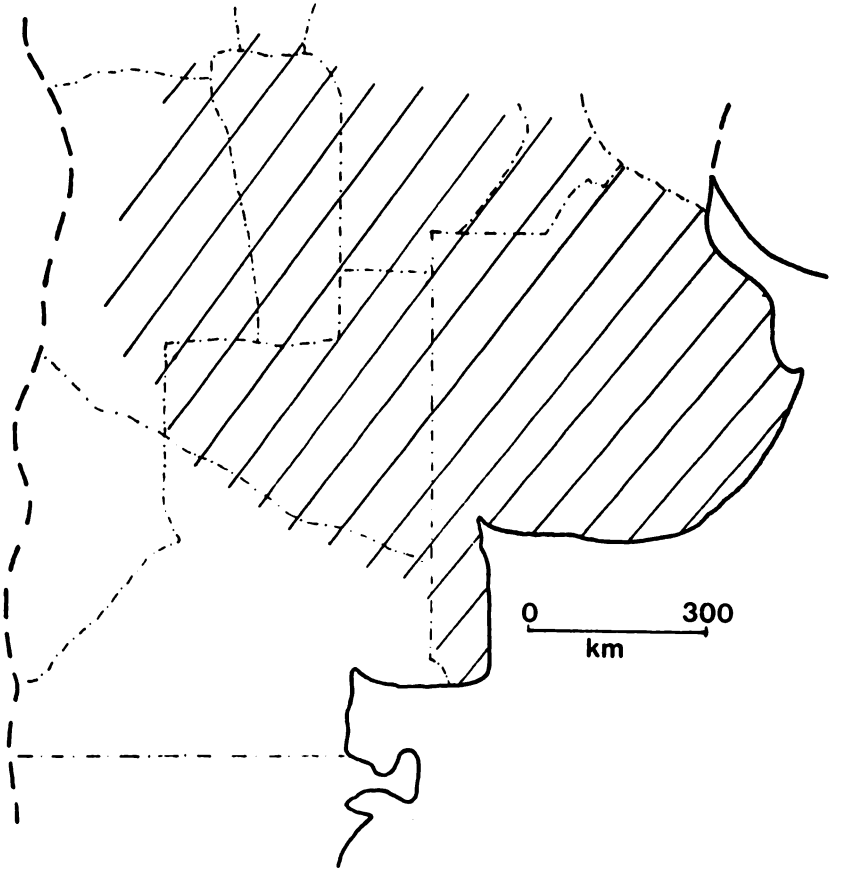
Although both the numbers and range of these two subspecies have been reduced, they are not considered to be endangered over all (Jungius, 1976).

(*c*) *O. b. celer* is the southernmost form, whose distribution used to encompass the vast Argentinian pampas (Map 1). Reports of explorers and pioneer settlers clearly demonstrate that this deer, known locally as the venado, was extremely adundant in the virgin pampas during the 18th and 19th centuries. Cabrera (1943) records that *celer* was still present throughout

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the region around 1900, yet today it is recognized as the most highly endangered cervid in the South American subcontinent (Holloway, 1975), being known only from the sites listed below and marked on Map 2.

Distribution of O.b.celer in 1800s

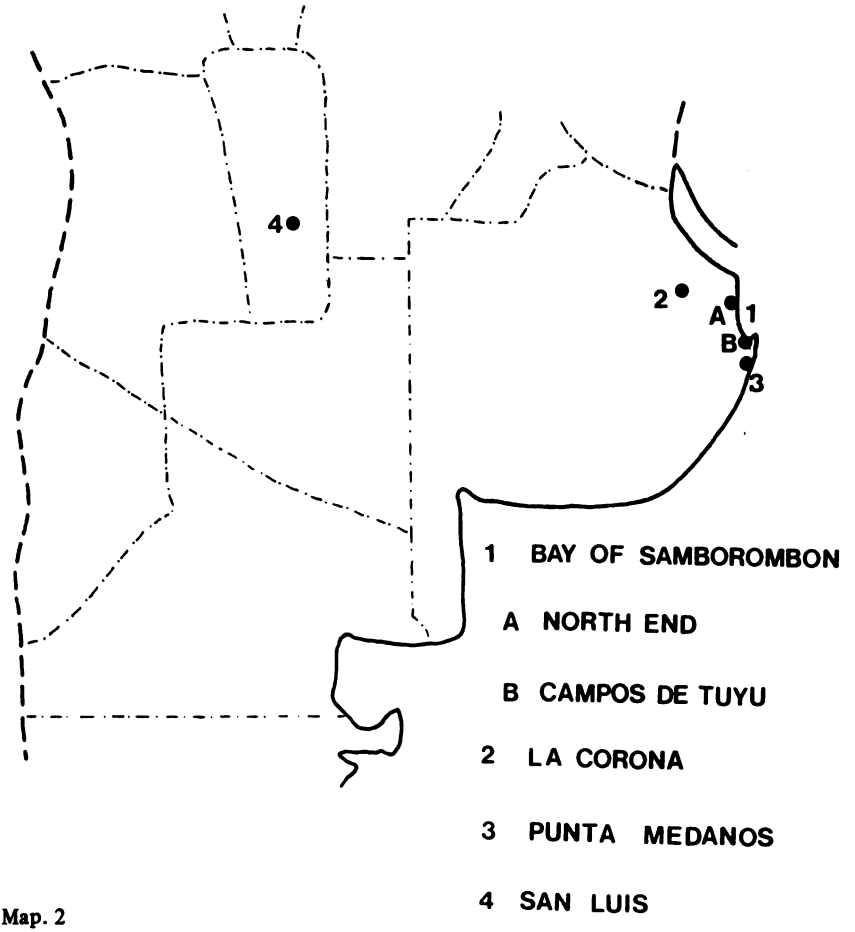


Map. 1

(1) Bay of Samborombon
  (*a*) North End with approximately 35 animals
  (*b*) Campos de Tuyù with at least 10 individuals;
(2) La Corona, where there are 22 specimens;
(3) Punta Médanos with an estimated population of eight;
(4) Province of San Luis, where 100–200 still survive.

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Distribution 1977



Map. 2

Groups 1, 2, 3 are in the Province of Buenos Aires; groups 1, 3 and 4 are wild whereas 2 is captive. A report received recently suggests that a group of pampas deer in western Uruguay are of the subspecies *celer.* There are no other confirmed examples in the world, either wild or in captivity.

The exact reasons for this catastrophic reduction in both numbers and distribution of the venado are hard to evaluate, especially after the event. The causative factors appear complex and cumulative but fall into four categories:

(i) Over exploitation

By the late 19th century, intensive commercial hunting of venado was practised with many thousands of skins exported annually. Daguerre (1970), for example, calculated the trade in venado pelts from 1860–70 as totalling

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2,130,000 and the Hunting Statistics note that in 1880, 61,401 Pampas deer hides were shipped from Argentina. Such figures may not be fully reliable but do reflect the magnitude of the operations. In addition, deer were killed for a variety of other reasons:- for sport and food, plus skins, antlers and stomach stones for everyday medicinal and superstitious usages. Despite longstanding official legal protection, which is rarely enforced, poaching is still a major threat today.

(ii) Habitat destruction

Increasing human occupation and development of the original pampas over the past few hundred years destroyed or drastically altered the deer's habitat. Vast tracts were drained, improved and enclosed to create the modern uniform expanses of grazing land and cereal fields typifying the eastern part of the pampas, where practically no natural areas remain.

(iii) Competition

In these new man-influenced environments, competition for both food and space with domestic livestock and introduced exotic herbivores such as axis (*Axis axis*) and fallow deer (*Dama dama*), and the European hare (*Lepus europaeus*) probably had a detrimental effect on the native cervids.

(iv) Disease

Certain of the diseases of domestic stock, notably foot and mouth disease (FMD) and possibly various gut parasites too, were transmitted to and have periodically decimated the populations of *O.b. celer.*

1.1. Past conservation measures

Direct responsibility for wildlife in the Province of Buenos Aires rests with the Directorate of Natural Resources, Ministry of Agriculture (DRN PBA) and with the Directorate of Renewable Natural Resources in San Luis (DRNR PSL).

With the exemplary exceptions of measures taken by conscientious landowners in San Luis and the Campos de Tuyú, the known history of conservation efforts for the venado in Argentina dates from the mid 1960s. Between 1967–69, four capture operations took place in the Bay of Samborombon to obtain specimens to establish captive breeding units; this was considered the only practical means of preventing the extinction of the deer in the Province of Buenos Aires. The first two operations, done without official sanction, were completely unsuccesful in forming captive breeding nuclei.

Due to the initiative of Lics. Bianchini and Perez of the Directorate for Fauna (now retitled DRN PBA), a status survey of the venado in Buenos Aires commenced in 1968 (Bianchini & Perez 1972a). They mounted the second two campaigns to obtain Bay of Samborombon stock to start the herd at La Corona. Wild deer were located from and driven by helicopter into creeks or lagoons were a man, leaping from the aircraft, captured them manually. Of the 25 taken in June 1968, 9 survived the ordeal (Bianchini & Perez 1972b); a repeat operation in December 1969 secured 7 specimens which were all transfered and succesfully introduced into the paddock.

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Further clandestine catching operations supposedly took place – one in the Bay of Samborombon and the other at Punta Médanos.

Active conservation, management or monitoring of the wild populations of La Corona from then onwards was sporadic and it was only the personal drive of Bianchini and Perez that seemingly kept any momentum and continuity going.

During April and May 1975, Dr Jungius of the World Wildlife Fund visited South America under the auspices of the IUCN/WWF Deer Programme (project no. 96). As a result of the discussions and evaluations of the plight of the venado, IUCN/WWF project no. 1303 was drawn up to study and conserve *O.b. celer* in Argentina.

1.3 Project resources

Various aspects of the project were started before my arrival in Argentina in September 1977. The initial team comprised myself with Lics. Bianchini and Galván, although due to other commitments neither can work full-time. Administrative and overall financial responsibility here belong to Sr. Staudt, based at his Buenos Aires office.

As the project has unfolded, our manpower has increased. In addition to the allowances paid to Bianchini and Galván, two men are now stationed in the Bay of Samborombon to act as resident full-time game guards and a peon works part-time in La Corona. A botanist will be contracted shortly and two students to participate during the vacations.

Besides these personnel, additional help has occasionally been provided by parasitologists, anatomists and vets at La Plata University. The project has had some catalytic effect in obtaining two postgraduate grants to study related wildlife ecology and in promoting a limnological survey in the Bay of Samborombon.

Laboratory facilities are provided in the Museum at La Plata, which also serves as a base. WWF paid for two project vehicles, a Citroen van and a used Ford pick-up. Other items of equipment bought, borrowed or acquired are listed for each site in turn.

1.4. General considerations

Since Dr Jungius's visit, a change of government has occurred following the military take-over of March 1976. Argentina was faced with an extremely difficult socio-economic climate; many of the support facilities proffered previously for the project were therefore not forthcoming. Conservation of wildlife was considered of little relevance compared with the other problems the country faced.

Hunting and fishing are major pastimes in Argentina. Poaching is a principal threat to many forms of wildlife, although the severe firearms regulations currently in force to combat subversion have undoubtably eased the situation. The venado has had legal protection for many years but there was little or no awareness of or respect for this amongst law enforcement bodies. Until recently, the DNR PBA maintained a force of some 60 officers responsible for faunal protection and dealing with hunting regulations; only four are still

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employed and are not available to assist the present project. The picture in San Luis is healthier, with a mobile, radio-linked unit of 9 men covering this far smaller and sparsely populated province.

Wildlife conservation in Argentina is in its embryonic stages. With notable exceptions, neither the general public nor high-level officials have much notion or concern for the rational use of fauna at present although they are slowly being enlightened thanks to the efforts of a growing number of conservation-minded folk. Project 1303 is the first of its type so there is no existing framework to work within.

The project's original intention was to study the ecology of the deer, prior to making and implementing conservation plans. However, the plight of the beasts was considered so grim that immediate action was needed to combat and remedy the most pressing problems and prevent further erosion of the dwindling stocks. Once this is accomplished, we can then start to gather sound information on the venado's ecological requirements to improve and amplify the initial emergency measures. With the resources available, it proved counterproductive to try and deal with all the widely separated sites concurrently, so the decision was taken to concentrate initially on the Bay of Samborombon and La Corona.

The problems and possible solutions applicable to the conservation of the venado are dealt with separately for each site since each presents its own unique set of circumstances.

2. BAY OF SAMBOROMBON

2.1. General situation

The narrow fringe of estuarine marshland stretching some 100 km along the Bay of Samborombon, represents one of the few remaining natural ecosystems in the otherwise highly agricultural Province of Buenos Aires. This zone, which is frequently innundated, consists of a mosaic of meandering creeks, drainage canals, lagoons and marismas; stands of taller grasses and sedges with copses of stunted trees grow on the few islets of higher ground. Access to the area is treacherous – and sufficiently difficult to ensure that some deer survived there despite substantial poaching pressure. The land is of minimal agricultural value or interest at present although cattle are increasingly invading to utilize the small amount of grazing. The causes of the decline of the venado here are the same as outlined in section 1.1., plus the removal or loss of animals as a result of the capture operations.

Working in the habitat is difficult and hazardous. Indirect census methods such as track and pellet group counts are of limited use as much of the place is flooded. Aerial censusing on open marshland provides reliable data but where the deer inhabit or rest in tall stands of pampas grass or tala spinnies their numbers are greatly underestimated (Bianchini 1976a).

2.2. North end

Survey work here in June 1968, before the major catching operations, found 66 venado; 25 were taken that month and censuses in September 1969

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counted 28 remaining. Flights in July 1976 saw only 14 animals in a very restricted locality compared to the late 1960s. Aerial and ground counts in early 1977 confirmed the findings of the previous July. Two additional herds, of 13 and 8 head, have recently been located in areas where they were thought to have died out (Jackson 1977d).

Obtaining the essential gear, permissions, contacts and people to effect the initial steps to protect the sparse populations took time but are now functional in a rudimentary form. These are:

(a) To prevent poaching:

(1) contracting a mobile gameguard to patrol the whole hinterland, also to act as a contact and public relations man with the local people and authorities:

(2) paying local commercial fisherman and gauchos allowances to act as gameguards before the permanent guard commenced his duties;

(3) contracting a second gameguard to live on site, patrolling on foot and horseback and establishing a permanent presence there;

(4) obtaining, overhauling and installing the equipment needed for the gameguard to live and work there (caravan, boat, horses, barn, tools, corrals);

(5) getting the active help of the local police, the coastguard to patrol coastal waters and the army to hold random arms searches on access roads;

(6) obtaining the support of and promoting public awareness in the local inhabitants;

(7) preventing unauthorised vehicular access by locked gates or other physical barriers.

(b) to reduce predation:

A start has been made on reducing the numbers of foxes which are probable predators on young fawns. Similarly the feral pig population will be culled.

(c) establishing a reserve:

Documentary investigations found that the venado live in a narrow but continuous belt of fiscal land – that is, belonging to the province. The DRN PBA have now made a formal application for this land to be transferred to their jurisdiction to form an integrated natural reserve. The land adjoins a fragment already administered by the DRN and the whole will cover an area of 9,420 ha. Anticipated administrative transfers should be completed by January 1978.

Once the land is acquired, it will need managing correctly on a long term basis. This means resident, trained gameguards with the neccesary housing, radios, boats and vehicles, fencing against intruding cattle plus a host of minor but essential alterations and additions to the reserve. The DRN has neither the men nor the resources to do this at present and alternative ways of funding are being sought (Bianchini & Jackson 1977).

Some preliminary scientific studies have been done on the deer and their habitat but work has concentrated on getting the protective measures installed. The long term hope is that a biological station will be founded to study all aspects of this rare ecosystem.

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2.3. Campos de Tuyú

This sector of coastal marshland (map 2), lying between General Lavalle and San Clemente de Tuyú, is akin to the northern end of the Bay of Samborombon but contains a greater percentage of tall cover and copses. The margin for error when dealing with small population numbers is wide, but aerial censuses of April 1977 indicate that the venado herd has not declined in the past decade and may even have built up slightly. On this occasion, 10 individuals were seen (Jackson 1977a); counts done in late 1975 over the same locality, employing comparable methodology, found four deer; and in September 1969, a helicopter survey noted only two animals whereas ground censuses demonstrated a population of 12 venado (Bianchini 1972a; 1976a).

The prime reason deer still survive here is the protection against poaching afforded them by the landowner. He would be in favour of an agreement with the province to strengthen the position of this population of the deer. Despite its apparent stability and possible minor increase, this population is still in grave danger of extinction.

3. LA CORONA

3.1. Introduction problems

In 1968/69, a 28 ha enclosure on the private estancia "La Corona" was stocked with 19 venado from the Bay of Samborombon (Bianchini & Perez 1972b). The land and perimeter fence were provided by the landowner, but the deer remain the property of the province; a ten year agreement exists between the two parties. This expires in July 1978 but no difficulties are anticipated in its renewal.

After an initial population increase to reach a reported maximum of 43 in May 1972, the numbers fell and since January 1974 have fluctuated between 19 and 26 head. The present herd status is 22 animals.

During the period from its foundation until mid 1975, only sporadic visits by personnel of DRN PBA were possible to study and monitor the herd's progress. Principally through force of circumstance, active management during this era was also negligible and the general state of the enclosure deteriorated sharply. This trend was particularly marked by the disappearance of the original short-cropped grassland and its replacement by long, rank, coarse tussock species, completely unsuitable as grazing for these deer.

Basically the project inherited 28 ha of coarse, tall poor quality grazing in a badly drained enclosure with minimal cover from the elements. From the past data available, the population is static because of a combination of low reproductive rate coupled with high mortality.

(a) Low reproductive success. The data are intermittent and do not stand critical numerical analysis but indicate that only about 50% of reproductively capable does bore a fawn each year. In the period September 1976–July 1977, 13 adult females produced 7 young. Given optimal conditions, this species should be capable of producing one fawn per doe per annum. Reasons

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for this poor reproductive success are multiple and could include qualitative or quantitative dietary deficiences, genetic or social problems or the ingestion of certain plant toxins causing foetal problems.

(b) High mortality rate. Mortality is excessive, especially in pre-reproductive animals. Causes of death were not always known since carcasses were often discovered only several months later, but are attributed to:- two major outbreaks of foot-and-mouth disease; clostridiosis; parasitic gastroenteritis; deaths due to cold in old or weak animals or in winter-born fawns; one doe killed by dogs (Bianchini 1976b). Since September 1976, six deer have died from the following causes:- a doe from FMD; an adult female and full-term foetus from a breach birth; a fawn from septicaemia after infection by the fly *Dermatobia*; a fawn during hand-rearing; and two juvenile deer from gastroenteritis.

3.2 Solutions tried

The herd size over the past three years has remained static. Raising the birth or reducing the death rates, or preferably both together, should result in a population increase. To attempt this, the following measures have been introduced:-

(a) Improved grazing regime. A key to much of the problem in the enclosure is the need to create and maintain areas of short, rich grazing. Nine hectares of new pasture planted in June 1976 have created a reasonable sward. The grazing pressure of the deer is insufficient to maintain it close-cropped and an adequate mower has still not been forthcoming to cut the grass and maintain the palatable sward against invasion by more competitive but unacceptable tussock species; either mowing on a regular basis or some other form of boosting grazing pressure must be found if the pasture deterioration of the past is to be avoided.

A further 4 ha of oats now serve as winter grazing and sections of the coarser grassland are cut to stimulate new soft growth to serve as emergency fodder. Maize cobs have been provided as additional winter and spring rations. Deer normally demonstrate an instinctive "nutritional wisdom" (Lockie 1967), rarely eating noxious herbage but, to be safe, two species of plants that can result in problems in domestic stock have been eradicated. Two commercial salt blocks tried were not touched by the deer, nor is there any evidence of any mineral deficiency.

(b) Reduction of disease. Drainage in the enclosure is poor, consisting of two choked canals feeding into a central lagoon. This large water body (4.5 ha) becomes stagnant periodically and has now been fenced off to reduce the possibility of further outbreaks of waterborne diseases such as clostridiosis. Other small water bodies are cleaned out and the canals are being redug. Dosing of remaining water with vermicides is done and monthly faecal samples are screened for assesment of parasite burdens. Foot and mouth disease is endemic throughout most of Argentina.

The value of capturing venado to vaccinate them against FMD and to dose them against parasites is debatable because of their known susceptibility to

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stress and its related problems when handled. Many of the animals taken in the Bay of Samborombon operations succumbed to cardiac problems; likewise, the experience of workers on *Ozotoceros bezoarticus* in Uruguay in Berlin Zoo show how fragile these animals appear to be. Catching and handling facilities in the enclosure have been mooted but are not available at the moment. Darting is also considered too great a risk for everyday use in terms of both the practical use of the weapon and the minimal knowledge of the optimum drugs or dosages for these deer.

Hand rearing of fawns to overcome the problem of high juvenile mortality was unsuccesful and has been discontinued.

It is hoped that the measures taken to reduce the incidence of disease plus the improved food supplies will both improve the general physical condition of the venado and reduce mortality substantially. At present, the external physical appearance of the animals is excellent.

(c) Shelters and cover. Long tussock grassland provides some protection but otherwise the enclosure is practically devoid of cover from adverse weather and biting insects. Seven shelters made of bales were constructed last autumn and the deer used them. Advice was sought from forestry experts on the optimum species, sizes of trees and planting times to create quick-growing windbreaks and shades. As a result over two thousand eucalyptus, cypress, willow, alder and bamboo were planted.

Various scientific studies of behaviour, area utilization, feeding habits, competition with hares and pasture evaluation are underway but have played a secondary role so far.

3.3 The future

The alterations and improvements outlined here should provide the answers to most of the immediate problems although it may be several years before the full benefits become apparent. Acquisition of a large mower is essential; various additional refinements including catching pens and subdivision of the enclosure to allow a rotation system will be undertaken if money is available and a firm commitment is forthcoming from the landowner and the DRN PBA that active management will continue when international support is withdrawn. As the herd builds up, animals will be taken to establish new breeding nuclei elsewhere; La Corona is the sole captive group of *O.b. celer* in the World and a major epidemic or natural disaster could easily wipe it out.

4. PUNTA MEDANOS

Various confused and conflicting stories existed concerning the status of the venado in the vicinity of Punta Médanos lighthouse. A selection of these are documented by Bianchini (1976a), the general consensus being that the local population was now extinct. Five visits by project staff have found that a small number do however still survive. The habitat frequented is a belt of sand dunes between the improved agricultural pastureland and the sea. Typical dune vegetation dominates; in the low lying hollows between the

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larger dunes, herb-rich pasture is present but is heavily grazed, trampled and soiled by numerous cattle and feral pigs. Little other food exists within the area and competition for the limited supply appears intense judging by the close cropped nature of the sward in the growing season. A series of shallow rain-filled temporary pools are foci of activity. The estimated population is 8 animals.

Poaching still takes place but the major threat is from tourist and industrial development in the zone. The new prestige coastal highway to link existing holiday resorts to the north and south of Punta Médanos is under construction and passes through the very centre of the venado habitat. Development of tourist facilities is already underway with the sale of building plots and afforestation. Recently, the government announced a feasibility study for constructing a deep-water port. No final decision on construction will be known until late November but if building goes ahead, all the dunes will go under concrete and we will have to try to evacuate the deer. If the port is not approved, the hope is to arrive at an agreement with the local landowners to create a sanctuary to the west of the road; this would need proper vigilance, water, fencing to exclude cattle and the necessary funds (Jackson 1977b). Excellent relationships exist with the local residents who are favourable to the idea.

The future of the venado at Punta Médanos is therefore grim but not without hope.

5. SAN LUIS

On the western edge of its original range, *O.b. celer* is still found in the south-eastern portion of the Province of San Luis. Two visits made by project staff to the vicinity have set up excellent relationships with high-ranking provincial officials, local landowners and residents. The venado appears on the coat of arms of San Luis and lately the province has officially declared its intention to conserve the animal – a fact that adds considerable impetus to and eases the bio-political problems of its conservation.

The principal reason why the venado still lives in this semi-arid area is the stringent protection by the estancia owner. Preliminary populations estimates set the number as about 100: further trips are already programmed to this remote and harsh locality.

The conservation set-up in San Luis seems both efficient and progressive and the genuine concern for the fauna that exists in the upper echelons of provincial government is both encouraging and exemplrary.

6. URUGUAY

Contacts in Uruguay suggest that Pampas deer in the western sector of this country are of the subspecies *celer*. Efforts are being made to confirm this on the basis of skull morphometrics, using material from museums worldwide. Visits to Uruguay are planned for the future.

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7. FUTURE SITES FOR REINTRODUCTIONS

One aspect of IUCN/WWF project no. 1303 is to investigate the feasability of reintroducing venado into natural or semi-natural habitats where they once thrived. Potential sites need careful scrutinizing before any reintroductions are contemplated; any environmental alterations required to increase the chance of their success need implementing well in advance. Ideally sites would be stocked with captive-bred animals from La Corona but should it ever be necessary to move deer out from an area in an emergency situation (see section 4), a holding site should be ready beforehand. One possible suitable site has been located in Sierra de la Ventana (Jackson 1977c). Several other promising offers of land have been made in both the Province of Buenos Aires and La Pampa, the suitability of which are under investigation.

8. FUTURE

Although the project members can do and have done a good deal to lay the foundations for the conservation of the venado or Argentinian Pampas Deer (*Ozotoceros bezoarticus celer*), we are at a point when official high-level support in an active form is fundamental to implement our recommendations, provide added impetus and incentive, and demonstrate that there will be a long-term, lasting commitment to ensure the continued existence of this subspecies in its native home once external financial and scientific aid is withdrawn. Such backing exists in the Province of San Luis but has not so far been genuinely evident in Buenos Aires.

The improvements at La Corona should allow the herd to increase and act as a supply unit for re-establishing and repopulating selected sites with venado. The creation of a reserve in the Bay of Samborombon to safeguard its rare ecosystem would set a leading example of progressive conservation not only in Argentina but in Latin America as a whole. Possibilities exist for boosting the numbers in the Campos de Tuyú but the situation at Punta Médanos presents a real challenge.

Argentina has an extremely rich and varied natural faunal heritage but one that is rapidly disappearing; the venado heads a depressingly long list of threatened wildlife. For that reason, it is crucial that IUCN/WWF project no. 1303 not only succeeds in its own aims of saving this subspecies of cervid but also in promoting the growing conservation cause here to safeguard other native fauna and flora before their numbers too decline to the absymally and critically low levels to which the venado has been permitted to sink.

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PART I. 1: THE IUCN THREATENED DEER PROGRAMME: SPECIES CLOSE TO EXTINCTION IN THE WILD

Summary of Discussion

Manipur brow-antlered deer Cervus eldi eldi **(M.K. Ranjitsinh)**

The author commented briefly on the status of the other two subspecies of brow-antlered deer. The Thailand brow-antlered deer *Cervus eldi siamensis* may be extinct in Thailand and its status in Cambodia is believed to be very precarious. The Burmese brow-antlered deer *Cervus eldi thamin* probably merited a place in the Red Data Book although its precise status was unknown. A recent report stated that the meat of this deer was being sold openly in markets.

The Manipur brow-antlered deer was closer to extinction in the wild than any other cervid. There were several threats to its future of which probably the most important was the construction of the Logtak Dam which could result in changes to the hydrology, and thus to the condition of the floating vegetation, of its remaining sanctuary at Keibul Lamjao. The constant water level now being maintained in the sanctuary eliminated the "dry season" for the floating vegetation and could affect its nutrient cycles and alter species composition. It might also affect the burning regimes which have been adopted in this area in the past. Reduction of the size of floating islands during the fawning period could result in intra-specific strife among females through overcrowding and thus reduce fawn survival.

There was clearly a need for a second sanctuary. Only one similar area of marshland was known in the vicinity of the Keibul Lamjao National Park. Its condition and the species that it contained required investigation. Historical evidence suggested that the present marshland area was not the preferred habitat of the deer; it had probably taken refuge here in response to expanding human populations and development. It was believed to be an animal of the wooded foothills of the vale of Manipur. Much of this original woodland had been destroyed by shifting agriculture, on a three year rotation. Forests at higher altitudes were subjected to grazing by domestic stock, so the scope for reintroducing the deer into its original habitat was virtually nil. The deer was a grazer, but bamboo rather than perennial grasses tended to colonize areas in this region subjected to shifting cultivation. It was possible that careful management of moister areas abandoned after cultivation could encourage the re-entry of perennial grasses.

The introduction of the deer into regions where it was not endemic was not considered advisable as there was some doubt as to whether it would adapt readily to a new environment. It was generally considered that Asiatic deer were specialists in regard to food habits and habitat utilization, whereas the deer in more northerly regions of the world were generalists and better able to colonize new habitats and adjust their feeding habits.

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In view of the extemely critical status of this deer, the Group agreed to recommend to the Government of India that Dr. Kurt should undertake a survey of the deer and its habitat before the end of 1977 and that Dr. Kurt and Mr. Panwar should be closely involved in the continuing conservation programme for the Keibul Lamjao National Park.

***Argentine pampas deer Ozotoceros bezoarticus celer* (J.E. Jackson)**

The grazing pressure of deer in the enclosure is insufficient to curb the spread of coarse perennial grasses to the detriment of preferred forage of the deer. Management practices currently include the mowing, ploughing and resowing of areas of the enclosure to reduce coarse grasses and encourage the return of preferred vegetation. It was suggested that trial plots should be established in the enclosure to cover a series of different treatments, such as fire, ploughing, cutting and stock grazing to determine optimal means of management. Whilst accepting this proposal in principle, it was stated that grazing by domestic stock had not been considered suitable because of the dangers of introducing disease and that the use of fire was avoided because of the fear of it getting out of control.

Reproduction rates of the deer as a whole, and especially within the enclosure, were very low. Various reasons for this situation were suggested including the disruption of social organization. Substantial improvement had been made recently in the development of immobilizing drugs and it was suggested that use of drugs to immobilize individuals in the enclosure for examination and marking might now be considered. Considerable caution was required. however, because past experience had shown this particular species to be an exceptionally nervous and excitable animal.

In the wild, competition between pampas deer, domestic stock and introduced chital and fallow deer was considered to be a potential problem in the deer's management. At present, introduced deer that enter pampas deer habitats are eliminated.

Poaching was still considered to be the main threat to the Argentine pampas deer. Efforts had been made to provide for a minimal degree of policing, at least, in the remaining areas in which the deer occurred, but in the long term greater effort was required to promote national and local interest and involvement in the need for conservation.

A general discussion on the study and management of critically endangered species produced the following conclusions:

(1) Conservation effort must be directed to conserving animal species and their habitat as integral and inter-dependent parts of a living system. Data on the habitat requirements of many species are presently inadequate. Habitats of most critically endangered species are almost certainly not optimal and more investigation is required into assessing the character and condition of the original habitat, as a basis for management. Historical records and anatomical characteristics of the animal were likely to be the principal sources of information on this subject.

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(2) Transplants should be made from captive herds rather than free-living populations of seriously depleted species, except where habitat of free-living populations is about to be lost through inundation, agricultural development and so on. Transplant populations should be restricted to areas within the original range of the species and to the former known habitats or areas most akin to them.

(3) Most threatened species' populations would probably benefit from manipulation of their present habitats. Provided adequate scientific data and staff are available, critically endangered species may also require manipulation of their populations. Manipulation may involve temporary removal of animals to breeding enclosures, to reduce the risk of extinction whilst degraded habitats are rehabilitated and protection against poaching is improved.

(4) Enclosures used in reintroduction or holding operations should be large and cover as wide a range of habitat types as possible for the health of the population and to provide conditions for etho-ecological studies to supplement work on the species in the wild.

(5) Threatened species projects, in general, frequently need to be initiated through use of international funding. Responsibility for subsequent conservation programmes, however, must be undertaken by the appropriate agencies within the country in which the species occurs, because international conservation funding is inadequate to sustain individual projects indefinitely and because of the need to promote national awareness and involvement in conservation.

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PART I: THE IUCN THREATENED DEER PROGRAMME

2. ENDANGERED, VULNERABLE AND RARE SPECIES UNDER CONTINUING PRESSURE

Preliminary Report on the Status of the Bawean Deer (*Axis kuhli*)

R.A. BLOUCH and S. ATMOSOEDIRDJO

ABSTRACT

This paper deals with the newly undertaken study of the Bawean deer (*Axis kuhli*). A description of the island including human geography is given. The successful captive herd (50) of Surabaya Zoo and the results of the first month of field work on the island are described with a view to the establishment of a proposed reserve.

1. INTRODUCTION

This report presents the results of the first month of field work on WWF Project 1324, a one year status survey of the Bawean deer (*Axis kuhli*, Müller and Schlegel 1836). This species is classified as rare in the IUCN Red Data Book, and is found only on Bawean Island, Indonesia, located in the Java Sea between Java and Kalimantan. The closest relatives of this small, secretive deer are the hog deer (*Axis porcinus*) of mainland south-east Asia and the Calamian deer (*Axis calamianensis*) found on the Calamian Islands of the Phillipines.

Several naturalists have made relatively short visits to Bawean Island and noted the status of the deer. Hoogerwerf (1966) felt that during his stay on the island in 1954 the deer was not very rare due to the enormous amount of fallow land covered with a secondary growth of shrubs and herbs, vegetation which he recognized as the deer's primary habitat. However, because of the rapidly increasing human population and the resultant increase in hunting and clearing of fallow land for agriculture, he feared the population might have declined to about 100 yds by 1966. Sitwell (1970) estimated the population at about 500 in 1969, but admitted his calculations could be wrong by a factor of two. He cited clearing of the forests to raise crops as the greatest threat to the deer, and did not think that hunting was intense enough to damage the population. Blower (1975) had a very different impression six year later. He reported that there were unlikely to be fewer than 500 deer, but that heavy hunting pressure was causing the population to decline.

The present study is funded by World Wildlife Fund in collaboration with

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the Indonesian Directorate of Nature Conservation (PPA). The research is being directed by the senior author, and the junior author is the counterpart PPA biologist on the project. Technical assistance is provided by the SSC/IUCN Deer Group. When completed, the project will provide the ecological data necessary to ensure the survival of the Bawean deer in the wild. Based on the results, we will advise PPA where to locate the boundaries of a nature reserve to be established for the protection of the species. Additionally, we will recommend management practices designed to restore and maintain the deer's productive status.

2. THE ISLAND

Bawean Island is of volcanic origin, roughly circular in shape, with an average diameter of about 15 km and an area of some 200 sq. km. The central region is mountainous with peaks of from 400 to 655 m in altitude. The coastal area is primarily agricultural land and is characterized by low hills separated by broad valleys. Precipitation comes mostly during the west monsoon period from mid October through March, and amounts to about 2500 mm a year at the town of Sangkapura on the south coast.

Forests cover 4700 ha or about 23% of the island. Teak plantations make up about 60% of the forested area. The remaining primary forests are confined to the steep sides and tops of the higher hills and mountains, often occurring as islands surrounded by teak. Planting of teak began about 35 years ago and, by 1954, Hoogerwerf (1966) noted that some hills were already entirely teak covered and that the Forestry Service was planting at an increasing rate. Most teak planting occurred 8 to 12 years ago with the last being done in 1975.

The human population on Bawean Island is dense and increasing rapidly. In 1954 there was 45,000 people (Hoogerwerf 1966), by 1975 there were 62,000 (Blower 1975), and today there are 70,000, mostly concentrated in the coastal belt. Principal occupations are fishing and farming, the main crops being rice, cassava, coconuts and bananas. Livestock on the island consists of about 7,000 cattle, 5,000 goats and sheep, and a few hundred oxen and horses. These are tethered and allowed to graze near the villages.

Bawean deer and wild pigs (*Sus scrofa*) are the only wild ungulates on the island. As mentioned earlier, the deer have been subjected to uncontrolled hunting, probably since the island was settled over 200 years ago. Due to the people's Muslim religion the wild pigs are not eaten, but they are somtimes killed as pests because of damage they cause to crops. Other animals of interest occurring on Bawean are long-tailed macaques (*Macaca fascicularis*), porcupines (*Hystrix* sp.), civet cats, flying foxes (*Pteropus* sp.), and pythons.

3. METHODS

The Surabaya Zoo in Java maintains a herd of 50 Bawean deer, and observations of these animals were made before we left for the island. The animals were classed according to sex and age. Fawns were those considered to be less

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than one year old, those between one and two years of age were classed as yearlings, and adults were defined as those over two years of age. Observation time totaled 91 deer-hours distributed from 0630 h. to 1730 h. The number of defecations per hour of observation time was noted for each sex and age class. Social interactions involving aggression and dominance were recorded.

Upon arrival on the island we decided to concentrate the study in the west central region and established living quarters there. A former deer hunter was hired as guide. We spent several days hiking the trails through known deer range to familiarize ourselves with the region. Three areas containing representative deer habitats were chosen for the establishment of permanent pellet count plots. The Kolpo-kolpo site consists of teak without understory, open teak with grass ground cover, teak with some brush understory, brushy secondary growth, and secondary forest. The Mt. Gadung site is located entirely within primary forest where selective cutting for firewood occurs. Plots at Mt. Mangoneng are mostly in primary forest seldom visited by humans.

Circular 20 sq. m plots were located randomly along randomly spaced compass lines. Two hundred and thirty six plots were spaced 10 to 50 m apart over 21 ha in the Kolpo-kolpo area. The same spacing was used for the 47 plots on about four ha at Mt. Mangoneng. Spacing between the 40 plots in three ha on Mt. Gadung varied between 10 and 40 m. Vegetation type and density, soil characteristics and fire history were recorded on each plot. Deer and wild pig pellets were removed from all plots and their occurrence noted. Tracks and evidence of feeding by these two species were also noted. The plots will be visited at monthly intervals to provide an idea of seasonal variations in habitat use.

Night counts are being made once a month in three sites, one each on Mt. Gadung and Kolpo-kolpo, and a third on Tumpeng Hill in a teak plantation. Barks heard, deer heard walking, and deer seen with the aid of a spotlight are all counted. Those deer seen are classified according to age and sex. It may be possible to identify the sex of a deer by its bark, but this technique requires further refinement.

All deer pellet groups encountered are dried and saved. The possibility of using pellet size as an estimator of herd composition will be investigated. Fecal analysis to determine the kinds and relative quantities of plants eaten may be undertaken in the future. A collection of deer food plants has been begun for identification by botanists at the National Herbarium in Bogor.

Frequent trips on foot have been made in the western part of the island to note deer signs and talk with the local people. Many have saved antlers from deer killed over the years, and these are measured whenever encountered.

4. PRELIMINARY RESULTS

The Bawean deer at the Surabaya Zoo are all descended from three females and two males captured in the wild between 1969 and 1972. In addition to the 50 deer present there in September 1977, five had been sent to zoos in Jakarta and Singapore. Officials report that the deer in Surabaya always give

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birth to single fawns, and that births occur year around. Assuming no mortality, the rate of increase from 1972 to 1977 would be accounted for by all yearling and adult females producing about 1.3 fawns per year. Our observations of these animals indicate that each deer deposits about 13 pellet groups per day, the rate being similar for all sex and age classes.

There are few reports of any recent hunting on the island, and we have seen no signs of it on our travels. At a meeting of all village headmen and government officials from the south side of the island we emphasized that the deer is protected by Indonesian law, and asked for the help of all present in discouraging hunting. Because of the respect which these officials have from the islanders, and because most sincerely seem to want to protect the deer, we are encouraged that hunting will remain minimal.

Since we have only checked the permanent plots one time, in most cases we do not know how long the pellets present have accumulated and therefore, with one exception, we cannot yet determine numerical values for intensity of use of each habitat type. What is already apparent, however, is the attractiveness to the deer of brushy vegetation, whether it occurs as an understory of teak or alone as young secondary growth. By the same token, teak plantations with no understory are receiving virtually no deer use.

In some places where an overstory is absent or very open there is fairly luxirent growth of grasses, predominantly lalang (*Imperata cylindrica*). Such openings are never very large, usually being considerably less than five hectares in size, but they are used intensively by deer, especially during the first month after a fire when grazing on returning lalang is often quite heavy. Since we have approximate dates of recent fires, and since almost all of the grassy opening covered by the Kolpo-kolpo plots has been burned recently, destroying or charring old pellets, we can estimate a deer use intensity of 15.5 deer/sq. km for this habitat during the late dry season.

Since we intend to use the pellet count technique as our primary estimator of deer numbers and habitat use, it is valuable at this point to check the accuracy of the above figure. The grassy opening sampled at Kolpo-kolpo is about four hectares in size. Applying the figure of 15.5 deer/sq. km, we find that it is supporting 0.62 deer. Since deer only visit the area after dark, and if we assume that each one spends around one hour grazing there, then about 15 deer must be coming to the opening each night. During our night observations we are able to count only the deer that come into the north half of the opening. On our two counts thus far we encountered five and seven deer, indicating that 10 and 14 deer, respectively, probably visited the entire opening on those nights. This checks well with the pellet count estimate.

Indications are that the deer use the primary forests mainly for sleeping or resting during the day. Deer trails are commonly found leading from the forest to the feeding areas in brushy teak and secondary growth at lower elevations. Our plots on the level top of Mt. Gadung show that this area is receiving very little deer use, probably because of the frequent disturbance caused by woodcutters. During one night of observation near a deer trail we counted five deer leaving the mountain. These animals probably spend the day in the forests on the steep inaccessible sides. The forest on Mt. Mangoneng

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is similar to that on Mt. Gadung, but because it is less accessible there is currently no wood cutting there. The first check of plots on Mt. Mangoneng indicates that this undisturbed forest is receiving good deer use.

As all previous visitors to the island have reported, the Bawean deer is a very wary animal which ventures out of dense cover only at night. They are usually encountered singly or in pairs made up of a doe with her young or a buck following a doe. They often encounter each other in grassy openings, although they cannot be said to congregate there.

Communication by barking is frequent and has several functions which are not yet fully understood. Often a few minutes after a pair of deer are surprised and separated one or both will bark, usually not more than two or three times, attempting to reestablish contact. The most sustained barking is done by males as a challenge to other males. In such a situation one deer was heard to bark 95 times during a 15 minute period. Foot stamping accompanies this bark and is quite loud, being audible to a human 40 or 50 metres away. Other bucks will rapidly approach a deer giving this call and answer it with a similar bark. It is reported that a fight will often follow, although we have not yet observed this. A man can induce deer to approach by imitating this bark with a short, sharp whistle.

An alarm bark has been described by Miller (1975) for hog deer in Thailand, and by Eisenberg and Lockhart (1972) for axis deer (*Axis axis*) and muntjac (*Muntiacus muntjac*) in Ceylon. We have never heard such a vocalization by the Bawean deer. When mildly alarmed they will always sneak quietly away, and when suddenly surprised they will run a short distance and move on quietly from there.

A python was recently killed that reportedly contained an intact adult deer. If the islanders are to be believed, these large snakes are quite common in some areas and may be a predator of some importance to the deer. Possibly the macaques and wild pigs take small fawns, but we have as yet seen no evidence of this. Additionally, there are reports of a few domestic dogs that have gone wild and kill deer.

5. DISCUSSION

Obviously the Bawean deer can breed successfully in captivity, in fact so successfully that the Surabaya Zoo is suffering from an overpopulation problem and officials are searching for other zoos to take their surplus animals. However in spite of cramped quarters the deer appear generally healthy. Many have deformed antlers, but perhaps the most likely explanation for this is that they are not able to avoid fights while their antlers are still in velvet. The estimated productivity for zoo does of 1.3 fawns per year indicates that each female over a year old gives birth to a single fawn once every nine months. This probably approximates to the birth rate among the free-living deer.

Presently the most serious threat to the wild population is loss of habitat. The enormous areas of secondary growth referred to by Hoogerwerf (1966) no longer exist, having been largely replaced by teak plantations and

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cultivation. Both primary and secondary forest are being steadily converted to cropland as the human population of the island continues to increase. More subtly, the brushy secondary growth attractive to deer is growing up or being shaded out by maturing teak. However, on the positive side, PPA will establish a reserve expressly to protect the deer. Additionally, initial indications are that the population should respond nicely to some fairly simple and inexpensive management techniques.

Based on the results of this study, one of our primary tasks will be to recommend boundaries for the proposed reserve. We do not yet understand the complexities of acquiring land for a reserve in Indonesia, but it is already apparent that fairly large areas of teak plantation must be included in addition to primary forest. Prime deer habitat is provided by small patches of brush within the plantations where secondary growth has outcompeted teak for one reason or another. Small clearcuts could be made within extensive areas of teak to duplicate these conditions. Also, older teak managed by PPA could be commercially thinned to open up the canopy and encourage the growth of brush. These policies are not likely to be initiated on lands managed by the Forestry Service since probably a teak plantation managed for timber and deer will not be as profitable as one managed for timber alone.

Beneath teak less than 12 or 15 years old brushy undergrowth can be fairly dense, providing good deer cover. Unfortunately extensive areas of this habitat are being burned every year, leaving a barren forest floor of no value to deer. These fires are apparently not an official tool of the Forestry Service, but are started for no obvious reasons by local people. An effective fire control program emphasizing education of the public will have to be initiated for the reserve.

Although they constitute a very small part of the total deer range, grassy openings are being found to be very important to the species both for grazing and as sites of social interaction. These areas need to be burned regularly to maintain their attractiveness since old lalang grass is not palatable. In addition to maintaining existing grassy openings it will be advisable to attempt to create new ones. Careful control of prescribed fires will be necessary to prevent their escape into neighbouring habitats.

The continuing cutting of wood in the more accessible primary forests will have to be strictly controlled. Aside from its effects on the forest, woodcutting during the day is certainly keeping the deer out of areas they would otherwise use for resting and sleeping. It may be a good public relations policy to allow supervised harvesting of dead trees for firewood during a short period each year.

Finally, we strongly recommend the hiring of local people as guards for the reserve. Former hunters know the island and the habits of the deer and, perhaps even more importantly, many have a respect and appreciation for the animal not found among off-islanders. Additionally, those who have worked with us will be familiar with the techniques we are employing during the study. Pellet counts and night observations will need to be continued after the reserve is established, and men experienced with this work will be valuable.

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We hesitate to make an estimate of the size of the population at this early stage, but there may be some value in stating that we feel there are more than 200 deer but probably fewer than 500. This figure could be revised as we become more familiar with the central part of the island. Many forested areas here appear suitable from a distance but are said to contain few if any deer. It is possible that the many wild pigs reported in this region are competing for space with the deer.

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PART I: IUCN THREATENED DEER PROGRAMME
2. ENDANGERED, VULBERABLE AND RARE SPECIES UNDER CONTINUING PRESSURE

Himalayan musk deer (Moschus moschiferus moschiferus)

MICHAEL J.B. GREEN

ABSTRACT

The Himalayan musk deer is a primitive, little studied cervid which is rapidly declining throughout its distribution, due to traditional land use practices and intense hunting pressures. The musk fetches a high price for its cosmetic and medicinal properties. Conservation measures and their economic effects are considered but, it is suggested, so long as the musk trade persists the species will be threatened.

1. INTRODUCTION

Relatively little is known about the Himalayan musk deer, one of five subspecies within the subfamily Moschinae. In fact the exact taxonomic status of the group remains unclear, Flerov (1952) distinguishing three species – *M. moschiferus, M. sibiricus* and *M. berezovskii,* and the southern species *M. moschiferus* being differentiated into the races *M. m. moschiferus* and *M. m. sibiricus.* Some work on musk deer has been undertaken by Flerov (1952); more recently the Chinese have experimented with farming musk deer. However, the literature is often contradictory with regard to the behaviour and ecology of musk deer and such issues will only be clarified by further fieldwork.

Musk deer have long been killed for their musk, which is used in cosmetics and medicines, but only in recent decades has its economic value risen sharply due to decreasing resources. The "threatened" status of *M. m. moschiferus* has been recognised (Holloway 1973) and the species is now classed as "vulnerable" in the Red Data Book (IUCN 1974).

The IUCN/WWF Joint Project Operations will support Project 1328, which is designed to determine the status and conservation needs of musk deer. It is hoped that this will commence in the Langtang National Park, Nepal, but the project awaits approval from His Majesty's Government.

This paper summarizes much of what is known about the Himalayan musk deer, supplemented with some preliminary information obtained from the Durham University Himalayan Expedition (DUHE) to the Langtang National Park, and outlines future conservation priorities.

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2. DISTRIBUTION

Formerly, the Himalayan musk deer was widespread from Pakistan, through Nepal, to Bhutan and northern Burma and extended into parts of Tibet and south-west China. Its overall range may have changed little but severe hunting pressure has resulted in populations occurring in isolated pockets in Nepal and the near extermination of the species in India (Jamwal 1972).

In Nepal it is found in the Lake Rara, Langtang and Sagamartha National Parks and also in Bajang, Dhoti, Tibrikot, Markhor Lekh, Dhorpatan, Manang, Jatapokhari, Thaplejung, Chipuwa, Arun Valley and Olanchungola (Dhungel 1977).

3. DESCRIPTION

The musk deer is like a large rabbit, with its long ears, arched back and bounding gait. It stands 51–61 cm high at the shoulder (5 cm higher at the rump), weighs up to 15 kg (12 kg for females) and may approach 1 m in body length. The coat is grey or brown, possibly according to the season, and the hair is peculiarly brittle and corrugated, having a plastic-like appearance. This may have special insulating properties.

Musk deer are regarded as primitive members of the Cervidae for they lack antlers and the males have elongated upper canines; in both respects they resemble the water-deer (*Hydropotes*). The presence of a gall bladder, not found in other deer species, is a bovid feature. The absence of tarsal, metatarsal and suborbital glands further distinguishes them from other Cervidae. However, musk deer possess a caudal gland and males have a musk sac which is situated between the umbilicus and penis. Flerov (1952) maintains that both these glands are concerned with sexual activity. McNeely (1973) suggests that the single pair of mammae in females (two pairs in other Cervidae), which resembles the musk gland of the male in gross appearance, may be an example of sexual mimicry. This sac of the male, known as a "pod" in the trade and unique amongst deer, is about 6.0 x 3.0 x 4.5 cm (Flerov 1952) and contains the gelatinous, odoriferous musk. The amount of musk contained within a pod varies with the season (Sterndale 1884, Allen 1940) and the age of the animal. Adult male pods weigh about 30–45 g (3–4 tola[1]), while those from immature males weigh 5 g (Flerov 1952). Musk deer are commonly killed in order to obtain the musk, but Flerov (1952) points out that, "It is not necessary to kill the animal in order to obtain the musk. To remove the musk from the bag it is only necessary to put a tube into the aperture, when a stream is excreted by slight pressure on the bag."

Several adaptations necessitate the genus *Moschus* to be placed in a subfamily (Moschinae) of its own (Flerov 1952). For instance, the lower incisors differ from other deer, being similarly sized and shaped; their spatulate form apparently facilitates the removal of mosses and lichens from rocks and trees. The well-developed upper canines in the male (7–10 cm long) are used as duelling weapons (Flerov 1952) rather than for digging up roots, as mentioned by Beddard (1909). The molars are not adapted for the

[1] 1 tola = 11.5 g

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trituration of hard grasses (Flerov 1952). The spinal lumbar region is enlarged to facilitate leaping and well-developed lateral hooves (though to a lesser extent in *M. moschiferus*) enable the animal to obtain a firm purchase on precipitous faces or snow slopes (Flerov 1952, McNeely 1973).

4. ECOLOGY AND BEHAVIOUR

Habitat

The Himalayan musk deer commonly occurs between 2,400 and 4,300 m in a variety of forest types, including birch (*Betula utilis*), fir (*Abies* spp.), juniper (*Juniperus* spp.) and rhododendron (*Rhododendron campanulatum*). In the Langtang National Park individuals have been seen between 3,000–4,100 m, though faeces have been found above the forest level up to 4,300 m.

Flower and Lydekker (1891) state that musk deer are rarely found below 2,100 m in the summer, thereby suggesting seasonal changes in altitudinal range, while McNeely (1973) gives the range as 1,800–4,300 m and mentions that one individual was seen at 2,300 m in January.

Activity and Range

Musk deer are crepuscular, being active at dawn and dusk. During the day they rest in "forms" (Lydekker 1907), often on cliff ledges (Flerov 1952). It is quite likely that they are active throughout the night; in the Langtang Valley musk deer were disturbed on two occasions near midnight, probably while feeding.

It seems likely that females occupy a relatively small area. For example, one female, observed on four separate occasions over a six month period, was always seen within the same area of about 200 x 400 m (Fleming Jr., 1977, pers. comm.). Since musk deer repeatedly defaecate in a number of definite sites, some form of territoriality seems likely.

Flower and Lydekker (1891) and Fox (1974) imply that higher summer altitudinal ranges exist but good evidence is lacking.

Group Size

Musk deer are generally solitary, except during the rut, though females and young may gather into small groups (Flerov 1952). In the Langtang National Park only solitary individuals were sighted by DUHE, on eight occasions.

Reproduction

The rut begins in December and females remain in oestrus for one month, during which time "Males are highly excited... and eat very little. The females, on the contrary, become extremely exhausted and continuously try to conceal themselves from the male by taking shelter in thick forest stands among rocks. It is precisely then that the males seek the females most intensely and fights between them (i.e. males) are particularly frequent" (Flerov 1952).

Gestation is five months (Walker, 1964, states 160 days) and usually one young is born between April and June (Flerov 1952). Females become

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sexually mature within a year (Sterndale 1884, Walker 1964), males within two years. Due to heavy hunting pressures, McNeely (1973) suggests that populations are probably stretched to maximum breeding capacity, with females having to reproduce in their first year.

Food Requirements

Grasses, leaves (e.g. those of *Skimmia laureola* – Fam. Rutaceae), roots, lichens (e.g. *Cetraria, Cladonia, Usnea* spp.) and bryophytes (e.g. *Hypnum, Marschantia* spp.) constitute the diet. During the winter, as snow depth increases, musk deer become more dependent on lichens from trees, though they may also scrape for mosses and dried perennials or grasses, using their hooves (Flerov 1952). At Khumjung (Sagamartha National Park) a female was observed on different occasions for a total of about 10 hours between December and May. *Usnea* sp. constituted about 99 percent of her diet and frequently she was seen on her hind legs reaching up for this pendulant lichen (Fleming Jr., 1977, pers. comm.). In the Langtang Valley the bark of *Abies spectabilis* is nibbled, probably by musk deer, and McNeely also mentions the needles of cedar (*Cedrus deodara*) being eaten. The Chinese, who have domesticated musk deer, have found some 20 species of herb to be essential constituents of the diet in maintaining healthy, captive animals (Anon. 1975).

Predators

Leopards (*Panthera pardus, P. uncia, Neofelis nebulosa*), lynx (*Felis lynx*), wolf (*Canis lupus*) and wild dog (*Cuon alpinus*) prey on musk deer, while large raptors and fox (*Vulpes vulpes*) allegedly take young individuals (Flerov 1952). In the Langtang National Park, predators are likely to be the wild dog (*Cuon alpinus*), common leopard (*Panthera pardus*) and Himalayan yellow-throated marten (*Martes flavigula*). Locals claim that martens hunt musk deer in pairs, chasing their prey until it is exhausted. Harper (1945) also mentions predation by this species.

5. EXPLOITATION OF MUSK DEER AND ITS HABITAT IN NEPAL

Musk deer populations are not only being depleted in Nepal but throughout their entire geographical range. However, since the best, and hence most valuable, musk comes from *m. moschiferus* (as opposed to *m. sibiricus*), mainly from Nepal, it is important to focus attention on this country from a conservation viewpoint.

1. Land Use Activities

Although not the main factor responsible for the decline in musk deer populations, increasing use of birch and rhododendron forests for fuel is progressively restricting this habitat. For instance, in the upper Langtang Valley the subalpine forests (birch-rhododendron) supply locals, tourists and the cheese factory with firewood. Rather than selectively thinning these forests, large stands are completely cropped; moreover, grazing by yak and cattle prevents the establishment of seedlings and hence forest regeneration.

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2. Poaching Activities

In Nepal, locals catch musk deer by using dogs, snares or poison (Jamwal 1972). In the Arun Valley (McNeely 1973) and Langtang National Park, traplines consist of brush barricades which may stretch for several kilometers. Gates are placed at intervals, wherever the barrier crosses a deer trail, and these are set with spring-loaded nooses which either ensnare the animal's foot or its neck.

Although Langtang was gazetted a National Park in March 1976, poaching is still rife (Fig. 1). Its upper subalpine zone (3,600–4,000 m), which is good



Figure 1. Snare for musk deer: Langtang National Park, Nepal.

musk deer habitat, covers 6.5 percent of the Park's 1,710 sq. km area. Approximately one fifth of this habitat was visited and some 86 percent was found to have been trapped within the last three years; in most cases the traplines were still in use (DUHE 1977). From 100 to 600 gates may operate in a one kilometre section of valley. Although the efficiency of this trapping method is not known, the above figures indicate the intensity of such poaching activities.

Furthermore, in the remote Namlang Valley, Jackson (1977) found that locals used poisoned spears which were strategically placed in the ground below ledges or near defaecation sites. Musk deer would be driven towards these traps by lighting fires in the grassland above the forest level. The 30 odd poachers, comprising six groups, hunted between November and the first snows in January, during which time they obtained 54 tolas of musk from 105 captured animals (including females and young). Assuming that, on

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average, adult males yield three tolas, then only one adult male was caught for every six animals trapped. This amply illustrates the indiscriminate killing of females and young by local trapping techniques, thereby severely affecting a population's breeding potential.

South of Dolpo poaching is well-organized and 200 musk deer were killed in the two years between 1963–65 (Jest, pers. comm.). Around Ganesh Himal, Manaslu and south of Kanjiroba locals say that musk deer are disappearing (Jest, 1977, pers. comm.) and hunters from Ankhu Khola are now going to Bhutan or Sikkim where it is apparently more plentiful (Toffin 1976).

Export of Musk

The musk trade is centuries old; for example, Hamilton's account of the Kingdom of Nepal (1819) states that, "The most valuable production of the southern face of these mountains (Nepal Himalayas) is the animal which produces musk of which vast numbers are killed annually." Rockhill (1891) frequently mentions the musk trade with China, one Shanghai agent purchasing over $150,000 worth annually. At that time it sold for 20 Rs[1] per ounce (two tolas), then equivalent to about half its weight in gold. In 1972 hunters from Seti Khola (northwest Nepal) were receiving 700 Rs per tola (Jest 1974), though 350–500 Rs is the usual figure which is quoted (Blower 1974). In 1974 the export value of musk was 1,400–2,500 Rs per tola (Blower 1974) or four times its weight in gold.

During 1972/73, 10,029 tolas of musk (116.34 kg)[2] was officially exported from Nepal to Hong Kong, Japan, S. Korea and France. This amounted to $1.1 million and represented 8.7 percent of Nepal's total exports. Since an adult male yields 3–5 tolas of musk, this export represents 2,000–3,300 individuals (Blower 1974). The number of musk deer actually killed could have been as high as 12,000–19,800 animals if Jackson's ratio of adult males to females and young (1:6) trapped is representative for the whole of Nepal.

6. CONSERVATION MEASURES TAKEN IN NEPAL

The National Parks and Wildlife Conservation Act, 1973, made the export of musk illegal. However, such legislation has merely driven the trade underground and, consequently, it has become difficult to elicit up to date information concerning the present situation.

As a result of the Act, mountain national parks have been established at Lake Rara, Langtang and Sagamartha. Moreover, other areas have been set aside as reserves. At present the park guards are ineffective in curbing poaching, even though hunters are occasionally apprehended. Hopefully, the land use factor (i.e. grazing, agriculture and forest cropping) will be properly controlled, following the introduction of the Himalayan National Park Regulations.

[1] In 1977, 12.45 Rs (Nepalese Currency) = $1

[2] The international trade requirement was then 2,400 kg per annum (Jamwal 1972).

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7. OUTLINE FOR CONSERVATION

Ways to ensure the conservation of musk deer in Nepal are summarized below. Most of these recommendations have already been incorporated in the management plan for the Langtang National Park (DUHE 1977).

1. Control of Land Use

Since the Langtang and Sagamartha National Parks contain resident human populations, it is essential that such areas are zoned so that local activities, such as grazing by livestock, agriculture and the collection of forest produce, are contained within certain areas, while others, including representative stands of musk deer habitat, are left undisturbed as "strict natural" or "wilderness" areas.[1]

2. Control of Poaching

The guards, assigned to Nepal's mountain national parks, should be effectively used in antipoaching. It has been recommended, for example, that the Langtang National Park be divided into five administrative sectors, each with one to three guard posts (13 men). During extensive patrols, poachers could soon be apprehended and traplines rendered ineffective.

3. Research

It is imperative that the status of existing musk deer populations be investigated, beginning with the Langtang National Park. Initially, a suitable census method would have to be determined. Given time, it should be possible to estimate the absolute number of musk deer within one or several small areas by direct observation. Such counts could then be related to the density of defaecation sites within each area by means of a coefficient. Thus, the densities of defaecation sites for other areas could be converted into absolute numbers of animals by using such an index. However, the non-random distribution of such sites would affect the sampling method.

The dietary requirements and behaviour of musk deer should also be investigated, with a view to captive breeding.

4. Musk Deer Farming

Since 1958, the Chinese have experimented with farming musk deer (Anon. 1975) and are now able to milk males up to 14 times without harming the animal. Until their methodology is perfected, however, they are unwilling to release further details.

In Nepal musk deer farming could meet the demands of the international market. For instance, a pilot scheme could be started in the Langtang National Park to determine the exact breeding requirements and develop a technique for extracting musk. As found by the Chinese, the dietary needs of musk deer would require particular attention.

An alternative to breeding musk deer in captivity would be to catch wild animals periodically, extract the musk and then release them. The problems

[1] As defined at the 11th General Assembly of IUCN, 1972

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involved in keeping penned animals would be avoided, though the net amount of musk obtained would be less than if they were bred in captivity.

5. Synthetic Substitutes

There are over 80 synthetic substitutes for the musk which is used in cosmetics as a fixative. A greater public awareness might be helpful in the acceptance of synthetic alternatives, though it should be noted that musk is also used in oriental medicines and, probably, as an aphrodisiac.

8. ECONOMIC EFFECTS OF PROPOSED CONSERVATION MEASURES

Musk was formerly Nepal's third largest export. It may still be so although, now that the trade operates on an illegal basis, His Majesty's Government of Nepal is losing a considerable source of official revenue. The successful establishment of musk deer farms could again result in the remunerative export of musk.

At a local level, it is important to consider the effects of curbing poaching since some villages are partly dependent on musk as a source of income. Jackson (1977) estimated that the 1976/77 hunting season provided a third of Dalphu villagers (about 60 families) with their annual cash requirements. Blower (1974) notes that a single musk pod (3–5 tolas) will provide a year's income for a family living in a remote hill region. Musk deer farms should employ poachers both to utilize their intimate knowledge of this species and to alleviate hardships from poaching control.

Also, musk deer hunters could be trained to extract musk from live animals, once a suitable technique had been developed, and allowed to capture and release them, on a controlled basis, in certain areas. Obviously hunters would need to develop new trapping methods, so that animals were not killed, and the purity of the musk, which is easily adulterated, would need to be checked. Such a scheme could be implemented whilst a pilot study on captive breeding was underway.

However, it should be realized that musk deer farming will not help conserve wild populations, which will still need to be protected from poaching. In fact, farming will merely sustain the commercial need for musk and so long as this trade exists the species' survival in the wild will remain jeopardized.

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PART I: THE IUCN THREATENED DEER PROGRAMME
2. ENDANGERED, VULNERABLE AND RARE SPECIES UNDER CONTINUING PRESSURE

Some aspects of the ecology of the swamp deer or barasingha (*Cervus d. duvauceli*) in Nepal

DIETRICH SCHAAF

ABSTRACT

Only 3 barasingha populations are known to survive in Nepal in the south-western lowlands, 2 of uncertain size and status in the Karnali-Bardia and Dhaka Reserves, and 1 of about 1,000 animals in the Sukla Phanta Reserve. Sukla Phanta is located in a poorly developed region beset by problems of renewable resource depletion and increasing human population. These factors along with poaching, livestock grazing and other human activity in the reserve may pose a threat to the long-term survival of the deer. Habitat preference surveys indicated that most of the barasingha remained all year on the southern grasslands, utilizing about 32 km^2 of the 147 km^2 reserve. The deer congregated annually in February–April in large herds, and censuses at that time gave minimum population estimates of 805 in 1975 and 908 in 1976. Data from a series of years are needed to determine population trend. Predation by tigers, and possibly also jackals, on small fawns is a source of mortality. Poaching accounts for some animals. In the recent past, severe flash floods of the Mahakali River also have affected the population adversely, and could recur at any time. Conservation recommendations include removal of all human disturbance, continued monitoring of population size and structure, securing the two other extant populations, investigating possibilities for introduction into other areas, and investigating prospects for a joint reserve between Nepal and India where Sukla Phanta adjoins Indian territory.

INTRODUCTION

Earlier studies of barasingha were undertaken on the southern subspecies (*C.d. branderi*) in the Kanha Park of central India (Schaller 1967, Martin 1975). Recently attention was turned to the more numerous and widespread (though still endangered) northern deer in their few remaining strongholds (Holloway 1973). The present study was made to evaluate the status of barasingha in the Sukla Phanta Reserve of Nepal (Figure 1) and, insofar as possible, to begin obtaining the data needed to plan for the conservation of this subspecies in the wild. This paper deals primarily with habitat preferences

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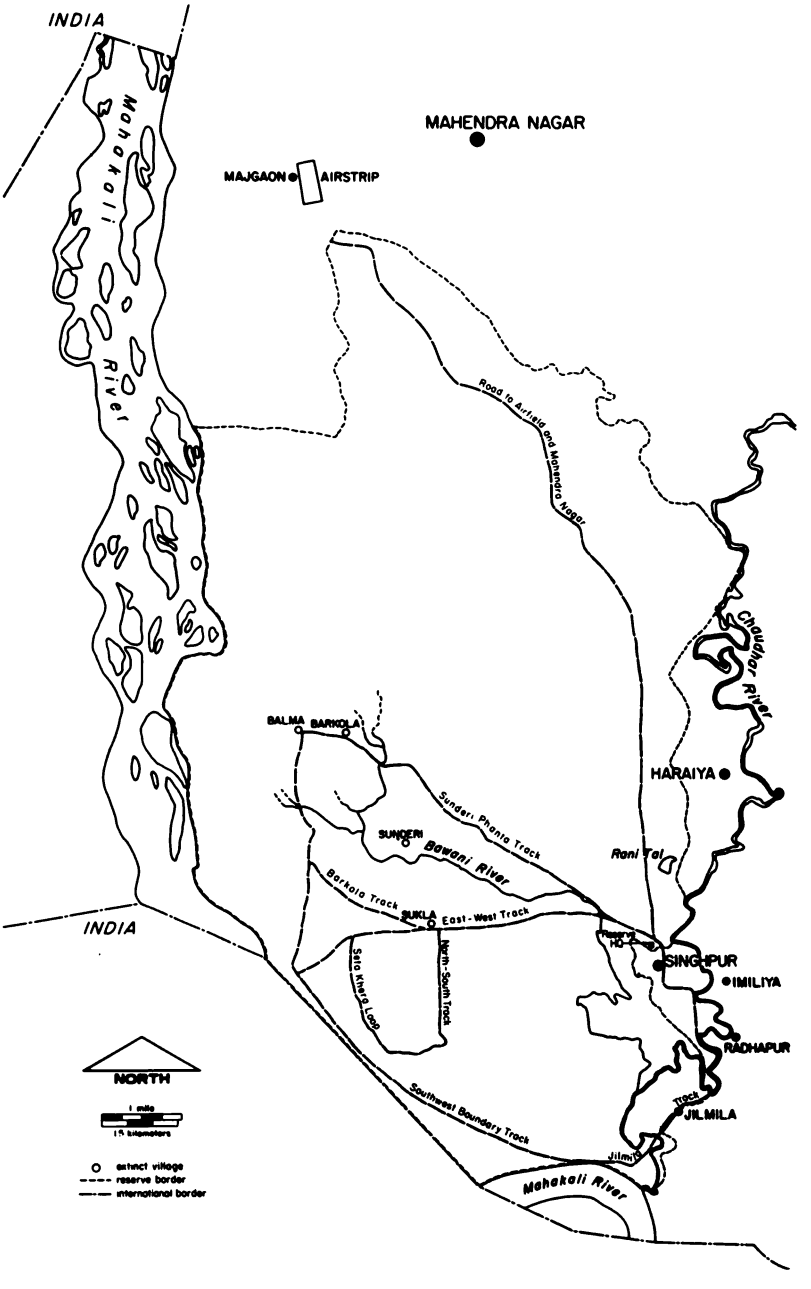


Figure 1. Sukla Phanta Reserve, Nepal – Location and main physical and political features.

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and deer distribution in the reserve, and estimated current population size and structure. Some recommendations to further conservation are also made. The study took place between April 1974 and May 1976.

2. BARASINGHA IN NEPAL

Barashingha in Nepal inhabit the *terai*, which is an extension of the North Indian Gangetic Plain, and fringes much of the southern edge of this otherwise mountainous country. During the 1950s, barasingha were found in the districts of Banke, Bardia, Kailali and Kanchanpur, or approximately the western third of the terai from about 25 km east of Nepalganj to the Mahakali River and beyond (K.M. Tamang, pers. com.).

In 1957 barasingha were also reported "in large numbers" from the Chitawan Valley of south central Nepal, an area today famous for a national park by the same name.

The barasingha of Chitawan lived in the once extensive marshy grass-lands north of the Rapti River, outside what is now the park (K.M. Tamang, pers. com.). According to Schaller (1967), a few animals were seen in Chitawan as late as 1963. None occur there now. The grasslands where they formerly lived have been settled and put to agricultural use.

At present only 3 barasingha populations are known to survive in Nepal, each isolated from the other 2 by distance and/or agricultural development. In 1976, "no more than 20" animals were reported by Dinerstein from the Karnali-Bardia Reserve (348 km^2) in Bardia District. Some 110 km further west a population of unknown size and status survives in the 37 km^2 Dhaka Shikar (Hunting) Reserve in Kanchanpur District. One stag was allegedly shot there on a government hunt in 1976 (H.R. Mishra, pers. com.), and local people have reported sightings and calls. I have not seen barasingha personally in Dhaka. The reserve was heavily used by graziers at the time of my visits, and it appeared that agricultural settlement also may have been encroaching. A few kilometers west of Dhaka, Sukla Phanta Wildlife Reserve (147 km^2) harbors the largest remaining population in Nepal, ca. 1,000 animals (see below).

3. THE STUDY AREA – SUKLA PHANTA[1] RESERVE

The reserve is located on the extreme southwestern terai. It is bounded on the west by the Mahakali (Sharda) River, a major tributary of the Ganges, and 6.1 km of its southern boundary are coincident with the international border between India and Nepal.

Soils of the reserve are alluvial, derived from deposits laid down by the Mahakali and its tributaries. The climate is monsoonal with over 90 percent of the annual rainfall occurring in the monsoon season between June and September. The highest temperature recorded during the course of this study

[1] The term "phanta" means an open, grassy plain. Sukla Phanta is one of several in the reserve, and the one for which it is named.

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was 48°C in the pre-monsoon hot season or summer; the lowest was 2°C during the cold season or winter.

The more elevated and better drained soils in the north-eastern portion of the reserve (ca. 80.5 km^2) support moist deciduous forest in which the sal tree (*Shorea robusta*) predominates (Champion and Seth, 1968). Open savanna grasslands are included in this forest. There is a distinct break in elevation in most places in the reserve between the sal forest environment and the mosaic of mixed deciduous forests, grasslands and marsh occupying the low lying, more recent alluvium in the southwest (ca. 66.8 km^2).

Animal life in the reserve is varied despite the loss of several large mammal species in recent years. Excluding most bats, rodents, insectivores and small carnivores, 26 mammal species were recorded, including tigers and 4 kinds of deer in addition to the barasingha.

4. SPECIAL PROBLEMS WITH REGARD TO POTENTIAL CONSERVATION CONSTRAINTS

4.1. Problems Associated with Reserve Location

(a) Sukla Phanta is situated in the least developed region of the Nepalese terai. In the past 10–15 years there has been a rapid degradation of forests and soils on which the area heavily depends, with clear-felling and conversion of the land for subsistence agriculture, and a steady influx of human population from the neighboring hill regions and India.

Since transporation and communication systems are marginal, and other facilities are lacking, it is unlikely that tourism, which has provided an incentive for conservation in other parts of the world, can help provide economic support for the reserve in the foreseeable future. Its survival will depend almost enitrely on the enlightened vigilance of the authorities.

(b) The common border with India permits incursions from that country, but hinders the Nepalese authorities once offenders slip back over the border. Since 1975, there has been settlement on the Indian side, some of it within sight and sound of the reserve. Humans thus are closer to the barasingha inhabiting the southern grasslands than they have been at any time since the reserve was first created as a hunting area for the King of Nepal in 1965, and animals that cross into India are unprotected and at the mercy of the local inhabitants.

4.2. Livestock Grazing

Grazing by cattle and domestic buffalo was prevalent throughout the reserve during the study. All areas, with the exception of the south central grasslands of Sukla Phanta proper and the immediate environs were affected to some degree. The latter area was probably not utilized by graziers because it is readily accessible from reserve headquarters and more frequently visited by staff than other parts of the reserve.

When livestock were not actually seen in the field, often the signs of their passage were evident. As many as 1,450 head of cattle and buffalo have been counted in one day in the south-eastern sector of the reserve during the

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premonsoon season, when grazing by domestic animals was heaviest in that area.

4.3. Poaching

While it is difficult to assess the impact of poaching, there is no doubt that it was prevalent during the course of this study. During the period from April 1974 to May 1976, 70 incidents related to poaching were recorded. Most of them took place during the winter and premonsoon seasons. By far the most common among them were shots heard while in the field, but also included were armed persons seen, hunting camps found, and encounters between forest guards and poachers, one of which resulted in 3 human deaths.

It is assumed that the most commonly taken large mammal was the spotted deer or chital (*Axis axis*), by virtue of its relative abundance and wide distribution in the reserve. Hog deer (*Axis porcinus*) and barasingha also were killed, although it is not known to what extent. I witnessed 2 unsuccessful attempts to kill barasingha, and one instance of hog deer poaching was recorded. The local authorities thought that my presence in the reserve acted as a deterrent to would-be barasingha poachers, but whether or not this was true could not be determined.

4.4. Grasscutting and Other Forms of Gathering

Each winter the local people were permitted to enter the reserve for a 30 day grass cutting season. The grass they collected was used for thatch and other building purposes. Virtually all reserve grasslands were affected. People came from as far as 50 km distant with carts and draft animals to haul away grass of a quality and abunadance which they said was hardly available elsewhere, a condition attesting to the extent of habitat degradation outside the reserve. The traffic into and out of the reserve at this time was very heavy. In one day during 5 hours at the height of the 1974 season, 338 loaded oxcarts and 582 people were recorded leaving the reserve by one of several main routes then in use.

On a smaller scale, grass was also collected for making rope and twine. This was done toward the end of the monsoon season in August, and involved primarily one species, *Eulaliopsis binata*, which grows most abundantly in the sal forest grasslands. At the same time the inner bark of the tree *Sterculia villosa* occasionally was stripped for rope making. These and other forms of gathering (e.g., wild fruits and vegetables, wood cutting) were only casually regulated during the course of the study.

5. HABITAT IN THE RESERVE

5.1. Vegetation Types

(a) *Sal forest* occupies the largest continuous area in the reserve (Figure 2). Much of the forest is open, and in most places a grass understory is present.

(b) *Sal savanna* is part of a seral continuum including forest and grassland, but trees are more widely scattered and/or smaller than in the forest. All grasslands in the sal forest are savannas, and most are fire maintained, while a few are annually flooded by the monsoon.

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Figure 2. Sukla Phanta Reserve, Nepal – Vegetation types and names of the main phantas or grasslands. Unshaded areas to the north and south are outlined according to the map key, and represent sal forest and lowland grasslands respectively.

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(c) *Mixed deciduous forest* occurs in scattered patches among the more extensive grasslands in the southwest of the reserve. Sal is absent and no single tree species is comparably dominant.

(d) *Dry grassland* covers large tracts in Sukla and adjacent phantas. It is "dry" in the sense that it is well drained and does not accumulate much standing water during the monsoon. Aside from a few widely scattered individuals, trees are absent.

(e) *Seasonally wet grassland* is similar to (d), but because of poor drainage or low elevation, extensive areas are flooded during the monsoon.

(f) *Lowland savanna* occurs on the fringes of all the main grasslands, and occupies most of Karaiya Phanta. Scattered trees are more numerous in these savannas, which otherwise are similar to (d) above.

(g) *Khair-sissoo forest* is a subtype of the mixed deciduous forest, named for the 2 tree species which predominate. It is an early successional stage which occupies the gravel bars, islands and abandoned beds of major north Indian rivers such as the Mahakali, and it is found in the southwest corner of the reserve.

(h) *Marsh* is found most extensively east of Sukla Phanta proper. The substrate is either soft and wet, or actually contains standing water throughout the year, and very tall, dense grasses predominate.

5.2. Fire

Annual grass fires during the winter and pre-monsoon seasons burn over a major portion of the reserve. The first fires were recorded on 29 November 1974 and 4 December 1975, and by the end of December in both years, most of the southern grasslands had been burned. Fires were virtually all man-made, beginning with the activities of grass cutters in the southern phantas of the reserve. Grass fires also may have swept across the southern border from India.

Burning in the sal forest and associated grasslands began 3–4 months later in the season. Since not all areas burned at once, some forage remained for grazing animals such as barasingha. Within a few days after a burn the first signs of new growth appeared. The fresh grass grew quickly and formed an an attractive food source for chital and hog deer as well as barasingha. Fire thus indirectly influences the movement and distribution of grazing animals, and helps to maintain the grassland habitats.

5.3. Availability of Water

Monsoon rains began on or about 17 June 1974 and 23 June 1975. During and immediately after the monsoon, water is available everywhere, and some remains in temporary ponds until late in the dry pre-monsoon season. Aside from the rivers (Mahakali, Bawani and Chaudhar, the latter dry by the time the monsoon begins), these are the main sources of drinking water in the southern grasslands. Several ponds are located on sukla Phanta proper and its immediate vicinity. All but 2 are dry by May, and these also disappear by the end of that month. Thereafter the nearest water is available in the marsh east of the main grasslands.

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Dew-falls in the dry season, recorded as late as mid-April, may alleviate the need to drink. Moisture is also present in the green grass, which remains fresh during the pre-monsoon drought due to the high level of the subsurface water table (Singh, 1966), especially in the seasonal wet grasslands.

In the sal forest and grasslands a similar situation exists. Two ponds are known to contain water into the month of May. Permanent water is located in the marshy center of Sunderi Phanta adjacent to the forest, and in Rani Tal, a small lake on the east side of the reserve. Since the water table is lower in the sal forest region and grass fires come later, less green forage is available before the monsoon commences.

5.4. Influence of the Mahakali River

Much of the southern lowland area of the reserve lies on the flood plain of the Mahakali River. The presence of oxbows and escarpments formed by old stream banks well within the grasslands indicates that over the years the river meandered south to its present course, in a manner characteristic of the large north Indian streams.

In 1928, a dam was built at Banbassa, north-west of the reserve in India, and river water was diverted to India for irrigation. The floods which had shaped the southern lowlands ceased, or occurred less frequently and with less force. Flooding today results mostly from the overflow of the Bawani River and through the accumulation of rainfall in poorly drained areas. However, in 1968 and 1972 severe flash floods occurred along the Mahakali with apparently disasterous results for humans and wildlife alike, as will be explained below.

6. BARASINGHA HABITAT PREFERENCES

Habitat preferences determine where animals will be found, and to some extent also determine the kinds of observations which can be made on them. For example, the methods used to count barasingha and estimate population size depend on the seasonal congregation of deer on the grasslands of south central Sukla Phanta, as explained in a later section of this paper.

6.1. Methods

Observations were collected from domestic elephant-back along 15 permanent transects in 6 of the vegetation types previously described[2] at the following times of year: March (1975), May–June, August–September, December, and again the following March (1976). With each sighting the following data were recorded: species (barasingha, hog deer or chital), group size (1 or more), estimated distance from observer, and habitat (vegetation) type.

Data were analyzed by comparing the observed number of animals with an expected number in each vegetation type, the expected number being derived from the proportion of the particular vegetation type in the total area

[2] Khair-sissoo forest and marsh were inaccessible even by elephant, and so dense at most times of the year that wild animals would not have been visible.

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surveyed (Neu *et al.*, 1974). Detection of a significant difference between observed and expected numbers using a chi-square test indicates that selection is taking place, but does not of itself suggest which types are being selected or avoided. For this purpose confidence intervals may be calculated using Bonferroni normal statistics (Z) to determine whether expected proportions lie within the range of significant effects. The larger of 2 significantly different proportions then indicates whether a type is being selected or avoided.

An estimate of area covered by season, vegetation type and deer species was made by determining the average sighting distance for each combination and using it to calculate strip width, which was multiplied by transect length. Strip width derived in this manner reflects a relative area covered, which would not be suitable for estimating animal density, but which is sufficient for determining relative numbers of animals in different vegetation types.

6.2. Results

Table 1 shows the data and calculations derived from them for March 1975. Data for the other 4 collection periods were similarly tabulated.

The chi-square test indicated a highly significant distribution for all 3 deer species during each data collection period. The smallest calculation chi-square value was 26.981, compared with a table value of 9.236 ($df = 5$, alpha = .10).

Considering barasingha alone, Table 2 presents a summary of the analyses which facilitates comparison between vegetation types and data collection periods. The symbols used denote whether animals prefer or avoid habitats, or use them without demonstrating a preference. Where no confidence intervals could be constructed (i.e., no animals were observed), inferences have been drawn from the raw data (number observed vs. expected). Inferences are based on the magnitude of observed differences, and comparison with other differences which proved significant. In the sal forest and savanna types in May–June, the data were insufficient to make a judgement between "no preference" and "avoidance".

6.3. Discussion

Barasingha were consistent each season in their preference for dry grassland. Lowland savanna was also preferred in March 1976, whereas a year earlier it had been avoided. This may be explained by the fact that the largest herds in 1976 occurred on the open dry grassland along a transect which was not included in the survey, in order not to disturb the animals then under observation for other purposes. Of 271 animals counted, 179 were seen in the savanna habitat. It is likely that if all animals in both habitats had been counted, a preference for dry grassland would have been shown, as in the previous year.

In May–June seasonally wet grassland in Seta Khera Phanta also were preferred. As the season progresses, grazing may be better at these lower elevations where grass is kept fresher by the high water table.

Drinking water also had disappeared from Sukla Phanta proper (see above) where the animals previously congregated.

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Table 1 *Occurrence of 3 deer species in 6 vegetation types in Sukla Phanta Reserve, Nepal – March 1975*

Habitat	Species	Area surveyed (ha)	Proportion of total area & expected prop. of deer (p_e)	Number observed	Number expected	Proportion observed (p_o)	Confidence interval on proportion of occurrence (90% family confidence coefficient)
Dry grassland	barasingha	634	.324	884	375	.765	$.736 < p_o < .794^{**}$
	hog deer	200	.304	10	16	.185	$.058 < p_o < .312$
	chital	467	.349	4	106	.013	$.003 < p_o < .029^{*}$
Seasonally wet grass land	barashingha	525	.268	23	310	.020	$.010 < p_o < .030^{*}$
	hog deer	166	.252	33	14	.611	$.453 < p_o < .769^{**}$
	chital	386	.288	89	88	.292	$.230 < p_o < .354$
Lowland savanna	barashingha	699	.357	249	413	.215	$.186 < p_o < .244^{*}$
	hog deer	252	.383	10	21	.185	$.058 < p_o < .312^{*}$
	chital	394	.294	201	90	.659	$.594 < p_o < .724^{**}$
Mixed deciduous forest	barashingha	24	.012	0	14	.000	–
	hog deer	15	.023	1	1	.019	–
	chital	31	.023	10	7	.033	$.009 < p_o < .057$
Sal savanna	barashingha	41	.021	0	24	.000	–
	hog deer	12	.018	0	1	.000	–
	chital	27	.020	0	6	.000	–
Sal forest	barashingha	35	.018	0	21	.000	–
	hog deer	13	.020	0	1	.000	–
	chital	33	.025	1	8	.003	$.000 < p_o < .009^{*}$
Totals	barasingha	1,958	1.000	1,156[1]	1,157	1.000	
	hog deer	658	1.000	54	54	1.000	
	chital	1,338	0.999	305	305	1.000	

[1] Since the survey took several days to complete, some animals are likely to have been tallied more than once.

** p_o significantly $> p_e$

* p_o significantly $< p_e$

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Table 2 *Occurrence of barasingha in 6 vegetation types, Sukla Phanta Reserve, Nepal. Summary of results for all seasons.*

	Dry grassland	Seasonally wet grassland	Lowland savanna	Mixed deciduous forest	Sal savanna	Sal forest
March 1975	+	–	–	–	–*	–*
March 1976	+	–*	+	0*	–*	–*
May–June 1975	+	+	–	0	0* or –*	0* or –*
Aug.–Sept. 1975	+	0	0	0*	–*	–
December 1975	+	–	0	0*	–	–*

+ = habitat preference indicated ($p_o > p_e$)
– = habitat avoidance indicated ($p_o < p_e$)
0 = no preference or avoidance indicated
* = no confidence interval possible, inferred from raw data (expected vs. observed numbers), and/or from comparison with expected vs. observed numbers which are significantly different.

Barasingha seemed consistently to avoid or showed no preference for mixed deciduous forest and the upland sal forest and savannas. They were found in the latter two types during the monsoon and post-monsoon seasons, but never in great numbers, only 10 animals having been sighted during the August–September and December surveys. A few were also seen during non-survey visits to the sal forest environment. The abundance of fresh grass and water during and after the monsoon probably allowed them to "radiate" from their pre-monsoon centers of concentration on the southern grasslands. With the onset of the rut in late August and early September, stags also may wander more widely in search of mates. After the rut, and with increasing drought, the animals move back to the southern grasslands where fresh forage is available following the winter burns.

Barasingha are grazers (Schaller 1967 Martin 1975), and this in part explains their preference for open grasslands. Schaller noted that while the animals may utilize a variety of vegetation types, including open forest where grasses are present, historically their greatest abundance was reached in the marshy grasslands bordering the north Indian river systems. The open dry and seasonally wet grasslands in the southern part of the reserve are part of this environment.

In central India, the southern subspecies of barasingha exists almost entirely in a sal forest environment. Martin (1975) found that the southern deer in Kanha infrequently entered the sal forest but confined themselves largely to meadows associated with this type (*cf.* sal savanna in Sukla Phanta). Unlike the Sukla Phanta barasingha, the Kanha deer migrated between seasonal ranges some 7 km apart in response to the changing availability of water and forage.

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Martin suggested that seasonality is more markedly felt in the central Indian highlands, which lack the riparian flats and marshes of north India, where green forage and water are available even in the dry season. Deer living in the latter environment, as in Sukla Phanta, where both the riverine and sal forest habitats exist, need not move far to satisfy their requirements.

7. POPULATION SIZE

Under most field conditions, estimates of population size are calculated from sample counts. Because of the nature of their seasonal distribution and the relatively small area in which they live, barasingha in Sukla Phanta afforded an opportunity to attempt direct counts of the whole population.

A large proportion of all barasingha seen during the habitat preference surveys each season were in Sukla and Seta Khera Phantas (see Fig. 2), but the largest concentrations of deer within this range occurred each year between February and mid-April on the open grasslands of Sukla Phanta proper. Since all sex and age groups were represented in these herds (see below), composition counts of the population also could be made.

7.1. Methods

Aerial surveys were conducted on 2–3 May 1974 and 26–27 March 1975. On each of the 4 flights made, flight lines began from the south-east corner of the reserve and proceeded north between the Mahakali and Chaudhar Rivers on alternative east-west, west-east courses as far as the northern portion of Sunderi Phanta. Under prevailing calm conditions, a constant rate of turn and bank was maintained at the end of each line, thereby keeping approximately equal distance between successive flight lines.

The area covered was so small (ca. 70 km^2) that there was little chance of straying off course or overlapping consecutive lines. Two observers recorded barasingha, one from each side of the plane. Large groups of animals were estimated, or partially counted and then estimated. When duplicate sightings occurred, the larger figure was included in the count, and sightings of small groups or individuals by one observer overlooked by the other were added to the total.

In addition to the aerial surveys, ground counts were conducted along a route which gave the greatest coverage to the areas most frequented by barasingha during the February to mid-April period of maximum deer concentration. An observer sitting on top of a vehicle driven slowly along the route tallied all deer seen, stopping to count large herds. The route was comprised of the East-West Track up to and including the Seta Khera Loop, and the North-South Track (see Fig. 1). Two short detours, one to the south from the east end of the East-West Track, and the other to the south-east just as the Seta Khera Loop turns onto the North-South Track, permitted extra coverage of areas not easily seen from the tracks.

7.2. Results

May 1974 aerial surveys yielded lower totals than those in March 1975 (Table 3). When sightings from both survey periods were combined and compared

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Table 3 *Aerial counts of barasingha in Sukla Phanta Reserve, Nepal*

Date	Time	Number of transects	Approx. distance between transects (m)	Approx. altitude (m)	Number of sightings	Range of group size	Total animals seen
May 2 1974	1600 – 1650	10	720	170	13	6–120	575
May 3 1974	0800 – 0845	10	720	170	26	1–130	349
Mar 26 1975	1550 – 1630	13	550	170	4	95–300	795
Mar 27 1975	0820 – 0910	10*	550	70	5	2–800	884

* The 3 southernmost transects were not repeated on the second day since the area they covered had been distributed by livestock, and no deer were seen.

with group size, a high inverse correlation was found between the number of sightings and group size, i.e., the larger the groups, the fewer groups seen ($r_s = 0.800$). A "group" or "herd" consisted of 1 animal or more.

A significant correlation existed between a low number of groups and large group size in 1975 on ground counts ($r_s = 0.708, p < 0.05$) (Figure 3), but a similarly significant correlation could not be demonstrated between these variables in 1976 ($r_s = 0.346$).

In both years the highest totals were recorded in March, followed by a decline beginning in the latter half of April. In 1975, the abrupt drop from 800 to less than 200 animals between April 11 and 19 probably was caused by visiting royalty on April 13, when a helicopter and a large number of vehicles and personnel were active on Sukla Phanta proper, and could have scattered the herds.

7.3. Discussion

The results obtained from aerial surveys were considered less accurate than ground counts because they were based partially on estimates instead of total group counts. Moreover, observer estimates diverged more as group size increased, and the 2 estimates made of the largest group seen on March 27 differed by 100 animals. The 3 maximum ground counts in March–April 1975 were in close agreement with each other and smaller than the March 27 estimate (see Fig. 3), further suggesting that the latter figure may have been in error. However, aerial surveys tended to confirm observations of deer distribution made on the ground, thereby helping to validate the rationale upon which ground census procedures were based. Thus, no sightings of barasingha in March or May occurred north of the forest bordering Sukla Phanta proper. A relatively small number of animals was seen during the May surveys because the largest herds had begun to decline after the season of maximum concentration. Many deer were in smaller groups and scattered,

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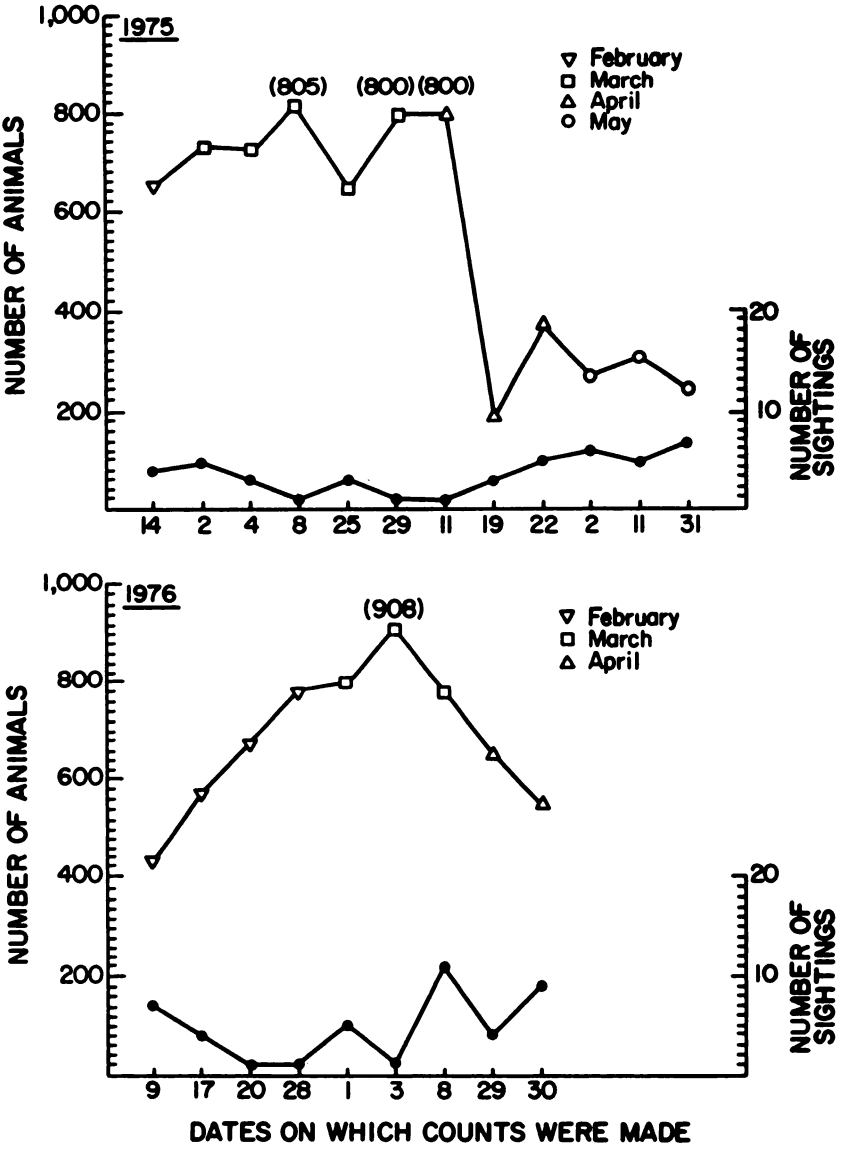


Figure 3. Ground census of Barasingha in Sukla Phanta Reserve, Nepal

and could be overlooked more easily. Aerial surveys also showed that barasingha entered a small piece of Indian territory (ca. 10 km^2) wedged between the Mahakali River and the southern border of the reserve, when on 3 May 1974, 21 animals were seen in India or close to the border. Human habitation

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was absent at that time, but by March 1975, settlement had begun on the Indian side of the border and subsequently no deer were seen there.

As noted earlier, the largest total counts were made annually in March. A lack of sightings elsewhere in the reserve at that time, and the fact that when group size was at a maximum, the number of groups tended to be at a minimum suggested that there were occasions during this period when maximum group size approached the total population size. Thus, maximum group counts over a series of years could be used as an index to population size and trend.

It is rarely possible to count every individual in a wild population, and the proportion of the total barasingha population counted when the largest herds were seen *ipso facto* remains unknown. However, the evidence cited above points to a high proportion, perhaps as much as 90 percent. Since the largest estimate obtained during the 1975 aerial survey was in doubt, and because the figures obtained on aerial surveys may not be comparable with those from ground counts, the largest ground counts in 1975 (805) and 1976 (908) were taken as minimum population estimates during March each year.

8. POPULATION CHARACTERISTICS

8.1. Sex and Age Composition

Counts to determine sex and age composition were attempted at various times from November to May, 1974–76. Since all sex and age classes mingled on the open grasslands in March, the composition of the larger herds at that time was likely to resemble that of the population as a whole. Counts at other times of year were hampered by dense vegetation and the more scattered distribution of animals.

All counts were made on Sukla Phanta proper with binoculars or a telescope, since the deer were wary and often could not be approached closely. The most favorable circumstances for complete and accurate determinations occurred when a herd was moving slowly, roughly in single file and at right angles to the direction of observation, so that individuals could be distinguished and classified. With such specialized requirements, opportunities for complete counts were few.

8.2. Fawning

Owing to the nature of the environment and the habits of the deer, no data were obtained on the proportion of new born fawns in the population each year. Fawns counted in March were 8–10 months old, and had passed through the first critical weeks of life when mortality was likely to be high. We do not know what proportion of the annual crop was lost between the monsoon fawning season and the next March, when the survivors are much more apt to reach breeding age themselves.

New fawns of the season were seen 36 times in 1974 and 23 times in 1975, during the period from June to August, either alone, with their mothers or in the company of deer other than their dams. Because of their relatively small size, their tendency to remain hidden early in life rather than to flush, and

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the concealing nature of the dense grasses, new fawns were the least visible segment of the population. Even when they began appearing among groups of older animals more often in mid-July, they were frequently hidden by the bodies of the older deer or in the grass instead of in the open.

8.3. Sources of Mortality and Potential Limiting Factors

(a) *Poaching and Predation*: Poaching was described briefly above, and as noted, its impact was not readily measurable. Today, with ostensibly improved law enforcement, it may be of less importance as a source of mortality than in the past.

The remains of 50 deer were found in Sukla Phanta proper and its vicinity during the study. Tweleve were identifiable as barasingha, but only 2 of these were definitely tiger kills. Tigers were the only wild predators then in the reserve capable of taking adult barasingha regularly.

It is not known how many tigers there were nor how often they killed barasingha. However, 40 tiger scats were collected in the lowland and sal forest environment, and when hair from these has been analyzed, it may be possible to estimate the degree of predation on barasingha.

Jackals (*Canis aureus*) were seen commonly in the reserve and have been observed in circumstances indicating that they occasionally are able to kill animals as large as hog deer and chital. If they take such large prey, jackals are also likely to be important predators on the new fawns of barasingha and other species. Other potential predators on barasingha, such as they hyena (*Hyaena hyaena*), wild dog (*Cuon alpinus*) and wolf (*Canis lupus*) allegedly were present at one time (local informants), but have been extinct in the reserve for a number of years.

(b) *Disease*: There was no indication that mortality from disease occurred during the study. Discolored, hairless patches on the hides of some barasingha were noticed during the pre-monsoon and monsoon seasons when coats were short, and may have been a form of dermatitis or mange. The afflicted individuals showed no signs of discomfort and appeared to function normally. This condition was not seen in any other species.

In March 1976, there was an outbreak of a livestock disease with some of the symptoms of rinderpest in Singhpur and neighboring villages (see Fig. 1). Large numbers of domestic stock died, especially buffalo, but fortunately wild ungulates apparently were not affected.

(c) *Physical Factors*: The flash floods in 1968 and 1972, mentioned earlier, took place when earthen dikes along the Mahakali River were breached during the monsoon. Local villagers claim that large numbers of barasingha and other animals were caught and drowned in both floods, and that barasingha only recently have begun to recover their numbers.

Local officials confirmed that the floods occurred and also took human lives. There is no assurance that severe flooding will not occur again under the right conditions, especially as catchment areas in the hills and mountains to the north are progressively deforested, and stream bed levels rise due to siltation (Robbe 1954).

(d) *Disruption of Rutting Activities*: Grass cutting took place in November-

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December when the rut is in progress. Based on the frequency of rutting calls, most rutting activity occurred during the twilight hours and at night, while grass cutters remained in the reserve only during the day. Although stags have been heard calling from areas where a few hours earlier grass cutters were active, the magnitude and duration of grass cutting operations may cause the animals to disperse in such a way that breeding success is impaired.

(e) *Competition with Livestock*: Aside from potential competition for food and the destruction of habitat through trampling by livestock, there is some evidence that the areas most frequented by domestic animals are avoided by barasingha, thus reducing the resources available to the deer, at least during the daylight hours while cattle and buffalo remained in the reserve. In the nearby Dudhwa Park of India, the removal of herdsmen and their animals from one area was followed by an increase in barasingha from 16 counted in the presence of livestock to 276 two years later (Schaaf and Singh 1977). In the southeastern grasslands of Sukla Phanta, livestock grazing declined towards the end of the premonsoon season each year, partially in response to the increasing age of forage plants, which are relished most by cattle in the early stages of growth (Bor 1960). At the same time, there was an increase in the occurrence of barasingha in areas formerly occupied by domestic animals.

Although barasingha movements during that season were also influenced by the availability of water and of forage left by domestic animals east of Sukla Phanta proper, the gradual disappearance of livestock may have permitted the deer to use this area which they frequented less earlier in the season.

8.4. Discussion

The results of composition counts are summarized in Table 4. The small number of animals classified, and the fact that some could not be classified before disappearing into the grass, accounts for much of the variation in proportions between counts made at the same time of year or at the same time from one year to the next. Differences in visibility before and after grass fires also influenced the results of counts. However, the small number of stags observed in November–December was influenced by the rut then in progress, when stags are liable to wander and be more widely distributed. Even though numbers of unclassified deer were highest during the November–December counts, stags were the least likely to be overlooked due to the prominence of their antlers.

Subgroups comprised entirely of adult males sometimes were seen among the large herds in March. Aside from suggesting that sexual segregation took place even within large concentrations of animals, their presence and the slightly increased proportions of males observed over other seasons supported the view that these herds contained all components of the population. Increased visual contact among the deer after grass fires, the response to renewed food resources as fresh grass grew and, among males, the continuation of post-rutting activities, all were factors which favored herd formation. In

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Table 4 *Population composition counts of barasingha in Sukla Phanta Reserve, Nepal*

	Apr– May 1974	Nov–Dec 1974	March 1975	March 1975	Nov–Dec 1975	March 1976	March 1976
Males	53	23	33	104	11	97	123
Females	86	47	56	112	31	115	158
Subadults (Yearlings)	34*	8	19	51	9	42	40
Fawns	–	20	11	38	11	39	62
Unclassified	4	15	–	13	5	4	16
Fawns: 100 females	–	–	–	27.5	–	28.7	34.8
Source	177 animals, various herds**	113 animals, various herds	119 animals, 1 herd	318 animals, 1 herd	67 animals, various herds	297 animals, 1 herd	399 animals, 1 herd

* Includes fawns.
** A herd is 1 or more animals.

