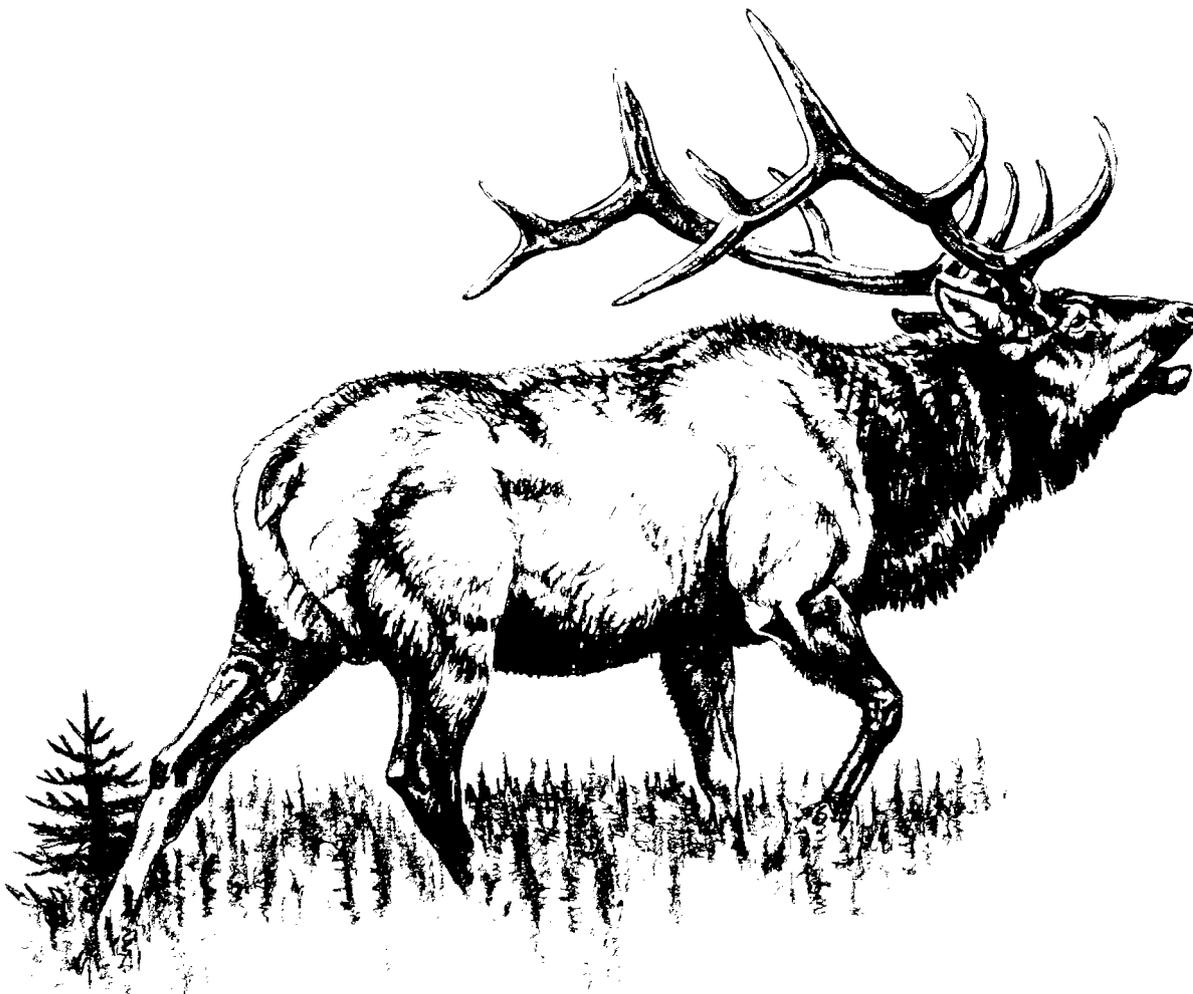


# PROCEEDINGS OF THE 1984 WESTERN STATES AND PROVINCES ELK WORKSHOP



APRIL 17 - 19, 1984  
EDMONTON, ALBERTA, CANADA

**Alberta**

ENERGY AND  
NATURAL RESOURCES  
Fish and Wildlife Division



**Alberta Fish & Wildlife**  
YOUR PARTNER IN CONSERVATION

PROCEEDINGS OF THE  
1984 WESTERN STATES AND PROVINCES  
ELK WORKSHOP

APRIL 17-19, 1984  
EDMONTON, ALBERTA

Editor & Chairman: R. Wayne Nelson - Alberta Fish & Wildlife  
Division, Edmonton.