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contrast, during the earlier rutting season, groups were very much smaller, no more than 12 animals having been seen together at one time.

The "breeding herds" observed by Schaller (1967) and Martin (1975) in Kanha apparently did not form in Sukla Phanta.

The 3 largest March counts, which included approximately 30–40 percent of the estimated minimum population at each count, provided the best available estimate of population structure, although observed proportions could have differed slightly from those in the population as a whole. The observed increase in the minimum population between March 1975 and March 1976 was 12.8 percent. Since approximately 30–40 percent of the population in 1975–76 was comprised of adult females, a somewhat higher potential rate of increase may be expected, the difference between observed and potential increase being the result of mortality or low breeding success, or a combination of the two. Martin (1975) found that similar to slightly higher percentages of adult females and fawn per 100 female ratios (26.7 in 1971, 41.2 in 1972 and 36.1 in 1973) permitted an 18–20 percent annual increment in Kanha. However, data from the two areas are not strictly comparable, since factors affecting population growth may be quite different in each. Data from a series of years are needed from the Sukla Phanta deer to determine what kind of population trend exists and how it varies from year to year.

9. CONCLUSION

Barasingha confine their activities throughout the year largely to the southern lowlands in the reserve. Evidence from various sources, including habitat preference and census data, indicated that Sukla and Seta Khera Phantas were most frequented. If adjacent savanna and marsh (the latter utilized by deer, but to an undetermined extent) are included, approximately 32 km^2 support as much as one third of the world's remaining wild barasingha population.

Although there were indications that the Sukla Phanta population was increasing, a larger population will not necessarily make the future of the species in the reserve any more secure, even if barasingha are now below an as yet undetermined carrying capacity. There is not necessarily "safety in numbers", especially where populations are confined to insular situations, such as Sukla Phanta, with no chance for repopulation from nearby areas if a natural or man-made disaster occurs. Thus, building up the herds in Sukla Phanta by another 200–300 individuals is not likely to reduce greatly their present vulnerability.

Nonetheless, given favorable conditions, the population will increase until limiting factors again reduce it or prevent further growth. Because natural population control may have a disastrous effect on the animals we wish to protect (e.g., through habitat degradation and malnutrition or disease brought on by overpopulation), management will be necessary.

In time this may mean selectivity cropping the population to maintain its health and that of the environment on which it depends.

Establishing populations in different locations reduces the vulnerability to extinction of an endangered species, since the loss of any given population

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is compensated for by the others. Thus in Nepal it may be possible to re-establish barasingha in the Karnali-Bardia Reserve, where as late as 1968–1969 they were more numerous and widespread than they are today (K.M. Tamang, pers. com.). An investigation of conditions in Karnali-Bardia would be needed before re-establishment is attempted.

Chitawan National Park may offer another location for establishing a separate barasingha population in Nepal. As mentioned earlier, there is no record that the deer ever occupied the area which is now the park, and an evaluation of the suitability of the habitat in Chitawan would be a pre-requisite to attempted introduction.

The situation in the Dhaka Reserve is presently uncertain. To my knowledge, Dhaka lies entirely in the upland sal forest environment but, if graziers and encroachment are brought under control, it may be possible to establish a barasingha herd there as well.

10. RECOMMENDATIONS

10.1. Administrative

(a) Poaching and livestock grazing should be eliminated from the reserve as quickly and completely as possible. In 1976 a special unit of the Nepal Army took over law enforcement in Sukla Phanta, and it is reported that the situation with respect to livestock grazing has improved vastly (C. Rice, *in litt.*).

(b) I have already made recommendations suggesting that grass cutting be eliminated over a 2 year period, that period to begin after the impending prohibition has been announced, in order to permit people to develop alternate means of roofing their houses, e.g., through the development of a local roofing tile industry. Bricks and tiles are already being made locally, and the raw material for their manufacture is readily available. During the interim period before grass cutting ceases, new regulations strictly controlling grass cutting and the areas to be harvested in the reserve would be in effect.

(c) The villages of Haraiya and Singhpur have been slated for removal and resettlement for some years. Jilmila Village which has grown up on the south-east corner of the reserve in the past 10–15 years should also be included in a resettlement plan. It is of more recent origin than the other 2 villages, and is comprised mostly of settlers from the hills rather than the indigenous Tharu people. Encroachment on reserve territory has been attempted by Jilmila residents, and livestock from Jilmila have grazed regularly in the southern portion of the reserve.

(d) Consideration might be given to the creation of an international wildlife reserve between India and Nepal. Such a reserve would include the existing Sukla Phanta Reserve, and that portion of Indian territory mentioned earlier, which is located between the Mahakali River and the southern boundary of Sukla Phanta. The Indian territory in question is ecologically part of the same natural area to which Sukla Phanta belongs, and before human settlement began it was used by barasingha and many of the other large mammals found in the reserve. A joint reserve between Nepal and India

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would help secure the entire area and protect the endangered species which live there.

International reserves have worked well in other parts of the world, and the proposed reserve would be the first of its kind in south Asia.

(e) The Dhaka Shikar Reserve should be secured and properly administered. Establishment of a protected barasingha population there would be a hedge against possible species extinction in the region, and Dhaka could still be used as a hunting reserve. Re-establishment of barasingha in Karnali-Bardia Reserve, and introduction in Chitawan Park also might be considered, as discussed above.

10.2. Research

(a) Annual barasingha population counts and sex and age composition counts should be continued in Sukla Phanta by reserve personnel, following the ground route described above at the appropriate time of year. Data collected over a series of years will help reveal population trends, and can be used in determining the status of the species. Reserve personnel should be trained to gather these data, and provided with the basic equipment to do the job, such as binoculars.

(b) A thorough vegetation survey and inventory should be made, culminating in descriptions of types, species lists, and an accurate vegetation map of the reserve. The data obtained would be the basis for further studies of the habitat, and could be used in monitoring vegetation changes or successional trends which may become important in maintaining animal populations. Additional research which should receive priority involves the effects of annual fires on the vegetation, and a study of barasingha feeding habits and food preferences.

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PART I: THE IUCN THREATENED DEER PROGRAMME
2. ENDANGERED, VULNERABLE AND RARE SPECIES UNDER CONTINUING PRESSURE

Kashmir deer (*Cervus elaphus hanglu*) in Dachigam

IUCN/WWF Project No. 1103 (22–4) Hangul, India – Ecological Study to Identify Conservation Needs.

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ABSTRACT

Although Dachigam (141 km^2) became a game preserve some fifty years ago and was declared a sanctuary in 1951, the Hangul (*Cervus elaphus hanglu*) population was drastically reduced from some 3000 animals to less than 10 percent of that figure and grazing by State owned sheep as well as water buffaloes and other livestock increased to such an extent that serious vegetation and soil detoriation led to erosion and floods as well as influencing the seasonal movement of the threatened deer. To day Hangul occur only in some 20 percent of the Sanctuary's area, namely the northern aspects and the riverain forests of Lower Dachigam, near other species living on the southerly slopes in the same part of the sanctuary, which lacks sufficiently effective ecological barriers to hinder Hangul from emigration.

1. INTRODUCTION

Around 1910, the last Maharaja of Jammu and Kashmir, Hari Singh, declared the valley and the catchment areas of the Dagwan river and its environs a game preserve or rakh, to provide sport for himself and his guests. There is also evidence to suggest that the need to secure the area as an undisturbed catchment zone for the Harwan reservoir, which furnishes the city of Srinagar with fresh water, was the principal reason for early protection of the valley and the resettlement of its human population. The last eviction is said to have occured in 1934. A force of game guards was created to police the area. Penalties for poaching were severe and the laws were strictly enforced (Holloway and Wani 1970).

During the political upheavals that followed the accession of Kashmir to India, the protection of wildlife detoriated within the Sanctuary. Crop planting and winter feeding ceased and the number of large mammals declined. A block of some 11 km^2 at the western edge of the lower valley was excised to compensate villagers who had formerly occupied the Dachigam Sanctuary. Poaching, grazing, wood cutting and burning have continued to present problems in recent years, as has the decline of many wildlife species,

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although Dachigam was declared a Sanctuary by State Order No. 276/C of 1951.

Within Dachigam Sanctuary a drastical decline of hangul population was observed within the last three decades. Around 1940, the population consisted of some 3000 head (Holloway 1970). In 1947, it was estimated at 2000, ten years later at 400 (Gee, 1966). The figures for the years 1958 to 1965 given by the Kashmir Forest Department range from 550 to 250. In 1968, Schaller (1969) censused the Hangul population during the period of rut and estimated its size at 180 animals. Holloway (1970) tallied 140–170 Hangul in February 1970.

The Hangul became a Red Data Book taxon (critically endangered). Dachigam contains the last viable population known. World Wildlife Fund International supported together with the Jammu and Kashmir Government a first survey in 1970 by Holloway and Wani (1970) on which a Management Plan for Dachigam Sanctuary was based. In 1975, IUCN/WWF Project No. 1103(22–4): "Hangul, India – Ecological Study to Identify Conservation Needs" was started and after a 18 months break continued in 1977. This project covers an ecological study of wild living Hangul in the Dachigam Sanctuary and environs. To provide essential scientific data for the management of this deer and to restore its productive status in the wild, the objective of research must be towards discovering the information of particular relevance to the survival of the species (Cowan and Holloway 1974).

2. PRESENT RANGE

Cervus elaphus hanglu is confined to the moist temperature forest of the Vale of Kashmir. According to Schaller (1969) the Hangul was once distributed widely in the mountains of Kashmir. Holloway (1970) states, that earlier in this century, its distribution was confined to an area of some 65 km in width to the north and east of Jhelum and lower Chenab rivers, from Shalurah in the north to Rhamnagar in the south. A number of unconfirmed reports suggest, that small remnant populations still occur within this range, particularly in the north (Fig. 1). The Gamagul Siya-Behi Sanctuary in Himachal Pradesh is the only area outside Jammu and Kashmir that probably retains a few Hangul. Nevertheless the only area in which a viable population has been confirmed is Dachigam Sanctuary some 14 km to the north of Srinagar.

According to older reports, Hangul spend the summer in Upper Dachigam, while their main winter range is confined to a small area of some 10 sq. km in Lower Dachigam. The summer and winter quarters are said to be separated by some 15 km (Schaller 1969). With the exception of a report from October 1975, according to which rutting calls were heard near Marsar Lake in Upper Dachigam, and old droppings found on one of my surveys in April 1977, near Sangargulu, no evidence could be found of Hangul in Upper Dachigam. In Dagwan, where an increasing number of sheep from the State Department of Animal Husbandry is summered, and in the vast areas of Nagaberan and Marsar, where thousands of water buffaloes, cattle, horses, goats and sheep

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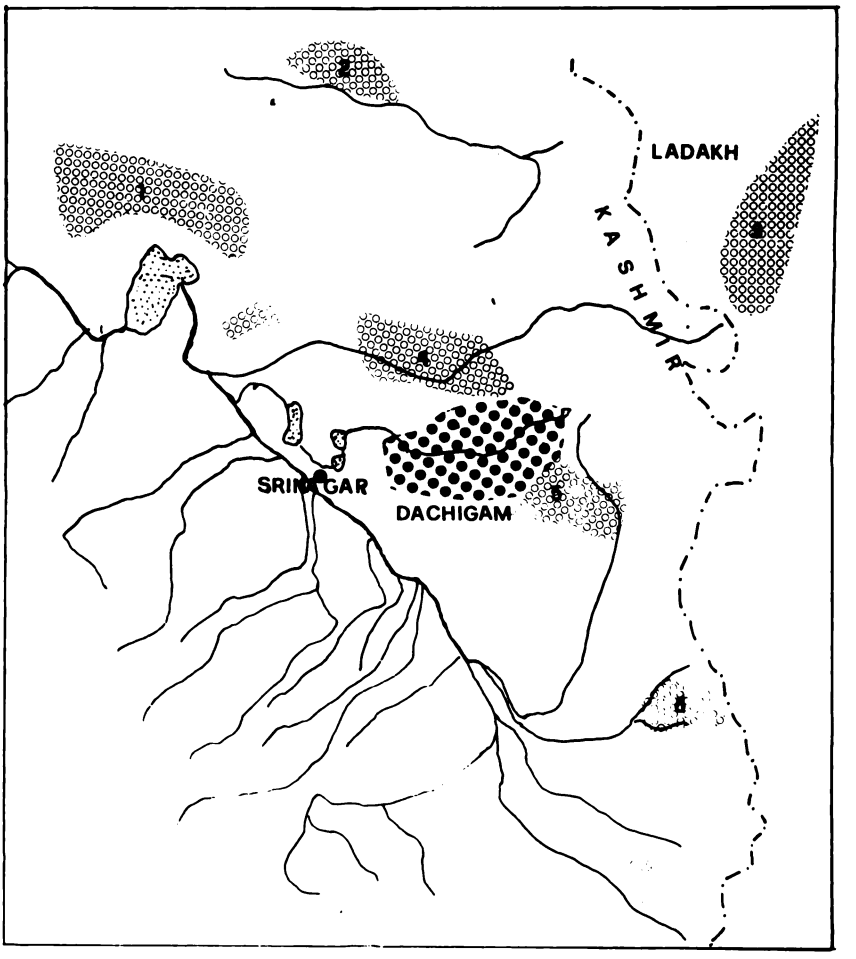


Figure 1. Areas in which Hangul have been reported according to Wani (pers. comm). The more popular are Bandipur (1), Gurez (2), Sindh Valley (4), Drass Valley (3), Lidder Valley (5) and Desu (6)

are summered by local graziers and gujjars from Kashmir as well as Bakkarwallas and Banyari from Jammu, no signs of Hangul could be found during a 5 day intensive survey by 22 observers in August 1977. It must therefore be assumed that human interferrence led to a considerable loss of the former range and that the present range of the Dachigam Hangul population is restricted to Lower Dachigam with its eastern boundries at Gretnar, Washkar and west of Dagwan. In the months of July and August 1977 Hangul were regularly observed in Lower Dachigam.

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3. DACHIGAM SANCTUARY

The Dachigam Sanctuary shows a strong vegetational contrast with the outside areas, which are subject to varied types of biotic interference, and, except for some steeper slopes, largely lack natural tree elements, being replaced in the valley by cultivated elements along roadsides, stream sides and in orchards, and largely determined by the extent and nature of human interference. The mountain slopes of the Dagwan valley and the river catchment areas support mostly natural vegetation and portions of the ravine support a mixture of planted and natural elements. Outisde the present sanctuary the Dagwan valley is largely under cultivation with patches of pastures and flood plains. The mountain slopes especially above Harwan village are dominated by pastures and scrubby communities with limited cultivation. The sanctuary is roughly rectangular in shape, approximately 22.5 km long and 8 km wide (Fig. 2). The area is divided into two sectors, Lower Dachigam, in the west, which comprises approximately a third of the area, and Upper Dachigam in the higher reaches in the east. The total planar area of the sanctuary has been estimated to be about 141 sq. km. The true area is considerably greater.

3.1 Topography and Geology

The mountain ranges enclosing Dachigam are a part of the great Zanskar range which forms the north-west branch of the central Himalayan axis bifurcating near Kulu and terminating in the high twin peaks of Nun Kun. The fold of this range is thrown into a number of undulations enclosing narrow gulleys, and broader outflanked gulleys locally known as "Nar". Two steep ridges, one rising from near Harwan reservoir (Barobal:2620 m, Bodyun:2835 m, Chargund:2980 m) and another east of New Thir (Mahadev. 4004 m) form the natural boundaries of the Sanctuary. The relevant portion of the ravine is artificially fenced to enclose the forest. The series of undulations present a variety of slope aspects, supporting an array of vegetational types. A number of rocky cliffs and scree slopes break the uniformity of the main slopes. The main stream, having its origin from Marsar Lake and continuing into the Harwan reservoir, is fed along its course by a network of mountain drains running through the gulleys.

Complex crystalline rocks, granites, gniesses and schists form the core of the Zanskar range. Sedimentry rocks consist of slates, phyllites, schists with embedded crystalline limestone.

3.2 Climate

Dachigam experiences an irregular climate with large interyearly variations in precipitation, length of dry periods and seasons of their occurrence. The average climate is sub-Mediterranean with b-xeric regime or two spells of dryness, one in June and another in September to November, and high precipitation during cool season, though typical Mediterrenean, tri-xeric and quadri-xeric types are also found over different years. With average annual precipitation for the period 1892–1971 of 664 mm, there has been a noticeable reduction in annual rainfall during 1970–1971, the dryness

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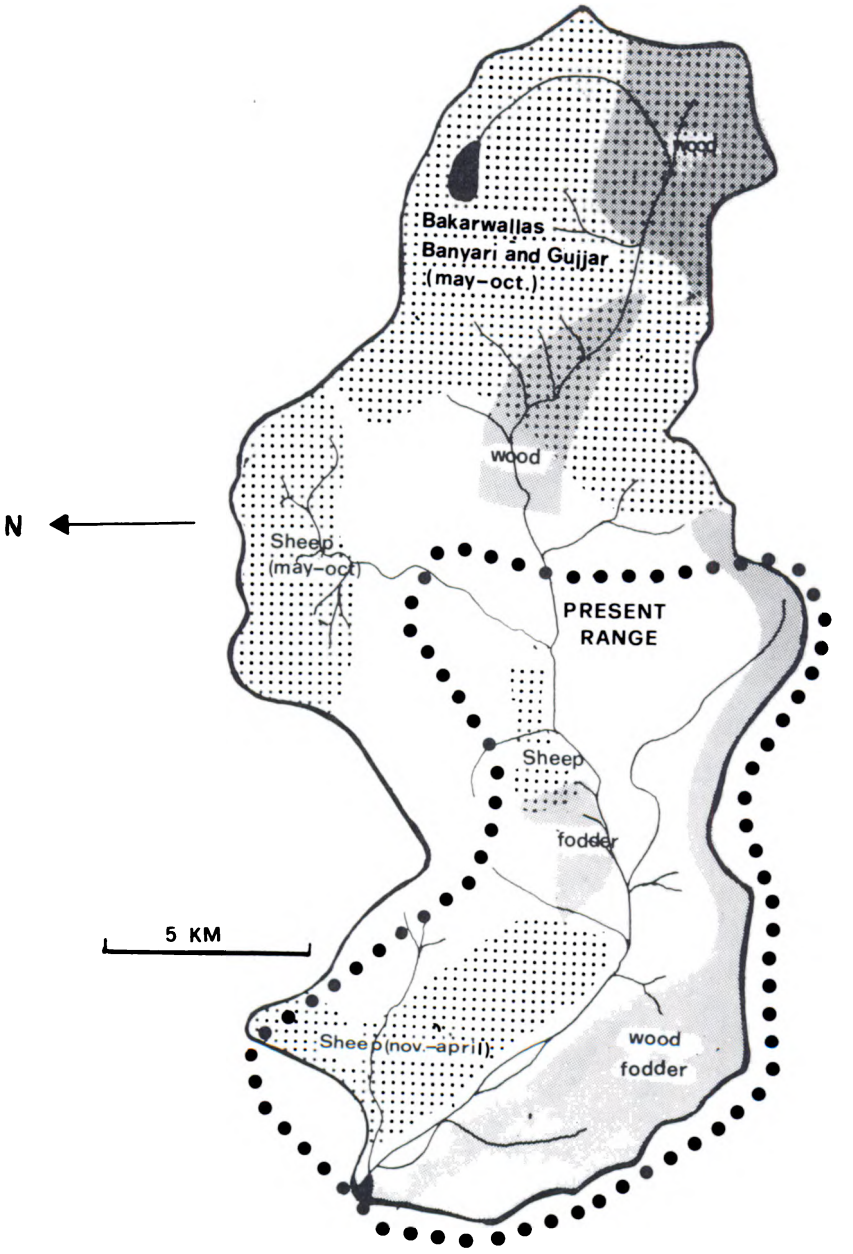


Figure 2: Human interference and present range of Hangul in Dachigam Sanctuary

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continuing over the month of December which generally is a wet month. Though a bi-xeric regime is more common, yet the later years showed an increase in number of xeric regimes from bi-xeric in 1963 to tri-xeric in 1970 and quadri-xeric in 1971 (Singh and Kachroo 1977). Mean monthly temperatures have been measured by Singh and Kachroo (1977) showing some 20° C in summer and 3° C in winter for evergreen forests at 1700 m.

3.3 Vegetation

The Dachigam Sanctuary exhibit a variety of vegetational types manifested by habit, form and density of dominant species, and controlled by a number of factors including habitat conditions, exposure, altitude and above all the degree of biotic interference. Singh and Kachroo (1977 and in press) carried out detailed plant ecological studies in Lower Dachigam and distinguished the following communities summarised in Table 1 and Fig. 3.

3.5 Human activities and interferences

3.5.1. Poaching

There is no doubt that the decline of the Hangul population is first of all due to poaching. Until recent years evidence is available suggesting that poachers comprised both civilian and military personnel (there are 2 army camps immediately to the south of Lower Dachigam). Poachers used to operate in gangs of 4 to 12 men, camping within the Dachigam Sanctuary and poaching seems to have occured at any time of the year. During the early 1950s Dachigam was occupied by military forces for several months and losses of wildlife were most probably substantial. In 1975, a serious step was undertaken by the Dept. of Game and Fisheries by stationing infantry from the Indian Armed Forces in Dachigam to cope with the poachers still operating in the area. Poaching seems to have significantly decreased, although anti-poaching patrols are not operating yearlong but only during the rut and the winter months and are restricted to Lower Dachigam. Upper Dachigam lacks almost all controls and shepherds are known for poaching wildlife species such as Bears, Hangul and mainly Musk Deer.

3.5.2. Grazing

While Hangul population of Dachigam decreased from some 3000 animals in the 1940s to some 200 by 1969, sheep introduced into Dachigam in 1961 by the State Animal Husbandry Department increased from 20 to some 3000 animals at present. According to the information of the Sheep Breeding Farm the actual number of sheep kept in Dachigam at present is far higher reaching numbers between 5000 and 7000 animals.

These State owned sheep stay yearlong in the sanctuary. At present they are summered in Dagwan, an area in Upper Dachigam (Fig. 2) and kept in Lower Dachigam in winter. Seasonal movements of the sheep herds are connected with grazing on the southern slopes of Lower Dachigam between Palipora and Washkar.

Since the 1950s the number of graziers increased in Nagaberan and Marsar,

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Table 1. *Plant communities in Dachigam Sanctuary*

Forest or shrub climax	Successions			
	forest	scrub	savanna	herb communities/pastures
Dwarf evergreen shrub (3500–3700 m)				**alpine herbs** (2500–3700 m)
Juniperus recurva Rhododendron anthropogon				Stachya sericea Sieversia elata Veronica melissaefolia
Tall evergreen shrub (3200–3400 m)				
Rhododendron campanulatum Syringa emodi				**alpine pasture** (2500–3000 m)
Birch forest (2900–3700 m) northern aspects		**dwarf evergreen** **tall evergreen**		Fritillaria Polygonum alp.
Betula utilis Rhododendron campanulatum				
Silver fir forest (2300–3200 m)	**blue pine**			**broadleaved belts** (2300–2900 m)
Abies pindrow with: Betula utilis (3100 m) Picea smithiana (2700 m) Rhus succedanea and Ulmus wallichiana (2400 m)	**Corylus/Padus** (2300–2900 m) Corylus colurna Padus cornuta	**Parrotiopsis** (1700–2400 m) P. jacquemontiana Rosa webbiana Indigofera heter. Isodon plecantr.	**scrub savanna** (1700–2400 m) Chrysopogon ech. Themeda anathera	Sambucus wightiana Stipa sibirica
Blue pine forest (1700–3000 m)		**deciduous thorn** (1700–2400 m)		**grasslands** (1800–2000 m)
Pinus griffithii with Rosa brunonii and		Rosa webbiana		Cynodon dact. Botryochloa p.

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Table 1. *Plant communities in Dachigam Sanctuary (cont'd)*

Forest or shrub climax	Successions			
	forest	scrub	savanna	herb communities/pastures
Blue pine forest (cont.) (1700–3000 m)		**deciduous thorn** (cont.) (1700–2400 m)		
Parrotiopsis jacqu. (1700 m) Viburnum cotinifolium and Staphylea emodi (2300 m)		Berberis lycium Indigofera heter.		
Morus alba community (1700–1900 m)		**deciduous thorn** (1700–1900 m)	**scrub savanna** (1700–1900 m)	
Morus alba Rhus succedanea		Rosa brunonii Rosa webbiana Indigofera het.	Chrysopogon echi- nulatus Themeda anathera Artemisia vestita	
Stream side Forest (1600–1800 m)	**Robinia*** (1800 m)			
Ulmus villosa Populus ciliata Salix caprea	Robinia pseudo- acacia Celtis caucasica			

* pseudo-climax

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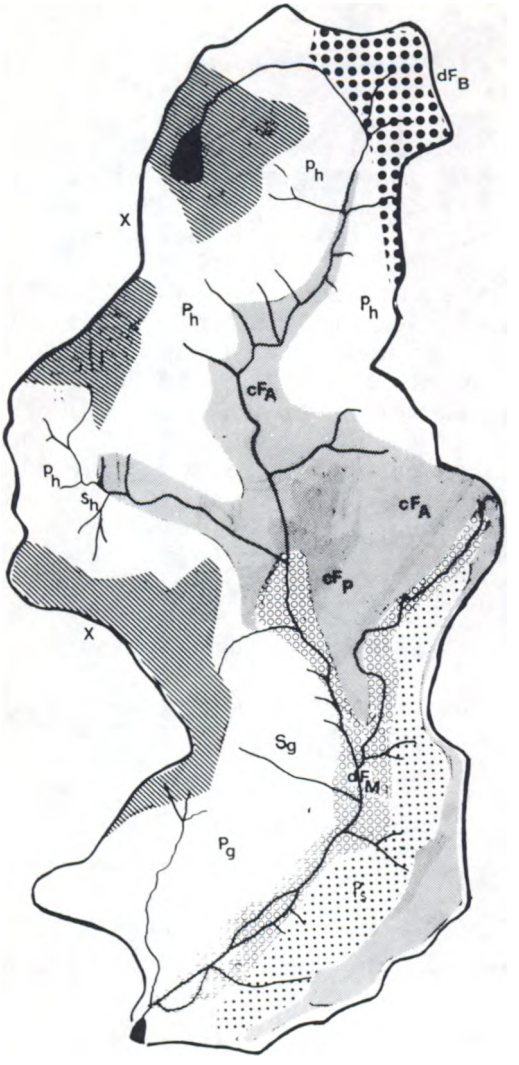


Figure 3: **The most prominent plant communities of Dachigam Sanctuary**
Birch forest (dF_B)
Coniferous Forest with Fir (cF_F) or Blue Pine (cF_P)
Parrotiopsis scrub (Pa)
Grass savanna (Sg)
Broad-leaved savanna (Sh)
Grass pasture (Pg)
Broad-leaved pasture (Ph)
Rocks and scree (x)
Riverain forest (dF_M)

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where around 1970 some 600 sheep and "some" buffaloes brought up from Jammu were illegally summered in Upper Dachigam. Since 1972 official permission was given to graziers from Jammu. Today Bakkarwallas and Banyari from the State's Lowlands drive some 5000 water buffaloes each spring to the Nagaberan and Marsar area, not to speak of cattle, horses, sheep and goats. Since lowland nomads were allowed into Upper Dachigam local shepherds, namely Gujjars, also increased the number of domestic livestock in Upper Dachigam. No accurate estimate of the livestock population has been carried out so far, but local experts mention figures of 10,000 and more animals.

Some thirty cattle graze almost permanently in Lower Dachigam close to Game guard headquarters. Some Gujjar families are summering their livestock west of Dagwan in an area on the northern boundary of the sanctuary between Upper and Lower Dachigam.

Grazing of domesticated livestock in the sanctuary does not only disturb wildlife and reduce the quality of vegetation units but also increases the poaching hazard, poses an additional fire risk, and introduces grass and wood cutting in the Dachigam Sanctuary. The present trend of development must give the impression that much is done to increase the number of graziers and to improve their conditions in Dachigam but little or nothing to control the effect of grazing in the catchment area of the fresh water supply for the country's capital.

The extent of grazing and wood cutting is summarised in Table 2.

Table 2. *Extent of grazing and wood cutting in different areas of Dachigam*

	area affected		impact on vegetation
Lower Dachigam			
1. cattle grazing in riverain forest	5 km²	± 30 animals	negligible
2. sheep grazing on southerly exposed slopes in winter	10 km²	at least 3000 animals	desertification
3. wood cutting in northerly exposed slopes	5 km²	12–30 persons daily	reduction of taller scrub
Upper Dachigam			
1. sheep grazing in Dagwan	8 km²	at least 3000 animals	desertification
2. Buffalo grazing in Nagaberan and Marsar	80 km²	at least 5000 animals	desertification
3. wood cutting in Nagaberan and Marsar	80 km²	100 persons daily	reduction of pine and birch forests.

3.5.3. Wood Cutting

In Upper Dachigam pine forests have been drastically thinned after the nomads started to build their summer quarters with pine logs. In addition

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to this, fuel is collected from the birch forests. Since dry wood is not always available, green trees are cut and collected after some time. The same practice of fuel collecting is found in Lower Dachigam where 12 wood collectors, so far unhindered by the Sanctuary's staff, were encountered within a single hour on 14 July 1977.

3.5.4. Grass cutting

Dry grass for feeding the State Sheep Farm is collected in Lower Dachigam in late summer. Permission for grass cutting is also given to villagers from Harwan and New Thir, who operate between August and November between Prapahama and Palipora.

3.5.5. Grass fires

The early winter months are generally dry and the southerly exposed slopes in Lower Dachigam are regularly burnt either by fires intentionally started by sheep breeders or by fires due to carelessness of shepherds. Areas affected by fire may measure between 6 to 10 sq. km. Fire is fought sometimes by the Game guards after it has started spreading. But no effort has been made to cut firelines, although it would be easy to achieve, because grass is anyway cut by local villagers on the basis of permission given by the Department of Game and Fisheries.

3.5.6. Other forms of land use

At Drapahama a large resthouse functions today as a V.I.P. lodge for visiting dignitaries and has recently been selected by the Chief Minister of Kashmir and Jammu as his summer residency. A Fish Hatchery comprising some five buildings is situated near the Dagwan river about 1.5 km from the entrance gate. In 1969, a small enclosure of a few acres was constructed near the fish hatchery to hold two captive hangul. Today the enclosure harbours only one deer. Additional enclosures display one goral, one musk deer, one leopard cat, three black bears and three pheasants.

4. THE HANGUL POPULATION

During the rutting period in 1968 Schaller (1969) tallied 86 Hangul in Lower Dachigam: 44 stags, 29 hinds and 13 calves, giving a ratio of 151 males: 100 females: 45 calves. The female:male ratio does probably not reflect the actual population composition since roaring stags are more easily spotted than silent hinds and their followers. Extremely high grass cover, green shrubs and trees hindered an accurate census during my own observations in the fall of 1975. Within 16 census units 35 adult stags were seen (21) or located by their roaring (13). The number of silent hinds and followers seen was definetely below the actual number. Under optimal conditions in the month of February, when herbaceous cover is under snow and shrubs and trees are leafless, Holloway (1972) counted 23 stags and 92 hinds and followers (juveniles in the first and second year of life). Calculated on this basis, the minimal population of Lower Dachigam would have been 5 times as high as

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the number of adult stags recorded, namely 175. This figure is higher than the most conservative figure of 140 given by Holloway in 1972. If deer located in Marsar (5) and in the smaller valleys bordering the Vale of Kashmir on the western boundaries of Dachigam, like Mahadev Nar, Hana Nar, Hari Kahin, Hadder Nala (20) are estimated at 25, which seems rather too low, the total minimal population would have consisted in 1975 of about 200 animals, or 60 more than 5 years earlier. Censuses carried out in winter 1976/77 and in spring 1977 (Kurt, in prep.) estimated the Dachigam population at some 250 animals, an increase of 25% from 1975 to 1976. This conclusion seems reasonable after poaching has been largely restricted with the assistance of the Indian Armed Forces. An intensive census is planned for February 1978.

4.1 Feeding

The food plants of the three seasons "winter" (February and March), "spring" (April) and "summer" (June, July) can clearly be separated into groups. While winter food consists mainly of buds and is restricted to woody species, spring food is dominated by monocotyledon perennial herbs; summer food consists on the other hand mainly of dicotyledon perennial herbs (Table 3).

Table 3. *Comparison of food types according to seasons:*

Food types	Winter (Feb.–March)	Spring (Apr.–May)	Summer (July–Aug.)
Woody species:	26	4	6
Perennial Herbs:	–	5	25
Monocotyledon:	–	5	5
Dicotyledon:	–	–	20
Annual Herbs:	–	–	6
Monocotyledon:	–	–	5
Dicotyledon:	–	–	1
Total:	26	9	37

During February and March *Fraxinus hookeri* and *Jasminum humile* are the most preferred food species since in all plots where they were found Hangul had fed on them. In April the most prominent food species are, next to *Fraxinus* and *Jasminum, Hemerocallis fulva* (estimated to account for 90 to 95% of the food taken), *Tulipa chesiana* and *Phragmites communis.*

Comparing the food availability (total cover of food plants expressed as the percentage of the 180 plots analysed) with the food taken (expressed as the cover of all food plants consumed within the plot) it was found that during February and March relatively high feeding activity occurred in areas where the cover food species was low (6% taken in plots with 10% cover of food plants). In plots were food plants were found to occur in 80 to 100% of the cover, feeding affected only 17 to 23% of the total cover (Fig. 4). Availability of food seems therefore to affect dispersal of the deer either not

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exclusively or very little during this period. Winter food is available in all plant communities with woody vegetation and the cover of food plants reaches almost 95% in *Parrotiopsis* scrub, the most prominent community of Lower Dachigam. Availability of winter food is lowest in forest formations such as silver fir, blue pine and *Corylus-Padus* Forests (Table 4).

Table 4. *Availability of winter food expressed as the percentage of the cover of dominant food species (based on findings from Singh and Kachroo, in prep.)*

Plant communities:	cover of food species	Food species*							
		Parrotiopsis	Rosa	Rubus	Viburnum	Indigofera	Prunus	Desmodium	Jasminum
Silver fir (2700 m)	5.5%	—	+	—	+	—	—	—	—
Blue pine (1800 m)	18.0%	+	+	—	—	—	—	—	—
Corylus/Padus (1900 m)	17.0%	—	+	+	+	+	—	—	—
Scrub savanna (2400 m)	19.0%	+	+	—	—	+	+	+	+
Scrub savanna (1900 m)	22.0%	+	+	—	—	+	—	—	—
Thorn scrub (1900 m)	38.0%	+	+	—	—	+	—	+	—
Parrotiopsis scrub (1900 m)	94.7%	+	+	—	—	+	—	—	—

*Important winter food species such as *Robinia pseudoacacia, Fraxinus hookeri, Padus cornuta* are not included since they were not found amongst dominant species.

Spring and summer food consists mainly of plants of the herbaceous cover. Food availability changes therefore according to the seasonal changes of vegetation. Since not all food plants of the summer period are identified so far, the data given on food availability (Fig. 4) must be considered as minimal values. Food species are widely found after June in all habitat types distinguished with the exception of *Robinia* Forests and pastures. In high altitude scrub and all savanna stands they form 50 or more percent of the total cover. In July they reach at least 30% of the herbaceous cover in lower scrub stands, while they are rarely found in blue pine forests. Between March and May food plants are relatively rare in all habitats studied with the exception of riverain, that is *Morus alba,* communities and stream side vegetation where first *Tulipa* dominates the diet and later *Hemerocallis.* Only

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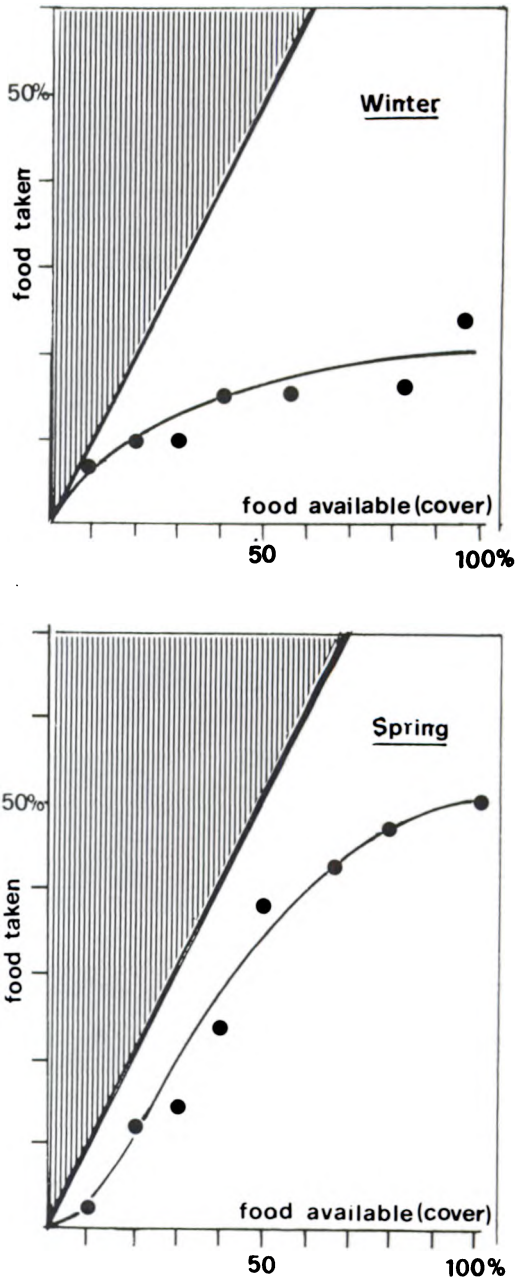


Figure 4: **Availability of food expressed as % of scrub cover (winter), and % of herbaceous cover (spring) compared with the amount of food taken expressed as the % cover of food plants affected by feeding.**

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during this period a positive correlation between food availability and food consumption could be clearly found (Fig. 4). Consumption follows the increase of food plants up to 60% cover. In plots where 100% of the area was covered with *Hemerocallis, Tulipa* or *Phragmites* almost 50% of the cover is affected by Hangul feeding. The 4 woody species utilised in spring can be disregarded in this consideration since they are either rarely eaten (*Rosa webbiana*) or rarely found (*Jasminum, Fraxinum*).

4.2. Seasonal movement and socio-ecological organisation

Food availability (Fig. 5) seems to influence the dispersal of the Hangul population in spring. During the months of April and early May, all animals seen, and all fresh tracks of Hangul found, were located in a narrow belt along the main stream and the larger side nalas (Badin Nala, Gretnar Nala) where *Hemerocallis* is the dominant herbaceous species at this time of the year. According to local information this concentration of the deer population takes place in late March when the animals, widely scattered during the winter months over the ravine and the slopes of Lower Dachigam, start to segregate in male groups and female-offspring groups. Separation of sexes could already be observed during the month of April, when females concentrated lower altitudes of the Dagwan ravine and the larger nalas. Separation of females and males reaches a peak between late June and mid-August, when males are exclusively found in higher altitudes of the southern and northern slopes, while females and newborns concentrate in the ravine or on lower altitudes of the southern slope, as indicated in Fig. 6.

In early fall the stag population seems to follow the ridges westwards reaching the lower parts of Lower Dachigam by the end of September and starts to descend to lower slope zones and the ravine by October. Females and followers arrive in the breeding ground along routes following lower slope zones and the riverain forests. Within a area of some 8 sq. km in the lowest section of the valley breeding takes place. Comparing the occurrence of stags and hinds with the morphology of Lower Dachigam, a socio-ecological model can be formulated, which suggests that the density of the population is highest at the lowest region of the ravine. Hinds are concentrated in this core accompanied by few males, while most of the stags are scattered over a wider area reaching to higher altitudes and forming the periphery around the female core. The same pattern is found during the summer months but the female core is not as dense as during the rut and its centre lies between Drapahama and Palipora.

5. LIMITING FACTORS

After Dachigam was declared a santuary in 1951, the development of the deer population was not characterised by any prominent increase, except for the last 2 or 3 years. Apart from the fact that poaching went on almost unhindered until 1975, large areas of Dachigam were taken over by man and his lifestock, habitat changes followed and the former range of the deer was extremely reduced (Fig. 2). To identify some of the possible natural or man

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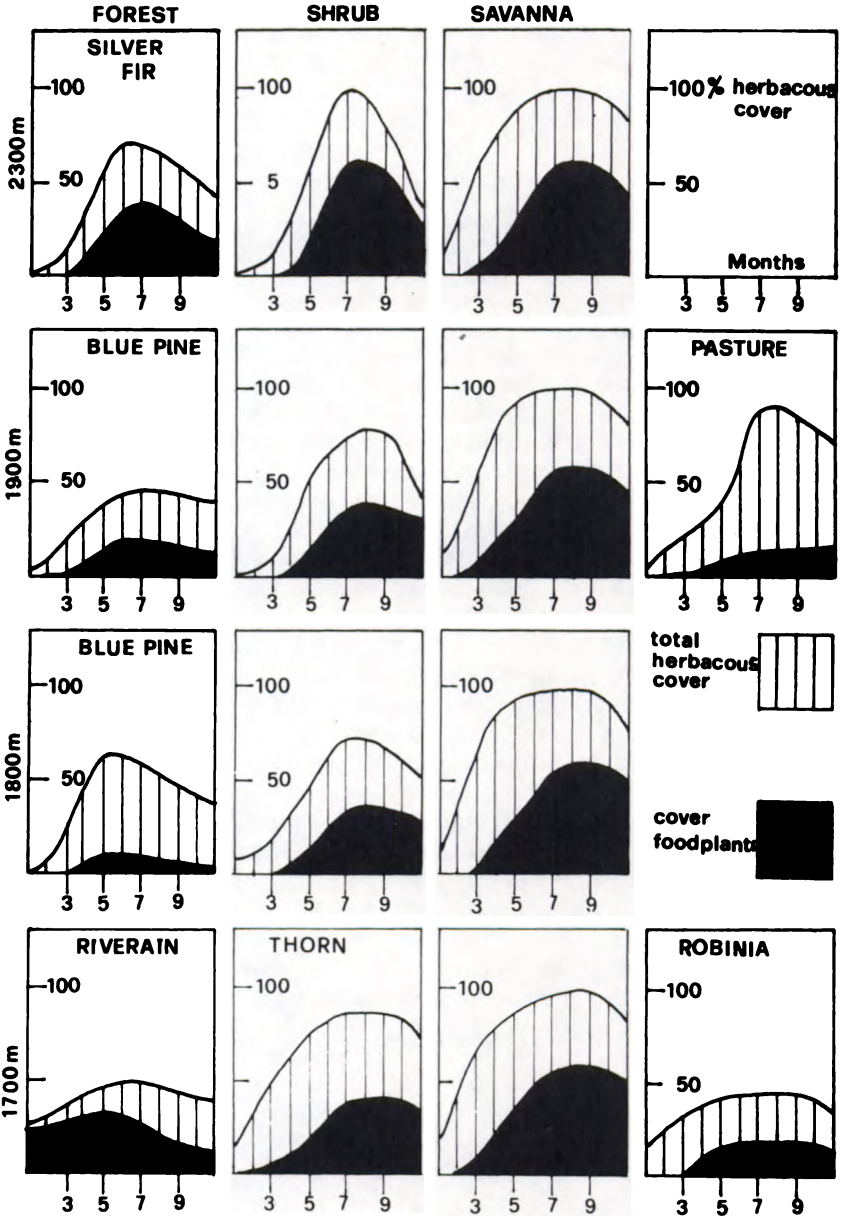


Figure 5: Seasonal variation of herbaceous cover and availability of herbaceous food plants according to own data and Singh and Kachroo (1977)

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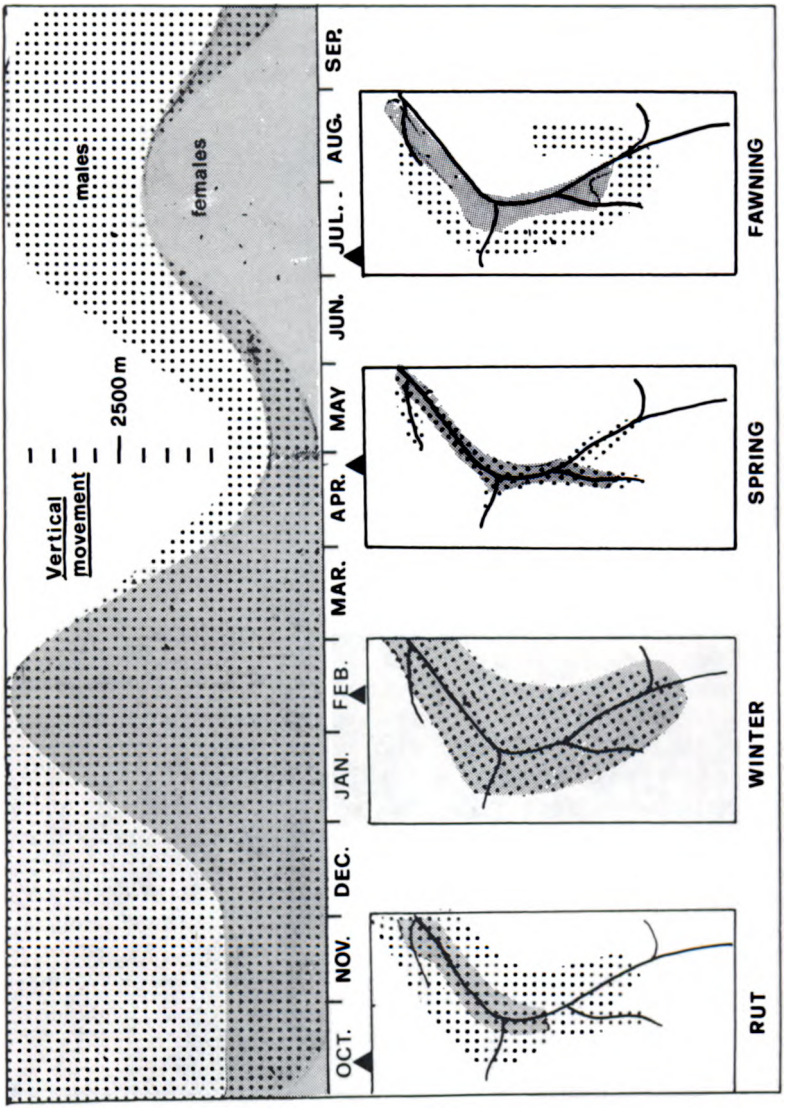


Figure 6: Seasonal movement of Hangul in Dachigam (below) and vertical movements between ravine and mountain ridges.

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introduced limiting factors the findings of the present study are discussed according to the series of research questions suggested by Cowan and Hollway (1974):

5.1. Habitat

According to a number of reports, Hangul expanded their range during the summer months, spending the period from mid-June to mid-September at altitudes of some 3000 m. Most of the high areas of Dachigam, namely the whole of Upper Dachigam including the areas of Dagwan, Nagaberan and Marsar, are today occupied by vast herds of livestock and in due course Hangul disappeared from them with the exception of a few strays.

Today the surviving Hangul population lives in Lower Dachigam. In fact during the time of the last Maharaja, when the complete valley was kept free from human interference, a certain number of the deer did live there during summer (Q. Wani, pers. comm.). Although there are no signs today that Lower Dachigam would not guarantee reproduction, which must be considered as good, the recent change of range has certainly serious consequences from the point of view of the deer ecology as well as from the point of view of conservation.

Firstly, most Hangul concentrate on the northerly exposed slopes since the seasonal vertical movement of the population no longer follows the ravine. The southern slopes in Lower Dachigam are gentle. Their ridges are covered by coniferous forests or grasslands which attract deer as well as shepherds from the neighbouring villages. The boundaries of the part of Sanctuary where most Hangul are found today are therefore ecologically the least effective. Upper Dachigam offered such conditions since the ridges encircling the areas of Dagwan, northern Nagaberan and Marsar are high and rocky and therefore hardly used by Hangul.

The northern slopes of Lower Dachigam are topped by similar ridges. But these areas, dominated by man-made savannas and formerly used as feeding grounds by Hangul during heavy snowfall on the steeper slopes, because of their higher temperatures and more sunshine (Singh and Kachroo 1977), became less important for the deer, especially as they are used by at last 3000 sheep during winter. Furthermore yearly burning, controlled and uncontrolled, or perennial grassland and scrub in November, has resulted in former scrub and tree savannas with relative high availability of winter food being replaced by monotonous grassland with extremely poor food resources.

Impact of wood cutting and consequently grazing on the mountain vegetation in Lower Dachigam has been studied in detail by Singh and Kachroo (1977): After trees of the forest climax are removed, the associations are dominated by *Parrotiopsis* and *Isodon* scrub which has a relatively high food value for Hangul. Since both these woody species form not only good fuel but also palatable foliage for cattle they tend to be consequently destroyed. After their disappearance, hardy species like *Indigofera heterantha, Rosa webbiana* and *Berberis lycium* increase. Though *Isodon* survives considerable grazing, further grazing may effect a thinning of its stands followed by

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increased association of "poisonous" herbs such as *Stipa sibirica, Artemisia vestita, Artemisia nilagirica* and *Origanum normale.* Increased trampling compacts the soil and results in gradual disappearance of invasive annual herbs and under the effect of excessive grazing a matted savanna dominated by *Cynodon dactylon* and *Botryochloa pertusa,* associated with only a few low-growing perennial herbs, is the result. Under extreme grazing and accompanying erosion, these matted grasslands also thin out resulting in the development of desert herb conditions.

On more southerly aspects overgrazing results in quick disappearance of *Chrysopogon echinulatus* and *Themeda anathera* followed by an increase of scrubs like *Rosa webbiana, Berberis lycium* and *Isodon plectranthoides.* Though some smaller herbs become more prominent, desert conditions are soon established by erosion.

Erosion as recorded during the last three years in Dagwan and Nagaberan has led to considerable fluctuations of the water flow in the ravine of Lower Dachigam and consequently to inundations. This trend may soon affect food conditions in riverside vegetation, where perennial herbs grow and form the food of Hangul during spring. *Hemerocallis fulva,* the main food of Hangul in April and May, is exclusively found along larger streams not higher than 2 m above and 30 m from water. This moisture dependent liliaceous species is unable to exist in nalas fed by water from eroding slopes. Inundation of the river in the ravine can consequently lead to the disappearance of this most important food plant, eventually forcing the deer population to spread to higher altitudes, i.e. Upper Dachigam, where chances of its survival are slim.

5.2. Predation

Four large predators could be considered to influence the Hangul population: the Brown Bear, the Snow Leopard, the Leopard and the Himalayan Black Bear. Brown Bear and Snow Leopard have been formerly reported from Upper Dachigam, where today the deer is absent. Both these species have become either extinct or extremely rare. The small Leopard population of Dachigam seems to concentrate closely in areas where sheep are kept and to depend, at least during the winter, on dead or killed sheep, as analyses from 21 faeces suggest. A number of Leopard faeces found in Lower Dachigam also contained hairs of rodents and bones of quails.

Prater (1971) considers the Himalayan Black Bear as carnivorous. Analyses of some 600 faeces collected in Lower Dachigam between April and October show however, that the main food of bears is vegetarian with only a small fraction of animal food consisting mainly of ants, bees and grasshoppers. Bears depend more in spring on animal food, after leaving their winter quarters. At this time fruits, berries and nuts, their main diet, are not yet available, and their plant food intake consists of leaves of *Dipsacus mitis.* In April occasional reports mention bears attacking cattle outside the sanctuary, but no records of Hangul being attacked are available.

A second period when predation from Black Bear on Hangul could be expected is during June and July when fawns are born and raised. Although a

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dense bear population concentrates in the same area of Lower Dachigam as the female core of the Hangul population, no indications have been found of bears preying on Hangul fawns.

5.3. Poaching

On 5 October 1975, we started our observations of rutting Hangul in Lower Dachigam shortly after sunrise. The routine work was interrupted at 6.45 a.m. by a single shot on the southern slopes. At 7.24 a.m. we noted on the opposite slope a stag and, at 7.40 a.m., 7 men chasing this stag. The animal escaped, while the men crossed towards Zahil Nala, where they disappeared at 8.15 a.m. At 9.28 a.m. a second shot was heard from Zahil Top. Two of the 7 men were armed.

According to the sanctuary staff, such incidents occasionally occur on the southern as well as on the northern mountain ridges, which mark the boundaries between the sanctuary and the cultivated lands outside. In 1975, Dachigam's staff was unable to scope with the poachers. While poachers infiltrate from the outskirts, the staff stationed in the centre of the Dagwan Valley depends on an abandoned system of guard paths, dating from the time of the last Maharaja, and reaches the ridges, if at all, only after several hours of climbing. It is difficult to give an estimate of the influence of poaching. Nevertheless, the fact that the deer population increased by 25% in one reproductive cycle after anti-poaching patrols became effective with the assistance of the Indian Armed Forces, suggests clearly that poaching must be considered as the most prominent limiting factor on the Hangul population. Anti-poaching patrols operated in winter 1976 and are planned for the coming rut and winter periods.

Although the assistance of the Armed Forces has led to a first success in Hangul conservation, poaching seems still to continue, mainly in Upper Dachigam where control is lacking. A better control by the State Police of Lower Dachigam became effective after 9 men, locally well known as notorious poachers, entered Dachigam one Friday, when the staff had gone for prayers, and stole some 12 carpets from the V.I.P. Lodge in Drapahama, the newly elected Chief Secretary's residence.

5.4. Diseases

A Hangul stag kept in an enclosure near the Fish Hatchery in Lower Dachigam died in early 1977 of Joline's Disease, which had earlier affected a part of the sheep population belonging to the State Sheep Breeding Farm in Dachigam. According to the Director of Game and Fisheries 120–150 sheep were found dead due to the disease. It is unnecessary to discuss at length the possible impact of the disease spreading out in the fresh water catchment area of a city like Srinagar with a human population heavily depending on sheep products. So far, no hangul in the wild has been reported as having been killed by Johne's Disease.

5.5. Disturbance by man

Dachigam is looked after by several Departments of the Jammu and Kashmir

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Government, such as Game (Protection and Animal Enclosures), Fisheries (Trout Hatchery), Tawaza Entertainment (V.I.P. Lodge at Drapahama and Lodge in Gretnar), Public Works (Maintenance of main road), Horticulture (Garden of V.I.P. Lodge), Water and Irrigation, Public Health (water surveys and water management) and Domestic Livestock (Sheep Farm). Each of these departments is represented by more or less permanently stationed staff ranging from one to several dozen people. The Game Department staff is one of the smallest. These Government employees use not only the main road linking the Gate with the V.I.P. Lodge, but also short cuts linking Drapahama and Palipora, which lead through the riverain forest and the grassland of the Pannar, creating serious disturbances through noise. As already mentioned by Schaller (1969), mating behaviour is interupted by workers. The present study showed clear differences in the activity patterns of rutting stags between the disturbed main valley and the parallel Badin Nala, where human interference is almost absent.

Next to the employees of the Government agencies a second serious source of almost daily disturbance comes from the vehicle traffic between the gate and the V.I.P. Lodge at Drapahama. Sometimes large parties with 20 to 40 vehicles driving at top speed and sounding their horns perpetually, although no traffic from the opposite direction could be expected, visited the V.I.P.'s residing at Drapahama.

Disturbance of Hangul behaviour is obvious in Lower Dachigam, but it is doubtful whether it actually influences the survival of the species. Human interference of the kind that occurs at higher altitudes of Lower Dachigam and in Upper Dachigam, when large numbers of men with a few rifles chase deer, seems on the other hand to be lethal for the animals concerned, although the hunt may not directly result in the killing of a deer. Since Hangul usually flee downhill when chased, they are definitely driven out of the sanctuary when found feeding on the southern slopes of the top ridges of Lower Dachigam. It is likely that the increasing number of straying Hangul reported from areas in the Dachigam environs have lost contact with the population in Dachigam. Animals forced to emigrate from Dachigam by man have hardly any chance of surviving outside the Sanctuary in areas bare of undergrowth and are sooner or later killed by villagers.

6. CONCLUSIONS

Dachigam Sanctuary harbours not only the last known viable population of Hangul but also still maintains a number of endangered large mammals such as the Leopard, the Musk Deer and the Serow, and may furthermore still have some Brown Bears and Snow Leopards. The valley is furthermore known for its rich avifauna and a unique flora including the Kashmir Elm (*Ulmus villosa*), which is a candidate for the IUCN Red Data Book of threatened Angiosperms. But, first and foremost, Dachigam has been the only fresh water catchment area for the city of Srinagar with its 500,000 inhabitants since, half a century ago, in the reign of Maharaja Pratap Singh, the scheme for supplying drinking water to Srinagar from Marsar involved the

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construction of a reservoir near Harwan. To prevent pollution of this water, the villagers situated along the stream were vacated and the area protected and later used as a hunting area.

Within the last few years vast herds of Government owned sheep and later nomads from Jammu with water buffaloes and other livestock have been allowed to graze the area, leading within a short time to such erosion that the fresh water supply became problematical in 1977, during heavy rainfall, because the Dagwan river water was polluted and could no longer be collected. Last year some 20 dead buffaloes were found in the waters in Upper Dachigam. This year an almost uncontrollable disease affecting sheep started to spread in Dachigam. In short, protection of Dachigam is of paramount importance for the welfare of people in Srinagar and the facts that the water supply can only be guaranteed by natural vegetation and health only by absence of domestic livestock and large human presence, need no further emphasis.

ACKNOWLEDGEMENTS

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PART I: THE IUCN THREATENED DEER PROGRAMME
2. ENDANGERED, VULNERABLE AND RARE SPECIES UNDER CONTINUING PRESSURE

The Chilean Huemul Project – A Case History (1975–76)

A. POVILITIS

ABSTRACT

The Chilean huemul was recently studied in the Nevados de Chillán area of Ñuble Province, the only Chilean locality where it is known to survive north of about 44° south latitude. Huemul groups were monitored under varying seasonal and topographical conditions in an effort to identify their basic ecological requirements, and the factors that threaten them. A track census within the 1200 km^2 Nevados area revealed that the huemul population is about forty animals. They occur typically in small family units that are found singly or in small clusters at sites with optimal protective cover. The reason for the huemul's decline is thought to involve a combination of poaching, disease, and loss of habitat to fire and domestic stock. As a result of current selection pressures, huemul social behavior appears to reflect more solitary living, monogamy, and a sex ratio that is perhaps in favor of the male.

South of 44° south latitude, huemuls are known to survive with certainty only in Aysen Province. A preliminary survey indicates that their numbers may be as low as several hundred.

Efforts at protecting the huemul have begun in Ñuble and at a site in Aysen. However, the huemul project is under-funded, and currently lacks the trained personnel and equipment necessary for the long term conservation of this deer.

1. INTRODUCTION

The purpose of this case history is to review a recent field study of the Chilean Huemul, and to describe those findings that are especially pertinent to the animal's future survival. In the process, we will consider the decimating effects of such factors as poaching, fire, and habitat abuse by domestic stock which, when acting simultaneously upon the biology of the huemul, have brought it to near extinction. In order to provide a background to the current predictament of this threatened deer, the paper will begin with a brief historical review. However, we should first introduce the Chilean huemul:

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Family: Cervidae Tribe: Odocoileini

Species: *Hippocamelus bisulcus*

Description: Body size and form – a moderately sized deer with short legs and a stocky build; about eighty centimeters tall at the shoulders, and 150 to 170 centimeters in length. Females are more slender and lighter in weight than males.

Pelage – brown with often a grey, red, or yellow cast.

Antlers (male only) – small; usually only two points per unit.

Other features) – some individuals, often adult males, have a dark Y-shaped facial pattern that extends along the muzzle and above eye-level. The undersurface of the tail and the inguinal area is white. Tarsal glands are present; metatarsal glands are absent.

Range: Southern Andes, Chile and Argentina.

Related species: *H. antisensis* of the northern Andes, principally of Peru and Bolivia. The two species of *Hippocamelus* are allopatric.

Estimated population (Chile 1976): approximately 375 to 1000.

Status: Endangered.

2. HISTORICAL PERSPECTIVE

The Spanish of the 16th Century, with warfare and gold on their minds, provided little or no record of Chile's fauna and flora. It is likely that the prolonged period of combat (1540–1882) between the Europeans and the Indians of south-central Chile resulted in intense hunting pressure on the huemul and other available game. Presumably, the impact of this early period on huemul numbers, distribution and behaviour throughout the region was very substantial. Toward the latter third of the period, the first description of the Chilean huemul, among other wildlife species, was made by the Talca-born Jesuit, Juan Ignacio Molina (1782). Additional historical information on the deer was later provided by naturalists and expeditioners, and most recently by elderly citizens of Chile.

Molina heard the name "huemul" from the Araucanian Indians who reportedly knew the animal well. In areas of south and central Chile, the Indians used the huemul for food, and for making clothing and protective armaments (Avaria 1976). How the animal was hunted is uncertain, but some Indians appeared to have used lances or bolas (Colditiz, 1925; Barros & Armstrong 1974). For some tribes, the huemul appeared to hold symbolic or religious value (Housse, 1953; Aviles, 1975). The Araucanian verb *huemin*, meaning "to follow another" may represent the earliest record of huemul behaviour – its mode of movement and escape.

European observations of huemul behavior in Patagonia (southward of 44° south latitude) emphasized the huemul's remarkable lack of wariness, and the ease in which it could be hunted. Grosse (1975) and Prichard (1902) attested to the animal's former naiveté toward man: its great curiosity and confidence while in his presence. Huemuls approached these observers to within a few meters and, on one occasion, reportedly sniffed the observer's boots before proceeding to follow him as he moved away. Hatcher, during an

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expedition in the late 1800s, demonstrated how readily huemuls could be shot within twenty feet of gunpoint. During the MacQueen expidition to Aysen in the 1930s, Latchen offered the less than insightful prediction that huemuls would be exterminated if left unprotected. His team had shot eight.

Some expeditioners and early settlers commented on the fine flavor and tenderness of huemul meat. Hatcher (1903) and Wolffsohn (1910) called it superior to that of the guanaco and European deer. Yet Grosse (1975) reports that during the 1940s local people in certain areas of Aysen fed venison to dogs. It seems that white men also had some use for huemul skins, as they were reportedly sold in Lonquimay (Fahrenkrog 1977), el Carmen and Bahia Blanca (Cabrera and Yepes 1960), and possibly along coastal Aysen with those of pudu (Latcham 1935).

Given the huemul's vulnerability to human predation, it is not surprising that, by the turn of the century, the deer was considered by some to be "rare" and "little known" in Chile's more populated provinces north of Patagonia (Philippi 1892, Wolffsohn 1910). By the late 1800s, the huemul was believed extinct from the northernmost area (about 34° south latitude) of what was probably its pre-Columbian range (Gigoux 1929). Nevertheless, during that time, the animal was reportedly hunted on numerous occasions within Chile's south-central region, and, as late as the 1920s, was taken from several localities between 37° and 40° south latitude (Housse 1953, Fahrenkrog 1977). With increasing settlement of the south Andes, much of the forest that had earlier buffered the huemul from encroaching European civilization was eliminated by fire and axe. The huemul had also to contend with ecological changes to its habitat made inevitable by newly arrived domestic bovids, horses and dogs. As its numbers declined, hunting of the huemul probably became increasingly opportunistic, as illustrated by the ranch worker who shot an animal at sixty meters and, upon discovering it to be huemul, ate it, and sent its skin to his *patron* in Canteras (Housse 1953).

As huemul numbers were being depleted, the deer itself became part of Andean legend, and found a place in the minds and hearts of many Chileans. In 1883, the huemul, along with the Andean condor, took its symbolic position on the Chilean coat of arms, and has since become an important aspect of Chile's national patrimony. In 1929, the same year that it was given full legal protection, Chile's Museum Director, Enrique Gigoux, expressed a concern for this national animal that has continued to this day: "We plead that the gracious deer of our forests and precious representative of our poor fauna does not vanish: that in the end it is not left an extinct species immobilized forever on the coat of arms; that we can also see it alive, running in its mountains. . ."

Most historical accounts indicate that the Chilean huemul is an exclusively Andean mammal; it apparently has not been reported from Chile's central valley nor its coastal range. In the Andes, the huemul's former habitat covers areas having a warm temperate climate with a prolonged dry season, to those having cold temperate conditions with prolonged rainy periods. Huemuls have been seen in temperate forests, in shrubland, and in open areas both above and below timberline. While they have been reported from relatively level

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areas along valleys and in the alpine zone, the evidence suggests that they have always inhabited areas in proximity to rugged topography. Huemul preference for steep precipitious terrain along the Straits of Magellan (Gigoux 1929) and within canyons (Hatcher 1903) has been reported.

In addition to the information on huemul habitat use, various historical accounts also provide evidence as to the animal's social behavior. Osgood (1943) observed an immature male with three adult females, one of which apparently led the group. From the 1940s, Grosse (1975) recalls mixed groups of females and males (some apparently immature) that numbered up to six or more deer. In other accounts, mention of male-female pairs with or without fawns, and males with two to four females was made four times in each case. Larger aggregations of the huemul were reported three times – the animals being clustered either in winter, or when their densities seemed especially high. Fighting among males, male bellowing at night, and an apparent excess of mature females to males were also observed (Housse 1953, Grosse 1975).

From the historical information that was reviewed, the huemul can be characterized as probably having been always a steep terrain animal, most frequently found in small groups, and, to some degree at least, polygamous. In remote areas it had little fear of, and considerable curiosity toward, man. The huemul was of some use to the Indians and early settlers, before it became a significant national symbol of Chile. Its initial decline can be viewed as one further outcome of the widespread overexploitation of fauna and habitat that coincided with European settlement of the New World.

3. INVESTIGATIONS

Field Surveys for the Huemul

Anyone wanting to study and protect the Chilean huemul is confronted with the problem of finding those animals that have survived along the 1800 kilometer stretch of the Andes mountains from about the latitude of Colchagua to Puerto Natales. The Andes, which are still uplifting, provide many rugged sites which might be suitable for huemuls. Most of the backcountry is served only by horse or foot trails. It is inhabited by *campesinos* who may or may not have an accurate knowledge of the local fauna, and who are often not inclined to take a stranger into their confidence. Natural resource organizations like Chile's *Corporación Nacional Forestal* (CONAF) have little direct contact with the high cordillera and its residents.

Based upon the most promising reports of huemul presence, we selected the south-central province of Ñuble (at approximately 37° south latitude) and the southern province of Aysen (at 45½° to 46°, and 47° south latitude) for examination (see Fig. 1). Our field surveys involved thirty-three days and 200 kilometers of foot travel in Ñuble, and about forty days and over 350 kilometers on foot and horse in Aysen.

The Navados de Chillán Study

A study of the huemul was undertaken in the Nevados de Chillán area of

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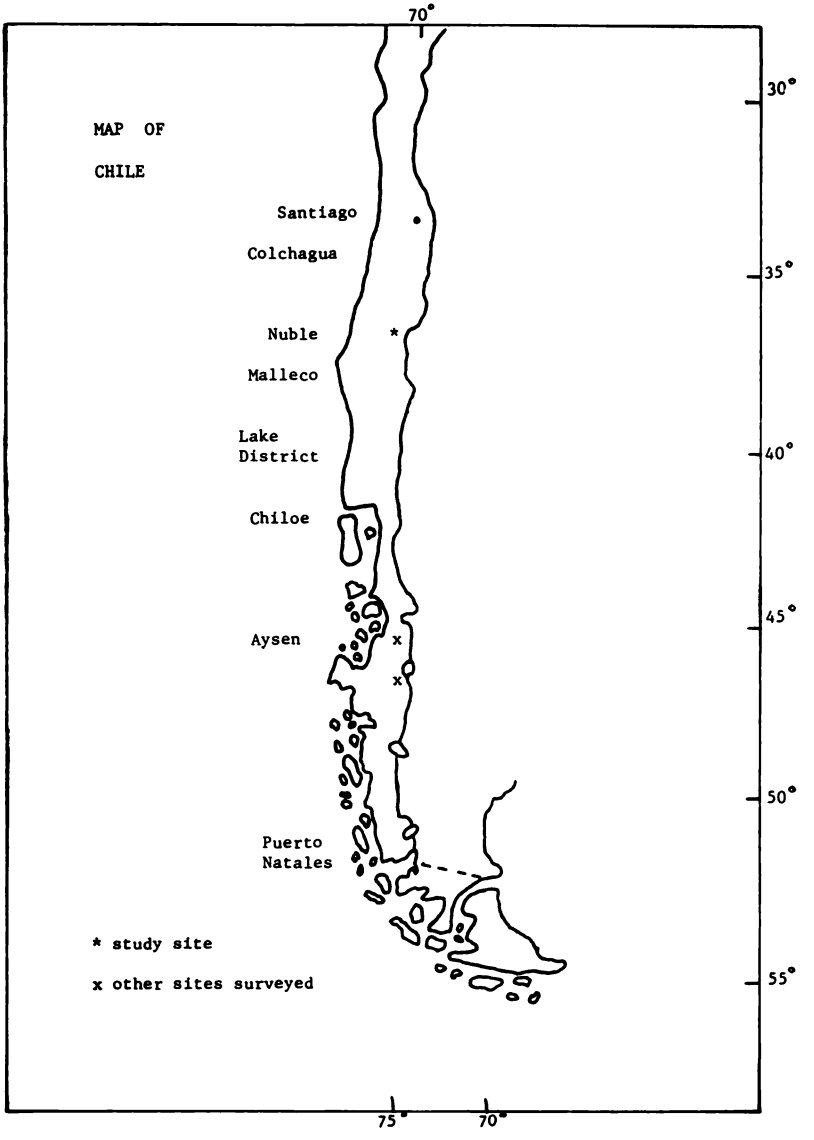


Figure 1.

Ñuble. Unlike Aysen, which is reached principally by airplane, this more northerly province offers access points to huemul sites that are within a day's trip by auto from most of Chile's major cities. The study in Ñuble therefore allowed investigators to call public attention to the plight of huemuls

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that survive at the average citizen's doorstep.[1] Most importantly, some immediate conservation steps could be taken in that part of Chile where the huemul is most highly endangered.

During the study, we monitored the huemul and its habitat under varying seasonal and topographic conditions. To this end, 136 days were spent at various field sites. Seventy-one percent of the time was about equally divided between two study sites. These are located along the Rios Ñuble and Chillán, and comprise about 1300 and 3000 hectares respectively. An additional third site at San Jose Creek (2500 hectares) was visited nine percent of the time (see Fig. 2). The remainder of the field time involved surveys at other promising sites within the 1200 km^2 Nevados area. These sites were selected on the basis of habitat evaluations that were made from maps, aircraft and high vantage points in the cordillera.

Field Methods and Materials

A track census was conducted to provide an estimate of the number of huemuls, and their sex and age characteristics. The work was best undertaken from late spring to early fall with the exception of the hottest months. The reasons are as follows: 1. the huemuls, if present, are readily detected along ridgetops and at valley heads where a survey can be conducted with relative ease and speed; 2. in hot weather, however, the huemuls prefer the heavy forest cover of shaded slopes where their detection can be difficult; and 3. the huemuls, during the winter, are often located in the most treacherous topography.

In order to try to distinguish individual huemuls and to classify them by age and sex, comparisons of characteristics (e.g. track size, age, and stride length) between different track sets were made.[2] When fresh tracks having similar characteristics were found at a site, we assumed there was only one animal. However, if such tracks were separated by topographical barriers, or by distances of one or more kilometers, we would then arbitrarily estimate an additional animal. When doubt occurred about the number of animals present at a site, a minimum, maximum and most probable estimate of the number was made.

When fresh tracks were found in the field, they were often followed for considerable distances. During this time, plant species that were conspicuously

[1] The interest and enthusiasm generated by the project gives testimony to the huemul's aesthetic appeal, and to its potential role in recreation and education. One manifestation of this has been the large number of articles (about twenty known) that have appeared in Chile's magazines and newspapers since May 1975. In addition, the project receives radio and national television coverage.

[2] In the absence of other evidence, huemuls were classified on the basis of track size as follows:

	Track Size (c.m.)	Class
	2.5 to 4.5	fawn
greater than	4.5 to 6.0	yearling
greater than	6.0 to 6.5	female adult
greater than	6.5 to 7.0	unknown adult
greater than	7.0	male adult

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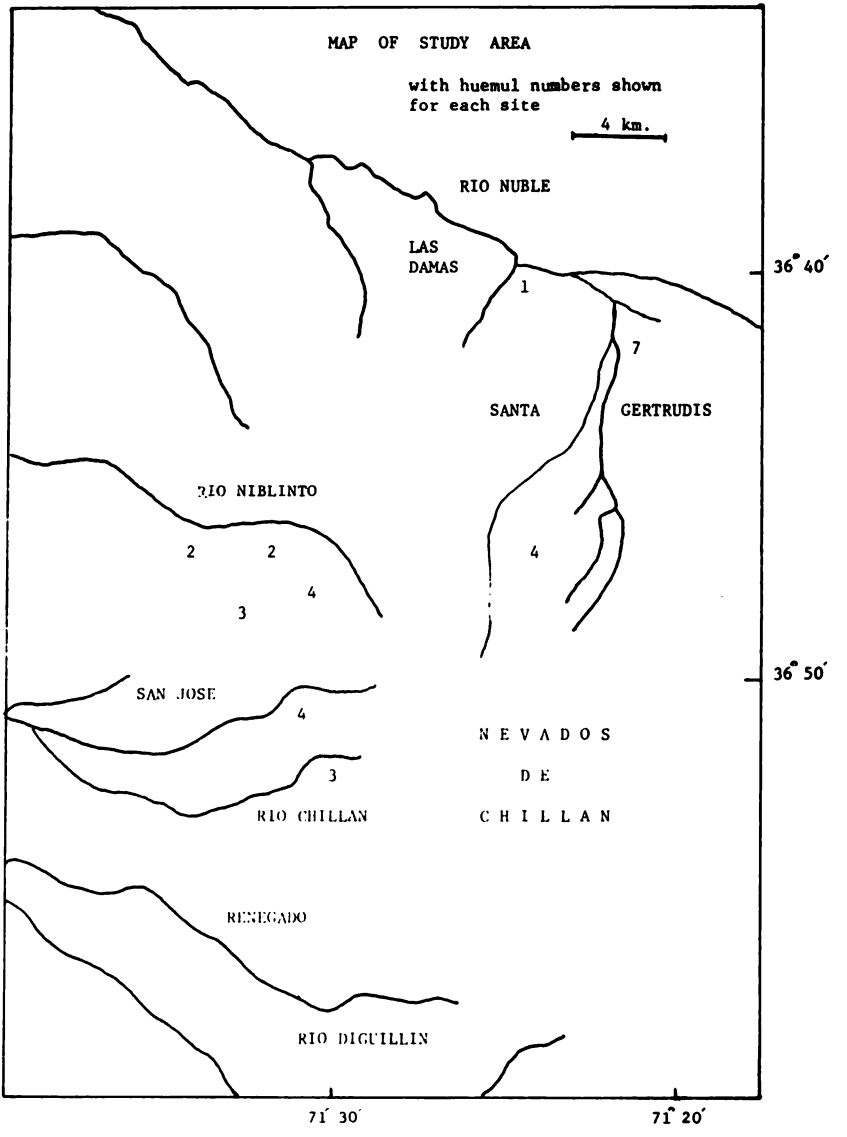


Figure 2.

browsed by huemul were recorded, and, in many cases, the degree of browsing was judged.

Similar observations of a lesser magnitude were made along domestic animal tracks. In addition, about eighty four-square-meter circular plots were set in the vegetation at fixed intervals along fresh huemul tracks, or at special feeding sites. The number of rooted and browsed stems for each species was recorded so as to provide information on huemul food preferences.

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To complement field observations on food habits, huemul feces were collected throughout the year, and analyzed microscopically for the characteristics of those plants observed in the field. The laboratory researcher in charge is also examining samples from goats, cows and hares in an effort to evaluate their diet overlap with that of the huemul.

Fresh fecal material from huemul and domestic stock was collected at study sites during the winter and spring months, and preserved in formalin for parasitological analysis by the Teuscher Technic.

In an effort to characterize the huemul's environment, habitat variables were recorded for many of over 200 huemul track locations (see Table 1). In addition, habitat-type maps (scale of 1:5000 of 1:10,000) were prepared for the main study sites. Vegetation types, fire effects and topographic and geological features were described and recorded on these maps. A record was also kept on the locations of domestic animals and on the incidence of fire at various sites. Soil samples were taken and their textures determined by the International Method. Visibility in several vegetation types was evaluated at approximately the huemul's standing position on the ground.[3] During each field trip, air temperatures were recorded with a pocket thermometer at sunrise, sunset, and during the mid-afternoon. Daily weather conditions were also described.

When the occasion arose, every effort was made to observe the huemul for as long a period as possible. Binoculars (8 x 40) and/or a hand-held spotting scope (20 to 45 power) were used. Since I was often alone a the time of observation, brief activity outlines were sketched while keeping the animal(s) in view. Details were added when the huemul(s) entered relatively inactive or constant states (e.g. napping, feeding, etc.). Since no more than three huemuls were seen at any one time, activity notes could usually be recorded simultaneously for all animals. When huemuls were known to be in an area, considerable care was taken not to distrub or alter their natural routine or behavior.

4. BEHAVIOR AND ECOLOGY

Huemul Distribution and Numbers

The number of huemuls at the Nevados de Chillán is estimated to be 40, with a minimum of 26 and a maximum of 59. Table 2 gives the estimates for various sites within the Nevados area.

In four out of six sites of the Nevados de Chillán, huemul groups are found in apparent isolation – that is, the home ranges of various groups do not overlap or abut, and the likelihood of interchange of animals between groups is very low. This pattern can be explained largely by the sporadic distribution of safe living places for huemuls. On the other hand, spacing

[3] A white cardboard, 20 X 50 centimeters and marked off into 10 X 10 centimeter squares, was held eighty centimeters above the ground, at a distance of ten meters from the observer. The percent visual obstruction of the cardboard was estimated. At each plot, readings were taken at 0, 90, 180 and 270 degree intervals; the first was determined by a random compass bearing.

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Table 1. *Data Recorded at Track Locations*

Description or Measurement of:	Method or Material Used:
Location to within 100 meters	Field maps
Vegetation type	Classification within a 50 meter radius
Vegetation cover	Ocular estimate of percent cover by dominant species
Physiography	Descriptive statement
Exposure	Compass
Elevation	Altimeter
Slope	Abney level
Distance to free water	Map or ocular estimate
Site moisture	Descriptive statement
Soil and geology	Descriptive statements
Escape cover	Visual evaluation
Plant species	Identification of most common plants within a 15 meter radius
Plants browsed	Examination of plants; rate degree browsed when possible
Fire effects	Descriptive statement
Presence and impact of domestic animals	Descriptive statement

Table 2. *Estimated Number of Huemuls at Nevados de Chillán Sites*

Sites	Probable	Minimum	Maximum
Rio Chillán, San José	7	6	8
Rio Niblinto	11	9	15
Las Damas, Santa Gertrudes	12	11	17
Renegado – Diguillin	0	0	0
Sub Total	30	26	40
Other*	10	0	19
Total Estimate	40	26	59

* Estimate based on aerial and map evaluations of habitat only.

between groups was apparent in the Rio Niblinto area, and at two sites in Aysen. At a Santa Gertruds site, where seven animals were thought to reside, some degree of range overlap between males was apparent. The probable number of huemuls for each site visited at the Nevados is shown in Fig. 2.

To the east of the Nevados de Chillán (i.e. longitude 71° 15[1]), vegetative cover and moisture is much reduced as a result of the Andean "rain shadow" effect. Consequently forest and shrubland are confined to lower slopes and to valleys that, as a rule, are well-settled by people. Suitable cover for the huemul is expected to be absent under these conditions.

Similar reasoning seems applicable to much of former huemul habitat in more northerly, and drier, provinces to the north of Linares (36° south

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latitude). If huemuls still survive in Colchagua (34–35° south latitude) as some believe (Pefaur 1968), their numbers are likely to be small.

The cordillera south to about the latitude of Puerto Montt (41° south latitude) seems no more promising for huemuls. The Andes are interruped by large accessible valleys, and habitat loss, especially from fire, has been widespread. In 1965, the huemul was not recorded during a survey of the mammals of Malleco province (38° south latitude). Local mountain residents were said to have no knowledge of it (Greer 1966). For the entire Lake District (39–41° south latitude) we have received no reports of huemuls, and they are not presently known in the national parks of this region.

For the far south, it is possible to estimate the numbers of huemuls from the data collected during our surveys in the province of Aysen. By combining the results obtained in the field with a map evaluation of the topography, we calculate a population of between 60 to 160 huemuls for the 7000 km^2 of the Puerto Aysen – Coyhaique area. By extrapolating these results for about 40,000 km^2 of mountain environment in the remainder of Aysen and in Magallanes,[4] we arrive at a rough estimate of between 350 and 900 huemuls. This estimate is realistic if we assume that, for the region as a whole, extinction and habitat factors are comparable to the sample area, or that variations tend to cancel out.

Finally, in the provinces of Linares (36° south latitude) and Chiloe (43–44° south latitude), huemuls are still thought by some to survive (CONAF 1977, CORFO 1965). It seems unwise, however, to assume their presence before field confirmation can be made.

Some Features of the Nevados de Chillán

The climate of our study area is considered warm temperate. Wet and cold weather prevails from about mid-April through August, and most of the region's precipitation (over 1000 millimeters annually) falls during this period. At huemul sites this often occurs at about 0°C, in the form of rain, sleet and/or snow. Temperatures at these sites during winter (June–August) generally range from 0° to 10°c during the day and may drop to a minimum of −5°C at night. With the exception of the hottest summer months (January and February), when day-time temperatures may reach 30°C, conditions both day and night are relatively mild.

In the Nevados area, forests of roble (*Nothofagus obliqua*), rauli (*N. alpina*), and the evergreen coigüe (*N. dombeyi*) are present along the valleys and lower to middle slopes. Roble is the dominant species along warm and dry exposures of middle slopes (up to 1500–1600 meters above sea level) while forests of lenga (*N. pumilio*) occur along southern (cold) exposures of middle slopes up to about 1700 meters above sea level. At higher elevations where the soil is less developed and where the climate is more severe, shrub types of roble, lenga, ñirre (*N. antarctica*), and the bamboo-like *Chusquea*

[4] Extensive glaciated areas, open water, and lowlands were omitted from the calculation of surface area. Only the large island of Wellington was included as huemuls are thought to reside there (Rottmann 1975). Smaller islands were omitted as there is considerable doubt as to the presence of huemuls (Azocar 1974).

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are found. Above 1550 meters, a low vegetation type consisting of a coarse *Festuca*, dwarf *Chusquea* and forbs may occur on all but the coldest exposures.

The elevation of the highest peaks at our study sites was about 2050 meters. However, the barren Nevados de Chillán rise to about 3200 meters above sea level, and support small glaciers and an active volcano. Major rock outcrops consist of granite, andesites and, to a lesser degree, basalt. Soils are usually sandy loams, and are shallow and easily disturbed. Volcanic glass, breccia, pyroclastics and ash are common in the area.

In addition to the huemul, other outstanding members of the faunal community include condor, Magellanic woodpecker, viscacha, fox, and very infrequently, mountain lion.

Huemul Use of Mountain Habitat

Most typically, the huemuls of the Nevados de Chillán are found at elevations between 1450 and 1700 meters, at slopes of 30° to 40°, along northern and western exposures (75%), and at localities with diversified and irregular terrain.[5] The animals prefer shrubland (65%) to forest (20%) and low vegetation types (15%). In winter, the huemuls use the steepest and rockiest localities available at somewhat lower elevations (1100–1500 meters), and are occasionally forced into still lower areas by heavy snow. Huemuls are also confined to a small fraction of their total annual range during the driest summer months when they seek shade, food and water in tall forests of lenga or roble. These special localities of both winter and summer afford the huemul protection during unfavorable periods, and seem essential for their survival. The extinction of huemuls from the Rio Renegado and Diguillin area of the Nevados may reflect the loss of security at such sites.

While certain zones within the total mountain environment appear to be preferred huemul habitat, others may be important for huemul dispersion and colonization, or serve as "channels" between winter and summer localities. Conditions in these secondary or less optimal habitats will greatly influence the total number of huemuls that the Nevados de Chillán area can support.

Predator Avoidance

During 19 of 34 occasions when a huemul was alarmed by the presence of an observer, it stood motionless with its head typically facing the intruder, its front legs held parallel, and its hind legs in a somewhat forward position. Since it is also likely that this response took place prior to those instances when a huemul was flushed[6] (in 8 of 34 cases), it appears that this initial predator avoidance behavior occurred on almost 80% of all alarm occasions.

A second step in predator avoidance is more variable and seems related to the distance between the huemul and the potential predator. Huemuls

[5] For elevation and slope, the figures given represent approximate interquartile ranges. Percent figures are those of the total number of huemul track locations.

[6] A flush is said to occur when the huemul is not seen prior to its running or bounding away from an observer.

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abruptly fled when this distance was short (mean of 34 meters). At intermediate distances (mean of 77 meters), huemuls would slowly cautiously and very deliberately move away as if to try to remain inconspicuous and avoid provoking an attack. Finally, at greater distances (mean of 190 meters), the animals would either simply walk away, or cautiously resume non-alarm activity.

When huemuls fled from an observer, topographic features (rock, ravine, ridge, fold, etc.) served to first conceal them from view 57% of the time. Shrub and forest cover together broke eye contact about 40% of the time. On one occasion the huemul chose simply to acquire a "safe" distance from the observer. However, for 37% of all escapes, huemuls were observed to flee a considerable distance from the observer either before or immediately after their visibility was initially lost.

Beyond merely describing the huemul's predator avoidance response and the protective role of cover, it is necessary to inquire as to how effective these are in preventing the ultimate outcome of predation – death. Prior to the arrival of the European, the huemul's principal natural enemy was undoubtedly *El Leon (Felis concolor).* In fact, the mountain lion was probably the *only* threat to adult huemuls from predation – there was no wolves, bear, or other large natural predators in the south Andes. We might therefore hypothesize that the huemul's anti-predator behavior evolved in response to a predator whose hunting strategy depends on stealth, and on visual cues from the prey. The huemul's tendency to stand "frozen" and alert in a fixed position may render it an uninteresting and difficult object for the lion to focus on. Furthermore, when a lion decides to stalk a huemul, it may inadvertently reveal its position to the deer with each movement it makes. At some intermediate distance from the mountain lion, the huemul would attempt to "sneak" away so as to not provoke an attack and, once at an even safer distance, would rapidly leave the area.

Once the modern human predator arrived in the Andes with arms, dogs and horses, the huemul's strategy of remaining motionless would appear ineffective unless cover for concealment and rapid escape was adequate. Consequently, it is probable that the huemul has survived in Ñuble because of the excellent topographic and vegetative cover available at certain sites. In addition, one might suspect that the value of this cover in preventing initial detection would be enhanced if huemul society assumed the smallest group size possible.

Social Organization

During the study period, huemuls were seen as solitary animals and in groups of two or three 76% and 24% of the time, respectively. Groups were exclusively composed of adult male-female pairs with or without fawns, or of female-fawn pairs. Table 3 gives sex and age compositions for the three group sizes that were observed.

Table 4 provides information on sex and age ratios as derived from visual observations and census data.

These data suggest the following: 1. huemuls in general are solitary over

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Table 3. *Huemul Sex and Age Composition for Three Group Sizes*

Group Size	Sex and Age Class					
	Male	Female	Yearling	Fawn	Unknown	Total
One	16	7	4	0	4	31
Two	2	6	0	4	0	12
Three	4	4	0	4	0	12

Table 4. *Huemul Sex and Age Structure at the Nevados de Chillán*

Data Source	Adult Male	Adult Female	Sex and Age Class		Unknown	Total
			Yearling	Fawn		
Census 1975–76						
Actual #	9	9	4	5	3	30
ratio	100 :	100 :	44 :	56		
Visual Observations						
Actual #	22	17	4	8	4	55
Ratio	129 :	100 :	24 :	47		

half the time; 2. males and yearlings are more often than not alone; 3. females are likely to be accompanied by a male, fawn, or both; and 4. there may be a preponderance of males to females.

The consistently small group size (mean of 1.4 animals) observed at the Nevados de Chillán, and the presence of only one adult female per male, contrasts with the impressions given earlier in our historical review. The explanation is likely to involve the huemul's current need for dense vegetation which, for ungulates, is often inversely related to group size. Hirth (1977), for example, found this true for North American white-tailed deer. In Peru, the taruca (*H. antisensis*) typically occurs in groups of five or more animals in its relatively "open" habitat (Roe and Rees 1976). Finally, at the Ñuble site itself, there is evidence that male-female pairs, when compared with solitary animals, were more likely to be seen in low vegetation types than can be expected by chance alone.

Aside from any stereotyped response of huemul social organization to vegetation density, it is suggested that the huemul's tendency to be solitary is a more specific behavioral adaptation to intense human predation. This possibility receives support from the observation that, on several occasions, huemuls in apparent association chose different routes of escape.

If current selection pressure does indeed favor small group size, this may also influence the huemul's mating system and its sex ratio. A family group at the Nevados today is comprised of a male, one female and a fawn. If the male were to acquire another female and her fawn, the group size would be increased by a factor of about 1.7. Consequently the groups detectability would be enhanced substantially. Human predation may therefore encourage

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monogany as well as small group size.[7] In these circumstances, the adult male may have certain advantages over his mate – the sole adult female of the group. When male-female pairs were observed, the female was consistently judged to be the most attentive and restless,[8] and always led the pair's escape. In addition, a single female, in being unable to share the responsibility with other females, must be attentive at all times both for herself and her offspring. Thus, the female pays most of the group's energy costs for maintaining vigilance. Since they also occur, on the average, in larger groups than either adult males or yearlings, they are theoretically more vulnerable to detection. These circumstances may have some bearing on the present sex ratio which may, in fact, favor the male sex.

5. DECIMATING FACTORS

Poaching

Central to the above discussion is the notion that humans continue to exert great pressure on the huemul by way of predation. Although Chilean law states that it is a crime to hunt, transport, possess or commercialize the huemul (Ley de Chile 1929), our observations indicate that this law is neutralized by its own obscurity and by the enforcement difficulties it presents in backcountry situations. During our field surveys in Aysen, we encountered two recent skins and a huemul's head at two different ranches, and three skins in the town of Coyhaique. Inhabitants of remote villages were familiar with the quality of huemul meat, although none admitted to having killed the animals in recent years. At the Nevados de Chillán, long-time residents report that in the not-too-distant past, huemuls were run down by dogs and lassoed in the snow. At a Rio Ñuble site, six huemuls were reported captured some twenty years ago and subsequently distributed to zoos (Gutierrez 1976).

Today there is an increasing danger from well-intended but misguided people who wish to capture huemuls for "preservation" in zoos or in private collections. Experience tells us that these huemuls will not survive for long. Four huemuls were obtained from coastal Aysen in 1973–74, and placed under a biologist's supervision at Punta Arenas in preparation for their introduction to Dawson Island (Texera 1975). All of these animals, including a fawn born after arrival, died over a ten month period from various causes related to their captivity. An adult female captured to the south of the Nevados area several years ago died in a Chillán zoo. In July 1975, a fawn was caught from the Nevados area and died about a week later at a ranch near the Andean foothills. Other unsuccessful attempts at keeping huemuls have been

[7] We recall that earlier reports indicate that single males were often accompanied by several females, and that agonistic interaction occurred between males. We may assume that some competition for females on the part of males did take place, and that polygamy, at least under certain circumstances, was operative. Sexual dimorphism in the huemul, although not outstanding, suggests some degree of male competition for females (sex selection) over evolutionary time.

[8] "Restlessness" was evaluated by the frequency of tail flicking and body movement.

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reported from the Rio Baker area (Allen 1975). We know of no instances where Chilean huemuls have done well in captivity, and are unaware of their presence in any zoo.

On the brighter side, there appear to be areas today where the huemul is left undistrubed. For example, in one coastal community of Aysen, there is an awareness, perhaps instilled by the Chilean Navy, that the huemul should not be hunted (Allen, 1975). In Ñuble, several residents have helped to create among the local people some notion of the huemul's value.

Fire in Huemul Habitat

Although proscribed by law, the setting of wild-fire in the Chilean Andes represents a serious threat to native vegetation, fauna, soil and water resources. Many people who set fires want to destroy vegetation as a means of increasing accessibility into the backcountry for domestic stock, and increasing the immediate availability of grasses as forage for cattle. Others have no clear motivation for starting fires.

Of shrub vegetation, the lenga type is most vulnerable. This type, which represents the sole seral stage in succession on most sites, is readily eliminated by fire, and recovery is seldom evident in burned-over areas. Roble-ñirre and roble-*Chusquea* shrub types are somewhat less susceptible to change by fire. While fire will kill the aerial parts of the dominant plants, *Chusquea* returns rapidly through new gound at its base, and roble more slowly through sprouting. Repeated fire in shrub types tends to reduce cover considerably and selectively eliminates lenga, ñirre and roble, in that order of ease. Also, the soil often becomes barren and subject to erosion. Fire, especially at higher and less favorable sites, may cause shrub types to change toward a *Festuca – Chusquea* low vegetation type.

At the San José site, extensive stands of lenga shrub are threatened with complete destruction if fires continue to burn at present rates. Serious fires in roble-*Chusquea* shrub occurred during the dry fall of 1976. Over three hectares at the Rio Ñuble site were burned out. At the Rio Chillán, cover was reduced by half at a nine hectares area frequently visited by huemuls. Such fires are seriously thinning out remaining cover at key locations.

The forests of the Nevados de Chillán fare no better. Most trees are readily damaged or killed by fire with a resulting accumulation of slash and snags. This often represents a build-up of dry fuel for successive fires. After hot and/or repeated fires, the soil is stripped of its cover and organic material. Many forbs that huemuls feed upon are intolerant of direct sunlight and cannot survive once the forest canopy is gone. The once extensive stands (over 4000 hectares) of lenga forest at the Rio Chillán – San José sites have been largely destroyed, as aerial photos indicate, within the last twenty years. At the Rio Chillán site last fall, about half of the trees of a twenty-five hectares stand of roble were largely destroyed by fire. Over seven hectares were affected at the Rio Ñuble site. As the forests of the Nevados disappear, a change to more arid habitat conditions seems inevitable.

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Domestic Animals

Domestic animals present a threat to huemuls when they cause unfavorable habitat changes, supplant huemuls on their range, compete with them for water and food resources, or transmit pathogens to them.

In the south Andes, cows, goats, sheep and horses are commonly set free to roam at large. Often the animals are rounded up in the fall and driven to the lower valleys. However, small residual numbers remain at huemul sites throughout the year. At the Rio Chillán and San José sites, small groups of cattle (usually about five to fifteen animals) will ascend the steeper slopes and occasionally feed along ridgetops. Often the animals eat and trample important forb species, damage shrubs and trees, and cause soil displacement by their sheer weight. Cattle are attracted to recently burned over sites, and seem to play a significant role in retarding the recovery of vegetation. Springs and small streams at such sites are often blocked up by soil and debris that are displaced by cattle. The resulting water stagnation greatly increases the risk of disease transmission between animals.

Goats are most commonly associated with low vegetation types and less commonly with shrub types. Large numbers of these animals often dominate ridgetops and timberline areas. About half of a Santa Gertrudis site receives intensive goat use and is no longer available to huemuls. At some localities, few forb or grass species remain after years of heavy use by goats. Their overgrazing leads to almost complete elimination of ground cover, uprooting of plants and gully erosion.

There is evidence at our study sites that domestic stock may displace huemuls, at least temporarily. At both the San José and Rio Chillán sites, cattle were found at localities that had been preferred by huemuls four to six weeks earlier. At a Rio Ñuble site, huemuls were seen to flee as goats moved through a rocky zone above them. As has been noted for wapiti in the heavily hunted Bighorn mountains of Wyoming (Povilitis, 1977b), huemuls are probably inclined to relocate when faced with the unsettling presence of domestic stock.

There are about twenty species of plants that huemuls in the Nevados area prefer. From a preliminary analysis of data, cattle feed on at least 70% of these; goats, 40%; and horses, 25%. But since cattle and goats tend to feed on a variety of plants, these figures are likely to be higher. Although in general the food supply for huemuls appears sufficient, food competition from domestic stock may be significant at seasonally crucial sites.

Parasites and Disease

The danger of disease transmission to huemuls is primarily from domestic bovids. However, in Aysen, autopsied huemuls were found to have bladderworm, *Cysticerous tenuicollis* (Texera 1975), which can seriously weaken or kill animals with heavy infections (Morgen and Hawkins 1953). This parasite is spread by fecal contamination of the environment by dogs.

Huemuls are known to be susceptible to hoof and mouth disease (Pefaur 1968), coccidiosis (Texera 1975), and nematodes of stronglyloidea (Texera 1975). Hoof and mouth disease is said to be present on the Argentinian side

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of the border with Ñuble and would re-enter Chile with the arrival of infected animals. At our study sites, we have found huemuls, as well as cattle and goats, with light infections of coccidia and strongyles. The tapeworm, *Monieza*, was found in both huemuls and cattle.

Other parasites and diseases of domestic animals that are prevalent in Ñuble and may infect huemuls are anthrax, foot-rot, contagious ecthyma, and *Fasciola hepatica* (Jaramillo, 1976). All the parasites and diseases mentioned are spread by infected animals that contaminate the environment – soil, water and vegetation.

Lumbering and Recreational Development

During the study we became aware of an unauthorized logging operation that threatens present huemul habitat. Along the upper San José valley, fellers were cutting stands of roble and rauli at less than 0.5 kilometers from winter locations of huemul.

The area of Estero Renegado is very well travelled by outside visitors as an all-weather road runs through part of it. The area, especially along the road, is receiving considerable use by picnickers and others engaged in outdoor activities. This presents an opportunity to provide the public with information on local wildlife and resource conservation. But it also creates a need to control resource damage (i.e. destruction of vegetation, water pollution, littering, etc.) and to accommodate recreation.

Another problem in the Renegado area involves the parcelling of the land, and the accelerated construction of bungalows and *rufugios*. The question of planned growth needs to be addressed.

6. HUEMUL CONSERVATION

It is not possible to specify a single principle cause for the decline of the huemul. At the Nevados de Chillán, habitat is being degraded and destroyed by poor land use practices and its use by the huemul has become very restricted. At the same time, the deer is subject to poaching and to the transmission of disease agents from domestic animals.

Areas where huemuls can survive in the long term must be:

1. Free from poaching, uncontrolled use of fire, over-exploitation of vegetation and range, and the hazards posed by domestic animals to huemuls.
2. Large and varied enough in habitat to support a sizeable huemul population that is resistant to extinction by local catastrophes (natural or man-caused) or by chance.
3. Contiguous, in the sense that huemuls can disperse, exchange genetic material between groups, and (re)colonize vacant sites.

Under present circumstances, these conditions can probably be met in certain well-administered national parks. Unfortunately, the huemul's presence has been confirmed only in Aysen's Parque Rio Simpson where a guardhouse was recently established to oversee at least part of the huemul population (Rosas and Hernandez 1977). This park comprises only about 400 square

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kilometers (Thelen and Miller 1976), and the number of huemuls it supports is not known. The huemul's future would seen precarious if it were only to survive in Parque Simpson. It appears that most surviving huemuls in Chile occur outside of areas that presently receive resource protection.

One approach to the problem would be to reintroduce huemuls into the large parks of southern Chile, such as Puyehue (1170 km^2), Vicente Perez Rosales (1362 km^2) and Torres del Paine (1110 km^2). However, a sophisticated research operation would be required to select suitable habitat in these parks, locate huemul donor populations, and successfully capture, transport and establish the reintroduced huemuls.

A second approach involves locating sizeable huemul populations, determining the extent of their year-round use of habitat, and protecting them *in situ*. This approach is currently being tried at the Nevados de Chillán area (1200 square kilometers) of Ñuble. CONAF, under current laws, can take action to prevent huemul poaching, the setting of wildfire, and the unauthorized exploitation of timber resources, even though most of the land at the Nevados is under private ownership. On the other hand, administrative and legal mechanisms will have to be found if land misuse and huemul disturbance by domestic animals is to be prevented.[9] A reserve plan for the Nevados de Chillán calls for the use of mountain patrols to ensure law enforcement, and to oversee land use agreements that may be worked out with landowners and residents (Povilitis 1977a). Three of six guards have been deployed (Rottmann 1977), but the project is in financial trouble (*Ercilla* 1977) as a result of apathy at certain administrative levels. Solicitation of funds from the public is being considered to help support the reserve (Rottmann 1977), but what is badly needed is a sustained financial commitment on the part of CONAF and other conservation organizations, both national and international.

The most conspicuous benefit of a huemul conservation program is the preservation of the deer as a part of Chile's patrimony, and as one of its four native ungulates. The huemul will in recreational, educational and scientific terms unquestionably add value to Chile's mountain landscape. It also has potential as a big game animal under a future management program.

Beyond this, a successful huemul conservation program for the south Andes would, as a matter of consequence, point the way to:

1. The protection of water quality and volume for the central valley.
2. The safeguarding of native wood, forest and soil resources.
3. Increased productivity of domestic stock by requiring herding practices that eliminate range abuse; screening and treatment of animals with parasites and disease; and more intensive and concentrated stock management procedures in general.

In any event, if such conservation practices are not adopted, it is feared that Chile will emerge, in terms of its natural resources, as a poorer country

[9] Priorities involve the closing of crucial huemul localities to unauthorized persons and to domestic animals, and the gradual diversion of domestic stock from huemul sites. The acquisition of some areas through purchase or land exchange may also be possible.

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– a process that so sadly will be symbolized by the final disappearance of its huemul.

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PART I. 2 THE IUCN THREATENED DEER PROGRAMME: ENDANGERED, VULNERABLE, AND RARE SPECIES UNDER CONTINUING PRESSURE

Summary of Discussion

Himalayan musk deer *Moschus moschiferus moschiferus* (M. Green)

Census techniques for this solitary and very secretive deer involved particular difficulties. Faecal pellet transects might be used to determine distribution and relative abundance, but for the latter purpose permanent transects or studies on pellet disintegration under the conditions of the study area would be required. Track counts might also provide data on distribution and relative abundance. Information on sex ratios from poached animals was questionable since the behavioural characteristics of the deer might cause fewer males to be killed and result in skewed ratio data. Population estimates based on musk exports needed to be treated with the greatest caution; the mixing of musk with synthetics before sale is a common practice.

Long term conservation of the deer posed further problems. The animal occurs in vast, isolated areas that are difficult to control. Local human populations are very poor and have traditionally hunted musk deer as a source of income and food; the value of musk is now extremely high so that the incentive to poach is substantial.

It was generally agreed that musk deer farming, in itself, would not solve conservation problems. Although musk deer had bred in captivity and reports on musk farming in the People's Republic of China were extremely favourable, the social system of the deer probably represented a serious impediment to regular successful reproduction in the captive state and the control of disease under farm conditions could pose a serious obstacle to good captive management. The solutions to these problems could only be devised on the basis of an etho-ecological study of the animal in the wild. Some participants at the meeting felt that captive breeding and resumption of legal trade in natural musk in the Himalayas would worsen the conservation situation by stimulating the market and providing an outlet for musk from poached animals. They considered that a total ban on the trade in natural musk from whatever source was essential. On the other hand, such an approach would inevitably reduce the value of the musk deer and the incentive to conserve both the deer and its habitat.

Initially, captive management of this resource and the returns from musk sales would probably rest in the hands of the Government and would provide no incentive to local people to discontinue poaching. Village farming of musk deer would place the resource and its benefits in local hands and probably ensure adequate care of the captive stock, but it is by no means certain that

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local people would accept the system or be ready to adapt to it. They might again be tempted to add to their farm stock from wild populations or increase their production of musk from poaching.

Controlled culling of populations in the wild for the production of musk and meat was certainly a possibility to be considered. If musk were easily extractable from the live animal, then a system of live captures in traps for musk extraction and subsequent release of the animal might be possible, although it would require careful supervision as the meat of all sexes and ages of musk deer was relished by local people.

In essence, conservation of this species would be no easy undertaking; careful planning and a combination of different approaches appeared necessary. The starting point must be an ecological study of the animal in the wild to provide the basic scientific data required for management, both in the field and in captivity. In the long term, a conservation programme would probably need socio-economic components to improve living standards of local people and reduce their dependance on musk deer hunting for their livelihood.

Langtang National Park was considered a suitable study area although it contained a number of villages and, consequently, population pressures, both on the periphery and within the Park. The biologist selected for the project was already familiar with this region, however, and had undertaken preliminary studies on the deer population; he felt that there were good prospects for sound management of the Park and control of human disturbance. The Group was greatly concerned, however, to note that although funds and a researcher for the project had been available for some months, HMG Nepal had not yet granted permission for the study to proceed. It was agreed that the Director General of IUCN be requested to write to HMG Nepal to urge them to approve the project officially as soon as possible. If approval could not be obtained in the near future, then it would be necessary to consider an alternative study area.

Swamp deer (northern) *Cervus duvauceli duvauceli* (D. Schaaf)

General approval was given to the recommendations to reduce or eliminate current threats to the Sukla Phanta Reserve and its swamp deer and to provide for the continuing assessment of animal populations and vegetation succession, with particular reference to the grass burning regimes. The final report on this project will be sent to HMG Nepal through IUCN, and the author agreed to maintain close liaison with IUCN, to urge national action on the recommendations and to encourage international cooperation in the deer's conservation, including the establishment of a reserve for swamp deer that had been recommended on the Indian border adjacent to Sukla Phanta.

Kashmir deer *Cervus elaphus hanglu* (F. Kurt)

It was reiterated that the principal threat to the Dachigam Sanctuary, which contains the last known viable population of the Kashmir deer, was livestock grazing, of government owned sheep in lower Dachigam and of buffalo herds of nomadic graziers at higher altitudes. The Sanctuary provides the catchment

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for water supplies to the city of Srinagar and its half million human inhabitants. Water quality has deteriorated as a result of soil erosion caused by stock grazing and by decomposition of stock carcases in rivers. It may deteriorate further since disease has been observed in the sheep. The State Government of Jammu and Kashmir were understood to be reconsidering the future of stock grazing in the Sanctuary, but if no action were taken in the immediate future, it was proposed that the Director General of IUCN be requested to contact the Government to draw its attention to the serious problems posed by the stock, both for the conservation of the area and public health, and to recommend the withdrawal of all stock from the Sanctuary.

Although the results of initial surveys had been disappointing, there was reason to believe that remnant groups of this deer still existed in the vale of Kashmir, in addition to the Dachigam population. It was considered that surveys to locate these remaining groups, if indeed they existed, should receive some priority over the next year of this continuing project.

Chilean huemul *Hippocamelus bisulcus* (A. Povilitis)

The most important requirement for the conservation of the Chilean huemul in the immediate future is the initiation of surveys to determine its status and distribution in the southern parts of its range. Populations were believed to be most numerous in this region and supporting studies could provide data on genetic isolation, which had been suggested as a possible problem. Forest development in the south may pose serious problems for entire ecosystems in the foreseeable future, and the need for surveys was urgent.

This conservation programme in Chile has met with much official and general public interest, but has suffered from insufficient funds to employ guards and scientific personnel. Government infrastructure for the mountain regions where the huemul occurs is poorly developed and requisite improvements in land use practices are complicated by a confused pattern of public and private ownership in the northern part of the huemul's range. Few land owners actually live on their land, which restricts the use of private agreement on land use practices that might benefit the deer.

Little information was available to Group Members on the status and distribution of the huemul in Argentina. A survey was to have been undertaken in 1977 and IUCN will try to obtain details of the results.

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PART I: THE IUCN THREATENED DEER PROGRAMME
3. SPECIES OF WHICH SOME POPULATIONS, AT LEAST, ARE RECOVERING OR HAVE RECOVERED

The Status of the Swamp Deer (*Cervus d. duvauceli*) in the Dudhwa National Park

ARJAN SINGH

ABSTRACT

The northern subspecies of Swamp Deer once ranged over most of the submontane area of North India but is now found only in the Kaziranga and Dudhwa Parks and the Nepalese Reserve of Sukla Phanta. Its disappearance has been due to habitat destruction and the encroachment of cultivation.

The Dudhwa National Park is 490 sq. km in area. For water it is largely dependent on the Soheli river, which is subject to annual flooding, draining away after the monsoon but persisting in the shape of swamps and sloughs till the hot season. There are two distinct zones in which the Swamp Deer is found: the 50 sq. km Sathiana area which has a population that has almost reached its optimum; and the 100–130 sq. km Kakraha area where there is room for considerable expansion once cattle grazing is controlled.

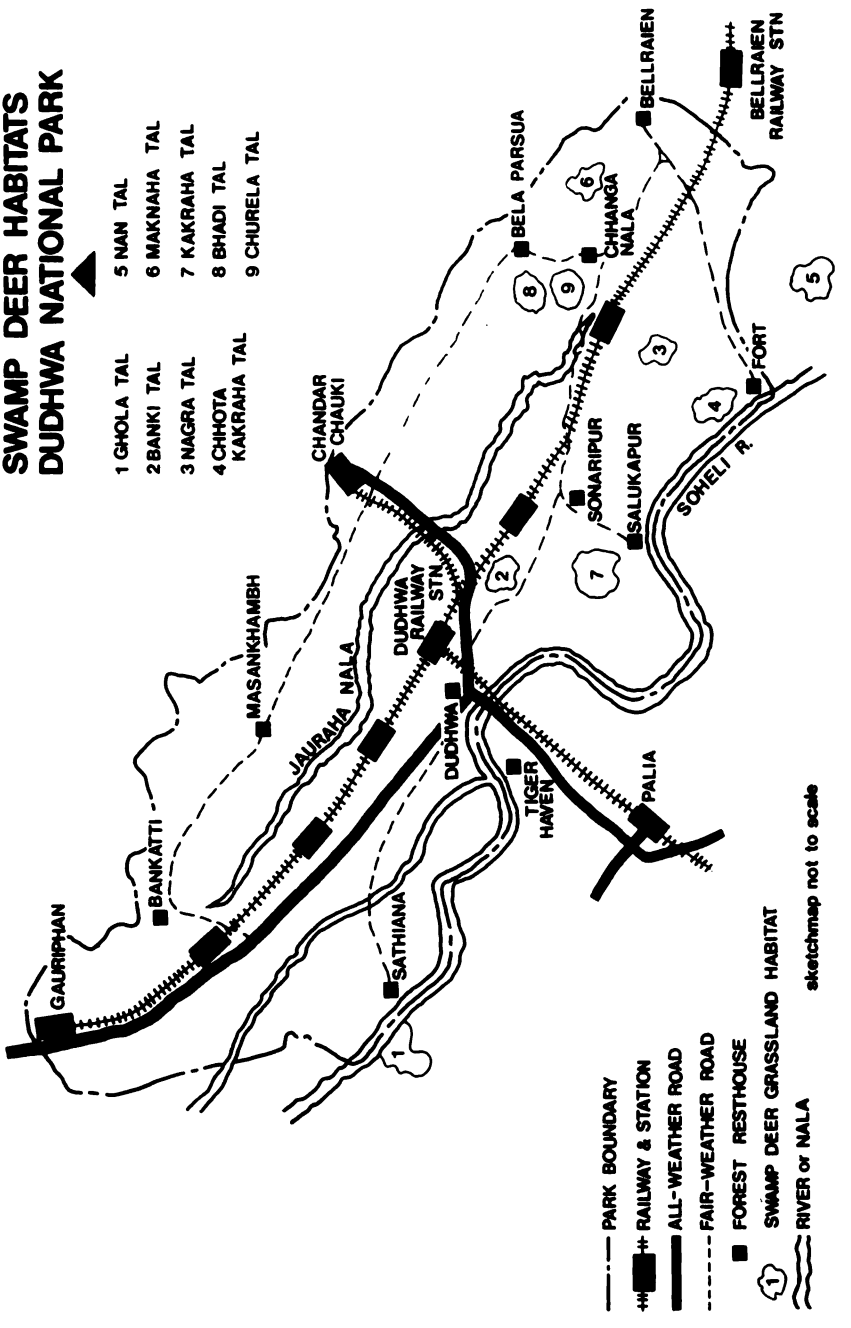
Apart from this competitive grazing, tiger predation is the main inhibiting factor on the deer population but does not appear to exercise a visibly depressive effect, as the deer seem to be colonizing fresh areas, mainly inside the forest, e.g. Bhadi, Maknaha, Churela, etc.

Scientific study is required to determine the extent of the deer migration from the Sathiana zone during the annual floods to areas outside the Park; also to determine the reason for their absence beyond and to the east of Kakraha. Some recommendations are made for protection and management.

1. RANGE AND STATUS

During the last century the Swamp Deer was recorded along the base of the Himalayas, from Upper Assam, in a few places in the Indo-Gangetic plain from the eastern Sunderbans to Bhawalpur and Rohri in Upper Sind, and locally throughout the area between the Ganges and the Godavari as far east as Mandla. Today viable populations exist in the Kaziranga National Park, Dudhwa National Park and Kanha National Park in India, and in the Sukla Phanta Reserve in Nepal. Isolated pockets exist elsewhere, but their future outside established National Parks is bleak and uncertain to say the least. Today it is true to say that populations have reached their last bastions.

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Beyond stretches the eternity of limbo, and unless we can consolidate our positions in such a way that National Parks retain the sacrosanctity and inviolability of a National monument, the process of erosion will merely decelerate and, in place of the cataclasmic decline of the last thiry years, the pace will slacken to a rate rendered more insidious by its very lack of conscious momentum. The legal battle has been won and in theory the Swamp Deer populations are safe in these Parks, but the compromise which the politician seeks between an increasing and voting public, and a decreasing and inarticulate section of wildlife, in the shape of human intrusion into animal habitats, must be resisted, as it merely sanctions a process which can only lead to a logical and disastrous conclusion. Unless conservationists can successfully combat this dénouement of the democratic processes of government, all hope is ended.

Total disappearance of vast herds no doubt has its parallels in other countries and is exemplified also in the fate of the blackbuck in India, from the days in the early part of this century when Dunbar Brander travelling from Allahabad to Bombay was seldom out of sight of these graceful antelopes, to the present when a lone survivor on the edge of the forest is not visible the following season. Vast herds of Swamp Deer used to inhabit the reed beds and stretches of tamarisk forming the buffer regions of the main rivers of the Indo-Gangetic plains, their spill over populations colonizing the mosaic of swamp and savanna of the Terai bordering the submontane forests of the lower Himalayas. Their numbers sometimes aggregated over a thousand animals in one herd, but today are no longer to be seen. Pushed back by the relentless advance of human populations seeking marginal lands, their remnants huddle in possibly brief insecurity in a few wildlife Reserves, a memory of the past and maybe a warning for the future that the days of the human race may also be numbered in their uncontained rush for living space.

2. HABITAT CHARACTERISTICS

The geomorphological structure of the soil in the submontane tracts of northern and eastern India has been largely influenced by the dominating presence of the Himalayas. The detritus washed down from the foothills by the annual monsoon rains has accumulated over the years to form a transitional belt of miscellaneous forest known as the Bhabar. The gravel texture of the subsoil is transected by seasonal watercourses or Nalas. Dry for most of the year, with occasional pools of water trapped amid huge boulders of sandstone, these become raging torrents after cloudbursts in the hills, the snap floods sweeping everything in their wake but soon to become mere trickles again as the tremendous velocity of water is lost in the limitless plains of India. The major timber varieties are shisham (*Dalbergia sissoo*), Khair (*Acacia catechu*) and a second quality sal (*Shorea robusta*). To the south of this transitional belt lie the great forests of the Terai where the main hardwood timber of Sal attains the optimum in growth and quality, and the gravel and sandstone of the sub-Himalayan watercourses give way to a heavy

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clay soil of marshland and swamp with stands of *Arundo donax* and *Sacharum* spp. rooted in perennial liquid and decaying vegetable matter.

3. DECLINE OF THE SPECIES

The terai has been the ultimate home of the northern variety of Swamp Deer (*Cervus duvauceli*) during the twentieth century, and its decline in status has been proportionate to the advance of human colonization, which has devastatingly accelerated during the post war years. Before 1939, hunting of Swamp Deer was intensive but sporadic and may even have been beneficial to the quality as trophy heads very often belonged to old stags past their breeding prime. A preponderance in the female/male ratio is essential among most mammals, and certainly pertains to the social ungulates, and therefore hunting of the Swamp Deer in prewar years gave a chance to the younger and more virile males to breed. The years of 1939–45 were the years of satisfaction for the Swamp Deer when men slaughtered each other for a change, and immediately after the war large herds numbering five hundred and over could be seen galloping through the tamarisk and grassy outcrops which formed the buffer zones of the Sharda river, their myriad hooves churning the soft sand. The dawn of Indian Independence however saw the twilight for the great herds which hitherto had shared the horizons with humanity. As the human population increased, land hunger grew, and displaced peoples from Pakistan provided additional pressure on marginal lands. Soon the deer populations from areas hitherto regarded as riverain wastes were displaced as cultivation closed in upon the river, and the steady retreat which was soon to become a rout began as the herds with their backs to the wall moved northwards. Slowly, but inexorably their numbers dwindled, hostages to the destruction of their age old habitats, the innumerable gun licences issued as political patronage also taking their toll as the breeding graph dropped steeply. Soon an area of 3000 acres was all that remained. Left by an Anglo-Indian General to his descendents, Lionel Hearsey doggedly defended this last stronghold during his lifetime, but this was not for long, and the land was leased out for cultivation to three large farmers. However, Government shortly afterwards introduced a land ceiling bill by which any land owned over a standard 40 acres was declared a surplus holding, reverting to the state until it could be allocated to landless tenants. At this stage, such land could have been allotted to the Forest Department but while the Government havered over the expenditure involved, squatters moved in and took possession. An opportunity was lost of saving an inarticulate animal species while democratic processes legalized these unlawful possessions. Soon afterwards, however, it was possible to move some of the deer into the adjoining Reserved forest, where they had a measure of protection, though it was still a hunting block. Gradually this forest area was declared a Sanctuary and then a National Park where the deer are legally safe; but they still continue to move into Ghola during the annual flooding and fewer return once the rains are over. Such a drain will continue until hopefully the lease-holders can be monetarily compensated and the land handed over to Park management.

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The Swamp Deer was always the showpiece of the sub-himalayan forests of the Kheri region during the prewar hunting era. Due to the vast numbers which inhabitated the plains bordering the forests, the search for trophy heads followed a process of unmitigated slaughter. The State of Singahi maintained a stable of elephants and a professional band of hunters to assist their British Rulers in their annual battues. From the galloping herds, rendered more spectacular by the habit of this animal of segregating into sex groups, the trophy heads were shot and severed from the body, leaving the innumerable carcases for the scavangers, both human and animal, for the bounty of the British Raj extended to the utmost corners of its far flung domain. All this activity ceased with the coming of independence in 1947, but it was replaced by the insidious process of habitat destruction, by which humans advanced to the edge of the Reserved Forest in search of cultivable land, encroaching into the forest lands whenever they found it possible, and intruded into the forests for their building material and with their innumerable head of scrub cattle. This process though seemingly less wanton has been far more destructive, and the close of the year 1977 leaves me with a sense of foreboding and the very doubtful satisfaction of having fought the good fight?

4. GENESIS OF THE DUDHWA NATIONAL PARK – A LAST REFUGE OF THE SWAMP DEER

The course of the Sharda river has fluctuated with the years over a latitudinal measurement of approximately 30 km from where the river debouches from the hills at Tanakpur, in the Naini Tal District, and passes through the administrative districts of Pilibhit and Kheri to join the Ghagra in the District of Sitapur. A linear distance of over 200 km bounded by the great Terai forests to the north, this area of cultivable grassland was the preferred home of the malaria mosquito and the Swamp Deer and many villages had gone out of cultivation because of the adverse conditions, reinforced by the depredations of gangs of dacoits who conducted forays into more populous areas and retreated into the fastnesses of the forest, where they were safe from the arm of the law. After the creation of Pakistan however, displaced Sikh farmers driven out of their ancestral home by genocidal killings, leased large acreages of land, which were then freely available, and though many of these sturdy husbandmen from the dry and arid lands of West Pakistan found their last resting place in the dank and humid settlements they were attempting to colonize, the remainder stayed on and the areas of swamp and grassland gradually gave way to green fields. A marvel of dogged pertinacity, the operation sounded the death knell for the Swamp Deer. The area of 3000 acres in Ghola leased to the descendents of Gen. Sir John Hearsey for services rendered during the mutiny, and adjoining the forests of North Kheri, remained for a few more years as a stronghold, but gradually while the State Government vacillated over ways of acquiring this land as a wildlife habitat, squatters moved in to take possession. That the Swamp Deer, or Gond as they are locally known, found a precarious foothold in the present Dudhwa

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National Park is a fortuitous circumstance to which the end has not been written as yet, for a change of government and a surge of the population could well drive them over the brink. It is a truism that wildlife populations flourished best in feudal regimes not because of the sanctity of inarticulate life, but because of the rapacity of the ruler. Now while the end remains the same, the means has perforce to be different, and the next decade are the critical years.

The Dudhwa National Park comprises an area of 490 sq. km with the Soheli River forming the southern boundary flowing due east for about 25–30 miles. The northern boundary of the mosaic of swamp and savannah thus formed is an escarpment also running due east at a distance of approximately two miles from the river. This is the preferred habitat of the Swamp Deer. That it has not been colonized in its entirety by the deer is due to the running battle which is continuously taking place with the innumerable head of scrub cattle which graze illegally in the Park and belong to the neighbouring villages. The situation of course is a very difficult one as these cattle have grazed in the Reserved Forest ever since cultivation reached the forest boundary, and with the present pressure on land there are no other grazing grounds for the vast herds which have been acquired by individual owners more as a status symbol rather than on any utilitarian grounds. That cattle can co-exist to a limited extent with wild ungulates is a fact, but this is only true when the numbers can be totally controlled and if cattle entering the common grazing ground can be inoculated against epidemic disease. As such a phase is not possible the only remedy is complete elimination, as not only are cattle more severe on the habitat but no compensation is possible when these livestock are backed by human graziers. The only solution would appear to be the replacement of these useless cattle by stall fed ones, but the people are conservative in their outlook and will require a process of education, for customs and usages acquired over generations cannot be dispelled overnight. That we have the time for this process is very doubtful.

The second barrier, and a more formidable one to the optimum proliferation of the Swamp Deer is the pressure of human population on the Park. The 490 sq. km has a minimal buffer zone to the north. Beyond is settlement comprising about 100 villages. The southern boundary has a similar number of villages abutting the Park, but without a buffer area. There is also cultivation on the east and west. These villages have also been dependent on forest produce, and many problems are being faced now that the Indian Wildlife Act of 1972 forbids human intrusion into a National Park. An interim period of compromise until these settlements can become independent of forest produce appears to be the only solution, and the Wildlife authorities are fully aware of this phase, but political and financial inhibitions are a formidable combination, and the only solution appears to be financial support by international organizations for the construction of permanent living quarters and cooking arrangements for these border inhabitants, which is the main purpose of the annual scavenge in the forest by an increasing number of humans and the resultant disturbance and degradation of habitat. The modern concept that the wellbeing of a wildlife area must be necessity be dependent on the

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goodwill of its peripheral human inhabitants, is an inescapable one, and it is only when these villagers feel that they have benefitted by the presence of the National Park will the infinite pressures of an increasing population ease off.

The meadow land running along the southern border of the National Park may be divided into two areas separated by a thin strip of farmland about a mile in width. It is a rectangular wedge of about a mile in length and merges into the continuous farm belt further to the south. This narrow strip has a few swamps and sloughs, but due to a desultory cultivation does not act as a permanent reservoir for Swamp Deer, though after the monsoon their stentorian bugling from this area during the early hours of the morning can be heard. It is also possible that a certain traffic between the western and eastern zones thus created does take place. The western or Sathiana zone is bounded on the east and south by the Soheli, a narrow and seasonal stream. The northern boundary is the Neora river emanating from Nepal and is subject to heavy annual flooding during the rains, inundating low lying areas for a distance of three to five miles. The flood waters flow back along the dry Soheli bed whose catchment areas provide a continuous flow from after the rains to the beginning of April. At the confluence the Soheli by some strange quirk becomes the main stream and flows as the southern boundary of the Park, until beyond the Forest boundary it becomes the Sarju, before its meeting with the Sharda River near the eastern boundary of the District of Kheri.

The Sathiana zone is about 50 sq. km in area, and adjoins the preferred habitat of Ghola which would have given another 13 sq. km of habitat, had it been acquired when it was possible. Along the eastern edge of this zone there is a railway embankment and also a road embankment which considerably aggravate the flood situation in the area. The river Neora flows along the base of the main escarpment which forms the plateau on which grows the main timber tree of the locality namely sal (*Shorea robusta*). The flooding therefore takes place to the south and the rising waters are liable to drive the Swamp Deer towards cultivation. There does not seem to be any remedy for this annual condition and there is no doubt that a certain number of deer are killed by human agency or drowned during heavy floods. Moreover the main fawning period appears to be from May to July, and it is credible that the fawn population is specially vulnerable and that this is instrumental in partially inhibiting a population growth. This aspect is worthy of further study. Bugling may be heard from September onwards, and the main rut would appear to be about Nov.-Dec. Stray bugling may however be heard as late as February. The rut probably takes place mainly outside the Park boundaries as large herds may be observed returning from the direction of cultivated areas in January and February, when the tall grasses start being burnt. Initially they remain near the southern boundary and move towards cultivation in the late evening. Later as the grasses are burnt they move further towards the centre of the Park meadow, where they remain till the beginning of the monsoon. With the pre-monsoon showers, numbers of stinging flies make their appearance and initially a number of animals seek shelter in the higher level forests, but though it is possible that a few of these

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animals do remain in the forest, the majority return to the meadow once the flies have subsided about the middle of July.

5. PREDATION AND FIRE

The tiger is the main predator and it is undoubtedly true that the Swamp Deer forms the main diet of the tigers, especially the males, in the area. Living close to the thicker grass of the meadow which form the habitat of tigers, their habit of milling around these thick grass areas when alarmed causes them to fall an easy prey. Also being the largest and visibly most prolific deer of the park, the impact of predation is more selective for the tigers. Tigresses seem to have a preference for the smaller hog deer and chital. Despite the heavy predation the main herds visually appear to be increasing but it will need a number of annual censuses to determine whether this apparent trend is correct. Forage is plentiful but the soil is agriculturally poor and coarse grasses predominate. No scientific habitat survey has been carried out, but species such as *Saccharum spontaneum, Themeda triandra, Imperata cylindrica* and *Vertiveria zizanioides* have been identified. The practical and controlled use of fire in the Park needs further study. Although it is a truism that the use of fire is liable to degrade the forage quality of grassy areas, these lands are annually flooded by the Neora-Soheli river, and it is probable that silt deposits adequately compensate the loss suffered by the topsoil in the annual burns. Moreover the Swamp Deer only start moving in from unsafe cultivated areas in large numbers once the thick grass is burnt, and I am therefore of the opinion that an early controlled and possibly induced burning is essential (1) for attracting the deer into the Park as soon as possible, (2) for providing them with a possible forage alternative to young crops and (3) for the viewing purposes of controlled tourism (I am convinced that in the long run it is only international Tourism which will save wildlife). During a count conducted in April 1975, an estimate of 1000–1200 deer was made. The available area is about 50 sq. km and another possible 25 sq. km is available outside the Park, in depressions and stands of sugarcane crops, as marginal and temporary refuges. A scientific study of the ecology, population dynamics, and movements of the Swamp Deer would in my opinion form a rewarding exercise in its future preservation.

6. EASTERN ZONE

The Kakraha or eastern zone comprises the remainder of the grassland area of the Park and is about 100–130 sp. km in area. Whereas colonization by the deer of the Sathiana area commenced in 1963–64, heavy grazing by domestic stock inhibited a similar development in Kakraha and in 1973 a count revealed only a small group of 16 deer. Thereafter thanks to control of grazing pressure an estimate of 150–200 animals was made in 1974 and a count in 1975 revealed the presence of 276 animals. The soil is agriculturally more fertile than the Sathiana zone and apart from the Soheli river water, swampy areas are always available in the Kakraha lakes system. The fact that

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they were not colonized until very recently by the deer was undoubtedly due to the heavy utilization by cattle and intrusion by humans. The phenomenal increase from 16 in 1973 to 175 in 1974 to 276 in 1975 is undoubtedly due to migration from different areas of the Park. As I mentioned earlier, immigration is also possible from the Sathiana zone. In addition, as the Soheli forms the southern boundary of the Park, the seasonal flooding takes place towards the escarpment and the centre of the Park, and the rising waters tend to push the deer into the forest. They therefore make much greater use of the forest than their western counterparts. The animals thus displaced return to the southern meadow from the forest the same way as the Sathiana herds return from cultivated areas, and in larger numbers once the disturbance from stock grazing has diminished.

It is Holloway's opinion that the Sathiana zone may conceivably have reached the optimum number of animals that the area can support. This view does not apply to the Kakraha zone which is at a preliminary expansionist stage, and once a stable habitat is assured there is room for a considerable increase. The soil is agriculturally more fertile and a comparison of the graining of dropped antlers between east and west zones, reveals a more prominent graining in those of the eastern animals. Though the general condition of deer from both areas was excellent, the fawn ratio appears to be more favourable in the Kakraha animals. The impact of flooding is less severe as there are no embankments to cause excessive waterlogging and as the seasonal migration is towards the high forest where presumably the main rut takes place, destruction by human predation and drowning does not occur to any notable extent. The tiger is the main predator, but like all natural predation does not appear to exercise any visibly depressive effect, and the area is undoubtedly a much more favourable one than its western counterpart. Flood waters as a natural hazard cannot be eliminated, but have been minimized by a favourable trend which drives the animals away from human cultivation and occupancy. Nevertheless, human intrusion and heavy competition from domestic stock will have to be contained if further expansion is to take place.

Swamp Deer are only visible up to the main Kakraha lake and are confined to an area of about 25–40 sq. km. Outside of that there are no deer, although suitable habitat is available from Salukapur to Kusumbha and to the west and east of the Fort Forest Rest House. The west has large expanses of grassland, and the Chhotta Kakraha lake system along part of the escarpment. The reason for the lack of Swamp Deer is the persistent grazing which continues inspite of efforts by the local staff to restrain it. Nan Tal lying to the east north east of the Rest House, a large lake bordering cultivation and distinguished by its growth of wild rice, is visited by the deer at night. During the day they retreat to Nagra Tal, another small lake which had lost its Swamp Deer due to human disturbance, but appears to have staged a limited comeback since the declaration of the Park in 1976. Other isolated pockets mainly consisting of seasonal lakes have small deer populations, namely Bhadi Tal, Naknaha Tal, Ranwas Tal and Churaila Tal in the Bellraein Forest Range and Banke Tal in the Sonaripur Range. However, water dries out after

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the middle of April, and the best chances for survival of these limited populations is the hope that the southern meadow will be able to accommodate them in the future, though they will no doubt be used as rutting areas during the early post monsoon season.

7. CONCLUSIONS

It is probable that of the four existing and viable areas where the Swamp Deer are found in the Indo-Nepal region, the Dudhwa National Park offers the best prospect for preservation and expansion; in Kaziranga, though fully protected, they do not seem to increase in numbers to any considerable extent, and it may be that the devastating floods in the Brahmaputra inhibit any further expansion of available habitat. Sukla Phanta is still a hunting reserve for the King of Nepal, and in 1975, the Iranian Crown Prince, as a State guest, came to collect specimens of Swamp Deer. Poaching is also undoubtedly another adverse factor.

The IUCN/WWF should spearhead a programme of international cooperation between Governments concerned, for tigers shot in Nepal have died in India and international "red-tapism" has maintained the status quo of the three little monkeys! The boundary between the Nepalese Reserve of Sukla Phanta and the Indian Reserved Forest of the Pilibhit Forest Division is Sharda River. Curiously enough a small loop in the river places a strip of Indian grassland in physical juxtaposition to the Swamp Deer Reserve. The Indian Government has sanctioned the settlement of landless persons on this strip. A perfect setting for international poaching and international non-cooperation!

No scientific study of Swamp Deer and its ecology has been undertaken so far, and I consider that the time is now ready for such an assessment. This deer is now established as one of the major ungulates of the Park, and populations are at an expansionist stage. At the same time legal protection is absolute, and it now requires a balanced study to make recommendations for long term conservation. Wildlife and forest have hitherto been state subjects, but through legislation during the much maligned emergency, they have been brought on to the concurrent list as a central subject. Unless this favourable legislation is reversed, which I hope will not be the case, the Central Government will exercise control of specific projects through the Directorate of Forests and Wildlife, through the allotment of funds, and through the Indian Board of Wildlife which is a quasi-official body with the finance minister as its present Chairman. The State Government though considerably influenced by political pressures is amenable to recommendations which do not seriously impinge on human right and with the Wildlife Act specifically laying down that National Parks will remain immune to ecological disturbances, there is no reason why a scientific assessment backed by recommendations from the central Government cannot be effectively implemented.

The appointed scientist will no doubt establish his own study priorities but I would suggest his assessment would relate to two diverse problems. The

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Western zone would require the study of the impact of the monsoon on population dynamics, on seasonal migrations, on fawning and on the quality of forage. The stability of the population, the likelyhood of having reached an optimum level and the possibility of an exchange in population with the Eastern zone are other points demanding attention. The Kakraha zone would have a different set of problems centred upon the adverse impact of grazing. The possibility of further immigration, once grazing by domestic stock has been virtually eliminated, and the impact of the enforced exodus into the forest during the seasonal rains on foraging habits, are the other topics needing investigation. In fact, to what extent does a forest existence encourage browsing and possibly better forage condition? What is the limiting factor which prevents the Kakraha deer from colonizing the eastern limit of the Park, and what further measures can be undertaken to enable them to do so? Consideration of these questions should finally lead to an integrated recommendation covering the protective and management principles involved.

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PART I: THE IUCN THREATENED DEER PROGRAMME
3. SPECIES OF WHICH SOME POPULATIONS, AT LEAST, ARE RECOVERING OR HAVE RECOVERED

Decline and restoration success of the Central Indian barasinga *Cervus duvauceli branderi*

H.S. PANWAR

ABSTRACT

The *branderi* barasinga had a wide distribution in Central Indian highlands until the last century. Its tenacious dependence on grasslands, which increasingly came under cultivation and ravage by stock-grazing, together with poaching caused its progressive decline until only 66 were left in their last resort in Kanha National Park. Even in Kanha in the available limited habitat the population was under excessive predation from an abnormally high tiger-congregation resulting from inadvertent artificial inducement.

Restorative measure were initiated from 1969 and those included normal-



Figure 1. Adult Central Indian barasinga *Cervus duvauceli branderi* stag.

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izing the tiger density by withdrawal of atificial inducement, stoppage of grazing and forestry operations, relocation of villages, anti-poaching and water development. The Park area was increased from 318 sq. km to 940 sq. km. The response has been a steady improvement in environmental conditions and a high growth-rate for barasinga.

The paper also reviews the studies carried out by Schaller and Martin together with the concurrent and on-going investigations by Park management. Efficacy of management and degree of response are evaluated.

The scope for the barasinga in the additional habitat within the Park and the prospects for its re-introduction in other sanctuaries in the central Indian highlands are discussed.

1. INTRODUCTION

1.1. The barasinga of the sub-Himalayan Terai and that of the Central Indian belong to the same species viz. *Cervus duvauceli.* Due largely to widely differing habitats, and also because of some morphological differences, the two populations have been recognised as separate sub-species. The Terai animal living exclusively in swampy grasslands is the nominate sub-species *Cervus duvauceli duvauceli*, whereas the central Indian type inhabiting the hard ground grassy openings and glades in deciduous forests has been designated as *Cervus duvauceli branderi.*

1.2. The *branderi* barasinga with which this paper is concerned had a wide distribution running east-west across the central chain of Vindhyan and Satpura ranges – the central Indian highlands (Forsyth 1889). From Hoshangebad in the west it was found eastwards in Chhindwara, Seoni, Balaghat, Mandla, Durg, Bilaspur, Raipur and Bastar districts of Madhya Pradesh, Bhandara and Chanda districts of Maharashtra and areas in Bihar and Orissa contiguous with bordering tracts harbouring this animal in Madhya Pradesh. Brander (1923) who was a Forest Officer in the erstwhile Central Provinces from the beginning of the century until the 1920s, reported fast shrinking in the habitat for barasinga and a drastic progressive reduction in its population. The decline continued at an accelerating pace and by the year 1970 a mere 66 head were left and that too in a single congregation in Kanha National Park – their last resort. Even as scepticism about the survival of the sub-species heightened, special conservation measures were initiated in the Park in 1969, which have put the barasinga back on an assured path of recovery, the population in July 1977 having risen to at least 283.

1.3. The object of this paper is to review the causes of decline in the light of past and the ongoing research, to enumerate the restoration measures, evaluate their efficacy by analysing responsive recovery both of the habitat and of the threatened species, and thus to evolve prognostic suggestions for the future.

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2. CAUSES OF DECLINE

2.1. The tenacious dependence of the barasinga on the grassland habitat has been indisputably established (Brander 1923; Schaller 1967; Panwar 1972; Martin 1975). Their breeding, food and also self-preservation are inevitably linked with the 'open areas'. Man and his traditional companions, the cattle, are also ecologically tagged with the open areas. Thus even if most of the large grassy clearings in the central Indian highlands are traceable to past human activity e.g. pasturing, shifting cultivation and settlements razed by sweeping epidemics, it is the later reversion of these very activities with a high and progressive momentum that spelled jeopardy for the barasinga. Mounting pressures from burgeoning populations of man and cattle took toll of the grassland habitat by way of expansive agriculture and exhaustive grazing. The open areas being the common activity centre for both man and barasinga, the latter also faced acute eliminative hunting/poaching pressures from the former. The rapid decline of the barasinga since the turn of the century is thus due to this progressive shrinking of habitat and the eliminative pressures.

2.2. Realising the jeopardy, a complete ban on licensed hunting of barasinga was imposed in 1954, but the control over poaching being inadequate this could not induce any improvement.

2.3. Chronology and causes of decline in Kanha: The area comprising the entire 1970 range of Barasinga in Kanha National Park has been a sanctuary since 1933, and has without any doubt enjoyed much better protection compared to other areas. Yet barasinga, over 3000 in 1938 dwindled to a meagre 66 in 1970. During the same period the chital (*Axis axis*) registered a gain from 2,800 to over 4,000. Schaller (1967) attributed the barasinga decline to "low fawn production, probably caused by the disease brucellosis, coupled with heavy predation by man and the tiger on the adult segment of the population".

2.3.1. While marginal losses to poaching cannot be ruled out, a steady decline in barasinga numbers over the last 30 years as opposed to a simultaneous steady gain in the status of chital cannot be explained thus, for poaching should normally affect both the species adversely. As for the disease brucellosis, even this supposed cause must affect all ungulate species to some degree or the other. However, the field observations during the period of Schaller's study, and also later, establish that the fawning rates among chital, sambar (*Cervus unicolor*) and black buck (*Antilope cervicapra*) have been quite satisfactory. This fact militates against the hypothesis of the disease singling out the barasinga.

2.3.3. Other conditions being equal, one must then look for some habitat adversity specific to the barasinga. Habitat deterioration factors rendering a large part of the earlier range unsuitable for the barasinga, appeared as the

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likely adversity in view of the fact that barasinga had disappeared from Kopedabri and Sonf which were 'the best spots perhaps' in 1912 (Mandla District Gazetteer 1912, quoted by Schaller, 1967). Up to 1968–69, Kopedabri, across the ridge on the south-west of Kanha, was under heavy grazing pressure from cattle, and Sonf, in the northern continuation of the Kanha Valley, was under a growing village settlement. The *maidans* Bhapsa Bahra, Bandri Bahra, Parsatola and Urnakhero lying in between Kanha and Sonf at the same time were subject to heavy cattle grazing (Panwar 1972). This ravage affecting most parts of the earlier home range resulted in a sharp decline in the availability of suitable habitat.

2.3.3. Since 1902–3, when Brander gave a cool-season burn to the central Kanha meadows, the practice of annual cool-season burning of the meadows had been in vogue until 1971. This early burning of the meadows was practised with the primary objective of obviating fire-hazard during summer. The operation was carried out in December-January every year when grass dried up because of frost. There still being plenty of moisture in the soil, this induced the rhizomes to put on green shoots soon after the burning and these shoots attracted ungulates in large numbers. The grazing pressure on the burnt meadows was maintained until the next monsoon. The result was that the rhizome vigour was sapped by the continuing production of the green shoots which themselves were not allowed to grow and rebuild the rhizomes through photosynthetic activity. Thus more palatable perennial grasses progressively disappeared from the central meadows, where grazing pressure was the heaviest. Similarly fire-tender annuals also suffered from destruction of seed by fire. This adversity affected the barasinga the most, whose sustaining grasses were wiped out over large areas (Panwar 1972).

2.3.4. As a result of cattle grazing in the northern part of the home range and annual burning in the southern part, the grass height even towards the end of the growth season (July to October) kept low. Tall grass areas are essential as fawning sites for the barasinga and lack of such areas resulted in high fawn mortality due to infant predation. Schaller's contention (1967) that low reproductive success could be due to brucellosis was not borne out. Analysis of blood samples from cattle of the area and from the carnivore kills of chital and barasinga, did not suggest the presence of the *brucella* parasite that causes the disease. Later substantial improvement in the breeding success in response to improved environmental conditions also dispels the contention.

2.3.5. Baiting for tigers has been practised in Kanha since 1961 and perhaps even earlier, in order to improve the chances of sighting a tiger by tourists. The frequency was however both low and irregular. By late 1964, baiting by individuals and by the Forest Department increased considerably and also became regular, there being two baiting sites within a kilometer of one another in the central meadows. This caused 8 tigers living in the central part of the Park (2 tigresses respectively with 3 and 2 cubs and a male), to become more or less sedentary in a small area of 15 sq.km of the central meadow complex

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containing most of the total barasinga habitat then available. As the sedetanry tigers preyed upon the free-ranging wild ungulates in the area in order to make up their food-supply, the barasinga, for whom this was the only habitat, came under abnormally high pressure of predation. At least 16 barasinga were killed by the tigers in 1964 (Schaller 1967) and although a much larger number of chital was also killed, the incidence on the barasinga was too great to be borne by a meagre population of about a hundred head. That this adversity was brought about by a purely artificial factor, could not be detected until 1969, and the decline of the barasinga continued steadily. The conclusion drawn by Schaller (1967) that the barasinga were under excessive predation from tiger was apparently without awareness of this artificial circumstance. That under normal distribution of the tiger, without such artificial inducement, the predation incidence on barasinga or other deer is not decimating has been established from later observations (Panwar 1972; Martin 1975). When the baiting site was shifted about a kilometer inside the woodland area north of Kanha in April 1969, it had immediate favourable effect and in 1970–71, only 3 barasinga kills by tiger were observed (Panwar, 1972). During April 1971 to March 1973, again only 3 barasinga kills by tiger could be found (Martin 1975).

2.3.6. Drying up of stray perennial pools in stream beds due to silting caused by soil erosion induced by heavy cattle grazing and cultivation of fragile marginal lands, also rendered some parts of the earlier (prior to the 1920s) habitat inhospitable for the barasinga, at least seasonally.

2.3.7. It would seem that even in the relatively far more secure area such as the Kanha National Park – a sanctuary since 1933 and a national park since 1955 – the barasinga suffered from the same jeopardy i.e. deprivation of suitable grassland habitat. Even though the cause – annual burning followed by heavy wild ungulate grazing – was different, the end result was the same. Progressively thus depleted, the small remnant population confined to the small remnant home range in the central Kanha meadows, came under excessive predation by an extra-normal congregation of tiger, which – inadvertence notwithstanding – was artificially induced.

3. RESTORATIVE MEASURES

3.1. Schaller's unique work, "The Deer and the Tiger" (1967) focussed world attention on the precarious condition of the barasinga in general and that of the *branderi* subspecies in particular. Strong pleas were made in the 1969 conference of the IUCN at New Delhi to organise a resolute programme to save the Kanha barasinga, facing imminent extinction.

3.2. Measures: Special rehabilitational efforts were initiated by the Park Management from early 1969 for combating the adversities inferred from field observations and the indications provided by Schaller's study. These are enumerated below:-

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3.2.1. Shifting of tiger-baiting site: This has already been described in 2.3.5 above.

3.2.2. Release of additional habitat: The basic approach in this direction was the elimination of human intrusion and disturbance from areas situated contiguous with the existing home range and forming part of the earlier range of the barasinga. Accordingly in 1969, grazing by cattle was stopped in the Bandri Bahra, Bhapsa Bahra, Parsatola and Urnakhero chain of meadows on the north of Kanha. The village of Sonf situated further north was also evacuated and relocated outside the Park in the same year (see map). This proved to be the most crucial measure in that it released an additional grassland habitat of over 1,000 hectares in extent, which is nearly equal to the total habitat then available in the Kanha meadows. Moreover the elimination of cattle grazing promoted excellent growth of grass during rains, affording extensive tall grass areas ideal for fawning, alongside the streams traversing these open areas. The meadows were colonised by chital and barasinga in 1970 and the evacuated village site of Sonf reported the first barasinga arrivals in 1971. The barasinga started using these meadows and Sonf for fawning from 1971 onwards.



Figure 2. Meadows before evacuation of Sonf village

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Figure 3. Meadows after evacuation of Sonf village

3.2.3. Construction of water bodies: Clearance of forests for cultivation and compaction of soil due to trampling by cattle impoverished the moisture regime. Similarly cultivation of marginal lands and denudation of grass cover in the upper sloping valleys due to overgrazing by cattle, caused soil erosion and the silting up of rare perennial pools. In order to obviate this adverse trend construction of water bodies was initiated. In 1969, a small dam was constructed at Kanha and another in Sonf in 1970. This improved the perennial availability of water both on the upstream side (storage) and the downstream side (seepage). The availability of green grass fodder along the stream beds was also proportionately enhanced. The programme has been continued in subsequent years and has certainly helped disperse wild ungulate densities over a wider area during the dry months; and the pressure on the Kanha meadows, where the only perennial water supply was largely concentrated earlier, has been eased.

3.2.4. Stoppage of annual early burning: Adverse effects of annual cool-season burning have been discussed in 2.3.3 above. In order to assess these effects more precisely part of the meadow was not given a wholescale winter burn in 1971–72. Alternating 20 meter-wide strips were burnt, the intervening strips unburnt. A qualitative examination next year indicated better

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growth in unburnt areas (Martin 1975). The dry grass in the unburnt areas also apparently provided a substantially higher supply of fodder as compared to burnt areas during the summer, when because of low soil moisture green grass was scarce. Accordingly since 1972–73, the practice of annual burning has been given up in the regressive central meadows, and instead only fire-breaks are cleared and burnt to create blocks insulated from fire against one another.

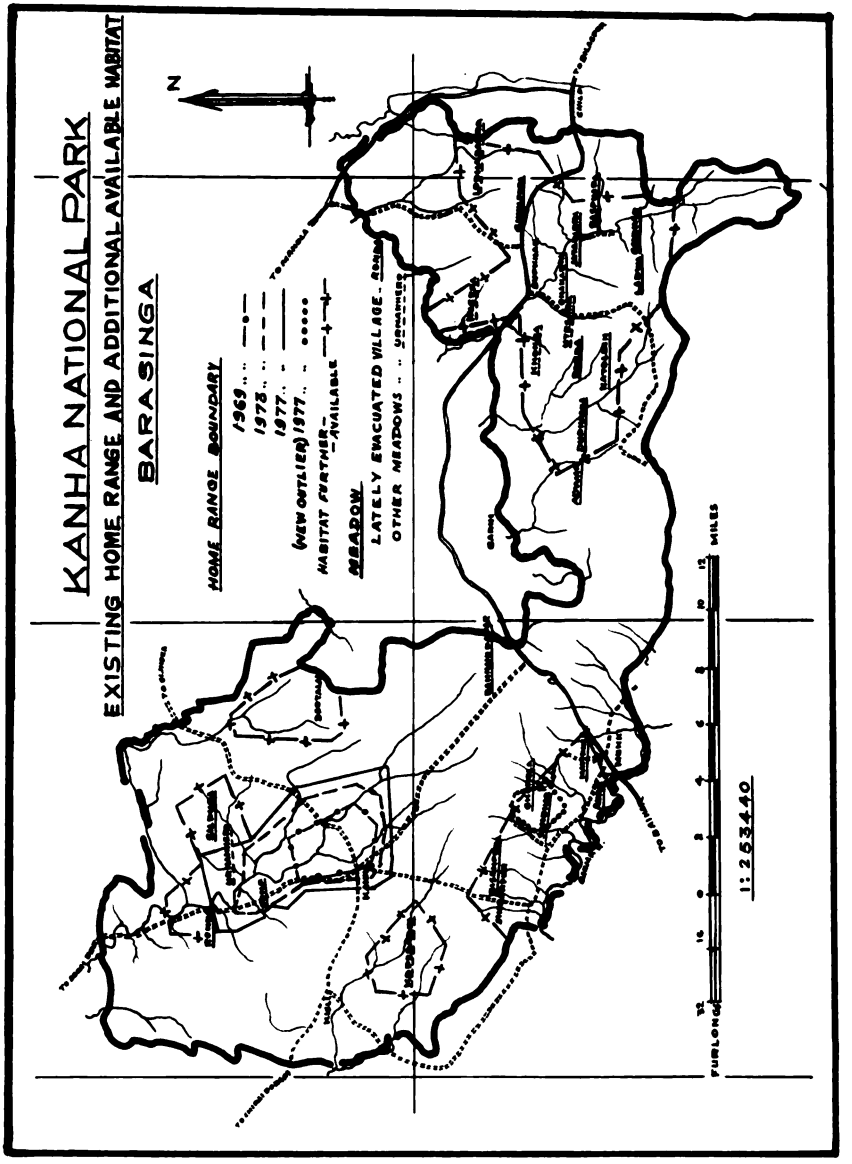
3.2.5. Anti-poaching: The breeding areas of the barasinga have been brought under intensive anti-poaching patrols during the rains since 1969, based on out-station patrol camps. With the creation of an independent whole time unit for the management of the Park in 1972, with considerable additional staff, a very firm control has become effective (Martin 1975).

3.2.6. Martin's study: While the efforts initiated in 1969 were underway, in March 1971, Claude Martin, from the University of Zurich, took up an intensive two year study on the status and ecology of the barasinga in Kanha, with a WWF grant under the SSC/IUCN Threatened Deer Programme. His work "Status and Ecology of the Barasinga in Kanha National Park" is an excellent and exhaustive treatise on the subject. Martin's study, as mentioned earlier and to be further discussed, proved that the efforts initiated from 1969 onwards, some of them during the early part of his stay in Kanha, were in the right direction.

3.2.7. Fall in incidence of predation: In response to favourable environmental conditions over a much enlarged habitat, the dispersal of the barasinga population occured as was expected. This situation, after the initial relief from excessive predation pressure brought about by the relocation of the baiting site, has been responsible for bringing down the predation to normal levels.

3.2.8. Further measures: The Park was extended in 1970 to include the Mukki valley in the south (see map), increasing the area from 318 sq. km to 446 sq. km. In 1974, under Project Tiger a large part of the upper Halon valley (Supkhar) to the east was added to the Park, under sanctuary status, and later merged statutorily with the Park, raising its total area to 940 sq. km. Forestry operations over the entire area have been given up; all cattle camps have been moved out; and grazing by cattle of outside villages have been stopped. Since 1971, these measures have brought down the incidence of cattle grazing by about 25,000 head. A programme with a target to relocate 17 villages outside the park was initiated in 1974–75, but by June 1977, 20 villages in all had already been moved out. Judicious addition of water facilities by way of construction of small dams, earthen bund tanks, development of seepage springs, and desilting of dried up pools, has been undertaken on a well distributed pattern. Fire protection effort in the entire Park area has become far more effective with the addition of wireless equipment and vehicles. Establishment of a string of out-station patrol camps and road check-posts has also become possible by substantial staff additions. This and

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Map 1.

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the availability of vehicles have tremendously improved the anti-poaching control.

3.2.9. The Halon valley, added to the Park in 1974, was a strong-hold of the barasinga in the past (Forsyth 1889), but on account of lack of protection and ravage of habitat the species had become extinct. Now, thanks to a better water supply and the availability of a large extent of grasslands, the new area is potentially a better habitat for the barasinga than the present range in the Kanha valley. Pockets of suitable barasinga habitat in the new area are shown on the Map.

4. RESPONSE TO MEASURES

4.1. Enlargement of and improvement in habitat: Based on his two year study (1971–73), Martin (1975) gives a detailed account of the extension in the home range and the improvement in habitat conditions. He has analysed the habitat conditions and evaluated these *vis-à-vis* barasinga requirements inferred from ethological investigations. He has concluded that, "more favourable environmental conditions were brought about by the increase in suitable habitat . . . and the ban of human and cattle activities from the northern part of the population's home range in 1969. Subsequent fire-management, anti-poaching control, and improvement of water conditions added to the suitability of available grassland habitat". Since 1973, the Park area has more than doubled and now includes the potentially better habitat provided by the upper Halon valley.

4.2. Response to favourable environmental conditions: The improved range conditions, enlargement of suitable habitat, including availability of additional safe fawning areas, better distributed water availability, the relief from extra-normal pressure of predation by tigers, provided initially by relocation of the baiting site and subsequently on a durable basis by dispersal of the population in the enlarged habitat, and effective general protection have all provided highly favourable environmental conditions for the barasinga. The response has been in the form of a higher reproductive success accompanied by tapering off of the predation pressure to normal levels and low fawn mortality. In consequence the population has been steadily increasing since 1971. This is evident from the following. The total population in 1970 was the lowest ever and stood at just 66 and Table 1 illustrates the increase.

4.2.1. The Table figures are from the annual census conducted by the Park management. Special care is taken in the barasinga count which is done by only the senior park staff. Each individual group, after initial location by staff, is verified by officers. The figures thus stand for the minimum population based on actual simultaneous sightings. It is conceded that there are some apparent anomalies in the figures, such as the abnormal male – female ratio in 1973, and the population-increase in 1976 exceeding the 1975 population by a number higher than the number of recorded fawns in 1976.

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Table 1. **Barasinga Census Results 1971–77 – Kanha National Park**

Year	Male	Female	Fawn	Total	No. of fawns per 100 of total population	No. of fawns per 100 of females	No. of males per 100 females
1971	32	44	12	88	13.6	27.3	72.7
1972	31	44	21	96	21.9	47.7	70.5
1973	35	61	22	118	18.6	36.1	57.4
1974	49	66	23	138	16.7	34.5	74.2
1975	54	76	35	165	21.2	46.0	71.0
1976	74	94	47	215	21.9	50.0	78.7
1977	93	122	68	283	31.6	55.7	76.2

These obviously arise from the fact that some groups or individuals were missed altogether, and this means that the real population stood higher than the census figures, although the difference may not be very great. This is quite in conformity with Martin's interpretation (1975). He has made assumptions of the real number of individuals in a given sex and age class on the basis of the maximum number recorded at any time of the year during the course of his field observations, in order to be able to compute the 'assumptive real population'. This computed population thus invariably exceeded the census figures. It would also be desirable to rationalize the above census figures by similar computations, but this cannot be done in absence of year-round observations of the actual maximum numbers in different sex and age classes. Nevertheless the census figures given above provide a sound basis for evaluation of the response of the population to the changed favourable habitat conditions.

4.3 Home-range extension and range-outlier: The map (page 151) compares the home ranges as they occurred in 1969, 1973 and 1977. The most encouraging feature is the inquisitive response lately shown by barasinga to the additional habitat available. The Mukki Valley has about the same elevation (600 to 650 above MSL) as the Kanha Valley but is separated by a ridge (750 to 925 m above MSL) with thickly forested sprawling slopes on either side. The Mukki valley was added to the Park in 1970, but Park management there only became effective in 1972. All the five villages in Mukki valley were relocated outside the Park in June 1975. The appearance of barasinga in two of the evacuated villages, Sondhar and Ghorella, in Sept.–Oct. 1975 was as much surprising as it was encouraging, because although such a movement was foreseen it was never anticipated that crossing of the formidable southern ridge and the forest-belt would occur so soon. Four barasinga were seen at the dated mentioned but subsequently there were no sightings, until in February to June 1977, a group of 4 barasinga again stayed in the area. This sedentary behaviour suggests the establishment of an outlier home-sub-range as the initial step towards mass colonization. As against this, the earlier movements in 1970–71, observed in the downward northern continuation of

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the Kanha valley following evacuation of Sonf village and stoppage of grazing in the Urnakhero meadows, were very much expected. Inquisitive response of the barasinga was confirmed again in October 1976, when 5 barasinga were observed in Silpura village-site evacuated in June 1976. This site is situated on an intermediate plateau (725 m above MSL) with the thickly forested slopes separating it from Sonf-Urnakhero meadow-complex (575 m above MSL).

4.4. Up to and including 1973, rutting activity was confined to the Kanha meadows but in 1974, a small herd of 8–10 animals stayed in Sonf and rutted there. The breaking up in smaller herds and occupation of different meadows by such groups during the rut has since progressively increased. Although Kanha meadows still had nearly half the population during the rut in December 1976–January 1977, the other sites besides Sonf where rutting groups were seen were the Urnakhero – Parsatola chain of meadows. Schaller (1976) presumed such a breaking up of rutting herds for a larger population on the basis of the writings of some earlier authors and the reports of some hunters. This feature is also suggestive of a favourable response.

5. EVALUATION

5.1. Evaluation of the present overall situation is relevant in order to be able to assess the efficacy of the present management and for formulating its future course. Three questions need to be answered in this context:

(i) Are range conditions satisfactory and do they have an assured future?
(ii) Is the growth rate of barasinga population satisfactory?
(iii) Are there any inter-specific competitions and what is the overall impact on the habitat conditions?

5.2 **Range conditions**: There has been considerable improvement in range conditions as a result of elimination of the decimating factors – human use, cattle grazing and rampant fires. The height of grass cover has gone up substantially and so has the quantiative fodder production. The regressive Kanha meadows, deprived of better perennial grasses on account of repeated annual burning (see para 2.3.3) in the past, on the one hand show a moderate improvement *vis-à-vis* barasinga in the species-composition of grass flora after five years of effective fire control, but on the other hand there are indications of 'scouting' by hardy pioneering tree species in the grassland. In the grass flora there is an apparent increase in the proportion of *Saccharum spontaneum* but the remnant clumps of *Themeda triandra*, although spared from being wiped out are not allowed to develop because of grazing pressure from a high density of wild ungulates. Appearance of seedlings and saplings of *Butea monosperma, Lagerstroemia parviflora* and *Terminalia tomentosa* suggests the onset of the process of advance of woodland on grassland. This process is to be expected when one considers the ecological status of the large grassy blanks in the valleys dominated by sal (*Shorea robusta*) forests in this tract

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(Panwar 1972). It must however be agreed that the perpetuation of grassy blanks is necessary to maintain the fodder productivity, not only for the barasinga but also for the entire herbivore complex. This calls for the evolution of a pragmatic regime of periodic burning which would on the one hand forestall deterioration of grass flora as a result of repeated annual burning and on the other prevent advance of woodland. Burning once in two for better and once in three years for regressive meadows, can be a reasonable regime, but this needs to be verified by field trials.

5.3 Growth rate of population: As concluded by Martin (1975) the reproductive success of the barasinga was highly satisfactory in 1971–73, the overall increase being about 20% and the fawn rate being higher than 30 per hundred hinds. From Table 1, it can be seen that after 1973, there has been a further progressive increase in the reproductive success particularly from 1974–75, when the overall growth has been more than 21% (21.2%, 21.9% and 31.6% respectively) and the fawn-rate has been more than 45 per 100 hinds (46, 50 and 55.7 respectively). The sudden spurt in the overall growth from 21.9% in 1975–76 to 31.6% in 1976–77 is explained by the possibility of some leftovers in the fawn class during the 1976 census, and it is evident that the actual overall growth rate for 1975–76 was higher than that seen in the census figures. As censuses were conducted in late June or early July, i.e. nearly 9 months after the fawning period, it can be concluded from the high fawn-rate that the fawn-mortality is really low. For monoestrous deer the growth rate (over 20%) and the fawn rate (over 45%) are near maximum (Martin, 1975). As clearly stated the pressure of predation has tapered off down to normal levels.

5.4 Interspecific competitions and habitat condition: The population trends of all the important herbivores in the Park are upwards, as would be evident from the following. The increase in chital and barasinga populations has been the highest. The number of chital is very large and of the total population of over 13,000 nearly 10,000 live only in the Kanha valley, which comprises the entire present range of the barasinga. Martin (1975) recognises the presence of 'competitive exploitation of certain species by chital and barasinga' during the cool-dry season at the time of 'food shortage in the Kanha Meadow after extensive burns have taken place'. Stoppage of annual burning of meadows and effective fire control have obviated the food shortage, though the availability of green forage inevitably is low during summer. Martin in his assessment of this competition did not, however, imply any detriment to the habitat. In fact even heavy composite utilization by all species during the cool-dry season cannot be harmful to the range conditions if the grasses have not been burnt, but the same phenomenon during the growing season can be harmful.

5.4.1. During the early growing season (late June and most of July) chital congregate in great numbers in the larger meadows in the Kanha valley. The barasinga also persist in these meadows and feed on new sprouts of several

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Table 2. *Census Results, Kanha National Park 1973–1976, excluding Halon Valley (Supkhar area)*

Species	1976	1975	1974	1973
Gaur	559	534	521	516
Sambar	1053	1060	981	803
Chital	13313	12320	9837	8477
Barasinga	215	165	138	118
Wild pig	1874	1373	1287	1171

grass species. Chital also graze similarly. Heavy pressure at this time may discourage the more favoured grass varieties. This aspect would be partially relevant to the regressive Kanha meadow. It is hence necessary to carry out monitoring of the range conditions in Kanha meadow. The impact of annual burning (see para 2.3.3) has been so pronounced that several of the better perennials, e.g. *Bothriochloa odorata* and *Themeda triandra,* have disappeared from large sections. On account of isolation of the regressive meadows from those in good condition having these grass species, natural restocking does not appear in sight. Since the cause of deterioration of the meadows was artificial (annual burning), the restocking by resorting to sporadic planting of rhizome clumps of the indigenous perennial grasses is being considered for the Kanha meadow, in order to provide the basis for early rehabilitation.

5.4.2. The increase in the area of the Park and the overall environmental improvement has been favourable for all the herbivores. The resultant dispersal of the other herbivore species has helped reduce competitive use. Even in the central Kanha meadows the congregations of chital were lower in 1976 than in 1975 and so also in 1977 as compared to those in 1976.

5.4.3. The barasinga habitat now stands greatly extended in Kanha and Mukki valleys with the evacuation of 8 villages. Thus there is plenty of scope within the Kanha-Mukki area for the extension in the range of barasinga beyond what has already occurred. Also the potentially richer Halon Valley already in the Park and from where 11 villages have been moved out, offers a vast additional habitat.

5.5. The answers to the questions raised in 5.1 will be:

(i) The range conditions are satisfactory and improving and can be maintained in an optimum productive stage, but only for the barasinga but for the entire herbivore complex.

(ii) Growth rate of the barasinga population is satisfactory, being near maximum for this monoestrous deer.

(iii) There are as yet no adverse inter-specific competitions except in a small area of regressive Kanha meadows. Enlargement of the Park and management aimed at general rehabilitation have progressively improved the pattern of dispersal of herbivores and have thus moderated this competitive factor, with good prospects for the evolution of an optimum use-pattern.

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6. ADVICE SOUGHT

6.1. A 28-hectare tiger and leopard proof enclosure was established in 1970 in the Kanha meadows in the typical barasinga habitat, with the object of attempting to save at least a small population of the threatened barasinga, one of the major threats supposedly (Schaller 1967) being excessive predation by tigers. Another objective of the construction of the enclosure and putting 5 barasinga in it was the relative ease it could offer to the study of behaviour of the species. The population in the enclosure has now risen to 18, after accounting for one old stag that died this year (1977). Needless to say that on the basis of the two objectives set for the enclosure, it has outlived its utility. The question now to be asked is whether this 'outlier' population, isolated for ever seven years from the main stock, if maintained in the enclosure for a few more years, can be of any use for mixing with the free ranging population later, so as to have some genetic advantage. The period of separation and the 'outlier' population being small, this question is refered for advice.

7. PROGNOSTIC PROJECTIONS

7.1. Stocking additional area in Halon Valley by translocation: The new area added to the Park within the Halon valley lies to the east of the old area in Kanha and Mukki valleys. The two segments, however, have communication through only a constricted corridor along the southern steep slopes of the main ridge system. A valley which springs from the slopes in this corridor area lies wholly outside the Park and is occupied by human habitation. Thus the corridor available is not likely to be negotiable by the barasinga and hence spontaneous colonization of the new area by barasinga, if at all it takes place, may be a very protracted process. It is therefore planned to translocate some (30 to 40) barasinga in two groups to the new area, along with chital for which there is a programme of mass-translocation of about 2,000 head for other management reasons. Pilot trials with chital have been completed and this has given confidence. Capture by corralling has been considered suitable for this operation. Capture of barasinga will be attempted only after a fair number of chital have been translocated. Introducing a mix of the free-ranging and the enclosure herd can also be considered.

7.2. Recently a large area (over 2,000 sq.km) has been declared a sanctuary for the threatened wild buffalo (*Bubalus bubalis*) in the Bastar district of Madhya Pradesh. The measures being adopted to improve conditions for the wild bufalo are bound to favour the barasinga also, because habitat requirements are similar. There were reports of sightings of barasinga in this area up till 1970, and it is not altogether unlikely that a small herd still persists there. Whether or not a herd does exist, the area will be the best candidate for translocating a small herd of the Kanha barasinga, so as to have at least an additional harbourage. An encouraging development in the State of Madya Pradesh has been the constitution of 15 sanctuaries besides the existing 3 national

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parks, all of which have been or are being brought under the exclusive wildlife wing of the State forestry department. Besides Kanha at least one other national park and five sanctuaries can offer potential harbourage for barasinga in the long term, within the range of its earlier distribution.

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PART I: THE IUCN THREATENED DEER PROGRAMME

3. SPECIES OF WHICH SOME POPULATIONS, AT LEAST, ARE RECOVERING OR HAVE RECOVERED

The present status of the Bactrian deer (*Cervus elaphus bactrianus*) in the USSR

A. BANNIKOV

ABSTRACT

The recent history of this subspecies of red deer (*Cervus elaphus bactrianus*) is given. An all time low was reached in the mid-sixties (300–400 animals). As a result of protection and active management, the population exceeded 900 in 1977. Habitat, population density, behaviour, general ecology and conservation needs are described. Joint Soviet-Afghan natural reserves are suggested.

1. DISTRIBUTION AND POPULATION

The Bactrian deer (*Cervus elaphus bactrianus* Lydekker, 1900) living amidst the desert, within a narrow strip of woody and shrubby thicket along river banks, has never been numerous. In the past, the range of this deer stretched as a band along river banks in the basins of the Amu-Darya and Syr-Darya Rivers (Fig. 1).

The history of reduction in the range and population of the Bactrian deer has been recently described by us (Bannikov and Shirnov 1971, 1973).

1.1 Range and population reduction

The intensive development of agriculture, tree and shrub felling on river banks, cattle grazing, hay making and uncontrolled hunting led to a rapid reduction in the range and population of the Bactrian deer as far back as the end of the 19th century. By the turn of the 20th century, the deer had disappeared from the Syr-Darya basin; only solitary deer were reported in remote areas of the middle reaches of this river before the 1950s (Antipin 1957).

In the mid-60s, the Bactrian deer were preserved only in natural reserves, namely the Reserve of the Aral-Paigambar Island on the Amu-Darya River (about 70 specimens) and the Tigrovaya Balka Reserve in the lower reaches of the Vakhsh River (about 250). Besides that, 12 to 15 deer lived in the Darganata area of the middle Amu-Darya, and single deer survived in the lower reaches of the Pyandzh River, east of the Tigrovaya Balka Reserve, and also in the Amu-Darya area west of this Reserve. The total population of the

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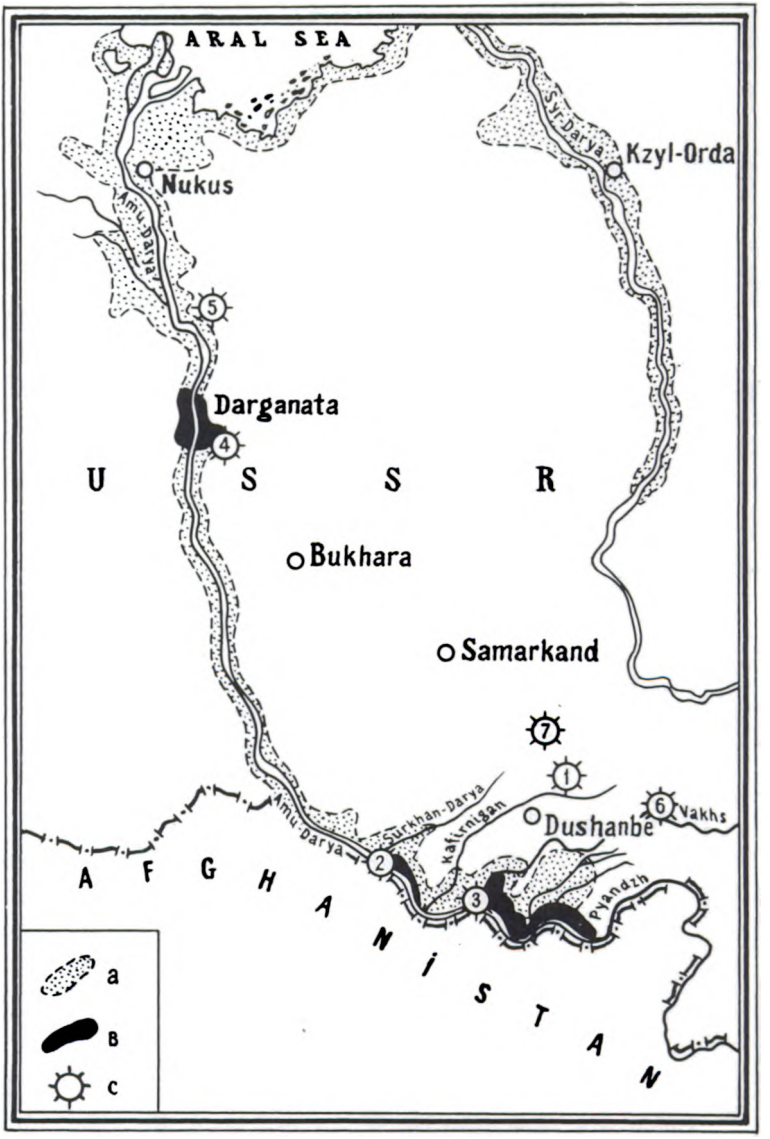


Figure 1: Distribution of Bactrian Deer
a Range at beginning of 19th century
b Range in 1976
c Reserves and sanctuaries
1. Ramit Reserve. 2. Aral-Paigambar Reserve. 3. Tigrovaya-Balka Reserve. 4. Kysylkum Reserve. 5. Badai-Tugai Reserve. 6. Sarykhosor sanctuary. 7. Kusavlisai sanctuary.

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Bactrian deer in the primary areas numbered not more than about 350 to 400 head. That seems to have been a period of the lowest population of the Bactrian deer in the U.S.S.R.

1.2 Population restoration and deer distribution

Owing to the measures taken to protect the Bactrian deer, its population began to grow continuously from the mid-60s. This process was brought about both by raising the number of the deer in various parts of their primary area and by artificial distribution of the deer (Bannikov 1972, 1977).

According to our data (Bannikov, Abdusalyamov and Sokov 1977), for example, the deer population in the natural reserve of Tigrovaya Balka on the Vakhsh River exceeded about 300 to 350 head by 1976. The deer began to migrate from there up the Pyandzh River, beyond the Vakhsh River mouth. Having joined the small populations of the deer preserved in this area, they formed large populations in some areas. The largest of these is found in the area of Kokul (about 120 head) and the area of Sayat (about 40 head). Groups of about 3 to 8 deer inhabit other areas. The total number of the deer living along the Pyandzh River is now about 240.

Thus, the total population of the Bactrian deer in the eastern part of its range has reached about 550 head.

In 1960–1961, 12 Bactrian deer were introduced into the natural reserve of Ramit situated on the southern slopes of the Gissar Ridge, and by 1976 had already increased to about 190 to 200.

The experience of introduction of the Bactrian deer to the Ramit Reserve has shown that the animals have quickly adapted themselves to mountain habitats that are quite new to them. They swam easily across the mountain rivers, moved about in the valleys and on the hillsides with ease, and readily ate the local plants. Rather safely did the deer live through the relatively snowy winters, too.

The experiment of introducing the Bactrian deer to the Ramit Reserve has shown the ecological plasticity of these animals and the possibility of their further distribution in the mountain regions. In the Ramit Reserve, however, where the sites suitable to the deer occupy only about 2500 to 3000 hectares, excessive population densities have already been formed. In this connection, capture of the deer has been undertaken here to distribute them in other places. Thus, for example, 9 Bactrian deer were brought to the Sarykhosor Sanctuary in 1972, and 13 deer to the Kusavlisai Sanctuary in 1975.

The Sarykhosor Sanctuary of about 40,000 hectares in area is situated in the upper reaches of the Shurobdarya River on the southern slopes of the Vakhsh Ridge at an altitude of about 1600 to 1800 m above sea level. The mountain slopes are covered by luxuriant woody-shrubby and herbaceous vegetation. Particularly favourable to the deer is a wide river valley locally overgrown with dense scrub and small groves.

During five years (1972–1977), the number of the deer in the Sarykhosor Sanctuary has trebled and reached 28 head. In case of an abundant snow fall, the deer are fed with hay, and also wolves are shot.

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Figure 2: Tigrovaya Balka Reserve



Figure 3: Ramit Reserve

The Kusavlisai Sanctuary, of 20,000 hectares, is situated on the northern slopes of the Turkestan Ridge at an altitude of about 2300 to 3000 m above sea level. The gentle mountain slopes are covered by juniper forests and dense scrub. The grass cover is very rich. Because of the snowy winters, however, four deer died during the two winters and only two females produced calves.

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As a result, in the summer of 1977, there were left in the Kusavlisai only nine adult deer out of the 13 imported in 1975, and only two calves were born in this year.

Thus, about 250 Bactrian deer now inhabit the mountain reserves and sanctuaries in Tajikistan.

Westward, in the natural island reserve of Aral-Paigambar on the Amu-Darya River, 4000 hectares in area, there were about 30 Bactrian deer at the time of its organization in 1962. By 1969, the deer population had reached 110 head. But the fire that spread over the island in the autumn of that year forced the deer to migrate from the island. The animals swam across the Amu-Darya in groups of 3 to 15, and kept to the desert and cotton fields for a long time. The deer numbers in the island dropped to 80 head. By 1976, however, the population had re-established itself up to the previous level (Volozheninov 1977).

Due to the organization of the natural reserve of Kyzylkum, 4000 hectares in area in the middle reaches of the Amu-Darya River, in 1971, the Bactrian deer population had increased up to 30 head by 1975. In the middle 1960s, there had been no more than 15 deer in this area (Darganat).

In 1976, two females and one male Bactrian deer were brought to the natural reserve of Badaitugai, 5000 hectares in area, in the lower reaches of the Amu-Darya River; one female produced a calf this year (Lim, 1977).

Hence, the total population of the Bactrian deer in the U.S.S.R. exceeded 900 by 1977.

2. ECOLOGY

2.1. Habitats

The Bactrian deer lives in the most extreme environments as compared with those usual to this species. Precipitation in the habitats it occupies is usually lower than 200 mm per year and the air temperature in summer often exceeds 45° C.

The band of woody and shrubby thickets along the desert rivers, the so-called "tugai", where the deer live, is about 0.5 to 1 km wide, seldom wider, and more often only 100 to 200 m.

These tugai forests are composed of poplar (*Populus pruinosa*), oleaster (*Elaeagnus* sp.), tamarisk (*Tamarix* sp.) and reed (*Phragmites communis*). The type of such woody and shrubby thickets varies in different areas and sites of the rivers, depending mainly on domination of one or another plant. Thus, for example, there can be groves consisting of almost poplar alone, unmixed tamarisk thickets, mixed forests or extensive reed areas, or else open meadows overgrown with grasses and herbs (Klyushkin 1949, 1954; Mambetshumaev 1961; Chernyshev 1958).

In winter and especially in early spring, the deer regularly come out of the tugai forests into the desert where they stay amidst haloxylon (*Haloxylon* sp.) shrubs or in the open desert.

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2.2 Population density

The Bactrian deer population density in primary natural environments, taking account of only the area that is actually used by the animals, is found to be 20 to 25 deer per 1000 hectares in the Tigrovaya Balka Reserve and 35 to 40 per 1000 hectares in the Aral-Paigambar Reserve.

The deer introduced to the Ramit Reserve in the mountains make up a population density of about 60 to 65 specimens per 1000 hectares. An overpopulation is observed here, which is testified by the suppressed vegetation in the places where the animals feed.

2.3. Migrations

Under favourable conditions, the Bactrian deer leads a settled life, keeping to permanent sites. Migration of the deer is observed only during major spring and summer river floods, when the animals leave the flooded sites.

Other non-periodical migrations of the deer are caused by fires during which the deer can move as far as 10 or 15 km away from their permanent habitats. For example, in the lower reaches of the Pyandzh River, migrations of the deer from Afghanistan to the U.S.S.R. were recorded in autumn almost every year during the period of reed burning. The fire on the Aral-Paigambar Island in 1969 caused migration of a considerable part of the population of the island to the right bank of the river. The deer are good swimmers and they easily overcome such wide and rapid rivers as the Amu-Darya and the Pyandzh.

Rare cases are known of single deer specimens migrating over long distances. For example, two deer were reported in the lower Amu-Darya area after heavy snow falls in 1964; they are believed to have covered a distance of over 300 km (Mambetzhumaev 1967).

Rather regular seasonal migrations of the Bactrian deer are known to have occurred in the 19th century: part of the population left the tugai forests of the Syr-Darya area for the *Haloxylon* deserts in winter, returning in summer (Bobrinsky 1933).

2.4. Daily movements

The Bactrian deer in different areas, depending on the season, cover distances from several hundreds of metres to 2 or 3 kilometres during twenty-four hours in search of food. And, as distinct from the northern subspecies, the Bactrian deer's daily movements are usually shorter in summer than in winter.

In the Tigrovaya Balka and Aral-Paigambar Reserves, with abundant succulent feed, the daily movement of the deer in summer is from 300 to 900 m, and the deer linger in sites that often do not exceed 150 or 200 hectares.

In winter and in spring, some of the deer in the Tigrovaya Balka Reserve regularly leave the tugai firests for the desert at night, and their daily movement in this case may reach 2.5 to 3 km or more. There seem to be no such appreciable seasonal variations in the daily movements of the deer in the Aral-Paigambar Island. Very few precise observations are available concerning the sizes of areas inhabited by single deer and their groups.

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2.5 Herd instinct

The maximum herd size in this deer is observed in winter, when herds of 5 to 7, more seldom 15 to 20, and still more seldom up to 50 to 60 specimens, are common in the Tigrovaya Balka Reserve.

The herds break up in spring, before calving, the females with their young keeping separate, adult males usually staying on their own and immatures forming groups of 3 to 5. During the rut period in autumn, from 1 to 4 females, seldom more, live with the adult male. The winter herds in the Aral-Paigambar Reserve are usually of the same size, but during the rut period in autumn the male is seldom followed by more than two females.

Large harems belonging to the males were recorded by us in the autumn of 1971 among the deer introduced to the Ramit Reserve: one male here had 4, 5, 7, and, in one case, 8 females.



Figure 4: Male with harem of 7, Ramit Reserve. Photo. A. Bannikov

2.6. Feeding and drinking

2.6.1. Food composition

More than 120 plant species are known to be eaten by the Bactrian deer. The basic fodder plants, however, include only 10 to 15 species.

Everywhere, herbaceous vegetation seems to constitute the basic food of the deer during all seasons of the year. Grasses are of prime importance among the herbaceous plants. An appreciable role is also played by fallen poplar leaves, both fresh and dry. Fruits of *Elaeagnus*, branches of *Haloxylon*, tamarisk and other plants can also be an important seasonally.

The general importance of some or other plant species as feed for the deer varies insignificantly in different parts of the range. Thus, for example, the grass *Aeluropus littoralis*, wild sugarcane (*Saccharum spontaneum*), wood-reed (*Calamagrostis*), lime-grass (*Erianthus*), poplar leaves, fruits of *Elaeagnus* and some others are everywhere readily eaten. In spring, the ephemeral desert

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plants, such as sand reed (*Carex pachystillis*), as well as aristida (*Aristida* spp.), brome-grass (*Bromus* sp.) and others generally serve as important food for the deer.

Unlike the deer in the Tigrovaya Balka Reserve, the deer in the Aral-Paigambar seldom eat *Haloxylon* branches in winter, but often feed on *Tamarix, Halimodendron, Artemisia* spp., *Ephedra, Atriplex, Suaeda, Salsola* spp. and other plants. Willingly and all year round the deer of the Aral-Paigambar eat liquorice (*Glycyrrhiza glabra*) and in summer leaves and occasionally roots of reeds and reed mace (*Typha*) (Volozheninov and Tikhomolov 1975), which has not been recorded for the deer of the Tigrovaya Balka.

The deer in the Aral-Paigambar Island very seldom pick up the bark of young poplars or other trees and shrubs.

2.6.2. Drinking places

On the hot days of summer, the Bactrian deer visit drinking places regularly, apparently every day. We happened to encounter the same animals several days running at watering places in the Tigrovaya Balka and Aral-Paigambar.

The deer seldom come to drinking places in spring, while the air temperatures are not too high and the plants are succulent. The number of the deer coming to the drinking places drops abruptly in autumn and in winter.

The deer resort to rivers to drink most often in open sites with gently sloping banks. However, in the Aral-Paigambar Island, there are sites with steep banks and stepped descents to the water, where the deer are always present.

2.7. Diurnal activity and behaviour

2.7.1. Diurnal activity

In summer, the deer are active at night and in the twilight, spending the hot periods of the day lying up on bed grounds. They rest in shade under the trees, usually cutting a small hollow in the ground with their hoofs. As soon as sunbeams reach the deer, it will change its bed ground and move into the shade. In the evening, shortly before the sunset, the deer visit their drinking places, graze for the larger part of the night and are again near the water at dawn. By mid August, they are often active in the hours before the sunset and in the morning.

During the height of the rut, i.e. in the middle of September, the adult males, judging by their voices, are active almost round the clock but most active during the dark hours. Late in autumn, the deer can be seen grazing in the day-time, too.

The deer are also active in winter and in spring mainly at night, when they often come out into the desert to feed. However, in winter, they can often be found feeding in the brakes during by day as well. During snow falls in winter, or dust storms and rains in spring, they seek shelter in the dense shrubs or reeds.

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Figure 5: Bactrian Deer stag, Sarykhosor Sanctuary



Figure 6: Bactrian Deer hind, Tigrovaya Balka Reserve. Photos. A. Bannikov

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2.7.2. Behaviour

The deer in the reserves are not easily frightened, especially the females, and allow a man to come as close as 50 or 60 paces in the open and still nearer in dense scrub.

If frightened the deer (both female and male) utters a shrill "bark" and runs away, enticing the other members of the herd after it. They will cover the first 50 to 100 metres swiftly and in disorder, crashing through the scrub. Having run off about 200 to 400 metres, they then stop and listen. If no chasing follows, the animals calm down. When chased, the deer run in a circle of long radius, trying to get into a position down wind of the pursuer.

A herd of the deer runs in a string, headed by an adult female. If the herd is a mixed one, the male brings up the rear. The male always runs last in the chain of females of his harem.

2.8. Reproduction

2.8.1. The rut

The first bellows of the males are heard in the last week of August. The height of the bellowing usually falls in the middle of September, and the last bellows of the males were recorded up to the beginning of October. These dates may shift in one or another direction by a week or occasionally longer, depending on the weather and the condition of the animals (Klyushkin 1949; Mambetzhumaev 1961; Chernyshev 1958; Volozheninov 1977). The height of the rut of the deer in the Ramit Reserve in the mountains is shifted to later dates, namely, late September to early October (Bannikov 1972). Yet later, during the second half of October, the Bactrian deer rutted in the Moscow Zoo (Tsalkin 1944).

The deer bellow all day and night long during the height of the rut, but largest numbers of bellowing males have been recorded from 11 p.m. till 7 a.m., usually with two peaks of bellowing intensity, in the morning and evening (Nikolsky, Novikov and Naumov 1975). The intensity of bellowing varies on different days depending on the weather, reducing sharply during strong winds and increasing after rain. Fights between rival males are relatively rare.

Sites where the deer bellow are permanent from year to year. The deer prefer places where woody and shrubby thickets alternate with open meadows of 30 to 100 m^2.

In the harems that are formed during the rut one adult male most often has 2 to 3 females. More rarely, up to 4 or 5 females have been recorded (the Tigrovaya Balka) and 7 to 8 in the Ramit. Not more than two females for one male were recorded in the Aral-Paigambar Island (Volozheninov 1977).

2.8.2. Calving and females' behaviour

Calving in the Tigrovaya Balka was observed from the end of April till the end of May, more often in the middle of May (Chernyshev 1958); and in the last days of May in the Ramit Reserve. Most females in the Moscow Zoo produced their offspring at the end of June and in July (Tsalkin 1944). As a rule, the females produce one calf each.

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Figure 7: Bactrian Deer male in rut, Ramit Reserve



Figure 8: Bactrian Deer juvenile, Tigrovaya Balka Reserve. Photos. A. Bannikov

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The females calve in secluded sites, usually in dense brakes and always near a river bank. The weak and helpless calves lie down almost all the time during the first two or three days. The females and their young whistle softly: the females calling up her calf and the young responding to its mother's call.

2.9. Development and moults

A new-born calf weighs 8 to 12 kg. At an age of about ten days the youngling starts running after its mother, but gets tired quickly. The calves begin to eat grass and leaves at an age of about one month, but suckling continues till winter, possibly longer.

The deer drop their antlers from the end of February till the beginning of March. Ossification of the antlers is completed between the end of July and the beginning of August.

The spring moult begins in April and finishes in June. The winter fur grows long by October, but the full winter coat is put on by the deer in early December.

2.10. Population increase

According to observations in the Tigrovaya Balka and the Aral-Paigambar Reserves, the younglings constitute, soon after their birth at the beginning of summer, from 10.7 to 22.2 per cent of the total population in different years. These data are probably underestimated, since the annual increase in population in these reserves was more than 20 per cent in some years. It can hardly be supposed that there was no loss of youngsters during the year or that the population increase was due to the deer coming from outside.

In the Ramit Reserve, where conditions for finding the young are much better, the new-born calves constituted in 1967–1971 from 30 to 31.7 per cent of the total number of the deer. After the high population density had been attained in the Ramit in 1972–1976, the percentage of the new-born calves went down and averaged about 20 per cent.

2.11. Enemies, rivals and death-rate from abiotic factors

2.11.1. Enemies

The main enemy of the Bactrian deer in the past was the tiger. In 1946–1950, 19 cases of the deer being killed by tigers were recorded in the Tigrovaya Balka Reserve, the number including 4 adult males, 12 females and 3 youngsters.

At the present time, wolves inflict the greatest losses upon the deer. Thus, for example, the wolves that came to the Aral-Paigambar Island in the winter of 1962–63, destroyed nearly all the younger deer, several adult females and one big male (Ishunin 1967). In September–October, when the wolves come down to the valleys, following the sheep flocks, into the Ramit Reserve, about 2 to 3 deer are killed by them annually (Bannikov 1972).

Parasites of the Bactrian deer have been studied but inadequately. Parasitism of 12 tick species is known, including *Dermacentor daghestanicus* and *Boophilus calcaratus* in great quantities (Mambetzhumaev 1961).

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2.11.2. Rivals

Domestic cattle are the main competitors of Bactrian deer that live outside reserves. At the beginning of the 1970s, some domestic buffaloes invaded the Tigrovaya Balka Reserve. They became wild and beyond the reach of man's control, multiplied and now compete with the Bactrian deer. Measures are being taken at the present time to remove the buffaloes from the Reserve.

2.11.3. Death-rate from abiotic factors

Occasional cold winters, in combination with heavy snow falls, may bring about losses of the deer. For example, losses of the deer were recorded in the middle reaches of the Amu-Darya after snow storms and severe cold. Cases are known to occur in the Tigrovaya Balka Reserve and in the Pyandzh River area, where deer were found dead during the cold winter of 1972.

Floods, when rivers burst their banks and cover large areas with sticky silt, are also a cause of losses. Thus, for example, the disastrous flood in the middle Amu-Darya area in 1949 resulted in the destruction of no less than 37 deer whose carcasses were found in the thick silt layer in the Darganat area (Klyushkin 1954). From June 1958 till March 1959, 13 deer were found stuck in silt deposited by the Vakhsh River in the Tigrovaya Balka Reserve (Mambetzhumaev 1961).

Fires also cause losses; they usually originate in autumn as a result of the burning of old reeds. Trying to escape from the fire, the deer flee to places that are unusual for them, such as open deserts or cultivated fields, where they often fall a prey to wolves or dogs.

3. SUMMARY AND RECOMMENDATIONS

The strict ecological association of the Bactrian deer with the narrow band of woody and shrubby thickets along desert river banks has made it a very vulnerable species. In such arid zone man's first choice for his settlements and agriculture is the banks of rivers and this inevitably leads to tree felling, cattle grazing and fires, and so the destruction of the deer's habitat. This process, coupled with the ease with which the deer can be hunted in the confined space of the brakes has brought about a rapid reduction in its range and populations.

The preservation of two large populations of the deer in the Amu-Darya basin, totalling about 350 to 400 head, achieved in the U.S.S.R. at the beginning of the 1960s, was owed entirely to the natural reserves.

The subsequent measures taken to protect the deer in the U.S.S.R. have resulted in an increase in the population of the deer in primary areas up 650 head by 1977. In addition, the deer were introduced into certain mountain reserves and sanctuaries, where their population has reached 250, bringing the total number of the Bactrian deer in the U.S.S.R. to over 900.

The basic ecological parameters discussed in this paper testify to a great plasticity of the Bactrian deer.

To increase the population of the Bactrian deer, it will be necessary to undertake further re-introductions of the deer to the areas along the

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Amu-Darya, Syr-Darya, Zaravshan and other rivers, where woody and shrubby thickets have been preserved, and also to the lakeshore strips of Lakes Arnasai, Aidara and Tuskanai in the Golodnaya Steppe, as well as a number of other regions.

It is also necessary to stop the burning of the reeds in the upper reaches of the Amu-Darya and in the lower reaches of the Pyandzh. In these regions, where the Bactrian deer inhabits both the Soviet and the Afghan banks, it would be expedient to organize joint Soviet-Afghan natural reserves.

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PART I: THE IUCN THREATENED DEER PROGRAMME
3. SPECIES OF WHICH SOME POPULATIONS, AT LEAST, ARE RECOVERING OR HAVE RECOVERED

Case Histories: The Tule Elk (*cervus canadensis nannodes*)

DALE R. MCCULLOUGH

ABSTRACT

The tule elk, which was endemic to California, was brought back from near extinction in the late 1860s through the actions of a wealthy private landowner. Numerous transplant attempts between 1910 and 1934 led to three main populations: free-roaming herds in Owens Valley and Cache Creek, and an enclosed population at Tupman. Management policy for the Owens Valley population, the one of greatest contention, has evolved under pressure from various special interest groups. The current policy calls for a maximum population of 490 head, the approximate natural carrying capacity of the valley. This policy is secured by both State and Federal laws. Recent transplant attempts have established three new populations, and other transplants are being planned. Current status of the subspecies is considered secure.

1. INTRODUCTION

From the mid 1950s until about 1974, the tule elk (*Cervus elaphus nannodes*) was the best-known case of a rare and endangered mammal in North America. The popular press and natural history magazines were filled with accounts of its plight. While there are still problems, the status of the tule elk is generally acknowledged to be secure, and recent popular books on rare and endangered species have not mentioned it at all. Therefore, conservation of the tule elk can be considered a moderate success.

2. HISTORY

The following account is taken from McCullough (1969). Originally the tule elk, which was endemic to the state of California, occurred in great numbers in the broad open valleys of the central and coastal parts of the state (Fig. 1). Of the subspecies of North American Wapiti, the tule elk was by far the most adapted to open country and semi-desert conditions. It was smaller, lighter in color, and had a different antler conformation from that of the typical Rocky Mountain race.

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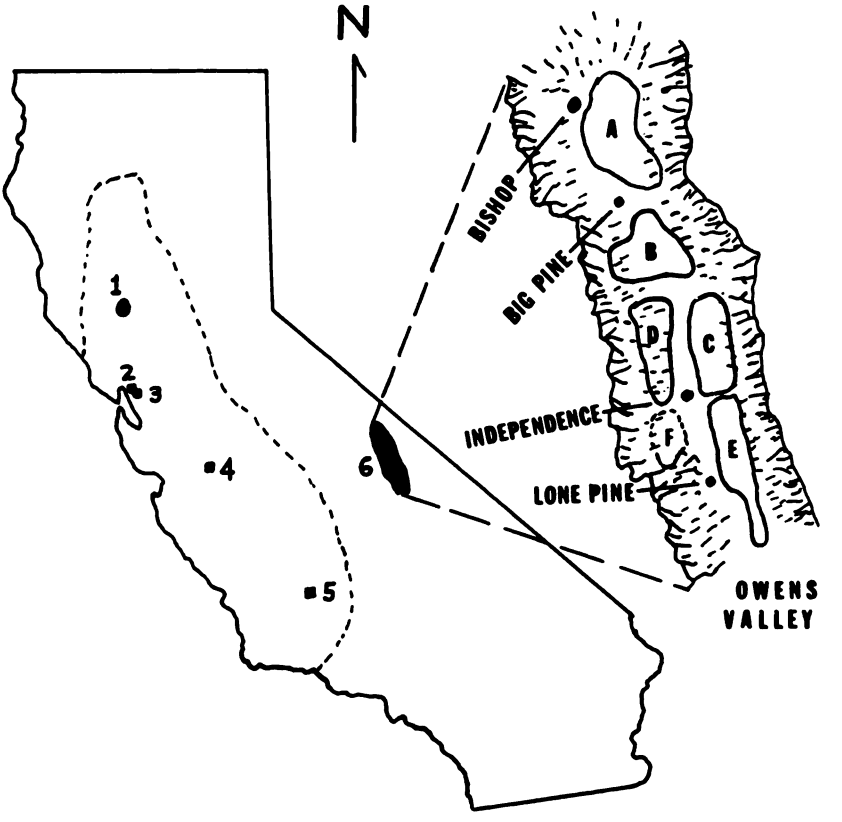


Figure 1. Locations of tule elk herds in California. Original range is shown by broken line. 1. Cache Creek. 2. Grizzly Island. 3. Concord Naval Station. 4. San Luis Island. 5. Tupman Reserve. 6. Owens Valley. A Bishop. B. Tinnehama. C. Independence. D. Goodale. E. Lone Pine. F. Mt. Whitney.

Populations in the original range held up well in the face of white European settlement of the state until the advent of the gold rush in 1849. The tule elk populations crashed in the subsequent years under heavy and persistent market hunting. By the late 1860s it was thought to be extinct. However, in 1874 a small remnant was discovered in the southern San Joaquin Valley by a rich rancher, and he afforded protection to this nucleus, said by a well-informed local game warden to be only two animals. By 1895 this herd was nursed up to a total of 28, and by 1920 it had grown to about 400. Persistent agricultural damage caused by the elk led to repeated transplant attempts between 1904 and 1934. These resulted in three main herds, two within the original range (Tupman Refuge, ± 32 head; Cache Creek herd, ± 140 head) and one outside of the original range (Owens Valley, ± 300 head) and a few animals in zoos by the time the tule elk became a rare species *cause célèbre* in the 1960s (Fig. 1).

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3. THE OWENS VALLEY POPULATION

Most of the controversy centered on the Owens Valley population, which was established by transplants in 1933 and 1934, totaling 54 animals. Owens Valley is a deep valley, some 80 miles long by 15 miles wide, lying between mountains east of the Sierra outside of the original range.

The mountains on either side, and unsuitable desert habitat to the north and south, serve as natural barriers to egress of tule elk from the valley. Climate and vegetation are semi-desert, with an average rainfall of around 12 cm per year. Most years are below average, with a few years of high percipitation (20–30 cm) raising the average above the "typical" year. This skewed frequency distribution of annual precipitation is a critical point in the management of the tule elk. Most precipitation occurs during the winter, and the valley is watered primarily by spring and summer runoff from snowmelt in the Sierra. Forage conditions for the elk are determined mainly by the amount of precipitation, although there is a small carry-over of feed from a good year into the following one.

The Owens Valley population is divided into six herds which are segregated, with the exception of bulls wandering during the rut. Four herds occur in the bottom lands, centered on natural flood areas where spring runoff surged out of stream channels in original times. These areas are characterized by temporary channels, shallow ponds and evaporation basins. Vegetative growth tends towards grasses and forbs of moderate to high alkaline tolerance, while outside of these areas, where plants must depend upon free precipitation, desert shrubs predominate. All plant types contribute to the diet of tule elk, but critical summer forage is produced in the flood basins.

The one herd which occupies an alluvial fan at the foot of the Sierra is dependent on a burned area for herbaceous forage, and this same burn serves as the primary rutting ground.

4. THE BIOLOGICAL BASIS FOR MANAGEMENT

From two years of full-time fieldwork (McCullough 1969) and a follow-up summer of work, the following major points emerged.

1. The natural carrying capacity of the valley for tule elk is low. Although virtually all of the area is used at one season or another, during the critical summer period, suitable habitat is restricted to a few key locations.
2. Quality and quantity of forage, hence carrying capacity, can vary enormously from year to year depending upon the amount of precipitation. The critical forage period occurs during the summertime, when physiological demands of the population are highest.
3. Range deterioration and competition with domestic stock, which are common problems with other subspecies of wapiti, do not apply to the tule elk. Competition between deer and elk for bitter brush occurs locally in the Goodale herd area.
4. While mortality factors such as illegal killing, predation, accidents etc, are present, the overriding variable is precipitation.

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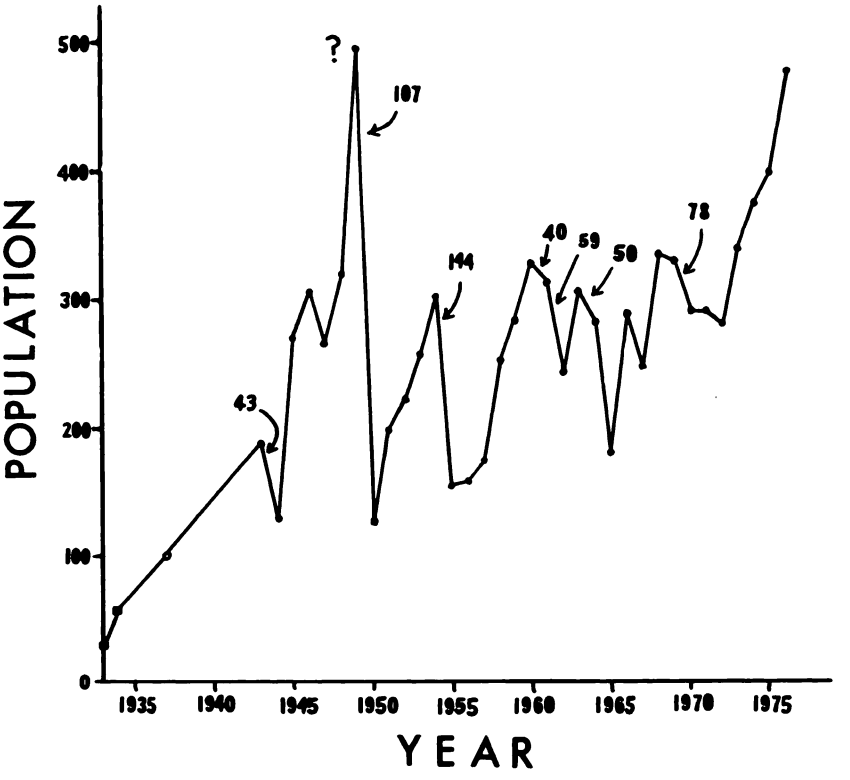


Figure 2. Estimates of the Owens Valley population of tule elk. Squares represent animals introduced; open circle is a subjective estimate; solid circles are aerial censuses made by CDFG. If more than one census was taken, the highest count was used. Numbers are animals removed in legal hunts. The question mark indicates an aerial census which probably included duplication.

5. Significant improvement of the habitat cannot be obtained without resorting to cultivation of artificial feed.

5. RATIONALE FOR PRESERVATION

The following rationale is based upon the belief that the tule elk should be maintained in its natural state in a healthy, functioning ecosystem with a minimum of artifical intervention by man.

In Owens Valley, my best estimate of the maximum carrying capacity was 500 head (McCullough 1969). Subsequent work by California Department of Fish and Game led to the figure of 490, and this is the figure currently used for management purposes. The difference is trivial in view of the fact that neither estimate is accurate to more than 10 percent of the real value, which is fluctuating from year to year in any event (Fig. 2).

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It is my belief that the population will rarely achieve 490 under natural conditions.[1] The natural equilibrium is around 400 (see McCullough p. 000 this volume), and the balance is struck, primarily, by failure of recruitment of calves. In good years the population will increase, and in poor years decline in a density dependent manner. Thus, the population number will vary as the frequency and order of high and low precipitation years.

It would not be necessary to exercise any control if it were not for the probability of several good years following in a row. The danger comes from having an excessively high population when the poor year occurs, which might lead to a precipitous crash. Herein lies a danger of extinction of the population. It is my opinion that extinction is extremely unlikely, given density dependent processes; but assuming the risk when control can be exercised seems ill-advised. Therefore, it is important that California Department of Fish and Game retain the authority to exercise control if the population exceeds 490. It should be noted that such control is not intended to prevent subsequent decline. Rather, it is to lessen the impact on the habitat as a hedge against a drastic decline.

A second reason for avoiding large numbers in Owens Valley is to keep the six herds as separate as at present to slow the spread of a virulent disease. If the population increases substantially above 500, the intervening spaces between the herds will tend to close, and the danger increases as unbroken contact between the individuals of the total population occurs. At present the contact between the herds is sporadic and irregular, even during rut. Outbreaks of contagious diseases, by their very nature, are not predictable. However, several outbreaks of anthrax have occurred in domestic cattle in Owens Valley in recent years.

Since the carrying capacity of Owens Valley is quite limited, increasing the total number of tule elk is dependent upon establishing herds elsewhere, and preferably within the original range of the subspecies. In the long run, this is the best insurance against extinction according to the maxim, "don't put all your eggs in one basket."