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Alberta Fish & Wildlife Division.

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## PREFACE

The 1984 Elk Workshop, hosted by the Alberta Fish and Wildlife Division at the Chateau Lacombe in Edmonton, was attended by 119 registrants from a very wide variety of agencies, organizations, and interest groups. Forty-seven people also enjoyed the hospitality, information, and sights provided at Elk Island National Park and the cooperative Alberta Fish and Wildlife/University of Alberta ungulate research station.

Workshop Format. In organizing this workshop we were very uncertain how best to serve the needs of the continent's elk managers. We were urged to ensure a relaxed atmosphere with time for all to question and discuss. We were also stimulated to seek a broad information exchange on all aspects relating to elk. The initial announcement solicited papers especially on two timely themes, "Nuisance Elk Management Techniques" and "Commercial Husbandry of Elk". It was hoped that the papers submitted for these would form the basis of two panel discussions, with considerable input from the floor, and these would be a focus of the 1984 meeting. Submissions for the first topic were few, and these were incorporated into the regular paper sessions. There were also few submissions on the second topic, but Bob Hudson picked up the reins and organized a stimulating panel discussion aimed at the current Alberta situation, and this brought much discussion from the floor. As will be seen in these Proceedings, there was a large number of interesting papers submitted on a wide variety of topics, and these formed the major part of this workshop.

The bulk of the workshop took on a conference format, with a difference. Speakers were allowed 20 minutes for their presentations followed by 10 minutes for questions and discussion. While this format (versus a strict workshop with discussion groups and topics to be worked on) allowed for a much wider selection of topics to be presented, it did not allow for indepth elaboration or discussion from the floor on these topics.

A satisfactory workshop might include three presentation formats - (1) a panel discussion, (2) a strict workshop session, and (3) a session with relaxed, conference-style presentations on broadly related topics followed by 1/2-1 hour of guided discussion on those topics.

Elk Status Reports. As directed by the 1982 Workshop, Bob Hernbrode prepared, circulated to the respective agencies, collated, and presented the results of a questionnaire on the status of elk in North America. A summary of this material is included in these Proceedings. This project trimmed several hours of verbal, repetitive presentations at the workshop down to just a few minutes and a few pages of summary plus a substantial document for distribution to the agencies.

Previously the verbal status reports from each state and province have included summaries or comments and discussions on new techniques, problem areas, and controversial subjects. These important matters will now appear before the group only if a specific panel discussion, workshop session, or paper presentation deals with them. Although some of this discussion simply will not now occur, there now is more time available in

the other parts of the workshop for such matters, and attendees are strongly encouraged to tackle these important topics in more detail by way of a paper, a panel, or a workshop session.

Business Meeting and 1986 Elk Workshop. Oregon volunteered to host the 1986 Western States and Provinces Elk Workshop. The business meeting discussed the format of the present meeting (see also the Workshop Summary) and concluded that we would give future organizers no formal instructions but would leave the format of that meeting in their hands.

Acknowledgements. For much-needed assistance with the organization and execution of the workshop I wish to thank the following: the staff at the Chateau Lacombe; Travel Alberta; Edmonton Tourism and Convention Authority; staff and students of the University of Alberta Department of Animal Science (especially Bob Hudson and Luigi Morgantini) and Department of Zoology; Elk Island National Park staff, in particular Chuck Blythe; our banquet speaker, Val Geist; and my colleagues at the Wildlife Branch of Alberta Fish & Wildlife Division, especially Bill Hall, Gerry Lynch, Eldon Bruns, Bill Glasgow, Harold Carr, Mike Watson, Reg Arbuckle, Bruce Treichel, Bill Wishart, Debbie Kneller, Denise Pesce, Per Anderson, and Laurie-Ann DeBlois who typed the final manuscript. My thanks, also, to those who presented papers, participated in the panel discussion and field trip, and otherwise contributed to making this a very informative and enjoyable gathering.

R. Wayne Nelson

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APRIL 17-19, 1984

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1984 ELK WORKSHOP PROGRAM

Tuesday, April 17.