6. NATURE OF THE CONTROVERSY

One of the most difficult problems facing conservation is the articulation and acceptance of objectives and goals of a given program. Once agreement is achieved in this sphere, appropriate programs often follow naturally. However, achieving a consensus can be elusive in a pluralistic society, and this has been a major obstacle in the case of the tule elk.

Consider the diversity of the parties to the controversy:

1. Los Angeles Department of Water and Power (LADWP). Most of the bottomlands of the Owens Valley are owned by the city of Los Angeles to secure water rights. About 80 percent of the water needs of the city are met by Owens Valley water transported via an aquaduct (see Phillips 1976, for

[1] However, this number was exceeded by the aerial census conducted in August 1977, when 582 tule elk were counted.

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further physical description of Owens Valley). The Department manages the city's operation of water export and power generation as well as agricultural grazing leases on their lands and local water uses (irrigation, recreation municipal etc.).

2. Bureau of Land Management (BLM). A federal agency with responsibility for a strip of land on either side of LADWP lands, and most of the lands north and south of Owens Valley in the desert, where they administer grazing, recreation and mining.

3. U.S. Forest Service (FS). A federal agency with responsibility for lands lying above BLM lands, encompassing most of the mountain masses on either side of the valley. In this area, recreation and a small amount of grazing and mining are their main responsibilities.

4. California Department of Fish and Game (CDFG). This agency holds responsibility for managing resident wildlife in California, including the tule elk. Traditionally their activities have focussed upon game species which have been managed for sport hunting; however, in recent years they have expanded their activities to non-game species.

5. County of Inyo (CI). A local governmental agency with certain wildlife perogratives and recreation programs.

6. U.S. Fish and Wildlife Service (USFWS). A federal agency potentially involved through the Rare and Endangered Species Act. However, the tule elk was never added to the endangered species list.

7. Committee for the Preservation of the Tule Elk (CPTE). A Los Angeles based citizens committee seeking protection of the tule elk. It served as the focus for the protectionist philosophy, although other similar groups, such as the Sierra Club, were involved to a lesser extent.

9. Inyo County Cattleman's Association and Sierra Packer's Association. Organizations representing the interests of the livestock industry in Owens Valley.

10. Various Individuals, mostly university based, acting independently or as consultants. They included biologists, conservationists, economists, geologists etc., with a wide variety of view-points and persuasions.

In 1971, the first five organizations enumerated above formed a coalition termed the Interagency Committee for Owens Valley Land and Wildlife. This committee has been instrumental in coordination of management plans, and a number of fish and wildlife projects have been jointly carried out, including work on the tule elk.

Following introduction to Owens Valley in 1933 and 1934, the tule elk population built up to the point where local ranchers (leasees on LADPW lands) began to complain about elk damage to alfalfa fields and fences. Legal hunts were held in 1943 and 1949 to reduce the herd. The relatively high removals (107 in 1949, plus an unknown number of crippling losses) led to concern on the part of sportsmen and conservationists and, following hearings, a policy of holding the population between 125 and 275 by aerial census was adopted. The next hunt was held in 1955, when 144 elk were killed from a herd estimated at 301. Poor hunter behavior and heavy crippling loss

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occurred. Thus, when CDFG proposed a hunt in 1960 in which 150 elk were to be taken from a population of 285, tremendous public opposition arose and led to the formation of CPTE. The proposed hunt was called off and, following hearings in 1961, the policy was changed to allow 300 head by the annual aerial census. If this number was exceeded, enough permits were issued to reduce the population to 250. Hunters would be controlled by a game warden guiding system, which effectively reduced crippling losses to negligible numbers. Hunts were held in 1961, 1962 and 1964, each with a removal of about 50 animals. Although CPTE opposed each of these hunts, they were unable to marshall broad support and functioned mainly as an outspoken minority. Their policies had evolved, by this time, to be (1) no killing of tule elk for any reason, (2) creation of a refuge in the southern half of the valley (from Tinnemaha Reservoir south), and (3) establishment of a minimum of 2000 elk in Owens Valley. Subsequently they changed their refuge demand to the entire valley, but their position on numbers of elk and control remained steadfast. The results of my biological study of the tule elk became available in 1966, and copies were given to the participants in the controversy.

The last half-decade of the 1960s was a period of intense conservation activity. The Endangered Species Act of 1966 and Earth Day in 1968 were milestones in the general raising of public consciousness. When the California Fish and Game Commission proposed a hunt in 1969, the CPTE was able to generate tremendous opposition, and made substantial inroads with a number of political bodies, including the Los Angeles City Council and the State and Federal legislatures. The hunt was carried out in the face of adverse publicity.

The experience convinced LADWP that they could not withstand the pressure of another public hunt of tule elk, and most of the other agencies agreed that something had to be done. CDFG resisted change in the management policy because it ran counter to their philosophy that control of the tule elk population was necessary and that, if animals were to be hunted, it should be done by licensed sportsmen. They also resisted setting the precedent of having department employees doing the control, which might spread to a number of other species for which they were receiving pressure.

LADWP approached me about the situation, and I agreed to serve as a consultant to help develop alternate policies. Thus I spent the summer of 1970 in Owens Valley doing field work to examine how the conclusions I had reached five years earlier had withstood the test of time. I found no evidence that my major conclusions were in error. At the same time radio-tagging study by the CDFG verified the separation of the five herds I had described, a point which was strongly contested by the CPTE. (It should be noted that a number of studies conducted by the various agencies since that time have considerably refined the results of my work, but have revealed no major discrepancies.)

Following the summer's work, several points stood out. First, more than 300 head of elk could be supported in Owens Valley provided they were distributed properly between the five herds, and if the population was

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expanded into a sixth area (called the Mt. Whitney herd area, it lies on the Sierra alluvial fan near the southern end of the valley), which was suitable. My initial estimate of 500 head carrying capacity was reasonable, although CDFG's estimate of 490 was adopted subsequently. Second, the point of the management policy which generated public opposition was the public hunt. This aspect accounted for most of the adverse publicity. (The correctness of this view was dramatically illustrated when the first rough draft of the habitat management plan was released in March 1976. It contained the statement that if tule elk were to be removed from Owens Valley, the first choice of removal would be a public hunt. This one sentence generated more letters of protest than the entire remainder of the report.)

It was my concern that if the present policy were continued, the authority for managing tule elk could be shifted, due to public pressure, either to the U.S. Fish and Wildlife Service through the addition of the tule elk to the Rare and Endangered species list (a move which the Fish and Wildlife Service did not want, both because they did not believe that the tule elk was endangered and because they were not anxious to assume the head aches involved) or by State legislative action, which could remove the tule elk from the authority of the CDFG.

Late in the summer a meeting was held between the LADWP and CDFG commissioners and department personnel at which I laid out my views that the total number of tule elk in Owens Valley be raised from 300 to 490, and the control, if necessary, be done by means other than a public hunt. CDFG could readily agree to the raising of the number from 300 to 490, but resisted the discontinuance of public hunts. After a lengthy discussion, a top executive of LADWP declared that if CDFG proposed another public hunt, LADWP would be forced to close its lands to hunting. Faced with this inevitability, CDFG reluctantly agreed, and the meeting came to a swift conclusion.

Changing a management policy by CDFG calls for a public hearing with an announced agenda, where anyone can present testimony for any change. As it turned out, the authority to remove elk by means other than public hunting already existed. Some of us at the meeting were dumbfounded when so informed, since we could not understand how such a change had been accomplished without a major uproar. CDFG has stream-lined their entire code and this provision was dropped from the tule elk management policy virtually without notice!! Thus, the only issue to be considered at the public hearing was raising the number of elk in Owens Valley from 300 to 490.

The hearing was held in March 1971 and the audience was heavily stacked by those in favor of the CPTE and other preservations, girded to do battle for 2000 elk in Owens Valley. I testified first, giving the biological justification for setting 490 as the natural carrying capacity. There followed a stormy, emotional session, complete with audience participation, in which several organizations testified for the proposal, but most testified against and in favor of 2000. As "the expert" I received most of the vituperation. The Commission showed a good bit of courage in the face of pressure in passing the proposal to raise the number to 490. That policy stands today.

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7. TULE ELK LEGISLATION

The publicity surrounding the 1969 hunt and urgings of the CPTE resulted in the introduction of legislation in both the State and Federal Legislatures in the following years. The first piece of Federal legislation (H.R. 14630) was a resolution introduced in 1970 by Congressman John D. Dingell, of Michigan, which called for the U.S. Department of Interior (through the Bureau of Land Management, Bureau of Sports, Fisheries and Wildlife, and National Parks Service) to conduct a thorough study of potential transplant sites for new tule elk populations. The Department of Interior complied with the intent of the bill of its own initiative (discussed below) and no further legislative action was taken on the bill.

The next piece of legislation was a State of California bill (SB722) passed in 1971, which became known as the Peter Behr bill. As originally written the bill called for no killing of tule elk until a population of 2000 existed in Owens Valley. However, when Mr. Behr was made aware of the results of biological studies of the tule elk in Owens Valley, he modified the bill to state that 490 elk would be maintained in Owens Valley, until and unless further study revealed that further animals could be safely carried, and that no elk would be killed until 2000 existed in the State of California. This bill was a most important piece of legislation since it essentially gave legislative sanction to the CDFG management policy and also created strong impetus to the establishment of additional populations.

The CPTE also gave their attention to the Federal Congress. The first of a series of refuge bills (H.J.Res. 547) was introduced in 1971 in the House by John D. Dingell and in the Senate (S.J.Res. 84) by Allen Cranston of California. Although the wording of the bills changed somewhat as reintroduced in subsequent sessions of Congress, the basic intent remained unchanged. In essence, the bill called for superimposition of a U.S. Fish and Wildlife Refuge over the existing framework of agencies, and for final authority on all matters pertaining to the tule elk to be held by this refuge. The agencies and I opposed the measure on several counts: (1) It would not improve the status of the tule elk in Owens Valley; (2) it would create a situation likely to foster artificial measures to increase the number of elk; (3) it would cause further confusion in an already complicated agency/authority framework, and these problems had been largely solved cooperatively through the Interagency Committee; and (4) it made little sense putting money into an unneeded refuge outside the original range when areas inside the original range were so badly needed to establish additional herds. Support for the bill from preservationist and animal protectionists organizations other than CPTE was desultory, and no ground-swell of public support developed (Committee on Merchant Marine and Fisheries, 1974). By this time whales, seals, porpoises and wolves occupied the public attention, and the tule elk was old hat. After numerous discussions and three public hearings, the Federal Congress in 1976 passed a joint resolution (H.J.Res. 738) which virtually duplicated the California Behr Bill.

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8. ESTABLISHMENT OF NEW HERDS

In my tule elk monograph I strongly recommended establishment of additional herds as the best hedge against extinction of the subspecies, and I suggested San Luis Island in the San Joaquin Valley near Los Banos, and Point Reyes National Seashore north of San Francisco (both within the original range) as likely sites. However, little action was taken until Congressmen Dingell introduced his transplant study resolution. The Department of Interior established an interagency team to review potential sites in California, Oregon, Nevada and Arizona. The committee was chaired by Clinton Lostetter of USFWS, and included James Blaisdale (National Park Service), Frank Stanton (BLM), and various temporary associates from State and Federal agencies, and myself as a consultant. At an initial planning meeting I introduced an outline of criteria for determining suitable habitat (topography, vegetation, climographs, natural or artificial barriers etc.). This outline was sent to all of the above named states and Federal agencies therein with the request that they submit a list of potential transplant sites.

No suitable sites were identified outside of California. It was apparent that the other states were not anxious to share the woes for a herd of non-native animals. Twenty-two potential sites were identified in California, and the team visited eight of the more promising ones. San Luis Island was rated the highest priority with Point Reyes next. Also, it was recommended that the potential sixth herd in Owens Valley (Mt. Whitney herd) be established. This was attempted by CDFG in November 1971, when two were captured and moved from the Goodale herd (the Sierra alluvial fan herd) in Owens Valley and January 1972, when 5 head were moved from the Tupman Refuge. I had recommended that the former animals be used because they were adapted to living in that habitat. This proved to be a poor judgement since these two promptly returned to the Goodale area! A few animals were occasionally seen in the Whitney herd area in the following years, and 19 were counted there in 1977 animal census.

The San Luis Island (a USFWS Refuge) herd was established in December 1974, with 18 animals from the San Diego Zoo, which had originated from the Tupman herd. This herd occupies a fenced enclosure of 307.6 ha and is estimated to have a capacity of 40 head. In January 1977, seven elk were released on the Concord Naval Weapons Station. Several mortalities occurred, but 5 animals including 2 calves remain. Total capacity of the area is estimated at 40 head. In May 1977, 8 elk (now increased to 11 by 3 calves) were released on Grizzly Island Wildlife Management Area, a State owned property. Capacity is estimated at 20 to 30 head. So far, the proposed transplant to Pt. Reyes National Seashore has been held up by lack of funding to construct a retaining fence. Thus, at the present time approximately 785 tule elk are present state-wide in six herds (Fig. 1, Table 1). Surplus animals are becoming available, but the number of suitable areas for transplant are limited. In addition, a small number of animals are held in zoos and zoological parks.

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Table 1. *Estimated numbers of tule elk, by herd, made by CDFG as of August 1977 (Hunt 1977).*

Area	Date of Establishment	Situation	Estimated number
Owens Valley	1933–34	Free roaming	582*
Tupman Refuge	1930	Fenced	65
Cache Creek	1922	Free roaming	80
San Luis Refuge	1974	Fenced	42
Concord Naval Sta.	1977	Fenced	5
Grizzly Island	1977	Free roaming	11
		TOTAL =	785

*Aerial census conducted in August, 1977.

9. ACTIVITIES OF THE INTERAGENCY COMMITTEE

The Interagency Committee on Owens Valley Land and Water was organized in 1970, with the objective of coordination and cooperation in projects having to do with fish and wildlife management and other natural resource use. The first project on tule elk involved the Tinnemaha herd, which is deficient in suitable summer forage and causes persistent damage to alfalfa fields. Since such damage occurred every year, it was decided to give over to elk use between April and October an alfalfa field between highway 395 and the Tinnemaha Reservoir. The Interagency Committee developed a wildlife view point on a nearby hill with good access from highway 395. Thus, during the summer months, the public can observe tule elk at a distance most mornings and evenings.

A second project of the Committee was the development of a tule elk habitat management plan, which has been completed. This plan was developed following a number of studies of range relationships between tule elk, domestic stock and the natural vegetation of the Valley. It outlines the goals and coordinates the activities of the various agencies in securing the habitat of the elk.

10. IN RETROSPECT

What lessons can be learned from the tule elk controversy? Most problems of a rare and endangered species are unique and present a set of problems unlike those of any other, and this is certainly true of the tule elk. Yet some important points have emerged from this controversy that would be useful in most cases.

The most important lesson for the biologist is that rare species problems are set in a total societal context. The tule elk had not been in serious danger of extinction since the late 1930s and the hunts of the 1960s certainly were not a threat. Since there was not a biological problem, many agencies assumed there was no problem.

In 1965 there were about 450 tule elk in existence. At present there are approximately 785, a gratifying increase. But the total number is orders of

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magnitude less than the number of wolves in Alaska, or porpoises, or the other species which are current issues in animal conservation in the U.S. What is at question is the whole ethical relationship between man and animals. Agencies pursuing narrow, parochial objectives do so at their own peril. The agencies involved in Owens Valley represent a diversity of missions and philosophies. Yet when it was imperative that they work together they found that cooperation served their own mutual interests, although each had to adjust its usual way of doing business.

As one who has adsorbed my share of vituperation and overt scorn at public hearings, I can testify that it is difficult to avoid casting the preservationists as the "heavies" in the controversy. But in all candor, it was public pressure that raised the number maintained in Owens Valley from 300 to 490, not the recommendations in my report; and it was public pressure and the legislation which resulted from it which led to establishment of additional herds whereas my urgings and pleadings had gotten nowhere.

Finally, the importance of research cannot be over-emphasized. The existence of agency records and my biological studies served as the basis for the policy and legislation which finally emerged from the political process. In the absence of this basic information, it is hard to imagine what sort of plan might have resulted.

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PART I: THE IUCN THREATENED DEER PROGRAMME
3. SPECIES OF WHICH SOME POPULATIONS, AT LEAST, ARE RECOVERING OR HAVE RECOVERED

Status of Columbian White-tailed Deer *Odocoileus virginianus leucurus:* some quantitative uses of biogeographic data

T. GAVIN

ABSTRACT

The Columbian white-tailed deer (*Odocoileus virginianus leucurus*) has been officially classified as "endangered" by the U.S. Department of Interior since 1968. Although this subspecies probably formed a continuous distribution along the Columbia and Willamette Rivers for several hundred kilometers prior to the 19th century, it is currently extant in only three disjunct areas. Two of these are along the Columbia River and the third occurs about 200 km south of the Columbia River in Douglas County, Oregon. A detailed evaluation of the status of whitetails along the lower Columbia River (one of the three disjunct areas) was based on each population's size, distribution, stability, habitat security and the dispersal potential of its individuals. A probability of extinction of 1 in 370 was calculated using only those population's in "secure" habitat. The formula used in this calculation requires a population mean based on a time series of several years, the standard deviation about this mean and an estimate of the minimum number of animals needed before extinction is inevitable. The continued survival of this subspecies can be viewed with optimism, especially if a taxonomic appraisal of the Douglas County herd results in its classification as *leucurus*.

1. INTRODUCTION

The white-tailed deer is the most abundant and widespread species of cervid found throughout most of the continental U.S. and southern Canada and extends south through Central American to northern Brazil. The taxon contains 38 recognized subspecies (Whitehead 1972), two of which have been considered threatened: the Florida Key deer (*Odocoileus virginianus clavium*) and the Columbian whitetail (*O. v. leucurus*). The Columbian white-tailed deer (CWTD) has been officially recognized as "endangered" by the U.S. Department of Interior since 1968; the Key deer is now considered out of danger (Red Data Book 1972).

Species classified as "endangered" may be recommended for reclassification to "threatened," a less critical category, if population status improves. If warranted, this is a desirable move since management options are less

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restrictive for this category. In addition, the public should be able to see some positive result from its financial and emotional support whenever possible. However, strong justification and documentation will need to accompany such a recommendation to be successful. Such decisions should be based on the best biological evidence possible; specific facts on the biogeography of the taxon under question should figure prominently at this stage.

To develop the point further, we will consider available information on the CWTD to examine its status as of 1977. This evaluation will utilize data on its past and present distribution, population size and stability where known, and habitat security for existing CWTD populations. In 1972, the prognosis for the survival of this taxon greatly improved with the establishment of the Columbian White-Tailed Deer National Wildlife Refuge (CWTDNWR). The Refuge provides security for habitat in the geographic area with the most dense CWTD population known (Fig. 1). However, is knowledge of the purchase and legal protection of nearly 2200 ha of CWTD habitat sufficient to appraise this deer's status and future prospects? I think not. It is hoped that this exercise can serve as a valuable prelude in determining whether the CWTD, after almost a decade as an "endangered" species, is ready for official reclassification to the "threatened" category.

From 1972–77, two studies of the CWTDNWR whitetail herd were conducted. Suring (1974) conducted the first of these studies which emphasized habitat use by these deer. The second study focused on the population ecology of this same herd and will be reported in my Ph.D. thesis in 1978. This paper does not track my presentation at the Longview meeting, in which part of the data on population ecology was discussed. Those data are not completely analyzed and are not ready for publication. Instead, this is a general look at the present status of this subspecies based on biogeographic characteristics of all known CWTD populations, with emphasis on the deer found along the lower Columbia River.

2. DISTRIBUTION: 19TH CENTURY

The sources of information on CWTD distribution during the 19th century are journals, government reports and diaries kept by naturalists and explorers who travelled in the Pacific Northwest. If one carefully examines these individual documents and then uses the references to white-tailed deer in toto, the "original" distribution of CWTD can be roughly reconstructed. Early accounts often refer to "deer" or even "small deer" that were observed or shot for food, but unless the author distinguishes whitetails from black-tailed deer (*O. hemionus columbianus*), the account is of limited value.

Lewis and Clark were probably the first white explorers to observe white-tailed deer in western Oregon and Washington. They reported them as common along the Columbia River in 1806 from what is now The Dalles, Oregon to Astoria, Oregon on the coast (Fig. 2((Thwaites 1905). A more detailed account of whitetail distribution, as well as the original description of the subspecies, was provided by David Douglas, the Scottish botanist and

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Figure 1. Aerial view of the Columbian White-tailed Deer National Wildlife Refuge, with Columbia River and Refuge islands in the background.

explorer (Douglas 1829, 1914). Although a type locality was not clearly designated in this description, whitetails were shot by Douglas or his party at several localities:

1. The mouth of the Columbia River (Douglas 1829, p. 332)
2. Above Willamette Falls on the Multnomah [Willamette] River about 36 miles south of the Columbia River (Douglas 1914, p. 58–59, 141)
3. On a tributary of the Umpqua River in Douglas County, Oregon (Douglas 1914, p. 220)

Douglas also mentioned that "great numbers" of whitetails were killed on the Multnomah [Willamette] River. He cited the observation of "small deer" along the Willamette as well as flushing a herd of 17 "small deer" along the Umpqua River. In this case, we can probably infer that these deer were whitetails since Douglas estimated blacktails to be about one-fifth larger. Douglas also wrote that black-tailed deer were rarely seen "on the plains," being restricted to hill country, and were "By no means such a plentiful animal as the former [black-tailed deer]" (Douglas 1914, p. 227). In describing the range of the whitetail, he wrote "This species is the most common of any in the districts adjoining the river Columbia, more especially in the fertile Prairies of the Cowalidske [Cowlitz] and Multnomah [Willamette] River, within one hundred miles of the Western Ocean" (Douglas 1829, p. 331). The rivers referred to are the Cowlitz River in southwestern Washington and the Willamette River in western Oregon, respectively.

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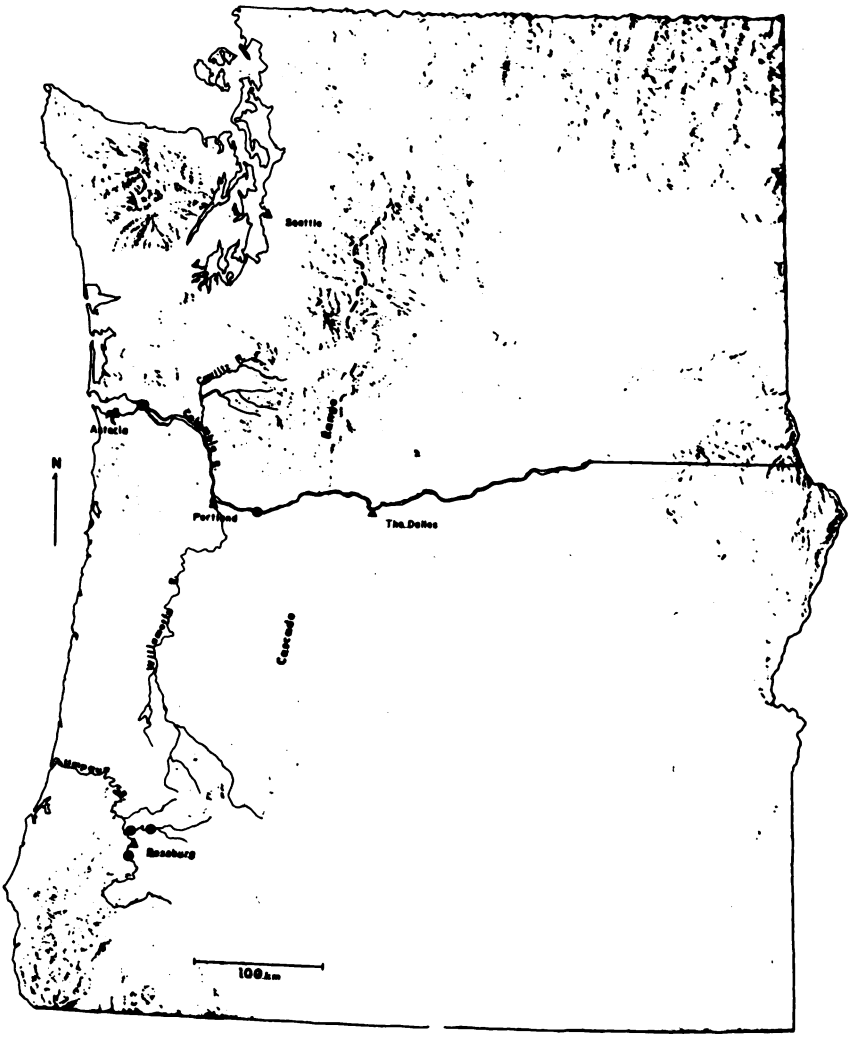


Figure 2. Distribution of Columbian white-tailed deer in western Oregon and western Washington. Solid dot refers to general area known to have whitetails.

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An 1841 excerpt from a diary kept by T. R. Peale, who was travelling from Oregon to California, substantiates the southern boundary of whitetail distribution:

> "The Umpqua mountains are the southern limit of the 'White tail' Deer (*C. leucurus*); here we killed the last as predicted by the hunters who were familiar with the route. They were here replaced by the 'Black-tail' which north of this we have seen only on rocky mountain ridges" (Drury 1957, p. 34).

The Umpqua mountains refer to a northwest-southeast trending portion of the Cascade range just south of the present town of Roseburg, Oregon (Fig. 2).

The northernmost extension of the CWTD's range is more obscure. Both Bailey (1936) and Allen (1942) stated that these deer occurred as far north as the Puget Sound country near Seattle, Washington, but neither offered any documentation to substantiate this claim. CWTD were found on the Washington side of the Columbia River, as they are today, and almost certainly occurred north along some of the rivers that empty into the Columbia (e.g. Cowlitz River).

At any rate, whitetails became scarce in the Willamette Valley of Oregon as the 19th century progressed. Bailey (1936) reported the last whitetail was seen or shot in the valley about 1898. The elimination from the Willamette Valley altered what had probably been a continuous distribution from the Columbia River to Douglas County, Oregon, resulting in a disjunct distribution.

3. REASON FOR DECLINE

The next logical question becomes: What caused the decline of white-tailed deer in the Willamette Valley during the 19th century? The answer would not only be of historical interest but might be of practical value in managing the remaining populations of whitetails.

We may never know exactly what caused the decline of CWTD, but changes in the valley's vegetation are correlated with it. After white settlers entered western Oregon in the 1840s, noticeable changes in the vegetation began to occur (Habeck 1961, Johannessen *et al.* 1971). Johannessen *et al.* provide a discussion of Willamette Valley flora both pre- and post-settlement. Their account, based on historical records and recent botanical analyses, indicate that "the broad, relatively flat terraces of the Willamette Valley were prairie lands" at the time of settlement. These prairies were maintained by fires set annually by the Indians in late summer and fall, which produced "plant associations in which woody plants were widely spaced." Prairies were low, wet and marshy adjacent to waterways, which supported riparian vegetation such as black cottonwood (*Populus trichocarpa*), white ash (*Fraxinus latifolia*), bigleaf maple (*Acer macrophyllum*), red alder (*Alnus rubra*) and some Ponderosa pine (*Pinus ponderosa*).

White settlers suppressed grass burning by the Indians, which altered the prairie-oak (*Quercus garryanna*) savannah aspect of the valley by allowing the establishment of less fire-adapted plants. Closed-canopy oak forests, and

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eventually the encroachment of Douglas fir (*Pseudotsuga menziesii*) down the sides of the valley changed the native grass-herb assocations. These changes were accelerated by the settlers' introduction of exotic grasses and herbs.

In addition, a micro-environment was eliminated that may have been important to whitetails, if their current preference for herbaceous forage on the CWTDNWR is any indication (Fig. 3). Nash (1976, p. 119) wrote in 1877 that bear (*Ursus americanus*) and deer occupied the level pieces of marshy valley bottom created by beaver-ponds. N. N. Moseley (1878, p. 26) also placed great importance on the fertility of these areas:



Figure 3. Adult whitetail male grazing on grass in April and wearing plastic collar used in ecological studies of Refuge herd.

> "By far the most fertile land in the State is beaver-dam land... They are stretches of flat land, composed of an extremely rich, black vegetable mould, often of enormous thickness, and are usually swampy until drained, but the drainage of them from the manner of their occurrence is a comparatively easy task, and they then yield wonderful crops. Unfortunately they are of small extent, but they occur in all parts of Western Oregon in the lower valleys, . . ."

Beaver-dams were replaced by man-made dams on Willamette River tributaries to control spring flooding; this flood-plain land was then drained and placed under cultivation.

We cannot discount the effects of shooting whitetails for food and sport by western Oregon settlers. There is some mention by Moseley (1878) that deer in the Cascade Mountains were shot for their hides and he cites a hunter

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who shot 150 deer in one winter. Whether CWTD were hunted commercially in the Willamette Valley is not known, but the opportunity to do so would have existed until their numbers became depleted.

As is usually the case, a combination of factors probably contributed to the reduction of CWTD west of the Cascade Mountains. As an aside, it is interesting that black-tailed deer are now common in the Willamette Valley and definitely not restricted to "rocky mountain ridges."

4. CWTD DISTRIBUTION AND DENSITY: THE PRESENT

The distribution of CWTD shown in Figure 2 is based solely on documented observations of whitetails in western Washington and Oregon since 1972. There are probably other small, perhaps isolated, populations of whitetails within the general geographic region covered by this map. Persistent reports for other areas of deer that resemble CWTD need to be investigated.

The easternmost distribution of CWTD is detailed in Fig. 4. Whitetails have been observed on Lady and Reed Islands, an unnamed island north of Multnomah Falls and just north of Ainsworth State Park. This cluster of sightings was reported by James A. Tabor (pers. comm.) of the Washington Department of Game during 1976–77. Although these observations are considered highly reliable, we know nothing about the density, movements or extent of distribution of these deer.

Near Roseburg, Oregon there are at least three areas that have concentrations of white-tailed deer (Fig. 2). Again, little is known about these deer. Several visits to this area have led me to conclude that whitetails in Douglas County are more widely distributed, but at lower densities than along the lower Columbia River. W. L. McCaleb, Jr. (pers. comm.) of the Oregon Department of Fish and Wildlife believes there may be 500 square km of whitetail habitat in the county, which may support 4 whitetails per square km. If systematic censusing confirms these estimates, the Roseburg group would constitute a sizable proportion of all known white-tailed deer in western Oregon and Washington. The CWTD Recovery Team, state and federal biologists assigned to develop a plan for the restoration of this subspecies, has given top priority to determining the taxonomic status of the Roseburg whitetails. The confusion is not alleviated by Douglas's (1829) vague reference to a type locality for this taxon when he described it. The biopolitical implications and significance of this taxonomic question are reviewed by Gavin (1978).

We will now examine in detail the biogeographic attributes of CWTD along the lower Columbia River (Fig. 5). The distribution, density and movements of these deer are better understood than for those areas listed above. Along the lower Columbia, whitetails are found in both "secure" and "non-secure" habitat (i.e. refuge and private land), on islands and mainland, and on diked lands with a history of agricultural use, as well as on some undisturbed areas. The number of CWTD believed to exist in these patches of habitat in 1975 can be compared to 1939 estimates by Scheffer (1940) (Table 1).

Although estimates of this type are seldom directly comparable, it is

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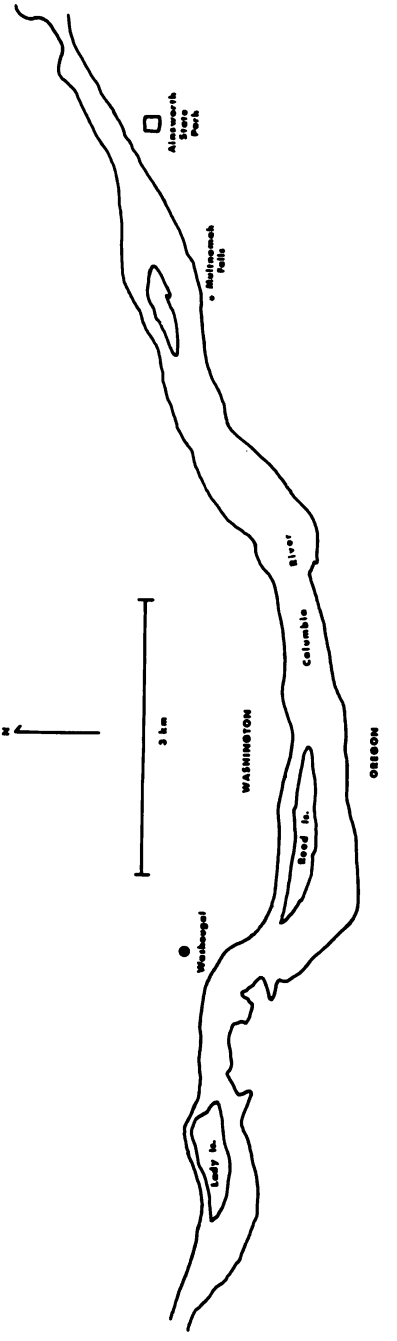


Figure 4. Geographic area east of Portland, Oregon, that contains Columbian white-tailed deer.

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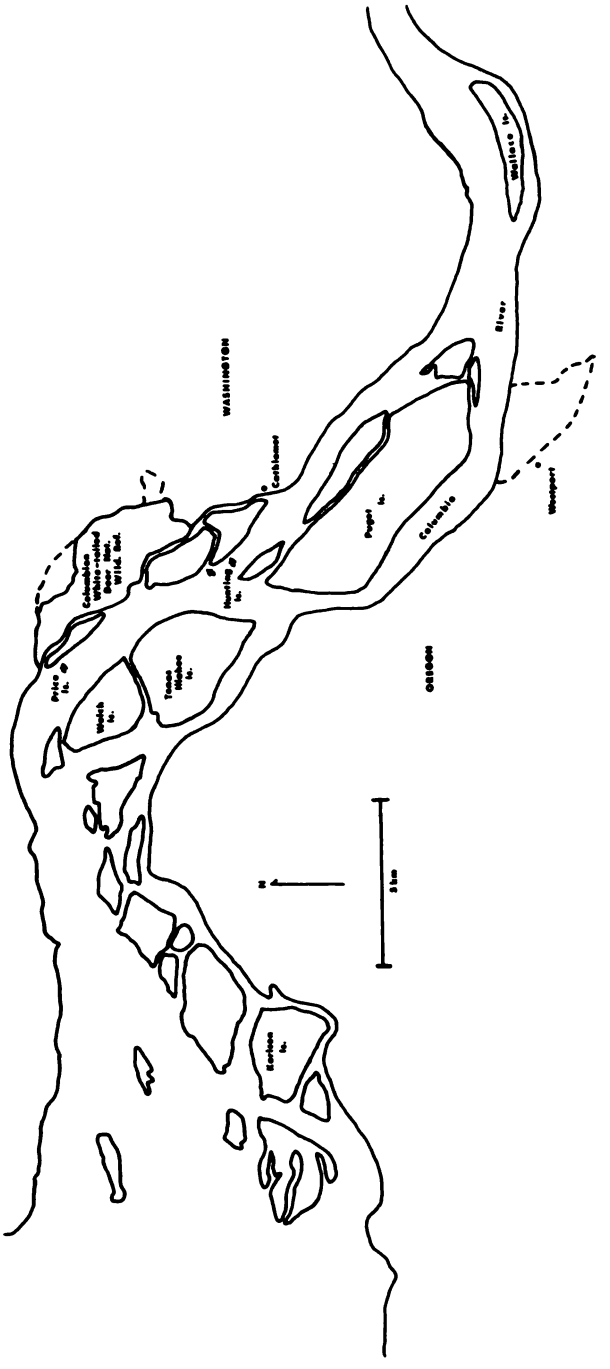


Figure 5. The geographic area, along the lower Columbia River, where the most dense populations of Columbian white-tailed deer occur. Dashed lines refer to mainland areas of private land where whitetails have been observed.

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Table 1. *Comparison of the number of Columbian white-tailed deer along the lower Columbia River in 1939 and 1975*

	Ownership	Area (ha)	Estimates	
			1939	1975
Washington shore near Cathlamet	Refuge	790	250–350	≥ 200
	Private	285		2–5
Hunting Islands, Washington	Refuge	390		several (?)
Price Island, Washington	Refuge	119	2–5	2–5
Tenas Illahee Island, Oregon	Refuge	830	2–5	≥ 50
Puget Island, Washington plus adjacent islands	Private, with some state land	3239	150	≥ 30
Vicinity of Westport, Oregon	Private	607	100–200	≅ 25
Wallace Island, Oregon	Private	364	several in the past, no evidence of any in 1939	whitetail skull found, fresh deer sign present; presumed to be whitetails present in small numbers
	Total	6624	507–710	307

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apparent there has been a decrease in the total number of deer. Scheffer's estimates were based on personal interviews with hunters, landowners and biologists and a brief reconnaissance of the area. The 1975 estimates were based on familiarity with these populations over a 3 year period (Suring 1974, Gavin unpub. data), and the use of a modified Petersen Index in estimating the size of the Refuge herd (Gavin unpub. data). Since the more recent estimates are known to be conservative, the decline along the lower Columbia River may not be as significant as indicated by the totals. The greatest changes have occurred on Puget and Tenas Illahee Islands, with a significant population decrease and increase respectively, and near Westport, Oregon where CWTD are now restricted to the western section of that diked flood-plain. These three trends are thought to be real, not simply artifacts of the census methods.

Currently, densities range from about 1 whitetail per 100 ha on Puget Island to a high of approximately 1 per 4 ha on the mainland portion of the CWTDNWR. It is important to note that these deer are not uniformly dispersed, so that actual densities for localized sections of either of these areas may be significantly higher or lower than those given here.

5. CRITERIA FOR ASSESSMENT OF STATUS

It would seem that knowledge of four aspects regarding the distribution and abundance of any endangered species is preliminary to an evaluation of its potential for survival:

1. Its geographic distribution, to include the size, shape and proximity of disjunct areas containing any members of the taxon.
2. The present size and recent historical persistence of each population within the taxon. (The persistence and density of the population can probably be used as a relative measure of habitat quality.)
3. The magnitude and/or frequency of dispersal among the extant populations.
4. The security from human degradation of the habitat of each existing population.

Obviously, complete knowledge of any taxon with respect to these aspects is virtually impossible, but the closer we come to attaining that ideal, the more reliable will any assessment of status become.

Given an array of endangered species, each of the above factors can vary in importance, relative to the other three, to lower that taxon's probability of extinction. For example, a high dispersal potential is more important to a taxon with small, widely-spaced populations than to one with large populations in close proximity. Certainly some minimum requirements must be met within each category before the endangered taxon has a reasonable chance of surviving, but there must be an almost infinite number of combinations that will allow a species' survival (Fig. 6).

For each population, its mean size $\bar{x}$, and standard deviation, s, need to be calculated for a series of years. A t value is then computed using the formula from Simpson *et al.* (1960):

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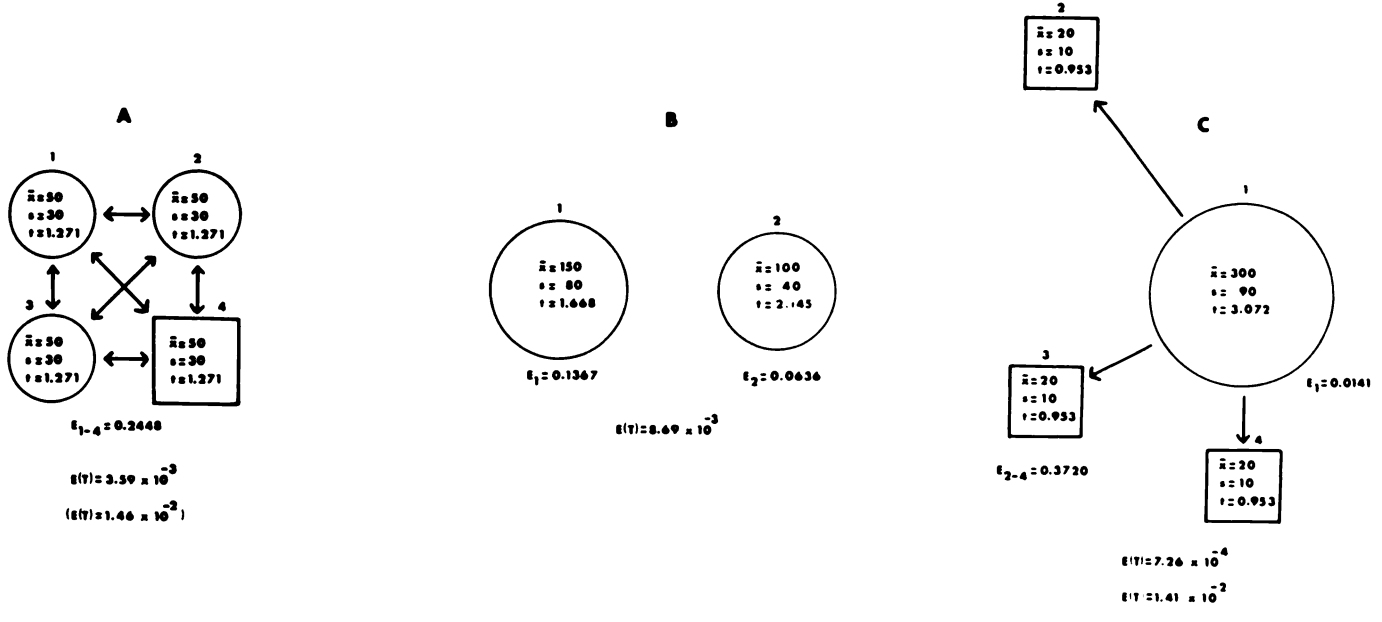


Figure 6. Three hypothetical sets of population-biogeographic characteristics of the same taxon. Circles represent "secure" habitat, squares represent "non-secure" habitat and arrows indicate the direction of dispersal. See text for full explanation.

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$$t = \frac{(\bar{x} - x)\sqrt{N/N+1}}{s}$$

where x is that minimum number of animals below which the population cannot recover and N is the number of years in the time series. Degrees of freedom equal $N-1$ and the probability of extinction is determined from a t table. A discussion of the validity of using this approach with a K-selected population exhibiting density dependent effects if found in McCullough (1978). He concludes, as I do, that this attempt at quantification is a worthwhile supplement to our personal judgment in assessing the probability of survival.

Both N and x were set equal to 10 in Figure 6. In Fig. 6A, each population had the same t value due to identical population characteristics, although not likely to occur in nature. The probability, E, of any one of these populations going extinct is therefore 0.2448 or about 1 in 4. However, assuming that the probability of extinction in one population of Fig. 6A is independent of any of the other populations, then the probability of the entire taxon going extinct in any one year is:

$$E_1 \times E_2 \times E_3 \times \ldots . E_n = E(T)$$

where E_1 is the extinction probability of one population, E_2 is that of the second etc., and $E(T)$ is the probability of extinction of the taxon to which these populations belong.

Any E_1 then represents an estimate of extinction probability based on a population mean and the past fluctuations of that population will behave similarly to the past. Obviously, if the habitat within which a population is found is totally destroyed by man, its probability of extinction will rise exceedingly high, regardless of the E_i that was calculated and based on past population performance. Because of this, security of habitat must be considered somewhat independently of documented population attributes. Revised $E(T)$ value are shown for Figs. 6A and 6C after assuming that all populations in "non-secure" habitat are totally lost due to human degradation of habitat. This increases $E(T)$ in 6A and 6C to about 1 in 68 and 1 in 71 respectively.

The remaining aspect to consider here is the dispersal among the populations in a taxon. Active dispersal should benefit a taxon in at least two ways:

1. By reducing the probability of deleterious genetic effects (e.g. inbreeding depression) brought about by small population size.

2. As a source of new individuals to a population that is declining toward x, the minimum size needed to remain viable.

These relationships are impossible to quantify at this time, although the addition of immigrants to a population may be reflected in $\bar{x}$ and s. However, if dispersers are more successful at establishing themselves in another population when it is at low density rather than high density, which seems reasonable biologically, the probability of this population dropping below x

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is decreased. If this buffering effect is efficient enough, it is conceivable that populations with less than x members, and incapable of recovering on their own, may be returned to a viable level through immigration. Knowledge that dispersal does occur among a taxon's populations, then, allows us to view its $E(T)$ in a conservative manner. Of course, the E_i value can also be made more conservative by choosing a higher value of x for its calculation.

This discussion is not meant to duplicate that of Bunnell (1978) or summarize the ideas found in Diamond (1975), Wilson and Willis (1975) or Terborgh (1975) regarding the design of nature preserves. The question they addressed can be stated: Due to the practical limitation (e.g. finances) of acquiring land for nature preserves in the protection of earth's fauna and flora, what are the optimum sizes and geometric designs that would minimize species' extinctions? My viewpoint was suggested by a slightly different question: How can we assess a taxon's probability of extinction given a real-world conglomerate of distribution, habitat security and population characteristics?

Figure 6 is intended to simulate actual relationships that may exist among these variables. We could conclude that the cervid in this example has a reasonable chance of survival in each situation and that the actual probabilities of extinction are quite similar, once we consider all factors, despite their very different population-biogeographic attributes. The point is that no one set of conditions is necessary to ensure reasonable survival for an endangered deer. A quantitative assessment with established guidelines should be concluded on any taxa that are candidates for reclassification to a less threatened category.

In summary, the approach consists of computing an $E(T)$ based on each population's probability of extinction within that taxon, and then evaluating the $E(T)$ in view of habitat security and dispersal among those populations.

6. THE COLUMBIAN WHITE-TAILED DEER

Table 2. *Population estimates for the mainland portion of the Columbian White-tailed Deer National Wildlife Refuge*

Date	Estimate	Method
1972–73 (winter)	200–230	daily census routes, spotlight index
1975 (January)	203	modified Petersen Index
1976 (January)	159	modified Petersen Index
1976 (November)	165	modified Petersen Index

Thus far, there are population estimates for only 4 years for the CWTDNWR mainland (Table 2). This small sample size precludes any meaningful test of normality. I have, therefore, assumed normality and computed a t value as a starting point. To estimate the probability of extinction conservatively, we will use a higher value of x, the minimum population size needed for survival,

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than is probably required. By using the midpoint of the 1972–73 estimates (i.e. 215) in our calculation of $\bar{x}$ and a value of x equal to 10, then:

$$t = \frac{(185.5 - 10)\sqrt{4/5}}{27.682}$$

$$= 5.670, \quad \text{with} \quad 3\,\text{d.f.}$$

Then, $E_1 = 0.011$ or about 1 in 91

Price and Hunting Islands are so close to the Refuge mainland that the whitetail population in this area can be treated as one (Fig. 5). The habitat on these islands is essentially "natural" (i.e. heavily wooded and brushy) and supports very low densities of whitetails as compared to the mainland, with its history of intensive agricultural use. Whitetails have been documented as moving between Price Island and the Refuge mainland (Paul Painter, unpub. data).

To estimate the overall probability of extinction of CWTD along the lower Columbia River, we will have to be even more hypothetical than when dealing with the Refuge mainland. This is due to the lack of any substantial data base on population size and fluctuation of the other populations. We can do this by using conservative population estimates available for those other areas and adopt standard deviations for those means that are comparable to the s found in the Refuge population. This can be done simply by finding that value of s that will result in the same coefficient of variability (CV) as for the Refuge mainland, where $CV = 100s/\bar{x}$ (Steel and Torrie 1960). This procedure assumes that the magnitude of population fluctuation in all lower Columbia River areas is the same. Since all of the populations that will be analyzed in this manner lie within a 25 km stretch of the river and occur in nearly identical habitat, the assumption is probably warranted. The populations that can be dealt with here includes those on Tenas Illahee and Puget Islands and the area near Westport, Oregon – populations in one "secure" and two "non-secure" habitats respectively.

Tenas Illahee Island was believed to support about 50 whitetails for at least several years prior to 1976, when the dike that surrounds most of the island was breached. This resulted in the inundation of 730 ha of the 830 ha island, reducing its carrying capacity. The dike was recently repaired, but complete recovery of the deer habitat may take several years.

If we use a conservative mean of 20 deer for Tenas Illahee, based on census work done after the dike broke, and $s = 3$, $x = 10$ and $N = 2$, we get $t = 2{,}721$ with 1 d.f., then $E_2 = 0.242$. Similarly, Puget Island with $\bar{x} = 30$, $s = 4.5$, $x = 10$ and $N = 4$ has $t = 3.975$ with 3 d.f., then $E_3 = 0.032$; the Westport population with $\bar{x} = 20, s = 3, x = 10$ and $N = 4$ has $t = 2{,}981$ with 3 d.f., then $E_4 = 0.062$.

Thus, the probability of all four CWTD populations along the lower Columbia River dropping below the critical minimum of 10 animals in the same year is the product of four probabilities, or 0.011 x 0.242 x 0.032 x

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$0.062 = 5.2 \times 10^{-6}$. If we consider only the two "secure" or refuge populations, the probability increases to 2.7×10^{-3} or 1 in 370.

There are several aspects to this exercise that need further explanation and emphasis. Movement of CWTD has not been documented among any of the four populations treated here. However, dispersal from Tenas Illahee Island to downriver areas does occur occasionally. The fate of these emigrants is unknown, but the islands downriver from Tenas Illahee do not contain suitable habitat for deer, with the possible exception of Welch Island. The other islands on which whitetails have been recently observed, Karlsen and Wallace, may be only temporary refugia for transient animals (Fig. 5). These cannot be counted upon to lower the probability of extinction for the general geographic area. Movement data for the CWTDNWR mainland population (Gavin, unpub. data) indicate these deer are extremely sedentary; this includes the yearling age class. If this is true of the other three populations discussed, then we are correct in treating them as independent, each with its own probability of extinction.

The probability of CWTD extinction for the lower Columbia can be viewed as conservative, based on the data used in the formulae for each population. The $\bar{x}$ used for the Refuge mainland approximates the true mean for that population. However, the census data used for the other areas more nearly represents the minimum number of deer known to be present, rather than the actual mean. This, together with what is probably a slightly inflated value of x, 10, yields higher probabilities of extinction than are actually the case. Of course, if the approach taken is too conservative, the output will be of little practical use.

The "apparent" as well as the "real" extinction probability can be lowered in several ways. (a) As N gets larger, the probability will decrease due to the nature of the formula and more degrees of freedom, even though the population mean remains the same. This can be effected by continuing data collection for more years. (b) Every population discovered will decrease the "apparent" $E(T)$ of that taxon dramatically, even though the new population has a high E_i. For example, the discovery of a small, isolated group will reduce the taxon's probability of extinction (in a given year) by one-half, if the E_i for that newly found group is 0.5. This makes early identification of these populations very important in assessing an endangered species' status; it also alerts conservation agencies so that habitat security can be provided if possible.

The "real" extinction probability can be reduced by establishing new populations through transplantation. This may occur naturally via dispersal and colonization, but dwindling habitat for most endangered deer makes it unlikely. Securing habitat that contains an endangered species is somewhat analogous to the establishment of a new population; this also lowers the "real" $E(T)$. This was accomplished for the CWTD by the purchase of private land, but can also be obtained by guaranteed land practices on the part of the private landowner. This latter approach may soon move the Westport, Oregon, whitetail population into the "habitat-secure" category, without the purchase of any land (CWTD Recovery Team, pers. comm).

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In addition to direct human degradation of habitat, there is the possibility of a catastrophic event adversely affecting several populations at the same time. For example, flooding of the Columbia River would affect all CWTD populations for which E_i were computed, rendering these probabilities meaningless. The occurrence of such an event, although unlikely, may serve as the greatest single threat to endangered taxa with small, clustered populations.

The formula used to calculate these probabilities must be utilized with caution, as was pointed out by McCullough (1978). The probabilities can serve only as a guide, since the major assumption is that those events that affect population size will continue as they have in the past. This is almost never true where man's activities are involved, and therefore, the emphasis is placed on the $E(T)$ using only "secure habitat."

In the case of the Columbian white-tailed deer, a probability of extinction along the lower Columbia River within "secure" habitat is 1 in 370. With the possibility of the Westport population becoming "secure" and with the expected population growth on Tenas Illahee Island, there is a good cause for optimism. If the whitetails found in Douglas County, Oregon are found to be *leucurus*, and in view of the recent discovery of CWTD on the Columbia River east of Portland, there would be compelling reason to recommend removal from the "endangered" category.

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PART I: THE IUCN THREATENED DEER PROGRAMME
3. SPECIES OF WHICH SOME POPULATIONS, AT LEAST, ARE RECOVERING OR HAVE RECOVERED

Summary of Discussion

Swamp deer (northern) ***Cervus duvauceli duvauceli*** **(A. Singh)**

In the absence of Mr. Arjan Singh, this paper was summarized by M. K. Ranjitsinh. In addition to the research needs identified in the paper, he considered that more information is required on the use of fire in the maintenance of the grasslands and its long term effects on the grassland ecosystem as a whole. It was felt that this area was another where international cooperation between India and Nepal was needed to promote the conservation of swamp deer on their adjacent borders.

Swamp deer (southern) ***Cervus duvauceli branderi*** **(H. Panwar)**
Studies were continuing in Kanha on the management of grasslands, the relative merits of grass cutting and burning at varying intervals of time, and the effects of vegetation succession and the swamp deer's ecological requirements.

If unaccompanied by fire, grass cutting by local people after a normal growth cycle appears to have little effect on the grass species or their vigour; in addition, it serves to reduce the hazard of serious, uncontrolled fires. It must be limited to a short period of time, however, to reduce human disturbance to the deer's breeding activities; the use of bullock carts to remove grass must also be restricted to avoid soil compaction, and the demand controlled by issuing cutting permits only to local villagers who have a traditional claim on this resource. Cutting should be rotational and restricted to those areas indicated by the Reserve authorities. These innovations are being applied gradually as abrupt changes in land use practices such as grass cutting could result in local resistance to the Park's conservation programme as a whole.

Whilst recognizing the need to promote local understanding and cooperation in conservation, which may involve changes to land use practices of long standing, it was felt that the protection of endangered species such as the swamp deer and the tiger in Kanha justified emergency action. The benefits of better conservation of the area, such as improved stream flow, assured sources of grass, fuelwood and other forest products, and promotion of income from tourism, would be apparent to local people after some years. In the meantime, the removal of villages and restriction of forest produce collection had not impaired the scope for local support for conservation in the long term. A broadly based community development programme was

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being developed in areas adjacent to the Park and the needs of displaced villagers were well considered. They were provided with alternative land and improved housing, education and medical facilities. The success of many conservation measures ultimately depended upon good planning and timing. The relocation of villages in mountain national parks in Nepal was stated to be an infinitely more difficult problem. There were, apparently, no alternative areas available for villages in the mountains and these people were culturally and physiologically unadapted to lowland conditions.

It was recommended that the captive herd of swamp deer in Kanha should be retained for the time being for study and as a potential source of animals for reintroduction. The deer should be marked before release. It should not be assumed that these animals were a social unit as had been suggested.

The continuing increase in swamp deer numbers at Kanha was considered to be very satisfactory, and the proposal to translocate a small herd to the Halon Valley, which has recently been added to the Park, was endorsed.

Tule elk *Cervus canadensis nannodes* (D. McCullough)

The main conclusions arising from discussions on this subject were, first, that the main threat to the survival of well-protected deer populations in a confined area such as the Owens Valley was a crash in the population if these animals exceeded the carrying capacity of the range. An estimate of the maximum biological capacity of the Valley had been made and deer numbers would be reduced if this figure were exceeded. Secondly, whilst conservationists in many developing countries are, rightly, endeavouring to increase public awareness of the conservation issues, this case history demonstrates that under certain circumstances increased awareness can create obstacles, as well as support, for sound conservation measures.

Columbian white-tailed deer *Odocoileus virginianus leucurus* (T. Gavin, E. C. Meslow, F. Martinsen)

Three presentations were made on the study and management of the Columbian white-tailed deer. A case history paper on the deer was subsequently prepared by Mr. Gavin and is reproduced in these Proceedings.

The biology, history and present status of the deer was reviewed by Mr. Tom Gavin, Oregon State University.

The current populations in the Columbian White-Tailed Deer National Wildlife Refuge and the islands on the Columbia river is estimated to be around 400 animals. A further population of questionable systematic status occurs 320 km south of this area in Douglas County, Oregon; there may be several hundred white-tailed deer in the county but no accurate estimates exist. Population decline has been caused principally by intensified agriculture (drainage and scrub clearance) and hunting.

In 1968, the deer was given endangered status and a 5,600 acre (2,265 ha) refuge was purchased. The mainland portion of the refuge, which is about 2,000 acres (810 ha) in size, has consistently held approximately 200 deer for the past few years. The refuge is an ecological "island" bounded by the river,

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a highway and unsuitable habitat. Agriculture has been gradually reduced on the refuge.

A fact sheet, which summarized life history data collected during the current study was distributed.

The role of the Columbian white-tailed deer recovery team was summarized by Dr. E. Charles Meslow, U.S. Fish and Wildlife Service. The recovery team approach is now used for all designated endangered species in the USA. The team is composed of members of all agencies involved in the conservation of the species. In this case, membership includes representatives from the Oregon Department of Fish and Wildlife, the Washington Department of Game, and the U.S. Fish and Wildlife Service. The team has a small budget of $2,000, mainly to cover the cost of meetings.

The task of the Recovery Team is to prepare a plan which assigns responsibilities for research and management for the rehabilitation and recovery of the species.

The Team is basically an advisory body and has no powers of enforcement, although its recommendations are usually followed as there is arrangement for public involvement throughout its deliberations. One of its main functions is to identify and recommend the designation of critical habitat for the species to the US Secretary of the Interior. Once an area has been designated, under existing legislation, Federal funds may not be used for any development that would adversely affect the species or its habitat. All agencies and the public are involved in the process.

Endangered species are totally protected throughout the country but there may be an argument for transplanted animals to revert to ordinary status. For example some potential reintroduction sites for the Columbia white-tailed deer may have to be rejected because they adjoin agricultural land and, under existing arrangements, animals that cause damage cannot be controlled.

The recent history and current plans for the study and management of the Columbia white-tailed deer in Washington State was outlined by Mr. Fred Martensen, Washington State Game Department.

Until 1970, the deer were hunted, employing a bucks only season. Additional hunting seasons were declared, as required, to reduce marauding animals in agricultural areas. The State now pays compensation for crop damage. The largest annual harvest in recent years was approximately 100 deer.

The State has completed several research projects and five new projects (on food habits, systematics, distribution, disease and parasites, and transplant studies) are about to begin.

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PART I: THE IUCN THREATENED DEER PROGRAMME

4. FUTURE DIRECTION AND ORGANIZATION

A review of its objectives, achievements, shortfalls and future requirements

COLIN W. HOLLOWAY

ABSTRACT

An assessment of the accomplishments of the IUCN Threatened Deer Programme since January 1974, matched against its original objectives suggests that most projects in the reasearch phase appear to be meeting these objectives and that the results of those in the conservation phase are very good. The major organizational requirements for the future are considered to be a phased five year plan of operations, to cover both field and supporting projects, and an assured source of funds to cover all planned activities. Some components for the plan are suggested, together with preliminary estimates of cost, as a basis for discussion.

INTRODUCTION

1. The purpose of this paper is to provide a basis for discussion on the future direction and organization of the IUCN Threatened Deer Programme. The paper examines the accomplishments of the Programme against its original objectives, identifies shortfalls in these achievements and proposes measures to remedy them in the future.

ESTABLISHMENT AND OBJECTIVES

Establishment

2. The IUCN Threatened Deer Programme was launched officially in January 1974. Preparations for the Programme had, in fact, begun in late 1970. They involved the establishment of contact with governments of countries in which world threatened species of deer occurred (to acquaint the governments with proposals for the Programme and to seek their cooperation); revision of the Red Data Book sheets for deer; the initiation of a pilot survey and a research project to provide experience in field project managment; the reorganization of the Deer Specialist Group of IUCN's Survival Service Commission; and the

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publication of two papers on the objectives, tasks and proposed organization of the programme (Cowan & Holloway, 1973; 1974).

Objectives

3. The Programme's objectives were: (i) to improve the status of all species and subspecies of deer that were considered to be threatened with extinction throughout their world range, by the collection and collation of information from research and the development of effective conservation measured based on these investigations; (ii) to stimulate and provide experience in sustained scientific and governmental involvement in the conservation of threatened taxa in general.

4. The species of deer to be covered by the first objective were those included in the mammal volume of the IUCN Red Data Book (Goodwin & Holloway, 1972–76). The scientific and common names of the deer are listed in the Annex, together with their status category ratings. It was reasoned that scientific data on which to base effective management of these deer were in most cases inadequate and that a detailed field research project should be undertaken on each species or subspecies to remedy the deficiencies. Management plans would then be prepared, based on the results of this reasearch, and their implementation would be the responsibility of the government concerned. The immediate aim would be to ensure the survival of the species and the long term aim would be to restore its productive status in the wild.

5. With respect to the Programme's second objective, the Cervidae were considered to be a very suitable subject for a pilot venture of this type that could have implications for the conservation of a wide range of other threatened vertebrate species. There was a substantial volume of data and considerable expertise on deer in the developed countries, which could be fairly readily applied to Cervid studies in other parts of the world. Furthermore, the threatened deer species occurred in a variety of countries and under widely differing geophysical conditions and could be expected to provide experience of a substantial range of ecological, behavioural, human sociological and educational problems.

Coordination

6. The IUCN Secretariat in Morges was to be responsible for the Programme's coordination and was to be assisted in this task by the Survival Service Commission's Deer Specialist Group. In addition to acting as a consultative body to IUCN on all conservation matters relating to the Cervidae, the Group was specifically required to identify principal objectives in threatened deer studies and provide critical reviews of field project proposals, given guidance in study projects and the formulation of management plans, and determine priorities for further investigation and action. Group membership was to be drawn from supervisors of field studies or senior field researchers, resource managers of areas containing significant populations of threatened deer, and other scientists and conservationists with special interest and expertise in these fields. Contact between members was to be maintained principally by correspondence but it was proposed that, sometime after the programme had

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been effectively launched, a working meeting of the Group would be held to review progress and re-assess the aims and priorities of the Programme. A newsletter, to be issued twice yearly, would provide all members with summaries of the progress made.

7. No special provision was made to fund the Programme. It was stated that the World Wildlife Fund was ready to consider approved field projects for funding but that project approval by the Deer Group would not carry a guarantee that funds would be forthcoming. It was hoped that some projects would be financed from university research grants and similar sources, and the possibility was to be explored of creating a "patronal committee", of representatives of hunting organizations and other interested individuals, which might consider the provision of funds for threatened deer studies, especially in developing countries.

ACHIEVEMENTS AND SHORTFALLS

Field Surveys and Research Projects

8. In the present context, field surveys refer to brief investigations into the status of one or more deer species during the course of a few days up to several weeks; research projects refer to detailed etho-ecological studies, normally of one to three years duration.

9. By August 1977, two regional field surveys (covering a total of 11 countries and 14 species or subspecies of deer), eight status surveys and ten research projects (including two continuing national projects that were incorporated into the Programme) had been initiated under, or in association with, the Threatened Deer Programme. In addition, one regional survey, four field status surveys and a research project on world threatened deer initiated during this period, were outside the Programme but could lead to its involvement at some subsequent date.

10. The objectives of the regional surveys were to establish contacts within government departments and ascertain their interest in establishing or cooperating in field projects, to assess existing facilities for field projects and identify study areas, and to revise information on threatened and potentially threatened deer. The first survey was undertaken in Asia, in 1974: it included Burma, India, Nepal, Pakistan and Thailand and concerned the Himalayan musk deer, Fea's muntjac, Persion fallow deer, the northern swamp deer, the Manipur and Thailand brow-antlered deers, the thamin (*Cervus eldi thamin*), which is a candidate for the Red Data Book, the shou and the hangul; only six of these deer were actually covered in field visits, current data on the remainder being obtained through verbal enquiries and correspondence (Holloway, 1974). The second survey took place in South America, in 1975: it included Argentina, Bolivia, Brazil, Paraguay and Peru and concerned the marsh deer, pampas deer (three subspecies), huemul and taruca (Jungius, 1975). A third survey, outside the Programme, also took place in South America in 1975 and 1976, covering different regions of Argentina, Bolivia, Brazil and Paraguay and including status surveys of marsh and pampas deer (Schaller, 1976a & 1976b).

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11. Field status surveys were completed in respect of Fea's muntjac, Bawean deer, Calamian deer, Manipur and Thailand brow-antlered deers and the Bactrian deer (Blower, 1975; Grimwood, 1976; Petocz, 1973; Ranjitsinh, 1975; C. R. Miller 1975 pers. comm.); and an extended field survey of the taruca and the dwarf brocket (*Mazama chunyi*), which is another candidate for the Red Data Book, produced information on the status of the species and more detailed ethological data (Roe & Rees, 1976). Field surveys on threatened deer that were undertaken outside the Programme during this period covered Formosan sika (undertaken by a Deer Group member), Corsican red deer, shou and the Barbary deer (Halisse, 1975; Massoli-Novelli, 1975; McCullough, 1974; Royal Bhutan Forest Service 1975, pers. comm.).

12. It is no easy task to assess the contribution that short field surveys (either regional or by individual species) have made to the Programme. Clearly, the field survey can be no substitute for a detailed research project. Furthermore, except where the field worker resides in the country concerned or undertakes his survey as part of a larger project in the region (most of the individual species surveys in the Programme have, in fact, fallen into these two categories), the survey can be expensive in relation to the probable conservation results. However, where contact by correspondence is difficult or impossible, where local information is poor, or where a threatened deer occurs in a number of countries, an on-the-spot assessment of potential study areas and the local facilities for research may be the only sure means of launching an effective research project. Since January 1974, all research projects for threatened deer except one (the huemul study) have been preceded by a field survey to identify a suitable study area and initiate negotiations for local assistance, although the northern swamp deer project was located in an alternative area to the one originally selected. With one further exception (the taruca project), all field surveys under the Programme have been followed by a research project, except where the survey suggested that the project would be politically or logistically impracticable in the foreseeable future (a research project for the Calamian deer is still under negotiation).

12. Only one research project, the original pilot study for the Programme on the southern race of the swamp deer, has been completed and the report published (Martin, 1975). Field work for two other projects (northern swamp deer and huemul) has been completed and reports are in preparation. Three further research projects are operational (for the Manipur brow-antlered deer, hangul and [1] Argentine pampas deer); one project (Bawean deer) has just commenced; and another project (Himalayan musk deer) is awaiting government approval, although the researcher has already undertaken preliminary studies of the deer in the study area. Two on-going national research projects for threatened deer (Persian fallow deer, in Iran, and Bactrian deer, in USSR) have been coopted into the Programme. One additional research project for a threatened deer (marsh deer) commenced in 1977, outside the Programme.

[1] Although included here under the research projects, the Argentine pampas deer project covers both research and management.

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14. Research progress reports have been received on the Manipur brow-antlered deer, which was initiated under the Programme but is exclusively Indian Government financed and staffed, and on the national projects for the Persian fallow deer and Bactrian deer, but at irregular intervals, which makes it difficult to provide an up-to-date assessment of these components of the Programme. Regular reports have been submitted for all the remaining research projects, however, and despite inevitable practical difficulties results have been generally very satisfactory and in accordance with the objectives of the Programme.

15. Nevertheless, one requirement that many research projects with researchers from overseas have failed to meet, is the recruitment of a local counterpart. The problem has arisen not through the negligence of the researchers and their supervisors but through the inability of the governments concerned to find suitable personnel. It admits to no simple solution but certainly merits further thought and investigation. A good local counterpart can provide considerable assistance to a field research project in its initial stages, but his main function is to provide a continuing source of scientific aid and advice to field staff after the researcher from overseas has left.

16. With few exceptions, government cooperation in the Programme has been very good, although the initiation of some projects has been delayed whilst awaiting government approval or visas for researchers; thus continuing delay over official approval for the Himalayan musk deer study presently gives growing cause for concern.

17. One early achievement of the research component of the Programme has been the accumulation of reliable information on the status and ecology of threatened deer. As a result of data collected under the Programme, three more deer have been added to the Red Data Book (Himalayan musk deer, Calamian deer and Cedros Island deer); two subspecies of the pampas deer have been removed, as their status is better than was formerly believed; and thirteen Red Book sheets for other deer have been revised since January 1974.

Conservation

18. Significant recovery of seriously depleted wildlife populations is usually a lengthy process and, as the bulk of the Programme is still in its initial research phase, it is too early to expect evidence of substantial improvement in threatened deer populations. However, field researchers under the Programme are expected to aid local conservation effort throughout the course of their projects, by practical assistance and advice to field management staff, by identifying new areas for protection and by generally setting an example of what needs to be known and to be done. Research progress reports suggest that, as a generalization, where studies are conducted in existing National Parks or reserves, initial improvement in the status of populations is apparent even during the course of the study project; initial improvements are infinitely more difficult to detect in projects located in unprotected areas. Conservation progress during the course of most research projects has been satisfactory and

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in some cases very good, although the precarious position of the Manipur brow-antlered deer shows little change (only 17 individuals are currently estimated to exist in the wild) and could require further emergency measures.

19. Projects under the Programme actually begun before January 1974 (for the southern swamp deer, Persian fallow deer and Bactrian deer) and to be regarded as in the conservation phase all report very satisfactory increases in the threatened deer populations (Bannikov, 1975; Panwar, 1976; Dept. of Environ., Iran, pers. comm.). As the original pilot project of the Programme, the remarkable and continuing increase in the southern race of the swamp deer, formerly a critically endangered animal, is particularly encouraging. It must be realized, however, that the circumstances attending this recovery have been unusually fortunate. The field manager for the swamp deer area throughout this period is very experienced, his activities have been supported by enlightened state and central governments and, in 1974, the area was included in the Indian Government's *Project Tiger* Programme, which has enabled very extensive conservation measures to be enforced. The conservation prospects for the northern race of the swamp deer, the research project for which has recently been completed, are also good, insofar as the main Nepalese population, at Sukla Phanta, again occurs in an *Operation Tiger* area and the main Indian population occurs at Dudhwa, which has recently been expanded into a national park and provided with funds for increased surveillance. The real test for conservation improvement within the Programme is likely to arise within the next few years with the completion of studies on several other Asian and some Latin American deer, where conservation prospects are, presently, less encouraging. The preparation of realistic management proposals and arrangement for international monitoring of conservation progress will be essential and an even greater accent on collection of data directly relevant to prospective management and promotion of initial conservation measures during the research phase may be required.

20. Field surveys, even when not immediately followed by a research project, have drawn local attention to the plight of threatened deer and in certain cases have been instrumental in prompting more concrete conservation measures. Two examples of the latter are the inclusion of part of the Fea's muntjac range in Thailand's *Operation Tiger* reserve, and the establishment of a captive breeding herd of Calamian deer in Europe, which was funded from private sources as an insurance against population depletion in the wild (I. R. Grimwood, 1977 pers. comm.)

Planning

21. In the initial phases of the Programme, there was no urgent incentive to undertake detailed planning of the order and speed of implementing field projects. The programme approach in international nature conservation was still new; there was no Programme budget to prompt orderly phasing of projects; and with many threatened deer populations perilously low there were infinitely more priorities than funding prospects to meet them. Within the very obvious constraints imposed by finance, a basically opportunistic approach was employed in selection of projects, dependent upon urgency

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(principally evidence of continuing decline of populations), expression of government interest in cooperating with the Programme, and availability of researchers with special qualifications for working in a particular country.

22. This situation has now changed. The Programme has reached sufficient size and complexity to make detailed planning essential, both for orderly phasing of projects and Programme comprehensiveness. Furthermore, conservation operations in both IUCN and WWF have now been switched to a programmed approach and an adequate plan for future operations (as well as proven ability to produce conservation results) are of the utmost importance if the Programme is to obtain the type of funding in future that it justifies.

Coordination

23. Basic coordination of the Programme has been the responsibility of one member of the IUCN secretariat since 1970. Membership of the Deer Group has been enlarged during the period of the Project to take account of the increased number of projects and is currently fourteen. Half the members are actively involved in the Programme's field projects as supervisors and researchers or field managers of threatened deer populations, and all have been actively involved in advising on Programme implementation and coordination. To date, the Group have been required mainly to provide critical comment on field project proposals and on the implementation of research projects in the light of research progress reports. Response to requests for advice on the former have been excellent but on the latter have been practically non-existent. Suggestions as to how this impasse might be circumvented have been made in the Group newsletter but the problem presently remains unresolved.

24. Only two Group newsletters have been issued during the Programme period, mainly because of pressure of other work on the coordinator. Six monthly bulletins remain the aim, however, and greater effort will be made in future to attain it. Although originally intended as a newsletter to be restricted to Group members and selected members of IUCN, WWF and IUCN's Commissions, numerous requests for copies have been received from various scientists and laymen interested in deer conservation, and a summary of the last newsletter contained in the IUCN Bulletin was recently republished in the British Deer Society's magazine. As an information/public relations exercise for the Programme there would appear to be no objection to this practice.

Funding

25. The earlier hopes that a proportion of field projects would be financed from university and other research institute funds have proved to be unfounded, and efforts through the WWF to establish a patronal funding committee for deer projects have so far come to nought. To date, most field surveys under the Programme have been financed by WWF, although some have been funded by other international organizations or governments. Of the ten main research projects included in the Programme, three have been financed by governments, one from a private foundation, one through the

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Peace Corps with a WWF contribution, and the remainder by WWF with contributions, in some cases, from governments, the Conseil International de la Chasse (CIC), and some other sources. Since January, 1974, the WWF have made the sum of $5,000/year available to the Programme as an emergency fund, to finance urgent field surveys or conservation operations, or to contribute to larger projects. With this exception, the Programme has had no access to a regular source of unpledged funds.

26. In fact, only one project approved under the Programme (the taruca project) has failed to be implemented through lack of funding. This simple statement, however, conveys no impression of the tremendous restraint that has been imposed on initiation of new project proposals because no financial source to cover their expenditure existed. An assured source of finance adequate to cover all planned activities, at least one year in advance of execution, would certainly appear to be the major future requirement of the Programme.

FUTURE REQUIREMENTS

Planning – Field Projects

27. Under existing arrangements, research projects in the Programme are designed to be precursors of conservation projects. Short field surveys may be required to precede research projects or to ascertain the status of candidate species for the Red Data Book, and it is possible that emergency conservation projects may be required in the future, for example to capture the remaining specimens of a critically endangered species under continuing threat. Nevertheless, the main planning requirement for field projects in the near future will be concerned with the initiation of research projects for threatened deer for which no adequate provision has yet been made.

28. Twenty-nine species and subspecies of deer are currently considered to be threatened throughout their world range and only twelve major research projects have been initiated for them. This figure includes projects for the Columbian white-tailed deer, between which and the Programme it is hoped some formal liaison will soon be established. It also includes a marsh deer project outside the Programme. The number of threatened taxa for which projects under the Programme could be implemented in the foreseeable future, however, is much lower than these figures would suggest. Seven of the remaining world threatened deer occur only within the People's Republic of China and it has not yet proved possible to establish liaison with the authorities regarding their conservation. An eighth deer, the shou, whose range formerly covered the Tibetan-Bhutanese border is now considered to be extinct in Bhutan. A cursory examination of the urgency and feasibility of initiating projects on the remaining nine is provided below:

(1) Fea's muntjac occurs on the Burmese-Thailand border; it is not considered to be under immediate threat of disappearance and the possibilities of initiating an international project in this politically sensitive area are not considered to be good.

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(2) The Calamian deer in the Philippines is categorized as vulnerable: negotiations are in progress between the Survival Service Commission and the Yulo-King ranch (on which a third of the total population occurs) to determine if the ranch authorities would consider the establishment of a reserve and employment of a biologist to study the deer.

(3) The Thailand brow-antlered deer is considered to be critically endangered and occurs in an extremely politically sensitive region of Indo-China. It is now considered to be extinct in the wild in Thailand but the government has plans for a captive breeding and reintroduction project (Pong Leng-Ee 1977, pers. comm.). It is possible that some conservation initiatives could be taken in respect of this deer and Fea's muntjac through the implementation of a national conservation plan for Thailand that IUCN expects to prepare in cooperation with the government in early 1978.

(4) The Formosan sika is almost certainly extinct in the wild; several hundred specimens exist in captivity, however, and proposals have been made for a reintroduction project (McCullough, 1974).

(5) The Ryukyu sika occurs in low numbers on three islands in the Kerama Group. It has been the subject of a study programme begun in 1971 and conducted by the University of the Ryukyus (Sadao Ikehara 1977, pers. comm.). The possible need for additional technical assistance under the Threatened Deer Programme is being investigated.

(6) The Corsican red deer is now confined to Sardinia; it is numbered in the low hundreds although some local initiatives have been taken for its conservation. Contact has been established with Sardinian conservationists and WWF (Italy) to explore the scope for initiating a field project under the Programme in 1978.

(7) The Barbary deer occurs on the Algeria-Tunisia border region; both countries have fairly substantial captive breeding groups. An IUCN staff member has just visited Algeria (January 1978) to determine if an international project for the deer is feasible in 1978.

(8) The Cedros Island deer is critically endangered; the Mexican Wildlife Service have undertaken a field status survey and would welcome the inclusion of this deer in the Threatened Deer Programme (Angel Salas Cuevas, 1977, pers. comm.). A Deer Group member and Wildlife Service personnel will visit the island in March 1978, to consider the most effective means of cooperation.

(9) The taruca in Peru was the subject of an approved research project, which failed to obtain sufficient priority for funding because the species' populations were considered to be higher than originally believed though admitted to be vulnerable. It was to have been included in a national survey of threatened species in 1977.

29. On the basis of urgency and probable feasibility, the Corsican, Barbary and Cedros Island deer would all appear to be possible candidates for research projects in the immediate future. It is suggested that project initiation for these nine species and subspecies over the next three years should be considered a major objective of the Programme and that renewed effort should

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be made to obtain up-to-date information on the feasibility of starting field projects as a basis for Programme planning.

30. Potential candidates for the Red Data Book presently comprise the thamin, dwarf brocket, and the two pudus (*Pudu pudu* and *P. mephistopheles*). Draft data sheets for these species are being compiled on the basis of existing information although current data on the thamin is very difficult to obtain. Field surveys to obtain data on some of these species may be desirable in the foreseeable future.

Planning – Supporting Projects

31. A conservation programme should provide for comprehensive solutions to natural resource management problems, and a series of supporting projects will be necessary to complement the main theme of the present Programme as reflected in the field projects. The formulation of such a list, which might comprise, initially, no more than half a dozen or so proposals, is regarded as an appropriate topic for discussion and resolution by the Deer Group at its meeting to reassess the Threatened Deer Programme. This paper will confine itself to examples of the types of project that might be considered.

32. In regard to the immediate problems set by the Programme on conservation of threatened deer, a critical re-examination of the systematics of some controversial deer species and subspecies (*Muntiacus, Cervus nippon* and *Ozotoceros bezoarticus* are examples of special relevance to the Programme) is suggested; and a comprehensive literature review, to be followed by field surveys if essential, of the current conservation status of all taxa of the Cervidae, would also merit consideration.

33. Under the broader issues of deer conservation as an indicator of threatened vertebrate needs in general, it is suggested that an examination of the possible physiological and behavioural degeneration of deer specimens following long periods of captivity and the problems of their readjustment to the wild following re-introduction might be undertaken. The projected re-introduction of Formosan sika should provide unusually good material for one such study. An investigation into human perception of wildlife, based on the completed, continuing and proposed field projects in the Programme and on its lessons for wildlife conservation, is another potential project that could be considered under this head.

Coordination

34. It is believed that the Programme could be expanded along the lines suggested in this paper without need of additional staff to service operations. The Deer Group may, of course, wish to consider an alternative method to that of coordinating the Programme through the IUCN Secretariat.

35. The principal problem arising from the advisory functions of the Deer Group, as presently prescribed, concerns the requirement to comment and advise on the implementation of research projects on the basis of research progress reports (see para. 23). It may be quite impractical to expect members to provide useful comments on research projects without their having an intimate knowledge of the practical circumstances of the investigation and

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the natural history of the area. The newsletter, if issued regularly, can keep members abreast of Programme development, and the circulation of research reports are not necessary for this purpose. It is suggested, therefore, that in future only the Chairman and any members that request research reports for a particular species should receive them, and that specific requests from field researchers for advice should be sent to the coordinator for forwarding to members with appropriate expertise in the field concerned.

36. It has been suggested that the newsletter should be sent to the senior executives of departments concerned with wildlife conservation in all countries in which threatened deer occur, with a covering letter to request information on the current conservation status of their own threatened deer species. The proposal, perhaps with some modification to the suggested procedure, certainly merits further discussion.

Funding

37. An assurance of finance sufficient to cover all planned activities under the Programme, at least one year in advance of execution, has been identified as a major requirement (see para. 26). In theory, this position could be attained by the preparation and dispatch of detailed project proposals to funding agencies some eighteen months in advance of each project's commencement. The practical difficulties of this process would, however, be substantial. It is suggested that the real aim should be to obtain a sum sufficient to cover the entire programme for a five year period. It would probably need to be procured from more than one funding source.

38. Current rates of inflation make a mockery of financial estimates but it is suggested that, excluding on-going projects that are already funded and new projects that could very probably be financed by governments or other known sources, the cost of a Programme as outlined in this paper over five years would be in the region of $600,000, made up as follows:

Item	*Requirement (US dollars)*
6 field research projects* (2 years field work, researcher & counterpart: 6 months report preparation)	300,000
8 supporting projects*	130,000
Contributions to national conservation projects	100,000
Field surveys	50,000
Contingencies	20,000

(*The actual number of projects is expected to be greater, but some could almost certainly be financed from alternative sources).

39. The potential sources of funding and methods of approach clearly require further discussion. The World Wildlife Fund has been the Programme's main source of support in the past and it is conceivable that one or more National Appeals might consider a special campaign to raise funds for this purpose. The aid and support of Deer Group members would be required both in advising on approaches to other private foundations or hunting associations and the provision of supporting data, slides and other material.

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40. The magnitude of the task must obviously not be underestimated, but the possession of a sound five year plan of phased operations, supported by the Programme's existing experience and achievements to date should provide a substantial base from which to raise the funds required.

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ANNEX

Cervidae *Species and Subspecies considered to be threatened with Extinction throughout their World Range*

* V	*Moschus moschiferus moschiferus*	Himalayan musk deer
I	*Muntiacus crinifrons*	Black muntjac
E	*Muntiacus feae*	Fea's muntjac
E	*Dama mesopotamica*	Persian fallow deer

*For status categories see end of Annex

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R	*Axis kuhli*	Bawean deer
V	*Axis calamianensis*	Calamian deer
E	*Cervus duvauceli duvauceli*	Swamp deer, northern race
E	*Cervus duvauceli branderi*	Swamp deer, southern race
E	*Cervus eldi eldi*	Manipur brow-antlered deer
E	*Cervus eldi siamensis*	Thailand brow-antlered deer
E	*Cervus nippon taiouanus*	Formosan sika
E	*Cervus nippon keramae*	Ryukyu sika
E	*Cervus nippon mandarinensis*	North China sika
E	*Cervus nippon grassianus*	Shansi sika
E	*Cervus nippon kopschi*	South China sika
I	*Cervus albirostris*	Thorold's deer
E	*Cervus elaphus corsicanus*	Corsican red deer
E	*Cervus elaphus wallichi*	Shou
E	*Cervus elaphus barbarus*	Barbary deer
E	*Cervus elaphus hanglu*	Kashmir stag or hangul
E	*Cervus elaphus yarkandensis*	Yarkand deer
E	*Cervus elaphus bactrianus*	Bactrian deer or Bokharan deer
I	*Cervus canadensis macneilli*	M'Neill's deer
E	*Odocoileus virginianus leucurus*	Columbia white-tailed deer
E	*Odocoileus hemionus cerrosensis*	Cedros Island deer
I	*Hippocamelus bisulcus*	Chilean huemul
V	*Hippocamelus antisensis*	Peruvian huemul or taruca
V	*Blastocerus dichotomus*	Marsh deer
E	*Ozotoceros bezoarticus celar*	Argentine Pampas deer or venado

The following deer formerly regarded as threatened with extinction are now no longer so:

O	*Cervus canadensis*	Tule elk
O	*Odocoileus virginianus clavium*	Key deer

* *Status categories:*

E: endangered
V: vulnerable
R: rare
I: indeterminate
O: out of danger

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PART I: THE IUCN THREATENED DEER PROGRAMME

4. FUTURE DIRECTION AND ORGANIZATION

Socio-Ecological Organization and Aspects of Management in South Asian Deer

FRED KURT

ABSTRACT

South Asian deer evolved from forest living forms best represented by the Muntiacinae. In their evolutionary trend they invaded deciduous forests, savanna, natural grasslands and in recent centuries man-made grasslands. Forest deer are rather small and maintain more or less territorial organizations. Savanna and grassland living species, which are taller, maintain gregarious organizations. South Asian deer became in their evolution specialized grazers. More advanced forms have large antlers and their coat is spotted, copying that of a newborn deer which is tolerated by dominant animals.

Recent research suggests that some of the originally forest living species adapted themselves to man-made open habitats, increased their population densities and are to be considered as transitional between a solitary or territorial mode of socio-ecological organization and a gregarious one. Such species are seemingly not regulated by natural regulating mechanisms, except for habitat deterioriation. They can therefore be considered as potential candidates for consumptive use, such as meat and leather production.

Advanced species, such as barasingha, thamin, hangul or shou, are strongly dependent on a natural habitat rich in diverse ecological niches and become seriously threatened when man alters the habitat. Their conservation can only be achieved by sound management of their present habitat and by restoration of lost ecological niches.

INTRODUCTION

A large number of investigations have been carried out on the ethology, ecology and sociology of African ungulates. In South Asia, however, such field studies must be considered as exceptional (Schaller and Simon, 1970) and in the last decade only a few data on deer behaviour became available through medium term studies of such threatened species as the Barasingha (*Cervus duvauceli*) by Martin (1975), the Hangul (*Cervus elaphus hanglu*) by Schaller (1969) and Kurt (1976 and 1977) or through more extended studies and surveys of threatened species and habitats (Hoogerwerf, 1970; Eisenberg and Lockhart, 1973; Kurt, 1973). Some of these first findings on sociology

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and ecology of South Asian deer are summarized in this paper to formulate a hypothesis concerning the evolution of socio-ecological organization in South Asian deer. I hope this first approach will stimulate discussion and may result in identifying central problems for research as well as management of the rich deer fauna of the region, which needs attention for several reasons.

In South Asia's fast dwindling wild areas deer must be considered as the most prominent ruminants, or indeed often as the most prominent ungulates present (Table 1). Therefore nature protection measures to maintain these ecosystems depend to a certain extent on a basic understanding of the socio-ecology of these herbivores, which reflects both the ecosystem's quality and the deers' generally high adaptability but may result in habitat deterioration after deforestation by man as has happened in Europe (Kurt, 1977) and could be expected to happen in South Asia following upon grass burning or other intensive man introduced habitat changes (Martin, 1975).

A relatively large number of South Asian deer species and subspecies are classified as endangered or threatened taxa in IUCN's Red Data Book. Most of them are more advanced forms like the barasingha, thamin, hangul or shou, which cannot be protected using only such rather "simple" methods as outlawing hunting and poaching, protecting marginal land from utilization by man or reintroducing a breeding unit from a zoological garden or some other area where the species is still viable, but the effective protection of which in fact depends on the practical application of ecological knowledge of food habits and socio-ecological traditions. This was recently proved in South Asia's best managed Kanha National Park by Panwar (1977), where the almost extinct hard-ground barasingha rapidly increased after perennial grasses were allowed to regrow and the deers' traditional breeding grounds were freed from human occupation.

Because of their naturally high abundance deer have a paramount importance for the survival of rare and endangered large carnivores such as tiger (Müller *et al.*, 1973; Martin, 1975), leopard, *Varanus komodoensis* (Hoogerwerf, 1970) or crocodiles (Kurt, 1978). Hence, the conservation of large predators relies on proper management of these prey species, a fact which has been taken into account by WWF/IUCN Operation Tiger in India. Similarly, certain deer species have increased in man-made and/or predatorless lands to such an extent, that they could be consumptively used by man if properly looked after, as suggested by Spillett (1970) for Indian axis deer (chital) or by Hoogerwerf (1970) for the Javan deer. Such exploitation depends again on a sound knowledge of the ecology and social behaviour of the species concerned.

TRENDS IN EVOLUTION OF SOUTH ASIAN DEER

It is generally agreed that the old world deer (Cervinae) evolved from small Muntjacinae of the early Miocene and that larger forms broke away from the small duiker-like muntjacs between the late Miocene and early Pliocene to evolve into second-stage deer with a "three-point" antler pattern instead of

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Table 1. *Estimations of crude densities and biomass of ungulates in some South Asian reserves (1: Hoogerwerf, 1970; (2) Martin, 1975, Panwar, 1977; (3) Eisenberg & Lockart (1973); (4) Kurt, 1978; (5) Spillett, 1966; (6) Kurt, 1977). The densities quoted ignore the variable habitat utilization patterns of the species in question, the crude estimates being based on treatment of each of the reserves concerned as a total habitat (Eisenberg & Lockart, 1973)*

Reserve	Total	Cerdivae						Bovidae							Sus sp.	Rhinoceront.		Elephas maximus
		Muntiacus muntjak	Axis porcinus	Axis axis	Cervus timorensis	Cervus duvaucceli	Cervus elaphus	Cervus unicolor	Antilope cervicapra	Capricornis sumatr.	Boselaphus tragocam.	Bos banteng	Bos gaurus	Bubalus bubalis		Rhinoceros sondaicus	Rhinoceros unicornis	
I. crude density																		
1. Udjung Kul.	9.6	*1.3*	–	–	0.8	–	–	–	–	–	–	0.7	–	–	6.7	0.1	–	–
2. Kanha	29.5	0.8	–	*22.2*	–	0.4	–	1.8	0.2	–	0.1	–	0.9	–	*3.1*	–	–	–
3. Wilpattu	8.1	0.4	–	*5.8*	–	–	–	*1.2*	–	–	–	–	–	0.3	0.3	–	–	0.1
4. Yala South	57.1	+	–	*20.2*	–	–	–	6.2	–	–	–	–	–	*16.1*	*14.1*	–	–	0.5
5. Kaziranga	3.5	–	–	–	–	–	*2.6*	–	–	0.5	–	–	–	–	0.4	–	–	–
6. L. Dachigam	15.6	+	*10.7*	–	–	0.6	–	0.7	–	–	–	–	+	*1.3*	0.4	–	1.0	0.9
II. biomass	kg/km²																	
1. Udjung Kul.	269.6	15.6	–	–	64.0	–	–	–	–	–	–	*140.*	–	–	*210.*	50.	–	–
2. Kanha	1558.	8.3	–	*999.*	–	38.	–	*243.*	3.	–	6.	–	198.	–	62.	=	–	–
3. Wilpattu	734	6.		*263*	–	–	–	158	–	–	–	–	–	82.	8	–	–	*217*
4. Yala South																		
5. Kaziranga	3192	+	160	–	–	57	–	94	–	–	–	–	+	353	8	–	*900*	*1620.*
6. L. Dachigam	278	–	–	–	–	–	*260*	–	–	10	–	–	–	–	9	–	–	–

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the "one or two-point" of the muntjacs (Geist, 1971). Present-day representatives of this group are the sambar (*Cervus (Rusa) unicolor*), rusa (*Cervus (Rusa) rusa*), Javan deer (*Cervus (Rusa) timorensis*), chital (*Axis axis*), hog deer (*Axis (Hyelaphus) porcinus*), Bawean deer (*Axis kuhli*) and Calamian deer (*Axis calamianensis*), as well as the more advanced species of the subgenus *Rucervus*, namely barasingha (*Cervus duvauceli*), brow-antlered deer (*Cervus eldi*) and Schomburgk's deer (*Cervus schomburgki*).

The construction of antlers in these advanced second stage deer is based on a "three-point" plan but luxuriates in a number of supernumerary tines. In barasingha (the name implies '12-pointer') the main beam gives off a number of vigorous vertical tines each of which throws out shoots; 10 to 14 points are usual, though there may be as many as 20 (Prater, 1965).

"Four-point", i.e. sika-like, deer probably evolved in the cold climates of the Himalayas early in the Villefranchian and dispersed from there northeastwards as far as Manchuria and north-westwards to the Mediterranean region of Europe and North Africa, where they are represented by the Atlas stag (*Cervus elaphus barbarus*), by more advanced forms like the fallow deer (*Dama dama*) with palmated antlers and, to a certain extent, by a number of European red deer subspecies with supernumerary tines.

In cold climates the genus evolved from a "four-point" antler plan to become a "five-pointer". These deer appear to-day to be relics of the major glaciations and seem to have dispersed east from Europe during the mid-Pleistocene and survived in central Asia and the Himalayas in areas largely untouched by the ice sheets of the Riss and Würm glaciations. They hybridized with a resident sika-like deer in China and the Himalayan foothills and seem even to have absorbed this old species of the genus *Cervus* (sensu stricto), which would account for their present diversity and the disappearance of sika-like deer from the area. At the periphery of the South-Asian region "five-point" deer are represented by the Kashmir stag or hangul (*Cervus elaphus hanglu*) and the shou (*Cervus elaphus wallachi*). The further development of the old world deer has been described in detail by Geist (1971). His "dispersal theory", linking the disciplines of ethology, ecology and zoogeography into a functional whole, generally predicates, for Pleistocene conditions, a specialization of social behaviour and organization, leading to gigantism, altered body proportions and bizarre hornlike organs, which principally occurred during the post-glacial dispersal into new habitats, while under tropical or pre-Pleistocene conditions social evolution followed ecological specialization.

There is abundant evidence for summarizing ecological specialization of South Asian deer as a development from small forest dwelling species with short antlers like the muntjac to large forms with impressive antlers like the barasingha (Table 2). But specialization also occurred in dentition and food selection. Primitive ungulates like the West African water chevrotain (*Hyemoschus aquaticus*) can be considered as omnivorous since they depend not only on plant food but also on insects and small vertebrates like fish (Bourlière in Kurt, 1963). Carnivorous tendencies, including hunting of birds, have been observed in *Cephalophus dorsalis* (Kurt, 1963) and it is well known that other

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Table 2. *Comparison of body weights, habitats and food preferences in South Asian deer (Hoogerwerf, 1970; Eisenberg & Lockhart, 1970; Prater, 1965; Kurt, 1977; Martin, 1975; Singh, 1977)*

Species	Weight of large males Kg	Habitat type				Food preferrence			
		rain forests	deciduous forests	man-made savannas and grasslands	natural savannas and grasslands	omnivorous	mixed feeders (browser and grazer)	mixed feeders (browser and grazer)	grazer
Tragulus meminna Tragulus javanicus	± 5	+	+			+			
Muntiacus muntjak	35	+	+			(+)	+		
Cervus unicolor	320	+	+	(+)	(+)		+		
Axis porcinus	50		+		+		+		
Axis axis	100		+	+				+	
Cervus timorensis	160		+	+	+			(+)	+
Cervus elaphus	160		+	+	+		+		
Cervus duvauceli	180			+	+				+
Cervus eldi	160			+	+				+

primitive Cervids like the muntjac, which mainly subsists on a variety of fruits, leaves, herbs and grasses, also show some tendency to be omnivores (Hoogerwerf, 1970; Prater, 1975). On the other hand, the advanced South Asian second stage deer, such as the hard-ground barasingha and the thamin, are exclusively graminivorous, depending largely on perennial grasses.

South Asia's natural vegetation was essentially arboreal and natural tropical grasslands and marshes occurred only in riparian flats periodically inundated by flood water of large rivers like the Brahmaputra, in alluvial areas of the middle and lower plains (e.g. of the Ganges), or in a few highlands notably in the Sunda Islands where the landscape is dominated by the monotonous lalang (*Imperata cylindrica*). Nevertheless the few original savanna-like habitats were sufficient to stimulate an evolution in South Asian deer similar to that of the Bovids in tropical Africa (Estes, 1973), from relatively small, water dependent browsers or mixed feeders to specialist grazers like the barasingha or species more or less independent of open water like the Javan deer (*Rusa timorensis*)(Hoogerwerf, 1970).

Two species listed in Table 2 obviously do not follow this general rule: the Kashmir stag and the sambar. Although *Cervus e. hanglu*, next to the

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shou, can be considered the most highly evolved deer in South Asia, belonging as it does to the third stage type with a "five-point" antler plan, its diet is far from being restricted to grass. It is in fact a mixed feeder utilizing food ranging from buds of deciduous scrubs and trees in winter, to Liliaceae in spring and various dicotyledonous herbs in summer (Kurt, 1977). However, the apparent contradiction is a clear confirmation of Geist's dispersal theory, which places the hangul with species which evolved by postglacial invasion into hitherto unoccupied habitats and not by ecological specialization like the tropical grazers. The sambar (*Cervus unicolor*), which is more or less restricted to a variety of often dense forest habitats, is in fact the largest and the heaviest of the south Asian deer (though a considerable range of weight, from 100–320 kg in stags, has been recorded), although one might have expected a small body size in such an animal. In the rain forest, however, the sambar is the only ruminant which does not occur exclusively close to water, its food therefore consisting at times mostly of leaves, fruit and bark of climax forest trees. In such climax forest, the oldest known terrestrial habitat, plants have evolved the most elaborate system of biochemical defences against browse (Whittaker & Feeney, 1971). Ungulates have, however, been able to overcome these toxins to some extent with the help of symbiotic microbes and by selective feeding of plant parts and plant species so that at any one time the individual animal may have relatively little toxin in the gut. Thus, extremely selective feeding is typical of many browsing deer (Juon, 1963), but a further adaptation to toxin in food plants would be the large body size found in sambar, large animals being capable of tolerating bigger doses of toxins than smaller animals (Clarks & Clarks, 1967).

The evolutionary trend from mixed browsers in dense forest habitat to more or less specialized grazers in open savanna or grassland is paralleled by increasing densities (number of animals per km^2 of habitat): e.g. sambar 1–6/km^2 (Eisenberg & Lockhart, 1973; Martin, 1975; Kurt, in prep.); hog deer 5(?)–11/km^2 (Spillett, 1966; Kurt, in prep.), chital 10–25/km^2 (Eisenberg & Lockhart, 1973; Martin, 1975; Kurt, 1978); northern barasingha 30/km^2 (Schaaf, 1977).

The relatively low carrying capacity and the rather dense vegetation hinder gregariousness among terrestrial ungulates in forest areas. The small forest deer have long upper canines, long antler pedicles, small spiked or forked antlers, a long tail and no rump patch. They exhibit the "duiker syndrome", having similar rounded back, long hind legs, low withers, large facial glands and small hornlike organs often hidden in a tuft of long hair.

In open habitats, by contrast, carrying capacity is relatively high and gregariousness is commonly found amongst large mobile species, characterized by sexual and age dimorphisms and optical rather than olfactory communication systems.

SOCIO-ECOLOGICAL ORGANIZATION

Social classes

Animal sociology is concerned with the interrelationship of members of different social classes existing within a given population. These social classes are

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defined by sex and age and by their physiological or, mainly, reproductive status (oestrus, pregnancy, lactation, hard antler, antler in velvet).

In the extremely primitive *Tragulus javanicus*, females become sexually mature at the age of 4½ months. Breeding season appears to be non-existant, since births seem to occur in almost every month of the year. The females come into a postpartum oestrus within a few hours and conceive at that time; hence females can reproduce at least twice a year (Davis, 1965; Hoogerwerf, 1970; Eisenberg & Lockhart, 1973). The following social classes can therefore be distinguished: adult males, adult females (pregnant and lactating), and offspring.

In the more advanced muntjacs, males have a physiologically regulated antler cycle and females conceive only after their offspring are weaned. Hence five social classes are to be distinguished: (1) males in a reproductive condition (hard antlers); (2) males in a non-reproductive condition (physiologically and/or socially, antlers in velvet); (3) pregnant females; (4) lactating females; and (5) offspring.

In larger even more advanced species, the newborn young are not hidden for a long period, as they are for instance in *Tragulus* and *Muntiacus*, but are integrated into social groups a few weeks or even a few days after birth. They reach sexual maturity after one (*Axis axis*) or two to three years (sambar, barasingha, hangul) and can therefore stay with their mothers for an equal length of time, until a new offspring is born, or even longer. Depending on the ecological circumstance, females in these large species may not reproduce every year but only at two year intervals (sambar, barasingha and hangul). Males often reach their largest antler size only after several years, when they become dominant enough to take actual part in reproduction. These dominant stags can clearly be distinguished by their black bodies (hog deer) or black necks (sambar and chital) or by extremely large antlers which often carry grass bundles (barasingha). In these advanced South Asian deer one may distinguish at least the following ten classes: (1) newborn young before weaning; (2) newborn after weaning; (3) yearlings; (4) pregnant females; (5) lactating females; (6) non-pregnant females with a calf at heel; (7) dominant males with hard antlers (physiologically and socially in a position to reproduce); (8) other males with hard antlers; (9) dominant males with antlers in velvet; (10) other males with antlers in velvet.

Advanced tropical deer often have no strict breeding season, so that the 10 different social classes exist at any time of the year, twice as many as in the more primitive muntjacs. The number of social classes existing at a given time in a given population is however reduced in species like the barasingha, thamin and hangul, which have a restricted breeding season. Reproduction is more or less seasonal in the specialized grazers (barasingha and thamin) or in species living in colder climate like the shou and the hangul. Also in north Indian sambar and chital reproduction seems to be restricted to certain times of the year due to relatively extreme climatical conditions (Prater, 1965).

In general we can conclude that large advanced species consist of many social classes, less than half of them belonging to reproductive ones. Hence the social organization of the population readily assumes a hierarchical pat-

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tern. On the other hand, societies of the more primitive small forms consist mainly of social classes which are in a reproductive condition and tend therefore towards a more aggressive social behaviour and so to be organized on a basis of solitary individuals.

Habitat categories

Every species has a series of more or less specific habitat requirements, like food plants, resting, drinking, fawning and wallowing places, etc. According to ecological and climatical conditions the availability of such requirements differs in abundance (density) and in pattern of distribution. They can be well mixed with relatively small distances between them or widely dispersed. Rainforest habitats are generally well mixed and not affected by climatical changes, but in deciduous types of such forests (tropical and others) the mixture varies in abundance and quality with climatic seasons. On the other hand, in savanna and grasslands small species may still find a good mixture of habitat requirements, but large forms, filling more specialized niches, must utilize a system of widely dispersed habitat features, as is shown by their daily activity patterns (feeding takes place in the open, resting in open habitat under single shady trees, fawning in dense woody vegetation, etc.). In habitats with separated niches one can also distinguish between situations which remain more or less the same throughout the year (humid grasslands for instance) and situations where the abundance and quality of vegetation varies with climatic changes during the year (alpine pastures or grasslands in monsoon regions, for instance).

In a situation in which habitat requirements are well mixed, with no seasonal variations, one would expect animal populations to have a sedentary way of life without fluctuations in population density. At the other extreme, where habit requirements are widely dispersed and obey a seasonal climatical regime, one can expect a gregarious organization following more or less pronounced seasonal movements and migrations.

When, in the course of their evolution, ungulates emerged from the tropical rainforest to occupy deciduous forest, savannas and grasslands, selection had to work against strict territoriality and in favour of a social life in the herds. However one should not be too strict about the idea that South Asian deer can only adopt gregarious behaviour in savanna or grassland. The chital is quite often found living in large groups in deciduous climax forest so long as the undergrowth is minimal and there is good visibility. It has become well adapted to the herds of grey langurs (*Presbytis entellus*), living in a commensal association with the langurs by feeding on leaves and fruits plucked but not eaten and dropped by the tree-living herbivores (Nagel, 1973).

Non-seasonal alternating territoriality

It is generally agreed that most primitive ungulates maintain a territorial socio-ecological organization (Estes, 1974). This is well adapted to tropical rain forest habitats where the carrying capacity for ground-living herbivores is low but the same amount of available food is yearlong. Moreover, conditions guarantee an optimal dispersal of the species in its range. Territoriality in deer

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is best represented in the muntjac, where males and females live in single territories and young ones are driven out after reaching puberty within about six months, being exposed to higher compensatory mortality until they can establish themselves in a free territory. But the system is subject to exceptions: thus muntjac males often tolerate other males in their territories provided they do not have hard antlers. It can be assumed, therefore, that territoriality does not occur yearlong in one particular male but only as long as it is in a reproductive phase. Since there is no seasonality in reproduction, territorial behaviour continues throughout the year but is not necessarily manifested in the same segment of the male population. Alternating reproductive and antler cycles in muntjac males do not hinder the population from yearlong breeding but allow each full-grown male to recuperate from the strains of territoriality (Geist, 1973), thus contributing towards an increased population density without stepping up intraspecific aggression.

Territorial overlapping occurs commonly among muntjac at waterholes where Eisenberg and Lockhart (1972) noted grouping and males attempting to court females. Open water must be considered as relatively rare feature in tropical forest where most of the rain is absorbed by the leaves of trees, and the tendency of muntjac towards less strict territoriality in its vicinity seems to have a certain survival value in a small extremely water dependent deer. In *Tragulus meminna*, an apparently non-seasonal territorial species, Eisenberg & Lockhart (1972) found that during the dry season they were suffering from lack of water; in drought conditions in the Wilpattu and Yala national parks of Sri Lanka, three individuals were captured in an advanced state of emaciation. Such a small ungulate obviously has limited mobility. Its home range in Sri Lanka and Sumatra has been found to be mostly confined to areas around permanent water holes and rivers (Kurt, 1970 and 1971).

A slightly more advanced deer than the muntjac, the hog deer (*Axis procinus*), favours grass jungles by the banks of rivers and grassy delta islands. On the banks of the Indus in Upper Sind it lives in scrub jungles close to water and in Burma it was once common in mangroves (Tu Yin, 1963; Prater, 1965). The name hog deer probably came from its pig-like appearance and movements. When running it keeps its head low and shows none of the bounding action so characteristic of deer. While its morphology still reflects the "duiker syndrome", its social organization is definitely far advanced from what is believed to be typical of small forest living species. In dense vegetation, where food requirements of this mixed feeder are everywhere plentiful, hog deer occur singly, in pairs or in small family units of 3 to 5. In Kaziranga's grass-jungle, however, *Axis porcinus* collects into herds of 10 to 20, since the ecological conditions are different with carrying capacity higher on the short grass meadows and ecological niches not mixed but present in a narrow but widely separated woven pattern.

Transitions from solitary and territorial to gregarious socio-ecological organization

In its obviously flexible social organization the hog deer reminds one strongly of the European roe deer (*Capreolus capreolus*) during the summer half year

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when territoriality operates. In its natural habitat, mixed deciduous forest, adult males (in their second year of life) establish territories, defend them against other adult males and mark them with secretion of a skin gland situated between their pedicles (Kurt, 1968). These territories are often maintained throughout the life of the bucks, despite the fact that considerable habitat changes can occur. Yearling males are either tolerated in the vicinity of adults (if weaker) or if already trying to establish their own territories are in due course driven out into less densely populated areas (Strandgaard, 1972). Females separate in spring from their yearlings, become solitary and restrict themselves to a traditionally used fawning area, where the twins are born and raised. In the fall, females with their offspring congregate with their pregnant daughters and occasionally males. In winter territoriality is almost absent, although rank position in adult males can be correlated with distance between fighting place and summer territory (Geiger & Krämer, 1974). In the following year the two-year-old daughter fawns remains in the vicinity of her mother and in the subsequent winter uses more or less the same home range, though they hardly group together, except when either of them loses all her fawns (Kurt, 1968).

In recent decades roe deer populations have increased explosively. This is partly due to lack of natural predators and hunters being unaware of the situation and unable to control the populations, but mostly to intensified agriculture which has greatly increased the carrying capacity of roe deer habitat. Summarizing the results of recent studies on roe deer ecology (Kurt, 1968: Bramley, 1970; Strandgaard, 1972; Mueller, 1972; Hartmann, 1973; Ellenberg, 1974), the following changes in socio-ecological organization seem to have occurred with increasing population density (Kurt, 1977): the proportion of territorial males has decreased, and the age at which males became territorial has risen. In a population where the density of adult males was estimated at 23/km^2, the territorial stage was only reached by males older than 4 years (Bramley, 1970). With increasing female density, the same fawning grounds are used at shorter time intervals; they are no longer traditionally used but almost group-wise subject to prevailing ecological conditions (Strandgaard, 1972). In Europe the roe deer is obviously at present in transition from a seasonal synchronized territorial organization towards a hierarchic gregarious type. In this context, it is of interest that non-territorial males show less pronounced antler growth than territorial males, testicular growth is retarded and, mainly in younger ones, the typical white coloration of the scrotum is absent (Ellenberg, 1974).

Like the roe deer the South Asian sambar (*Cervus unicolor*) is originally a forest living browser, normally solitary and with alternating territoriality independent of season in central and south Indian forests, where reproduction occurs yearlong with one or two peaks, or territoriality synchronised with season in northern India, where reproduction seems to be restricted to a certain period (Schaller, 1967; Prater, 1965). In Sri Lanka, however, the sambar can be observed in large groups of 30 to 40 animals in areas close to the sea, where large grasslands or savannas, so-called "villus", were created by man some centuries ago. The Ceylonese lowland sambar

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lacks the so-called sore spot, a 10 to 15 cm wide bare path on the throat, and, although this has been the subject of much controversy, it is believed to be connected with its territorial behaviour (Schaller, 1967). The large groups do not persist throughout the day, but occur mainly in the early morning and late afternoon or early evening in open areas. The gathering places must have been frequented for many generations, since they are well known to the local people, the largest of them being known as the "gona labbe" or "sambar villu". When grouping occurs, adult males with hard antlers still show a tendency to remain solitary or in small groups, and adult males in velvet also show a tendency to stay in smaller groups, but females and young are increasingly often found in large groups.

Sambar stags with hard antlers or with antlers in velvet may nevertheless form small male groups. But when these groups or solitary stags join female and offspring groups, adult males with hard antlers start to fight, obviously for the possession of the female group. Mixed groups consist of several families (females with newborn young and yearlings), single females, males with antlers in velvet and males with hard antlers belonging to small size classes. But the groups maintain only one dominant stag, recognizable by his dark body, black neck and relatively large antlers. Dominant stags can change constantly in a given herd.

Both by day and at night sambar stay in small groups or singly for resting and wallowing after feeding in the nearby scrub forests. Males are not seen in female-offspring groups during this time, but even frequent such niches as lagoons and sea shores (where they cool themselves in the spray of breaking waves) although feeding along forest edges. Females and offspring feed inside the forest, resting under certain trees, and hardly ever use the wallows and bathing places frequented by the males.

In sambar, separation of adult males and adult females is maintained by different factors: in groups social hierarchies force non-dominant males out to the peripheries of the group; among feeding and resting animals the separation is achieved through different habitat preferences. Observations in Sri Lanka (Kurt, 1978) showed clearly that sambars are not permanently gregarious though they can live in rather dense populations. On the other hand, axis deer, the most typical Asian savanna species after *Cervus timorensis*, must be considered as permanently gregarious, though size and composition of groups may constantly vary.

Gregarious social organization

In open savanna *Axis axis* may attain groups of trememdous size, 800 or more individuals. The same applied to *Cervus timorensis* in Javan high grassland areas, before populations dwindled due to over-kill (Hoogerwerf, 1970). Hartmann *et al.* (1973), studying the composition of *axis* herds of varying size in Kanha national park, found that small groups (less than 100) consist of significantly more females and less males than larger groups, often with a calf at heel. The relatively small male fraction in small groups consisted of significantly more dominant males than occurred in large groups, Small groups, obviously in a reproductive state, were commonly found in open grasslands

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while large groups, where less or no breeding was taking place, were often met with along forest edges. Although separation of sexes is not always very pronounced in the chital, notwithstanding the large all male groups recorded by several observers, e.g. Krishnan in South India, the tendency for such separation becomes obvious if one observes the herds. One or few dominating males with very large antlers and very dark necks constantly keep other males away from the centre of the herd, which frequently results in a clear separation of sexes within a given herd: most of the males form a periphery to the mother-offspring nucleus, with the dominating males in its centre. How far separation of sexes in chital is related to different ecological habitat preferences will not be discussed here. It must be stressed, however, that in chital separation also to some extent results in freeing the home ranges of females and offspring from surplus males, namely those in a non-reproductive state and those of the subordinate age classes.

The more highly gregarious South Asian deer consist of mixed feeders with a preference for grass (axis and Javan deer), the highly specialized grazers (thamin and barasingha) and the hangul, the food of which differs as previously mentioned. In all these species sexual dimorphism is relatively extreme, and the male fraction of the population is characterized by a remarkable variability of antler sizes and forms (Table 3). In these species fighting is highly ritualized and serious combats only actually take place between stags belonging to the same strength and "antler" class. The permanent gragarious species can be characterized by the fact that the coats of adults are either permanently spotted (chital) or with spotting more or less pronounced during the summer half of the year, when young are born. A dappled coat is probably protective since it gives better concealment by breaking up the contours of the body and harmonizing with the flecks of light and shade made by sunshine filtering through the leaves. In cold country, when the leaves fall in autumn, fallow deer (*Dama dama*) and other northern species, including the hangul (*Cervus e. hanglu*) change their spotted summer coats for a uniform livery more in keeping with the uniform light of the winter landscape. How far the protective value of a spotted coat applies to deer living under tropical conditions remains to be investigated, but it is

Table 3. *Comparison of sexual and age class dimorphisms in South Asian deer*

Species	sexual dimorphism			spotted coat in adults			antlers	
	± absent	present	pronounced	absent	occ. present	present	% of shoulder height	number of tines (max.)
Muntiacus	+			+			24	2
C. unicolor			+	+			86	3
A. porcinus		+		+	(+)		62	3
A. axis			+			+	112	3 + (2)
C. timorensis		+			(+)		58	3 + (?)
C. elaphus h.			+		+		102	5 + 11
C. duvauceli			+				77	3 + (17)
C. eldi			+		(+)		89	3 + (7)

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worth remarking that a broken background of light and shade is a more or less constant feature of the forest habitat of the sambar, yet the sambar's coat is without spots throughout the year. By contrast, the chital wears its bright rows of spots at all seasons, which certainly has a protective value in forest, where it replicates the light and shade filtering through the leaves. (Prater, 1965); yet chital seldom live in dense cover, preferring forest or savanna woodland fringes where their bright dappled coats catch the eye and show little harmony with their evenly lit surroundings. It is the same with the barasingha (*Cervus duvauceli*). In the Terai they conceal themselves in tall grass but during the hot season, when their coats are spotted, they come out to feed in the open where grass has been burned or flooded, to feed on the new grass, or they wade into open stretches of water to feed on aquatic plants. A spotted coat under such conditions scarcely makes for concealment (Prater, 1965). Or again, the hog deer (*Axis porcinus*) feeds among reeds and bushes by river banks where there is dappled light and shade, yet when adult it is usually uniform dark brown and only young stags and hinds show some scarcely visible spotting. Of course, the spotting which is so pronounced in the young of all South Asian species, has a definitive protective quality in the dense cover, where the newborn of even highly gregarious species such as the barasingha or the hangul lie hidden for the first days after birth. But in adults spotting seems to function more for social signal purposes and it can be hypothesized that spotted coats in gregarious deer have a function like many other juvenile features, helping towards a suppression of aggression by dominant individuals (see Geist, 1968). Dark coloration of the body or neck is found in species (hog deer, muntjac and sambar) or individuals (sambar, chital, barasingha, thamin, Javan deer, hangul) which live either solitarily and/or territorially or maintain a dominant position within the herd.

Chital stags live gregariously with females and other stags throughout the year. The species shows some seasonal movements governed by water conditions; its density during the dry season around the few permanent waterholes in the Wilpattu and Yala national parks may be ten times as high as during the rains when the population is more widely spread over the system of semi-permanent water resources in the vicinity (Eisenberg & Lockhart, 1972; Kurt, 1978). However, such movements do not amount to migration, which has never had to evolve because chital are not very particular concerning food and can survive for quite a time in commensal association with langurs (*Presbytis entellus*), as already mentioned. Seasonal migration patterns evolved in deer species along with the evolution of prolonged mother-child units (Eisenberg, 1966), as shown, for instance, in European red deer (Schloeth, 1961 and 1966). In chital the prospects for any very lengthy mother-daughter relationship are slim, since puberty is reached at one year or even less and fawning intervals are similarly no more than a year or slightly less (Schaller,(1967). During extreme droughts chital are incapable of leaving their ranges in long-distance search for water and die in large numbers, while Asiatic elephants (*Elephas maximus*) which share the same habitat, migrate to far off waters of which traditional knowledge persists (Kurt, 1978).

Clear migration patterns are found in hangul and barasingha, the fawing

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and rutting of which are clearly confined to certain areas of their habitat (Martin, 1975; Kurt, 1977). In this context it is noteworthy that barasingha stags appear in the rutting grounds before the hinds. It is therefore unclear whether this tradition resulted from the mother-son relationship or from the fact that males form herds. Wallows are traditionally used by barasingha stags over decades (Martin, 1975). Migratory patterns have also evolved in populations where the food and cover conditions change with the seasons and/or temporary over-utilization of the food resources (e.g. red deer in the Swiss national park; Schloeth, 1966; Burckhardt, 1970). In this connection it may be remarked that chances of intensifying the mother-daughter association and of establishing new traditional breeding grounds are increased in areas with sub-optimal food conditions which have the effect of delaying puberty and prolonging birth intervals (as observed for sambar, Javan deer and red deer by Asdell, 1969).

Migration can also occur at irregular intervals due to floods (barasingha) or heavy snow falls (hangul). Whether such movements are traditional or not in deer is unknown, although in the long-lived Asiatic elephant, they are based on traditionally maintained patterns (Kurt, 1978).

Gregarious social organizations based on more or less hierarchical principles are found in those large highly mobile deer which at least to a certain extent live on grass in open forest and scrub country or in natural and man-made grasslands, where their habitat requirements are not well mixed and vary in abundance or distribution according to seasonal or non-seasonal abiotic factors. In all such species males live more or less separately from breeding units, a situation that has come about as a result of social behaviour (*Axis axis*) and/or of different habitat preferences outside the rutting period (*Axis axis*, *Cervus e. hanglu, Cervus duvauceli*).

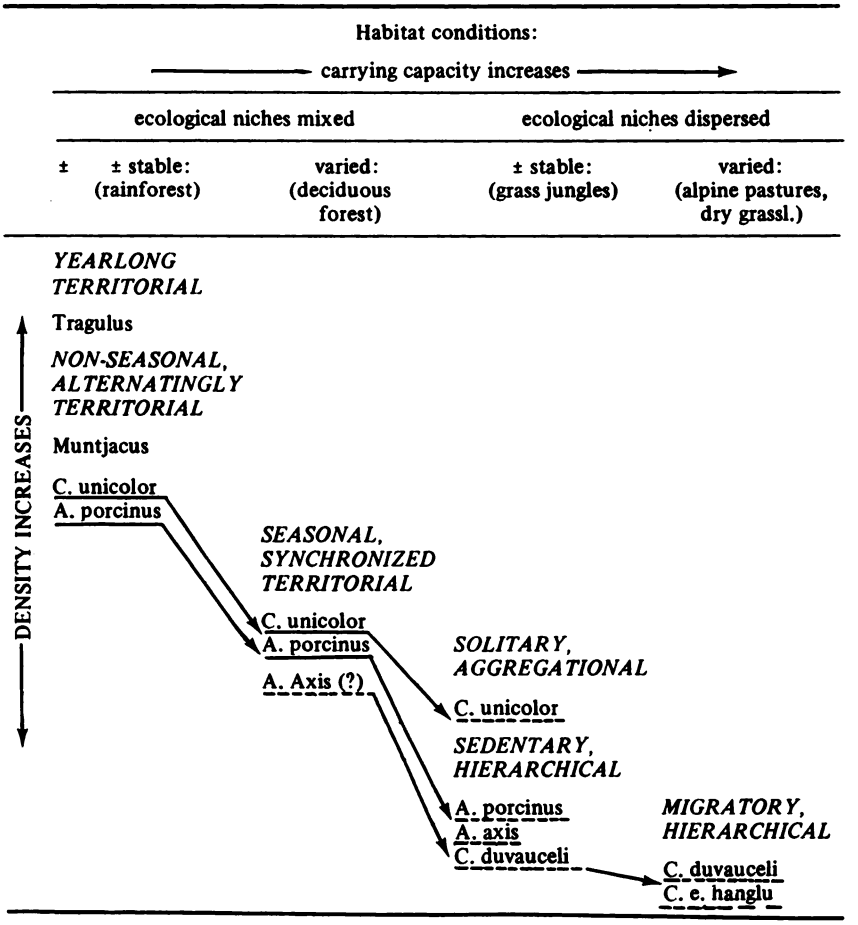
That the present known social organization of gregarious South Asian deer can change under certain ecological conditions must be suspected from results of studies of African antelopes (see Leuthold, 1966) or, to quote an Asiatic ungulate, of feral water buffaloes in the Yala national park (Kummer & Kurt, 1974; Kurt, 1978). In a mixed forest-scrub vegatation, where water and small meadows are well mixed, buffaloes live in mother-offspring units of 2 to 23 individuals kept more or less permanently together by an adult bull. In this type of habitat their density is 10/km^2. In areas of vast man-made grasslands, however, the density rises to 70/km^2 and the social organization is completely different. Here herd sizes may be as large as 850 animals and herds or their sub-units mainly consist either of females or of young or of males. During the breeding seasons bulls establish lek behaviour like kob (*Kobus* spp.) occupying territories of 30 m or less in diameter every day and marking their boundaries with urine splashes.

CONCLUSIONS

A comparison of social organization in some South Asian deer has proven that the more primitive species of the Cervinae, namely *Axis porcinus*, *Cervus unicolor* and *Axis axis*, have flexible responses to habitat changes, natural or

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Table 4. *Adaptation of socio-ecological organizations to habitat conditions and population densities*



man-introduced (see Table 4), so their socio-ecological patterns should not be used for taxonomy. Man introduced habitat changes have led deer from forest areas with relatively low carrying capacities for terrestrial ungulates and well mixed niches to savanna and grasslands with relatively high carrying capacity and dispersed niches. Originally forest living forms adapted themselves to the new conditions, increased their population densities and gave up their strict patterns of territoriality in males by suppression of dominancy, antler development and development of other secondary sexual organs (e.g. white scrotum in roe deer). Clearly they were able to cope with the situation as a result of socially induced physiological mechanisms, a phenomenon typical of more advanced gregarious species such as chital, thamin, barasingha and hangul and illustrated here by juvenile coat coloration, extreme antler dimorphism and ritualized aggressive behaviour.

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Advanced forms, however, seem not to have such a potential for adaptation to man-made habitat and though it is known that the hard-ground barasingha is now restricted to man-made grasslands in Madhya Pradesh, its survival could only be guaranteed after certain habitat changes took place.

Little is known about the threatened muntjacs. It must be assumed, however, that these rather small species, typical of the "duiker syndrome", are too conservative and also too hampered by their rather restricted mobility to adapt themselves to any significant deforestation of their rainforest habitats.

Management problems

Threatened taxa of some of the more primitive Cervinae, namely the Bawean deer (*Axis kuhli*) and the Calamian deer (*Axis calamianensis*), have adapted themselves well to man-made habitats. They are, however, threatened by poaching and their conservation can only be achieved by strict control of poaching and the establishment of a habitat which can be used by the deer yearlong. The same applies to the hangul (*Cervus e. hanglu*).

The advanced grazers, namely the thamin (*Cervus eldi*) and the barasingha (*Cervus duvauceli*) have not only been reduced by hunters and poachers, who were after their huge antlers (often believed to have medical powers), but also by destruction of suitable habitats with perennial grasses, through cultivation, irrigation, grass burn, etc. Their conservation can only be achieved by sound knowledge of habitat conditions and habitat management.

In the Indian pensinsula the advanced species have decreased and the less advanced ones have increased. In both cases this must be considered as a response to interference by man and a sign of unbalanced ecosystems. This is why nature conservation and wildlife management must also pay attention to the fact that a certain species suddenly increases. In this context, two questions need to be discussed in the next two sections, namely why such suddenly increasing species were not controlled by natural predation, since predators are well protected in Indian reserves; and, secondly, what are the possible impacts that large densities of adaptable deer may have on the vegetation?

Predation

In 1969, a IUCN mission visiting Kanha national park suggested that domestic livestock should be kept in the park as additional prey for the tiger population it was desired to protect, because it was feared that the tigers were likely to reduce the number of deer. In fact, both species increased in the next few years: the tiger from 25 in 1965 to 35 in 1972, the chital its main prey from 880 in 1965 to 2050 in 1972. The prey species increased obviously faster than the predator.

Deer breed not only more frequently and more successfully than the large Felids like tiger and leoopard, but also find in the open, man-made savannas both food and better protection from predation by the large cats which do not usually leave the forest for hunting. The Indian wild dog or dhole (*Cuon alpinus*), however, hunts in packs and can easily chase deer in open habitats. A short study on the hunting behaviour and prey of the dhole

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by Keller (1973) came to the conclusion that dogs usually kill stags staying at the periphery of the alert herds; the same was found to be the case with leopards in Sri Lanka (Kurt, 1978). If large predators reduce mainly the male fraction of a population they do little to check population growth and, on the contrary, may even accelerate productivity by freeing the habitat from surplus males. Little or nothing is known of the impact of smaller carnivores, mainly jackal (*Canis aureus*). Although they may exert quite heavy pressure on newborn deer hidden in dense undergrowth, their influence is far too small to stabilize numbers of the prey species, as the growing chital population in several Indian reserves demonstrates. The impact of predators on originally forest-dwelling deer species seem to have been effective only in the natural habitat; in man-made open habitats it can be largely ignored. This, of course, suggests a possibility of cropping large forest-dwelling species now found in man-made savannas, an idea which is worth investigating even by conservationists when vegetation is adversely affected by the deer.

Impact on vegetation

Dense chital populations are thought to have an impact on vegetation, mainly in connection with uncontrolled fires (Martin, 1975) or in connection with introduced or invading plant species such as *Cassia thora* and *Lantana* sp. (Ceylon Dept. of Wildlife). Similar observations have been made on Javan deer in several Indonesian regions (Hoogerwerf, 1970). The effects may include selective reduction of relatively rare plant species, e.g. certain perennial grasses which may be a prominent ingredient in the diet of advanced grazers (Martin, 1975). Although no work has been done on this very important subject in Asian reserves, it is likely that large chital, hog deer and eventually sambar populations may introduce changes in vegetation diversity in the same way as happened in Europe when the small originally forest-dwelling roe deer escalated in numbers and in due course virtually wiped out several orchid species and inhibited the regeneration of certain coniferous trees (Kurt, 1977).

The more advanced species, such as the barasingha and thamin, are not known to have any impact on the diversity of their food plants, mainly perennial grasses. This may be due to the fact that they have become very rare and definitely below the carrying capacity of their range, at least in so far as the wet grasslands of northern and north-eastern India are concerned. In central India grazing by the barasingha does not prevent the vegetation reaching its forest climax and it looks as if in the northern India and Assam the grassland climax may be due to insufficient grazing pressure.

Grass burning

Management of advanced South Asian deer suggests that the carrying capacity of a habitat for these specialized grazers can be improved when open habitat can be maintained over the years in large enough areas. In deciduous forest lands burning has proven insufficient for this purpose, since perennial grasses tend to be seriously reduced by fire and subsequent trampling, depletion of groundwater resources, etc. (Martin, 1975). A more elaborate system of grass

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cutting and patchwork burning (to hinder forest regrowth) has had to be applied (Panwar, 1977). In wet grasslands, however, burning seems to be the only way to increase carrying capacity and seems to have no adverse effect on the diversity of plant species provided the burning is carried out during a period when the stolons are not damaged by the fire. Nor does the burning have any effect on soil and ground water since these areas get plenty of rain and are often flooded.

Habitat orientated conservation

In South Asia the most advanced species are also the most endangered and, while rather primitive endangered Cervinae like *Axis kuhli* and *Axis calamianensis* can apparently be conserved by protecting them from poachers, they do depend on certain plants often destroyed by man in the course of overusing the habitat (perennial grasses in the case of the barasingha and thamin, Liliaceae in that of the hangul) and also on being able to establish themselves in the habitat by the use of traditional rutting and fawning grounds and more occasionally of refuges from extreme conditions such as inundations or heavy snow falls. None of the populations of advanced South Asian deer so far investigated are found in reserves with boundaries corresponding to the original range of the species concerned. Kaziranga may come closest to original conditions since the barasingha can still retreat during extreme inundations of the Brahmaputra to a rather small reserved area in the Mikir Hills. In Kanha the habitat could be improved to favour the hard-ground barasingha by creating artifical pounds which simulate the conditions of low wetlands. But in the hangul's last refuge, Dachigam sanctuary, rutting grounds are constantly disturbed by man and the only possible retreat from heavy snowfalls, the steep south-facing slopes, is occupied by State owned sheep. Similar considerations apply to the forthcoming study on the conservation needs of thamin in Manipur, and research should be directed towards solving the following questions. Is this deer still capable of reproducing itself in its present restricted area? If not can suitable areas be added to the reserve or can such areas be reconstructed?

Reintroduction of advanced deer.

This technique for species that are relatively common in captive breeding herds does not dispense with a sound habitat-orientated study; for example, the area proposed for reintroduction may not include all niches necessary to guarantee survival and breeding on a continuing basis, especially if it is occasionally exposed to extreme climatic conditions. The following facts should always be taken into consideration. Advanced deer are highly mobile, non-territorial and specialized in their feeding. They are, moreover, bound by tradition in the utilization of their habitat. The best approach, therefore, would seem to be to link tradition with reintroduction and accustom the deer to be reintroduced to the new conditions in an enclosure large enough to maintain a breeding population without artificial feeding for a period of three reproductive seasons (until the first generation of locally born females reaches maturity). Such an enclosure was built in Kanha for barasingha. The first

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animals to be released should be part of the male population, since males in these species normally pioneer seasonal movements and losses of males are less important than losses of females. Males should be attracted by the still captive females during the rutting period. When males are found to have returned during the rut to the enclosure, the females can be released. The enclosure must, however, remain accessible to the deer subsequently, since it could still be traditionally used by females for fawning.

Cropping

Clearing of primary forest in Asia may lead under certain circumstances to ecosystems supporting increasing numbers of ungulates, though in Sumatra populations of forest-dwelling serow (*Capricornis sumatraensis*) can also build up in man-made *Imperata*-grasslands (Kurt, 1970). Present conservation policy can therefore often lead to excessive densities in reserves, the artificially high populations sooner or later threatening the stability of the ecosystem by overuse of the vegetation and accelerating the ecological disruption initiated by man. To restore an equilibrium, artifical reduction of stocks is imperative and economic use may share the same purpose as conservation, namely the maintenance of a stable environment. Consumptive use of deer can cover the production of meat, leather, antlers, pantocrine and even musk from musk deer.

If a species is considered as of potential value for consumptive use, which can only happen when former forest species have escaped their natural regulators by invading a savanna habitat, management has to be carried out in the following three stages: (1) full protection of the species until its number reaches the carrying capacity of the habitat; (2) cropping of surplus males and old animals to stabilize the population at the level of the carrying capacity, in the process stimulating the reproduction rate of the population; and (3) full cropping of all age and sex classes.

Such a system can be applied to species invading man-made habitats, enabling meat and leather products derived from otherwise unusable marginal lands. However, other products from organs linked with sexual activity, such as antler bones and the pantocrine produced from dried antler velvet or musk from musk glands, obviously cannot be produced on a large scale from excess populations of deer in these circumstances, for the simple reason that a decline of physiological processes in non-dominant males is the typical reaction of deer involved in a major population increase in man-made open habitats, resulting in antlers and other organs being of poor quality or ceasing to develop altogether.

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PART I: THE IUCN THREATENED DEER PROGRAMME

4. FUTURE DIRECTION AND ORGANIZATION

Summary of Discussion

The IUCN Threatened Deer Programme: A review of its objectives, achievements, shortfalls and future requirements (C. Holloway)

It was agreed to adopt a phased five year plan of operations for the Threatened Deer Programme along the lines suggested in the paper.

In regard to the selection of main field projects for the plan, it was agreed: (a) priorities should be accorded to the remaining world threatened deer for which no project has been initiated to date; (b) threatened deer taxa that occurred only within the People's Republic of China should be excluded from consideration until such time as effective liaison had been established between IUCN and the Chinese Government; (c) although, for reasons of economy only one major research project would normally be launched for each threatened deer taxon, exceptions to this rule may be considered where the deer's range was wide and previous studies had covered only a small and possibly unrepresentative section of the range, e.g. the Chilean huemul, which should be added to the listed projects for 1978/82; (d) some existing research projects, e.g. Argentine pampas deer and possibly the Bawean deer, may require initial conservation funding but these requirements would be considered under the contributions to national conservation programmes. Two sub-committees were set up to formulate initial proposals for essential supporting projects.

As a result of further discussion and the report of the sub-committees, the main components of a five year plan, as set out below in the next section of these Proceedings under the heading – '*Elements for the Threatened Deer Programme 1978–82*', were approved. It was recognized that additional projects may be added to the plan as its development proceeds. The IUCN staff member was empowered to submit a preliminary version of parts of this plan to funding organizations in the immediate future if an opportunity for obtaining financial support presented itself.

There was a need to broaden the Programme's funding base beyond the WWF International and the various WWF National Appeals that have provided most financing to date. Reference was made to the possibility of finding private organizations that were involved in conservation work and which might consider funding threatened deer projects. The plan to request the Yulo King Ranch to undertake a research and conservation programme for the Calamian deer was given as an example. Further investigation should be made into associating Peace Corps projects with the Programme, although

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experience had shown that preparations for such proposals needed to be made well in advance of the volunteer's arrival in the country concerned. Group members agreed to inform IUCN of potential sources of international funding that might come to their notice and to be prepared to provide material for fund raising purposes if required to do so.

Preliminary surveys and correspondence to establish arrangements for research projects needed to take greater account of counterpart needs and early local involvement. A distinction was drawn between a scientific counterpart to an overseas researcher under the Programme, and a field assistant. The former would normally be a qualified biologist, able to undertake separate sectors of the research Programme, should usually be drawn from a local university and might require separate funding. The field assistant should be primarily concerned with conservation and management, would normally be drawn from the appropriate Government agency and funded by the Government. Government agencies and nature conservation organizations, including the WWF National Appeals, should be brought into field project operations as early as possible. Management of WWF funded projects was likely to become the responsibility of IUCN in the near future and this arrangement should make it easier to act on these proposals.

Universities in developed countries might be regularly associated with projects in a developing country or region to aid continuity and use of accumulated expertise. For researchers working for higher degrees, some flexibility was needed in research plans to balance the need for strictly applied research required to meet conservation objectives and the type of pure research required by university degree standards.

The idea of establishing recovery teams for threatened deer species was discussed. The consensus was that a different type of team was required to that established in the USA and subsequently explained in the discussion on the Columbian white-tailed deer. Teams for threatened deer in developing countries should be composed of biologists and local forest, agricultural, administrative and police officers, to widen responsibility and improve the opportunities for local action. A recovery team for the Chilean huemul should be established as a pilot venture and the proposal extended to other species if the pilot scheme proved successful.

The IUCN staff member concerned with the coordination of the Programme will use his discretion in regard to what type of reports from field researchers should be circulated to Group members for comment. A comment sheet should be designed and circulated with each report to be returned to IUCN with member's remarks.

The Deer Group Newsletter should include a list of reports that have been received by IUCN and might also include information on other deer projects outside the IUCN Programme that might be of interest to the Group. Information on the latter would need to be provided principally by Group members. no firm conclusion was reached on whether or not the newsletter should be sent to senior Government officials concerned with natural resource management in countries where world threatened deer occurred. Information of this type sent to Latin America would have greater impact if translated

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into Spanish and, whilst Dr. Jackson agreed to translate extracts if required, translation of the entire newsletter would be a substantial undertaking for a still relatively restricted audience. It was suggested that the editor of *Parks* magazine, which was published in three different languages, might agree to publish extracts from the newsletter.

It was agreed that the Threatened Deer Programme section of the Proceedings of this meeting should include papers on the Persian fallow, Bawean, Bactrian and Columbian white-tailed deers as essential components of the Programme, even though these papers were not discussed at the meeting. Two additional introductory papers were required, the first to consider man and deer, with special reference to the values of deer to man, his effects upon their populations, the deer's adaptation to changing land use and the need for management, and the second to provide summaries of the geographical location and current conservation status of all world threatened deer.

Socio-Ecological Organization and Aspects of Management South Asian Deer (F. Kurt)

The ideas expressed in this paper were agreed to be of considerable interest to deer management and would undoubtedly provide the basis for further discussion in ensuing months between Group members, when they had had further opportunity to consider implications.

The flexibility of deer behavioural patterns was stressed; it was suggested, for example, that territoriality may be facultative or obligatory and depends largely on behavioural characteristics and habitats. It was agreed that the use of behavioural phenomena as a basis for taxonomic classification should be avoided.

The social strategies of Old and New World deer were considered to be substantially different and the literature on the two should not be confounded. The North American elk was, of course, considered to be an Old World deer.

The logical follow-up to this paper should be a greater concentration on studies to identify the inter-relationships and impact of the more advanced deer upon newly colonized habitats in Asia.

ELEMENTS FOR THE IUCN THREATENED DEER PROGRAMME 1978–1982

1. Major field projects

A. Continuing projects

Research phase –

Himalayan musk deer	*Moschus moschiferus moschiferus*
Bawean deer	*Axis kuhli*
Swamp deer (northern race)	*Cervus duvauceli duvauceli*
Manipur brow-antlered deer	*Cervus eldi eldi*

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Kashmir deer	*Cervus elaphus hanglu*
Chilean huemul	*Hippocamelus bisulcus*
Argentine pampas deer	*Ozotoceros bezoarticus celer*

Conservation phase –

Persian fallow deer	*Dama mesopotamica*
Swamp deer (southern race)	*Cervus duvauceli branderi*
Bactrian deer	*Cervus elaphus bactrianus*
Columbia white-tailed deer	*Odocoileus virginianus leucurus*

B. New projects

Research phase –

Projects should be initiated for all world threatened deer that are not the subjects of projects in the threatened deer or related programmes. Consideration of projects on deer occurring only in the People's Republic of China should await establishment of liaison between the Government and IUCN. Deer, for which projects should be considered in 1978–80, are:

Fea's muntjac	*Muntiacus feae*
Calamian deer	*Axis calamianensis*
Thailand brow-antlered deer	*Cervus eldi siamensis*
Formosan sika	*Cervus nippon taiouanus*
Ryukyu sika	*Cervus nippon keramae*
Corsican red deer	*Cervus elaphus corsicanus*
Cedros Island deer	*Odocoileus hemionus cerrosensis*
Peruvian huemul or taruca	*Hippocamelus antisensis*

Research and Conservation phase –

Chilean huemul	*Hippocamelus bisulcus*

2. Management support for selected projects

Support will usually consist of financial aid, for the purchase of vehicles and equipment or for construction of staff quarters in the initial conservation phase of a project, where national agencies are unable to supply them.

Argentine pampas deer	*Ozotoceros bezoarticus celer*

3. Field surveys

Field surveys will usually be employed to assess the national conservation situation prior to the initiation of a major project, select study areas and arrange for counterparts and national assistance for the project. Some new projects under 1.B. above have already had field surveys (Fea's muntjac, Calamian deer, Formosan sika and Peruvian huemul). Taxa that are expected to require surveys in 1978 are:

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Corsican red deer	*Cervus elaphus corsicanus*
Barbary deer	*Cervus elaphus barbarus*
Cedros Island deer	*Odocoileus hemionus cerrosensis*

4. Supporting projects

The following preliminary list will be expanded and otherwise modified as the programme is developed.

1) A critical re-examination of the systematics of controversial Cervidae.

a) Establishment of criteria to be used in designating taxa of Cervidae (e.g. which skeletal and cranial features are to be examined and whether haematological or electrophoretic studies are to be employed).

b) Initial efforts should be directed to *Muntiacus, Cervus nippon, Blastoceros, Hippocamelus, Mazama, Ozotoceros, Pudu, Rusa* deer (*Cervus* or *Rusa*), *Cervus elaphus/canadensis, Cervus duvauceli.*

Action – IUCN to contact appropriate societies and specialists in this field to devise a programme.

2) Register of captive animals and herds whose genetic integrity has been verified.
The register will record what threatened deer exist in captivity, where they are located, and who owns them.

Action – IUCN to discuss with associations of zoological gardens and editor of the International Zoo Yearbook. B. K. Whitehead to assist in the formulation of the project.

3) Guidelines for reintroductions

Reintroductions are expected to become an important feature in the IUCN Threatened Deer Programme; guidelines should be made available to all agencies and organizations involved in these operations.

Action – Assess reintroduction criteria and guidelines prepared for the dossier on threatened species restoration, to determine if additional work required on these subjects.

4) Development of a rational statement on the genetic constraints of small populations, with the aim of estimating minimum viable population sizes for wild ungulate species.

Action – IUCN to make contact with University of California. Berkeley, and other institutions involved in this field.

5) Guidelines for application of the principles of applied biogeography to species management.

Action – F. Bunnell and a research student to undertake further literature research and compile guidelines. Ideally, the content of this

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statement should take account of results from project No. 4.

6) Comprehensive review of the current conservation status of all Cervidae, with the principal aim of identifying additional candidate species for the Red Data Book.

Action – Detailed assessment by Deer Group members, in cooperation with the compiler of the Red Data Book Volume I, of cervid species of low populations and precarious status.

7) A review and synthesis of ungulate biology.

Provision of a conceptual, synthetic framework generated from present data. The sparse information for lesser-known species needs to be rapidly supplemented so as to allow their location in the framework and possibly permit anticipation of features of their biology from existing data for other species.

Action – Will involve a team discussion and investigation of literature. F. Bunnell to devise a plan and budget.

8) Preparation of a concise field hand book or bibliography to guide ungulate studies.

Action – Proposal to be reconsidered after publication of the dossier.

9) Investigation of physiological degeneration of captive animals.

Action – To be considered.

10) Identification of museum holdings of skeletal material of threatened deer; verification of material; and coordination of preservation of specimens from known captive herds by museums.

Action – To be investigated.

11) Human perception of wildlife; integration of human sociological components into threatened species field studies.

Action – Project to be developed by D. Pitt.

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PART II: A DOSSIER ON THE PLANNING OF RESTORATION PROGRAMMES FOR THREATENED UNGULATES WITH SPECIAL REFERENCE TO DEER

Introduction

The past decade has witnessed a marked increase in interest and activity in the study and conservation of threatened species. In spite of the accumulation of data and experience in this field, however, there is no readily accessible compendium of information on constraints, criteria, strategies and techniques to guide the planning and compilation of projects for the restoration of depleted animal populations.

The dossier, which forms the second part of this volume, has been prepared to meet this need. Although primarily directed to the study and management of threatened ungulates, and especially the cervids, much of the information it contains is readily applicable to other mammal species, and the approach may serve as a blueprint for the preparation of similar compendia for a range of vertebrate animals.

In brief, it is hoped that this document may serve three principal functions:

(i) as a set of guidelines for the planning and execution of field projects by research workers, government agencies and conservation organizations;
(ii) as a check-list of aims, techniques and approaches for use in the screening and assessment of project proposals by government agencies and other fund-providing organizations;
(iii) As a basis for the preparation of similar dossiers for other vertebrate families by national and international conservation bodies.

The dossier comprises a summary of criteria and guidelines on the planning of restoration programmes for threatened ungulates, with special reference to deer, and fourteen supporting papers on which the summary is based. Most of these papers were prepared by members of the Deer Group and were discussed at the Group's working meeting in Longview. Three additional papers were later prepared to fill gaps identified during this review.

Three main fields, all of which are basic to the long-range planning and organization of species rehabilitation projects, are covered by the dossier. They are, first, the constraints imposed by small populations and local human community problems; secondly, the aims and requirements of research programmes on which management measures should be based; and, thirdly, the principles, strategies and techniques of conservation practice relevant to this subject.

The document as a whole should be regarded as a contribution by the Deer Group to a more comprehensive approach to the conservation of threatened species. It is intended primarily to guide the compilation of programmes and does not purport to establish fixed policies on any of the numerous topics

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that are included. It is recognized that the dossier will require periodic revision if it is to retain its usefulness and IUCN would welcome constructive criticism and comment for consideration in the next revision.

Summary of Criteria and Guidelines

1. BASIC CONSIDERATIONS FOR RESTORATION PROGRAMMES

1. Constraints Imposed by Small Populations

(*ref.* Bunnell, F. L.: Constraints of small populations, pp. 264–287 below)

a) Small Habitats and Applied Biogeography

(1) Individual preserves must be large. Since the areas will always be fixed by political compromise the minimal request should be the area at which further acquisition of land would lead to diminishing returns for the taxa most prone to extinction.

(2) The random component of extinction indicates that unique habitats and biotas are best contained in multiple reserves. Such reserves should be located as closely together as possible where natural migration still occurs and disease poses no threat. Where disease poses significant threat or natural migration is impossible, widely separated reserves may ensure greater security.

(3) Preserves of a fixed area should be as round in shape and as continuous as possible.

(4) Extinction models of the kind devised by Diamond and Terborgh should not be restricted to the most conspicuous or vulnerable organisms, but should eventually be developed for all taxa. Those taxa displaying the highest degree of endemicity and vulnerability (generally correlated) deserve first attention but no group should be ignored. Full taxonomic surveys underway in natural preserves, should be supplemented by studies of species dynamics and equilibria.

(5) When assigning priorities and more specific information is lacking, the concept of ecological truncation suggests that specialists and large taxa in a guild should be considered most vulnerable.

b) Genetic Diversity

(1) Priorities for research and action in response to genetical considerations should be: first, confined populations of recently reduced taxa; second, newly-isolated groups; and third, long-isolated groups. Long-isolated taxa are more likely to respond better to small group confinement and to provide better potential for transplant as small groups.

(2) Research on mating systems, herd structure and dispersal are critical to the forecast of potential evolutionary change and should be encouraged.

(3) Research on genetic differences in all wildlife species should be encouraged and effort made to standardize techniques (e.g. Selander *et al.* 1971). Initial estimates of heritability among Cervidae may be obtained from domesticated taxa (*Rangifer, Alces*) and central European work on management for trophy stags (*Cervus*).

(4) The possibility of sperm banks should be considered.

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(5) Prescriptions for viable size and structure of captive herds depend on information encompassed by (2) above. In general, the larger the population the better, and even a few individuals can alter rates of drift significantly. As many males as social organization permits should be incorporated. Rates of evolution within confined groups will likely be greater than those predicted from drift alone.

(6) Acknowledging drift and selection, every effort should be made to maintain several natural populations of each taxa (see also point (2) concerning natural reserves).

(7) The principles of gene-flow should be exploited. Exchange of males is essential to maintain variability within small populations. Exchange can be effective at intervals of about ten generations or less.

(8) Acknowledging the subtle effects of selection, confined populations should be maintained in environments which approximate the natural environment as closely as possible.

(9) Judicious culling may be required to inhibit drift from increasing deleterious genotypes in the population.

(10) As a matter of policy, the purpose of confinement is to return species to the wild as soon as possible.

(11) Reintroduction should, wherever possible, include both wild-reared and pen-reared stock, so as to maximize 'cultural' transfer of relations with habitat.

(12) In all releases or transplants, the animals should be thoroughly tested for diseases or parasites acquired while in captivity and only 'clean' animals liberated.

c) Assessment

(1) All schemes of assessment for endangered species should recognize explicitly the broad components of disturbance features, mitigation targets, impact indicators and mitigative actions.

(2) Within an assessment scheme, population distribution merits consideration at least equal to density.

(3) Measures of population structure are critical to effective conservation programmes and should be collected with their relevance to behaviour in mind. They do not obviate density measures and are frequently poor indicators of impact.

2. Constraints imposed by Human Societies

(*ref.* Pitt, D.: Human Constraints and Conservation: the case of rural communities in the third world, pp. 288–295 below)

(1) The fact that human constraints may. be critical in study and action programmes needs to be recognized.

(2) In selecting key human constraints there needs to be a study of the ecological effects of social, political and economic institutions.

(3) Close attention also needs to be paid to the attitudes, beliefs and aspirations of the local people, not only because these may be critical factors in themselves but also because understanding and rapport will help in both the study and the implementation of programmes.

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(4) In carrying out research on human constraints there should be as close as possible a liaison between the field biologists and social scientists who are familiar with socio-ecological problems.

(5) Although existing models in the social sciences may provide valuable clues, eclectic models based on a commonsense study of local conditions and an appreciation of local problems will be just as significant.

(6) In all programmes there should be an awareness of local customs and protocols, and an attempt to provide assistance to on-going processes of development.

(7) There should be an awareness that human and social problems are very complex and that a maximum of tolerance and even flexibility is needed in any decisions taken.

(8) Amongst the sociological topics that can be investigated are the following:

Topic	**Ecological relevance**
Kinship	Totemic Rites de Passage*
Religion/Cosmology	Taboos, totems, mythology
Political organization	Use of territory – Relations with outside agencies – Political entities
Economic organization	Use of animals etc., in trade and exchange (in Maussian sense)** – traditional conservation
Land tenure/use	Exploitation of environment especially 'danger' methods – fire, etc.
Jural/law	Sanctions on abuses of taboos, conservation rules, poaching
Conceptual systems	Ethno-zoology, categorization of fauna/flora, etc.
Social mobility	Exploitation of environment in status systems
Social change – nutrition	Effects of changing diet demands
Social change – demography	Effects of population pressure
Social change – wants	Effects of new product demands, both cash and subsistence
Social change – conflict	Effect on environment of wars, revolts, etc.
Social change – technology	Effects of new kinds of machinery, etc., on environmental use
Social change – authority	Overlapping jurisdictions in environmental matters
Education	Inculcation of conservation ideals

*the key ritual points in an individual's progress through life

**A Maussian exchange system is one in which there is not just economic exchange but a total exchange of all kinds of goods and services (Mauss, M. (1954). *The Gift*. Cohen & West, London).

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Communications	Effects of mass media on idea patterns and transmission of values
Social aspects of health	Beliefs and action in man-animal disease transmission
Management	Kinds of concepts with regard to land managment
Futurology	Planning attitudes to landscape, territory and environment
	Agents of change
Roles of special social categories, e.g. women, youth, cultural brokers (in the Geertz sense)*	
Indigenous movements	Capability of accomplishing development from below processes

2. COMPONENTS OF STUDY PROGRAMMES

1. Etho-ecological Studies

(*ref.* Geist, V.: How to generate etho-ecological data in field studies of endangered ungulates, pp. 297– below)

(1) In order to obtain data useful in conservation of an endangered population, as well as to gain knowledge about a form that may become extinct, it is recommended that:

(i) precise illustrations and descriptions be made of all sex-age classes throughout all seasons, including the range of individual variations in external appearance;

(ii) dead specimens be deposited in a secure collection and their existence be kept on record;

(iii) the habitat be documented and described throughout the seasons.

(2) In order to miss as little relevant information about the study population as possible, one ought to have a system which focuses attention on answering *questions* relevant to the species biology. Such a system is derivable from the concept of reproductive fitness (inclusive fitness). There are seven basic or primary questions. How does an individual, throughout each stage of ontogeny and adulthood,

(i) maintain physiological homeostasis;

(ii) minimize resource expenditures on maintenance to free maximum resources for reproduction;

(iii) maintain access to scarce resources essential to reproduction;

(iv) take advantage of unused resources;

(v) reduce the reproductive fitness of others;

(vi) support closely related genotypes;

*Geertz has pointed to the crucial role of persons who mediate and act as middle men between two cultures (Geertz. C. (1974). *Myth, culture and symbol.* Norton, New York).

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(vii) obtain a mate or mates equal or superior to itself in fulfilling the above demands?

This set of questions is only as good a means towards relevant research as the investigator's background permits it to be.

2. Population Structure and Dynamics

(*ref.* McCullough D. R.: Essential data required on population structure and dynamics in field studies on threatened herbivores, pp. – below)

(1) The status of a population cannot be determined from age structure alone. Population size must be known to interpret age structure data although a reliable index to population size is usually more practical to obtain.

(2) Habitat quality, quantity and successional state are necessary to interpret population status. Since age structure and population size are reflections of what happened in the past, if the habitat is changing in amount or quality, population parameters will shift in response to habitat change.

(3) Fluctuations in population size over time are important in assessing probabilities of extinction. Since controlled removals can stabilize fluctuations in populations size, properly culled populations can be less subject to extinction than totally protected ones.

(4) With field data, the assumptions of life-table analysis are seldom met and results are subject to question. Use of recruitment rate derived from time-specific age structure can avoid some of these problems. In large mammals, recruitment rates often vary with population size, and analysis of this density dependent relationship may give useful models for management.

3. Disease investigations

(*ref.* McDiarmid, A.: Threatened deer – disease implications, field work and management, pp. – below)

(1) Very few diseases can be diagnosed with certainty by unqualified personnel and laboratory facilities are nearly always essential for differential diagnosis, particularly in many of the more important viral diseases.

(2) The best policy for the field biologist who wishes to investigate the health status of a rare ungulate is to contact the local veterinary service, in advance, to ascertain:

(i) the prevalence of domesticated stock diseases in the area;

(ii) ways and means of handling samples for examination from the species under study.

A code of practice may then be established and, possibly, the laboratory facilities and veterinary advice made available to the investigator.

(3) Under field conditions, it is extremely difficult to determine the precise cause of death of an animal. Even if animals have been dead for some-time prior to discovery, the internal organs may still be worth examining, particularly in regard to endo-parasites in the alimentary tract. Heavy investation of ecto-parasites should be noted.

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(4) The investigator should learn to know the normal appearance of all the internal tissues and thus be able to identify any deviations. Nodules, particularly in the thorax and abdominal cavities, should be investigated by tissue fixation and subsequent sectioning. Careful notes should be made of any evidence of haemorrhages in the different organs.

(5) If tissues are fresh, attempts may be made in the laboratory to cultivate possible causal agents from the viscera or heart blood. The most useful material of all is a blood sample, if the animal is still alive. Even clotted blood from the heart of a recently dead animal can be useful. The serum recovered from these samples can be used to isolate certain virus and bacterial infections. Dried films of the blood can sometimes be used to identify blood-borne protozoa.

(6) Faecal pellets can also reveal the presence of parasites. Urine, if fresh, may be used to show the presence of leptospires by laboratory examination.

4. Field Study Techniques

(*ref.* Taber, R. D.: Field study techniques of special application to deleted populations, pp. – below)

(1) The ultimate objective of a field study on a threatened species is to identify the factors which are limiting population increase, and to develop practicable plans to alleviate their effect and allow the population to increase to secure status. It is assumed that studies of free-living populations of seriously depleted species will not normally include capture.

(2) Significant parameters of an endangered population include distribution, density, structure, productivity, mortality, nutrition, growth rate, and size at maturity.

(3) Growth rate and size at maturity can be used as an index of short-term and long-term nutrition, respectively, provided that comparative data from well-nourished individuals exists. Such data may be obtained from museum collections and captive populations. These also can provide data on age by tooth characters, hematology, patterns of reproduction, track size and faecal pellet production rate, and size. Surveys of the availability of collections, and guidance with respect to the preservation and accumulation of specimens and data should be encouraged by the Deer Specialist Group.

(4) Ideally, if full use of museum collections and captive herds has been made, the field investigator would begin with knowledge of deer anatomy as it related to age, sex and physical condition, as well as pellet size by age and seasonal rate of pellet production, and the morphometry of tracks and skeletal proportions.

(5) Distribution of a free-living population is determined from presence-absence indicators such as tracks, sign, calls, and the observations of informants. Density estimates require sampling, which is often stratified by major landscape classes. For deer, the two usual methods are the pellet-group count and the strip count. Pellets collected in connection with the former can be used for food habits and nutrient-level determination.

(6) Population structure may be measured by means of size distribution of pellets and tracks, and by direct observation, which also provides evidence

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of physical condition.

(7) Study of individuals found dead provides data on age, sex, season of death, physical condition at time of death, and skeletal size in relation to age.

(8) Movement can be studied well only with marked or individually recognizable individuals.

(9) When developing conservation plans, it is useful to have an analysis of seasonal habitat use and non-use. Used areas provide data on food production, availablity and use. A useful approach to habitat analysis is based on a gridding of area into cells of uniform size, the recording of all field data in terms of cell location, and the thorough ecological description of every cell, including its proximity to water, roads and other habitat elements. These data provide a basis for hypotheses concerning potentials for habitat maintenance or enhancement. These hypotheses should be tested and validated before the field investigation can be considered complete.

5. Research framework

(*ref.* Cowan, I. McT. & Holloway, C. W.: Research towards conservation of threatened deer of the world, pp. 329–338 below)

A slightly revised version of the framework for research, which has been used to guide all major projects initiated under the Threatened Deer Programme, since it was launched officially in January 1974, is reproduced below in its entirety.

Objectives

IMMEDIATE – to establish the species or subspecies in such number and so distributed as to provide reasonable likelihood of its surviving in its native habitat with its genetic spectrum intact.

LONG-TERM – to restore the species or subspecies to productive status in the wild.

Research questions

The first objective of research upon rare or endangered species must be towards discovering the information that is of particular relevance to the survival of the species. This requires care that the research itself does not serve, directly or indirectly, as an additional disturbing factor leading to reduced effective reproduction or increased mortality rate. For many species the impact of man through continuing killing or by overuse of essential range for domestic livestock, is the probable immediate cause of the small numbers. Thus research must be directed to social and political issues as well as biological questions.

We have developed a series of questions which we believe will assist in the planning of research studies designed to provide data that are essential to the effective conservation of an endangered species.

(1) How does the ecotype by which the species or subspecies is surviving differ in adaptive requirements vis-à-vis the probable conditions originally forming the optimum habitat for the organism?

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Action potential: Can a programme of range restoration be planned while maintaining a viable population of deer? If so, what measures are required both in terms of land-use and animal management?

(2) Does the population adequately exploit all areas of available habitat?

If no: What are the forces preventing the animals from fully occupying the area?
Action potential: Can the inhibiting causes be reduced or removed by management of habitat structure, or reduction of human impact, or other management action?

(3) At any season of the year, or even occasionally from year to year, does the present population of the species exceed the capacity of the present habitat to provide feed that is adequate in quantity and quality?

If yes: Under what circumstances does this occur, and which age-sex group suffers impaired growth and which dies? Is fecundity influenced by malnutrition? Is the condition the consequence of competition from other species, wild or domestic?
Action potential: Are there opportunities for improving the capacity of the habitat (reduced competition, altering cover-type, setting back succession, fertilization, provision of supplementary feed through short-lived critical periods, etc.)?

(4) At any season of the year, or even throughout some years, does the present population lack adequate water or mineral sources or other special facilities leading to density-dependent mortality from this cause?

If yes: Does this lead to on-site mortality or to the abandonment of otherwise secure habitat for other less secure or less suitable areas?
Action potential: What can be done to improve the amount, quality, or distribution, of water supply or other limiting resources?

(5) Is there evidence for territoriality by males or by females, and is the population size limited by the number of territories available?

If yes: Does this lead to surplus animals which are being lost each year?
Action potential: (i) Can any opportunity be envisaged for increasing the number of territories through changing the mix of habitat components by manipulation of cover or resources, or by increasing the available area so as to add essential components that will permit the original area to serve more animals?
(ii) Can surplus animals be used for establishing new colonies or for interchange with other herds to increase heterosis?

(6) Is predation, either by steady drain or by periodic concentration upon animals rendered especially vulnerable by life-stage or weather circumstances, a limiting factor?

If yes: Is the predator itself a very valuable species: will reduction in loss from predators place the species in a different density-dependent mortality

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situation?
If no: then
Action potential: Reduce predation losses preferably by altering the habitat to improve security, by introduction of artificial protection, or, failing these, by removal of the individual predators from predation-inducing contact with the prey.

(7) Is illegal killing by Man an important factor in lack of increase?

If yes: What are the circumstances that lead to this poaching loss?
Action potential: Can these circumstances be altered by social action, physical barrier, improved legislation, improved enforcement, or augmented educational effort?

(8) Are parasites or infectious (contagious) diseases an important source of loss to the population of individuals that would otherwise contribute to an increase in the population?

If yes: Are the parasites or causes of disease species specific or transmitted *via* other species?
Action potential: Can habitat modification reduce disease losses? Can elimnation of alternate hosts, or removal or treatment of domestic livestock, reduce losses due to disease?

(9) Are accidental deaths from man-made hazards (highways, irrigation ditches, canals, flooded reservoirs, etc.) an important factor in the mortality rate?

If yes: Where and under what circumstances?
Action potential: Can losses be reduced by altering the habitats, fencing or screening the hazard, providing escape facilities, or other steps to reduce hazard?

(10) Is disturbance by Man, his livestock or his technology, an important factor inhibiting effective reproduction or increasing mortality rate?

If yes: What are the disturbing influences, and when and under what circumstances do they operate? What evidence is there that disturbance is or is likely to become density-dependent?
Action potential: Can steps be taken to reduce the disturbance (removal of source, alteration of habitat, change of level, timing, or other aspects of source)?

(11) Are major events in the biology of the species seasonal?

If yes: How long are the rut, fawning, lactation, antler regeneration, time of hardened antlers, or calling, *versus* actual breeding season? Are any of these actively confined to specific habitats, parts of habitats or recognizable localities? Are these a natural feature of the biology of the species, or imposed by circumstances of numbers or habitat?
Action potential: Special protection of rutting areas, calving grounds, wintering areas and other particular features used by the species.

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Future Development of the Research Framework
It is intended that this research framework will continue to be revised in the light of further research on threatened and secure deer populations and of projects designed specially to improve study methods of relevance to wildlife conservation. For example, the present meeting has emphasized the importance of integrating human sociological components into threatened species studies, and the preparation of guidelines on this subject has already begun (D. Pitt, 1977, pers. comm.). Future revision of the framework will take account of these developments and of any comments that users of the framework and others may send to the authors.

3. COMPONENTS OF MANAGEMENT PROGRAMMES

1. Reintroductions

(*ref.* Jungius, H.: Criteria for the reintroduction of threatened species into parts of their former range, pp. – below)

Reintroduction involves the rehabilitation of a species in an area in which it became extinct in historical times; it is appropriate when:

– the reasons for the disappearance of the species are known and have been removed.
– the habitat of the species has not been significantly altered since its disappearance
– basic research has been undertaken to provide the necessary scientific and technical guidelines for a reintroduction programme.

The basic programme should include

– feasibility study
– preparation phase
– release phase
– follow-up phase.

a) *Feasibility Study*

(1) The aim of the study should be:

(i) to provide information on the ecological and behavioural characteristics of the species and on the quality of the habitat (reintroduction area);
(ii) to identify the species' needs in relation to the environment;
(iii) to check if the habitat fulfils the species' requirements.

(2) The following data should be collected:

(i) Species – complete study on distribution and basic information on ecology and behaviour, habitat requirements (food, water, shelter, space), interspecific relationships, relation to man, factors limiting population growth.
(ii) Habitat – location, access, climate, topography, flora and fauna, and

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land use of reintroduction area; identification of potential conflicts with other species or existing land use and recommendations for solution.

b) *Preparation phase*

(1) The aim of this phase should be:

(i) to ensure that the right kind and composition of specimens are selected;
(ii) to arrange for safe transport to the reintroduction area and the proper acclimatization of the animals prior to release, and include the necessary legal and administrative preparations to ensure optimal release conditions.

(2) The following matters require attention:

(i) Species – animals to be released should come from the same, or if this no longer exists, the nearest subspecies to those that became extinct. Specimens should normally come from a harsher climate than that of the reintroduction area. Numbers, age and sex ratios, should be based on the species' biological characteristics. Veterinary care should be assured prior to transport, during transport and before release. Import permits must be obtained where required. Animals which have been in captivity for a long time must be taught how to feed in the wild (requiring a large enclosure with natural vegetation).
(ii) Enclosures – may have to be built to acclimatize animals before release or for breeding them in captivity for subsequent releases. The breeding unit should be kept under veterinary care. Enclosures should be in the centre of the reintroduction area. They should, preferably, be large enough to enable the animals to live and breed under free-range conditions with as little artificial feeding as possible. Animals should be kept according to their social ecological pattern, for instance mixed herds with different age groups and where males and females are in constant contact with each other. Fencing must be predator-proof. Enclosures should have devices for separating animals, such as small adjacent enclosures, or capture devices – for instance around artificial watering and feeding places or shelters.
(iii) The area – official approval should be obtained for the release programme and for legal protection for the species, the reintroduction area and its surroundings. Human disturbance must be decreased or eliminated and local people informed about the programme and their support obtained.

c) *Release phase*

(1) The aim of this phase is to fix the animals on the release site and restrict dispersal.
(2) Experience has shown that repeated releases of large numbers, preferably in different but connected habitats, is necessary to make reintroduction a success.
(3) Prior acclimatization of animals in an enclosure has also proved to increase the chance of success.
(4) Reintroduction during the most unfavourable season of the year to the

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best habitat seems to be advantageous and prevents dispersal. Animals can also be kept together more easily by artificial feeding.

(5) Species that depend on different seasonal ranges should always be reintroduced into their critical habitat area, i.e. winter range in temperate regions and summer or dry range in Mediterranean or tropical areas. This range is normally restricted in extent and locality, and knowledge of its location is vital to the animals' survival.

(6) Imprinting animals on their winter range can be done by:

(i) release into the winter range in late autumn;

(ii) keeping animals in an enclosure in the area throughout winter: preferably young animals should be used in which imprinting and the establishment of new tradition is easier than in adults;

(iii) imprinting young animals on a human leader who will lead the animals into the new area and provide them with the knowledge they require may also be tried before wintering them in an enclosure.

(7) Establishment of a captive breeding unit under free range conditions from which surplus animals can be released provides a continuous flow of specimens for subsequent releases. This technique should be considered for rare species where stocks for reintroduction are limited, whilst recognizing the possible dangers of releasing only a few animals at a time.

(8) Release of males prior to release of females may be used to test the quality of the new environment; if males establish themselves, females may follow. Another way of using males as pioneers is by releasing some from a captive herd. These will explore the new environment and may settle down. If they return during the rutting season, some females may be allowed to join them.

(9) Animals should be marked prior to release.

d) *Follow up phase*

(1) The aim of this phase should be to determine:

(i) the rate of adaptation and of dispersal;
(ii) the need for further releases;
(iii) the reasons for success or failure of the programme;
(iv) the impact on habitat and to advise on management.

2. Captive breeding

(*ref.* Whitehead, G. K.: Captive breeding as a practical aid to preventing extinction and providing animals for reintroduction, pp. – below)

(1) Loss of habitat and/or commercial hunting has resulted in many species of deer – particularly in Asia – being classified as endangered. The values, therefore, of establishing captive breeding groups, either within or outside their country of origin, cannot be overstressed. Indeed, had not captive stocks of such ruminants as the Arabian oryx, European bison and Père David's deer been preserved in captivity, all three would probably be extinct today.

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(2) In order to ascertain the whereabouts of captive endangered deer, a World Register should be inaugurated for each species. At present, the only deer for which such a register exists is Père David's deer, *Elaphurus davidianus*, which can no longer be considered endangered.

(3) There must be close liaison between zoos holding endangered species, so that inter-zoo exchanges can be achieved with the minimum delay.

(4) The crossing of a rare deer with a different species or subspecies to maintain captive collections should never be permitted so long as there are still pure specimens elsewhere in captivity or the wild.

(5) Transplanting live ruminants around the world in order to build up small viable herds can be very expensive, quite apart from the risk. The establishment of sperm banks for rare deer should, therefore, be seriously considered.

(6) Captive stocks should be distributed among a number of breeding centres so as to reduce risk of disease eliminating the entire herd. Rare or endangered species should never be allowed to share an enclosure, or an adjacent enclosure, with domestic stock for fear of their being infected with disease.

(7) The main purpose of captive breeding of endangered deer must be to preserve and build up one or more herds of pure stock, to provide animals for reintroduction and for study under controlled conditions.

(8) Capture of rare or endangered animals for relocation or for the establishment of captive breeding units should take account of the following:

(i) capture for purely commercial reasons not justified;

(ii) capture and subsequent handling of animals, must be undertaken by experienced personnel;

(iii) capture for the establishment of an enclosed breeding unit should not be contemplated if there is evidence to believe species will not breed in captivity;

(iv) sufficient animals should be captured to ensure breeding viability but should not prejudice the survival of the remaining wild stock.

3. Management and disease

(*ref*; McDiarmid, A.: Threatened deer – implications, field work and management, pp. – below)

(1) Wild ungulates, such as deer, are remarkably resistant to a very wide range of pathogens. Similarly, there is considerable tolerance between deer and their endoparasites but inadequate management of deer populations and their habitat, leading to overstocking, poor nutrition and absence of shelter in bad weather, can upset this balance and the health of the animals suffers in consequence.

(2) many threatened deer occur at low densities and fewer animals in the herds lessens the risk of contracting disease. Many serious diseases, however, are transmitted by domesticated stock (e.g. viral diseases, such as foot and mouth, malignant catarrh and rinderpest). Endoparasitic burdens can also be increased by mixed grazing with cattle and, especially, sheep to the point

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where clinical diseases are precipitated. Domesticated stock grazing in reserves that contain populations of threatened species must be eliminated if such risks are to be avoided.

(3) Animals wounded by poaching may well die not necessarily from wounds but from wound contamination by screw worms or potentially pathogenic bacteria present on the skin of the animal or in the soil.

(4) Probably the most serious diseases are the viral infections, which produce a high level of mortality and about which little can be done to alleviate the situation. Anthrax is probably the most serious of the bacterial infections. Endoparasites are not normally a serious problem if over-stocking is avoided.

(5) In captive populations, the following require special attention:

(i) maintenance of adequate food, shelter and cover (rotational grazing should be practised where possible);

(ii) water sources should be reliable and free from contamination;

(iii) marshy ground (where snails, the intermediate host of liver flukes, can occur) must be fenced, drained or treated with a snail killing agent;

(iv) domesticated stock, especially sheep, must be excluded;

(v) normal behaviour patterns should be maintained by attention to sex ratios and age structures;

(vi) sick animals should be isolated at once and veterinary diagnosis and treatment arranged as soon as possible;

(vii) stress must be avoided in capture of individual animals.

4. Utilization of wildlife

(*ref.* Petrides, G.A.: The values of deer and other wildlife, both as secure and endangered populations, pp. 379–387 below;
Povilitis, A.: The aesthetic value of wildlife with special reference to rare forms, pp. 388–391 below)

(1) Wildlife has a wide range of aesthetic, cultural, scientific and economic values to mankind, which should be recognized and emphasized by conservationists. The extinction of a species before its known values have been realized and its potential values have been explored is a tragedy for man.

(2) Aesthetic qualities of wildlife appeal to people's senses, emotions and intellect, and they derive educational and inspirational benefits from these experiences. Successful conservation may ultimately depend on a better understanding of how wild forms contribute to an enriched and enjoyable life.

(3) Wildlife has important cultural associations for man in many parts of the world, as symbols on coins, flags, stamps and emblems; it contributes to solidarity and survival of human societies.

(4) Wildlife has contributed to advances in biological knowledge, in fields such as biotic evolution, continental drift and other scientific concepts of cultural and applied value. It has also provided the basis for substantial medical advances and has been widely used in research and the preparation of modern and traditional medicines.

(5) The economic values of wildlife are utilized through

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(i) sport hunting, which is a vast recreational outlet for millions of people;

(ii) subsistence hunting: many people in Africa, Asia and Latin America are still dependent to some degree on wildlife as their protein source;

(iii) wildlife viewing and nature tourism, which is a significant source of income for many developing nations;

(iv) game ranching: wildlife's resistance to disease and its ability to utilize coarse forage grasses and withstand drought makes it better able to produce protein in marginal lands than domesticated stock; and

(v) domestication.

(6) Threatened species possess these attributes but their populations require restoration before they can be safely utilized, even for tourist viewing. Possibly the wisest use of threatened species is as indicators of environmental disturbance and as practical illustration of the need for remedial action, and for education and public relations purposes in conservation.

5. Improving the effectiveness of conservation measures

(*ref.* Holloway, C. W.: Promotion of national conservation measures and support for the restoration of threatened species, pp. 392–406 below;

Panwar, H.: Threatened species conservation vis-à-vis community welfare in developing countries, pp. 407–414 below)

Possibly the greatest present need for the conservation of threatened species throughout the world is to improve the effectiveness of existing legal protection for these species and their habitats. Comprehensive solutions to these problems require long term education and public awareness campaigns, but, in the meantime, numerous measures can be taken to affect early and substantial improvement to existing situations.

(1) Governments should

(i) adhere to international conservation conventions that impose obligations on contracting nations to meet agreed standards for the study, protection and management of designated species or natural areas and that provide for international cooperation in the furtherance of national conservation aims.

(ii) Participate in study and management programmes that are sponsored by international organizations such as UNEP, FAO, UNESCO, IUCN and WWF, seek technical and financial aid for conservation and training programmes, and make use of appropriate literature issued by such organizations.

(iii) Develop national conservation policies to guide the activities of government services and private corporations in land management, establish agencies with specific responsibility for conservation and initiate training programmes in natural resource management.

(iv) Consider nature conservation as an integral component in rural development programmes to raise living standards without causing irreversible damage to the natural environment.

(2) Nature conservation organizations, universities, natural history museums and zoos can

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(i) help to assess nature conservation needs and prompt government action on important conservation issues.

(ii) Undertake field research and publish scientific data and other information, check lists and popular articles on the country's fauna and flora.

(iii) Promote public relations and education campaigns, especially in schools and among youth groups.

(iv) Cooperate and assist in national and international projects to conserve natural biotic communities.

(3) Natural resource agencies of government should

(i) ensure that field staff are fully informed of their responsibilities, adequately equipped and provided with in-service training.

(ii) Promote good relations with human populations in and around conservation areas through establishment of liaison committees; employment of local people as staff; establishment of systems, where possible, that provide for cropping of wildlife, harvesting of grass, fuelwood and building poles as sustained yields; adaption of traditional hunting systems to modern needs; and the organization and zoning of protected areas to meet these requirements.

(iii) Provide facilities (accommodation, transport, interpretation) for visitors, especially young people, to parks and conservation areas, and for continuing scientific research in these reserves.

(iv) Stimulate, in cooperation with non-governmental organizations, national pride and concern in individual species or areas to promote wider interest and understanding of nature conservation.

(4) Field biologists can

(i) assist in the preparation of management plans or management plan components for conservation areas, and in the training of field staff.

(ii) Collect and transmit data not only on immediate biological problems, but also on human sociology, public education and other matters of critical concern to effective wildlife management.

(iii) Provide up-to-date material on recent conservation developments and the broader issues of nature conservation for dissemination in public relations programmes.

(iv) Alert governments and government agencies to conservation problems requiring immediate remedial action and propose realistic measures to meet these needs.

6. Management – practice and policy

(*ref.* Cowan, I. McT.: Some aspects of policy and practice in management of endangered deer, pp. 415–425 below)

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PART II. DOSSIER ON PLANNING RESTORATION PROGRAMMES FOR THREATENED UNGULATES ESPECIALLY DEER

1. BASIC CONSIDERATIONS FOR STUDY AND MANAGEMENT PROGRAMMES

Constraints of Small Populations

FRED L. BUNNELL

ABSTRACT

The study and management of small populations are consistently challenged or constrained by the very size of these populations. Study is beset with sampling problems and the inability to extract data by the brute force of large, destructive samples. Management is complicated by concerns for both habitat and population or genetic diversity. Decisions are fraught with value judgements. Value judgements influence interpretation of observations and it is appropriate to acknowledge them at the outset.

In the midst of an information explosion and wavering epistemes few broad principles can be accepted as absolute. We can nevertheless hope that one of them will be an ethic of organic diversity. Wilson and Willis (1975: 522) state the ethic –

> "that for an indefinite period of time man must add as little as possible to the rate of worldwide species extinction and where possible he should lower it."

Our goal as conservationists cannot be to enforce stasis upon nature; evolution is inexorable and such enforcement impossible. Rather, the goal is to prevent the world wide rate of species extinction from rapidly outstripping species gain. The rate of species gain is slow, bounded by the slow rate of mutation and other agents of evolution; the rate of extinction encounters no such bounds. The present treatment of constraints imposed by small populations acknowledges these observations and the stated goal and ethic. Treatment begins broadly with concerns of area (indirectly habitat), then treats more specific matters of genetic diversity and study techniques.

SMALL POPULATIONS, SMALL HABITATS AND APPLIED BIOGEOGRAPHY

The day is all too rapidly approaching when the remnants of the natural environment will be contained in a patchwork of parks and reserves. Much of the world's endowment will be locked into insular refugia, surrounded by inhospitable landscape (Terborgh, 1974b), islands in a sea of habitat modified by man. Dispersal over this inhospitable sea will be hazardous or impossible.

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Our primary concern will be for local extinctions within the refugia, a phenomenon already active (e.g. Barro Colorado). In our confrontation with local extinction the principles of biogeography can offer guidance.

Some principles

While there are many specific phenomena that could be catalogued as potentially significant in the structure and diversity of habitat, it is the objective of the present treatment to address broad principles. In their review and extension of the theory of island biogeography MacArthur and Wilson (1967) documented that the number of species belonging to a single broad taxon equilibrates at a level that is a function of the area and degree of isolation of the island. Recent review articles indicate that the phenomenon is general and of widespread occurrence (see Cody and Diamond, 1975). Brown (1971), Cody (1975) and others have extended analyses to "islands" of habitat on continents. When the distance to the principal source area of resident species is held constant, the number of species, S, increases as a simple power function of the area, A:

$$S = b_o A^b 1$$

The relationship of equation 1 holds whether the source area is a continent,

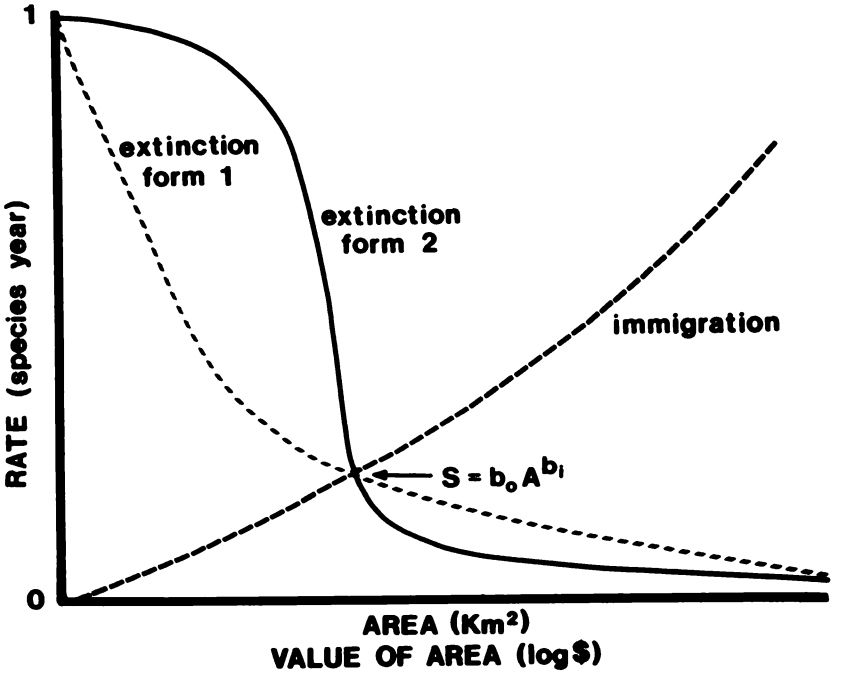


Figure 1. Rates of species immigration and extinction as a function of area.

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set of islands or just similar habitat nearby (Wilson & Willis, 1975). The value of b_1 decreases with increasing distance of isolation in a manner specific for each broad taxon and broad geographic location. However, b_1 generally lies between 0.2 and 0.4 (see MacArthur & Wilson, 1967: Table 2; Diamond 1972, 1975b; and May, 1975, for examples). A very general rule (using the approximate mean, $b_1 = 0.3$) is that the reduction of available area by an order of magnitude (ten fold), halves the probable number of species at equilibrium.

The underlying phenomena generating the equilibrium value for S, appear well documented (Diamond, 1975a: 134–135). The species number on an island is set by (or approaches) an equilibrium between immigration rates and extinction rates (Figure 1). These relationships are expressed in terms of numbers of species, S. The implications for a single species are nevertheless telling. When a natural reserve is set aside it is destined to become an island in a sea of inhospitable habitat. The relationships of equation 1 will hold and the species number will shift from its original equilibrium because of the area and distance effects described. Both Diamond (1972, 1973, 1975b) and Terborgh (1974b) have documented that in newly disconnected sea-islands, significant drops in the number of species occur in decades for islands the size of small natural reserves on continents (10 to 50 km^2) and over centuries in islands the size of larger National Parks (1000 km^2).

The extension of spontaneous extinction rates to particular species must be made with caution. Most biogeographical studies have examined birds (highly mobile) or insects (subject to wind dispersal). The expression of equation 1 results largely from dispersal patterns. Species which have been isolated or confined to small areas for a long period of time may have become sedentary to the point that generalizations concerning equation 1 do not apply. This caution does *not* apply to species which have been restricted in areal extent by over-hunting or inhospitable practices of land use. Similarly, the particular idiosyncratic causes of extinction of particular species on an "island" are frequently impossible to pinpoint and probably varied. In the case of Barro Colorado they may be associated with secondary succession (Willis, 1974), a phenomenon of general relevance. Alternatively, because the range of more specific habitats will be limited within a broader habitat type or type island, refugia may not exist during exceptionally wet, dry, cold or warm years. Under such extreme conditions the size of the "island" shrinks involving the threat formalized in equation 1. While secondary succession presumably represents no threat to long-isolated species, the concept of refugia, critical habitat or conversely resource "hot spots" (*sensu* Diamond, 1975b) is important to both long and newly isolated taxa.

The relationships of equation 1 represent the central principle of island biogeography but there are other principles that may prove equally insightful to stewards of small populations. One of these is a well-known but seldom emphasized concept of "ecological truncation". It is simply the early loss (extinction) of specialists and of large species which truncates an ecological guild, such as insectivorous birds. One of the better documented, recent examples is from Barro Colorado where both specialists and larger species were among the first to disappear, but the applicability of the concept appears

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universal (Terborgh, 1974b; Willis, 1974; Wilson & Willis, 1975). Equally pertinent are the more recent concepts of "incidence functions" and "assembly rules". Incidence functions formalize the observation that species composition as well as species numbers are a function of the island (or refuge) area. The incidence function of an individual species may prove useful in suggesting the minimum area of a refuge that would be adequate to ensure survival of that species (Diamond, 1975a). Diamond (1975b) has extended the concepts of incidence functions to assembly rules. A central objective or research into assembly rules is the identification of those traits which allow certain sets of species, but not others, to be fitted together in the same ecosystem.

Although peripheral to the main body of theory and principles of biogeography, there is a further set of concepts that relates to the size of area occupied by given taxa. These are the relationships governing the size of home range or territory. There are numerous examples of introductions, transplants, parks or reserves failing to accommodate the natural movements of species. Similarly, the early loss of larger species (ecological truncation) from a defined area appears to be associated with the larger home ranges and thus less dense (smaller) populations of these species. Among studies predicting size of home range the work of McNab (1963) is seminal, but has been greatly extended and refined, most recently by Harestad and Bunnell (1977). These authors document highly predictive relationships between size of home range and the predictor variables body size, trophic proclivity and habitat productivity. The relationships are well defined for birds and mammals, but are less clear for lizards and amphibians. They have the general form $H = aW^k$ where H is area of home range (ha) and W is body weight (kg). Among mammals the equations are $H = .003W^{.98}$ for herbivores and $H = .022W^{1.3}$ for carnivores. Their relevance to the present discussion is their ability to predict size of home range knowing no more than approximate weight and trophic proclivity. Such predictions can aid decisions concerning the size of reserves. Their major weakness is an inability to incorporate behavioral responses including migration.

Implications for small populations

Cowan and Holloway (1973) noted that 40% of the threatened deer taxa occurred on moist, relatively fertile land within a basically arid region. All of these taxa had been affected by modification of their habitat. This observation alone encourages concern for the nature of available habitat. Concern is enlarged by the fact that socio-economic phenomena frequently exert strong centipedal pressure on the extent of habitat that is to be preserved or managed for threatened species.

The principles of biogeography are especially telling for small populations because: 1) socio-economic pressures are disturbingly eager to equate small populations with small habitats; and 2) small populations can move disturbingly quickly along the biogeographers' "random walk to extinction". The broad but pertinent question is – how can the principles of biogeography be applied to the management of small populations?

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Preston (1962), Terborgh (1974a), Diamond (1975a and 1975b) and Wilson and Willis (1975) have pointed out that the most straightforward application is in the design of natural preserves. The fact that we acknowledge habitats as discrete entities, reveals an implicit acceptance of habitats as islands, and in fact plant ecologists and land managers increasingly refer to particular vegetation or soil types as "type islands".

The major implication from biogeography is that individual preserves should be large. Multiple regression analyses have shown that area alone accounts for most of the variation in numbers on islands (Hamilton *et al.*, 1964; Hamilton & Rubinoff, 1967) and in parks (Gavareski, 1976). Area, however, is itself correlated with environmental diversity (see for example Power, 1976). This latter observation means only that particular mechanisms are confounded, the empirical relationships with area still hold. The confusing issue is how large.

Wilson and Willis (1974; 528) suggest as large as possible. Taken literally such guidance suggests all of Vancouver Island to protect *Marmota vancouverensis* or all of Malagasy to protect the aye-aye (*Daubentonia madagascarensis*). The suggestion provides little guidance to a biologist offering advice, and little sustenance to credibility in an adversary environment. We can do better. There is sufficient generality in rates of extinction (see Cody & Diamond, 1975) that estimates may be made of these rates, as a function of time and area, for the most vulnerable taxa. A reasonable objective is to request minimal areas of reserves for which the initial (highest) extinction rates are tolerably low. What is tolerable is arbitrary (a value judgement), but might be assigned the probability of one taxon per century. Alternatively, projected rates of extinction can be used to estimate the size at which only large increments of reserved land will lower these rates significantly further (Wilson & Willis, 1975). That is, land acquisition ideally should attain the point of diminishing returns for the taxa most prone to extinction. Two problems arise. If the form of the extinction rate against area is continuous (form 1 of Figure 1) as some studies suggest, there is no convenient breaking point. Secondly, the cost of acquiring area increases more rapidly than area itself, perhaps logarithmically (Figure 1). In this situation socio-economic arguments are likely to outweigh biological arguments. Computation of extinction rates will nonetheless allow rational statements about the probabilities of local extinction. Very generally, these probabilities range from the loss of about 20% of the initial taxa over a century from areas of 10–20 km^2 to less than 1% from areas of 5000 km^2. The incidence functions of Diamond (1975a and b) suggest that for some species the form of the extinction curve may approximate that of form 2 in Figure 1. In this latter case, convenient thresholds exist and decisions regarding size of reserve are simplified.

The strong random component of extinction suggests an equally important implication: multiple reserves should be utilized. Species seldom become extinct simultaneously in every part of their range. Reciprocal and natural intercolonization between reserves can proceed indefinitely, and, if aided by deliberate transplants, might extend the life of the species well beyond expectations associated with a single reserve. Based on the area effect

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(equation 1), biogeographers have suggested that the larger preserve is always superior to a number of smaller preserves totalling to equivalent area (Terborgh, 1974b; Wilson & Willis, 1975). For some taxa this statement may not be true, a fortunate happenstance given the difficulties in acquiring large tracts of land. The relevant factors are the shape of the extinction curve, the possibilities of exchange between areas, and the degree of synchrony in the phenomenon inducing local extinction. Consider a relatively steep extinction curve with probabilities of 0.5 for an area of 100 km^2 and 0.4 for an area of 200 km^2 over some time period. If extinction indeed acts randomly, the probability of its simultaneous occurrence in two 100 km^2 reserves is only 0.25, significantly less than 0.4. Provided the reserves are in close proximity, or transplants are possible, smaller reserves may enhance the probability of an *individual* taxon's survival. How close is determined by the specific taxon's capabilities of and proclivities towards dispersal and barriers to dispersal as well as the feasibility of transplants (the desirability of transplants is addressed further in the discussion of genetics and gene flow). Biogeographers have suggested that multiple reserves should be located as closely together as possible. The suggestion is based on two assumptions: 1) that natural dispersal is possible, 2) that disease poses no threat. If the area surrounding reserves is indeed inhospitable to migrants and dispersal is not aerial or if disease represents a significant threat, disjunct, widely separated reserves may provide greater security. In short, the large continuous reserve is not the universally best strategy. On average, where large assemblages of species are considered the large reserve will prove most secure. Where there is no information on relevant extinction curves, conservatism is prudent and the large contiguous reserve the desirable objective, but there is room for legitimate compromise and small multiple reserves within the broader strategy.

Biogeography contributes further guidance to the optimal geometry of reserves through the "peninsula effect" (Simpson, 1964; MacArthur & Wilson, 1967; 114–115 and Figure 37). Although pronounced in such true peninsulae as Baja California, Florida and Yucatan the reduction in species diversity has not been well documented for habitat peninsulae on continents. In the face of ignorance, conservatism is again advisable and preserves of a given area should be as round in shape and as continuous as possible.

Individuals concerned with the preservation of particular species may find the implications noted above distressingly general. With biogeography concepts of critical habitat appear to be encompassed only indirectly by such terms as "resource hot spots". Because birds show greater visibility, mobility and vocalization (ease of sampling) than mammals, their study has contributed most to the principles. Specific causes for extinction are seldom clarified in biogeographical studies. Such observations are cautionary only and do not detract from the broad applicability of biogeographic principles. Where critical habitats or specific causes for decline have been identified the general principles concerning area, shape and distribution of reserves still will hold for most taxa. Mammals may show slower spontaneous rates of extinction because of their generally lower vagility than birds. Indeed, Preston (1962) noted a greater tendency for isolation in mammals. However, studies on insects

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(Wilson, 1961; MacArthur & Wilson, 1967), diatoms (Patrick, 1967, 1975) and land plants (Hamilton *et al.*, 1963; Johnson & Raven, 1973) suggest that the principles generally hold over broad taxa.

The generality of ecological truncation may also be queried. It is clear that many large forms have become extinct over the last few milennia (direwolf, giant lion (*Panthera atrox*), super-llama (*Camelops*), mammoths, ground sloths, the asphalt stork, and large raptors *Teratornis merriami* and *T. incredibilis*), and that larger members of broad taxa frequent the Red Data Book (giant otter (*Pteronura brasilensis*), giant anteater (*Myrmecophaga tridactyla*), giant panda (*Ailuropoda melanoleuca*), thylacine, (*Thylacinus cynocephalus*, etc.).

When applied to Cervidae the concept of ecological truncation is potentially confounded by man's pursuit of meat and antlers. Nevertheless, predicted patterns emerge broadly. To examine the applicability of the concept to Cervidae, I have had to employ shoulder height as a measure of size; information on weights is too sparse. Whitehead (1972) was the major source utilized. Within Europe and northern Asia the two smallest genera (*Moschus* and *Capreolus*) until recently contained no threatened taxa. *Moschus* has become threatened by the musk trade, a phenomenon specific to this genus among Cervidae. Among *Cervus nippon* it is primarily the larger subspecies that are endangered (e.g. *C.n. kopschi, C.n. grassianus, C.m. taiouanus*). Other endangered or potentially endangered taxa are also among the larger forms (e.g. *Dama d. mesopotamica, C. albirostris, C. elaphus hanglu* and *C.e. yarkandensis*). *Alces, Rangifer* and *C.e. hippelaphus* are exceptions. The trend is clearer for South America where the larger taxa are the most vulnerable or endangered (*Blastocerus, Hippocamelus* and *Ozotoceros*) while the *Pudu* and *Mazama* appear in no immediate danger. Within southeast Asia and the far east, larger forms of *Muntiacus* (*M. crinifrons* and *M. feae*) appear most endangered as do the larger forms of *Cervus* (*C. eldi* and *C. duvauceli*), with the exception of the sambar (*C. unicolor*). Such evaluation is by no means rigorous but serves to indicate that one further principle of biogeography holds broadly despite potential confounding by human activities.

Despite their apparent broad applicability, general principles *should be invoked in a general way* and are not meant to replace specific information. This is particularly true for the equations predicting size of home range and potential densities. These equations, while useful as a theoretical construct, should guide management decisions only where more detailed information on dispersal including migration is unavailable.

An important value of the consideration of biogeographic principles is that it can encourage visionary, imaginative approaches. For example, recommendation 4) below does not flow simply from a commitment to the ethic of organic diversity, but is based in part on incidence functions and assembly rules. As Wilson & Willis (1975) noted, these concepts suggest that assortive equilibria can be planned that exceed any occurring in nature. It is theoretically possible that species on the brink of extinction in their native range can be fitted into specific alien communities elsewhere without the frustrating domino effects that occasionally have been observed in the past

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(see *Oryx* 14:60). Studies on accidental combinations of birds and insects are encouraging, particularly for ruminants. The rather catholic food habits of ruminants suggest that they can be integrated into alternative communities without great difficulty. Potential for generating new assemblages should not be ignored as a possible option, but neither should the difficulties. The difficulties are particularly great where predatory forms are involved. Present quantitative treatments confirm observations that small prey populations can be decimated by even low numbers of predators (Haber, Walters & Cowan, 1976).

The alternative to grasping the vision and principles of biogeography is to allow these principles to enact their consequences unhampered. As Wilson & Willis (1975: 530) have noted, "the island effect and truncation, taken to their extremes, result in the domination of small parks by rats, cockroaches and sparrows, and similar invaders from nearby human areas". Their concern, based on theory, is justified. Gavareski (1976) has documented the domination of small parks in Washington by avian "weed" species. Obviously, a thousand such small parks are far less valuable for the maintenance of biotas than one refuge of equivalent total area.

Recommendations

Acknowledging these concepts of biogeography, it is apparent that planners of any form of natural reserve would be prudent to consider the spontaneous extinction rate and choose appropriate measures to minimize it. Some of these principles are depicted graphically in Figure 2, others are stated specifically below (for much of this I paraphrase Terborgh, 1974b; Diamond, 1975a; and Wilson & Willis, 1975).

1) Individual preserves must be large. Since the areas will always be fixed by political compromise the minimal request should be the area which further acquisition of land would lead to diminishing returns for the taxa most prone to extinction.

2) The random component of extinction indicates that unique habitats and biotas are best contained in multiple reserves. Such reserves should be located as closely together as possible where natural migration is possible and disease poses no threat. Where disease poses significant threat or natural migration is impossible, widely separated reserves may ensure greater security.

3) Preserves of a fixed area should be as round in shape and as continuous as possible.

4) Extinction models of the kind devised by Diamond and Terborgh should not be restricted to the most conspicuous or vulnerable organisms, but should eventually be developed for all taxa. Those taxa displaying the highest degree of endemicity and vulnerability (generally correlated) deserve first attention but no group should be ignored. The full taxonomic surveys underway in natural preserves (*inter alia* MAB), should be supplemented by studies of species dynamics and equilibria.

5) When assigning priorities and more specific information is lacking, the concept of ecological truncation suggests that specialists and large taxa in a guild should be considered most vulnerable.

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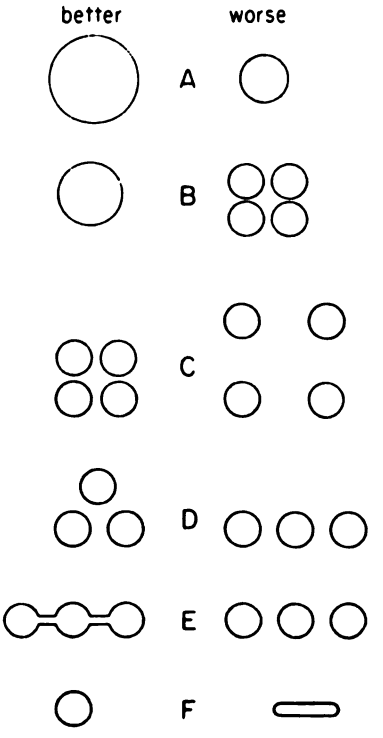


Figure 2. The geometric rules of design of natural preserves derived from biogeographic theory. For cases B through F, both the right figures have the same total area and represent preserves in a homogeneous environment. A: larger is better than smaller (area effects). B: a continuous preserve is often better than a fragmented one (boundary effects; exceptions in text). C: closer fragments are better than fragments farther apart (distance effects; exceptions in text). D: clumped fragments are better than those arranged linearly (distance effects). E: connecting corridors reduce extinction rates no matter how thin (Wilson, 1974). F: a round design is best (peninsula or boundary effect). (From Ddiamond, 1975a).

SMALL POPULATIONS AND GENETIC DIVERSITY

The value judgement remains that diversity must be preserved. We must recognize, however, that evolution has not stopped and will not stop. To some extent we grapple with a chimera.

Some principles

Despite its enormous advantages in presenting a new array of genotypes at each diploid generation, sexual reproduction impels little change in the fundamental genetic elements, alleles, and their frequencies. Five other phenomenon are important in altering gene frequencies and thus creating new genotypes. The first four of these as listed are deterministic, their rates and directions

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can be measured, and their effects predicted. The fifth is stochastic and we can speak only in terms of likelihood or probability. The five are: 1) mutation pressure, 2) meiotic drive, 3) gene flow, 4) selection and 5) genetic drift.

Mutation pressure and meiotic drive we can consider unimportant in our concerns for small populations, particularly vertebrate populations. Although mutations provide new genetic material thereby altering gene frequencies, for most mutations the instantenous rate is 10^{-4}/cell/generation or very much less. Thus, most mutations would require about 11,000 generations to reduce gene frequency to one third of its initial value [$t = (\ln 0.33/10^{-4})$], and more than twice that amount to reduce it to one tenth. A greater length of time would be required if reverse mutation or other evolutionary agents (e.g. frequency dependent selection) were acting. While mutation pressure may be important in microorganisms it is unlikely to be significant in multicellular organisms. Evidence is less clear for meiotic drive (the unequal production of gametes attributable solely to the mechanics of meiosis). The phenomenon is potentially disruptive because when one allele is included in more than half the successful gametes of heterozygotes, the allele can increase in frequency even if it has a harmful effect (Crow & Kimura, 1970). Meiotic drive has been studied as an evolutionary agent only for the past 20 years and neither its distribution nor significance are well known. Available information suggests it to be a much less potent agent of change than gene flow or selection.

These latter two phenomena plus genetic drift are of considerable significance to small populations. Apart from selection, the introduction of a group of genetically different individuals into a population is the most rapid way of altering gene frequencies. Gene flow or the amount of change in gene frequency over a generation can be defined by $-p(f_\alpha - f_\beta)$ where p is the proportion of different individuals (from population β) and f_α and f_β are the gene frequencies from the original population and population β respectively. It is apparent that only a small difference in gene frequencies together with a moderate migration coefficient (p) will effect significant evolutionary change. The implications for small populations, particularly captive groups, are clear. Because the population (α) is small, the introduction of only a few animals of different gene frequency will generate a large value for p (population β/ population α) and rates of gene flow will be high. It is equally obvious that the empirical relationship can be as great an advantage as a hindrance. Genetic material of the desired form can be incorporated as rapidly as undesirable material.

Gene flow can occur concomitantly with or independently of selection. Wilson and Bossert defined natural selection as "the differential change in relative frequency of genotypes due to differences in the ability of their phenotypes to obtain representation in the next generation" (Wilson & Bossert, 1971: 41). The variation in ability can result from many causes, a large number of which are influenced by man's actions. There is little value in enumerating the variety of causes in this brief consideration of principles. It is pertinent, however, to note a few aspects of the quantitative theory of directional selection. Directional (or dynamic) selection is the principle agent through which progressive evolution or cumulative shifts in gene frequencies are

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obtained, and is the type most relevant to small, isolated populations. The fundamental theorem of natural selection as expressed qualitatively by Darwin and partially formalized by R. A. Fisher in 1930, is succinctly defined by Wilson & Bossert (1971) as "The rate of evolution is proportional to the genetic variance of the population". Thus when selection pressure (S) increases linearly along a gradient of ecotypes, the rate of evolutionary change in a population equals the product of the intensity of selection and the genotypic variance (SV). The theorem grows from the concept of heritability which is exploited by all selective breeding activities and can be formalized as $h^2 = V_a/V_p$ where h^2 is heritability in its narrow sense, V_a is the variance due to the additive affect of genes contributing to individual genotypes and V_p is the total phenotypic variance. Acknowledging this notation the theory of selection can be expressed more precisely as $R = h^2S$ where R is the response of the population to selection, h^2 as above, and S is a parameter determined in part by the proportion of the population included in the selection process.

While the rates and directions of mutation, meiotic drive, gene flow and selection can be measured accurately for large populations experiencing short generation times, small populations are bedevilled by "sampling error". The error, termed genetic drift, may be that associated with the design of genetic research, chance mixing during sexual reproduction, or haphazard reduction of the initial genetic frequencies (e.g. via mortality induced by man). The latter instances concern those interested in maintaining the full genetic spectrum of small, natural populations. Wilson & Bossert (1971) summarized the three situations in which genetic drift may play an effective role in the evolution of small natural populations. These can be paraphrased as:

1) *Continuous drift*. The population remains small and sampling error is effective each generation.

2) *Intermittent drift*. The population is intermittently reduced to a size sufficiently small to allow drift to operate. If mortality is random at the time of reduction the sample of survivors may have a different genetic composition due to chance alone ("bottleneck effect"). If the population remains small over two generations continuous drift is initiated.

3) *The founder principle*. New populations started from small numbers of individuals may carry only a fraction of the genetic variability of the parent population and thus differ from it. Whenever chance operates in the selection of the founder individuals new populations will differ from the parent population.

The most important result of genetic drift is the loss of heterozygosity in populations. Sewall Wright deduced the theorem: In the absence of other evolutionary force [selection, mutation, gene flow, meiotic drive], fixation and loss each proceed at a rate of about 1/(4N) per locus per generation (where N = the number of organisms). The time to fixation or extinction of any given allele is thus roughly 4N generations on the average. If N is of the

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order 10 to 100 individuals, alleles can be lost at a rate of about .03 to .003 per locus per generation.

Implications for small populations

Acknowledging these principles and recent experience there are a number of implications for the preservation and enhancement of small, natural populations. There are two broad questions that elicit concern:

1) Are formerly large populations being reduced in size to the extent that genetic drift, perhaps coupled with selection, is operating to generate markedly different genotypes? Related to this concern, is the phenomenon of formerly continuous ranges being rendered disjunct, as with grizzly bears?

2) Are the numbers and conditions associated with transplants and captive herds encouraging shifts in genotype?

Before addressing these questions an important caveat is necessary. The principles and formal relations superficially treated above represent a small portion of the mathematical theory of genetics. The purpose of mathematical theory is ever to treat "all possible worlds". The purpose of experimental or ecological genetics is to deal with the real world (Bunnell, 1973). As Wilson and Bossert (1971) noted, most of the controversies over evolutionary theory in recent years do not concern true theory at all, but the magnitude in real populations of the parameters defined in theory. It is similarly important to recall that the fundamental Hardy-Weinberg formula or law invokes the assumption of panmixia (mating is random with respect to the genes in question).