- 8:15 - WELCOME AND OPENING REMARKS.  
Bill Hall. Alberta Fish & Wildlife, Edmonton.
- 8:45 - CURRENT STATUS OF ELK IN NORTH AMERICA.  
Bob Hernbrode. Colorado Division of Wildlife,
- 10:00 - TECHNICAL SESSION - Effects of Disturbances.  
CHAIRMAN: Gerry Lynch. Alberta Fish & Wildlife,  
Edmonton.
- 10:00 - The Response of Elk and Mule Deer to Firewood Gathering on  
the Medicine Bow Range in Southcentral Wyoming.  
A. Lorin Ward. Rocky Mtn. Forest & Range Experiment  
Station, Laramie, WY.
- 10:30 - Roosevelt Elk and Black-tailed Deer Response to Habitat  
Changes Related to Old-growth Forest Conversion in  
Southwestern Oregon.  
Douglas A. Smithey & Michael J. Wisdom. Bureau of Land  
Management, Coos Bay, OR.  
William W. Hines. Oregon Dept. of Fish & Wildlife,  
Charleston, OR.
- 11:00 - Elk Concentrations in Areas Closed to Hunting.  
W. Daniel Edge, C. Les Marcum, & Sally L. Olson.  
School of Forestry, Univ. of Montana, Missoula, MT.
- 11:30 - Elk Status/Problems in Idaho.  
Lloyd E. Oldenburg. Idaho Dept. of Fish & Game, Boise
- 13:00 - TECHNICAL SESSION - Habitat Use, Foraging, & Techniques.  
CHAIRMAN: Eldon Bruns. Alberta Fish & Wildlife, Rocky  
Mountain House, Alberta.
- 13:00 - Habitat Utilization by East Kootenay Elk Populations.  
Goetz Schuerholz. Transamerica Environmental Science  
Consultants, Duncan, B.C.
- 13:30 - Assessment of Three Elk Winter Ranges in Alberta: an  
Appraisal.  
Luigi Morgantini. Dept. of Animal Science, Univ. of  
Alberta, Edmonton.  
Eldon Bruns. Alberta Fish & Wildlife Division, Rocky  
Mountain House, Alberta.
- 14:00 - Modeling Elk Habitat Use by Probability.  
Terry N. Lonner. Dept. of Fish, Wildlife and Parks,  
Bozeman, MT.

- 14:30 - A Tentative Model of Elk Habitat Selection.  
L. Jack Lyon. Forest Science Lab, Missoula, MT.
- 14:45 - Foraging Ecology of Wapiti in the Boreal Mixed-wood Forest, Central Alberta.  
Marie Nietfeld. Dept. of Animal Science, Univ. of Alberta, Edmonton.
- 15:30 - Digestive Efficiency of Wapiti with Variation in Diet: a Comparative Approach.  
Lyle A. Renecker. Dept. of Animal Science, Univ. of Alberta, Edmonton.
- 16:00 - Methodology for the Determination of DAPA (2,6 diaminopimelic acid) in Feces of Large Ruminants.  
Bruce B. Davitt & Jack R. Nelson. Dept. of Forestry & Range Mgmt., Washington State Univ., Pullman, WA.
- 16:30 - Artificial Breeding of Captive Wapiti.  
J.C. Haigh. Western College of Veterinary Medicine, Univ. of Saskatchewan, Saskatoon.
- 19:00 - Banquet. Guest Address - "The Great Newcomer - Elk".  
Val Geist. Faculty of Environmental Design, Univ. of Calgary, Calgary, Alberta.

Wednesday, April 18.

- 8:30 - PANEL DISCUSSION - Commercial Husbandry of Elk.  
CHAIRMAN: Bob Hudson. Dept. of Animal Science, Univ. of Alberta, Edmonton.
- 8:30 - Introduction: Elk Farming - Bob Hudson.
- 9:15 - Mixed Species Game Ranching.  
Elmer Ghostkeeper, Alberta Federation of Metis Settlement Associations, Edmonton.
- 10:00 - Legislative Controls and Enforcement.  
Jim Nichols, Alberta Fish & Wildlife, Edmonton.
- 10:30 - Social & Environmental Implications.  
Val Geist, Faculty of Environmental Design, Univ. of Calgary.
- 11:00 - Discussion.
- 13:00 - TECHNICAL SESSION - Elk Hunters, Research Techniques, Mortality, and Distribution.  
CHAIRMAN: Bill Glasgow, Alberta Fish & Wildlife, Red Deer.