In most if not all vertebrates panmixia does not hold and social structure imposes constraints on mating patterns. These constraints differ broadly among groups. Whereas more than 90 per cent of all bird species are monogamous (Lack, 1968), monogamy and its implications are relatively rare phenomena in mammals (Eisenberg, 1966; Orians, 1969; Alexander, 1974) with less than 3 per cent of mammalian species reported as monogamous (Kleiman, 1977). Despite its general rarity, among some mammalian families, e.g. *Callitrichidae* (marmosets and tamarins) and *Canidae* (dogs and foxes), monogamy is the most common form of social organization (Kleiman, 1977). Within ungulates it has been documented for only seven species, all of family Bovidae.

Territoriality poses further constraints. The phenomenon is of widespread occurrence, but of varying incidence, among the ungulate families. It seems prevalent among the antelopes of subfamily Bovinae, appears in some equids, rhinoceroses, camelids and the sole antilocaprid extant, but is largely absent from Bovini, Caprinae, and Cervidae (Owen-Smith, 1977; Table 1). In his review Owen-Smith noted that among Cervidae non-territoriality has been reported for *Alces alces, Cervus axis, C. canadensis, C. duvauceli, C. elaphus, C. unicolor, Rangifer tarandus, Odocoileus hemionus,* and *O. virginianus* (Owen-Smith, 1977: Table 2). I am aware that other interpretations exist for some species, e.g. by Miller (1974) for *O. hemionus*. The major point is not whether a specific species is territorial, but that social organizations differ

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among vertebrates and usually act to prohibit the assumption of panmixia. Among Cervidae only *Capreolus capreolus* is reported as territorial (Kurt, 1968; Bramley, 1970; Strandgaard, 1972), monogamy is absent and the most common mating systems may be termed "roving" (e.g. *A. alces, C. axis, R. tarandus*) or "harem" (e.g. *C. canadensis, C. elaphus*). While roving may approximate panmixia, harem or rank-based systems thwart the simple mathematical models of evolutionary trends. The models do not become intractable, but it becomes far more difficult to apply them to the questions generated by concern for the genetic integrity of small, natural populations.

Several significant points are embraced by this general caveat. The first point grows from observations that studies in protein variation have shown that there is spatial variability in gene frequency among populations of most species. Some form of genetic subdivision has been demonstrated for fish from different rivers (Utter *et al.*, 1973; Morgan & Koo, 1973; Avise & Smith, 1974; Echelle *et al.*, 1975; Iwata, 1975), and mammals from different regions including *O. virginianus* (Harris *et al.*, 1973; Smith *et al.*, 1973); *Dipodomys* (Johnson & Selander, 1971); *Thomomys* (Nevo *et al.*, 1974); and *Geomys* (Selander *et al.*, 1974). The phenomenon is general and embraces birds (Ferguson, 1971; Redfield, 1974; Baker, 1975), as well as lizards (Webster & Burns, 1973) and amphibians (Guttman & Wilson, 1973). In some instances these differences in gene frequency have been shown to vary with population density or time (e.g. Redfield, 1973; Krebs *et al.*, 1973; Pickering *et al.*, 1974) and with such phenotypic characteristics as per cent of eggs hatched (Frelinger, 1972). In short, real and important differences in genetic material exist within natural populations but presently are poorly understood (see summary of Smith *et al.*, 1976: Table 1). Such differences must be acknowledged before even the simplest models of quantitative genetics can be employed to guide decisions. A further point concerns the social organization and mating systems of the species being considered. Application of any general model or guideline requires that the mating system be known. As Cowan and Holloway (1974) noted "we have almost no data upon the variability, the breeding pattern, or sex ratios, of any of the endangered or rare deer, though such data are badly needed". To the population measures noted by Cowan and Holloway we should add dispersal. The theorectical importance of gene flow for small populations has been noted. The real world importance is equally critical, for empirical observations suggest that dispersal of males is significant, particularly among Cervidae (Staines, 1974; Kammermyer & Marchinton, 1976). In our concerns for the genetic integrity of small natural populations, we are confronting a problem of widespread occurrence and significance but with virtually no known measures of critical features.

Returning to the two broad questions earlier posed for small populations, consider first the formerly large population reduced in size through overharvest or modification of habitat. The agent of primary evolutionary importance is likely genetic drift. The population has been reduced in size either randomly or through forms of selection novel in the history of the species. Gene flow if it is significant will be acting positively to maintain the integrity

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of the genetic pool. Selection, if it is acting through harvest or expulsion to suboptimal habitat, will be enforced by genetic drift. In a population of 50 panmictic individuals the *maximum* rate of drift will generate the fixation or extinction of alleles at the rate of .005 per locus per generation or, on average, one allele per 200 generations. Within rank or harem mating systems the rate will be increased roughly in proportion to the females served per male. With a harem size of five the probability of allele extinction in the population of 50 would be less than 40 generations. If the evolutionary change is a function primarily of genetic drift there are few counteracting mechanisms that could be enacted. This might be the situation in newly isolated populations where mechanisms of frequency-dependent selection or heterozygote superiority were not well developed to maintain balanced polymorphism. It is noteworthy that in species with a low intrinsic rate of increase (e.g. *Ovibos moschus* and *Ursus arctos*), the isolation of small populations, perhaps via modification of habitat, may invoke a phenomenon more akin to continuous than to intermitten drift.

The apparently alarming rate of potential genetic change should also be considered in terms of the total genetic material involved. The possible number of diploid genotypes containing n loci of 2 alleles each is 3^n. For both *Drosophila melanogaster* and man, it has been estimated that about 10,000 or more loci exist, many bearing numerous alleles. Thus, the total number of diploid genotypes is enormous. Through genetic drift an allele on a particular locus could be fixed or lost rather quickly (40 generations) but it is completely unclear what that change might effect.

In long isolated populations the prospects are less alarming. The genetic complement probably has been fixed and balanced polymorphism is likely maintained by well developed mechanisms of frequency-dependent selection or heterozygote superiority. Where these mechanisms are sufficiently developed they will invoke their own selection pressure as the population is further reduced and thus help to counteract drift. We know that the actual rate of loss of adaptively important genes (whose frequency of occurrence approximates 50%) is much less than that predicted by Sewall Wright's theorem. Selection to maintain balanced polymorphism may also be acting in many species whose habitat requirements generate quasi-isolated populations scattered over particular seral stages. Redfield *et al.* (1972) concluded that it was selection which maintained balanced polymorphism in the Ng locus of blue grouse (*Dendragapus obscurus*).

In short, recently isolated populations appear more likely to approximate the maximum possible rates of genetic drift than are long-isolated populations. For recently-isolated populations of about 50 animals 30 to 200 generations would be required on average to fix or lose one allele. The time span within which a permanent shift in gene frequency may occur thus varies broadly from about 15 years (some insects, rodents and insectivores) to 1400 years (bears). For long-isolated populations and possibly those showing well-developed dispersal (Cervidae?) the rate of drift appears limited by mechanisms maintaining balanced polymorphism.

We must be less sanguine about concerns for captive populations (zoos,

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game farms, enclosures in native habitat). Among these populations gene flow, selection and genetic drift are each important. Genetic drift is surely operating and mechanisms for maintaining balanced polymorphism are perhaps not well developed. The situation is one of the founder principle rather than of continuous or intermittent drift as is the case of "naturally" isolated populations. Rates of genetic drift will be the same but selection pressure may be acting subtly. Recall that the rate of evolution can be expressed as $R = h^2S$. Within captive groups the magnitude of S may be significant because S is 1) directional associated with conditions of confinement and 2) large, because the entire captive population may be subjected. One effect of drift will likely be to increase heritability, h^2, as an increasing amount of genetic variability will be associated with phenotypic variability. With both h^2 and S increasing, the rate of evolution may increase dramatically beyond the potential rates of genetic drift alone.

It is unfortunately impossible to assign rates beyond the theoretical maxima associated with genetic drift or "inbreeding depression" (*sensu* Mayr, 1963). In some cases the value of h^2 might be estimated from domesticated relatives. Both the magnitude of S and the effect of genetic drift on h^2 can be no better than guesses. The potential rate of change is theoretically great and abundant evidence of its deleterious effects among laboratory populations and livestock are reported by Falconer (1960). Recent evidence for "wild" species includes that for Przewalski's horse, the head and legs of which may be changing because of selection over a period of captivity of approximately 75 years (*Oryx* 14: 62).

Recommendations

These recommendations summarize and extend the points of Cowan and Holloway (1974), utilizing the principles and discussion presented above.

1) Priorities for research and action in response to genetical considerations should be: first, confined populations of recently reduced taxa; second, newly-isolated groups; and third, long-isolated groups. Long-isolated taxa are more likely to respond better to small group confinement and to provide better potential for transplant as small groups.

2) Research on mating systems, herd structure and dispersal are critical to the forecast of potential evolutionary change and should be encouraged.

3) Research on genetic differences in all wildlife species should be encouraged and effort made to standardize techniques (e.g. Selander *et al.*, 1971). Initial estimates of heritability among Cervidae may be obtained from domesticated taxa (*Rangifer, Alces*) and central European work on management for trophy stags (*Cervus*).

4) The possibility of sperm banks should be considered.

5) Prescriptions for viable size and structure of captive herds depend on information encompassed by 2) above. In general, the larger the population the better, and even a few individuals can alter rates of drift significantly. As many males as social organization permits should be incorporated. Rates of evolution with confined groups will likely be greater than those predicted from drift alone.

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6) Acknowledging drift and selection every effort should be made to maintain several natural populations of each taxon (see also recommendation 2 concerning natural reserves).

7) The principles of gene-flow should be exploited. Exchange of males is essential to maintain variability within small populations. Exchange can be effective at intervals of about ten generations or less.

8) Acknowledging the subtle effects of selection, confined populations should be maintained in environments which approximate the natural environment as closely as possible.

9) Judicious culling may be required to inhibit drift from increasing deleterious genotypes in the population.

10) As a matter of policy, the purpose of confinement is to return species to the wild as soon as possible.

11) Reintroduction should, wherever possible, include both wild-reared and pen-reared stock, so as to maximize 'cultural' transfer of relations with habitat.

12) In all releases or transplants, the animals should be thoroughly tested for diseases or parasites acquired while in captivity and only 'clean' animals liberated.

ASSESSING SMALL POPULATIONS – WHAT TO MEASURE

This discussion does not address specific components of studies of threatened species (see Cowan and Holloway, Geist, McCullough, and Taber for treatment of specifics). Present comments are a much more general treatment that attempts to encompass the broadest features of such studies and to extract recommendations from these. I present the comments acknowledging that there is a danger in generality. Attempts to distinguish the forest from the trees, can be pursued with such vigor that the forest itself is lost from sight. Nevertheless, I submit that the general question we ask is "what activities impact upon this taxon, how are they mediated and how can they be mitigated".

Some principles and empiricisms

Given the general question we can acknowledge four major components of the system being studied. These we can term "disturbance features", "mitigation targets", "impact indicators", and "mitigative actions" (Table 1). The major rubrics of Table 1 are modified from Gross (in press), the phenomena listed within rubrics are my suggestions. Elements of each of the four major components are important in any scheme of assessment. Present disturbance features must be identified to enact effective mitigation. Mitigation targets are important for they may foretell the magnitude of the impact and may also be meliorated by means other than direct control of specific disturbance features. For example, artificial feeding may maintain energy balance even though detrimental effects of land use practices are persistent. The necessity of impact indicators and mitigative actions are clear. Ideally impact indicators should be capable of assessing not only disturbance features, but also the effects of mitigative actions.

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Table 1. *Major features important in assessing the present and future status of population*

Disturbance Features (physical actions that cause change)
Harvest for meat, antlers, etc.
Logging
Cultivation
Drainage
Predation
etc.
Mitigation Targets (primary requirements that are disturbed by physical actions)
Energy
Nutrients
Cover
Living space
etc.
Impact Indicators (measures that are changed by physical actions)
Population size
Population composition
Population distribution
etc.
Mitigative Actions (physical actions that meliorate disturbed mitigation targets)
Habitat enhancement
Habitat replacement
Habitat substitution
Control of disturbance feature
etc.

Acknowledging these major components and the universe of social and economic constants, we can suggest desirable or ideal capabilities of any scheme of assessment, some of these modified from Gross (in press):

1) The capacity to discriminate impact over spatial areas from about five km^2 to several thousand km^2;
2) The capacity to discriminate between influences of different vegetation or habitat types in the geographic area of interest;
3) The capacity to assess a broad representation of all animal species in the area of interest (recall the discussion of incidence functions and assembly rules);
4) The capacity to distinguish between different disturbance features;
5) The capacity to predict the magnitude that the impact will attain and its time course.
6) The capacity to provide meaningful associations between the accumulation of baseline information, the prediction of impact, the monitoring of impact, and the planning of corrective measures. In particular, the capacity

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to meet administrators' expectations and concerns for the utility of the assessment.

7) The capacity for rapid analysis and review of information.

8) The capacity to synthesize assessment information in an incremental fashion.

9) The provision of a rationale framework for evaluation in a potentially "adversary" atmosphere.

Having presented some ideal characteristics of a system for assessment it is useful to acknowledge some frequent failings. Failure is less often documented than success, but there are sources that supplement personal impressions. The sources deal either with the failure of specific programmes within the International Biological Programme to provide information relevant to management (Battelle, 1975; Mitchell *et al.*, 1976) or published evaluations of environmental impact assessments (e.g. Gross in press). Four common failings emerge:

1) Much of the information collected makes no clear contribution to the conclusions of the assessment.

2) The acquisition of data, their synthesis and interpretation are insufficiently comprehensive to establish scientific or administrative credibility for conclusions of the assessment.

3) Conclusions of the assessment consider only a few of the species known to inhabit the area of interest.

4) Conclusions of the assessment involve such broad confidence intervals that their use by administration generates as much confusion as clarity.

A dilemma is apparent: although a lot of apparently useless information is collected, insufficient information is collected. While the structure of the solution is obvious (collect more information of the right kind), the approach to the solution is unclear. It is a useful exercise to consider the means by which many large, well-funded programmes (e.g. impact assessments) find themselves squarely in the dilemma. Although the amount of funding may differ the principles apply equally to assessment of endangered species. Concern for endangered species is generated when numbers become much reduced. That the numbers are small can be documented firmly, but still inform us little of the mechanisms generating the observed result. Consider now the typical *modus operandi* of the large programme. Mitigation targets are the elements of a taxon's requirements that are affected by the disturbance features being evaluated. These requirements are critical in maintaining the taxon's welfare. Even where funding is generous, projects are thwarted by insufficient ecological or physiological knowledge to both accurately and precisely assess the state of all requirements. Elaborate simulation models may be constructed based on intelligent surmise and data from related species. The common geometry between increased detail, increased assumptions and reduced understanding is invoked (Bunnell, 1973). The resultant frustration almost invariably leads to a search for broader integrative measures or surrogate variables. The information from these surrogates is intended to suffice not only as measurements of change in the status of the taxon's require-

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ments, but also as a diagnosis of the nature of the impact to guide the design of mitigative actions.

Almost without exception population density becomes the surrogate variable (Milner, 1972; Anderson *et al.*, 1974; Bunnell, 1974; Bunnell *et al.*, 1975). The choice is not simply because we know more about population dynamics and armed with a hammer keep searching for nails. Density really does integrate the effects of an enormous number of variables. Unfortunately, the number is unmanageably large. One need only refer to the much simplified depiction of relations between density and causal factors in Cowan and Holloway (1974: Figure 1) to appreciate why population density fails to achieve its implied role in the assessment process. A multitude of phenomena react to generate population density, any one of which may be critical singly or in combination with others.

The confusion density generates as an impact indicator becomes apparent when one attempts to deduce the nature of changes in life requirements by observing a change in density. We confront recalcitrant reality and the crux of the dilemma – we can collect less information by monitoring only density; but is it the right information? To acquire information on the status of and functional relations among life requirements involves an enormous expansion of effort and leads to the common syndrome of measuring everything that can be funded.

A common compromise is to incorporate more detail in the demographic measures of the taxon. These include turnover (mother/young ratios), age composition and sex composition. Incorporating such refinements we find that reality is not only recalcitrant in the face of our good intentions, but also frequently capricious. Recent analyses of most of these measures reveal that as commonly used they can generate not simply poor information but misinformation (Caughley, 1966, 1974 and 1976; Bunnell & Tait, 1977; McCullough this volume). For a detailed discussion see the authors cited, here I need summarize only the major principles. These can be stated briefly:

1) For animals such as Cervidae (early sexual maturity, constant rate of mortality after the first one or two years), *detailed* information on age structure provides little useful information.

2) By themselves, gross age ratios (adult/young) rapidly become less useful with decreasing age of sexual maturity and are of little use in assessing populations of taxa reproducing earlier than five to six years of age.

3) Adult/young ratios *can* provide useful information when measured repeatedly and in conjunction with population density.

4) Sex ratios are of little use in assessing population status in other than heavily overharvested populations.

Among the impact indicators listed in Table 1, population distribution remains to be discussed. Measures of distribution frequently have advantages over estimates of density. There are three broad ones. First, the only data required are whether or not the taxon occurs at the points of interest. The measures thus require much less time, effort and money than is normally necessary to estimate population density. Second, measurement of a taxon's distribution often lies within the capability of field methods, while measure-

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ment of density frequently does not. Confidence limits around density estimates are notoriously wide. Third, measures of a taxon's distribution can satisfy many of the attributes of the ideal scheme of assessment previously discussed (page 280). Potential pitfalls exist. It is unclear whether changes in population size caused by disturbance features or mitigative actions will be accompanied by changes in distribution large enough to measure. Similarly, the impossibility of actually proving absence of a species may provide such a bias that information on population distribution will prove equally difficult to obtain as density measures.

Implications for small populations

Approximate density will ever be of initial concern in determining the status of populations suspected of being threatened, rare or endangered. It is clear, however, that rapidly diminishing distribution provides as useful a prognosis as rapidly diminishing density. As an impact indicator to define mitigation targets and mitigative actions, density will always prove wanting. This observation is not an argument against using measures of density, but against relying heavily upon measures of density. The concern for reliability, thus credibility, of measures will always bedevil density, particularly for small populations where confidence intervals will be great. One may take grim comfort in the fact that such measures will frequently be conservative, but this fact does nothing to enhance credibility in an atmosphere of adversity.

Refining measures of population structure is a wasteful exercise if the action is intended to avoid the high costs of accurate estimates of density. Some measures derived from structure can only be interpreted when coupled with estimates of density. The problem is particularly acute in small populations because most such measures invoke ratios. The capriciousness of these measures lies in the fact that changes in either the denominator or numerator alter the ratio. In small populations a change of a few individuals becomes significant.

It is important to recognize that the unreliability of measures of population structure does not obviate their use. Male/female ratios provide essential information for the effective propagation of confined herds and effective release of transplants. It is as indicators of impact that measures of population composition are frequently wanting and sometimes misleading. Measures of population distribution are presented not as a panacea for the difficulties inherent in measures of population density and structure, but as an important supplement and potential substitute. If the assessment scheme is indeed incremental, as recommended, measures of distribution merit consideration as a first step. It is worth emphasizing that the patient unobtrusive observer collecting information on no more than distribution and social structure can make a worthwhile contribution.

Recommendations

These recommendations are purposefully general in keeping with the broad overview taken. For specifics see Cowan and Holloway, Geist, McCullough, and Taber.

1) All schemes of assessment for endangered species should recognize

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explicitly the broad components of disturbance features, mitigation targets, impact indicators and mitigative actions (Table 1)

2) Within an assessment scheme, population distribution merits consideration at least equal to density.

3) Measures of population structure are critical to effective conservation programs and should be collected with their relevance to behavior in mind. They do not obviate density measures and are frequently poor indicators of impact.

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PART II: DOSSIER ON PLANNING RESTORATION PROGRAMMES FOR THREATENED UNGULATES ESPECIALLY DEER

1. BASIC CONSIDERATIONS FOR STUDY AND MANAGEMENT PROGRAMMES

Human Constraints and Conservation – The Case of Rural Communities in the third world

DAVID PITT

ABSTRACT

The paper begins by criticizing models of human constraints in the conservation field – singling out particularly determinism, lack of communication, and lack of relevance. An exception might be certain anthropological models but these have the deficiency of not being practical enough. In third world societies major constraints are apathy, the primacy of economic objectives and the absence of local involvement in conservation programmes. What is needed is a better understanding of conceptions of nature and conservation, more and better education, fuller communication and devolution.

* * * *

Human or social constraints in conservation form a huge, fundamental and, I would argue, neglected area in research and action in the conservation field. We have now, thanks in no small measure to the IUCN, excellent classifications of endangered species and a growing literature on animal behaviour itself. We have very much less on the role of man in his relationships with nature in general and conservation in particular. I apologize in advance for the inevitable sweeping generalizations in any brief paper on such a huge topic, my only defence being that I feel a start has to be made somewhere. I will however restrict myself to a focus on the relationship between rural societies and conservation, particularly in the third world. Unfortunately the material on deer is not very large in this area, so there is some overspill into a more general discussion.

Isolating the main human obstacles and constraints themselves is not the difficult part of the task – ignorance, greed, need, apathy and misguided actions are probably the pillars of any problem.[1] To understand these problems however needs an analysis of causal patterns in time and space. The problem really begins outside the third world, where there is supposedly a repository of knowledge and from where the impetus for conservation comes.

[1] Dr. Richard Taber has proposed a division of affected social groups most characterized by one or other of these features, e.g. rural poor (greed, need), conservation officials (apathy) and urban intellectuals (ignorance).

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Basically of course we do not know enough, certainly about deer[2] but also more generally.[3] The problem is more complex than a simple absence of empirical data. I would like to argue that the first problem of conservation is that the theories and models that we have in the physical, life and social sciences or, even more significantly, inter-disciplinary, are not capable as they stand of providing a frame for vitally needed research, for interpreting the data we already have and even more for any action programmes.

My fundamental criticism is of the simplisticism and centrism of the models that we have. We talk in portmanteau terms of human constraints, of the third world, national societies and so on, from what is presumed to be a common, usually labelled scientific, viewpoint. Yet we do know that we live in a pluralistic[4] world, fragmented and cross-cut by national, subnational, ethnic, ideological, economic class and many other attitudinal and behavioural divisions. And those who study these societies are part of them. This affects the basic definitions and starting points such as conservation itself. A widely accepted definition is 'the rational' use of the human environment and its natural resources to attain the highest sustainable quality of living for mankind.[5] But there is not consensus on what is rational, and some have argued that no mankind (even admitting womankind) but rather nature[6] or even the welfare of animal-kind should be the focus. And here ideological divisions become important. One group's concept of conservation may be another's exploitation; whilst exploitation, even the disappearance of a species, may be justified on grounds of evolutionary selection, health risks to humans (a recent example is rabies[7]), economic competition or other reputedly 'scientific' criteria which always contain some elements of bias, and certainly of a debate between what has been called the 'hard' and the 'soft'.[8] These

[2] For the list of 25 species put forward by I. McTaggart Cowan and C. W. Holloway (1973 – Threatened Deer of the World – *Biological Conservation* 5 (4)). There is practically no ethnographic material.

[3] Reverdin, O. (1973 – De la prise de conscience au programme d'action – *Proceedings of the 12th Technical Meeting of IUCN*, Banff, September 1972: IUCN new series 28, pp. 71–82).

[4] We use the term here in the sense of Furnivall, i.e. of parts of social structure which meet but do not mix. (cf. Pitt, D. C. and Macpherson, C. 1974 – *Emerging Pluralism* – London, Longmans).

[5] e.g. Dasmann, R. F. (1973 – Ecological Principles and Their Application to Development Planning – Proceedings of the 12th Technical Meeting of IUCN, Banff, September 1972: IUCN new series 28, pp. 131–136).

[6] See Ashby, E. (1976 – Towards an Environment Ethic – *Nature* 262: 8/7/76). The exploitation and the enslavement of animals and the case for the improvement in their status has been graphically described (see, for example, Godlovitch, S. and R., and Harris, J. (1972 – *Animals, Men and Morals* – Taplinger, New York; Clark, S. R. L. 1977 – *The Moral Status of Animals* – Oxford University Press). The argument that plants should have rights is well made in Stone, C. D. (1974 – *Should Trees have Standing* – Kauffman, Los Altos, California).

[7] See for example Kaplan, C. (ed) (1977 – *Rabies* – Oxford University Press). One reviewer (Nature 268: 7/7/77), however, regarded this book as somewhat irresponsible and certainly there is no documentation given on the question of deer.

[8] cf. Tribe, L. H., Schelling, C. S. and Voss, J. (eds) (1974 – *When Values Conflict* – Ballinger, Cambridge, Mass.).

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ideological divisions are part of the basic dialectics in European if not world philosophy – determinism/freewill, nature/nurture, inheritance/environment, reductionism/meaning, cost benefit/quality of life, yin/yang, and so on. Whilst such debates may be productive there is a tendency to run along ruts.[9]

A more serious constraint is the problem of communication between broad groups of disciplines,[10] not so much the Leavis-Snow two cultures as a social/physical and life sciences gap. This may be a variant (in the eyes of some social scientists at least) of the hard/soft division related to the dominance of some science (or scientists) in what some have seen as an undemocratic[11] power structure.[12] Whatever the causes, the social scientist in environmental programmes (e.g. UNESCO/MAB) is often something of a token being, whilst 'social factors', even if included, are reduced to vague or meaningless inputs. However, if there are faults on the side of physical or life sciences, the schools in the social sciences have failed to provide adequate models for analyzing and taking action on conservation problems. Even more significantly there are very few people, with skills from both sides of the scientific fence, collecting relevant information.[13]

One of the fastest growing schools, and one that is activist in political terms is Marxism, though the difficulties of definition are becoming so complex that one recent commentator[14] has in resignation called Marxism a type of non-conformity.

In the Marxist position, conservation is hindered by a class (bourgeoisie, capitalist and, possibly, 'tame' scientists) seeking only profit, and exploiting both the environment and other social groups or, to take the case of hunting deer, to preserve an aristocratic privilege. Marxism as an explanatory pardigm in conservation, as elsewhere, is hindered by its undue determinism (after all, in deer management properly regulated hunting and aristocratic deer parks have been a means of conservation, whilst the efforts of responsible capitalism have been important too), by its blind spots (particularly towards the rural peasantry whom Marx disparagingly referred to as 'a sack of potatoes'), and by the difficulties of establishing a dialogue between Marxists and non-Marxists.

Clearly there is much more to the man/nature relationship too than exploitation, profit, or economic factors. Here the work of some social

[9] See for example the current debate in Nature 268: 7/7/77, p. 11, where May, drawing on the work of Medawar, Feldman and Cavilli-Sforza, shows that either or both inheritance and environment may be critical, or the well known Alpbach Symposium (Doestler A. & Smythies, J. 1969 – *Beyond Reductionism* – Macmillan, London; and c.f. Dawkins, M. 1976 – The Spirit of Nature needs Rekindling. *Nature* 264; p. 586).

[10] For an example in Africa, see Richards, P. (1976 – What Environmental Crisis means in Africa. *Nature* 259: 29/1/76).

[11] cf. Lowe, P. and Warboys, M. (1976 – The Ecology of Ecology – *Nature* 262: 5/8/76).

[12] For examples of some basically Marxist approaches see Rose H. and S. (1976 – *Ideology in the Natural Sciences* – Macmillan, London).

[13] I am grateful to Dr. George Petrides for drawing my attention to an exception, the work of S. A. Marks (e.g. 1976 – *Large Mammals and a Brave People* – University of Washington Press, Seattle).

[14] cf. Bottomore, I. (1976 – *Marxist Sociology* – Macmillan, London).

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anthropological schools (structuralist, structural-functionalist, etc.) seems at first sight to be quite relevant. Take for example, Leacock on the Montagnais.[15] When this people stopped hunting deer for fur trapping it was a complex result of other societal changes. As the informant Mathieu graphically commented, 'No family. No kill 'em deer. Man alone, no kill deer. Too heavy bring back. Eat flour, porcupine, rabbits, fish. Long ago see 'em deer, kill 'em. No flour. Got no eat. Got to kill 'em deer.' The anthropologists have also been responsible for showing that in traditional societies there were conservatory rules expressed through taboo and other rituals,[16] and many contemporary third world conservation problems can be said to be the result of the breakdown of traditional controls and sanctions without any effective substitute, especially when there are dramatic technological changes such as the introduction of firearms. Most significant of all, Levi-Strauss, Leach[17] and others (through Durkheim[18]) have been responsible for showing how the images of nature reflect logical structures relating to other parts of society towards which there are positive or negative behaviours. Animals then may be totems (possibly exalted) or taboo and outcast.

These theories may be argued to have an application far beyond the third world rural communities from which they derived. As far as deer are concerned, conservation policies may well depend on whether the official image is nearer the totemic or the taboo end of the scale. In New Zealand for example, deer, once a totem and freely introduced, are now taboo, officially described as 'noxious pests' to be exterminated, even though it is freely admitted that there is little idea of numbers (the absence of migratory routes restricts counting), of different effects on species (some rate species are undoubtedly threatened), of internal deer population control[19] or of the effects of the extermination squads of helicopter wide-spectrum poisons. There is certainly some damage done by deer in concentrated areas but this concentration may itself be caused by the official constraints which restrict movement.

These symbolistic theories however have their own constraints. Social anthropologists are still deeply immersed in the traditional world and only minimally involved in social change areas such as conservation. Also, much of the work is deterministic (Levi-Strauss has been claimed as 'Hegelian'). Morris recently[20] has shown how classification of animals in tribal societies may have a logic of their own, whilst Bulmer (in ethno-ornithology) claims

[15] Leacock E. – (The Montagnais Hunting Territory – *American Anthropologist* 78: 26).

[16] Unfortunately the ethnographic literature on deer in this regard, especially the endangered species is very slight but cf. Condomings, G. (1957 – *Nous avons mangè la forèt* – Mercure, Paris).

[17] Leach, E. (1976 – *Culture and Communication* – Cambridge University Press).

[18] E. G. Durkheim, E. and Mauss, M. (1963 – *Primitive Classification* – Cohen and West, London).

[19] The ideas of Wynne Edwards may be relevant here.

[20] Morris, B. (1976 – Whither the Savage Mind – *Man* 11 (4): 542–57).

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that there is too much reification, 'egghead' before the chicken in his metaphor.[21]

One of the key constraints in fact is the general inability of theoretical models to suggest practical modes of action. Practical constraints on which we now focus are blind spots sometimes because of complexity but more often because they do not easily fit a given frame of reference or are simply overlooked. Like Sherlock Holmes's dog in the night, problems of conservation in the third world are basically due to something that is not there. i.e. help from the developed countries. This in turn reflects internationally first of all the relative absence of any political 'muscle' of the conservation lobbies. Some have argued[22] that since Stockholm there has been a declining interest in environmental questions generally, as doomsday seemed no nearer, as not enough solid scientific evidence was forthcoming, as politicians, 'planistrators', etc.[23] became less convinced of the costs of environmental exploitation over the benefits in economic growth; – perhaps as multinational and commercial interests became more important. In addition there were many blocks within the conservation institutions, confused and overlapping laws and jurisdictions,[24] overcentralized,[25] bureaucratic inefficiencies, and conflicts between the important supports, e.g. sportsmen (pro-hunting) and the anti-hunters. Certainly there remained a considerable public interest (e.g. nature films, books etc), some participation and even ecological political parties,[26] but relatively few people were involved from a fairly narrow middle class background.

The underlying constraint worldwide was the general apathy. Reverdin[27] has argued that conservation problems will not be solved unless the world experiences a mass feeling of fear like 'la grande terreur' which swept Europe in AD 1000 when it was feared the world would end.

Within the third world, specifically, there is certainly not this fear. There is now a good deal of evidence[28] to show that politicians and people want

[21] in Pouillon and Maranda, P. (1970 – *Èxchanges et communications* – Mouton, Paris).

[22] Kay, D. A. and Skolnikoff, E. B. (1972 – *World Ecocrisis* – University of Wisconsin Press; Sandford, R. 1977 – Towards a Pollution Policy – *Nature* 267: 30/6/77).

[23] In Pitt D. C. (ed.)(1976 – *Development from Below* – Mouton, Paris and The Hague.

[24] See for example V. J. Chapman in Polunin N. (ed.)(1972 – *The Environmental Future* – Macmillan, London).

[25] cf. Taylor, G. R. (1977 – Down with the Nannies – *The Ecologist* 7 (5): 158) for a scathing criticism. An interesting discussion of centralized direction is in Kelley, D. R., Sturkes K. R. and Westcott, R. R. (1976 – The Economic Superpowers and the Environment – Freeman, San Francisco.), who deal with USSR and Japan.

[26] cf. Lowe D. and Warboys, M. (1976 – The Ecology of Ecology – *Nature* 262: 5/8/76).

[27] Reverdin, O. (1973 – De la prise de conscience au programme d'action – *Proceedings of the 12th Technical Meeting of IUCN*, Banff, 1972: IUCN new series 28, pp. 71–82).

[28] Galtung, J. *et al.* (1976 – *Images of the World 2000* – The Hague). My own fieldwork in the Pacific Islands bears out this economic ambition even in a very traditional context. See Pitt, D. C. (1970 – *Tradition and Economic Progress* – Oxford University Press).

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economic growth as a priority even if it means a neglect of the environment. Mahbub ul Haq, one of the most influential of third world spokesmen, has put it very bluntly: "If, for instance," he writes[29] "an irrigation project is being contemplated in a certain country – this in fact is an actual example – which is going to destroy one of the famous national parks, this is a cost that the society has to cheerfully bear as there are no other economic alternatives. And the society has neither the time nor the option to quibble too much about whether it is a reversible or irreversible damage." However, as others[30] have argued, development and conservation must be compatible. Adequate conservation need not compete with agriculture.[31] Tourism in national parks, etc., may be a significant means of earning income, as countries like Kenya have shown. One might well turn Haq on his head and argue that third world poverty is in part due at least in some cases, e.g. the Sahel and some montane areas[32] to environmental neglect, even if this neglect reflects the socio-economic inequalities and official ineffectiveness within third world countries themselves,[33] a fact which is certainly recognized by the peasants who nicknamed seismic disasters 'classquakes'.[34]

The question of the degree to which rural communities themselves contribute to conservation problems and more significantly can contribute to conservation action programmes is problematical in a situation where government controls outside the village are constantly being extended. But some points can be made. We have already alluded to the 'traditional' state of affairs where the regime of taboos, sanctions, laws and custom provided some kind of conservation system, even if based on magic rather than science: and even if, as far as deer were concerned, there were problems e.g. the traditional use of musk. The impact of the colonial period was essentially to destroy this traditional fabric without providing a replacement, within or outside legal institutions, though, on the credit side, a system of European wildlife values, in part enforced, was established. This has at least led to the creation of reserves and sanctuaries and a store of knowledge of indigenous biota. However, because of massive social changes, some rural communities are socially unstable. The results may sometimes be complete, almost pathological apathy (see Turnbull[35]), often a breakdown of order, (a dangerous situation for deer when combined with the spread of firearms), and usually population redistribution (e.g. urban drift, rural concentrations). This may in fact create some pressures on resources, though as far as deer are concerned there has

[29] Haq, Mahbub ul, (1976 – *The Poverty Curtain* – Columbia University Press, p.109).

[30] cf. Dasmann, R., Milton, J. and Freeman, P. (1972 – Ecological principles for Economic Development – Wiley, New York).

[31] cf. Ratcliffe, D. (1977 – *A Nature Conservation Review* – Cambridge University Press), who suggests from a monumental survey that 92% of the land in Britain is of no or negligible agricultural value.

[32] cf. Pitt, D. C. (ed.)(*Men and Mountains* – Leiden – Martinus Nijhoff, Leiden – in press).

[33] See for example Pitt, D. C. (1976 – *Social Dynamics of Development* – Pergamon, Oxford).

[34] O'Keefe, P. *et al.* (1976 – in *Nature* 260: 15/4/76, p. 566).

[35] Turnbull, C. (1972 – The Mountain People – Cape, London).

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been a population decline amongst hunting peoples, whilst there is some evidence to suggest that the third world population 'explosion' may have fewer resource effects than the early sensational literature suggested.[36] In fact some human populations are themselves endangered species, sometimes in numerical terms and certainly culturally. The case for the conservation of the traditional is not that it was reasonably effective environmentally (we must guard against any excessive idealization à la Rousseau, which has permeated some anthropology) but that it was a vehicle for local identity, for community development, for both local initiatives and a harmonious relationship with the agencies outside the villages[37] which seek to introduce new ideas. In this situation of instability it needs only hunger and firearms for there to be a massive overkill.

There remains one critical area, that of communication and education. Even if there is some kind of renaissance of community development, there is still a great need for accurate information and guidance. Certainly there is in the media, in books, on radio, TV and at the cinema, a strong environmental voice, but in the third world it is often drowned by soap opera or politics. Also, it may not be practical enough. Clearly much needs to be done in the schools, in youth clubs, etc., to tap the undoubted enthusiasm of third world youth towards conservation goals. Communication too is most necessary to and from and between the conservation 'experts' themselves.

In summary and conclusion, then, we have constraints in both theory and practice. To provide for a worthwhile model for the conservation of deer, or conservation generally, needs initially a much better understanding of how nature is conceptualized and why people act (or don't act) the way they do. This necessitates much closer cooperation between those involved in conservation whether scientists, advisers, bureaucrats, or 'consumers', probably initially in well thought out pilot schemes that can work at practical grass roots level. We need scientists who are familiar with both the physical/natural and the social aspects of conservation and who are willing to work in this hitherto unexplored territory, probably, like most hybrids, shunned by purist colleagues. Genuine interdisciplinary projects may still be some way off, but a start can be made, initially, and this work has already begun; a manual and checklist of social science factors could be provided for field biologists, so that a very basic, commonsense collection of data can begin. We need also to understand the relationships between change and the agents who analyze and seek to influence it. Although conservation seems to need to come initially from above (in the third world from outside), the ultimate object should be to encourage devolution; conservation from below, like development from below, is likely in the long run to be the most effective method.

[36] For documentation on this point see Pitt, D. C. (1976 – *Population and Development* – University of Auckland, Work Papers in Comparative Sociology No. 7).

[37] See for example Pitt, D. C. (1976 – *Social Dynamics of Development* – Pergamon Press, Oxford).

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PART II. A DOSSIER ON THE PLANNING OF RESTORATION PROGRAMMES FOR THREATENED UNGULATES WITH SPECIAL REFERENCE TO DEER

1. BASIC CONSIDERATIONS FOR STUDY AND MANAGEMENT PROGRAMMES

SUMMARY OF DISCUSSION

Constraints of small populations (F. Bunnell).

Most of the discussion was concerned with the application of biogeographic theory to the maintenance of small populations and the conclusions that could be drawn from the conservation of species and biotic communities. Particular attention was drawn to figure 2 of the paper, which illustrated the importance of size, shape and dispersal of reserves for the preservation of a species and their habitats. The first consideration, however, is that the reserve should provide for all the species' requirements and, ideally, it should protect the entire biotic community of which the species is a part.

Consideration of conservation requirements from the view point of biogeography emphasizes the importance of distribution of small populations, the location of inhabited areas and the travel routes between them. Migratory species require different conservation approaches to sedentary animals and, as insularity is species-specific, reserves selected for one species are rarely satisfactory for another. One of the main conclusions to be drawn was that a reserve system alone was insufficient to ensure the survival of a species and that management for conservation of areas outside the reserves was essential.

The importance of genetic drift in small populations in the wild may be over-estimated, but it is certainly a matter for concern in captive populations.

Human constraints and conservation – The case of rural communities in the Third World (D. Pitt)

Dr. Taber provided a summary of this paper in the absence of Professor Pitt. There was general agreement that, if future conservation plans were to be realistic and culturally viable, conservationsists needed to take much greater account of human sociology in studies designed to provide a better basis for the management of natural resources.

As a first step, Professor Pitt had agreed to prepare a set of guidelines on cultural and sociological problems that should be examined in field studies on threatened species.

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PART II: A DOSSIER ON THE PLANNING OF RESTORATION PROGRAMMES FOR THREATENED UNGULATES WITH SPECIAL REFERENCE TO DEER

2. COMPONENTS OF STUDY PROGRAMMES

How to Generate Etho-ecological Data in Field Studies of Endangered Ungulates

VALERIUS GEIST

ABSTRACT

By focusing on questions derived from the concept of reproductive fitness, the field researcher can maximize information pertinent to two objectives: to obtain date of immediate relevance in safeguarding the relief population and to obtain insights into a species that may become extinct and is then beyond research. It is also vital that detailed descriptions of the sex-age classes throughout the season be compiled, all remains of dead individuals stored in reputable museums, and an exacting written and pictorial record of the habitat of the species be obtained and deposited in reputable archives.

INTRODUCTION

In the study of a wild animal in the field, data may be gathered from a diversity of viewpoints. In the study of endangered species, however, when resources and time are scarce, one must focus on those aspects of field work that are most likely to help achieve two principle objectives:

(a) obtaining data of immediate use in safeguarding or enlarging the population in question, as well as gaining information useful for future reintroductions;

(b) obtaining basic data on the population and its history because extinction of that population may eliminate all future possibility of studying that species.

As in all scientific investigations it is very important to ask those questions that are most relevant to the above objectives, and to know what form the final study is likely to take. Today we have a relatively large number of field studies of ungulates available for perusal. Because of this, is it possible to devise a system that will generate relevant questions for a field study? I shall show that there is such a system.

In addition, it is very important that a detailed, verifiable, description of

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the animal and its habitat under investigation be presented also. This is important, not only in view of the possible extinction of the population, but also because such descriptions provide a basis for deciding whether an endangered population's taxonomic status is valid or not. We are today beginning to understand how to segregate purely phenotypic features from species-specific genotypic ones; this understanding is derived from classical animal science dealing with growth priorities of tissues in response to nutrition (e.g. Hammond, 1960). The obligation of the field worker, however, ends with his providing precise descriptions of the study animal and, if possible, depositing specimens in recognized collections. The above considerations generate a series of requirements.

REQUIREMENTS

(1) The field worker ought to supply an accurate illustration and description of all sex-age classes of the species investigated throughout the yearly cycle. This should include all the pelage phases, the time of the year when changes occur and a quantitative recording of the polymorphisms encountered. The descriptions ought to be backed up by sketches, photographs and film where possible.

(2) The remains of dead specimens – even apparently trivial items – should be deposited with a secure, reliable, natural history museum or university museum. These specimens ought to be recorded with IUCN for future reference. A description and analysis of the remains of dead specimens should be part of the report on the completion of the field work.

(3) A detailed photographic and film record of the habitat, as well as of the signs left by the study animal, ought to be compiled and deposited for future reference with a university library. This record should include landscape pictures in all seasons, the important forage plants, signs of browsing, preferred cover, bedding sites, tracks, trails, feces, marking sites, etc.

In order to minimize the loss of relevant information, and focus on attributes of behaviour highly relevant to the objectives of a study of an endangered species, one can use the following system to generate relevant questions. One asks what the individual does to maximize reproductive fitness. This generates seven primary requirements –

(a) How to maintain homeostasis? (How to remain healthy?) This asks what strategies and tactics are used by individuals at all life stages to obtain resources, reduce contact with predators, parasites and pathogens, and how body care or hygiene is practised. It forces one to answer such questions as: is the individual occupying a given habitat because of its forage resources or does it simply feed on what it does because it chooses a habitat in order to escape predation or harassment by humans? Food habits may be secondary to safety; if so, the field worker must evaluate to what extent the food habits he observes are an artifact of circumstances.

The habitat preferences, diurnal activity, the manner of running and responding to disturbance, become clues to the adaptations against becoming prey. By contemplating such activities in an evolutionary perspective, the

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field worker can at times identify what predators the species in question was selected to avoid.

The task of studying an endangered species is much more demanding of intellect than the study of a common species because the population is likely to exist in a damaged ecosystem. This calls on the investigator to reconstruct as well as possible the prehistoric conditions for his study animal.

(b) How to minimize expenditures on maintenance so that a maximum of resources is left for reproduction? (This is the law of least effort.) All individuals can be expected to gravitate towards a behaviour conforming to this requirement. Do the circumstances in which the endangered population is found impose undue maintenance costs? Are individuals harassed, or do they have to move uneconomically in order to find food or cover? What can be done so that individuals can live more cheaply?

Note that by addressing the above requirement we do more than investigate food; we investigate how it is used. One can increase reproduction not only by providing more resources but also by preventing waste of existing resources.

(c) How to maintain access to scarce resources essential to reproduction? This requirement forces one to evaluate first what resources are critical for reproduction and which are not. Second, it forces one to determine how individuals compete for these resources.

Resources may be safeguarded by contest over them or by passive competition. The prerequisite to answering the above question is a detailed study of food habits, as well as an evaluation of all possible constraints on reproduction. One must also be able to tell whether we are dealing with obligatory territoriality in which resources are defended all year round by individuals, with facultative territoriality in which local resource concentrations are defended opportunistically while the same resource in low concentration is obtained by speedier harvest, or whether 'scramble' (speedier harvest) is the normal form of resource competition. Different sex-age classes may act quite differently here.

A clue to the nature of competition is the weapon system of the species in question. Weapons maximizing surface damage to the body, coupled with attack on the body – generally a damaging combat – indicate resource defence; weapons that permit wrestling matçhes, hierarchical social organization and sparring matches indicate scramble competition for resources (see Geist, 1977a).

(d) How to expand into unused resources or habitats? This question addresses the manner of dispersal, as well as the general reproductive strategy of the species. What prevents dispersal or colonization of unoccupied land? What measures are required to trigger and enhance colonization? Does the species generate annually a surplus of young adults above and beyond the number required to replace mortality? Only rarely has the question been answered as to how a species disperses, for it has been assumed that dispersal patterns are to some extent uniform and thus nothing one need worry about. Only in recent years has it become apparent that species may practise very different means of dispersal, from those that scatter young adults with

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every reproductive season (r-selected) to those that conserve youngsters and whose home ranges are passed on as a tradition (K-selected).

(e) How to reduce the reproductive fitness of others directly? Again it has only recently become apparent that individuals may maximize their reproductive fitness not only by successful competition but also by directly destroying the nests or young of other individuals or, by a diversity of means, may increase the rate of attrition of competitors. I reviewed and discussed some of these possibilities in Geist (1977a). Unfortunately, we are still ignorant of when such activities occur maximally, and it behoves the field investigator to keep his eyes open to discern the circumstances in which they occur.

(f) How to support identical or closely related genotypes? This is, of course, the converse of the previous principle and is the focal point of much debate in socio-biology (e.g. Wilson, 1975). It is important to know that in habitats of high productivity the defence of resources by demes is possible and that kin-selection may set in. Individuals may parcel out resources in relation to their relatedness. They may settle where they can support a relative against other con-specifics or gain protection from a relative.

(g) How to find a partner equal or superior to oneself in maximizing reproductive fitness? Here we are dealing with the strategies and tactics of mate selection. These are not independent of strategies of resource exploitation, as I have reviewed and discussed for ungulates in Geist (1974) and more recently in Geist (1977b). It may be that a species' advertisement strategies make it subject to human predation. It is important to know how sexual competition operates, for this points to the requirements for successful mating.

The above set of requirements, posed as questions, are a system that is only as good as the field worker is capable of making it. I have found it to be useful, but not easy to use in that it poses questions to which answers may not be readily forthcoming. Its virtue is that it prevents one from doing uncritically what has been done before with other species and so stereotyping the process of field work. It forces one to ask biologically relevant questions and to search the literature accordingly.

Since any relict population is likely to be an artifact, no effort should be spared in gathering information about the species from old people who formerly hunted it, reviewing the travel, hunting and zoological literature of earlier decades and centuries, and ascertaining the role the animal played in tales gathered by anthropologists. Much can be gleaned about an animal's habits if one knows how it was trapped or hunted, when it was done, where and by how many persons. One can also glimpse some of the animal's attributes from the tales about it and the powers ascribed to it.

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PART II: A DOSSIER ON THE PLANNING OF RESTORATION PROGRAMMES FOR THREATENED UNGULATES WITH SPECIAL REFERENCE TO DEER

2. COMPONENTS OF STUDY PROGRAMMES

Essential data required on population structure and dynamics in field studies of threatened herbivores

DALE R. McCULLOUGH

ABSTRACT

Population data are necessary to determine the status of rare species. Age structure data alone cannot be safely interpreted without knowing population size and the trend in the habitat for the species in question. Most sources of age structure data are biased by underpresentation of the 0 age class. Using recruitment, rather than raw age structure, can overcome some problems with this bias. Approximate methods are given for calculating probability of extinction, population performance and population status. The reliability of these calculations will depend upon the quality of the data, and the results should be used in conjunction with other information on the biology of the species in reaching conclusions.

REASONS FOR OBTAINING POPULATION DATA

Introduction

The purpose of determining population structure and dynamics of any species is to establish the current status and indicated future trend of the population. Large herbivores are K-selected[1]; i.e., over evolutionary time they have been subject to selection for ability to compete for resources in a density dependent environment. The population consequences of such selection are usually large body size, low reproductive rate with high parental care, long life span, and overlapping generations. The management consequences of dealing with K-selected species are that knowing all about the population dynamics will be of little use without also knowing about the quality and quantity of suitable habitat available to the species.

[1] K-selected animals are those that live at or near the carrying capacity of the environment (K of the logistic model of population growth; hence K-selected), and are selected for strong competitive ability in securing resources (see MacArthur & Wilson, 1967; Pianka, 1970).

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INTERPRETING AGE STRUCTURE

There is a good deal of erroneous information in the literature about the interpretation of age structure data. For example one frequently encounters the text book conclusion that age pyramids with a broad base indicate a rapidly growing population while those with a narrow base are declining. This idea can be very misleading. Assume a K-selected species is being consistently over-exploited by man. As density is reduced, density dependent competition decreases and survivorship of young goes up. This is the typical compensatory response of K-selected species in which the lower the density, the younger the distribution of age structure. If we followed the textbook interpretation we would conclude that the population over time was showing an **increasing population growth**, when the actual case is that the population is inexorably being driven to extinction by over-exploitation.

On the other hand, a population at subsistence or K-carrying capacity, typically stabilizes with an old structure with failure of most of the recruitment class. Thus the age pyramid is top heavy. The population need not be declining and, in fact, usually would be at the greatest size possible. Even a young age class being smaller than an older one is no great cause of alarm since, in poor years, recruitment can be expected to drop below the equilibrium number. One recruitment class failure in a long-lived K-selected species has a relatively minor impact on the total population number. Even failure of several consecutive recruitment classes will occur if temporary overshoot of K has occurred. Indeed, stable equilibrium at K is uncommon in subsistence populations where a dynamic, oscillatory equilibrium is more likely. The point is that an age pyramid with a broad top may not indicate a declining population. But neither is it safe to assume that such an age structure shows that the population is at carrying capacity. The California condor and whooping crane, rare species with low populations, show such age structures.

To reiterate the point, it cannot be determined what the status of the population is on the basis of age structure alone. Age pyramids with broad bases or narrow bases may be obtained from declining, stable or increasing populations. And the extreme case of the recruitment class being smaller than older classes, which indicates at least a temporary population decline, cannot be interpreted in a longer term frame of reference. (Indeed, the seemingly safe assumption of a temporary population decline might be unsafe. Because of the high compensatory nature of population responses in a K-selected species, the early failure of the recruitment class may lower competition to the extent that old animals survive better than normal, and the total population could remain unchanged.) Thus, we can state our first rule of population dynamics.

Rule I. Age structure data cannot be interpreted safely without also knowing total population size

It is said that rules are made to be broken and since this is such a demanding and impracticable one in the real world, we will attempt to find ways of getting around it. But the corollary is that when you break rules, you sometimes get caught, and then you pay the penalty. Ignoring this rule can lead to some mistaken conclusions.

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Perhaps the safest substitute for knowing absolute population size is knowing population trend. Indeed, if the index to trend is perfectly correlated with absolute population size, trend is, for practical purposes, every bit as good as population size, although esthetically less satisfying. The problem is that indices to trend are normally used because absolute population cannot be determined. In the absence of population size, the correlation with the index cannot be established statistically, and reliance on the index is based upon an assumed relationship. At best one hopes that such a correlation does exist, but the reliance which can be placed on it is unknown since the variance is not known. At worst, the correlation may not be significant (we will exclude the possibility of a significant correlation, but of the opposite sign of that expected).

Indices used might be number of animals observed per unit of time or effort, number of tracks or droppings per unit area, etc. Note that with a few exceptions of aerial counts in open situations, what we call census methods are nothing more than such indices manipulated by one or more factors to yield an estimate of the total population. Thus, methods can be obtained from compilations of census methods in the literature such as the Wildlife Techniques Manual (Giles, 1971), IBP Handbook Series (Golley and Buechner, 1968; Petrusewicz and MacFadyen, 1970), and overviews such as McCullough (1970). Theory behind the methods can be found in Richer (1975) and Seber (1973). Note further, that such procedures contain two sources of error. The first is the sampling error of the index deriving from the fact that the correlation between the true population and the index is not perfect. The second is the error due to bias in the correction factors used to manipulate the index value. Thus, failure of the method as a population estimator does not necessarily mean it is a poor trend indicator since the failure may be due to such bias in the correction factors.

The need for population trend in order to interpret age structure is so great that even if the methods leave much to be desired a poor estimate is better than none at all.

A second substitute for absolute population size is population density. Density, or the number of animals per unit area, presents its own problems of interpretation. For example one block of habitat might be of far greater quality than another. Yet, if populations of the species of herbivore are at subsistence in both, the age structures might be identical. But absolute population may be much higher in the block of habitat which was of high quality, and density there should be much higher. One would have to know something about habitat quality to explain this outcome. Conversely if the population in the high quality habitat were heavily exploited by unknown illegal hunting, the density in the two blocks might be equal, but the age structures would be entirely different. This puzzle would be baffling if one knew only density and habitat quality. But given all three only an unknown source of high mortality in the high quality block would account for the discrepancy.

The importance of knowing habitat quantity and quality can be illustrated further by considering some hypothetical cases of a rare species of deer. Suppose we had population data which showed that the recruitment of a given species was strong, survivorship predictable and population size stable.

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Given no further information, we would conclude that the status of the species was satisfactory. But suppose we also were able to determine the absolute population size, and it was 100 head. That would be cause for alarm. But suppose we had a second rare species of 500 head which showed erratic population responses such as failure of recruitment in certain years, highly variable survivorship schedules, etc. It would be reasonable to conclude that this species was in a more precarious state than the one with 100 head since the one with 500 head can be expected to fluctuate violently, while the one with 100 head shows a good deal of stability. We might conclude that most of our efforts should be directed to stabilizing the dynamics of the erratic species. However, suppose we learned that the species with a stable population of 100 was living in a subclimax habitat, that the useful life expectancy of the habitat was being approached through succession and that appropriate new habitat was not being created. In that case, only a crash program of habitat management would avert the imminent extinction of the apparently stable population.

We could elaborate these examples *ad nauseam*, but the point should be clear; no set of population dynamics can be interpreted without reference to the habitat. Thus, we can give a second rule.

Rule 2. Even a complete set of data on population dynamics cannot be fully interpreted without knowing about habitat quantity, quality and successional state

It is well beyond the scope of this paper to discuss methods of habitat study. The reader is directed to Giles (1971), Golley and Buechner (1968), National Academy of Sciences (1962) and Greig-Smith (1964) for basic descriptions of methods and procedures. Suffice to say that habitat assessment and inventory are necessary background work to place population studies into context. Lack of habitat information can lead to serious errors in interpretation of population data, and a misassessment of the status of a rare or threatened species.

SOURCES OF POPULATION DATA

With some species, total counts from the air are possible if the normal habitat is of an open kind. As the typical habitat of the species includes more concealment cover, censusing becomes much more difficult. A fair number of rare species occur in heavy forest, are nocturnal, and are extremely difficult to count. Some are almost never observed directly. Indirect methods, described in the references previously quoted, must be used, and these contain many pitfalls. Mark and recapture methods are cumbersome and expensive with large ungulates. Both capture by drugs and trapping usually result in some mortality, and with a rare species may not be acceptable. Experience with mark-recapture methods with ungulates have not been very satisfactory unless a very large proportion of the population was marked (Strangaard, 1967; author's data). Mapping territorial size in territorial species has some potential, but has major drawbacks of non-random distribution of territories, and the existence of a non-territorial, "floating" segment of the population.

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In summary, most census methods are not very satisfactory and do not seem likely to improve rapidly (McCullough, 1970). It is my opinion that efforts should be directed mainly at developing population indices which can be used to establish trends. If such indices are precise (i.e. have low variances) they will be highly useful even though they are inaccurate (i.e., do not give reliable estimates of total population).

The typical source of age structure is examination of commercial or sporting take. Most rare species have legal protection, and this source of information is unavailable. Illegal kills are difficult to obtain since the poachers are not liable to be cooperative. The bones of larger ungulates, particularly those in drier habitats, may persist well enough for collection and aging of skulls to be useful. Such methods are almost always biased with the youngest age classes being underrepresented, but this is not necessarily an unsurmountable problem. If large numbers of animals are captured live, age determinations should be attempted. Often a lower incisor or a premolar can be removed from older animals with a full mouth for sectioning for cementum counts, with little damage to the animal. If, because of its endangered status, the species is completely protected, the only age structure data obtainable may be field observations. Sex usually can be determined because of dimorphism in secondary sexual characteristics except in the very smallest individuals. As to age, young of the year usually can be distinguished in all ungulates, while in those of intermediate size yearling animals can usually be distinguished. In very large ones, three or four juvenile classes may be separated. Biases due to sex and age segregation are common in data from direct observations, and experience, proficiency in the field and good optics are necessary to derive reliable results.

II. METHODS OF ANALYZING POPULATION DATA

Probability of extinction

The fundamental problem in working with rare or endangered species is the question of how many are necessary to guard against extinction. This is a question which cannot be answered precisely. Yet, intuitively, we recognize certain species as being in greater danger than others, and it is desirable to state the criteria more explicitly.

There are two sources of danger of extinction. The first is through the continuance of a generally unsatisfactory status of a given population. The second is a sudden, catastrophic event. The first can be analyzed in terms of statistical probabilities. Catastrophic events (devastating fires, typhoons, introduction of an exotic disease into populations lacking immunity) occur so irregularly as to be independent of any statistical distribution, except perhaps on a geological time scale, which is hardly an appropriate scale for establishing policies for rare species.

The only reliable strategy for guarding against catastrophic extinction is to establish several, separate and isolated populations at points far enough apart so as to be unlikely to be equally subject to a catastrophic event. Ideally this situation would be achieved in the wild but, if not, captive stocks can play the same role. Genetically, the species may be saved from

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extinction by introduction from captive stock, but esthetically something has been lost in the process.

For extinction in the course of normal events, the number necessary to prevent extinction will depend upon the position on the r- to K-selected[2] spectrum. In general, the more K-selected the species, the fewer individuals necessary and the more r-selected, the greater. This is because K-selected species are largely density dependent, and population size tends to track carrying capacity. Thus variance in population size will be less over time and, in general, the higher the variance, the greater the population size needs to be to avoid dropping to extinction. As one moves to the r end of the spectrum, population responses become more and more density independent, and population persistence through time is secured by large numbers surviving at random. Thus, the statistical probabilities based upon a time series are likely to be reliable since the assumption of independence of the observations is valid. Thus, one can determine the probability of the population dropping below a certain minimum number from which it cannot recover by the formula (Simpson *et al.*, 1960):

$$t = \frac{(\bar{x} - x)\sqrt{\frac{N}{N+1}}}{S}$$

where $\bar{x}$ is the mean, x the population size from which the species cannot recover, N the sample size, and S the standard deviation. The probability of extinction is determined by checking the t value with a t table. The degree of freedom is $N - 1$.

K-selected species do not meet the assumption of independent observations since the size of the population in one year is likely to be related to the size of the population in the following year. Nevertheless, this procedure gives a much better indication of the danger of extinction than simple intuition, although no scientist should suspend personal judgment. Furthermore it should be noted that, in practice, strict adherence to parametric statistics assumptions is seldom met and, in fact, they are relatively insensitive to violation.

If the 34 years of tule elk population data[3] for Owens Valley (McCullough, this volume) are treated this way one gets a t-value of 3.098, which gives a probability of dropping to 5 head (considered the minimum likely to have both sexes present) of 0.004. This probability, equivalent to 1 in 250, seems acceptably low.

Whether the distribution of observations approximates a normal distribution can be checked by plotting the values as a frequency histogram and

[2] The opposite strategy of reproduction from K-selected is r-selected. These animals produce the maximum possible number of offspring, have short life spans, and give little or no parental care (e.g. most insects) The intrinsic rate of increase (r_{max}) of the logistic population growth curve expresses this tendency, hence r-selected (MacArthur and Wilson, 1967).

[3] The 1977 census data were not available at the time of preparation of this paper, and these figures are not included in the analysis.

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examining visually for a bell-shape (Fig. 1). More sophisticated techniques for testing normality are given in most texts on basic statistics (e.g. Remington and Schork, 1970; p. 218–225). The tule elk data for 34 years tested in this way was found to meet the test of normality ($a_3 = 0.4250$) and to be slightly leptokurtic ($a_4 = 3.39$; i.e. with a strong central tendency).

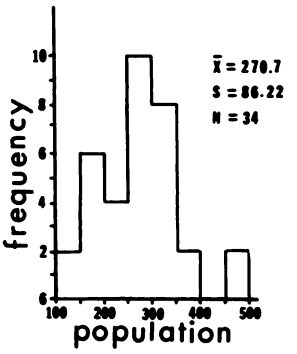


Figure 1. Frequency histogram of 34 years of aerial counts of the Owens Valley population of tule elk conducted by California Department of Fish and Game.

Unfortunately, tests of skewness by parametric methods require large sample sizes. Non-parametric sign tests (Remington and Schork, 1970; p. 316–322) may reveal severe skewness, but these tests are not powerful and usually reveal little that cannot be judged from a frequency histogram. For example, the tule elk data passed the running sign test for normality (Remington and Schork, 1970).

It has been shown (McCullough, unpubl. ms.) that there is a threshold point in K-selected species with a balanced sex ration of a mean maximum annual production of young of about 2.5 below which tracking of K carrying capacity is high.[4] Most ungulates would fall into this group, and the probability of these populations not meeting the assumption of normality would be greatest. Thus, this volume deals with animals in which the assumptions of normality are least likely to be met, and examination of this assumption is in order.

Again, it should be emphasized that this is merely a tool, a useful reference point. Even if the assumptions of the statistics are met, the biological assumption behind the approach is that the environment or habitat is going to continue to be as it was over the period during which the data were derived. Therefore, the experienced biologist should make decisions based upon all information available.

[4] This does not imply that equilibrium will be achieved at K carrying capacity; only that the population shows a general tendency to move towards K. Shifts in K and time lags in population response make a stable equilibrium unlikely.

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Is protection always right?

Usually concern about a species arises because it has fallen to low numbers, and the typical response is to give protection, particularly if human exploitation is involved. Usually this is the correct course of initial action. However, K-selected species must be managed relative to K carrying capacity, and it is not axiomatic that total protection yields the greatest hedge against extinction. Consider the example of the tule elk (McCullough, this volume). Between 1950 and 1970 the population was controlled by hunting to 300 head. Based upon data for these 11 years, the t value of dropping to 5 is $t = 0.0002$ or 1 in 5000. By contrast, for the first 16 years with large hunting removals, it was 1 in 36 and for the total protection of the last 7 years 1 in 238. While the assumption of normality is not met, the point should be clear. A responsible program of control can reduce the probability of extinction by introducing stability in the population.

Similar results were obtained from models derived from the George Reserve deer herd (McCullough, unpubl. ms.) where simulations with complete protection led to much greater variation in population size than did moderate to heavy exploitation. Analysis of the results of the two management schemes showed that the probability of extinction under complete protection was much greater than under relatively heavy hunting. The biological reason for this is that populations at carrying capacity are at the fine edge, and hard winters, dry periods, etc., cause a disproportionate impact on the population. This "crash" tends to produce an equally strong recovery, with potential overshoot of K. Thus the population tends to bounce about rather erratically. However, at the lower densities resulting from hunting, individual animals are in much better condition, have greater fat reserves, and less intraspecific competition. Because of lower feeding pressure, the habitat is in better condition. Thus, the impact of bad periods can be withstood more readily, and this dampens out oscillations in the population over time. Therefore, a moderate hunting take can result in a more stable population than allowing the population to grow to K. And this is particularly true of those species which have the capacity to overshoot K and cause habitat degradation.

Analyzing population performance

Although sufficient data are seldom available on a rare species, the general approach to analysis of population performance can be illustrated by the tule elk data (footnote 3 on p. 307). First it is necessary to determine if density dependent responses are shown by the population. This can be determined by regressing rate of population change on population size (Fig. 2). Note that the data include errors in censusing as well as actual population responses, thus calling for a type II regression model. However, calculation of the regression equation by the Bartlett method (Sokal and Rohlf, 1969) gave results virtually identical to those obtained by the least squares method, so the latter was used. The slope was negative, as one would expect

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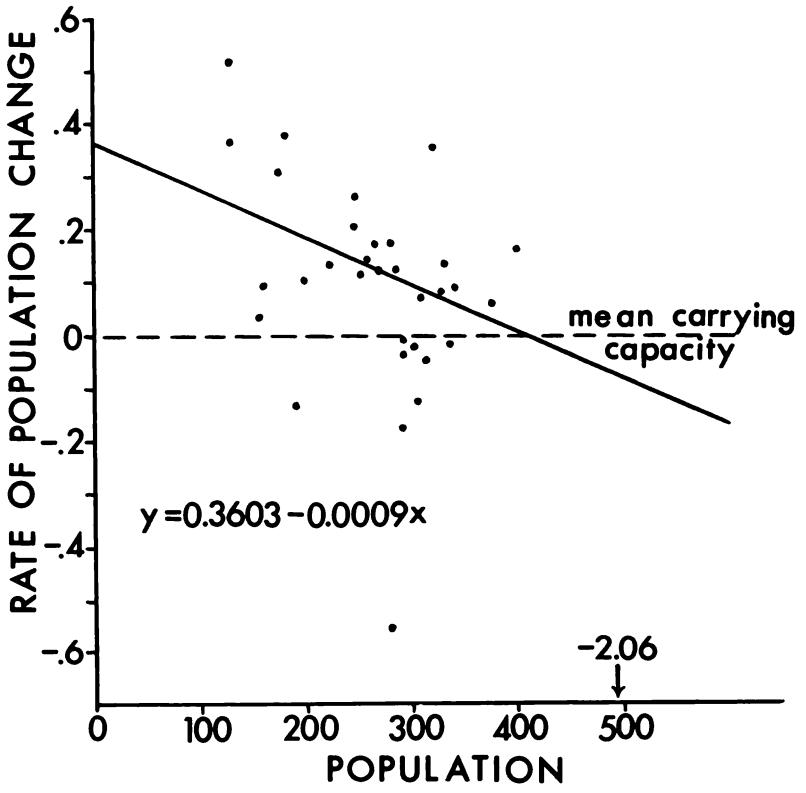


Figure 2. Regression of rate of population change on population size for the Owens Valley tule elk population. The r^2 value is for all 34 years, while the regression line and equation are based upon the deletion of the extreme value (495 population, −2.06 rate).

if the population were showing density dependent responses. Because the one extreme point is, beyond doubt, an error in censusing it is excluded in deriving the mean regression line. Average carrying capacity in terms of numbers is given by the point at which the regression crosses zero population change (i.e. at a population of about 414.6), although the high variance indicates that carrying capacity fluctuates greatly between years.[5] But on average, if the population is less than 414 it tends to increase, and if greater than 414 it tends to decline. The maximum sustainable yield (MSY), that point at which population increase is greatest, is always given by K/2 if the regression is linear. This occurs at a population of 207.3 at which average population growth is 37.4 individuals (Fig. 3).

[5] High variation in carrying capacity due to fluctuations in precipitation between years is discussed by McCullough (this volume).

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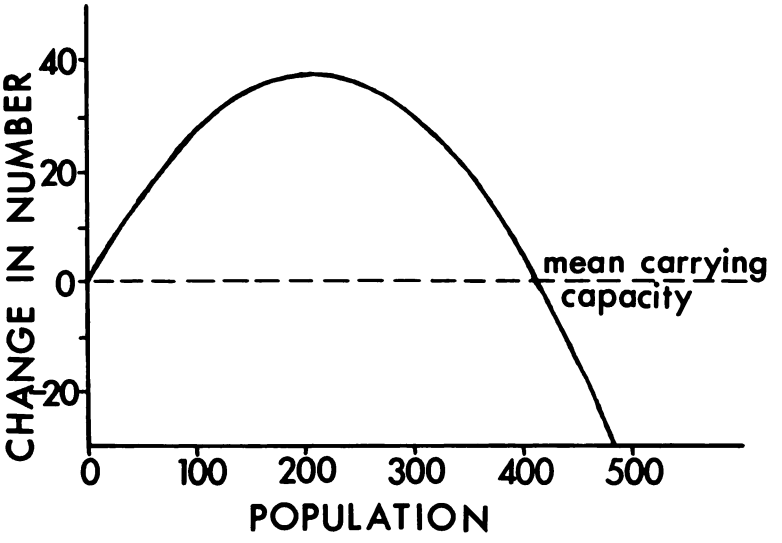


Figure 3. Change in numbers of Owens Valley tule elk depending upon population size as derived from the regression in Fig. 2.

The regression can be used to generate a mean population growth curve by starting with two animals, determining population change (growth in this case), and reiterating the process with each iteration being a year in time (Fig. 4). Reaching equilibrium at 414.6 required 42 years. The relatively slow rate of increase of tule elk results in a very symmetrical growth curve (which approximates the logistic model) and shows a relatively low tendency to overshoot. In other words, the tule elk population tends to track carrying capacity.

This tendency can be evaluated numerically by the formula (Maynard Smith, 1968):

$$L = bNK$$

where L is a measure of equilibrium tendency (i.e. the population tends to track K), b is the slope of the regression of the rate of population change on population size, and NK is the average maximum carrying capacity. If K is stable, and L is between 0 and 1, equilibrium at K is achieved; if between 1 and 2, overshoot of K occurs but is dampened out in gradually decreasing oscillations to K; and if greater than 2, oscillations of ever increasing magnitude eventually lead to extinction. If K is variable (the usual case in nature), these relative values of L express the tendency of the population to change in the correct direction as to approach K.

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For the tule elk the result is:

$$L = 0.0009\,(414.6)$$
$$L = 0.3731$$

which is well below 1. The tendency to track K increases as L approaches 0 (but see footnote 3).

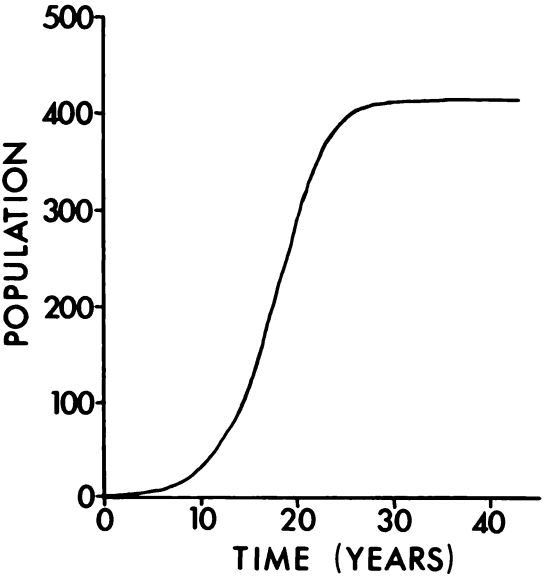


Figure 4. Mean population growth curve of Owens Valley tule elk as predicted from the regression in Fig. 2.

The intrinsic rate of population increase (r_{max})[6] can be determined from this growth curve by the method of Pearl (1930) where the $\log_e$ (K − N/N) is regressed on time. The slope of the regression gives the estimate of r_{max}, and in this case it is 0.3933. The finite rate of increase (λ)[7], is given by $\lambda = e^{r_{max}}$ and is 1.4819. Thus, at low density the population tends to increase 1.48 times per year.

Of course, such rates are seldom achieved in nature. The realized rate of population growth (r) for the tule elk in Owens Valley from the 54 introduced in 1934 to the first aerial count of 189 obtained 9 years later in 1943 is given by:

[6] The maximum rate of increase (instantaneous rate) in an ideal environment (see Krebs, 1972, for further explanation).

[7] The finite rate of increase times the population size gives the new population size at the end of the time interval, in this case one year.

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$$r = \frac{\log_e 189 - \log_e 54}{9} = 0.1393$$

Thus, the realized rate of population growth during this period of low density was only about one-third of the maximum rate.

In summing up, we can see that in spite of errors in censusing, variation in carrying capacity, and random error in population response, we have derived a model which is useful in making judgements about the tule elk. We know the approximate rate of increase, average carrying capacity, average maximum sustained yield, and average equilibrium expected from a given management plan. It would be foolhardy to place absolute faith in this model. But surely it is more useful than guessing from the raw data of CDFG census values (McCullough, this volume, Fig. 2). And as further information accumulates, prediction of the model can be tested in an integrated policy-management plan-model prediction system.

ANALYSING AGE STRUCTURE

The usual method of age structure analysis is the life table approach which is described in most basic texts in ecology (for example, Krebs, 1972; Ricklefs, 1973). A particularly useful source is Mertz (1970).

Caughley (1966) has pointed out that in most sets of age structure data the 0 age class (young of the year) tends to be biased to the low side. This is because a major time of mortality is at or shortly after birth, and these small young are easily destroyed by carnivores and scavengers. This is a major difficulty with using traditional life table methods. Furthermore, life table analysis is dependent upon the existence of a stable age distribution (Caughley, 1966) and this condition is seldom met in K-selected species. In fact, it can be shown that a stable age distribution will only be approximated at mid-ranges of population density (McCullough, unpubl. ms.). At both low and high extremes of density the normal age structure will depart significantly from a stable age distribution.

Severe biases in the young age classes can usually be determined by plotting a frequency distribution of age classes as shown Fig. 5. The difficulty of biased young age classes should be obvious from the figure. Furthermore, the example used purposely approximated a stable age distribution. Thus, while in theory, life table analysis is a powerful technique, in practice it would be a rare case where a set of field data would give accurate life table results. Furthermore, life table results are static relative to the changes in dynamics of actual populations.

One useful bypass is to treat the addition of new animals to the population as recruitment.[8] Thus recruitment is some outcome of number of births and early mortality. In the third tier of graphs in Fig. 5, recruitment would be defined as the 2 age class. This approach is most useful with time-specific data. Thus a recruitment rate can be calculated. In the second tier example of

[8] Recruitment is usually defined as those new individuals which are added to the adult stock after the high initial mortality of early life has passed. Usually recruits are of large enough size and age to be part of the harvestable population.

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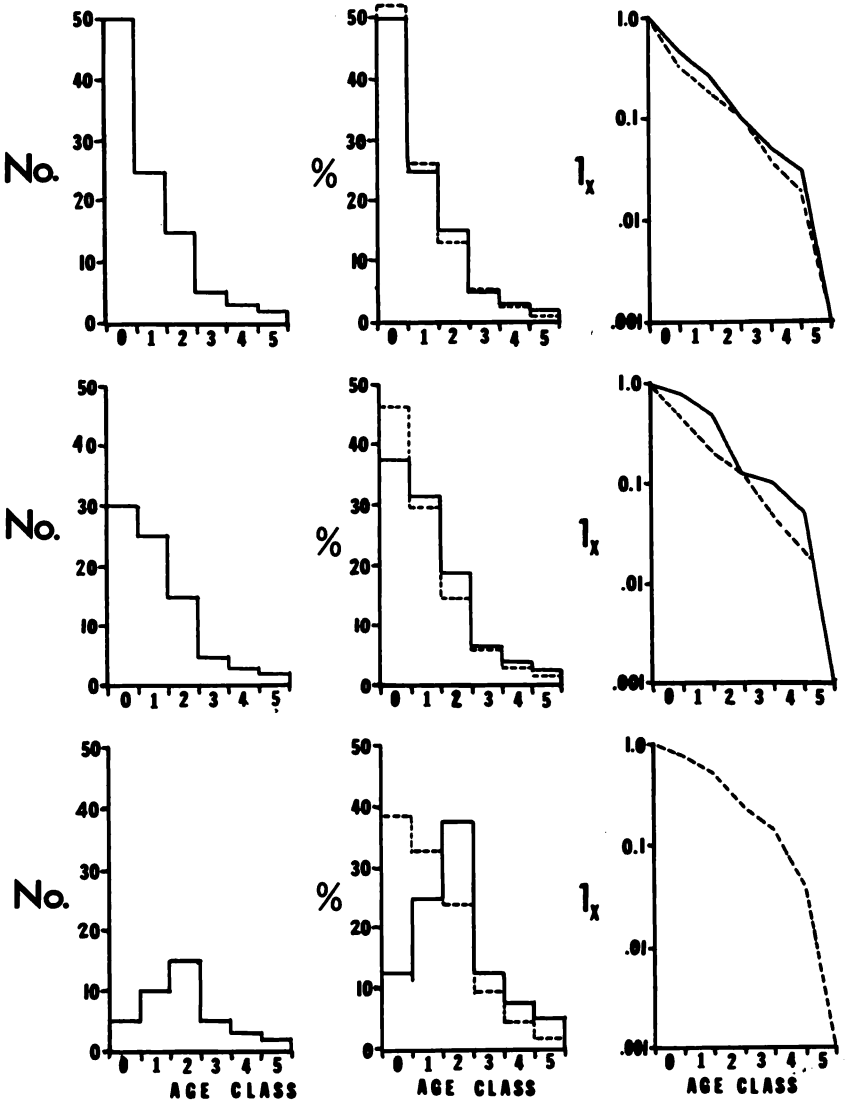


Figure 5. Some hypothetical examples of age structure based upon collections of skulls of animals found dead. The top left graph represents a total unbiased collection of 100 skulls. Top middle histogram gives frequency distribution of skulls d_x(solid lines) and 1_x series derived therefrom (dashed line). Top left gives survivorship curves based upon d_x and 1_x series. Middle tier of graphs shows effect of moderate bias due to failure to locate 20 skulls of the 0 age class, and the bottom tier of graphs a severe bias of missing 45 0 age class and 15 1 age class skulls.

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Fig. 5 30 0-class recruits were produced by 50 old animals for a recruitment rate of 0.60. Comparing recruitment rates over subsequent reproductive periods can give indications of population performance over time. Since the definition of recruitment is arbitrary, recruitment rates can be compared only within a given context. For example, in the case of the third tiers of Fig. 5 recruitment is defined as the 2 age class, where 15 recruits are produced by 10 old animals for a rate of 1.5. This is higher than the previous rate for tier two, but if compared on the 2 age class as the recruitment class, they are identical. Recruitment rates become more valuable as repeated over a series of years, and particularly as combined with a population estimate or index, as will be shown next.

Population status from limited data

Assume a situation where a rare species of ungulate is completely protected and only observational techniques can be used. How might one derive a crude assessment of its status? We will examine the case of the tule elk during the two years of my study, in which the above constraints were present. Table 1 gives the necessary population parameters and their estimates taken from McCullough (1969).

Table 1. *Population parameters and their estimations for tule elk in Owens Valley in 1963–64*

Parameters	Estimate
1. Population index	CDFG count 1963 308 1964 279 $\bar{x}$ 293.5
2. Sex and age structure	1963 55♂♂:100♀♀[1]:33cc[2] 1964 55♂♂:100♀♀:25cc
3. Recruitment rate	1963 33/155 = 0.21 1964 25/155 = 0.16 $\bar{x}$ = 0.19
4. Age at first reproduction	2.5 years
5. Litter size	1 young/♀

[1] Female yearlings represent about 17.0% of females older than calves.
[2] Calves.

We now need to derive a maximum recruitment rate estimate at very low population level, say 10 individuals. Since 54.35 percent are 1.5 years or older, and 17.0% of these are non-reproductive females, we come up with an estimate of 4.5 females, each of which produces an offspring. Thus recruitment rate is 4.5/10 = 0.45. Thus, we can obtain a recruitment rate curve (Fig. 6). Note that the estimates of K and K/2 will exceed the values for the population change curve (cf. Figs. 2 and 3) since the latter includes mortality of adults as well. Parenthetically it should be noted that adult mortality can be estimated from the difference between the recruitment regression and the

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population change regression, and in this case it amounts to an average of 8.4% of the adult population. The fact that it is slightly greater at low densities than at high densities indicates that one or both regressions is slightly in error, since the reverse case would be expected in a K-selected species.

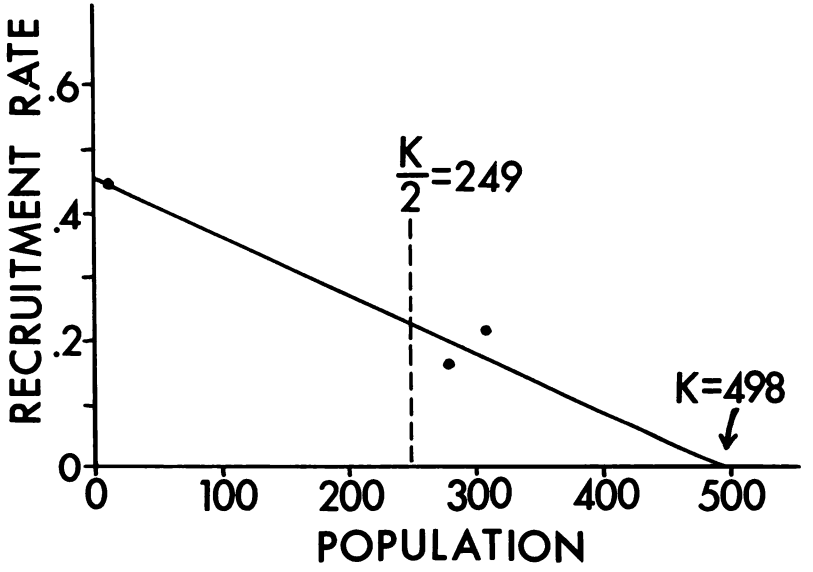


Figure 6. Recruitment rate graph derived from data collected during 1963–64 for the Owens Valley population of tule elk. See text for further explanation.

Judgments about population status based upon recruitment rate curves must be made relative to the values given by the curve. The critical judgment is whether the observed point lies to the right or left of the MSY or K/2. If to the right, the conclusion is that the population is functioning within its zone of resilience and can achieve equilibrium within the habitat available. If the point is to the left of the MSY, it is beyond its ability to reach equilibrium and is highly susceptible to being driven to extinction. Complete and rigorous protection is called for. If the observed point is near MSY, increased protection may be desirable to allow the subsequent points to move further to the right, since MSY is a rather precarious balance. Thus, we would conclude on the basis of this limited test that the tule elk population in Owens Valley was in a reasonably satisfactory state. Again, the reader should be cautious in putting too much faith in this tool. However, it will allow predictions as to the direction the parameters should shift with management action taken and, as points accumulate, the results can be further refined.

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PART II: A DOSSIER ON THE PLANNING OF RESTORATION PROGRAMMES FOR THREATENED UNGULATES WITH SPECIAL REFERENCE TO DEER

3. COMPONENTS OF STUDY PROGRAMS

Field Study Techniques of Special Application to Depleted Populations

R. TABER

ABSTRACT

A basic aim in the study of endangered deer is to identify factors limiting population recovery, devise plans to alleviate these constraints, and work toward implementation of these plans. Useful data include that on the individual (e.g. morphology in relation to nutrition, criteria of age and sex, behaviour, tracks and fecal rhythm) and that on the population (e.g. distribbution, density, grouping, structure and productivity). Data on individuals can be obtained from captives, so the location of captive stocks of endangered deer should be identified.

Distribution of free-living deer is shown by tracks, feces, calls, sightings. Density is estimated by pellet-deposition, strip counts, and ratio-counts including recognizable individuals. Population structure is studied by pellet-size, and observation of sex, age and condition classes. Seasonal estimates of population structure reveal patterns of loss. Analysis of feces indicates seasonal diet composition and quality. Patterns of season and of mortality help identify factors limiting populations. Analysis of habitat selection and avoidance is facilitated by division of the study region into cells of equal size, each cell described by both intrinsic and extrinsic characteristics. Analysis of seasonal patterns of use leads to hypotheses concerning limiting factors, and proposals for experimental alleviation.

INTRODUCTION

Though it is a truism, we need constantly to remember that a major reason for studying endangered wildlife is to devise workable plans for the increase of the species and its ultimate removal from the *endangered* category. To be most effective in this endeavour, we should bring to bear all relevant lines of investigation. With this in mind, I have included in this brief review not only field studies *per se*, but also studies of museum specimens and captive animals.

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MUSEUM SPECIMENS

Museum specimens, with their accompanying data, provide information such as: live weight, total length, reproductive condition by season, age according to tooth eruption and wear, size and degree of ossification of individual bones. Such data can provide indications concerning season of reproduction, and age at first breeding, litter size, seasonal physical condition (Taber *et al.*, 1959), growth rate, and schedule of skeletal maturation, all of which are related to nutrition (Bandy *et al.*, 1956; Klein, 1964; Bandy, 1965). A convenient index of current physical condition is live weight divided by total length. Nutritional plane over the past year is reflected in the size, conformation, and especially the antler development of yearling males. Long-term nutritional regime will be reflected in the schedule of ossification of the long bones in relation to age, and to the relative sizes of various bones at maturity.

CAPTIVE ANIMALS

If newborn captive animals were individually marked, then when they ultimately died their remains, of known age, could be incorporated in museum collections.

Live captive animals constitute a rich source of basic data including:

A. Schedule of tooth eruption and wear in relation to age. To my knowledge, there has been no systematic review of tooth eruption schedules in all genera of the *Cervidae*, although *Odocoileus*, *Cervus* and *Alces* are reported in Giles (1971). Presumably similar data exist for *Rangifer*, *Dama* and *Capreolus*, but not for *Axis*, *Moschus*, *Muntiacus*, *Hippocamelus*, *Blastocerus* or *Ozotoceros*, the latter all listed by Cowan and Holloway (1973) as of conservation concern.

B. Hematology in relation to age, sex, and season. Blood values obtained routinely for captive animals in good condition would provide a basis for interpretation of the necessarily more scattered data that might be obtained in field investigations. Physical condition, particularly, is vividly reflected in blood characteristics. The values found most highly correlated with physical condition in moose are: calcium, phosphorus, total protein, hemoglobin, and packed cell volume (Franzmann, n.d.).

C. Physical characteristics in relation to age, sex and season. When captive animals are well-nourished, their physical characters should express their genetic potential. From such a herd one could obtain periodic data on growth, size and proportion. These would include such characters as hoof-size and stride as an aid in the interpretation of tracks. From an animal found dead in a field investigation, or captured alive for examination, one could compare measurements with those for captive individuals, and gain insight concerning nutritional history as well as current physical condition.

D. Feces are a rich source of data in the *Cervidae*. Pellet-group counts are used to estimate population density, and fecal analysis yields data on food habits and plane of nutrition. In order to use pellet-group counts for census, one must know the daily rate of pellet-group production per individual. This

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is commonly found to be 13 in winter for *Odocoileus* and *Cervus*, with a somewhat high value for summer, when the daily feeding rate is presumably higher.

The size or volume of the average pellet produced by each age and sex class would, if known, provide the basis for an estimate of population structure in field investigations.

The chemical and physical composition of a pellet is presumably related to the composition of the forage and the rate of waste excretion. Nitrogen levels in domestic sheep pellets are regarded as an indication of forage digestability (Lancaster, 1949). And the proportional amount of undigested (fibrous) material in a pellet can be considered inversely correlated with forage quality (Hansen, 1977, pers. comm.).

Field-collected pellets can be dried and later transported to the laboratory for chemical and physical analysis. Comparisons can be made between different sub-populations (e.g. with and without competition from domestic livestock), different types of habitat, different seasons, or different years.

In the case of fecal analysis for quantitative food habits determination, such studies have fortunately already been conducted (Storr, 1961; Stewart, 1967; Dearden *et al.*, (1975). The general finding is that every species which is eaten can be detected by careful fecal examination, and that those species which make up the bulk of the diet also make up the bulk of the fecal fragments. There is some tendency for soft plants to be under-represented and woodier plants to be over-represented. This is illustrated by a comparison of rumen analysis and fecal analysis for a sample of seven mule deer and collected in winter (Burrell, 1977) as shown in Table 1.

Table 1. Comparison frequency of forage species in rumen and feces for *Odocoileus hemionus* (from Burrell, 1977)

Plant species	Rumen	Fecal
Purshia tridentata[1]	61%	74%
Eriogonum spp.[2]	33	19
Other shrubs (4 sp.) each	2	2
Other forb-like (6 sp.) each	2	2

[1] shrub [2] perennial forb

From Table 1 it is clear that two species comprise the bulk of the diet. Assuming the rumen content to represent actual proportions eaten, then the frequencies observed in the feces must be multiplied by 0.8 (shrub) and 1.7 (forb) to obtain true values. Presumably, the greater the difference in digestibility between one item and another in the same diet, the greater the quantitative bias in fecal analysis. If all items are of the same digestibility, whether high or low, fecal analysis should give an accurate quantitative reflection of the relative proportion of species making up the diet. Since feces for analysis and reference slides of diet items are so readily obtained in the field, this technique has wide applicability.

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E. Captive animals can provide still further information useful in field studies, such as that related to the mechanics or "vocabulary" of behavior. Patterns of behavior, on the other hand, are notoriously different between captive and wild populations.

This section was introduced with the suggestion that the skeletons of captive individuals that die should be permanently preserved in museum collections. Depending upon the cause of death, such individuals could be a source also of data on anatomy and histology, as a basis again for interpretation of comparable evidence from field investigations.

In view of these various studies which can be carried out on captive animals, the Endangered Deer Committee might consider a program to identify all captive endangered deer, encourage their systematic study, and maintain files of the results, as an aid in the interpretation of findings from the field.

INVESTIGATION OF FREE-LIVING POPULATIONS

Ideally, if full use of museum collections and captive herds has been made, the field investigator would begin with knowledge of deer anatomy as it relates to age, sex and physical condition, as well as pellet size and rate of production, and the morphometry of tracks. All these would find application in the study phases described below.

Determination of the distribution and relative density of the study population is generally a first objective. Realistically, it should be broadened to include other species that have a potential for influencing the study population.

Direct observation of tracks, feces and other signs, and sometimes the detection of calls, indicates presence or absence, but estimates of density require systematic sampling. There are two basic methods, the pellet-group count and the strip count. Both, properly employed, provide reliable data.

The pellet-group count requires a knowledge of the average number of defecations per day per individual. Sample plots are cleared of pellets and after an interval of time the accumulated pellet groups are counted. Some considerations are: the length of time that pellets will persist as recognizable entities; the ability of the observer to detect a pellet-group; the size, number, and distribution of sample plots. In the cold-temperate rainforest with characteristically heavy precipitation, a pellet-group of *Cervus* will be recognizable for six months but under rainy tropical conditions pellet-group disappearance is much more rapid. The rate of disappearance can be determined by local observation.

The ability of the observer to detect a pellet-group deposited during the known time-interval is influenced by the size of the plot, the nature of the ground cover, and the amount of leaf-fall during the interval. Errors tend to be cumulative in the direction of under-estimation except for the tendency to count pellet-groups on the plot periphery as on the plot when they are actually just outside. This is apparently due to the natural tendency of the

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observer to want to have something positive to record. Since the most accurate pattern of sampling is through the use of small circular plots, and many plots are without pellet-groups, this is a real source of bias which must be guarded against.

The total number of plots and the frequency reading will be determined by local conditions, but a method of randomizing plot location is worth mentioning here. Assume that plots will be arranged in straight lines and decide how many lines and how many plots there will be, and along what compass-bearing the plots will lie. Project the greatest diameter of the study area at right angles to this compass-bearing, and along this diameter distribute at random a number of points equal to the desired number of lines. From each of these points erect a perpendicular; this marks a line of plots. If a certain perpendicular is 5 per cent of the whole, and the total number of plots is to be 1000, then .05 x 1000 or 50 plots will lie along that perpendicular. Their spacing will be randomized just as the spacing of perpendiculars was randomized. Since plots will be separated by different distances, each distance must be recorded. In practice, it may be found that some distances are so great that an inordinate amount of time must be spent searching for the next plot. Such distances may be excluded from the plan.

The data obtained are: total area; area of each plot; total number of plots; total number of pellet-groups found; daily defecation rate; time interval between plot-searches. From this, the total number of animals is calculated.

Another method of determining population density depends upon the visibility of the species being studied; this is the strip-count. The observer moves along a specified route and observes to each side, recording the distance of each animal sighted, at a right angle to his route. To determine the distance at which his species could be seen in each sort of cover Berwick (1974) used silhouettes of appropriate size and shape. The data obtained by this method include: total area; distance travelled; average scanning-distance to each side of the line of travel; and animals observed per trip. This method is well described in Gates *et al.* (1968); Quinn (1977) has shown that it is applicable to aggregated as well as randomly distributed individuals.

When individuals of the study population can be marked or individually recognized and observed subsequently, total numbers can be estimated by the Lincoln Index method (Giles, 1971). If the total number of marked individuals (MP) is known, then the total population (TP) can be calculated from counts of marked animals (OM) and total animals (OT), as follows:

$$\frac{TP}{MP} = \frac{OT}{OM} \quad \text{and} \quad \frac{TP}{1} = \frac{MP \times OT}{OM}$$

There are three ways to estimate population structure: through pellet size; through tracks; and through direct observation. Pellets and tracks have not yet actually been used, to my knowledge, in field studies, but their study should yield useful data.

Direct observation of population structure yields herd composition counts. The usefulness of these is affected by the observer's ability to distinguish between different age and sex classes, and the relative observability of these

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classes at the time of observation (Dasmann & Taber, 1956). In *Cervidae* it is generally possible, at some seasons, to distinguish adult males, yearling males, females, and young-of-the-year. If yearling females can be distinguished from other females, much additional information can be derived from these counts. Visibility of various classes may vary seasonally: newborn are usually hidden; adult males are conspicuous during the rut but retiring at other seasons; yearling males can be identified only when antlered; yearlings may be especially active at the season of birth: and possibly lactating females forage longer and so are more visible than females which are barren or have lost their newborn young.

Assuming that counts of reasonable accuracy can be made, data which can be derived from them will include:

- young at heel per 100 adult (2 yr. + older) females.
- shrinkage of 0–1 cohort through the year.
- survival of young (as yearling males plus yearling females) to one year of age.
- sex ratio in adults.

Herd composition counts can sometimes be made at night, with the aid of a light. Sometimes deer can be observed in red light with little apparent disturbance.

The direct observation of deer for herd composition counts can also yield data on physical condition and on forage relations. Physical condition is reflected in the appearance of the individual. Riney (1955) described several classes for red deer in New Zealand. A more detailed scale has been developed for moose in Alaska by Franzmann (n.d.) as follows (pp. 4–5):

Class 10. Prime; fat moose with thick firm rump fat by sight. Well fleshed over back and loin. Shoulders are round and full.

Class 9. Choice; fat moose with evidence of rump fat by feel. Fleshed over back and loin. Shoulders are round and full.

Class 8. Good; fat moose with slight evidence of rump fat by feel. Bony structures of back and loin not prominent. Shoulders well fleshed.

Class 7. Average moose with no evidence of rump fat, but well fleshed. Bony structures of back and loin evident by feel. Shoulders with some angularity.

Class 6. Moderately fleshed moose beginning to demonstrate *one* of the following conditions: (A) definition of neck from shoulders; (B) upper fore leg (humerus and musculature) distinct from chest; or (C) rib cage is prominent.

Class 5. A condition in which *two* of the characteristics listed in *Class 6* are evident.

Class 4. A condition in which all *three* of the characteristics listed in *Class 6* are evident.

Class 3. Hide fits loosely about neck and shoulders. Head is carried at a lower profile. Walking and running postures appear normal.

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Class 2. Outline of the scapula is evident. Head and neck low and extended. Animal walks normally but trots and paces with difficulty, and cannot canter.

Class 1. Walks with difficulty and can no longer trot or pace.

Class 0. Dead from malnutrition and/or accompanying circumstances.

The condition of the pelage is also a reflection of physical condition. As condition declines the appearance of the coat becomes rougher and hair may be rubbed or broken off in patches. Burrell (1977) used the following scale for wintering mule deer; 3-less than half the coat is rough; 2-over half the coat is rough; 1-at least one broken or rubbed patch in addition to rough coat.

Altmann related physical condition to nervousness as shown by tendency to flee from disturbance. She quantified the distance from the source of disturbance to the responding individual as *object-flight-distance*, and hypothesized that this distance increased as physical condition declined.

Burrell (1977) used two observable criteria, *foraging time* and *group size* as reflections of forage quality. He hypothesized from Mackie (1965) that the amount of time spent in feeding is proportional to the "range of quality choices" in the feeding area. In other words, if many highly preferred bites are scattered through the foraging area, it is worthwhile for the animal to spend energy in searching for them, whereas if there are few or none such searching would not be rewarded and so would soon be abandoned. Burrell (1977) applies this concept by classifying all visible deer at regular intervals as *foraging* or *not foraging*, and found one population spent 53% of the daylight hours foraging while another spent 45%.

Group size, in mule deer, was found by Mackie (1965) to be low in summer and high in winter, while forage quality was the reverse. Mackie hypothesized that as overall forage quality declined there was a greater and greater tendency for the deer to concentrate on the dwindling number of sites providing the best available food. Burrell (1977) compared foraging groups in two winter mule deer populations and found that the one which foraged for 53% of the day had an average group size of 5.75, while the one which foraged for 45% of the day had an average group size of 6.15. Although the differences between the two populations are small, they are consistent, the "better" range showing longer foraging time and smaller group size, and the "poorer" range the reverse. These measures seem worthy of further investigation.

When it is possible to discover dead animals from the study population, further data may be obtained. The first question is: did the individual die in poor physical condition or good physical condition? If poor (i.e. Class 0 Franzmann), then the cause is probably some combination of malnutrition and disease. If good, then the cause may be epidemic disease but is more likely to be violence, ordinarily predation. The remains of an animal found dead can ideally be classified by age (teeth, size, and degree of ossification of long bones), sex (head, soft parts, pelvis, long bones), season (state of preservation, pelage) and physical condition at time of death. The physical condition at time of death will be shown by the relative roughness of the pelage

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and by the presence of fat in the marrow-cavities of the long bone, which thus has a greasy look and feel if the individual had fat reserves at time of death.

An individual which dies when in good physical condition may be considered a representative member of the living population with regard to fat reserves, rumen contents, reproduction, growth in relation to age, stage of molt, etc.

Usually it is desirable to relate these various lines of evidence to populations of endangered deer in different habits or to potential competitors occupying the same habitat. Therefore methods of habitat analysis are useful. These are on two levels: range analysis; and overall environmental analysis.

Range analysis, for our purposes here, is related principally to the degree of seasonal competition, if any, within the endangered deer population or between it and one or more other species. It consists of determining whether there are substantial diet overlaps, and whether the forage in the area of overlap is in limited supply. Evidence for diet overlap comes best from fecal analysis. The standard sample for fecal analysis consists of two pellets from each of fifty pellet groups representative of one range and time period.

Quantitative data on diet can be combined with quantitative data on forage availability. Forage can be qualified in many different ways, discussion of which is beyond the scope of this review. However, it should be borne in mind that the area subject to range analysis should coincide exactly with the seasonal foraging area of the study population if diet and availability are to be taken together to determine seasonal forage preference. Seasonal preference for a certain plant species can be expressed as:

$$\frac{\text{proportion in diet}}{\text{proportion available}} \times 100$$

on a dry-weight basis, so that a rating 200, for example, indicates a degree of seasonal preference, and one of 25 indicates the reverse.

Overall environmental analysis is a huge topic, but certain approaches are useful even in the most difficult field studies. Since the ultimate object is to increase the deer population, it is important to discuss just what parts of the present environmental mosaic actually constitute its seasonal habitats, and what other parts are apparently suitable but not actually used, possibly because of competitive exclusion, harassment, state of plant succession, etc.

Often, field workers develop a base map which is essentially a cover map, delineating the mosaic of plant communities. Animal locations are plotted on this map, the unstated assumption being that the animal species being studied responds to the same environmental factors that plants do. This is usually true to a degree, but the animal also responds to other factors, such as juxtaposition of its daily environmental necessities, presence of other animal species, sources of disturbance, etc. In addition, whereas the plant is influenced most by average climatic conditions, the animal is often influenced by short-term microclimatic extremes. For reasons such as these animal

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habitat use cannot be explained or understood with reference only to the characteristics of the plant community.

These difficulties can be overcome if the habitat map is gridded on a co-ordinate system into numbered *cells*, whose size will depend upon the intensity of the study. These cells are used as follows: all field data is related to specific cells, each cell is ecologically described, and habitat use by the deer is correlated with cell attributes. In order to relate field data to specific cells, the observer needs to know in which cell he is when each observation is made, a consideration which will probably influence cell size. The ecological description of each cell will include such data as is available on topographic maps (elevation, aspect, slope), aerial photographs (= plant community type, degree of canopy closure), and geographic maps (roads, trails, streams, villages, cultivated fields). In order to relate the data on a number of different maps, of different scale, to one cell-system, it is necessary only to have a number of grid overlays, each representing the same cell-system on an appropriate scale. For each cell, then, all available information can be recorded systematically, both for the area within the cell and for the area beyond the cell. For example 2 cells may have similar internal characters, but differ in that one lies near water or a road or cultivated fields, while the other does not. The presence or absence of the endangered deer under study can be positively or negatively correlated with particular cells by means of the seasonal abundance of tracks and pellets, and evidence of feeding, supplemented by direct observation.

The objectives of this sort of habitat analysis are: to determine the extent to which habitat use can be successfully explained on the basis of the attributes measured; to determine which landscape elements represent preferred habitat and which do not; and to provide the basis for hypotheses concerning potential avenues of habitat maintenance or enhancement.

For successful prediction of habitat preference, one must be able to determine the habitat attributes to which the study population actually responds. The first step toward this is to determine the degree to which the descriptive attributes used can "explain" or correlate with the habitat use actually observed. If the degree of correlation is low, the researcher had better think of and measure attributes which are more significant to the ecology of the endangered deer. Only when the significant attributes have been identified and measured can the habitat analysis produce reliable predictions.

DISCUSSION

There is no reason to assume that a population of endangered deer is occupying excellent habitat or is enjoying excellent health and vigor. On the contrary, the fact of the endangerment implies some severe constraint on the natural tendency of this population to increase and spread.

If the constraint is nutritional, it may be manifested in below-normal skeletal size, rate of reproduction or survival, or appearance of pelage, size of foraging group, time spent feeding, or the chemical or physical characteristics of the feces. For each type of data, some "normal" is needed for

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a yardstick, and it has been suggested that this can be developed to some extent from museum specimens and captive animals. This, in turn, suggests that the Endangered Deer Committee might undertake to identify present museum collections and captive herds, encourage improvement in maintenance and record-keeping, and systematically devise and implement a system of describing "normality" for each endangered deer.

If evidence shows that the constraint on an endangered deer population is nutritional, as a basic problem, it still remains to determine what the immediate causes of this problem may be. Nutritional stress might be caused by long-term changes in the habitat, including habitat conversion by human use. It might be caused by interaction between the endangered deer and another species, including diet overlap, behavioral dominance or transmission of disease.

Conversely, the population may be constrained by predation. In such a case the survivors would probably not be under severe nutritional stress. The various lines of evidence developed in field investigations can never in themselves benefit an endangered deer population. But from such evidence it should be possible to develop plans aimed at enhancing that population. Tests of these on a pilot-plan scale constitute experiments testing definite hypotheses concerning limiting factors and their alleviation. Such experiments, when successful, can lead to increase of the population in question.

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PART II: A DOSSIER ON THE PLANNING OF RESTORATION PROGRAMMES FOR THREATENED UNGULATES WITH SPECIAL REFERENCE TO DEER

2. COMPONENTS OF STUDY PROGRAMMES

Research toward conservation of threatened deer of the world

I. McT. COWAN and C. W. HOLLOWAY

ABSTRACT

In 1973, a research framework was designed and published to guide the planning of projects that were initiated under the Threatened Deer Programme. This paper discusses the bases for the construction of the framework and provides a revised version of the original, which has been modified in the light of experience gained under the Programme since early 1974. The framework will continue to be revised as further data and experience are accumulated.

INTRODUCTION

It is now (September 1977) four years since IUCN introduced its programme of concentration upon the threatened deer of the world. At that time Cowan and Holloway (1973) reviewed the status of the rare and endangered deer as then known. The same authors (1974) outlined some of the important constraints which characterize such species and presented a framework for research directed toward improving the status and prospects of their populations.

During the four years 1974–7 several species have been the subject of research studies. The conference to which this paper was presented was designed to bring together all those scientists engaged in research on threatened deer along with some others whose research with species of still-abundant cervids was leading to new concepts.

In the light of events over the four years, we have re-examined some of the unique biological conditions influencing species of deer existing in small numbers and generally on small land areas. Many of our thoughts of 1974 are still relevant and have been included in this paper in substantially the same terms. The concepts of island biogeography have been considerably expanded. It is now clear that the principles apply only to faunas and species in biological islands regardless of the isolating medium.

Research since the early 1970s on the behaviour of the large ungulates has been highly productive of new insights of importance in conservation of rare

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species (see particularly Geist and Walther, 1974). We have attempted to identify some important principles derived from this research.

SOME SPECIAL ATTRIBUTES OF ENDANGERED DEER AS RESEARCH SUBJECTS

Conservation of a species or subspecies is the management or guidance by Man of the complex natural processes which sustain it. A species or subspecies has a genetical constitution arising from the sum of its past environmental experiences. Conservation practices alter the environment of a species and may therefore induce genetical changes. This is particularly true where close confinement under zoo or game-farm conditions is involved.

A species or subspecies which was once numerous and widely distributed almost certainly encountered a variety of distinctive environmental circumstances, and became adapted to them. Some of this adaptation may have been genetical. If, in such a species, the dispersed distance of individuals (especially males) was great, the species is probably widely heterozygous. Such a species, when reduced to a small remnant, will have already suffered the loss of much of its original genetic diversity (Falconer, 1961), which preadapted it to a range of environmental circumstances. It will also be likely to suffer from 'inbreeding depression' leading to a general reduction of fitness (Mayr, 1963). On the other hand Berry (1970), with special reference to species being rescued from extinction, states: 'Leaving aside the question as to why the species has become so rare (which in many cases seems to suggest some adaptive inflexibility), there is no reason to expect that any particular genetical problems will arise.'

It may be that for the special circumstances of the restricted survival range the species is well adapted. Problems may arise, however, when reintroductions are planned into areas of former range environmentally different from that upon which the species survives.

The genetic circumstances will be quite different for animals, such as the Manipur brow-antlered deer (*Cervus eldi eldi*), in which the entire surviving population occurs in a few square kilometres with special environmental properties, than it may be for the Argentine pampas deer (*Ozotoceros bezoarticus celer*) and the Chilean huemul (*Hippocamelus bisulcus*) scattered populations of which exist under different environmental circumstances. The latter are more likely to maintain a substantial part of the original variability. These two patterns are important as background for research and management.

There are also important considerations arising from the size, shape and distribution of the habitats within which rare species of deer are surviving. Small populations isolated in areas devoid of the species are islands and experience the degradation of their faunas that has been explored by a number of authors (Diamond, 1975; MacArthur & Wilson, 1967). The larger species, with larger home range requirements have the highest vulnerability to extinction on small areas of suitable habitat. There appears to be an essential relationship between body size and home range that Harestad & Bunnell (1977) have described for herbivores as $H = 003W^{\cdot 98}$, where H is

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home range in hectares and W is body weight in kilograms. This formula can be used by researchers to gain a theoretical estimate of home range requirements, which together with knowledge of social organization, can provide useful insight into the potential capacity of refuges or areas being considered for re-establishment.

The direct applicability of this concept to the several species of threatened deer is unknown. Species of similar mass may differ considerably in normal social structure and in their ability to adapt behaviourally and thus in their tolerance of restricted habitat. Spatial behaviour within a single species can involve several patterns differing by sex, age, reproductive status and dominance position of the individuals (Miller, 1974). These factors are described for only a few species. Then, too, the structure and productivity of the habitat itself has an important influence on its carrying capacity for deer. These relationships require research exploration.

Species or subspecies which have lived in the wild for many generations in isolated groups of small numbers will have been subject to the steady culling of environmental pressures and will probably have been stripped of their recessive lethal genes. The same effect can arise where even a widely dispersed species is narrowly inbreeding. Species or subspecies already stripped of their recessives will be more likely to respond successfully to small-group confinement and to provide better potential for transplant as small groups. Thus the matters of genetic history and genetic integrity are important in conservation. They will dictate decisions on the approximate minimum effective size of a population that is designated for special conservation measures. They will also influence the probable success of efforts at reintroduction into the wild. Research should be directed toward elucidating the genetic history of the species.

The objective is maximizing genetic variability. In part this is an outcome of size and composition of the population, longevity of individuals (number of mating seasons), the number of home-range group females found in ecologically different habitats, the extent of movement of males between clans, and the number of females served by one male in a year. Increased variability can be gained by splitting female groups and increasing the chances for a number of males to breed. Alternatively, it can also be gained by arranging for two or more home-range groups (clans) of females in a limited population, distributed so that males form the genetic link between them.

As an example, if it is assumed that each male of breeding age has an equal chance each year of mating with any four females, then as a rule-of-thumb the number of mature males in the herd should be 2 x the number of years you may want to hold the herd as an isolated breeding unit. This arrangement will provide the likelihood of preserving 95 per cent of the genetic variability over the period involved.

Under these assumptions a herd, to be preserved in isolation for an anticipated 10 years, will require 20 males of breeding age, 80 mature females, and a mix of young animals adequate to meet the anticipated turn-over rate of the adults. The possibility of maintaining a herd of this size will rest upon the adequacy of available range and the availability of the brood stock. In practice it is seldom possible to achieve.

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Furthermore, opportunities for random assortative mating seldom occurs in deer. Social dominance and differences in movement patterns inhibit it.

The concern to maximize genetic variability, along with the desirability of taking steps to prevent extinction by accident, to which small populations are particularly vulnerable, demand attention to the size and spacing of refuge areas for endangered deer. Practical experience, well supported by theory, points to the value of having small populations in two or more sufficiently isolated centres, so that they are unlikely to experience the same extinguishing impacts synchronously. At the same time, where practicable, it is desirable to have the nucleus herds close enough so that they can exchange males. Capture and transplanting of males will serve the same purpose.

Under zoo conditions, where very small breeding units are usual, it is particularly important to arrange for frequent transfer of males. If this is to achieve its purpose there should be a stud book covering the captive animals of every rare deer. This should maintain not only a record of the ancestry of each individual but a record of the important physical and behavioural characteristics of the individual.

There is strong evidence that the heritable characteristics of an individual include behavioural and physiological features important in adaptation along with physical differences. In some vertebrates wildness is heritable. Black-tailed deer (*Odocoileus hemionus*) we have pen-reared have shown great differences in tameability, aggressivess, sexual vitality, sexual attractiveness, capacity for dominance, alertness and other behavioural characteristics.

Under zoo or game farm conditions it is particularly important to avoid exerting selective pressure in directions regarded as most favourable by the keeper, but not necessarily related to survival in the wild.

All but one of the species of threatened deer probably still occur as wild populations. The success of efforts to increase the numbers of individuals on their small remaining ranges leads inevitably to a new set of problems. Research will be required to determine the key attributes to be sought in any area to be selected for reintroduction and to detect the potential for introducing the species into a new species mix.

Reintroduction should, wherever possible, include both wild-reared and pen-reared stock, so as to maximize 'cultural' transferal of how to use habitat and forage. It is important, in releases or in transplants, that the animals be thoroughly tested for diseases or parasites that are likely to be carried to the new site, and only 'clean' animals liberated. Where it will be necessary for a species to migrate in order to find its year round requirements, careful study is required to determine the most appropriate time and place within the total range to make the reintroduction.

Considering the widespread distribution of deer, the large number of distinctive species and subspecies that exist, and the importance that deer have as a source of food, recreation, or damage to forests or agricultural crops, it is surprising how few studies have been made that provide biological data adequate to guide conservation programmes. Among the rare species, only the tule elk (*Cervus canadensis nannodes*)(McCullough, 1969; Ciriacy-Wantrup & Phillips, 1970) has been the subject of recent detailed studies directed

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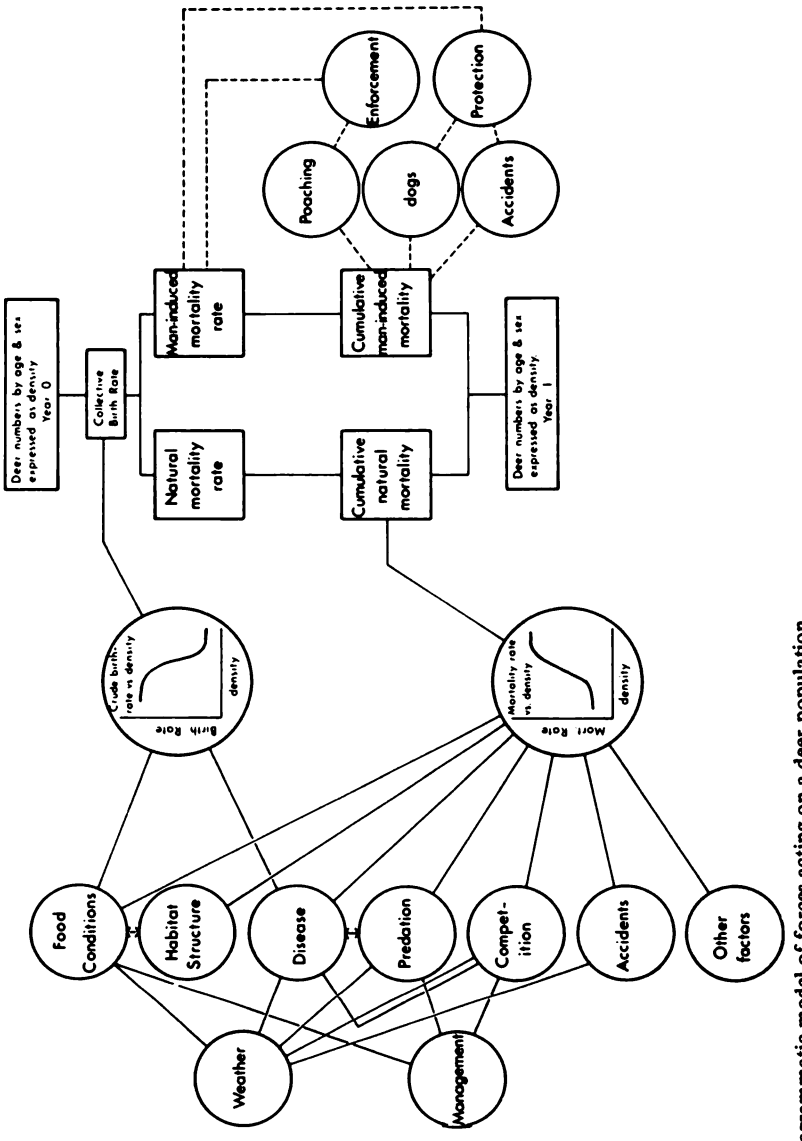


Figure 1. Diagrammatic model of forces acting on a deer population

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towards its conservation. Anderson (1972) has introduced a new component into the management of deer populations, using a computer simulation model of a black-tailed deer (*Odocoileus hemionus columbianus*) population. A framework for conservation-oriented research, adapted from Anderson (1972) and previously used by Cowan and Holloway (1974), is presented here to guide the planning and conduct of research upon the threatened species or subspecies of deer (Fig. 1).

Scientists planning to study any of the rare or endangered species face an intellectual and scientific challenge to study the animal without altering the home-range patterns or the routines followed by the population. Students of these species require strong methodology that is designed to gain the maximum information from living animals, thus reducing disturbance and the need for killing individuals for research purposes.

Many of the parameters usually investigated during the course of research upon deer populations contribute little to immediate improvement in the conservation of a threatened species. It is important to determine in advance the questions most likely to yield data significant to the task of conservation. Sometimes a computer simulation can be helpful in identifying research topics likely to yield important data.

Density is commonly useful, primarily in relation to details of behaviour and distribution and the limitations on numbers to which reference has already been made. Age ratios can provide useful data provided that they are repeated annually. Mortality rates of young and the rate of replacement of breeding adults can provide important clues as to the population processes at work. However, they are of greater use in generating a new series of research questions. Sex ratios are usually most difficult to obtain because of seasonal changes in the behaviour of the sex and age groups through the year. They may be of limited significance in conservation unless the discrepancies are so great as to inhibit reproduction.

Bunnell (1978: this volume, page 280) has given nine criteria that he regards as important in an assessment of a threatened deer. His outline contains features usually overlooked by those planning research on deer. They rest on the important objective of all such research, viz. to acquire data which will guide programmes to improve the chances of restoring threatened deer to a secure status. McCullough (1978: this volume, p. 302) has also outlined four categories of data required for an understanding of population structure.

Bunnell (*loc. cit.*) prefaces his presentation of research questions by posing the general question: "What activities impact upon this taxon, how are they mediated and how can they be mitigated?" This author's outline of the ideal capabilities of any scheme of assessment and his treatment of our common failings of published environmental impact assessments of endangered species should be read by all those planning research upon a threatened species of deer.

FRAMEWORK FOR RESEARCH

The following is, in fact, little changed from our 1974 publication.

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Objectives

Immediate – To establish the species or subspecies in such numbers and so distributed as to provide reasonable likelihood of its surviving in its native habitat with its genetic spectrum intact.

Long-term – To restore the species or subspecies to productive status in the wild.

Research Questions

The first objective of research upon rare or endangered species must be towards discovering the information that is of particular relevance to the survival of the species. This requires care that the research itself does not serve, directly or indirectly as an additional disturbing factor leading to less effective reproduction or an increased mortality rate. For many species the impact of man through continuing killing, or by overuse of essential range for domestic livestock, is the probable immediate cause of the small numbers. Thus research must be directed to social and political issues as well as biological questions.

We have developed a series of questions which we believe will assist in the planning of research studies designed to provide data that are essential to the effective conservation of an endangered species.

(a) How does the ecotype by which the species or subspecies is surviving differ in adaptive requirements *vis-à-vis* the probable conditions originally forming the optimum habitat for the organism?

Action potential. Can a programme of range restoration be planned while maintaining a viable population of deer? If so, what measures are required both in terms of land-use and animal management?

(b) Does the population adequately exploit all areas of available habitat?

If 'no', what are the forces preventing the animals from fully occupying the area?

Action potential. Can the inhibiting causes be reduced or removed by management of habitat structure, or reduction of human impact, or other management action?

(c) At any season of the year, or even occasionally from year to year, does the present population of the species exceed the capacity of the present habitat to provide feed that is adequate in quantity and quality?

If 'yes', under what circumstances does this occur, and which age-sex group suffers impaired growth and which dies? Is fecundity influenced by malnutrition? Is the condition the consequence of competition from other species, wild or domestic?

Action potential. Are there opportunities for improving the capacity of the habitat (reducing competition, altering cover-type, setting back succession, fertilization, provision of supplementary feed through short-lived critical periods, etc.)?

(d) At any season of the year, or even throughout some years, does the present population lack adequate water or mineral sources or other special facilities, leading to density-dependent mortality from this cause?

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If 'yes', does this lead to on-site mortality or to the abandonment of otherwise secure habitat for other less secure or less suitable areas?

Action potential. What can be done to improve the amount, quality, or distribution of water supply or other limiting resources?

(e) Is there evidence for territoriality by males or by females, and is the population size limited by the number of territories available?

If 'yes', does this lead to surplus animals which are being lost each year?

Action potential. (i) Can any opportunity be envisaged for increasing the number of territories through changing the mix of habitat components by manipulation of cover or resources, or by increasing the available area so as to add essential components that will permit the original area to serve more animals?

(ii) Can surplus animals be used for establishing new colonies or for interchange with other herds to increase heterosis?

(f) Is predation, either by steady drain or by periodic concentration upon animals rendered especially vulnerable by life-stage or weather conditions, a limiting factor?

If 'yes', is the predator itself a very valuable species? Will reduction in loss from predators place the species in a different density-dependent mortality situation?

If 'no', then –

Action potential. Reduce predation losses preferably by altering the habitat to improve security, or by introduction of artifcial protection, or, failing these, by removal of individual predators from predation-inducing contact with the prey.

(g) Is illegal killing by Man an important factor in lack of increase?

If 'yes', what are the circumstances that lead to this poaching loss?

Action potential. Can these circumstances be altered by social action, physical barrier, improved legislation, improved enforcement, or augmented educational effort?

(h) Are parasites or infectious (contagious) diseases an important source of less to the population or individuals that would otherwise contribute to an increase in the population?

If 'yes', are the parasites or causes of disease species specific or transmitted through other species?

Action potential. Can habitat modification reduce disease losses? Can elimination of alternate hosts, or removal or treatment of domestic livestock, reduce losses due to disease?

(i) Are accidental deaths from man-made hazards (highways, irrigation ditches, canals, flooded reservoirs, etc.) an important factor in the mortality rate?

If 'yes', where and under what circumstances?

Action potential. Can losses be reduced by altering the habitats, fencing or screening the hazard, providing escape facilities, or other steps to reduce the hazard?

(j) Is disturbance by Man, his livestock or his technology, an important factor inhibiting effective reproduction or increasing mortality rate?

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If 'yes', what are the disturbing influences, and when and under what circumstances do they operate? What evidence is there that disturbance is or is likely to become density-dependent?

Action potential. Can steps be taken to reduce the disturbance (removal of its source, alteration of habitat, or change of level, timing or any other of its aspects)?

(k) Are major events in the biology of the species seasonal?

If 'yes', how long are its rut, fawning, lactation, antler regeneration, time of hardened antlers or calling compared with its actual breeding season? Are any of these activities confined to specific habitats, parts of habitats or recognizable localities? Are they natural features of the biology of the species or imposed by circumstances of numbers or habitat?

Action potential. Special protection of rutting areas, calving grounds, wintering areas, and other particular features used by the species.

FUTURE DEVELOPMENT OF THE RESEARCH FRAMEWORK

It is intended that this research framework will continue to be revised in the light of further research on threatened and secure deer populations and of projects designed specially to improve study methods of relevance to wildlife conservation. For example, the present meeting has emphasized the importance of integrating human sociological components into threatened species studies, and the preparation of guidelines on this subject has already begun (D. Pitt, 1977, pers. comm.). Future revision of the framework will take account of these developments and of any comments that users of the framework and others may send to the authors.

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PART II: A DOSSIER ON THE PLANNING OF RESTORATION PROGRAMMES FOR THREATENED SPECIES WITH SPECIAL REFERENCE TO DEER

2. COMPONENTS OF STUDY PROGRAMMES

Summary of Discussion

Essential etho-ecological data required in field studies of threatened herbivores (V. Geist)

There is a clear distinction between tactics and strategies in animal behaviour and several examples were given that demonstrated the difference. When studying adaptive strategies, the observer should start with collection of data on individuals rather than on the population in general.

The concept of "habitat" is a human abstraction, which we see from our own perspective in terms in which we have been trained to see it. Animals have no concept of habitat in the generally accepted sense of the term.

Animals in the wild have always been subjected to bioenergetic disturbances but it is doubtful if the human protection now given to many wild animal populations could cause genetic drift or selective pressures in any one direction. Human investigators tend to under-estimate the cerebral qualities of the animals that they are studying.

The basis of speciation and differentiation of species and subspecies was discussed. Differentiation based on examination of museum collections may be much greater than museum calipers can measure. The order of importance of change for speciation was considered to be, first, behaviour (which was the most plastic), secondly, physiology and, thirdly, morphology (which was the least plastic). Nutrition can affect morphology very quickly, but growth rates and priorities are well known in ungulates, and growth forms could be used to interpret morphological response to the habitat in which the animals were collected. The main point is that species should not be distinguished on the basis of behavioural patterns.

The principal needs in ecological training are to teach students how to observe and to translate objectives into practical approaches.

It was recommended that people in possession of 16 mm cine-films on threatened deer or other endangered species should arrange to deposit a copy with the Institute of Scientific Films, Federal Republic of Germany. The Institute can copy the original, edit and assemble it, and make it available to interested parties on request.

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Essential data required on population structure and dynamics in field studies of threatened herbivores (D. McCullough)

In response to questions, two methods of determining the number of animals in the first age class of life tables were suggested. Either the number of females of reproductive age and data on fecundity can be used to calculate the number that should have been produced, or the figure can be obtained by projecting a fitted line through the plot of the number of animals in each age class back to the first age class. Figures calculated by these two methods, separately, were usually in close agreement for long-lived species of up to 12–30 years.

Some members took issue with the statement that one recruitment class failure in a long-lived, K-selected species has a relatively minor impact on total population numbers. Whilst it was often true that the failure was compensated by a high recruitment rate in the following year, the reproductive potential of both species and individual populations can vary considerably, and the statement required qualification.

The concepts of r and K selection are undoubtedly useful, but they may not be real, and species can be both r and K selected, depending on circumstances.

Field study techniques for special application to depleted populations (R. Taber)

It was agreed that if a threatened deer species on which a field study was to be initiated occurred in a zoo or captive herd, then arrangements should be made for the researcher to spend several weeks at the zoo to undertake observations on faecal deposition rates and behaviour, etc., in preparation for his work in the field.

It was accepted that observations on captive animals needed to be treated with caution in applying the results to animals in the wild. For example, behavioural observations should be restricted to mechanical behaviour; observations on social behaviour were of little relevance to wild populations.

IUCN should be requested to examine the feasibility of identifying holdings of threatened deer specimens and material in zoos and museums. Skeletal remains of threatened deer from zoos should not be discarded but, where possible, should be lodged in museums or other collections. Arrangements would need to be made to verify not only the holdings of specimens but the accuracy of species identification. The lists of captive deer published in the International Zoo Yearbook should be checked.

The use of radio telemetry was not considered in the paper, which confined its attention to study methods that avoided capture and handling of animals. In many of the situations in which threatened deer occurred, the cost of monitoring radio-tagged animals would in any case be prohibitive because of inaccessibility.

The systematic collection of data based on area cell-units has much to recommend it. It provides for quantification of information and systematic testing of hypotheses. In using the system, the observer must concern himself not only with where the animal has been, but also why it has been there.

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In studies of short duration it is wise to stratify habitat types and allocate cells to strata.

Revision of the research framework for threatened deer studies (I. McTaggart Cowan & C. Holloway)

Most discussion under this topic comprised consideration of comments on the usefulness of the original research framework, especially from researchers who had used it in the field, and suggestions for revision and amendment. It was suggested that some rearrangement of the framework's content might be considered to provide a more orderly sequence and that new sections should be added, or existing ones expanded, to cover: distribution and abundance of populations with special reference to new sites for reintroduction; competition with other wild ungulates; the role of fire in vegetative succession; and human sociology.

It was agreed that a second paper of similar arrangement was required to provide guidelines for management. It should include the concept of management plans and the use of recovery teams, and address some of the management topics on which the Deer Group had been requested to formulate opinions during the course of the present meeting.

Finally, some discussion took place on the organization and composition of recovery teams. It was suggested that (a) the formation of recovery teams for threatened deer should be prompted, if not actually initiated, by IUCN; (b) each team should have an international member, both to advise it and aid continuity of activities, who would not necessarily participate directly in its activities but keep in continuing contact with it through correspondence; (c) the team should not be solely an advisory body but its membership should be selected to provide for authority in direction of conservation effort; and (d) where the deer concerned ranges over two adjacent countries, the team should be a truly international one with representatives from both those countries.

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PART II: A DOSSIER ON THE PLANNING OF RESTORATION PROGRAMMES FOR THREATENED UNGULATES WITH SPECIAL REFERENCE TO DEER

3. COMPONENTS OF MANAGEMENT PROGRAMMES

Criteria for the Reintroduction of Threatened Species into Parts of Their Former Range

H. JUNGIUS

ABSTRACT

This paper discusses the different objectives and consequences of introductions. The basic requirements for well planned reintroduction programmes are outlined. These programmes should include: a feasibility study, a preparatory phase, the actual reintroduction by releasing animals and a follow-up programme. The feasibility of reintroducing threatened deer species is also evaluated.

INTRODUCTION

Man's growing need for space and food have increased the pressure on the natural environment and accelerated the modification and destruction of natural habitats. His over-exploitation of animal populations has led to the disappearance or extermination of many plants and animals, a process whereby predators and ungulates have suffered particularly through being his main competitors. Habitats formerly occupied by these animals have also consequently suffered.

Ungulates, as all herbivores, are important components of natural ecosystems and influence their functioning and productivity. Overpopulations cause over-exploitation of vegetation resources, which results in depreciation of habitats. It is uncertain as to what extent loss or reduced numbers of a species affect an ecosystem by disturbing or disrupting ecological cycles, by causing changes in energy flow, or by weakening the stability of ecosystems. What we do know is that low population densities or complete loss of a species may affect other species and thus disturb the equilibrium of an ecosystem. For example, the extermination of roe deer and red deer in the Abruzzo range in Italy led to increased predation by wolves and bears on domestic stock and on the Abruzzo chamois, an endangered species. Increased wolf predation might also be the reason for low numbers of the Abruzzo chamois and its now restricted range.

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A completely different consequence of extermination of a species is the loss of animals or plants as an existing or potential economic resource for man (for instance, as food, medicine, or tourism). Another effect is the loss of scientific and sometimes cultural values, the importance of which should never be underestimated.

These facts need to be understood when considering reintroduction of species. Rehabilitation of a species to its original habitat should not only be a contribution to re-establishing the natural composition of an ecosystem and strengthening its stability, but also as a restoration of nature for man's long-term benefit.

REINTRODUCTION OR INTRODUCTION

The composition of living communities is the result of dynamic processes subjected to continuing changes. Man has influenced this process considerably during historical times by changing habitats, translocating species, and by hunting. The results of such activities are impoverishment of natural habitats and the agricultural landscapes of today, which no longer provide habitats adequate for many plants and animals. In several cases, species extinct in specific areas cannot be returned despite intensive management practices because their ecological requirements no longer can be provided. New habitats with different ecological niches have been created which, sometimes, remain unoccupied. The question should therefore be raised if and to what extent these empty niches could be filled by introducing exotic species which never occurred in the area before but which exist in similar types of habitat elsewhere. In the past many introductions have failed; others have caused environmental disturbance, such as displacement of native species by the newcomer, or a population explosion followed by habitat destruction due to absence of natural controls. The following examples illustrate this:

Red deer, introduced to Chile and Argentina, have been reported as competing with the huemul and pudu for food and space, forcing the native species to less attractive habitats (Niethammer, 1963; Taber, Miller & Rottmann, 1974). Sika deer, introduced from Japan to north Germany, are competing with red deer and fallow deer and are causing damage to forests and fields (Müller-Using, 1960). Red deer and elk, introduced to New Zealand, have adapted well, but lack of natural control mechanisms and insufficient management have resulted in population explosions and severe habitat damage.

We also record, however, that introductions do not always fail or become disastrous. The introduction of the fallow deer to south and central Europe is the earliest large-scale deer translocation known and has proved to be a convincing success. While the deer is threatened in its remaining traditional habitat in Turkey and Iran, it thrives in its new environment (Heidemann, 1973). It may well prove that this introduction has saved the species from extinction in the long run.

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Rejecting introductions on principle is, in my view, scientifically unjustified. We must realise that some introductions have been a success from the ecological point of view and contributed to the enrichment of disturbed habitats. It may well be that some threatened or rare species whose habitats have been lost can only be saved by such measures, unless we want to put them into zoos, where free interaction between animals and their environment is no longer possible and where the genetic potential of a species may deteriorate rapidly. Niethammer (1963), Reichholf (1977), and others have expressed similar views. I hope, therefore, that these thoughts will provoke and stimulate biologists and conservationists to examine introductions more critically and to take ecological principles into consideration, in addition to cultural and aesthetic ones. This may lead to a less emotional discussion. The assertion that a species does not belong here or there is not a convincing argument.

Reintroduction is less controversial than introduction. It involves the rehabilitation of a species in an area in which it became extinct in historical times (Holloway & Jungius, 1973). According to IUCN's definition, reintroduction is appropriate. "Where a wild species has become locally extinct and the reasons for its disappearance have been removed without any radical alteration in the condition of the habitat, it may be reintroduced with relative safety into its old range, because it will be again interacting with the biotic and physical system in which it evolved" (Petrides, 1968).

At present, reintroduction produces great interest in conservation circles. Much effort is being put into re-establishing predators in central Europe, the lynx in particular; plus ungulates exterminated in the wild, such as the threatened Arabian oryx. They are on their way back (Jungius, 1977). As to threatened deer, reintroduction is being considered as feasible for several species.

Many reintroductions have been undertaken and are still planned without proper preparation and execution. The operations lack scientific background and often lead to failure. The success of reintroduction projects depends on a clear understanding of: the reasons for a species' disappearance; the present status and potential of the habitat in the reintroduction area; the biological characteristics of the species concerned; and its ecological requirements within the reintroduction area. Only on the basis of this knowledge can the best techniques for re-establishing the species and fixing it to the new habitat be developed. This is of particular importance for threatened species where loss of only a few individuals may lead to extinction.

BASIC CONSIDERATIONS FOR REINTRODUCTION PROGRAMMES

Any well planned reintroduction programme should include a feasibility study, a preparatory phase, the actual reintroduction by releasing the animals, and a follow-up programme (Holloway & Jungius, 1973).

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a) The Feasibility Study

i) The species

Data on the species' ecological and behavioural characteristics must be collected. This should include a complete study of its systematic status and distribution, habitat requirements (food, water, cover), reproductive behaviour, interactions with other species (effects of competition, co-existence, predation), relation to man and human-induced habitat disturbances or changes. Particular attention must be paid to space requirements (territoriality, home ranges, seasonal movements). Diseases and factors limiting population growth and distribution need to be investigated.

ii) The habitat

Data must be gathered on location, access and basic characteristics (climate, topography, flora and fauna, land use). It needs to be determined to what degree the reintroduction area meets the species' requirements. Potential conflicts with other species (competition and predation) and current land use forms must be identified. Recommendations to alleviate these problems must be made.

b) Preparation of Reintrodution Programme

i) The species

The animals to be released should belong to the same or, if this no longer exists, the nearest subspecies to those that became extinct. The specimens should come from the same or a harsher climate than that of the reintroduction area. If this is not possible, sufficient time for adaptation must be given. The ideal age and sex ratio of the animals required must be determined to provide maximum reproduction potential. The best season and techniques for transport must be chosen. Animals for reintroduction must be free from diseases and parasites. This requires veterinary examination and vaccinations. The required animals must be vaccinated prior to transport and release to prevent transmission of infections from other animals to the reintroduction area. If animals need to be imported from other countries, permits have to be requested. Where threatened species are translocated from one country to another, the regulations of the Washington Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973) must be followed.

In most cases an enclosure will have to be built in the reintroduction area for acclimatizing animals before release, or for breeding them in captivity for subsequent releases. The establishment of breeding units in the reintroduction area should be considered for all threatened species. This would reduce the drain from the remaining stocks and would provide a continuous supply of animals for release by which it would be possible to experiment with different release techniques where required. It would also allow the exchange of animals with other breeding centres to increase the genetic potential. The animals of the breeding unit could be kept under veterinary care which would reduce losses.

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The site for any enclosure must be selected carefully. Fencing must be safe and predator proof if risks exist. The place must be easily accessible and should preferably be in the centre of the area. The enclosure should be large enought to fulfil the species' requirements and allow the animals to live under natural conditions, if possible without artificial feeding. Where social animals are concerned, mixed herds composed of both sexes and of differing age classes should be built up where males and females are in contact with each other. Pregnant females should be able to find ample space to withdraw for parturition but should remain in communication with the males of the herd. Dolan (1976) and Jungius (1977) have shown that this is vital for maximum productivity in herd animals such as the Arabian oryx.

Kurt (these Proceedings, pp. 236–237) suggests that the enclosure should be large enough to allow animals to maintain a breeding population for a period of at least three reproductive seasons until the first captive-born calves reach maturity. They would be imprinted on the area and when released the possibility would be high that they would stay in its vicinity. Kurt (pers. comm., (1977) recommends also that the enclosure should not be pulled down once all animals have been released. The site may continue to be an important attraction to the animals for traditional or ecological reasons and may help to keep them in the chosen area.

All enclosures should have shelters, capture devices, devices for separating animals, or small adjacent enclosures where animals can be kept. If it is impossible to have large enclosures with natural food and water supplies, artificial watering and feeding places and shelters must be established.

For animals which have been in captivity for a long time or come from captive-bred stock, it will be important that they are taught how to feed in the wild. A large enclosure with natural vegetation would facilitate this process and allow the animals to select palatable food themselves and to adapt gradually. If necessary, some artificial feeding can still be continued.

Several deer species are food specialists under natural conditions, and depend on a special fauna of endosymbionts in their rumen, such as bacteria to split cellulose and infusoria which store glycogen. These endosymbionts may disappear in captivity if animals are fed for generations with "pellets" or other artificial foods. Animals being prepared for reintroduction should, therefore, be infested with endosymbionts before release. This can be done by feeding them with natural food.

ii) The area

Action will be required to obtain approval and support from the official and private institutions and organisations responsible for, and working in, the area. Adequate legal protection of the species, the release area and its surroundings, should be obtained. Where possible, reintroduction programmes should be backed by special laws to give the project the highest official support possible. Poaching must be eradicated and human disturbance must be reduced. Education information campaigns should be developed to explain to the people of the region the reasons for the reintroduction programme and to encourage their full involvement from the beginning.

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c) Release of Animals

The basic purpose of any reintroduction is the establishment of a reproductive population of the species in a selected area. This requires means whereby the animals are fixed to the release site to prevent dispersal of individuals and to reduce long distance movements into adjoining unsuitable and unproductive areas. It is essential, therefore, that all biological requirements of a species should be met, including good cover, food and water. Special release techniques must be used, for instance: introducing animals into an area which is surrounded by unfavourable habitats; or releasing animals to the best habitat during the most unfavourable season of the year, so that they are then surrounded by less attractive areas. This will prevent animals from dispersing from the best site into habitats which will become unsuitable at other seasons of the year. During the bad season it will also be easier to keep animals together by artificial feeding and by providing shelter. This might help to build group cohesion.

Social spacing mechanisms will also be less pronounced during this time of the year than during periods when living conditions are optimum. This will again help to prevent dispersal of animals and support the formation of groups which will make reintroduction much easier. These social groups (of, for example, mother–young or male–female) can be used for reintroduction, for instance by releasing one social group, i.e. mother and young, while keeping the other group in a fenced area.

Release in winter is of particular importance for species with restricted winter ranges such as bighorn sheep or ibex.

Knowledge of summer and winter ranges is a function of tradition (Geist, 1975). While summer range is in principle abundant, winter range is restricted in extent and locality (sunny and steep terraced slopes are preferred with little or no snow cover). It is therefore preferable to introduce animals which depend on restricted winter ranges into such areas during winter. The animals will get to know the location and return to it when food resources are depleted in other parts of their range.

Imprinting animals on their winter range can be done in various ways. Ibex were released successfully on suitable winter habitat (mountain slopes) in the Swiss Alps in late autumn. The animals were either released from transport cages or given a tranquillizer. The latter allowed them to recover slowly which had the advantage that they were able to explore the new habitat gradually without human disturbance. Also, adult animals could be imprinted without difficulty on the release site if it was a suitable habitat (Nievergelt, pers. comm., 1977).

The safest way of reintroducing animals, in particular where numbers are low, is via an enclosure in the reintroduction area. Preferably young specimens, lambs or yearlings, should be used which are not yet imprinted on a particular area. Geist (1975) recommends in the case of the bighorn sheep that males and females should be introduced to different areas. This will copy the natural pattern by which competition between sexes is reduced. The animals should be released from the enclosure in spring. By then they

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will have learnt to recognise the area and be able to return to it. A tradition will thus have been established.

If this technique does not work and the animals do not return in winter, the hand leading method propagated by Geist (1975) should be tried. Geist suggests imprinting bighorn sheep lambs by hand rearing on a human who will lead males and females into separate winter ranges. After having become accustomed to the area, males and females will be wintered in "their" range in enclosures and released in spring. After this, a group of wild caught yearlings should be released into each group. They will mix with the resident animals and pick up their traditions. Hand reared males should be removed after two or three years because they might become dangerous to man. This technique has been practised successfully by Bergerud (1974) with the introduction of caribou in Newfoundland.

Kurt (1968) has also demonstrated that introduction of hand reared roe deer fawns is possible. Kurt led his animals through the area where he wanted them to live. All six animals adapted to the place. This experiment was done in winter (December/January).

When dealing with a threatened species, the rarity of the animal will not allow experimentation. It will prevent the release of large numbers and supplementary releases if the first release fails, or the use of trial introductions in different areas. It is, therefore, strongly recommended that for reintroduction of threatened species, a captive breeding unit is established in which animals are kept under free range conditions. This has the advantage of keeping a reproductive nucleus. It allows for the establishment of ideal social groups from surplus animals for release at the most appropriate season and provides a continuous flow of specimens for supplementary release. Another advantage is that all animals can be kept under veterinary care, and can be treated prior to release, if required.

Enclosures are also necessary to prevent immediate dispersal of animals after release into unsuitable habitats. Experience with elk (McCullough, pers. comm., 1977) and red deer (my own observations in the Abruzzo National Park, Italy) has shown that animals which are released without prior acclimatization in an enclosure start wandering immediately and lose contact with each other. This lowers the reproductive potential of the new population and frequently causes high mortality. If these animals are kept in enclosures – in the case of red deer, four weeks were sufficient – they get to know each other and become accustomed to their new environment and stay together after release. Similar experiences were made with elk.

When considering the reintroduction of rare species, females are usually the most valuable animals, while a surplus of males is often available. It is recommended that some of the males be used as pioneers and to release females only after males have established themselves. This technique was used frequently when reintroducing ibex into the Swiss Alps. Male ibex were available in large numbers and proved to be a good tool to test if the environment was suitable for the species. They proved to be more mobile than females and better able to locate more favourable habitats if the one chosen by man was of low quality. After the males had settled down, females were

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released to join them (Nievergelt, 1966). The release of males before females may impede the formation of reproductive units. However, we must realise that males, in particular in social species, possess the necessary behaviour pattern to locate females or to attract them, in particular during the rutting season – deer for instance by roaring.

Another possibility would be to keep females in an enclosure but to allow some males to leave. They will explore the area and might return during the rutting season, attracted by the females. If this happens, some females could be released and allowed to leave with the males (Kurt, these Proceedings p. 237).

Past experience has shown that repeated releases of large numbers of specimens are necessary, preferably in different but connected areas, to make the reintroduction project a success. As a generalization, one can say that the higher the number of animals released the greater is the chance of success.

d) Follow up of Release

Follow up observations of released animals must be an integral part of any reintroduction programme. Where possible, a long-term research programme should be initiated to determine the rate of adaptation and of dispersal, the need for further releases, and to identify the reasons for success or failure of the programme. The research should also monitor the species' impact on the habitat and advise on management techniques to prevent damage or improve conditions. To facilitate observations, all animals should be marked before release, some, if possible, with radio collars to facilitate observation of movement.

Any reintroduction programme must be considered as a long-term process and several subsequent releases of animals may be necessary until the species is fully established.

REINTRODUCTION OF THREATENED DEER SPECIES

Few attempts have been made to reintroduce threatened deer species. A project initiated by Nogueira-Neto (1973) to rehabilitate the marsh deer in Brazil failed. A similar project, aimed at establishing a captive breeding unit of marsh deer for later release into the wild in Argentina failed as well. Reasons for this were lack of knowledge on the species' biology and special habitat requirements. This re-emphasizes that pre-knowledge of basic ecological and biological characteristics and requirements of the species is essential to make reintroductions a success. This is of particular importance for threatened species with specialized habitat requirements.

That reintroduction of a threatened deer species can be a success if carefully planned has been demonstrated in the USSR by two successful reintroductions of the bactrian deer (Goodwin & Holloway, 1976). Additional knowledge can be obtained from reintroduction of other deer species and introductions which follow similar basic considerations (Bump, 1951 and 1963; Westerskov, 1952; Lindemann, 1956; Neithammer, 1963).

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With regard to the foregoing, reintroductions of threatened deer are or may be considered for the following species, based on the IUCN Red Data Book; Holloway, pers. comm., 1977; and own investigations:

Persian fallow deer – two wild populations are known, totalling between 40 and 65 animals. In addition to this there is a captive herd of 55 animals (this number does not include the suspect hybrid animals of the von Opel herd). Breeding up of this herd is being considered to provide specimens for reintroduction into a wildlife park in north-eastern Iran and elsewhere.

Southern race of the swamp deer (barasingha) – the population is limited to the Kanha National Park and has increased from 70 in 1969 to about 280 in 1977. Sufficient wild stock is available for reintroduction. Proposals have been made for translocating deer to other parts of the Kanha National Park. Reintroduction to other suitable and protected areas in other parts of central India should also be considered.

Manipur brow-antlered deer – at present there are only 18 specimens left in the wild and 49 in zoos. Establishment of a second wild population in a suitable habitat is being considered. Animals for such a reintroduction should be provided from zoos (Ranjitsinh, these Proceedings, pp. 26–32).

Formosan sika – this species is extinct in the wild. Most of its habitat has been destroyed. A captive herd of about 200 animals exists. A reintroduction to a protected area similar to its original habitat has been suggested.

Ryukyu sika or *Kerama deer* – the species is confined to a few islets in the Keramas. Its habitat is deteriorating, partly due to the presence of feral goats. Reintroduction of the deer to other islands of the archipelago should be considered to ensure its survival.

Corsican red deer – extinct in Corsica but still occurring in Sardinia. The species' range in Corsica was restricted to a rather small area on the east coast. Most of this original habitat has been destroyed. If specimens are available from Sardinia, reintroduction to Corsica should be considered. Introduction of the deer into habitats in Corsica similar to the one in Sardinia should be investigated.

Barbary deer – almost extinct in the wild. In Algeria, it is estimated that there are between 400 and 600 and there is another captive population in Tunisia, with more than 100 animals, but overcrowding of the enclosure has been reported. There is scope for reintroducing deer from these captive herds to protected areas, in particular in Morocco.

Kashmir stag – the only area in which a viable population has been confirmed is the Dachigam Sanctuary. Sufficient stock is available and reintroduction to other areas would be feasible if the remaining habitats have not undergone dramatic changes and if protection can be assured.

Columbian white-tailed deer – the population has been reduced to about 650 animals principally through loss of habitat. The possibilities for reintroducing deer from captive stocks are being considered.

Argentinian pampas deer – the total wild population is put at about 250 animals. The largest single population numbers about 200. There are several smaller herds consisting of only a few animals, plus a captive herd of 21 specimens. Reintroduction of captive bred animals to a protected

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provincial park with natural grassland is currently being considered (Jackson, 1977).

When contemplating reintroduction of these threatened deer, preference should be given to species where stocks exist in captivity and where animals can be taken from the wild without disrupting the population. The fullest possible use should be made of all the basic knowledge of the species' biology, ecology and habitat requirements available and the guidelines mentioned above must be followed. But, in addition to this, one must realise that returning a species to the wild is a long process which needs a lot of knowledge, patience, energy and stamina.

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PART II: A DOSSIER ON THE PLANNING OF RESTORATION PROGRAMMES FOR THREATENED UNGULATES WITH SPECIAL REFERENCE TO DEER

3. COMPONENTS OF MANAGEMENT PROGRAMMES

Captive Breeding as a Practical Aid to Preventing Extinction, and Providing Animals for Re-introduction

G. KENNETH WHITEHEAD

Of the forty living species of deer which represent just under 200 subspecies, no fewer than twenty-nine are included in the Red Data Book of the I.U.C.N. and, of these, nineteen are classified as **endangered** (Red sheet), three **vulnerable** (Amber sheet), one **rare** (White sheet), two **out of danger** (Green sheet) and four **indeterminate** (Grey sheet). Only about half of these endangered or threatened deer are represented in zoological collections, and these include three which may now be extinct in the wild.

Many of the deer of Northern India, Tibet and China are much reduced in numbers to what they were at the beginning of the century, and in almost every case the reason has been the same – over-hunting and loss of habitat, the former undoubtedly made more effective by the accuracy of the modern firearm. Unfortunately, information about the present status of some of the Asiatic deer is almost non-existent and although lack of data may suggest near extinction, one always hopes that the picture is not as bad as might first appear.

The main reason for the decline in the wild of many of these Asiatic deer has been merciless hunting for the sake of their antlers – particularly whilst still in velvet – for, ground-up and dried, they are used as an aphrodisiac, one type of which is called *pantocrine*. In recent years, however, it has been found possible to farm deer for the sole purpose of producing antlers which can be cut off without the owner having to be killed – an operation that cannot, of course, be done with wild deer. According to a recent article in *China Pictorial*, Thorold's deer *Cervus albirostris* are now being domesticated on a farm in Chinghai (Tsinghai) Province, so the main cause of their decline in recent years may now be their salvation as domesticated stocks build up on deer farms. A few years ago this deer was present in two zoos – a hind in Colombo Zoo, Sri Lanka, and 7 stags and 4 hinds in Peking Zoo, China.

The Sika deer *Cervus nippon*, has a wide distribution in eastern Asia, and although some thirteen different races are recognized, many of these, and in particular those at present in China, are now considered to be endangered.

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It is unfortunate, therefore, that this important group of deer has not been covered at this Conference.

One of the rarest of the sikine deer is that found on the island of Formosa or Taiwan – the Formosan Sika deer *C. n. taiouanus* – which, like some of the mainland forms, is now on the verge of extinction. During the years Formosa was under Japanese rule the deer were protected, but this is no longer the case, and the deer have declined to near extinction. Any that now remain in the wild state do so in the mountainous southern parts of the island. This deer, however, is now kept in at least thirty zoos and parks throughout the world, including six collections in England. Off the Chinese coast a number of Formosan Sika deer are raised on Lu-tao (Green Island) for their antlers, a pair of which, in 1972, was said to be worth about 100 dollars.

Another sika deer of which the world population would appear to be under fifty animals is the Kerama or Ryukyu Sika Deer *C. n. keramae* of the Ryukyu Islands. This deer is prone to melanism, and occasionally all black animals occur. A herd of some 14 animals is held at Whipsnade, but due to crossing with *C. n. nippon* can no longer be considered pure.

The diminutive Musk deer *Moschus moschiferus*, which is a native of the high mountainous forests of Asia, is another deer which may well find salvation in deer farming, for although it carries no antlers it has always been persecuted for the musk which is secreted by the male in a sac located beneath the skin of its abdomen. Previously it was only possible to collect the musk from a killed specimen but since 1958, when the first experimental Musk deer farm was set up, it has been found possible to collect the musk from a living animal. Farming Musk deer, however, is still very much in its infancy and will probably not, in the immediate future, cause much reduction in the persecution of the wild animal.

Of the five species of muntjac *Muntiacus*, two are considered endangered – namely the Black or Hairy-fronted muntjac *Muntiacus crinifrons* of Eastern China and Fea's muntjac *M. feae* of Tenasserim and Thailand. Very little is known about the status of the Black muntjac and until recently only about three specimens appear to have been recorded – and two of these were taken some ninety years ago from Ningpo, Chekiang. It has always been assumed that the absence of sightings may have been due to the secretive nature of the animals – an assumption which is partially confirmed by a record in the Zoological Magazine of Anhwei University Biology Dept. (1976, No. 1), which reports that between the winter of 1973 and spring of 1974, 80 skins of *Muntiacus crinifrons* were collected in Anwhei province, which is adjacent to Chekiang. It would appear, therefore, that this deer may not be as scarce as generally assumed – indeed it may be quite plentiful, for the report goes on to say that local hunting and animal husbandry departments consider this an animal that has to be controlled. Fea's muntjac may be scarcer, but in Thailand a recent report (1972) suggests that in some of the more remote mountainous areas "it is not particularly scarce".

Little is known about the status of the Tufted deer *Elaphodus cephalophus*, which occurs in northern Burma and in central and southern China, but it would seem to be rare in much of its range. Three subspecies are recognized,

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and although the Zoological magazine of Anwhei University records that between the winter of 1973 and spring of 1974 20 specimens of Tufted deer were collected in the province, it concludes by saying that this deer – which is presumably the subspecies *Elaphodus cephalophus michianus* – should be given the protection necessary for a precious animal that has a docile temperament, is easy to domesticate, and is one that has very good prospects for captive breeding.

The status of two species of the genus *Axis* are certainly at risk – namely the Bawean or Kuhl's deer *Axis kuhli* and the Calamian deer *Axis calamianensis*, which is restricted to the Calamian group of islands lying to the west of the main Philippine Group, and in particular to the islands of Buswanga and Culion. Following a visit to the islands in February and March 1975, Major I. R. Grimwood suggested that the total population of this deer on all the islands would not exceed more than about 900, with the biggest number on Buswanga, 450. "The Calamian deer" he wrote, "has suffered a great reduction in numbers over the last thirty years and, although nominally protected, continues to decline in every part of its limited range .... The species is unaffected by habitat destruction and the cause of its decline is solely illegal hunting. Unless that hunting can be brought under control, or an effective sanctuary can be created for it, the species, therefore, appeared doomed to early extinction".

The Calamian deer, which resembles the Hog deer *Axis porcinus*, is the only deer on the Calamian Islands and the sole representative of the genus *Axis* found anywhere in the Philippines, all the other deer being sambar *Cervus unicolor*.

In 1976, some Calamian deer (4 males and 3 females) were caught on Culion and sent to England by way of Naples, where the deer spent some time in quarantine before continuing their journey to England, where they arrived in February 1977. At the present time they are in quarantine in Plymouth but when this is complete they will be transferred to John Aspinall's zoo at Port Lympne. When the deer finally reach Lympne it should be possible for the zoologists to decide whether this deer should be given specific status, or considered a subspecies of *Axis porcinus* i.e. *A. p. calamianensis*.

Of the seven deer which left Culion, only two stags and two hinds as well as a calf as yet unsexed reached England, two of the stags unfortunately having to be left in Naples to pay for part of the quarantine, and a third hind having apparently died. How the two stags will be disposed of is anybody's guess but if used for breeding, then presumably whoever purchases them will attempt to cross them with a species that approximates closely to the Calamian deer – and that, in all probability, would have to be the Hog deer, for there are no pure bred Calamian deer hinds in any of the European zoos.

Of the four native deer of South America that are at present causing some concern, only one – the Argentine Pampas deer *Ozotoceros bezoarticus celer* – is considered to be in any real danger. Fortunately about 25 animals are in captivity in the La Corona Estancia but the rate of reproduction has

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been poor. This deer is the subject of another paper (J. Jackson, these Proceedings, pp. 33–45).

In May 1972, the first international conference on the planned breeding of endangered species in captivity was held in Jersey. According to Sir Peter Scott, man has increased the rate of extinction of species by a factor of four over the last two hundred years. In order to redress the balance, we must look to zoos, not merely as places of captivity, "stationary circuses", but as "wild life banks" acting as breeding centres with a view to returning captively bred endangered species to their natural habitats.

At the 1972 conference, however, Miss Moira Warland (then Executive Officer of the Survival Service Commission) held a different view, and was not convinced that the captive breeding of an endangered species really did play such an important role in its conservation. "For years now", she said, "the Survival Service Commission (SSC) has been freely used by many zoos and other institutions to help them obtain specimens of endangered species, supposedly as a contribution to conservation". She was of the opinion, however, that "this can no longer be considered acceptable and the keeping of captive stock *per se* should not be considered as a vindication for the continued acquisition of specimens of endangered species from the wild. On balance, zoos are still undoubtedly consumers rather than producers of wild life", and she considered that "one of the most important practical contributions that zoos and other breeding centres can make to conservation is the establishment of captive stocks of endangered species for sale or exchange to other zoos, in order to reduce consumer demand on ever-decreasing stocks".

In my opinion, however, the value of capturing some specimens of endangered species of deer and placing them in reserves either within or outside their country of origin so that captive bred individuals can at some future date be released into the wild, cannot be over-stressed. Indeed, had not captive stocks of such ruminants as the Arabian oryx, the European bison and Père David's deer been preserved in zoo collections, all three would undoubtedly have been extinct today. It is equally important that the location, numbers and sexes of all endangered species held in collections should be widely known, for where one zoo has a single male of a rare species and another a single female, inter-zoo matings or exchanges should be arranged. It is most important that there should be close liaison between zoos having endangered animals and the classic example of how such liaison between zoos can save an animal from extinction was when at the end of the last century, between 1894 and 1901, the zoos of Europe agreed to let the eleventh Duke of Bedford have a total of eighteen Père David deer *Elaphurus davidianus* (Fig. 1) consisting of seven stags, nine hinds and two calves, so that he could build up a viable herd in his 700 hectares park at Woburn. But for that co-operation, this unique deer would probably have been extinct today, for none of the zoos of Europe had been successful in breeding the species and even at Woburn, during the initial seven years, out of 13 calves born, only 4 survived. However, this deer thereafter soon acclimatized themselves to the open park, and the herd now numbers about 350. Moreover, during the past thirty years

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many zoos of the world have received specimens from Woburn with the result that the present world population is in the region of 800 animals, spread around eighty or so different collections. So the survival of this species now seems assured.



Figure 1. Père David stag in August

It is important that there should be an exchange of information concerning the breeding habits and feeding of a rare deer in captivity, so that any problems or difficulties experienced should be as widely known as possible among zoos; for only by the spread of such knowledge can repetition of failure be avoided. This is especially important when deer are brought from one continent to another, and a number of deer species which are now rare and which were tried at Woburn early in the century, failed due to unsuitable habitat, it being found that some species could only survive if kept in a dry yard. For instance, it was found that the Hangul or Kashmir deer *Cervus elaphus hanglu* was most sensitive to internal parasites and quite incapable of being kept on grass. However, a decent sized herd was maintained in a large yard until the war led to their destruction. The 1914 war also saw the end of the Eld's deer *Cervus eldi* at Woburn – a species which did quite well in confinement so long as the deer were warmly housed and well fed during the late autumn and winter, when most births took place. Apart from the fine herd of Père David's deer *Elaphurus davidianus*, the rarest species of deer at Woburn today is the Swamp deer *Cervus duvauceli*. But for a number of years now they have barely held their own and few calves manage to survive;

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for they are extremely sensitive to cold and wet, and a late frost or heavy rain soon kills them. Whilst cold-country deer taken to the Antipodes change their breeding season almost immediately, the majority of tropical deer seem quite incapable of adapting themselves to the seasons of western Europe.

Another equally important point is that no individual zoo should "go it alone" and attempt to retain a species reduced to perhaps one animal only in their collection, by crossing it with a near species or subspecies, as has occurred in recent years in one or two collections.

In an attempt to find the whereabouts of endangered animals the London Zoological Society, some fifteen years ago, circularized the zoos of the world with a questionnaire on which was listed animals considered to be rare in the wild. As a result, the International Zoo Year Book, which is published annually by the Zoological Society of London, now contains a Census of Rare Mammals in Captivity and this has been the primary source of information concerning captive animals in the *Red Data Book*. Obviously, the species of deer that cause most concern are the nineteen species or subspecies which are listed as Endangered, and unfortunately, only about half of these are at present being preserved in captivity. However, the majority of omissions concern Asiatic deer, which one would normally expect to be exhibited within the People's Republic of China. Unfortunately, of the Chinese zoos, only Peking replied to the 1976 census, and so the total absence of the others from the census may not truly reflect their captive populations.

One of the recommendations made at the Symposium on Zoos and Conservation held at the Zoological Society of London in June 1964, was that stud-books should be started for certain rare species in captivity but so far as I am aware, little has been done in this direction for any of the endangered species of the Cervidae. Indeed, a stud-book in its true sense is hardly necessary for any species of deer but I am of the firm opinion that a World Register such as is already being collected at Whipsnade (Zoological Society of London) for the Père David deer should be kept for as many of the endangered species of deer as possible; and I believe it would not be too difficult to start Registers for some of those species which are already being held in captivity, such as the Swamp deer *Cervus duvauceli*, Hangul or Kashmir deer *Cervus elaphus hanglu*, Eld's or brow-antlered deer *Cervus eldi* (all three subspecies), Formosan Sika deer *Cervus nippon taiouanus*, Bawean or Kuhl's deer *Axis kuhli*, Calamian deer *Axis calamianensis*, Pampas deer *Ozotoceros bezoarticus celer* and the Persian fallow deer *Dama dama mesopotamica*.

For many of the above mentioned species a certain amount of information is already available in the International Zoo Year Book but it is felt that if a proper register existed it would be some encouragement for zoos to be more conscientious about supplying the required data. For instance, I note that there has been no data in the Zoo Year Book concerning Formosan sika deer since 1972, yet this deer may already be extinct in the wild and the total world population, therefore, probably exists only in zoos or deer farms.

Furthermore, I am of the opinion that once it has been considered necessary to start a world register of any species, then there should be some control on the management and movement of registered animals so as to avoid the

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purity of any species being contaminated by ill-considered cross-breeding, as has occurred in some zoo establishments.

For instance, in 1957 a yearling Persian fallow deer doe was sent from Iran to Georg von Opel's private zoo at Kronberg in Germany, and as there was no Persian fallow buck there, she was allowed to mate with a European fallow buck, *D. d. dama* which resulted in a *D. d. dama*/*D. d. mesopotamica* doe fawn being born, and for the next six years, it would appear that these two animals were listed as pure *D. d. mesopotamica* in the International Zoo Year Book.

Then in 1965, a pure *D. d. mesopotamica* buck was obtained from Iran by which time there was at Kronberg, in addition to the pure bred doe, one buck and three does as a result of mating the pure bred doe and her female progeny with a European fallow buck *D. d. dama*, but these were not listed in the International Zoo Year Book. Three years later (1968) according to the International Zoo Year Book, the number of Persian Fallow deer at Kronberg was 7 (3 bucks and 4 does) but in my opinion this number could not possibly have been achieved from a single pair. In 1970, I was informed by letter that there were fourteen "pure" *D. d. mesopotamica* at Kronberg (6 bucks and 8 does) and this is the number which appeared in the International Zoo Year Book. Once again, I find it hard to believe that the herd could have reached this figure unless the pure bred Persian fallow buck had been allowed to mate with one or two of the cross-bred does which were at Kronberg when it arrived.

What became of the cross-bred animals which were at Kronberg before arrival of the pure buck in 1965 is not clear though a certain number – including a buck – stated to be 75% pure Persian – did reach Munich Zoo, whence at least one buck was later transferred to Prinz Reuss's Wildlife Park at Mautern in Austria. Between 1968 and 1974, the number of cross-bred Fallow deer at Munich varied between 7 in 1968 to 9 in 1974 (*International Zoo Year Books*).

Georg von Opel died in August 1971, and shortly after his death a number of fallow deer from Kronberg were returned to Iran, but in a subsequent discussion I had in Tehran with Prince Abdorreza and others, deep concern was being expressed as to whether the animals received from Kronberg could be accepted as being 100% pure *D. d. mesopotamica*, particularly as some of the cast antlers suggested otherwise. The antler format of the Persian Fallow deer is one of its distinctive features. I was shown a number of these cast antlers, and when asked for an opinion my only possible reply was that if in doubt, kill the lot rather than contaminate the existing herd in Iran, which was known to be 100% pure and must remain so. In September 1977, I was informed by letter that up to that date the deer received from Kronberg – referred to as "German Fallow" and numbering 8 bucks, 13 does and 5 fawns – were being kept in an enclosure separate from the pure Persian Fallow, of which there were then 49 (20 bucks, 20 does and 9 fawns) in captivity.

I have dealt at considerable length on this unfortunate episode at Kronberg for it is an outstanding – and extremely regrettable – instance of how

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irresponsible management can defeat the whole object of captive breeding, which must be to preserve the purity of an endangered species. Indeed, such cross-breeding should only be considered as a *last* resort when all efforts to locate pure specimens have failed. In this particular instance, if a pure buck was, at the time, unobtainable from Iran, then I believe the wisest course would have been to return the pure bred doe to Iran to assist the Iranian captive herd breeding programme. Furthermore, once it was known in Iran that crossing Persian with European fallow had taken place at Kronberg, it was a great mistake for any of the Kronberg specimens to have been returned to Iran.

Persian Fallow is not the only rare species of which the purity has been tainted by ill-considered cross-breeding in some zoos. In a wildlife park in the north of England, for instance, Formosan sika *C. n. tiaouanus* have been allowed to mingle with Japanese sika *C. n. nippon*, and crossing has undoubtedly occurred. Although this particular deer is represented in at least six collections in England, and a number of collections elsewhere, it is probably extinct in the wild, and this makes it even more important that all captive herds should be kept pure. The only known herd in captivity of the rare melanistic Kerama sika deer *C. n. keramae*, at Whipsnade, is unfortunately no longer pure either, for crossing with the Japanese race *C. n. nippon* has occurred.

The IUCN policy on the capture of rare or endangered animals for *relocation* or for the establishment of *captive breeding* units was clearly defined in its Bulletin published July/September 1970 (New Series, Vol. 2, No. 16) and can be summarized as follows:

1. Capture for purely commercial reasons not justified.
2. Capture, and subsequent handling of animals, must be undertaken by experienced personnel.
3. Capture should not prejudice the survival of the remaining wild stock.
4. Capture for the establishment of an enclosed breeding unit should not be contemplated if there is evidence to believe species will not breed in captivity.
5. Sufficient animals should be captured to ensure breeding viability.
6. Reintroduction of a species into an area in which it no longer occurs should not be undertaken without competent ecological advice.

Further comment on the above is unnecessary, except to stress the importance of observing 2 and 3, for failure to do so can prove disastrous to wild stocks, as occurred in the capture of the Argentine Pampas deer in 1968 by a man jumping from a helicopter on to deer which had been chased into water. Prior to this capture, the population estimate for the area was 66; twentyfive deer were caught, but sixteen died before reaching the enclosure at La Corona; the 25 deer taken from the herd in 1968, previously estimated at 66, should have left a wild stock of at least 41. But in 1969 the estimated population in the area was only 28, so it would seem that catching by the method of chasing deer by helicopter to the point of exhaustian had

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caused casualties not only among the deer caught but also those that had escaped capture.

Captive stock should be distributed amongst a number of breeding centres so as to eliminate the risk of disease or other catastrophe befalling the entire stock. Such a tragedy almost befell the Arabian oryx in Qatar, for an epidemic wiped out one-third of the herd, but fortunately two other herds were located elsewhere. In the spring of 1959, several Père David deer at Whipsnade became infected with 'malignant catarrh' and several died. Fortunately, at the time the herd at Whipsnade was divided into two enclosures, the original herd in one enclosure and the younger, more recent animals obtained from Woburn, in another. All the animals in the infected herd were destroyed to prevent the spread of the disease to other ruminants. Fortunately, the second herd escaped and the disease did not spread to any other deer at Whipsnade. Had this disease affected the Père David deer some seventy years earlier, when the only small herd in the world was located at Woburn, it is probable that this species would now be extinct.

A rare or endangered species should never to allowed to share an enclosure with domestic stock, for fear of being infected with diseases of the latter. In Great Britain there is no known case of a deer being infected, for instance, with foot and mouth disease, yet should cattle in a deer park be infected, the Ministry would immediately order the slaughter of all the cloven-footed animals in the area. Some years ago, therefore, I suggested that all the Bovidae in Woburn Park, which included the American bison and Chartley cattle, should be removed from the area used by the Père David deer, to reduce the risk of such a catastrophe ever happening, and this has been done.

Adverse comment about the ill-effects of in-breeding is, in my opinion, often exaggerated, and provided the area is well looked after and not overstocked, there should be no harmful effects. Overcrowding is one of the foremost causes of parasitic disease and should always be avoided unless artifical feeding on an extensive scale can be maintained. Indeed, deterioration in a herd is often blamed on in-breeding when the real cause is overcrowding on impoverished pasture. No living mammal could be more in-bred than the Père David deer, for the whole world stock is derived from the initial Woburn stock, yet it seems to have changed little over the years.

Although it is impossible to estimate, in cash terms, the true value of an endangered or threatened species, no one can question the fact that the rarer an animal becomes, the higher the price tag, and it is therefore preferable if, when rare animals change hands between zoos, the transaction can be completed on an exchange rather than cash basis. The majority of zoos, however, are run on a commercial basis – they are there to make money – and money can only come from the visiting public. A propos the value, therefore, of rare animals, it is not, unfortunately, just rarity that counts, but also exhibition value; the Giant Panda for instance, or a snow leopard is worth far more than a rare deer as the public in general are inclined to lump all deer together, and many just consider all large deer as Father Christmas's "Reindeer" and all small deer as "Bambis".

When a rare animal has to be purchased on a cash basis, it is, in practice,

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only the larger establishments that can afford to pay out large sums of money, and yet may be reluctant to do so far lack of public appeal. On the other hand, there are a number of true conservationists who could provide excellent breeding quarters for a rare species, but have not the financial backing to purchase a rare animal, and all the additional transport and quarantine costs, etc., generally involved, which could more than treble the cost.

As a case in point, although the cost of capturing some Calamian deer in the Philippines was just under £2,000, by the time these deer reached England and were finally received by the owner, quarantine, transport and other charges had more than trebled this figure. £6,000 can never be recouped from any additional public coming to see these deer, and indeed, the only financial return from transactions of this nature is when a proper herd has been fully established and it is then possible to sell or exchange surplus stock.

I am aware that any capture programmes for rare or endangered animals should be submitted to the Survival Service Commission for advice and approval, and that the SSC will, if required, endeavour to raise funds for the project. I have often wondered, however, if some of the more seriously endangered mammals of the world could not be owned in whole or in part by the IUCN or WWF, which would be responsible for paying the initial capture charges and perhaps make a grant towards the cost of transport, quarantine and other charges involved, so that a captive herd could be built up on an estate which need not necessarily be a zoological establishment with considerable financial backing. The animals would remain the property of the organization and any funds accruing from the paying public viewing the animals, or from the disposal of surplus stock, would in due course have to be paid back in whole or part.

Once a herd has become established and the carrying capacity of the holding ground is reached, it is always necessary to dispose of surplus animals, and whilst the younger animals can be sold to start fresh herds elsewhere, the only financial return for the older beasts which will probably have to be culled, is from the sale of venison. Transplanting live ruminants around the world in order to build up small viable herds can, as already mentioned, be very expensive, quite part from the risk of some misfortune occurring to the valuable traveller. Sperm banks of rare deer for artificial insemination should, therefore, be seriously considered.

In conclusion, I think we must all agree that the deer park or zoological collection, whether its function is to provide a refuge for a rare deer to breed unmolested so as to provide a 'bank' for some subsequent release into the wild, or for farming deer commercially, without having to slaughter indiscriminately the wild deer until its very existence becomes endangered, must have an important part to play in the future survival of the world's Cervidae. Preservation of their habitat is obviously very desirable, but in some cases habitats have already been destroyed beyond repair, and when the time comes to return captive bred animals to the wild, fresh habitats will often have to be found. Furthermore, for the purposes of such reintroduction, it is essential that the animals are 100% pure stock, for it only needs the involvement of one unscrupulous zoo in the chain of exchanged stock, to place in doubt the purity of perhaps a world population.

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PART 1: A DOSSIER ON THE PLANNING OF RESTORATION PROGRAMMES FOR THREATENED UNGULATES WITH SPECIAL REFERENCE TO DEER

3. COMPONENTS OF MANAGEMENT PROGRAMMES

Threatened Deer – Disease Implications, Field Work and Management

A. McDIARMID

ABSTRACT

Various disease affecting Cervidae are set forth in this paper, such as nutritional diseases, natural toxicological factors, viral, bacterial and protozoal diseases, Rickettsial infections, neoplastic disease, ectoparasites, endoparasites and their implications for threatened deer populations. Disease investigations in threatened deer field work and management are also discussed.

1. SOME OF THE MAJOR DISEASES AND PARASITES OF DEER

It has been said disease is merely a deviation from the normal but this can only be a very broad definition as there are so many variations of such deviations. Consequently it is almost impossible to draw a clearcut line between disease and normal health. From the practical point of view, anthing which prevents an animal leading a normal life, e.g. moving, eating, reproducing, etc., may be considered a disease. In recent years, much interest has been shown in the metabolic disease of farm animals. This is understandable, as these species are called upon to behave in a totally abnormal manner, e.g. a cow has to produce far more milk than it requires for feeding its own calf and sheep and pigs are often asked to produce more progeny in a season than hitherto. Fortunately, so far, deer have none of these difficulties to contend with, but nevertheless they do suffer from various nutritional disorders according to their habitats. Disease is, however, generally caused either by eco- or endo-parasites or by a host of microorganisms ranging from minute viruses to the larger bacterial, protozoa and fungi. It is remarkable how resistant deer appear to be to a very wide range of potential pathogens and the various metabolic disorders which can readily be produced in cattle by nutritional changes. In the latter instance, New Zealand red deer *Cervus elaphus* even if they are grazing a lush mixture of wild white clover and rye grass, do not appear to suffer from bloat, a condition which would undoubtedly occur in domestic cattle in the same environment unless suitable precautions were taken to prevent it. Likewise on the bacteriological side, red deer grazing a Scottish

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mountain do not appear to suffer from braxy, a disease caused by a clostridial organism, in the same way as the sheep in the vicinity.

Apart from a few notable exceptions the association between deer and their parasites appears to involve a great deal of tolerance between the infective agents and their hosts unless some other extraneous factors intervene, such as bad management, e.g. overstocking, poor nutrition or severe climatic conditions. Thus the disease agents are often present in apparently healthy deer and a breakdown in health occurs when the balance between the host and the parasite is upset. There are many other complicating factors such as the necessity, in some instances, for more than one micro-organism to be present to precipitate a clinical attack and often stress of one kind or another is involved. Some diseases such as Foot and Mouth Disease are clear cut entities and Koch's postulates can readily be fulfilled,* but other diseases are sometimes very complex and not at all easy to reproduce experimentally. Sometimes genetic factors are suspected of playing a part, such as in the case of enzootic ataxia in red deer *Cervus elaphus*. This disease which causes the animal to stagger and eventually lose control of its hindquarters, is associated with a depressed copper level in the body and bilateral demyelination of the spinal cord and is quite common in the United Kingdom. It is remarkable that cases have never been seen in freeliving wild deer, only in those confined in deer parks, where the master stags have every opportunity to mate with their own offspring. This example is given merely to illustrate the complexities of disease in deer and other animals and to emphasise the fact that it is brought about by a mixture of circumstances, many of which are very difficult to identify.

(a) Nutritional Diseases

The most common nutritional disease of deer is general food deficiency. This is especially true in circumstances such as exist in the Scottish Highlands. The report by Cheatum and Severinghaus (1950) demonstrated very clearly that the productivity of a deer herd depends on the availability of food under natural conditions. They examined deer on good and on poor ground and found the latter situation was associated with the production of fewer embryos. In fact they showed that 10 does on good quality food, produced as many fawns as 15 does on poor ground. Maybe the most striking example of this phenomenon concerns the Scottish red deer population where hinds frequently produce a calf in alternative years, although the same species in New Zealand can produce a viable calf per hind every year and sometimes even twins, a situation virtually unknown in Scotland. It is clear protein difficiency, due for example to overbrowsing, must be at least a contributing factor to poor reproductive performance in deer. Mortality, associated with malnutrition, can be continued with the subsequent fawn crop and, in herds which are very badly managed, this juvenile mortality can be very high, e.g. even 50 per cent. Quite apart from its direct effect, food deficiency can predispose the animals to many diseases and parasitic infestations which, under

* i.e. the disease in question can be readily reproduced experimentally in other animals and the causal agent can be recovered and identified from them.

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normal conditions, would probably not affect them clinically. Good management is therefore vital to prevent losses from disease which are normally subclinical. It must be stressed, however, that good feeding will not control losses from some of the more important highly contagious or infectious diseases, especially those of viral origin, such as Foot and Mouth Disease or Rinderpest.

Sometimes specific mineral deficiencies occur and imbalance of the calcium/phosphorus ratio can visibly affect antler growth, but generally these are not of much importance so far as actual mortality is concerned. Deer, in reasonable numbers, tend to have a far larger selection of browse in most areas than farm stock and hence do not show so much effect from the lack of specific local trace elements as do their domestic counterparts.

(b) Natural Toxicological Factors

Plant poisoning is very rare in deer apart from a few exceptional circumstances. Laurel has been incriminated from time to time. In England, laurel trimmings from a garden, thrown into a deer park and allowed to wilt were attractive enough to the fallow deer to be responsible for the sudden deaths of several of the best bucks. A similar situation could perhaps arise in an enclosure containing rare deer. Yew poisoning can also occur, particularly in a hard winter when browse is scarce or when the tree falls down; fallow deer in the New Forest, England, have died from this cause. On the whole, deer will not eat poisonous plants unless forced to do so. Isolated individual cases of mortality, caused by black nightshade and similar toxic plants, have also been reported in the U.S.A.

Chemical poisoning is uncommon, e.g. arsenic (Hayes *et al.*, 1957). Again, it was overgrazing of the habitat which forced the deer to eat cotton plants which had been previously dusted with arsenic. Other insecticides have sometimes been incriminated but these instances are rare and of little significance in practice. They should, however, be watched carefully for harmful effects in the future when their use might be increased. Fortunately, deer consume a very large variety of foods and not very much of any one substance at any one time; they often eat potentially poisonous plants when they are least toxic. Good herd management with adequate food for the number of animals involved, will always act as an effective insurance against possible poisoning.

VIRAL DISEASES

Foot and Mouth Disease - (F.M.D.).

Deer can become infected with F.M.D. under natural conditions and as long ago as 1924, there was a serious outbreak in the Stanislaus Forest in California. It was decided to try to control the outbreak by a slaughter policy and 22,000 deer were killed. Ten percent of these animals showed evidence of past or present clinical disease. Many different species of deer have since been shown to be affected, particularly in Germany, but on the whole, deer seem to have played little or no part in the general epidemiology of this condition. In the past, despite many outbreaks of the disease in farm livestock in the

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United Kingdom and despite the considerable number of different species of deer obviously at risk, no natural cases of this disease have ever been confirmed in deer. Subsequent to the last outbreak of F.M.D. some ten years ago, it was decided that the susceptibility of British deer should be determined by experimental infection.

Accordingly, samples of the various species were assembled and exposed to infection under controlled conditions at the Animal Virus Research Institute in the United Kingdom. The results were reported by Gibbs *et al.*, (1975) and showed quite clearly that all five species of deer found in the British countryside, namely, red, fallow, roe *Capreolus capreolus*, sika *Cervus nippon* and muntjac *Muntiacus reevesi* became infected. The clinical disease was severe in roe and muntjac and some animals actually died from the infection. The disease was less severe in sika and subclinical in red and fallow deer. Transmission from deer to their own species and to cattle was confirmed. The excretion of virus from the affected deer was similar to excretion in sheep and cattle. Some deer became persistent carriers, shedding virus for at least 28 days after infection. There can be no doubt therefore that a range of different species of deer are susceptible to a varying degree although, under normal field conditions in Britain, they appear to play no part in the general epidemiology of the disease.

Epizootic haemorrhagic disease (E.H.D.)

This acute, highly fatal, virus disease was first reported by Shope *et al.* (1955) in white-tailed deer *Odocoileus virginanus*, in New Jersey. It occurs in several other States as well in the U.S.A. Several distinct serotypes have been described. Mortality can sometimes be very high, e.g. 60% in the 1971 outbreak. After exposure to experimental infection with the virus, the animals exhibit a diphasic febrile reaction in about 3–5 days; – severe congestion of the visible mucous membranes and the eye is sometimes followed by bleeding. Death often ensues rather rapidly, within a day or two. On post mortem examination, there are visible and microscopic haemorrhages in virtually every tissue of the body and often considerable oedema. So far, there is no evidence of successful transmission to other species apart from deer. The deer themselves show considerable variation in susceptibility. The disease, may, in fact, have been present in the endemic areas for a considerable time and Shope *et al.* (1960) suggested that 'Black tongue' was in all probability E.H.D. The white-tailed deer seem particularly susceptible and details of experimental transmission to this species are available from the paper by Jones *et al.* (1977) who also pointed out that *Culicoides variipennis* was the vector of E.H.D. virus. Recently Gibbs *et al.*, (1977) pointed out the close similarity of this agent to Blue tongue virus and showed that E.H.D. virus injected experimentally into British red, fallow and roe deer, failed to produce any clinical disease, although viraemia occurred in all three species. They also showed that the maximum titres associated with the viraemia were higher in cattle, sheep and muntjac deer.

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Rinderpest

Although this has always been a very important viral infection of cattle and big game animals in Africa and the Middle and Far East, the disease has never reached North America. Outbreaks have occurred in several species of deer in zoological collections in Europe and in India and Gupta and Verma (1949), describing such an outbreak at the Calcutta zoo, suggested it might have originated from fodder brought from an area where cattle were already infected. The mortality rate in the deer was 61% but the virus was not isolated although the clinical signs were considered good enough presumptive evidence. Vaccination against this disease was eventually so successful that in some instances a false sense of security was created and this resulted in a pandemic across the Middle East from Afghanistan to the Mediterranean. Despite the severity of this outbreak, no species of wild life seemed to be implicated. This very serious outbreak was eventually halted by vaccination and stringent quarantine regulations.

All the natural hosts for this virus are in the Order Artiodactyla and the check list by Curasson (1932) has recently been updated by Scott (1976). There is great variation between the species in their reaction to the virus but this disease must be considered as one of the most serious potential infections of the cervids. Some recent experimental work by Hamby and others (1975) showed that white-tailed deer were very susceptible, death occurring in 5 to 6 days after exposure to the virus.

Blue Tongue (B.T.V.)

Although closely allied to E.H.D. this viral disease does not appear to cause much trouble in deer. Thomas and Prestwood (1976) showed that many white-tailed deer were positive to antibody tests for the virus but clinical disease does not apparently ensue subsequent to infections. More evidence is provided by Hoff and others (1974) and white tailed deer in Texas showed an antibody response of the order of 89%. The disease has also been experimentally transmitted to elk *Cervus Canadensis* (Murray and Trainer, 1970), showing that the animals were susceptible, antibody being detected in two weeks although clinical signs were mild.

In its natural hosts, B.T.V. does not appear to be of much consequence. The main problem is how the virus might react with a new, hitherto unknown cervine host.

Malignant Catarrh (M.C.F.)

This infection, due to a fragile virus, is obviously of considerable importance so far as deer are concerned. Originally it was reported in African buffaloes, which were considered to be the main reservoir hosts, but sheep are now considered to be of even greater significance, little or no clinical disease appearing in them although they are a potent source of virus. One of the most interesting outbreaks ever recorded in deer occurred in the Père David deer *E. davidianus* at Whipsnade Zoo in England (Huck *et al.*, 1961). The infection was readily transmitted to experimental red deer and one of the interesting features was the long incubation period of up to 48 days. The

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disease then had a sudden onset, the animals were very dull and had a mucopurulent discharge from the eyes and nose with considerable salivation. The source of the infection was never adequately explained. Quite recently another small outbreak occurred in Scotland in a small group of red deer which had been moved into a paddock recently vacated by sheep. Sanford *et al.*, (1977) described the condition in detail. The first U.S.A. report concerned Axis deer *Axis axis* followed by other reports in white-tailed deer and mule deer *O. hemionus*. Cases in sika were also recorded, in which the deer had been in close contact with sheep. It appears that this disease is of considerable significance, as a wide range of deer species appear to be susceptible and its prevention is rendered difficult by the presence of virus in symptomless carriers and hitherto unknown natural hosts.

Mucosal disease

Richards and others (1956) have given a good description of this disease in white-tailed deer and mule deer in North Dakota. Apparently it has been transmitted both ways using bacteria-free blood and tissue suspensions. The clinical signs are weakness, lack of sensitivity, dehydration and emaciation; the faeces contain stringy mucus and drops of blood. Post mortem examination reveals much the same picture as in cattle, viz. erosions and ulcerations of the alimentary tract, but deer do not show the encrustations on the muzzle and there are no erosions of the oral cavity. In many ways the clinical syndrome is similar to E.H.D. but differs mainly in the fact that it is readily transmitted to cattle. Nevertheless, there is still considerable confusion in differential diagnosis.

Vesicular Stomatitis (VSV)

Deer are susceptible to this disease and Karstad *et al.* (1956) reported a survey of natural cases. Subsequently, this virus produced cases experimentally in white-tailed deer. It appears that at least some species of deer are highly susceptible but usually only a mild disease results with rapid recovery. An insect vector may well be involved and infection may even be associated with entry of the virus at sites damaged by screw worms. Laboratory examinations are essential for differential diagnosis particularly from F.M.D. It is probable that deer constitute the main natural source of virus.

Rabies

Although deer of various species are liable to develop clinical rabies if they come into contact with the virus, they do not constitute a serious problem in nature. Outbreaks have been encounted in Park deer and the outbreak in Richmond Park in England in the last century is well documented; but on the whole the cases in deer are accidents and incidental to the usual perpetuation of the infection in nature. The disease is associated with excitement, antagonism, uncoordination, and eventual paralysis; on the whole cases are very rare although at least 7 different cervine species have been involved so far.

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Pseudorabies (Aujesky's Disease)
This is also a very rare disease in deer although of considerable importance to the individual animal. It has been reported in roe from Yugoslavia by Nikolitsch (1954), and from red deer in Germany by Bouvier and others 1958). The clinical signs consist of marked itching and hyperaesthesia.

BACTERIAL DISEASES

So far as deer are concerned, few diseases caused by bacteria, appear to be of much significance. Individual deer may develop a variety of superficial pyogenic conditions, involving the skin and occasionally the deeper tissues. Even the joints can be affected in rare instances, but most of these infections are associated with previous external damage, e.g. skin penetration from thorns and other sharp objects along the deer tracks in thick cover, and sometimes from injury by other deers' antlers. The bacteria merely invade the damaged tissue and give rise to abscesses. The corynebacteria are frequently responsible for this and staphylococci and streptococci are also sometimes involved. These are individual cases and do not constitute a herd problem. There are, however, a few bacterial diseases which are of considerable importance to deer.

Brucellosis
Although of little significance in most species of deer, brucellosis is of importance in caribou and reindeer *Rangifer sp*. The causal organism (*B. rangiferi*) is closely related to *B. suis* and can cause considerable clinical trouble, not only in the caribou and reindeer herds, but also in their attendants (Neiland *et al.*, 1968). Few reliable records exist in other species and in an extensive study of the situation in the United Kingdom at a time when there was plenty of infection in the cattle population, there was very little evidence of antibody in the blood of deer of various species and the organism has never been recovered from their foetuses or foetal membranes (McDiarmid & Matthews, 1974). This is surprising in view of the fact that the erythritol content of the deer's uterus, when compared to that of the cow, is sufficient to support the growth of this organism in that particular location (Roberts *et al.*, 1976). On the Continent of Europe several isolated cases have been recorded, particularly in roe, e.g. by Schiel (1936) and Preum (1936) in Germany. Cases have also been described in Switzerland by Burgisser (1954), but these are rare.

Tuberculosis
Very few cases of the bovine or human types of infection have ever been recorded in free living wild deer. Some have occurred in zoological and other parks, usually associated with a clear cut source of infection. Avian strains of various types can, however, often be isolated from apparently healthy deer and on occasions can cause clinical disease, particularly in red deer (McDiarmid, 1975).

A survey of the ileocaecal lymph nodes has revealed a high carriage rate in

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some species, e.g. roe deer in the United Kingdom (26 per cent) and it is interesting to note that the species producing the majority of clinical cases has only a 5 percent carriage rate. Confusion could have existed in the past when it was said that deer could develop paratuberculosis, a condition associated with another member of the mycobacterial group. It is more likely that these cases were due to aberrant forms of the avian bacillus, as no cases of paratuberculosis have been found in deer in recent years.

Leptospirosis

Cases of this disease are extremely rare in deer in the United Kingdom (Twigg *et al.*, 1973) but in some other countries it is considered to be important. Much of the investigational work has been done in the last 20 years, particularly in the U.S.A. where the interest of the research workers has centered mainly on the white-tailed deer. In Illinois, 10 percent carried antibody for *L. pomona* (Ferris *et al.*, 1961) and 16 percent were positive serologically to the same organism in Minnesota (Wedman and Driver, 1957). The infection cannot be detected clinically in unbred deer but can cause abortion in pregnant animals. Several isolations of *L. pomona* have now been made in the U.S.A. and Canada and other serotypes have occasionally been recovered. Much more evidence is required concerning the precise significance of leptospirosis in deer, but in the meantime its possible importance must not be under-estimated in various parts of the world.

Salmonellosis and clostridial infections

In an extensive investigation of Salmonellosis in the U.K., McDiarmid (1975) isolated one strain of *S. dublin* from a fallow deer in the New Forest. Deer appear to be extremely resistent to infection with Salmonellae and there are very few records elsewhere in the world. Clostridial infections are also virtually non-existent and this is surprising when one considers the opportunities deer have for contracting such diseases from domestic farm stock. Anthrax is the exception. In recent years it seems to have assumed greater importance and it has been pointed out that in the Etosha National Park in South Africa 54% of all the mortality in wildlife was caused by this disease. Most wild animals appear to have a considerable degree of resistance, deer being no exception, but this can readily be broken down by stresses of various kinds, such as overcrowding and degenerated habitats. In the past however, it is believed anthrax outbreaks killed vast numbers of deer in Europe, e.g. in 1874 in Prussia 2000 red deer and fallow deer are considered to have died from this disease (Wetzel and Rieck, 1966); these authors state that the disease still occurs in red, fallow, roe deer and elk in Europe, Anthrax has also been reported in deer in several States in the U.S.A.

The clinical signs of the disease vary considerably; it may cause death in 2 or 3 days or a more chronic infection ensues, but the main signs are similar to those in cattle, namely sudden death in the peracute type, with a frothy bloody discharge from the nostrils, and dark tarry-looking blood from the natural orifices in the less acute cases. It must be stressed, however, the disease can readily be confused with other conditions and it is essential that microscopic and bacteriological methods are employed for diagnosis.

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PROTOZOAL DISEASES

Various protozoal diseases are known to exist in deer of various species but their roles in the production of disease are still merely speculative in most instances. This applies particularly to diseases such as sarcosporidiosis which occurs in mule deer and elk and toxoplasmosis which has been described in numerous species. It has been suggested that the animals have to be stressed to provoke any clinical response to these agents. On the other hand, some diseases of protozoal origin are of significance more for their possible impact on farm livestock.

Piroplasmosis

The causal agent of red water fever is *Babesia bigemina*, the infection is tick-transmitted, and the symptoms are basically fever, anaemia and haemoglobinuria. White-tailed deer, particularly in the Panama region, and reindeer in the tundra of the far north, are commonly affected. Deer might well be a reservoir of this infection in the enzootic areas. It is, however, probable that these blood parasites could be host specific. Recently, in the U.K., it has been shown that roe deer and red deer carry Babesia. Transmission experiments in splenectomised bovine calves have so far failed, although the infection has been transmitted to susceptible red deer calves by experimental inoculation.

Anaplasmosis

This infection is now considered to be spread widely throughout the temperate zones as well as in the warmer areas. It can be transmitted by a wide range of insects from ticks to stable flies and mosquitoes. The affected animals can show pronounced anaemia without haemoglobinuria. In contrast to red water fever, infection has been transmitted from deer to cattle by experimental inoculation. Although deer in enzootic areas probably act as silent reservoirs of this infection and show no clinical signs, the possibility exists that other species of deer brought into such areas might become clinically affected.

RICKETTSIAL INFECTIONS

Q fever antibody has been demonstrated in white-tailed deer in the U.S.A. but no significant clinical disease has been reported. Likewise, tick borne fever (TBF) originally thought to be a rickettsial infection and now classified in the genus *Cytoecetes*, is common in all the main species of deer in the tick-infested areas in the U.K. without apparent clinical disease. The infection can readily be transmitted to cattle and sheep by experimental inoculation and it can cause abortion in these animals. It also plays an important part in the establishment of other disease such as Louping ill (meningoencephalomeningitis) and staphylococcal infection in lambs; introduced susceptible deer from a non-tick area might well exhibit similar symptoms on their first meeting with the T.B.F. agent.

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NEOPLASTIC DISEASE

Several varieties of tumours have been found in a wide range of deer species. They are of little significance so far as the herd is concerned, but they are of interest from the medical/veterinary angle. Lymphosarcoma is probably the most common; frequently it can be fatal in fallow and roe deer. Red deer in Scotland are affected with skin tumours of a fibrous nature, very similar to those described in the U.S.A. They appear to be species-specific and cattle cannot be infected by experimental inoculation.

ECTOPARASITES

On the whole, these are of little significance so far as mortality is concerned, except where the parasites are acting as vectors for an insect-born disease. In the United Kingdom the warble fly (*Hypoderma diana*) can play havoc with the skins of red deer, thereby greatly reducing their market value. Mortality can occur where the wounds from the emerging warble larvae are parasitized by other insects. Likewise, the nasal or bot fly (*Cephenemyia auribaris*) probably occurs throughout Britain but again it is the red deer in the North of Scotland which are mainly affected. Several species of *Cephenemyia* are involved with the black-tailed deer, mule deer and white-tailed deer in the U.S.A. and Canada; sometimes elk and moose are also affected. Deaths have been attributed to heavy infestations of these parasites. In the warm summer months the head fly (*Hydrotaea irritans*) can cause great distress and could be associated with the deers' diminished food intake at that time of year. Lice seem to be of little significance and the deer keds, apart from causing debility if they are present in large numbers, are not important parasites. The ticks however, are of importance, not so much for their own blood sucking activities but mainly because of the infections they transmit such as tick borne fever, louping ill and red water fever. These are all of considerable importance to farm livestock but the local deer do not appear to suffer any serious disease from any of them. It is interesting to note that in the U.S.A., prior to the screw worm fly eradication programme initiated in 1958/9 by the U.S. Department of Agriculture, 80% of the deer fawns in certain areas in Texas were killed by these parasites. Deer herds in Florida have increased by 60% since this parasite was controlled by releasing adult screw worm flies rendered sterile by exposure to radioactive cobalt in the pupal stage. The object of this exercise was to try to reduce the infection of wounds of farm stock with this parasite but, indirectly, deer and other wild life benefited greatly from this technique. There are many recorded instances where deer have become infected with these parasites when sharing their habitat with farm animals. Rare cases have occurred where the developing antlers of male deer, in the velvet stage, have been parasitised by flies and the larvae from their eggs have penetrated through the skull, causing death. Attempts at introducing deer to a new area have been thwarted by these parasites, which the deer collected from decaying seaweed. In one particular instance no male deer survived and the attempt at translocation had to be abandoned.

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ENDOPARASITES

With rare exceptions, much has yet to be discovered concerning helminths in deer. Many, especially those in the intestinal tract, are common to various species of deer and domestic animals. They are mostly *Trichostrongylus* spp. in the abomasum particularly *T. axei*; generally the worm burden is low in the small intestine. Under natural conditions, the helminths in the intestinal tract are of little importance with regard to disease but this situation can alter dramatically under bad conditions of management, e.g. too many animals in a confined space, or a badly run park. Two important helminths of deer, particularly in the United Kingdom, are *Fasciola hepatica*, the common liver-fluke, and a *Dictyocaulus* sp. of lungworm. Clinical disease is rarely encountered, unless management is bad, but roe deer appear particularly susceptible to both parasites, particularly the latter which is responsible for causing considerable mortality, often as much as 16% of the yearlings. Lungworm is undoubtedly the main factor concerned with the difficulty of keeping roe deer in small enclosures and this could well apply to more exotic species as well. Several species of deer appear resistant to these two infections. This is most noticeable in areas where sheep are present as well as red deer. Often there is high mortality in the sheep and yet the deer show low egg counts in their faeces and only slight fibrotic scarring in their livers (McDiarmid, 1975). Work in Canada has also confirmed that the white-tailed deer are extremely resistant to experimental infection with *Fasciola hepatica* (Presidente *et al.*, 1974). Liver fluke disease is virtually unknown in sika deer living under natural conditions in the United Kingdom. Roe deer will, however, often die from liver fluke, particularly in areas such as the West of Scotland, where it is the main controlling factor on the population. The disease in roe closely resembles the condition in sheep. Severe outbreaks of liver fluke disease have occurred in various species of park deer, where the management has been at fault. Often the situation can be remedied by fencing off the snail habitat, e.g. marshy ground. Another parasitic condition, prevalent in North American deer, affects the central nervous system. This neurological disease is often known as 'moose sickness'. It is basically a cerebrospinal nematodiasis caused by *Parelaphostrongylus tenuis*, which invades the cranial subdural space and cranial venous sinuses. The parasite's main host appear to be the white-tailed deer but moose and wapiti can be severely affected. The presence of the disease in moose seems to be associated with the spread of the white-tailed deer. Environmental changes in the last twenty years have in many instances, brought this species into close contact with other cervide such as the moose, the mule deer and woodland caribou to the north of its established range. It is interesting to note that severe disease has been caused in fallow deer and this must serve as a warning that more exotic deer could also be highly susceptible if brought into contact with it. Another serious parasitic disease, particularly of elk, which causes blindness, deformed ears and antler damage, as well as affecting the central nervous system, is caused by the filarial worm *Elaeophora schneideri*, often called the arterial or blood worm. It is widespread throughout the west and south west U.S.A.

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II. DISEASE AND THREATENED DEER

It is usually appreciated that the fewer animals in the herd the less risk of them contracting disease, but the important point, so far as deer are concerned, is that many diseases are transmitted from other species, including farm livestock such as cattle and sheep. The mixing of a group of threatened deer with other deer or farmstock directly, or even indirectly, in adjacent paddocks, is liable to produce a situation where certain infections could easily pass to the deer. We have good evidence that this has already happened with viral diseases, such as Foot and Mouth Disease, Malignant Catarrh and Rinderpest, and in some instances direct contact was not required, the virus being transmitted by imported feeding stuffs. Likewise, the burden of endoparasites which the threatened deer might have to bear, can readily be augmented by mixed grazing with cattle and/or sheep, particularly the latter; often this extra load of internal parasites is sufficient in conjunction with the deer's own specific parasites, to tip the balance between host and parasites and precipitate clinical disease. It seems probable on the present evidence, which admittedly is scanty, that the most important diseases to guard against are the viral infections, as some of these often produce a very high level of mortality and little can be done to alleviate the situation and save the animals. Of all the bacterial infections, probably anthrax is the most important as it can produce a rapidly fatal septicaemia and an accurate diagnosis can often come too late. Fortunately, with the wide range of antibiotics now available, bacterial infections such as this, can usually be dealt with if the animals are accessible for treatment in an enclosure. Preventive vaccination against anthrax has even been carried out successfully in a species of rare free-living antelope in an infected area in the Kruger National Park in South Africa; the vaccine was administered by dart guns from helicopters. This was obviously an extreme case, but it shows what can be done if all else fails.

The endoparasites generally produce a much slower type of clinical condition and are, in many instances, amenable to treatment with appropriate vermicides. Provided the range of habitat is large enough and overstocking is not practised, it is seldom such drastic action is needed. If poaching is prevalent in an area where there is a threatened species, it is likely that some animals will be wounded and may well die, not necessarily from the wounds inflicted by the poachers but also from the contamination of those wounds by screw worms and/or potentially pathogenic bacteria present on the skin of the animal itself or in the soil. Whereas this would be of little significance in a well established population, it could be of considerable importance where small numbers of threatened deer are concerned.

III. DISEASE INVESTIGATIONS IN THREATENED DEER - FIELD WORK

Under primitive conditions in the field it is always very difficult or even impossible, to determine the precise cause of death of any animal. It is difficult enough even in the Highlands of Scotland far more in the wilderness of South

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America or the forests or mountains of the Far East. Firstly, the animals have often been dead for some time prior to discovery and this often precludes any reasonable microscopic examination being done. Sometimes, however, the internal organs are still worth examining and this applies particularly to the endoparasites in the alimentary tract. Ectoparasites may also provide some clues, e.g. heavy tick infestation. The main point is to try to know the normal appearance of all the tissues and thus be able to identify any deviations, e.g. the lungs looking like liver tissue. Any nodules, particularly in the thorax or abdominal cavities, are always worth further investigation although probably only by fixation of the tissues and subsequent sectioning. Tuberculosis can often be detected in this way. Careful notes should be made of any evidence of haemorrhages in the different organs.

If the tissues are fresh and facilities for laboratory examination are not too far distant, then attempts at cultivating a possible causal agent may be made from the viscera or the heart blood. Probably the most useful material of all is a blood sample taken from the animal if still alive; even the clotted blood from the heart of a deer which has recently died can be useful. When the serum is recovered from such a sample, much can sometimes be discovered by various antibody tests for viruses and bacterial infections. Dried films, prepared from the animal's blood and fixed if possible, are sometimes useful so far as the blood-borne protozoa are concerned. Faecal pellets may reveal the presence of liver fluke eggs or those of other endoparasites. Urine, if fresh, may show the presence of leptospires if facilities for such examinations are close at hand.

Probably the best policy for any field biologist who wishes to study the health status of any rare deer species, is to contact the local veterinary services well in advance to find out the prevalence of certain diseases in the domesticated stock, if any, in the study area, and discuss the ways and means of handling samples from the deer for examination. A code of practice might then be established and whatever laboratory facilities are present in the area, might be put at the investigator's disposal. Very few diseases can be diagnosed, with certainty, by non-qualified personnel – often it is difficult enough for trained veterinary surgeons. Moreover, laboratory facilities are nearly always essential for differential diagnosis, particularly in many of the more important viral diseases, and to try to attempt to identify the cause of illness or death of a deer without them is virtually impossible.

IV. DEER MANAGEMENT AND DISEASE

From the foregoing, it will no doubt be appreciated that there are many close links between Management and disease. Little can be done under natural conditions where animals are free-living in an uncontrolled environment, but even there attempts can sometimes be made to improve the situation by encouraging the type of browse or herbage favoured by the deer and attempting to create an undisturbed habitat by controlling poaching activities. Tourism can often be as great a hazard as poaching from the disturbance point of view. When the deer are confined in an enclosed fenced

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park, much more can be done. Firstly, an adequate food supply must be maintained suitable for the species. The water supply must be reliable and free from contamination. If there is a marshy piece of ground where snails, the intermediate hosts for liver fluke, are present, this should be fenced off, drained or treated with a snail-killing agent. The most important point of all is to try to avoid a situation where the deer are sharing the grazing with farm livestock, particularly sheep. If it is practicable, some form of rotational grazing is a great advantage. Sometimes more than one species of deer can be accommodated in the same park, provided their health history is impeccable before introduction to the park. Adequate cover must always be available for parturition and shelter for the subsequent fawns; suitable fraying stocks for the males to clean their antlers on are always desirable. The actual stocking rate is very important and the correct sex and age ratios for the species must be assessed carefully so as to maintain the normal behaviour pattern within the herd. Any sick animals must be isolated at once and if veterinary help is at hand an attempt must be made to reach an accurate diagnosis and institute the correct treatment at a very early stage. At all times, stress must be avoided and if it is necessary to handle the deer suitable dart weapons and drugs should be available. These must not, however, be used indiscriminately as there is always a risk of individual idiosyncrosy and fatalities can result with certain species according to the drugs.

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PART II: A DOSSIER ON THE PLANNING OF RESTORATION PROGRAMMES FOR THREATENED UNGULATES WITH SPECIAL REFERENCE TO DEER

3. COMPONENTS OF MANAGEMENT PROGRAMMES

The Values of Deer and other Wildlife, both as Secure and Endangered Populations

G. PETRIDES

ABSTRACT

Hoofed mammals engender economic development through sport-hunting, game-viewing, meat-cropping, and advances in biological and medical knowledge.

The aesthetic pleasures derived from observing wildlife in natural settings are of unmeasured significance and nature tourism is one of the world's fastest-growing industries. Sport-hunting is a vast recreational outlet and a source of food of great importance, especially in developing societies around the world. Game ranching is a burgeoning activity in some nations and deer now are being raised commercially in the Orient, New Zealand, Papua New Guinea and perhaps elsewhere. Though no substitute for wildlife preservation, wild species as a source of domesticated stock offer potential values to mankind.

Large mammals are of significant value as indicators of environmental quality. They contribute heavily to medical progress and also provide evidence for biotic evolution, continental drift, and other scientific concepts of cultural and applied value.

INTRODUCTION

Man and his cultivated crops, domesticated livestock, industrial enterprises, and resource exploitations, are invading the world's remaining wild areas with increasing rapidity and ever-burgeoning intensity. Not only industrial pollution, but the mouths and hooves of livestock too numerous for their ranges to support are changing the world'd landscape even in the most remote regions. We know that environmental changes can induce increases in the numbers of some animal species. Yet other changes may cause certain species to become rare or extinct.

The aim of this paper is to review the uses of wildlife, both those species which have become common and those which are rare. Deer are mainly in mind, since the Cervidae are the particular object of this conference. Often,

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however, comments regarding other forms of life are made in the belief that certain principles illustrated thereby may be applicable nevertheless to deer. Reference should also be made to Whitehead (1972: 7–18).

Sport Hunting

The 1970 National Survey of Hunting and Fishing (U.S. Dept. Interior, 1970) determined that the several big-game species were pursued by 7,774,000 people throughout the United States. These hunters spent $122 per person in connection with big-game hunting, for a total of $952,563,000.

A comparison of these data with those for 1955 and 1960 (U.S. Dept. Interior, 1960) reveals that big-game hunters increased in numbers at an average rate of 3.8% per year over the 15-year period while the funds which they committed to this sport burgeoned at a mean rate of 7.5% annually. In 1970, big-game hunters averaged slightly more than seven days in the field.

While no national data seem to be available to enable the separation of deer hunting from the pursuit of other big-game, it seems likely that at least 70%–80% of the hunters and their expenditures were related to the sport-shooting of the several American deer species. There can be no doubt that deer-hunting in the USA, at least, is a sport which involves a great many people and is, in at least an economic sense, a large segment of the recreation industry. In addition, of course, there are social and esthetic benefits related to outdoor and nature appreciation which cannot be computed in quantitative terms. And while the data above apply to the United States, the social and other values derived from hunting elsewhere in the world may be of even greater significance in various local cultures.

The hunting of deer and other big-game offers economic and recreational benefits to industrialized societies in which opportunities to be close to nature are restricted. In modern developed societies, nevertheless, many people still are unable to appreciate the difference between unmanaged hunting and scientifically-controlled game harvests. Despite their exposure to food crops which are harvested regularly and yet remain abundant, there are wide-spread fears among such peoples that hunting will destroy or reduce wild animal populations.

Educational programs are badly needed to inform such publics that properly-regulated hunting tends to replace natural mortality rather than add to it. They require instruction to realize that where hunting is not excessive and where the habitat is otherwise favorable, dead animals are readily replaced by live ones.

Because the American public, at least, does not understand or accept such concepts, deer herds are insufficiently harvested and damage by various deer species to their overgrazed and overbrowsed ranges is widespread. In the U.S.A. this comprises a most-serious problem in deer conservation.

HARVEST OF WILD MEAT

Though wild animals are eaten everywhere, it has been noted especially in West Africa that many peoples are heavily dependent on wild animals for

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protein. In the rainforest and savanna districts of that region, tsetse flies carrying livestock diseases prevent commercial meat and milk production. Where hares, porcupines, monkeys, lemurs, pangolins, aardvarks, or various antelopes can be secured, these are taken. In Nigeria (Petrides, 1965) even the skins of small antelopes are eaten. In tsetse areas, people also avidly hunt and eat rats, mice, bats, snakes, lizards, insects, snails and other small animals (Petrides, 1965; Asibey, 1969, 1974).

It has been determined for African areas that in Ghana up to 73 percent of locally produced meat is wild (Asibey, 1974), in Nigeria up to 85 percent of the meat diet is of wild origin (Petrides, 1965). In Senegal (Cremoux, 1963) and Ivory Coast (Roure, 1963) often more than half of the meat eaten is from the bush, and in Botswana (von Richter, 1969) 60 percent of such meat in the diet is general. With low fat content, the protein percentage in wild meats is generally high. Yet despite these great protein values, as Asibey (1974) reports, "to this day, nothing has been done seriously to ensure proper management" of this resource.

In primitive societies, there has often been a centuries-long dependence on animals for food combined with a great uncertainty whether food animals could be located when needed or whether capture methods would be successful. The tendency to kill when the opportunity arises must become almost instinctive in such peoples. When modern weapons become available to individuals reared in such cultures, excessive slaughters are likely to occur despite the biological need to maintain game herds. Where wild meats are important in the diet of the local people, therefore, it is essential that controls be established to prevent depletion of these resources.

In much of the world, deer are not looked upon as sources of meat so much as they are valued for their sporting qualities. The prevalence of illegal deer hunting in parts of the United States and elsewhere, however, indicates that even there the many deer species have great importance as food. The increased prices often charged by hotels and caterers when game dinners are served is further evidence of the high status in which venison often is held.

WILDLIFE TOURISM

It is unfortunate that separate data are not available to reveal the extent to which tourism, both local and international, is based on nature and wildlife. Dr. A. Faymann, a United Nations tourism economist from Austria, stated (*Kabul Times*, Afghanistan, 28 November 1972) that international tourism is the "fastest-growing economic sector of the world". He pointed out that international tourist arrivals increased from 29 million in 1950 to 190 million in 1970, with a forecast of 280 million by 1980.

International tourism is a most significant source of foreign currency earnings for many nations. Tourism generates important income transfers from richer to poorer countries. It also promotes employment within nations and the sale of handicrafts and national products.

Tourism has become the foremost foreign-currency earner in several nations. Often wildlife is the primary tourist attraction. The tourist industry

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in Kenya, for example, is its most important foreign-exchange earner. And tourism in East Africa is based largely on wildlife spectacles. Game-viewing had become vastly more significant than hunting as a basis for tourism, even before Kenya's recent total ban on shooting. In addition to international travel, local tourism too is most important. This is not only from an economic viewpoint but also with regard to maintaining local public interest in nature preservation.

Deer are absent from Africa except for remnant herds of Barbary red deer (*Cervus elaphus barbarus*) near the Mediterranean Sea. And almost everywhere in the world, deer form only one component of the local fauna. Yet their attraction is considerable. It is a rare tourist automobile in Scandinavia that does not display souvenir reindeer (*Rangifer tarandus*) antlers on the roof or a skin in the rear window. The roe deer (*C. caproelus*), fallow deer (*D. dama*) and red deer (*Cervus elaphus*) of Europe, the chital (*A. axis*), barking deer (*Muntiacus muntjak*) and sambar (*Cervus unicolor*) of southeast Asia, sika deer (*Cervus nippon*) of Japan, the brockets (*Mazama*) and other deer of Latin America, and the mule deer (*Odocoileus hemionus*) and elk (*Cervus canadensis*) of Yellowstone, all give the visitor a thrill when they are seen. The contribution that deer make the world tourism has not been measured but it is real indeed.

Hunting is important even to the non-hunting tourist. The aura of danger and adventure which surrounds the trophy hunter adds excitement also to camera safaris. Were sport-hunting to cease everywhere, the loss would be felt not only by the non-hunter and average tourist but also by tour operators and governments whose incomes benefit from tourism. Sport-hunters have long been the principal direct financial support of conservation policies and their indirect support must now also be acknowledged and maintained.

Tourism is important in providing funds and incentive for the preservation of wild species and natural areas. Where truly-threatened ungulates populations are involved, however, it may be critical to species survival that discipline among visitors be strictly enforced. Only small and carefully controlled groups may be allowed in some areas.

GAME RANCHING

The management and commercial harvest of large wild animals living freely on either fenced or unfenced lands constitutes what has been termed game ranching. Often this activity is concerned with species introduced into foreign lands, such as the water buffalo (*B. bubalis*) in northern Australia (*State Journal*, Lansing, MI., USA 6/5/60) and the red deer in New Zealand (Wodzicky, 1950). Native animals, however, also may be game-ranched. Commercial harvests of kangaroos and other marsupials have been widespread in Australia (Frith, 1968), saiga antelopes (*Saiga tatarica*) are cropped regularly in the USSR by professional hunters (Bannikov *et al.*, 1961), and ranching of local ungulates has been undertaken in several nations in southern and eastern Africa. Bison (*Bison bison*) are being commercially managed for

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meat and hides on some ranches in western Canada, utilizing only native grasslands (Geist, pers. comm.).

The superior abilities of many wild ungulates to resist diseases, to utilize coarse forage plants, to withstand abnormal droughts, and to reproduce and gain weight readily even under harsh conditions, have been reviewed by many investigators (Petrides, 1956; Dasmann & Mossman, 1960; Darling, 1960; Bannikov, 1962; French, 1965; Maloiy, 1965; Talbot, 1966; Talbot *et al.*, 1965; Taylor, 1968; Child, 1970; Nasimovich, 1970).

Talbot (1966) stated that on one ranch in Rhodesia the yield from game was "greater than that of cattle on the same land". Riney (1963) also reported on the generally higher productivity of springbok and blesbok on cattle ranches in South Africa. While a case can be made in favor of the superior qualities and benefits of wild animals over traditional livestock, it would be good if additional and more-precise comparative data could be accumulated. Experiments actually to test the superiority of presently-wild species have begun in a few places (Blankenship & Qvortrup, 1974) but have not been undertaken in satisfactory numbers. Perhaps, as of this moment, only the hypothesis should be stated that on at least some wild rangelands certain wild ungulates can offer superior productivity and economic return.

Telfer and Scoter (1975) in their appraisal of the possibilities for game ranching in Canadian aspen forests include moose, elk and deer as having the potential for producing meat under climatic and forage conditions which are unsuitable for livestock. Commercial ranching operations involving free-ranging rusa deer (*Cervus timorensis*) have recently begun in Papua New Guinea, where each carcass sells for US $250 (Eric Balson, pers. comm.).

DOMESTICATION

While the ranching of wild ungulates is still largely of potential worth, the domestication and husbandry of eland (*Taurotragus oryx*), blesbok (*Damaliscus dorcus*), springbok (*Antidorcas marsupialis*), Thomson's gazelle (*Gazella thomsoni*) and other African antelopes is being actively and successfully pursued in southern, central and eastern Africa (Dasmann & Mossman, 1960; Petrides *et al.*, 1970). The African eland has been domesticated since 1892 in the USSR (Bannikov *et al.*, 1961) and is regularly milked. The banteng (*Bos banteng*) has long been domesticated in Indonesia.

Within the Cervidae, reindeer have been domesticated for centuries in Eurasia and have been translocated into the North American arctic. Moose (*A. alces*) have been tamed in Siberia as draft and dairy animals (Knorre, 1961). Following earlier successes in taming chital (Lung, 1975), attempts are being made in the People's Republic of China (Anon., 1975) to farm the musk deer (*Moschus moschiferus*) for the production of musk for the medical and perfume trades. In addition chital, sika and fallow deer have become at least semi-domesticated as ornamental species in deer parks. Pére David's deer (*Elaphurus davidianus*) survives only in captive herds (Whitehead, 1972).

There seems to be no reason why any of the ungulates, including all deer species, cannot be domesticated. In view of world protein needs, it may be

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important to investigate possible benefits therefrom. As an example, Choompol Ngampongsai (1977) is finding in Thailand that the sambar uses new growth of the coarse field-invading lalang grass (*Imperata cylindrica*) as a preferred forage and attains excellent productivity on this dietary item. It may well be better on such areas, under either game-ranching or domesticated conditions, to graze sambar on fallow fields or burned areas rather than beef cattle on improved pastures.

While species domestication offers new resources to mankind, it is important to recognize that captive populations tend to lose inherited wild characteristics and survival abilities. A tame animal is not the same as its wild counterpart. Domestication and other forms of captivity are in no way a substitute for wildlife preservation.

HUMAN MEDICINE

Wildlife is of immense value in the control of human diseases. Increasing use is being made of wild animals in medical research and in the treatment of human diseases.

The public and scientific press has reported numerous cases in which wild fauna have proved of outstanding worth in human medicine. In the last decade alone, venom from Chinese snakes has been used to trace nerve impulses in the human brain, rhesus monkeys have enabled tests of intrauterine birth control devices, chimpanzees have been used to study the intensity and duration of pituitary and other hormonal interactions, the owl monkey has "become a vital model for the study of human malaria" (Southwick, Siddiqi & Siddiqi, 1970), marmosets injected with a herpes virus from squirrel monkeys have yielded viral tumors adapted for study, and the first control of a (Herpes) virus infection has been achieved through the use of chemicals found in a marine sponge. In the medical treatment of humans, baboons have tested artificial heart valves. Blood vessels of kidney-disease victims also have been linked with those of baboons to enable blood purification without endangering human volunteers.

In mainland China, deer antlers, while in velvet and growing, have long been used in the preparation of traditional medicines. Recently (Lung, 1975), a liquid medicine from this source has been marketed commercially under the name pantocrine. There were news reports, some years ago, of deer antlers being used in connection with studies of bone development in humans.

Geist (pers. comm.) believes that experiences in natural situations and in seeing animals as they live in the wild not only have educational and inspirational benefits for participants but also induce physical effects, which include increased body weight and brain development. Enhanced environmental quality, he believes, constitutes preventive medicine. Elsewhere in these proceedings (pp. 388–391), Povilitis also reviews the great importance of the esthetic values of deer and other wildlife.

ENVIRONMENTAL EVALUATION

The abundance of wild species or their absence from certain habitats enables bio-assays to be made of environmental conditions as these may change through time, affecting the welfare of human communities. In Lebanon, for

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example, the original Cedar-of-Lebanon forest of the region survives mainly as a tiny 5- to 10-hectare sample growing behind the stone walls surrounding a Maronite Church. There it may be seen growing and reproducing freely. Except for this site, centered in farmlands in the northern part of the country, however, the countryside has been almost totally stripped of these and other trees. If it were not for this presumably-unplanned enclosure (perhaps on holy ground), it would be logical to conclude that the climate had changed drastically during the five thousand or so years since Biblical references indicate that Solomon built ships of these trees. The serious environmental degradation by fuel-hungry people and browsing goats would likely have been overlooked as a cause of the desertification process. While vegetation may be a more frequent indicator of environmental health than animal life, the occurrence of relict animal species and communities is frequently used as evidence that environmental conditions now limited to a few locations once were more widespread.

Deer seem often to be used unconsciously as an indicator of environmental values. When deer are seen either by local people or by travellers, there is an invariably pleasurable reaction implying that all is right with the world at that time and place. The rarity of huemals, barasingha and brow-antlered deer as discussed elsewhere in these proceedings indicates that all is *not* well with some environments in Chile, Nepal and India, respectively.

PURE SCIENCE AND CULTURAL DEVELOPMENT

Matters of pure science are also important to mankind. The theory of evolution has been of vital significance in the breeding of domestic crops and herds. The concept of continental drift, too, may well be critical in planning for mineral exploitation and the disposal of radioactive materials. Though deer may not have been involved, the distribution pattern of plants and animals have provided evidence for both organic evolution and the movement of tectonic plates.

Where local endemic or relict species occur, they are in particular danger of depletion or extinction because of low numbers, local concentrations, and isolation. Yet these forms, including some cervids, eventually may well provide further clues to events in evolution and earth history. They may also have inherited genetic qualities of value not only in a cultural sense but also in the breeding of protein-productive livestock or medically-important laboratory animals.

As symbols, wild species are also important in human affars. Christmas without reindeer is unthinkable, at least in northern nations. Political parties often adopt mammals as symbols. The bison on American and the caribou on Canadian coins, stamps and flags, are examples of ungulate symbols which contribute to the solidarity and survival of human societies.

RARE AND ENDANGERED SPECIES

Because so many of the benefits from wildlife have become evident only in recent years and along lines previously unsuspected, it is vital to human welfare that deer and other ungulates be managed to insure their preservation.

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Basically, wildlife preservation is achieved through habitat preservation. And habitat preservation insures that the species continues to interact with environmental forces in a natural way. The full values of a species can never be recovered once it becomes extinct.

SOME CONCLUSIONS

1. Sport-hunting is an important economic benefit and continues to expand but at a slower rate than formerly, at least in the USA. Wild meats are still an important, and often vital, protein resource in developing parts of the world. The importance of managing these resources for sustained maximum yields, however, is everywhere largely overlooked.

2. Investigations of the potentials of wild mammals as superior meat-producers have been insufficiently investigated. There is clear evidence that both the ranching of wild game and the domestication of presently-wild species holds promise as a resource-development procedure in some regions. Despite the values of these measures, however, it must be understood that captive animals are not wild ones. Domestication is distinct from and does not achieve wildlife preservation.

3. Game-viewing and wildlife tourism is of considerable cultural and economic significance and is growing world-wide at an ever-increasing rate. For some nations, international tourism is a major source of foreign-currency earnings. Tourists could cause disturbance to threatened species and, while a rare occurrence, visitor impacts must be monitored and controlled. Because of the economic incentive, however, tourism tends to preserve wildlife, including endangered deer.

4. The values of wild mammals in the development of new approaches to human medicine are great and have scarcely begun to be explored. Their uses as agents in the biological assay of deteriorating environments similarly is most important, yet needs additional study. Their contributions to scientific theory and human cultural development continue to accumulate.

5. That wildlife and endangered-species preservation depends mainly on habitat management should become well-understood not only by hunters but also by wildlife-viewers, land managers, resource economists and government administrators.

6. The preservation of deer and other wild mammals, it is evident, is of great economic, recreational, medical, environmental, scientific, and cultural value to mankind. These values are not yet fully realized but, in an overall sense, they must be large indeed. It is essential that all endangered species be maintained as natural populations so that their total values may be ascertained and so that human benefits can be drivered in full.

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PART II: A DOSSIER ON THE PLANNING OF RESTORATION PROGRAMMES FOR THREATENED UNGULATES WITH SPECIAL REFERENCE TO DEER

3. COMPONENTS OF MANAGEMENT PROGRAMMES

The Aesthetic Value of Wildlife, with Special Reference to Threatened Forms

A. POVILITIS

ABSTRACT

Although wildlife is widely appreciated and protected for its beauty, its aesthetic value receives little formal attention and assessment. While an analytical approach to the subject is beyond the scope of this paper, certain aesthetic qualities of wildlife are illustrated as they act upon the senses, emotions and intellect of people.

* * * *

Wildlife is enjoyed for its beauty by recreationists, tourists and other persons engaged in a wide variety of outdoor activities. Its appreciation is recorded the world over in motion pictures, song, art, folklore and literature. As a consequence, the aesthetic value of wildlife offers a sound reason for wildlife conservation. Indeed, the natural beauty that wildlife generates undoubtedly provides much of the impetus for conservation programs, particularly those that involve threatened forms. Nevertheless, in spite of its importance, the aesthetic enjoyment of wildlife is often greatly overshadowed by other wildlife values that are based on conventional concepts of use *sensu stricto*. The reason probably lies in the fact that aesthetic appreciation is difficult to appraise even in qualitative terms. It is therefore desirable to briefly illustrate how wildlife appeals aesthetically to the senses, emotions and intellect of people.

The world "aesthetics" is derived from the Greek αἰσθητικά meaning "things perceptible". At its simplest level, wildlife aesthetics involves sheer perceptual enjoyment in viewing, hearing and, in some cases, touching and smelling. For example, Walt Whitman (Eastman, 1970) relates the manner in which the eagle integrates form, motion and sound so as to provide perceptual appeal:

"Skirting the river road,
Skyward in air a sudden muffled sound, the dalliance of eagles
The rushing amorous contact high in space together
The clinching interlocking claws, a living, fierce, gyrating wheel,
Four beating wings, two beaks, a swirling mass tight grappling,

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> In tumbling turning clustering loops, straight downward falling,
> Till o'er the river pois'd, the twain yet one, a moment's lull,
> A motionless still balance in the air, then parting, talon's loosing,
> Upward again on slow-firm pinions slanting, their separate diverse flight,
> She hers, he his, pursuing."

Most persons seeing such an event would, without doubt, find it as pleasing as it is remarkable. While Whitman's description confirms the artistic value of poetry, it is the intrinsic physical beauty of the eagle that concerns us here. Long ago Marcus Aurelius (Gilbert and Kuhn, 1954) felt similiarly that anyone of sensibility "will look on the actual gaping jaws of wild beasts with no less pleasure than the representations of them by limners and modellers".

In art, as well as at zoos and small enclosures, one's enjoyment of wildlife is limited to objects, representations or abstractions that are detached from the natural world. In contrast, wildlife form, motion and sound in nature exist within unique environs of interacting natural elements – both living and inanimate. For any particular wildlife observation, the quality of the background is highly correlated with its aesthetic value. This can be seen, for instance, during Thoreau's (1910) interaction with a loon at Walden Pond:

> "Though the sky was by this time overcast, the pond was so smooth that I could see where he broke the surface when I did not hear him. His white breast, the stillness of the air, and the smoothness of the water were all against him. At length having come up fifty rods off, he uttered one of those prolonged howls, as if calling the god of loons to aid him, and immediately there came a wind from the east and rippled the surface, and filled the whole air with a misty rain. . ."

It is evident that Thoreau was involved not only with the loon, but with the physical aspects of its habitat as well. Elsewhere, Thoreau refers more directly to the notion of contextual import:

> "Some, seeing and admiring the neat figure of the hawk sailing two or three hundred feet above their heads, wish to get nearer and hold it in their hands, perchance not realizing that they can see it best at this distance, better now, perhaps, than ever they will again".

Beyond mere perception, the aesthetic enjoyment of wildlife often involves dramatic modifications of a person's emotional state. When the director of Chile's Department of Conservation first viewed the rare and threatened Chilean huemul, a pair of Andean condors appeared overhead as if to highlight the event for him. The moment's excitement led him to exclaim: "How spectacular! I am so privileged to become one of the few Chileans who has seen this part of our national patrimony. . . This has been without doubt the outstanding moment of my career with the Department of Conservation". Similarly, near Mt. Escudilla, Aldo Leopold (1949) relates the story of how Arizona's last grizzly bear perpetuated an aura of danger and awe for local cowboys. Once the grizzly was gone, so were the emotions it stirred, and so

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was a special value that the mountain once held. Wordsworth (Krutch, 1950) sums up nature's great potential for exalting the mind and spirit: "To me the meanest flower that blows can give thoughts that do often lie too deep for tears".

From these examples it is clear that wild forms have aesthetic value beyond their mere physical qualities. I have already alluded to the inspirational value of wildlife in art. By stimulating creative thought, the aesthetics of wildlife is also of great consequence to scientific and educational development. Wildlife form, motion and sound are not generated randomly; they have special function, meaning and evolutionary significance for an animal. For example, in being of sensory and artistic interest, a buck's branching antlers, migrating wildebeest over the Serengeti, and a wolf's call in the arctic night call attention to broad natural patterns and concepts.

In a symbolic way, wildlife represents human hopes, feelings and sentiments. A good example of an animal with symbolic value is the threatened Chilean huemul which stands on Chile's national coat of arms. The following excerpt from my field notes, recorded during an investigation of the deer, illustrates the animal's significance:

> "During a rainstorm we took refuge at a small and modest ranch house. We sat together with the *campesino* and his wife around their kitchen's open fireplace. At one point we began talking about how some wildlife species could produce wool and hide, and even serve as a source of protein. Then the *campesino* flatly declared that the rare huemul was, in any case, the most valuable of all. I sat with my ears cocked pretending not to be aroused by his statement as I gazed into the crackling fire. The man paused briefly and continued: 'The huemul is the most valuable because it is the symbol of our land; it was born of the place we call Chile'."

Almost a half century ago, Chile's museum director (Gigoux, 1929) also eloquently expressed concern for his nation's living symbol:

> "We plead that the gracious deer of our forests and precious representative of our poor fauna does not vanish: that in the end it is not left an extinct species immobilized forever on the coat of arms; that we can also see it alive running in its mountains. . ."

In addition to serving as cultural symbols, wildlife has played an important role in many religious, spiritual and philosophical beliefs. In the past, for example, wildlife forms ranked as spirits and gods in Nazca and Zuni New World cultures (Zerries, 1968; Spencer, 1965). Today, the idea of wildlife as part of a unified natural order has aesthetic as well as spiritual and philosophical appeal. It is not the rare individual who feels that wild animals and plants have a right to exist irrespective of concepts of use and value. There is satisfaction in knowing that one co-inhabits the world with other living forms – that there is living structure, function, and process apart from our own. Alexander Pope (Krutch, 1950) offers an alternative to the anthropocentric view:

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"Know nature's children all divide her care;
the fur that warms a monarch, warm'd a bear.
While man exclaims, 'See all things for my use'
'See man for mine!' replies a pamper'd goose:
And just as short of reason he must fall
Who thinks all made for one, not one for all"

In summary the aesthetic appreciation of wildlife is evident at sensual, emotional and intellectual levels. Indeed, such appreciation pervades so much of what we see, do and think about wildlife, that it is too often taken for granted and overlooked. It is important to prevent this from happening; successful wildlife conservation may, in the last analysis, depend on a better human understanding of how wild forms contribute to an enriched and enjoyable life. Of the many values we derive from wildlife, beauty is perhaps the most fundamental and meaningful of all.

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PART II: A DOSSIER ON THE PLANNING OF RESTORATION PROGRAMMES FOR THREATENED UNGULATES WITH SPECIAL REFERENCE TO DEER

3. COMPONENTS OF MANAGEMENT PROGRAMMES

Promotion of National Conservation Measures and Support for the Restoration of Threatened Species of Mammals

C. W. HOLLOWAY

ABSTRACT

Total populations of at least half of the species and subspecies of world threatened mammals may still be declining in spite of legal protection and the inclusion of many of these species in protected areas. The immediate cause of the problem is inadequate enforcement of protection and underlying causes are considered to be deficiencies in existing institutional arrangements and public apathy. Comprehensive solutions to these problems could require decades to take effect, and the paper reviews and discusses interim measures to encourage and support national conservation initiatives under institutional and field approaches, with special reference to encouraging local cooperation and involvement in conservation schemes.

INTRODUCTION

The Problem

1. The major causes of species extinction are overexploitation of populations and modification of their environment. The former has posed particular problems for the large species of vertebrates and vascular plants, which often have a readily realizable value to man, either for immediate subsistence or trade. It has sometimes taken the form of deliberate extermination, especially of some mammalian families, because they are regarded as inimical to human interests as a result of their depredations on livestock and croplands or because they act as disease vectors. The commonest form of modification of a species' environment is the destruction or degradation of its habitat through cultivation, stock grazing, forest exploitation or burning. It may take the form of introduction of exotic animals and plants that compete with indigenous species for food and living space, or involve more subtle interference with populations, such as continued human disturbance of wild ungulates in their traditional rutting and calving grounds.

2. The conventional means of combating these problems are to provide legal protection for the species against killing, capture or harassment and to

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conserve selected populations of the species and their habitat in protected areas. Provided protection is enforced and the remaining populations are not so low and their habitats not so degraded as to render their natural regeneration impossible, this combination of protection systems should rarely, if ever, fail.

3. An analysis of population trends compared with the protected status of mammals that are threatened with extinction throughout their world range, however, shows that although nearly 90% of these taxa have complete or partial protection by law and over 50% of them occur in one or more protected areas, at least half of the total populations of these species and subspecies are still considered to be decreasing (Table 1). A more detailed examination of these data demonstrates no marked improvement in population trends with increased protection effort, as measured by categories of protection that the species have been granted (Table 2).

4. Considerable caution is required in interpreting the results of analyses as simple as these, which take no account of a great variety of mitigating influences on the conservation of individual species. A significant proportion of these animals are known to have been protected only within the past decade, enforcement of wildlife laws and management of protected areas has had to be organized and it is probably too early to expect widespread improvement in wildlife populations. Furthermore, the data in Tables 1 and 2 refer to *total* populations, but approximately 15% of those species whose total populations are decreasing, frequently as a result of loss of habitat to land development, are considered to be adequately protected in reserves and safeguarded against extinction. In spite of these considerations, the inescapable conclusion from these analyses is that conventional protection in many parts of the world is failing to conserve species because it is not being adequately enforced. Alternatively, it might be said that the protective measures taken, to date, are not sufficiently realistic or adapted to local conditions. There are countless case histories in the Red Data Book, in other literature and on the IUCN and WWF files to confirm this view.

5. Wildlife and natural area management have been recognized as accepted forms of land-use relatively recently, and it is not generally realized that only about 20% of national administrations in the world (including both developed and developing countries) have separate departments to deal with each or, in some cases, both of these subjects. Elsewhere, wildlife and national parks are the concern of long established services, principally Forest Departments, which may have sections or sub-departments with special responsibility for these matters. In these circumstances, the protection of wildlife over vast areas of forest or marginal areas is effectively in the hands of territorial forest staff, who often lack not only technical training in wildlife management but also any real feeling of responsibility for this peripheral concern to what is seen as their main duties.

6. Public attitudes towards conservation vary very considerably but, especially in developing countries, urban populations' attitudes are often indifferent and rural people's attitudes can range from incomprehension to hostility, if wildlife and natural area conservation has caused them to lose a

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Table 1. *World Threatened Species and Subspecies of Mammals* Total Population Trands in relation to Animals' Protected Status*
(numbers of species and subspecies and percentages of totals)

Has Legal Protection			Occurs in Protected Area		Population Trend			
Yes	Partial	No	Yes	No	Increasing	Decreasing	Stable	Unknown
188	68	31	168	119	24	134	34	95
65.5%	23.7%	10.8%	58.5%	41.5%	8.4%	46.7%	11.8%	33.1%

Table 2: *World Threatened Species and Subspecies of Mammals* Population Trends in relation to category of Animals' Protected Status†*

	No. of Species and subspecies	Population Trend (percentage of totals)			
		Increasing	Decreasing	Stable	Unknown
Legal protection and protected area	166	8.4	50.6	18.1	22.9
Legal protection, no protected area	89	12.4	36.0	2.2	49.4
Protected area but no legal protection	2	0.0	50.0	0.0	50.0
No legal protection or protected area	29	0.0	51.7	3.5	44.8

* from IUCN Red Data Book, Vol. 1 Mammalia, revised to 1977
† numbers of species and subspecies and percentage of totals

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source of meat, hides, fuelwood and fodder for their stock, without compensation.

The Solutions

7. Comprehensive solutions to these problems require long-term education and public awareness campaigns, supported by necessary research, for mobilizing public opinion, prompting government allocation of manpower and resources sufficient for the tasks, and fostering a conservation ethic among a broad sector of the community that will actively support natural resource conservation. Unfortunately, the time taken to effect such changes in public attitudes may be measured in decades rather than years, by which time many threatened species will probably be extinct.

8. Although comprehensive solutions should remain the goal, there is clearly a need for interim measures that are designed to encourage and support national conservation initiatives and to improve public attitudes and local willingness to cooperate in conservation schemes, especially in areas of special significance to threatened species and biotic community preservation. This topic forms the subject of the present paper. Its first section reviews institutional approaches to furthering these aims and is directed principally at the field worker who may be presently unaware of these programmes and the publications and facilities that they provide, or who may have the opportunity to promote local involvement in them. The second section discusses practical approaches and opportunities for increasing the effectiveness of conservation measures and encouraging local involvement, with examples of methods and techniques that have been employed in certain countries and which may have wider application. Most of the examples are taken from developing countries. The paper does not consider formal education and training.

INSTITUTIONAL APPROACHES

International Conventions

9. International conventions on conservation impose obligations in contracting nations to meet agreed standards for the study, protection and management of designated species or natural areas. They support national initiatives by providing for cooperation in these fields between nations (including meetings of contracting parties), they may provide for international monitoring of conservation effort and, in some cases, provide sources of funds for survey, research and management operations. Many of these conventions were originally prepared and developed by international conservation agencies, who frequently provide the bureau for their administration. There are numerous international conventions on conservation and it is not proposed to list them all but merely to refer to some examples.

10. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (Washington, 1973) provides for severe restriction on the export and import of endangered species and their products and for monitoring of trade in depleted species, (IUCN, 1973). Insofar as a relatively small

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number of developed nations provide the principal world markets for certain threatened species products, and control of illicit trade is infinitely easier in the customs shed than in the jungle, this Convention is expected to provide a strong measure of support for national conservation efforts.

A provision of the Convention requires each party to establish, within its governmental structure, a Scientific and a Management Authority, both of which have statutory power to monitor the national status of species and to recommend steps for their protection. A draft international convention on the conservation of migratory species of wild fauna is presently under consideration. Its aim is to standardize conservation measures for species that move across international boundaries and are, therefore, subject to differing standards of protection and control (Navid, 1976). The final draft will be considered by a plenipotentiary conference in 1979. Other international conventions or agreements on the conservation of threatened species exist (e.g. the polar bear) but the range of animals covered is relatively restricted.

11. The African Convention for the Conservation of Nature and Natural Resources (Algiers, 1968) covers not only conservation of species but also of soil and water, and makes provision for promoting research, conservation education, organization of conservation services, and consideration of ecological factors in development plans (Burhenne, 1969). Standards of protection are specified for two categories of designated species (endangered and depleted), which are listed in appendices. Another conservation convention for a specific region is the Convention for the South Pacific (Apia, 1976), which is designed to promote the creation of reserves and the protection of indigenous fauna and flora (IUCN, 1976a). The oldest convention of this type is the Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere (Washington, 1940).

12. The Convention concerning the Protection of the World Cultural and Natural Heritage (Paris, 1972) was launched under the auspices of UNESCO and covers the protection of monuments, buildings and natural features and sites (which can include biological formations) of "outstanding universal value". It has a committee to administer the convention and a trust fund from which to meet requests for international assistance (UNESCO, 1972). The International Convention on Wetlands of International Importance especially as Wildfowl Habitat (Ramsar, 1971) requires contracting States to designate suitable wetland areas for inclusion in an international list. The parties must conserve these areas, encourage research in them and the international exchange of data, and provide for training of research and management personnel (Carp, 1972). Other draft international conventions under consideration on the conservation of natural biotic communities cover islands and tropical rain forests.

International Programmes, Strategies and Guidelines for Conservation

13. The four international agencies primarily concerned with the conservation of wild species and natural areas are the United Nations Environment Programme (UNEP, Nairobi), the Food and Agricultural Organization of the United Nations (FAO, Rome), the United Nations Educational, Scientific

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and Cultural Organization (UNESCO, Paris) and, a non-governmental body, the International Union for Conservation of Nature and Natural Resources (IUCN, Morges). These four organizations have formed an Ecosystem Conservation Group to coordinate their conservation operations.

14. UNEP was established to implement the plan for concerted international action on major environment concerns and long-term objectives that was formulated by the UN Conference on the Human Environment, in Stockholm, 1972, and to co-ordinate environmental activity among UN agencies. It sponsors a wide variety of wildlife inventories and status reports on ecosystem conservation, through contracting agencies, and operates a number of global projects, such as the Earthwatch Programme that monitors environmental quality, including the state of biotic communities.

15. FAO is concerned, among numerous other topics, with the rational utilization of wild animal resources including the conservation of natural areas. It operates a considerable number of field projects on these and related topics in various countries, many of which have been funded under the United Nations Development Programme (UNDP). Its Regional Forestry Commissions cover the conservation of terrestrial fauna. It has provided technical staff and aid to establish wildlife training schools in Africa (Mweka and Garuoa) and the formation of similar schools in Asia and Latin America is under consideration. It also has training programmes for senior wildlife personnel through fellowships,

16. UNESCO collects and disseminates scientific information on terrestrial and aquatic ecology. It has a special interest in education. It is responsible for the Man and the Biosphere (MAB) Programme, which is an integrated approach, involving research, training and conservation, to the relationship between man and his environment. Several of the fourteen major research projects in the Programme are of concern to the preservation of wild fauna and flora. Project 8 covers the conservation of natural areas and the genetic material that they contain and has provided the basis for the plan to create a network of protected research areas, or biosphere reserves (see also para. 42 below).

17. IUCN has six Commissions, for survival of species (which has a series of specialist groups to advise it), protection of natural areas, ecology, environmental policy, law and administration, environmental planning, and environmental education. Its Environmental Law Centre, at Bonn, can provide advice on a wide range of environmental concerns and the Centre's statutory library contains over 20,000 relevant laws, regulations and conventions from more than 130 jurisdictions. It is the largest of its kind in the world. Major programmes in which IUCN is presently involved and that are of relevance to encouraging and supporting national conservation initiatives include (a) the preparation of a World Conservation Strategy document, which will identify measures to further conservation of ecosystems and species, assess their priority and feasibility and indicate the means of implementation (including the national or international operating agency); (b) regional surveys of ecosystems and species to identify additional areas for reservation to provide comprehensive protection for all major ecosystems and biotic communities;

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and (c) initiation of a scheme for the preparation of national conservation plans, to cover species and natural area conservation and related forms of land use, law, education, institutions and environmental planning (plans, in broad outline, exist or are in preparation for Indonesia and Pakistan, and a detailed plan is presently being prepared for Thailand).

18. A fifth international organization that is much involved in conservation of species is the World Wildlife Fund (WWF, Morges), which is concerned primarily with fund-raising and public awareness and which operates through twenty-six national appeals. Since its formation in 1961, it has contributed a very substantial funding for the study and management of threatened species, the establishment of national parks and equivalent reserves, training of field staff, and conservation education. It has also contributed funds to several large conservation programmes, notably *Operation Tiger*, Tropical Rain Forest Conservation, and the Marine Programme.

19. All of these organizations have published literature that can serve to guide wildlife and natural area policies and management in many countries of the world. FAO's field project reports on these subjects probably cover the widest range. It has recently begun a series of handbooks on practical conservation techniques, commencing with national park planning and extension work (FAO), 1976a; 1976b). UNESCO's MAB "green book" series identifies research needs in a variety of natural resource fields and provides current details of national projects on these subjects. IUCN has published a number of reference books that, in addition, set criteria and standards for threatened species and national parks. They include the Red Data Book volumes of world threatened species, the UN List of National Parks (IUCN, 1975a), and more detailed descriptions for selected countries in the World Directory of National Parks (IUCN, 1975b). It has produced an ecological guideline series to guide planning and management practices in a range of different ecosystems (IUCN 1975c; IUCN 1975d; IUCN 1976b; Odum 1976; Poore, 1976); further guidelines are in preparation for high mountains and deserts. The WWF Yearbooks provide summary details of all field and other conservation projects supported during the previous year.

20. International conservation effort is by no means confined to these five organizations. Most of the major regions of the world have multinational or intergovernmental bodies (e.g. Council of Europe, Organization of African Unity, Organization of American States, South Pacific Commission) which have coordinating roles and, very often, active conservation components in their programmes.

National Institutions

21. Governments with separate departments that are specifically responsible for the conservation of species and natural areas are still in the minority and, in most countries, these subjects are administered by sections of larger natural resource departments, such as forestry, agriculture or land development. Inevitably, such an arrangement can lead to conservation being treated as the "Cinderella" of natural resource management and one of the principal conservation needs at the present time is for governments to raise the status of these

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sections and to provide them with adequate staff, training and funds to enable them to execute their responsibilities effectively. It is essential to maintain the support and cooperation of the parent department during the transition. The FAO Forestry Department has an internal directory of natural resource departments concerned with wildlife and natural area conservation. It covers only national administrations, although forestry and wildlife in some countries are, in fact, provincial concerns.

22. Universities, natural history museums and zoological gardens in developing countries are a source of researchers or of counterparts for overseas researchers in field studies, if government agencies are unable to provide a suitable officer. All of these institutions normally publish their own research bulletins and scientific magazines that may contain a wealth of local ecological data that are not readily available outside the country. Unfortunately, shortage of funds has often forced biological science departments of universities to concentrate on museum and laboratory work rather than field studies. Natural history museums tend to have at least one or two field biologist-collectors, who may be extremely knowledgeable about fauna and flora in relatively isolated areas of the country.

23. Nature Conservation Societies and National Trusts have also been responsible for producing very useful literature on their countries' natural history and have often served as activists in prompting government attention to conservation issues. WWF National Appeals come under this head and, among their public awareness and education campaigns, several are developing youth organizations based on the highly successful Wildlife Clubs of Kenya Association (WCK). The Association was founded in 1968 and its aim is to spread interest and knowledge about wildlife and the need for conservation. It has a Council on which private organizations and governments are represented, a headquarters staff of six, and a membership, in 1977, of 20,000 students in 483 clubs from secondary schools and colleges throughout the country. It provides newsletters, bulletins, booklets and other magazines, has a weekly radio programme and a series of field courses. Visits to national parks are organized and members have raised funds to purchase camping equipment and binoculars for this purpose. The Association has a mobile film unit that visits 60 schools each term and a mobile library. Student members have organized peaceful demonstrations and petitions to the government on illegal hunting (Anon., 1977; Price, 1975).

Similar clubs exist or are being developed in Cameroun, Uganda, Zambia and India. In Zambia, the Chongololo programme is directed principally at primary schools and has 1,300 registered clubs, half of which are in rural areas (Tanner, 1977).

24. National Scout Associations occur in 110 countries and have a membership of approximately 16 million. Since 1973, a cooperative programme between the World Scout Bureau and WWF has introduced conservation training into the Scout Movement. A proficiency badge in conservation has been established (24,000 badges were issued in 1976), conservation pamphlets have been translated into numerous languages, community development and conservation seminars have been organized and several professional training

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courses have been conducted. An African Conservation Seminar was held in 1976 (Hines, 1977).

25. Even in the absence of conservation oriented institutions, groups of local naturalists can exercise influence on government policies by letters to the press and other forms of local pressure. A handful of local naturalists in Mauritius provided crucial practical aid in emergency conservation measures for the critically endangered Mauritius kestrel (*Falco punctatus*) and pink pigeon (*Nesoenas mayeri*) by providing temporary aviary space for captive breeding (Temple, 1975).

26. IUCN has some 270 organizational members that represent over 100 countries. The vast majority of this membership is non-governmental (i.e. universities, museums, societies) and just over 50 of them occur in developing countries. Details of these organizations can be provided to visiting researchers on approved projects in these countries and would be to the mutual benefit of both sides.

FIELD APPROACHES AND OPPORTUNITIES

National Parks and Sanctuaries

27. Ecological data are required on a wide range of threatened species to guide management aims and effective practices. Field work on threatened species in national parks and other protected areas can provide the field researcher, whether a national of the country concerned or from overseas, with unparalleled opportunities to influence existing management. This statement presupposes that the field worker can establish and maintain a good working relationship with the field staff and that they, in turn, are willing to cooperate. Initially, his influence may be exercised most effectively by example rather than overt instruction or advice. If staff members accompany him on field work and, together, they visit all parts of the reserve, follow animals at all hours and inquire into all matters that affect the species' populations, then adequate field training will be provided for the staff and mutual confidence between them and the researcher will be established. Communication with field staff can obviously be greatly facilitated for an overseas researcher by the presence of a good counterpart.

28. Effort should be made to provide for a continuing scientific presence in the Park when the researcher leaves. If there is no local counterpart to continue, then arrangements should be made, if possible, to involve a local university or other government research establishment in research visits before the field worker's departure. The ideal arrangement would be to establish a research unit in the vicinity but failing this, the construction of accommodation for visiting government survey officers, museum biologists or silviculturists may serve as a step in this direction.

29. If, at the other extreme, park management is seriously hampered by the lack of equipment, a vehicle or guard accommodation, then an application from the field project should be submitted to WWF, which can sometimes provide grants at short notice for modest requests of this type from emergency funds.

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30. If relations between the researcher and the Park Warden are good, then they should cooperate in the preparation of realistic management proposals for the area. Initially, proposals may be confined to management plan components, such as precise patrolling plans for guards (Esser, 1975), but should lead ultimately to the preparation of a full Park management plan. Special attention will usually be required to protection of the Park perimeter and establishment, where feasible, of buffer zones, to arrangements for liaison with other Departments in the management of surrounding areas (see para. 35), and the encouragement of local appreciation of the Park.

31. The latter subjects obviously pose special problems (see paras. 33–41). There is relatively little that can be done within the Park itself to reconcile surrounding villages to the loss of former privileges that the Park's creation may have caused, other than to provide some of them with employment as guards, trackers, and boundary and road maintenance workers, insofar as funds and management requirements allow. Some misunderstandings and problems that arise with local people over Park management operations might be avoided by the establishment of liaison committees of local village representatives and Park authorities to investigate real or imaginary grievences and genuine cases of hardhsip.

32. On the broader issues of national park appreciation, it is obviously not sufficient to state that local visitors and, especially, school parties will be encouraged; the facilities to receive and instruct them must be established. Either camps or dormitory accommodation should be built for supervised school parties and, in some cases, transport may need to be provided. In Zambia, "wildlife schools" for visiting parties of students have been established in Kafue and Luangwa National Parks. The Indian Project Tiger Reserves and several other national parks have had good results from bringing youth groups into the reserves for several week periods for general education purposes and to employ them in data collection and the construction of nature trails.

33. Many universities in developing countries have student organizations for environmental conservation (Thailand, alone, has nearly 50 societies of this type) and there is considerable scope for involving young people with these interests in the study and conservation of nature reserves as a voluntary service. The USSR has a Nature Guard organization, founded in 1861 and composed mainly of university students in biology, which assists permanent reserve staff in anti-poaching operations, research and public relations (Zabelin, 1977).

34. Field researchers, especially from overseas, are frequently called upon to discuss the Park, its resources and management with politicians and senior officials who are visiting the region. It seems to be common practice, throughout the world, for local dignitaries to attach greater importance to the views expressed by foreigners than those of their own officers, even when these views are the same! Under such circumstances, it is essential that the full range of existing and potential values of the area to the people of the region are stressed and that discussion is not confined to the scientific value of one or more threatened species. Removal of the government sheep that have

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plagued Dachigam Sanctuary, in Kashmir, for fiteen years may be accomplished not because the Sanctuary contains the world's last viable population of hangul (*Cervus elaphus hanglu*), but because the sheep are degrading the city of Srinagar's water supply (F. Kurt, 1977, pers. comm.).

Rural Conservation Education (Park buffer zones, forests and marginal lands)

35. If human attitudes and practices in the vicinity of a critically endangered species' habitat are posing a threat to the animals' survival, then the human occupants of such areas should be one of the principal targets for conservation education or other methods designed to improve the situation.

36. WWF has a special project to promote conservation education in developing countries that has included the design of slide and tape communication kits and a mobile unit fitted with generator projection equipment and public address system (Boulton, 1976), basically for use in rural areas. Some countries, such as Indonesia and Thailand, have already concentrated the use of similar mobile education units in villages that surround national parks and equivalent reserves. Whilst a carefully conceived programme of this type can lead to a better understanding of the long-term objectives of conservation, it obviously provides no practical compensation to villagers who have lost a source of food or income because of the establishment of the park.

37. Good land use planning should require that national parks are not created in isolation but are established with full recognition of their effect on surrounding areas. Their long-term ecological effects on adjacent areas are undoubtedly good, but their short-term sociological effects can be quite the opposite. It was recognition of this situation that prompted the Project Tiger Appraisal Mission to recommend consideration of rural development schemes for villages adjacent to Tiger Reserves, to include dairy marketing schemes (using improved breeds of stall-fed cattle to eliminate dependence on illicit grazing), soil conservation and improved cultivation (including shelter belts and village woodlots) and the organization of small dispersed industries, at safe distances from the Reserves, to absorb surplus labour from agricultural areas (Holloway *et al.*, 1976). It was pointed out that the alternative might be continued and mounting human pressure on the Reserves and increasing costs of anti-poaching and other restrictive operations.

38. One way in which local people might benefit directly from protected areas or wildlife management schemes, and thereby have an incentive to support protection efforts, is through regulated hunting of wildlife in the buffer zones of national parks or in selected areas of forest or marginal land where wildlife restoration schemes are in operation. Even if retention of total protection were essential for threatened species, other more numerous species might sustain a harvest. The main difficulty is that wildlife in these areas is frequently already seriously depleted, total protection would probably be required to restore populations, even partially, the initial culls would need to be restricted and the establishment of such schemes and their supervision could prove to be even more costly and difficult than total protection.

39. Considerable interest has been aroused in ecodevelopment (which is

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defined as development of the locality, taking the fullest sustainable advantage of that locality's physical, biological and cultural resources) and the contribution that it could make to nature conservation. It may involve traditional hunting methods within an area that were probably effective until they broke down with the introduction of firearms or the expansion of human populations. Studies of traditional hunting methods would certainly merit inclusion in threatened species research programmes. If a modified form of supervised traditional hunting could be employed in selected conservation areas that was acceptable to local people and wildlife managers, the latter might find themselves in the happy position of having local people regulating wildlife populations and effectively protecting the animals against poachers in their own interests.

40. In West Africa, the economic incentives to overharvest "bushmeat" (which covers a wide range of vertebrate and invertebrate species) are eroding traditional systems of harvest control, but the traditions certainly still exist and could be revised and modified to provide higher sustained yields (Asibey, 1977). In many other regions, traditional hunting methods have probably long disappeared or are quite unsuitable for re-instatement and new systems would need to be developed.

41. One such approach that has been employed successfully in Tanzania stems from the *ujamaa* system. Villages or groups of villages are allotted hunting units of land and one man is appointed in each group to hunt for the group as a whole. The supervision of one man's kill is no difficult task, the cull is limited and the villagers throughout the group guard against the intrusion of hunters from other areas (J. Kundaeli, 1977, pers. comm.).

42. Modification of the existing structure of reserves or the adoption of new concepts of conservation units may also contribute to better conservation, through greater flexibility of management including provision for controlled human use of wild fauna and flora. An example of the former was the recommendation to create totally protected micro-cores, of some 10–20 km^2, in unmerchantable blocks of forest in the buffer zone of a Tiger Reserve in India. Reserves presently consist of one central totally protected core and a larger surrounding buffer zone. It was argued that the system would provide sanctuaries from disturbance (each of which could be policed by one guard), but would still enable forestry, wildlife viewing and, ultimately, cropping to occur in surrounding areas (Holloway *et al.*, 1976). An example of new concepts in conservation units is the adoption by the SSC/IUCN Elephant Group of "elephant ranges", which are extremely large tracts, principally of forest and scrub that cover the full seasonal range of key elephant populations and in which culling of elephant would be permitted, provided it did not fragment herds or prevent seasonal migration and that habitat condition indicated that control was necessary (SSC/IUCN Elephant Group, 1977). The biosphere reserve concept was developed for the study and conservation of both natural and semi-natural ecosystems, including those maintained by long-established land use practice, and require research on controlled utilization in their buffer zones.

43. For very seriously depeleted species, however, there is no alternative

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to good protection to ensure early recuperation of populations – a view which is confirmed by case histories of success in the rehabilitation of formerly threatened species. Thus, the continuing conservation of the saiga (*Saiga tartarica*) has certainly depended on highly organized cropping schemes with monitoring of populations, but its original restoration was apparently achieved by rigid protection during a period when political conditions facilitated such an approach (Bannikov, 1969; Linnard, 1963).

Urban Conservation Education

44. Whilst of less immediate relevance to practical wildlife conservation, the long-term importance of urban conservation education is immense, for these are the areas of high human populations (and voters), where letters to the press are debated, students demonstrate, and politicians presumably check the pulse of the electorate.

45. Communication through newspapers, radio and TV is much easier than in rural areas and, although urban dwellers are usually far removed from nature, perhaps it is partly the appreciation of this loss that often prompts them to comprehend and to accept the conservation concept more rapidly and enthusiastically than rural populations.

46. Although scientists engaged in field projects may lack easy access to cities, they do have an obligation to contribute to public discussion on conservation topics on which they are knowledgeable. The ecologist who worked on threatened raptors in Mauritius wrote a weekly newspaper series on local conservation, which created considerable interest and the entire eighteen month series was eventually reprinted as a nature guide for schools (Temple, 1975).

47. The conservation interest and concern generated by a feeling of national responsibility for a threatened species was first recognized by the Survival Service Commission which, in 1967, instituted an *ultimate responsibility* scheme for selected species, under which governments undertook long-term responsibility for their survival. The success of conservation efforts to conserve the vicuna (*Vicugna vicugna*) and the tiger (*Panthera tigris*) may be due in no small measure to their adoption or re-adoption by certain countries as their national animals (Anon., 1975). The human community that possesses a rare animal species may regard the situation as a cause for prestige and responsibility. A conservation project for the waldrapp (*Geronticus eremita*) at Birecik, in Turkey, which is its last breeding place in Eurasia, revived the former festivities that accompanied the annual arrival of the birds and attracted many visitors from surrounding regions (Hirsch, 1975).

48. Large scale conservation education programmes in developing countries are still relatively few. The WWF sponsored conservation education programme in Indonesia has prepared audio-visual slide programmes, educational and propaganda literature, and has established visitor centres in certain nature reserves (Frey, 1976; 1977). The project is being developed in conjunction with the government and most of the project personnel are Indonesian. It is not known, however, to what degree basically Western approaches to conservation education are appropriate to other regions of the world. There would

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appear to be a strong case for more basic research into these matters before programmes are launched, or to adopt flexible, experimental programmes that are carefully monitored and can be modified in the light of needs and good results identified as the project develops. An integrated conservation education programme with monitoring of this type is being exployed in the Gambia (M. Boulton, 1977, pers. comm.).

49. In conclusion, a special target for conservation education in towns is the hunting clubs or societies that exist in many countries for wildlife trophy hunters. If their support and cooperation can be obtained, they can often provide useful information on wildlife distribution and population trends. Most of the original wildlife distribution maps in Turkey were compiled from responses to questionnaires from hunting clubs. They are the sector of the population that know and visit the principal wildlife areas of the country and, if they are convinced of the need for conservation, they can encourage support for the concept in these areas and provide sources of information.

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PART II: A DOSSIER ON THE PLANNING OF RESTORATION PROGRAMMES FOR THREATENED UNGULATES WITH SPECIAL REFERENCE TO DEER

3. COMPONENTS OF MANAGEMENT PROGRAMMES

Threatened Species Conservation *vis-à-vis* Community Welfare in Developing Countries

H. S. PANWAR

ABSTRACT

Scarce resources committed to basic development and diverse community demands upon forests render it difficult for developing countries to assign desired priority to conservation. This situation ordains formulation of well conceived conservation projects for threatened species, which provide alternatives for the community uses curtailed by dovetailing such projects with ongoing community development programmes.

The species' last strongholds, selected after a joint survey by an experienced scientist and the personnel earmarked for implementing the project, should be brought under intensive reamelioratory management and compensatory development, by a well equipped field sut-up. Detailed etho-ecological investigations should proceed simultaneously to find crucial requirements of the species for improving management. Community conservation-education programmes should be introduced to elicit cooperation for durable success.

INTRODUCTION

1.1 Developing countries are often in a social stress that derives from tight financial resources, on the one hand, and pressures from a huge and burgeoning population stagnating at sub-normal living standards on the other. Chronic progressive shortages of arable land and pasture dominate the scene at the rural community level. In result therefore, afloat on expediency, the mode of land-use drifts irrationally with a helpless emphasis on the expansive pattern, not infrequently regardless of the functional suitability of the land in question or of the potential hazard of its fragility.

1.2 Such a situation, in spite of governmental awareness and a strong motivation from conscious citizens, militates against the intensification and acceleration of the conservation effort. This is not to say that there is no scope for any significant conservation effort, but rather to emphasize that long term success of such efforts cannot be ensured unless the projects are carefully planned on a realistic appreciation of this 'environmental resistance',

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providing for minimum alternatives in lieu of the restrictions which such a programme would inevitably impose upon the essential community uses. Whereas rigid enforcement will be a must in the initial stages, a simultaneous concerted attempt must be made by social education to promote rational land use and awareness for nature conservation, in particular seeking involvement of the local people in the national and global responsibility for the preservation of a threatened species.

GENESIS & MODE OF OPERATION OF HUMAN CONSTRAINTS

2.1 Retarded infrastructural development, over prolonged periods in the preceding times in which the populations continued to soar, is responsible for the current social and economic deficiencies. Moreover because of the totalitarian controls by which the conservation effort was sustained in the colonial-feudal past, together with the fact that there existed little general educational base for the understanding of the values of conservation, such restrictions could not be readily replaced by popular self discipline in the post-independence era.

2.2 The human constraints that operate against conservation in such a situation can broadly be traced to the following three sources:-

(i) Use of resource by the rural communities
(ii) Use of resource by urban populations
(iii) Organised development and resource-utilisation activities run or sponsored by the government.

2.3 Use by rural communities:
Agriculture in rural settlements is, as a rule, the main sustenance of the bulk of the population, with cattle keeping as the main concurrent industry. Often most conservation areas are situated in interior forests which are subject to the traditional uses of the tribal populations inhabiting the tract. The uses and their implications for conservation are briefly discussed below.

2.3.1 Settlements and Grazing:
Village pastures and marginal lands in the forests have been progressively brought under the plough, depriving the cattle and also the wild herbivores of their grazing grounds. Nonetheless, the cattle populations have continued to grow in step with the human populations. The resultant onward thrust of the cattle into interior forest areas has further impoverished the overall grazing potential, through direct fall in the productivity and the proliferation of unpalatable weeds, causing particular jeopardy to wildlife. Grazing during the rainy season moreover does not allow the grass to grow, thereby degenerating the cover conditions essential for many wild species. In tropical deciduous forests, the stray perennial pools are the only sustaining source of water during the prolonged dry season. Cultivation of marginal lands and overgrazing from cattle camps situated in interior hilly forests have induced land erosion resulting in silting up of many stream beds, and the consequent disappearance of such rare perennial pools. Similarly the interior settlements or

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cattle-camps occur alongside the still surviving perennial water holes, depriving wild animals of their traditional use of them. Thus besides the direct disturbance inevitable from such intensive interior use, this factor spells adversity for wildlife with respect to all the essential ingredients, viz. food, water and the crucial shelter.

2.3.2 Collection of daily needs and occurrence of fires

Villagers are traditionally used to entering the forests at different seasons for the collection of leaves, flowers, fruits, mushrooms, honey, fibres, firewood, small timber, bamboo, shed antlers and the like. Some of these collections are for sale to supplement their living, but most of them are for their own use. These collections for domestic use are permitted in most forests as concessions, and are sometimes organized by the forestry departments if the produce is commercial. Disturbance through such movements apart, the greatest harm resulting from them in deciduous tropical forests are the recurrent fires started either inadvertently or deliberately to clear the forest floor in order to ease the collections. Fires are also sometimes started as offerings to deities under tribal beliefs. These sweeping ground fires destroy all green and dry fodder in the browsing level and thus, in conjunction with water scarcity, introduce a pronounced pinch period in summer.

2.3.4 Hunting, poaching and fishing:

Under tribal traditions hunting may be done individually, in small groups or in large community congregations. In the community hunts people often set a forest area on fire from all but one escape direction, and then shoot the escaping animals by bows and arrows or by muzzle-loading fire-arms. This is a terrible practice which not only results in mass killing irrespective of sex and age, but also destroys temporarily all fodder and cover besides setting in regressive trends in vegetation. When entering into forests individually or in small groups hunters or poachers may operate by setting traps and snares or by bows and arrows and fire-arms. Not until lately was traditional tribal hunting recognized as a concession, but one that has mostly been discarded now. Surreptitious poaching both by large community groups and small groups is also on the decline but is still to be reckoned with. Villagers also kill animals when the latter invade their crops. Most of such kills are for meat but predators may be killed by poisoning of partly eaten cattle kills, in order to avenge the loss and to reduce the future incidence of cattle lifting by carnivores. Collection of the meat of a partly eaten carcass of an animal killed by a predator is also not uncommon. Fishing, in addition to angling and netting, may be carried out by draining or poisoning of pools. Again, uncontrolled fires are a byproduct of such activities.

2.4 Urban use:

In the countries that have recognized the poor status of their wildlife and the threat that it faces, licensed hunting is now largely restricted. The urban pressure on wildlife resource is thus limited to the disturbance potential from tourism and aberrantly to poaching by the white collar worker. Both

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aspects, however, lend themselves to control by enforcement if the Government is determined.

2.5 Organized development or resource-utilization activities:
These include farming, irrigation and power, mining or other industrial projects. Also coming within this category are forestry operations involving both exploitation and plantations. These are essential activities from the national standpoint but adjustments are clearly possible to accommodate conservation programmes, in general, and threatened species programmes, in particular, if these are well conceived with respect to their relative importance in the overall perspective.

2.6. Experience has shown that adverse consequences of urban use and development projects can be minimized to within tolerance limits by addressing an appeal to the governmental awareness that grows with every successful implementation of a conservation programme.

2.7 It is further evident that adverse effects on conservation resulting from community use are due to abuse, overuse and aberrant practices that harm the resource, to the people's own disadvantage, by lowering the productivity of fodder and of all other produce, besides inducing overall environmental degeneration by way of land erosion and a depleted water-regime. The snag for the redressal of this adversity, however, lies in the paucity of economic resources needed for providing immediate alternatives in the shape of rational and intensive rather than expedient and expansive land-use, and emphasis on quality rather than numbers of cattle, so as to wean the people from the present depletary practices.

APPROACHES TO RESTORATION PROGRAMMES

3.1 Fortunately this aspect of quality-intensive oriented improvements in land-use forms an important segment of the community-development programmes in all the developing countries. In predominently agro-rural populations that as a rule comprise the bulk in the developing countries, unless this aspect is taken care of, the welfare of the people on a long term basis cannot be secured. Needless to say improvements in this sector will *ipso facto* help conservation, but it is equally true that paucity of resources will ordain this to be a relatively slow process. Such a slow pace may not be adequate to ensure the survival of a threatened species for which efforts are required almost on an emergency basis. It is here that the national and the international conservation organizations are called upon to exercise their persuasive faculties in order to inspire the governments to assign a high priority to selected conservation areas and their vicinities, both in the field of community welfare and in that of nature conservation. It can be stated from experience that although the beginning may appear humble, the pace and the coverage of the later strides may surprise even those planning and executing the programme.

3.2 In the light of the foregoing a plausible programme for the restoration of a threatened species may follow, *mutatis mutandis*, the following steps. The suggestions for the concurrent management and research imperatives are given alongside.

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3.3 Selection of area:
From among the last refuges of the species concerned, if any choices are open, its relative strongholds should be selected as probable conservation areas on the following criteria:-

(i) Conduciveness of the area to the requirements of the species with respect to extent and habitat diversity.
(ii) Scope for enlargement of area in order to meet the prospective or projected requirements.
(iii) Availability of financial resources.

3.3.1 A short investigation by an experienced wildlife ecologist/manager should precede selection so as to facilitate a proper choice. This is necessary to guard against selection of areas and the delimitation of units on an arbitrary basis. The investigation should involve a general status survey of the threatened species in its last refuges, the choice of potential conservation units on broad considerations, the identification within each unit of the existing home range and its logical extension to make up for existing critical habitat deficiencies, and a broad appraisal of the limiting factors. This vital foundation work will be beyond the scope of a beginner and it is important that for this purpose the services of an experienced scientist (ecologist or manager) are commissioned.

3.4 Personnel:
At least the key personnel should be picked up and earmarked at this stage to look after the management of the units. The short investigation aforesaid should be jointly carried out by the scientist and these personnel. This would give the latter a first hand knowledge of the habitat attributes and at the same time help to inculcate in them a pioneer's involvement with the area. Such an involvement is sure to greatly enhance the efficacy of management and these personnel, unless they later prove unsuitable, must be allowed to stay in the unit for a long period of 8 to 10 years, subject to suitable provision for their career opportunities.

3.5 Interim management plan:
Based on the data of the preliminary investigations, the final choice, size and layout of the unit/units should be decided. The earmarked person/persons for each unit should be asked to prepare an interim management plan, providing for the reameliorative management and the compensatory development of the habitat in favour of the threatened species in question.

3.6 Legal status:
A minimum core within the conservation unit should be recognised as a *sanctum sanctorum* and given the highest statutory conservation status in the country, e.g. national park. The remaining part of the unit could be recognized as the buffer zone and given appropriate statutory status.

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3.7 Restrictions on community use:
From the core all human activity, except conservation, research and management, should be eliminated. This may involve relocation of villages, stoppage of cattle grazing, discontinuation of all forestry operations, including community collections of minor forest produce, and even restriction of rights of way. A potent enforcement organization with necessary equipment, e.g. vehicles and wireless, should be in complete control of the core area. In the buffer zone, also, decimating human use should be restricted by regulation of activities like forestry operations and grazing. If the buffer zone is not too large and hence a vital complement of the core, its total management must also vest with the organization for the core. However, if the buffer area is large and carries a wide function-diversity, at least the wildlife protection and management must remain with the core organization.

3.8 Alternatives:
Provision of alternatives for the restrictions on essential community uses must be provided by dovetailing the limited allocations from the conservation budget for this purpose into larger allocations under the community welfare budget. In fact most of the units are likely to be found in remote interiors harbouring the most backward communities which are in need of accelerated uplift. Very good chances therefore exist for finding the resources for a well coordinated multi-faceted community welfare programme. Provision of alternatives and other welfare factors will be looked after if the programme includes social forestry, pasture improvement, improved grazing practices, cattle breed improvement with simultaneous indirect reduction in cattle populations by castration of scrub bulls and fertilization of only healthy cows, soil conservation, irrigation, other agricultural development activities, and education. It may be a good idea for the unit-management to 'adopt' one or two villages and either to directly execute or at least closely supervise the welfare programmes in such villages.

3.9 Conservation education:
The unit must have a conservation-education-centre for the communities, equipped with audio-visual aids and having facilities for taking people round to demonstrate the rejuvenation of habitat as a result of restrictive use and reameliorative management. This would enable the people to infer conclusions against the background of conditions obtaining earlier, thereby encouraging them to imbibe the discipline naturally demanded for successful enhancement and maintenance of productivity levels. Attempts should also be made to bring home the idea that it was because of the location of the conservation unit in their area that they have had the preferential priority in welfare programmes. This overall measure is bound to moderate and eventually overcome initial resistance against the curtailment of the past community uses. Eventual promotion of conservation consciousness among the communities so as to elicit their spontaneous cooperation in the effort will be the aim of the centre.

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3.10 Reameliorative management:
Past abuse and overuse by the communities is bound to have left a number of adverse consequences, e.g. altered composition of flora including disappearance of more palatable perennial grasses and proliferation of weeds from the combined effect of fires and overgrazing by cattle. A depleted water-regime can be another feature. In addition, for quite sometime, disturbing and decimating influences from nearby communities can be expected to be encountered, in the way of fire hazard, poaching, illicit grazing, unauthorized collection of forest produce and the like. Reameliorative management would hence entail activities like assiduous anti-poaching control, concerted fire prevention and fire fighting, control over grazing and unauthorized movements, rejuvenation of dried-up water-holes, eradication of weeds, and reintroduction of grasses and plants initially occurring in different parts of the area.

3.11 Compensatory development:
Very often it may be difficult to establish the conservation unit coterminously with the eco-unit, because of inability to include an established habitation or other human use-complexes. Thus a traditional water hole or crucial rutting/mating or fawning/littering areas may have been excluded. In such situations creation of a water-hole within the area or manipulation of cover or other attributes to provide the crucial life-stage sites may become necessary. Similarly it may also become necessary to maintain the vegetation in some parts at a higher or a lower stage in the succession to suit specific requirements of the threatened species and this may have to be achieved by canopy manipulation or introduction of a fire regime. All such actions would be justified for the purpose of providing as optimum a habitat as rational management can provide for the threatened species population. Of course, caution against overdoing things in this sphere will be a necessary requisite. Concerted research and monitoring should provide the clues for the restraint/modification of the management practices.

3.12 Research imperatives:
Detailed etho-ecological investigations must be taken up from the beginning in order to have a better understanding of the requirements of the species in question. The work should also cover monitoring of habitat changes in response to reameliorative and manipulatory management. The monitoring of the response of animal populations, e.g. numerical increase, rate of growth and dispersal, is also important. Refinements in management practices can be introduced from preliminary inferences, even as the studies are progressing. These can serve as pilot trials in testing the effecacy of the research-suggested practices. The on-going research findings would yield clues as to the giving up or modification of certain management practices, or adding to the size of the unit in order to include a vital complement to the habitat initially not considered essential and/or to enlarge the scope of compensatory development measures to make up for habitat deficiencies.

3.12.1 Cowan and Holloway (1974), have evolved a fairly exhaustive

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questionnaire which enumerates the problems on which investigations ought to be initiated. These investigations, together with the monitoring studies suggested above, should answer most of the questions that may arise when deciding upon the course of the most plausible long-term management.

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PART II: A DOSSIER ON THE PLANNING OF RESTORATION PROGRAMMES FOR THREATENED UNGULATES WITH SPECIAL REFERENCE TO DEER

3. COMPONENTS OF MANAGEMENT PROGRAMMES

Management of Endangered Deer: Some Aspects of Policy and Practice

I. McT. COWAN

ABSTRACT

The two most important sources of destruction of deer populations are overkill and habitat alteration by man. Programs for conservation have identified some important generalizations: (1)early identification of all surviving stocks is important; (2) management plans should be formed, written and public, so as to ensure they survive staff changes; (3) in many instances projects will benefit from management by a recovery team bringing together the different jurisdictions involved in the management of the land, its people and wildlife; and (4) international cooperation is essential where endangered species or their potential habitats cross boundaries.

Approaches to management may include habitat enhancement, by manipulation of vegetation, reduction of competition from domestic livestock, development of water sources and the development or maintenance of shelter areas, protection from poaching, predators, accidents (largely associated with man-made artefacts) and disease. The role of captive rearing and introductions is discussed.

INTRODUCTION

Most species of large mammals which have come to the extreme of endangerment are there as a consequence of inappropriate actions by man. In many instances the forces which brought them close to extinction are still operating. Thus the management of an endangered deer in the interest of its survival is largely an exercise in man management.

One can strive to know as much as possible about the species and thus to have a sensitive finger on the population to be managed, but it is usually imperative to do what can be done as soon as possible, to act from best judgement and to act while learning. This in no way derogates the value of research; it merely recognizes that it is usually possible to find out quite quickly one or two avenues likely to mediate the plight of the species.

The two most important destructive influences on deer are overkill and alteration of the habitat, this can include overgrazing by domestic livestock.

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These are likely to provide the focus for initial management activity while research is exploring for details.

Although the long-term objective of the conservation of an endangered deer may have, as a realistic goal, the eventual return of the species to the wild in numbers which will permit it to be used as a food resource or for recreational purposes, the immediate goal of every manager is to assure its survival. Almost never will the manager have at his disposal an adequate body of biological data to permit a thorough analysis of carrying capacity, the construction of a life-table, the secondary or even the primary sources of mortality, and the other parameters which would permit a sensitive management scheme. Frequently all that is known is that the species is less numerous than it once was and is confined to a smaller area of range.

In approaching the task of management of threatened deer, there are some overriding generalizations derived from experience:

1. Identification of all surviving stocks

This can be a difficult task, especially where very small numbers may be scattered over large areas of difficult terrain included in more than one political jurisdiction. None the less this should be adopted as an early priority. Not until all stocks are identified can the researcher or manager appreciate the dimensions of the task or its opportunities.

2. Management plans and monitoring

All reserves that contain significant populations of threatened deer should be managed according to objectives contained in a management plan, to ensure maintenance of standards and continuity in spite of staff changes. Initially, the plans may be fairly simple documents concerned primarily with administration and the organization of protection and collection of field data (Holloway & Wani, 1970), but subsequent plans can be refined as ecological information is accumulated on the area. One early requirement would be the classification of vegetation in relation to deer habitat requirements as a basis for management prescriptions (Stocker *et al.*, 1977; Stocker & Gilbert, 1977).

Provision for monitoring changes in vegetation and vertebrate populations in response to management is a subject of special concern. Programmes devised for monitoring vegetation and large herbivore populations in the *Project Tiger* Reserves in India might be considered as models for monitoring programmes in similar reserves (Sykes & Horrill, 1977; Lowe, 1977).

3. The Recovery Team

An effective organizational innovation has been developed out of the restoration activities centred on the Columbian white-tailed deer *Odocoileus virginianus leucurus* (see T. A. Gavin, these Proceedings, Pp. 185–202). This is the development of a "Recovery Team" to guide the project. This team can bring together representatives of different government departments (e.g. agriculture, forestry, wildlife) or representatives of different states, where a species ranges across boundaries. The team can oversee the project,

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clear the way through otherwise frustrating bureaucratic jungles, and generally facilitate the recovery and wise management of the species.

Another important issue has emerged from experience with the Columbian white-tailed deer. This is the need for clear definitions – probably arrived at for the species in question – as to what level of population can be regarded as no longer threatened. This can be important to permit the species to be transferred from one administrative situation to a more appropriate one as the conservation program meets with success.

4. International cooperation in the conservation of threatened deer

A fairly high proportion of threatened deer species and subspecies occur within the areas of international boundaries. This situation probably arises partly because of the prevalence of riverain and mountain forms among the threatened deer and the common use of these topographical features to delimit such boundaries, and partly because of the restriction on human use and development of these areas, which has afforded some protection to the species.

Where these circumstances occur, it is important the cooperation between national authorities be established to ensure common conservation goals, which might take various forms including the formation of adjacent reserves that are managed with common objectives. Threatened deer that are presently believed to have contiguous populations on international boundaries include Fea's muntjac *Muntiacus feae* (Burma and Thailand), the northern race of the swamp deer *Cervus duvauceli duvauceli* (India and Nepal), the Barbary deer *Cervus elaphus barbarus* (Algeria and Tunisia) and the Bactrian deer *Cervus elaphus bactrianus* (Afghanistan and USSR). In addition, there may be scope for similar cooperative arrangements for other deer that occur in the vicinity of international boundary regions, although interchange between populations is less likely, e.g. the Himalayan musk deer *Moschus moschiferus moschiferus*, the Thailand brow-antlered deer *Cervus eldi siamensis*, the Kashmir deer *Cervus elaphus hanglu*, the Chilean and Peruvian huemuls *Hippocamelus bisulcus* and *H. antisensis*, and the marsh deer *Blastocerus dichotomus*.

SOME APPROACHES TO MANAGEMENT

The most important first question for answer is whether the species is present in numbers that approximate the carrying capacity of the habitat at the time of year when that capacity is at its lowest. Data must be sought on such indicators of a saturated environment as the proportion of the mature hinds with young at the end of the birth season; the proportion of the herd which represents the annual increment to the breeding age animals; the size of the antlers of mature stags, all of these relative to the known circumstances in the best known of closely allied species. The condition of the preferred food plants can provide additional information.

If the species is at capacity, little will be achieved by concentrating on protecting it from poaching or predation, unless losses of this sort are exceeding

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the annual gain. First priority must be given to raising the capacity of the habitat by one or more of the many available techniques.

If the species is well below the capacity of its range and there has been no recent die-off or exodus, then protection of the surviving individuals can be taken as first priority while efforts are being made to identify and priorize the sources of loss in detail. Always, if you are to know the success or failure of your management strategy, monitoring for changes in numbers is imperative. This can be most difficult in brush-inhabiting species. Only after the species is secure will it be true that "one of the principal objectives of deer management is to hold the numbers of animals on each range at a level in balance with the supply of nutritious forage, potable water and adequate cover" (Dasmann, 1971).

Management for survival can involve species in the wild or in captivity. In considering first the management of a wild living population I can reiterate the general question posed by Bunnell (these Proceedings, p. 279 ff.): "What activities impact upon this taxon, how are they medicated and how can they be mitigated?" Mitigation is the task of management.

Mitigation of environmental deficiencies can include habitat enhancement, habitat replacement and habitat substitution; and in seeking management strategies it helps to think in these categories.

Habitat enhancement

Improvement of feed in amount and quality can be a difficult task. Planting of preferred species has been tried but the numbers of shrubs that must be set out to make any measurable difference in the feed available usually makes this impractical. In cases where competition from domestic livestock has reduced feed available to the deer, reduction of the competition is a ready strategy. This need not involve the complete removal of livestock. Depending upon the food plants used by the deer, there may be little competition from cattle but much from sheep and goats, or vice versa.

Techniques of manipulating food plants have also involved cutting down to a stump trees that have the response of producing basal sprouts palatable to deer. Some deer species are favoured by the early successional stages of vegetation and find their feed most abundant and most nutritious after the later successional stages have been disturbed. For these species, fire, regrowth following cultivation or deforesting, offer management opportunities. A case in point is referred to by Jackson (these Proceedings, p. 41) in his paper on the pampas deer in Argentina. He reports that mowing or cultivation helped to favour the grasses providing preferred deer feed as against the coarse perennial grasses which dominated the undisturbed sward.

Few herbivores can find all their requirements in optimum if they are confined to relatively small areas. Some species require the opportunity to migrate altitudinally with the seasons so as to select the most nutritious feed available. Some of our studies of the energy gain of migration in bighorn sheep certainly apply also to deer (Hebert, 1971). The protein content of the feed selected from different parts of the range during the cycle of seasons provided a superior diet, whereas confinement on any one part of

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of the range led to starvation levels of protein. I expect that this will be found to be operative also with the Kashmir stag.

The artificial supplementation of wild feeds with hay or artificial combinations of feed as meal or pellets has been a practice for many years in the management of deer parks and hunting reserves. Its success depends upon the type of diet usually sought by the deer. Hay offered to starving deer of species that normally browse is likely to do more harm than good. Pelleted rations have been used successfully with such species. The delivery system is important. Feeders must be designed to be accessible to all ages and both sexes, with and without antlers. They must also be sufficient in number and so placed that they cannot be preempted by a few aggressive animals.

Improved distribution of habitat types can be sought, based upon the well recognized principle of edge effect. It involves not just access to a variety of food sources but equally to water, shelter and the special facilities that the species requires. A special case arises where a threatened deer survives on areas where intensive forestry is practised or where introduced plant species threaten native vegetation.

Tree plantations and exotic plants in protected areas.

The object of the Threatened Deer Programme is to restore populations of deer that are presently threatened with extinction and to conserve them and the natural environment, of which they are an integral part, in perpetuity. In the foreseeable future, attainment of this objective for many species will require concentration on management of populations within protected areas. Numerous protected areas in Asia in which threatened deer occur contain significant areas of tree plantations of a single species of indigenous or exotic origin. Research is required to determine the precise effects of such areas on wildlife and the reserve area as a whole. In general terms, however, young plantations especially if afforded protection against stock grazing by fencing may provide good feeding and cover for wildlife, but as the planted trees at regular spacing begin to close canopy, undergrowth is killed by shade and root competition and the areas are of limited value to large wild herbivores. Exotic tree species have no place in natural protected areas and in extreme cases, such as the establishment of *Eucalyptus* spp. plantations in swamp grasslands in Uttar Pradesh that are utilized by swamp deer *Cervus duvauceli*, could be instrumental in causing the extinction of the deer (Holloway, 1973).

It may be impracticable to remove these plantations until they have reached merchantable size, but their management including modification of their density, structure and composition, should be determined by conservation needs as demonstrated by research and not by commercial requirements.

Similarly, several reserves in Asia that contain threatened deer and other endangered species are affected by the spread of exotic weed species, such as *Mikania scandens* and *Lantana camara*, to the detriment of indigenous vegetation and wildlife and the integrity of the natural area. Steps should be

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taken to map the occurrence and spread of these weeds and to eliminate them by biological methods (Holloway *et al.*, 1976).

Development of water sources.

Many species of deer require access to water more than once a day. In areas where water is scarce, its distribution can govern the presence or absence of a species and govern the efficient use of feed sources. Often also the available water sources may be taken over by domestic livestock and by men, thus denying them to the wildlife.

Much can be done to improve water sources. Seasonal sources can be trapped and stored in cisterns; catchment areas can be designed to run rain water into cisterns from which it can be dispensed over a long period with the use of piping, troughs and float valves. Biologists and sportsmen together have perfected many techniques of water management as part of the program to increase the numbers of desert bighorn sheep in California. Detailed designs can be obtained from them.

Then, too, seeps so meagre they make only a muddy patch on the ground can provide a steady source of hundreds of gallons of water when they are excavated, run into a cistern and piped to troughs with float valve control. Not only does the development of such sources serve to provide ready water not previously available, it can have a secondary advantage of cleaning up what are often fetid mud holes with significant advantage in the reduction of some forms of wildlife disease. Necrobacillosis is one of these.

Shelter is an important element in the habitat of deer. Shelter from the sun, cooler areas where flies can be escaped, quiet secluded places where birth and early mothering can take place, shelter from cold and storms, all are important to a species. Of particular importance is shelter from human disturbance.

Human use may alter habitats in ways destructive to deer, clearcut logging in some forest types, short-cycle agriculture following burning of the original forest, gathering of grass or reeds, overgrazing by livestock sometimes to the extent that trees are felled to provide feed for the beasts, or merely harassment by the continuous activity of people. Often these activities are looked upon as an essential part of the way of life of local residents and change is resisted. Frequently human use of adjacent areas has become dependent upon access to the area upon which the deer are to be managed, and designing compatible forms of use and getting these implemented and enforced can be challenging and frustrating tasks.

Improved shelter is often most effectively gained by designing fences that will exclude domestic livestock but not deer. These can be built around selected copses located and spaced to be of maximum use to the deer.

Habitat improvement can be achieved by negotiating revised boundaries to the reserved areas to include elements missing or deficient in the original plan. The size, shape and distribution of reserved areas for endangered deer have been discussed by Bunnell (these Proceedings, pp. 269–272), to which reference should be made. Frequently the manager has little choice but to work within existing areas.

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Protection from poaching.
If the habitat for the endangered deer appears to be adequate, fawn production and survival are good, and the mature males produce antlers considered normal for the species, adequate nutrition can be assumed. It may be judged necessary then to look at ways of decreasing direct mortality in the herd. Prominent among these is likely to be poaching.

Illegal killing is very difficult to eliminate whether it is done for food, for objects for sale, or as part of cultural behaviour or sport. Enactment of protective legislation is one thing; enforcement is another. Other strategies include attempts to remove the profit to be gained from illegal sale of such products as canine teeth, hides, meat, antlers or musk. It is difficult to be sanguine about the success of these attempts to control losses of deer. The international trade in poached wildlife products has seldom been better organized.

Many of the endangered deer are in areas where enforcement staff is meagre and ill equipped. Often the backup they receive from their own government is inadequate. Then, too, some villagers may count on the small amount of venison they obtain as an essential part of their diet. Many countries find conservation of endangered species relatively low on the list of national priorities. Panwar (these Proceedings, pp. 408–410) has outlined many of the social constraints of good management.

Protection from predators.
Predators may be native species or domestic dogs. The control techniques are well known and widely publicized. When the predator itself is also an endangered species, trapping and live removal are favoured over any of the ways of killing the individual. In assessing the impact of predation, particular attention should be paid to losses of fawns. Such predation is often inconspicuous. Most deer have skulking young which remain apart from the mother for long periods during the first month of life. The young are vulnerable to opportunists such as bears as well as to jackal or coyote-sized canids and the medium sized cats such as lynx and the bobcat or their counterparts in other continents. It has been shown that, under some circumstances, predators can indeed induce serious decline in the numbers of deers or inhibit increase (Mech, 1977; Bergerud, 1971; Haber *et al.*, 1976).

Protection from accident.
Where the numbers of a species are very small, the loss of even one or two individuals can be important. There are many sources of accidents introduced by man: irrigation channels which are not equipped with escape ramps, poorly strung fencing, collision with highway vehicles or railroad engines, are all cause of loss to deer. In each instance mitigation techniques have been described.

In some instances fencing the entire refuge upon which the deer are living proves to be the most effective answer to protecting the deer from a variety of deleterious impacts.

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Disease protection.

Disease as a threat to endangered deer is a complicated issue. It includes not only the self-transmission of parasites or infectious organisms damaging to the endangered deer, but interactions between some species of deer. A number of other diseases are known to be transmissible between domestic animals and deer. McDiarmid (these Proceedings, pp. 364–378) has provided a useful overview of the disease conditions known in deer. Epizootic hemorrhagic disease, malignant catarrh, anthrax, brucellosis and cerebrospinal nematodiasis are all known to have caused heavy mortality in one or more species of deer. It is noteworthy that all of these are species specific in their importance.

Not only may outbreak of disease cause serious losses in deer already scarce, but each is known to affect some species more than others. Thus some deer may be resistant to a parasite or disease which is highly destructive to others, e.g. brucellosis seems to be a damaging disease to *Rangifer* though the response of most endangered deer is unknown. A case in point is *Pneumostrongylus tenuis* to which white-tailed deer are specially tolerant while moose and caribou are susceptible.

A further concern is the diagnosis of a disease in deer which is known to be dangerous to domestic livestock. Local pressures can be exerted to remove the deer.

The general principles that arise suggest that endangered deer and domestic livestock should not be grazed over the same ground. When transplanting deer from one area to another in the wild, they should be thoroughly tested for the diseases known to be important to deer. The same applies to the release of animals from captive herds.

Genetic management.

It is not a necessary consequence of the small size of a population that its members will suffer genetic degeneration. As Whitehead has pointed out (these Proceedings, p. 361), the entire present world population of Pere David's deer descended from just a few captive individuals. The stock has remained vigorous. The likelihood is that a species represented by just a few individuals will lose some of its variability. Indeed the rate of loss has been calculated (Cowan & Holloway, 1974). The losses may reduce the competence of the species to adapt to altered environmental circumstances.

Management strategy will involve judicious culling of individuals with undesirable characteristics, along with some of the mitigation procedures outlined by Cowan and Holloway (these Proceedings, pp. 330–334). This may involve interchange of males, maintaining several populations and making periodic transfers between them, patterning the habitat to foster a number of breeding units within the same population.

Captive rearing.

Under some circumstances, it may be judged that protective and restorative management of the deer in the wild is unlikely to be successful in preventing early extinction. Even when fair numbers of a species or subspecies are known to exist there may be good reason to consider the maintenance of a

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captive group as insurance against disaster in the wild. Captive stock can provide reservoirs of animals for restocking and can also provide opportunities for study of the animal's biology under controlled conditions. The maintenance of deer in captive colonies must, however, be regarded as supplementary to conservation of a species in its natural environment and not as a substitute for such protection.

There are important principles to be considered in the choice of a site for the establishment of a captive herd. The herd itself becomes a responsibility and there should be reasonable assurance that its custody can be guaranteed and that it will be managed in accordance with the best information. Keeping in mind the ultimate objective of restoring the deer to the wild, the captive colony could well be located in a climatically similar habitat, which is at the same time removed from the special threats to the wild population.

It should be recognized that many conventional zoological gardens have neither the funds, space nor other facilities to establish and maintain large herds of threatened species in captivity. The establishment of separate breeding and research centers for threatened species by individual zoos, such as the Fort Royal Conservation and Research Center in Virginia (Wemmer, 1977) or cooperative projects involving zoos and conservation organizations, such as the world herd of Arabian oryx, in Phoenix, Arizona (Dolan, 1976), should offer much greater opportunity for study and the production of surplus animals for re-introduction.

The International Zoo Yearbook's census of rare animals in captivity in 1976 showed that 15 of the 29 species and subspecies of world threatened deer are presently held in captive collections (Olney, 1977). The absence of some species from captive groups is caused not so much by their rarity as by the difficulty of keeping some of them in captivity. The Chilean heumul (*Hippocamelus bisulcus*) is an example of such a species (see Povilitis, these Proceedings, p. 122), and the taruca (*Hippocamelus antisensis*) may be another. Priority rating of field research projects under the Threatened Deer Programme must take account of this problem and the etho-ecological studies in the field should be alert to development data which can be used to improve our capacity to maintain healthy herds in captivity.

Deer farming, for the commercial production of antlers, musk, hides, meat and other products, is almost confined to Asia and is a special category of captive breeding of wildlife. The consensus within the Deer Group is that, under present circumstances, deer farming does little to promote the conservation of deer in the wild, apart from providing a potential source of animals for re-introduction. Indeed, by maintaining a market for these products, it may actually stimulate the poaching of wild deer. Projects for the farming of threatened deer should not be encouraged unless the illegal exploitation of wild individuals of that species or subspecies can be controlled and a system evolved for the identification of the farm-reared products.

Re-introduction and introductions of species.

Re-introduction of a species involves its rehabilitation into an area in which it became extinct within historical times. Provided the original cause of

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extinction has been removed or substantially alleviated and the habitat has not suffered irreparable damage in the meantime, the species can normally be re-introduced without serious difficulty or ecological disturbance because it will again be interacting with the biotic and physical system in which it evolved (Petrides, 1968). This practice has already been adopted in the Threatened Deer Programme (Bannikov, these Proceedings, p. 171) and is expected to become an important component of the Programme in future.

Introduction, on the other hand, involves the establishment of a species in an area in which it has not occurred before. It can be attended by risks of environmental disturbance such as displacement of indigenous species by the exotic (Jungius, these Proceedings, p. 343 refers to several threatened deer species that have been affected by this problem). It may fail to become established because the new habitat is different to its native area or it may create a nuisance through high reproduction in the absence of natural controls. Where the scope for re-introducing a threatened species into its original range does not exist, its introduction into a related area, preferably within its country of origin, must be considered, but only after a detailed assessment of the possible ecological consequences and an adequate period of acclimatization of the species under captive conditions in the new environment.

Capture and relocation of threatened species.

Whitehead (these Proceedings, pp. 360–362) has listed the main provisions to be observed in planning a capture and translocation operation for threatened species. Considerable advances have been made in this field within recent years and a relocation project for a rare species requires expert advice and the use of experienced personnel. Young (1973) provides a useful compilation of information on chemical immobilization, mechanical capture, transport, accommodation and nutrition of wild animals in captivity, as well as post-capture complications and treatment under African conditions.

Research.

This topic is discussed elsewhere in this symposium (Cowan & Holloway, pp. 329–338; Bunnell, pp. 278–284). Management and research should be mutually supportive. Research procedure should be planned so as not to impair the survival of any individual of the endangered stock. With care, good management and adequate planning, it is possible to obtain the research data essential to the design of effective management without increasing the exposure of the deer to new hazards. Research while essential to management must be planned to focus on those data determined to be important to the conservation objective (see Bunnell, *loc. cit.*).

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PART II: A DOSSIER ON THE PLANNING OF RESTORATION PROGRAMMES FOR THREATENED UNGULATES WITH SPECIAL REFERENCE TO DEER

3. COMPONENTS OF MANAGEMENT PROGRAMMES

Summary of Discussion

Criteria for the reintroduction of threatened species into parts of their former range (H. Jungius)

In the absence of Dr. Jungius, the paper was presented by Dr. Petrides.

It was agreed that the Threatened Deer Programme was primarily concerned with reintroduction of species as a conservation measure. In brief, introductions should normally be considered only where the species was definitely in danger of extinction and where its original habitat had been irretrievably lost, and where the possible ecological consequences of the introduction could be predicted with reasonable accuracy on the basis of scientific study. Each case must be examined on its merits. Introductions should never be made of different subspecies within the same or adjacent areas. Introduction of island species into mainland areas needed to be approached with particular caution as changes in the physiology and morphology of these forms could occur quite rapidly.

The main research need is to study the dispersal patterns of animals after release in the new area. Dispersal of animals in a number of introductions and reintroductions in the past had been poor, or the transplants had died out, because animals had been used from the extremities of their range (e.g. animals from the southernmost part of their range reintroduced to the northern extremities of it). Preparatory work for reintroduction required a careful study of the entire distribution of the species, investigation of the availability of animals and examination of the best ages and sexes to be used, leading to detailed prescriptions on how the animals should be procured, maintained and released.

In general, animals should be released in the best habitat, prior to the unfavourable season of the year. This approach prevented them from dispersing into unfavourable habitat and helped to build group cohesion. Under certain circumstances, artificial feeding may be required during the first unfavourable season following release. Animals that have been captive for a long time will have to be acclimatized and may have to be taught to feed in the wild.

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Captive breeding as a practical aid to preventing extinction and providing animals for reintroduction (G. K. Whitehead)

It was reiterated that the value of captive animals, such as threatened deer, for studies as a basis for field research could be seriously impaired by misidentification of animals. A number of examples were quoted. There was a need for a registry of threatened deer held in zoos and game farms, whose identification had been verified. The task of registering, verifying and certifying stock in zoos and other collections was almost certainly beyond the scope and resources of the Deer Group, but the IUCN staff member was requested to refer the matter to the IUCN Zoo Liaison Committee for its comments.

Hybrids of threatened species should not be released in the wild because of their threat to the genetic integrity of wild stock. Even their retention in captivity should be discouraged, lest animals should escape. In this connection, it was recommended that the Chairman of the Survival Service Commission should be requested to write to the Department of the Environment in Iran, and state that since the captive herd of Persian fallow deer was increasing satisfactorily, the captive herd of Persian/European fallow deer could serve no useful purpose and, in the opinion of the SSC/IUCN Deer Group, it should be destroyed.

In future, conservationists may need to pay greater attention to new techniques for propagation of threatened species in captivity, such as the maintenance of sperm banks. It was recommended that data on this topic should be circulated among Group members for more detailed consideration at a later date.

It was suggested that certain other topics related to captive breeding were of special concern to conservation and should receive more attention in the final version of the paper. The items suggested were species that are difficult to breed or raise in captivity, possible degeneration of animals after generations of captivity, and how these problems might be reduced, the advantages of retention of captive herds in parks or field pens compared with zoos, and the basic construction needs for pens to allow for capture and examination of animals.

The values of deer and other wildlife both as secure and endangered populations (G. Petrides)

Extreme doubt was expressed as to whether any wild animal would be domesticated, in the true sense of the word, by man in the future and as to whether the presence of animals in domestication could contribute to conservation of animals in the wild. The consensus was that retention of presently wild animals in domestic form was, at best, a poor substitute for conservation of the wild animal in its natural environment and that whilst conservationists needed to take note of the practice they should do nothing to encourage it.

It was felt that the sections of the draft paper on the use of threatened species (through carefully controlled ourist viewing, their adoption as national animals, the use of case histories in public relations campaigns, etc.) required

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expansion. Tourism in reserves for threatened species needed to be examined very critically because of the problems of disturbance that it might cause. In more general terms, it must be recognized that national reliance on overseas tourist income could be dangerous; it could provide an incentive to over-exploitation of natural areas and was often one of the first industries to suffer at times of international economic crises.

Aesthetic and educational values of wildlife also required more emphasis and a more thorough analysis. They are extremely important in human development. It has been shown that children raised without contact with nature are retarded in speech development, for example, and in physiological development. These values should be included among the numerous factors used to counter-balance ill-founded economic arguments against conservation.

A number of participants referred to literature on the perception of wildlife and wildlife values, and on production of medicaments from wildlife, which they agreed to circulate among members of the Group especially interested in these subjects. It was agreed that an additional paper on the aesthetic value of wildlife would be a useful addition to the proceedings (a paper prepared subsequently by Mr. A. Povilitis is included in these Proceedings, pp. 388–391).

Management of endangered deer. Some aspect of policy and practice (I. McT. Cowan)

This paper was prepared as a summing up of the Working Meeting and identified the main conclusions reached in the Discussion as follows.

a) Basic generalizations.

(i) It is important to identify all surving stocks of the threatened species.

(ii) Management plans should be written, approved and made widely known, so that they may better survive changes in staff.

(iii) Management plans should include arrangements for monitoring changes in the numbers and sex and age classes in the threatened deer population as well as changes in the environment, so that the effectiveness of the plan can be determined or new problems appreciated and responded to.

(iv) The organization of a recovery team, to include representatives of different jurisdictions involved in the management of the habitat used by the deer, along with the wildlife authorities, can be a useful management innovation.

(v) Many endangered deer occur adjacent to international boundaries and cooperation is essential to success.

b) Some management approaches.

(i) A first task is to determine whether the deer population is as large as the habitat will support.

(ii) If the species is below the carrying capacity, management should be directed toward improving productivity and reducing mortality.

(iii) If the stock is below capacity, sources of mortality to be controlled

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including killing by man, killing by domestic dogs, wild predators, disease or accident.

(iv) Disturbance can be an important influence particularly on the successful rearing of young.

(v) If the capacity of the habitat is a limiting factor, the extent of competition from domestic or wild herbivores must be determined and controlled.

(vi) Habitat improvement techniques available include those directed toward providing more or better distributed shelter, foodplants or water sources.

(vii) Supplemental feeding may be a useful short term expedient.

(viii) Judicious culling of undesirable genotypes may be required.

(ix) Captive rearing has the long term objective of returning the species to the wild.

(x) Reintroductions and introductions can be made using captive-reared or wild caught animals. The animals should be tested for parasites and disease and only "clean" animals released (see Jungius, pp. 345).

(xi) Research should support the conservation objectives (see Bunnell, p. 280).

Promotion of national conservation measures and support for the restoration of threatened species of mammals (C. Holloway)

Threatened species conservation vis-à-vis community welfare in developing countries (H. Panwar)

These two papers were discussed together.

It was suggested that conservation education programmes should be directed at urban populations, since they exert the principal pressures on rural areas, e.g. either directly, by the use of these areas for recreation, or indirectly, by stimulating the demand for hydro-electric dams. The people that benefit, therefore, are different from those that are most obviously affected, and this link between the land and urban population must be made clearer to the urban populace. Whilst this suggestion was accepted in broad terms for developed countries, it was stated that in developing countries the emergency situation posed by threatened species coupled with a shortage of resources for conservation made it essential that priority be given to rural areas, where local activity may easily result in extinction of species.

In many developing countries the living standards of ordinary people are low and the first priority of government, understandably, is to improve the conditions of the people. Good conservation of natural resources also contributes to this aim although its immediate benefits are usually less easy to demonstrate. It is important, therefore, that conservation programmes be carefully integrated with other development programmes, so that no effort is wasted and ordinary people learn to associate conservation with better standards of living. The maintenance of good working relations between government officers concerned with natural resource management and those concerned with administration and land development is very important.

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Conservation efforts to date have been directed primarily at governments and a greater effort may be required to influence multi-national corporations, especially those with land holdings and industry in developing countries. They might provide sources of conservation funding and could be influenced to adopt less destructive methods of land development and industrial production.

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OTHER BUSINESS

1. Management problems of special concern to the conservation species

A Group member suggested that the meeting should formulate opinions, which might eventually lead to policy statements, on several subjects of particular concern to the management of threatened species and with special reference to deer.

The subjects were as follows:-

1. Effects of (a) fire and of (b) grazing by domestic stock on the habitat of deer in general and endangered deer in particular.
2. The effect of forestry practices, particularly the establishment of monocultures, and of exotic plant introductions on deer conservation.
3. Control of predators and of other species if they constitute a threat to critically endangered cervids, in both national parks and other reserves.
4. The maintenance of genetic purity of endangered subspecies and the question whether a subspecies, whose extinction is imminent, should be crossed with a related, more numerous subspecies to conserve a portion of the original genes.
5. Criteria for reintroduction of threatened deer and other species.
6. Recommendations from the Group on specific areas of international cooperation (e.g. the swamp deer area between Nepal and India) in the threatened deer programme.
7. Policy with regard to captive breeding of deer to prevent extinction.
8. Policy or opinions on game-farming and trade in animals and animal products derived from threatened deer species (musk in particular).

It was agreed that comprehensive policy statements on the first three subjects would be extremely difficult, as the needs of different species and biotic communities and corresponding management requirements would vary very considerably. Several of the remaining subjects would be covered to varying degrees by the dossier papers on captive breeding and reintroductions and by individual case history papers, such as those on the musk and swamp deers. The meeting was unequivocally in favour of international cooperation in conservation, especially where the range of a threatened species crossed international boundaries. The threatened deer that might require cooperation of this sort included: the musk deer, Fea's muntjac, the swamp, Thailand brow-antlered, Barbary, Kashmir and Bactrian deers, Chilean and Peruvian huemuls, and the marsh deer.

Brief statements on each of these subjects were considered by the meeting and approved in principle. The consensus, however, was that it had not been possible to do justice to these topics in the time available, and that they needed to be reconsidered against the background of problems on management of threatened species and their habitats as a whole.

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It was, therefore, recommended that:

a) these subjects should receive consideration in the paper on management that had been proposed for inclusion as an additional paper to the dossier (for the Paper accordingly prepared by I. McTaggart Cowan, see pp. 415–425), and a copy of the draft statements should be transmitted to the prospective author of that paper;

b) authors of case histories on threatened deer that were affected by those considerations should make specific reference to these problems and what was being, or could be done, to solve or circumvent them, in the final versions of their papers.

2. Dissemination of information on the Programme

In addition to the dissemination of information on field projects in the Group Newsletter, IUCN Bulletin and WWF Yearbook, IUCN and WWF were interested in receiving information that was suitable for press releases, for fund raising and public relations. Information of this type should normally be tied to a particular event, such as the formation of a national park associated with the project, discovery of an additional population of an endangered species and so on, to which background information on the progress of the project should be added. Field researchers are the most appropriate people to prepare this information, although they may require advice on its compilation and format from IUCN/WWF in Morges.

WWF, in particular, was often in a position to help with advice and material in the preparation and dissemination of information for local public relations exercises. Field workers who were contemplating the launching of local campaigns should contact WWF.

3. Review of the content of the dossier

It was felt that the principal omission from the dossier subjects was a paper on diseases and parasites in deer. The name of a suitable author was suggested and it was agreed that he should be requested to prepare a paper on this subject for inclusion in the publication (for the Paper accordingly contributed by A. McDiarmid, see pp. 364–378).

4. Next meeting of the SSC/IUCN Deer Group

It was agreed that the Group should meet again in two or three years time, preferably in a developing country that has threatened deer projects in operation. The Threatened Deer Programme should be subjected to further review and the main topics for consideration should comprise a detailed examination of management problems associated with the habitats of threatened deer, and if possible, the status of threatened deer in the People's Republic of China.

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