- 13:00 - An Alberta Elk Hunter Profile.  
W.L. Adamowicz & W.E. Phillips. Dept. of Rural  
Economy, Univ. of Alberta, Edmonton.
- 13:30 - A Regional Cooperative DAPA Research and Development  
Program.  
Jack R. Nelson & Bruce B. Davitt. Dept. of Forestry &  
Range Mgmt., Washington State Univ., Pullman.
- 14:00 - Visibility Bias in Aerial Surveys.  
M.D. Samuel, M.W. Schlegel, & E.O. Garton. College  
of Forestry, Wildlife & Range Science, Univ. of  
Idaho, Moscow, ID.
- 14:30 - Vital Statistics of Winter Elk Mortalities on the National  
Elk Refuge, Wyoming.  
Bruce L. Smith. U.S. Fish & Wildlife Service, National  
Elk Refuge, Jackson, WY.
- 15:15 - Precision of Age and Sex Ratios: a Cluster Sampling  
Approach.  
M. D. Samuel & E. O. Garton. College of Forestry,  
Wildlife & Range Science, Univ. of Idaho, Moscow, ID.
- 15:45 - Factors Affecting the Survivorship of Male Elk in  
Southwestern Manitoba.  
Kenneth J. Rebizant. Dept. of Zoology, Univ. of  
Manitoba, Winnipeg, Manitoba.
- 16:15 - Wapiti in the Peace Region - Northern Limit of the  
Species.  
R. J. McFetridge. Alberta Fish & Wildlife, Peace River.
- 16:45 - Legal and Ethical Aspects of Reddeer Husbandry in Chile.  
Goetz Schuerholz. Transamerica Environmental Science  
Consultants, Duncan, B.C.
- 17:15 - Elk Workshop Business Meeting.
- 19:30 - TECHNICAL SESSION - Pot pourri & wrap-up.  
CHAIRMAN: Wayne Nelson. Alberta Fish & Wildlife,  
Edmonton.
- 19:30 - An Innovative Approach to Cutting Elk Mortalities on the  
Trans-Canada Highway, Yoho Park.  
Eric Langshaw. Parks Canada, Field, B.C.

20:00 - Xylazine, Yohimbine and 4-aminopyridine: Immobilization and Antagonism in Captive and Free-ranging Wapiti.  
Chris D. Olsen & Lyle A. Renecker. Dept. of Animal Science, Univ. of Alberta, Edmonton.

20:20 - Elk Depredation and Winter Feeding in Colorado.  
Bob Hernbrode. Colorado Division of Wildlife, Denver.

20:50 - Elk Workshop Summary.  
Harold Carr. Alberta Fish & Wildlife, Calgary.

21:10 - "Autumn Symphony".  
Luigi Morgantini. Dept. of Animal Science, Univ. of Alberta, Edmonton.

Thursday, April 19

8:00 - 15:00 - FIELD TRIP by bus to Elk Island National Park (elk traps and management) and the cooperative Alberta Fish & Wildlife/University of Alberta ungulate research station (elk bioenergetics demonstrations).

CURRENT STATUS OF ELK  
IN NORTH AMERICA

Bob Hernbrode, Compiler



## CURRENT STATUS OF ELK IN NORTH AMERICA

ROBERT D. HERNBRODE, Colorado Division of Wildlife, 6060 Broadway, Denver,  
CO. 80216

Prior to the 1984 Elk Workshop in Edmonton last April, State/Province Status Reports required 4 to 6 hours of a two-day meeting. The information presented was important, but was deadly boring and consequently, lost. To streamline the operation, I sent out a questionnaire to every State/Province/Country listed in Elk of North America (Thomas and Toweill 1982; pp. 36-59) even remotely appearing to have elk in 1983-84. I thought the product would give us a current continent-wide summary of elk status, contacts in Management and Research, reviews of ongoing research, and also which of the various States/Provinces are dealing with surprisingly similar problems. We were partly successful. The mimeo-copied report handed out at the Workshop has a wealth of information even though it is far from complete and does not give a complete continent-wide status.

I know I get tired of filling out questionnaires and apologize for forcing another one on you; but short of 4 to 6 hours of oral reports, I don't know any other way to streamline the dissemination of the information. Any ideas or suggestions?

The questionnaires were summarized (Table 1). A complete report is available through my office upon request. Send requests and comments to the address above.

For the 1986 Workshop, I will try again to get a continent-wide status report. A draft questionnaire is attached for your comments and recommendations.

### References:

Hernbrode, R. D., compiler, 1984. State and Province Elk Status Report, 1984. Presented at Western States and Provinces Elk Workshop. Edmonton, Alberta. April 1984. 102 pp. mimeo.

Thomas, J. W., and D. E. Toweill, eds. 1982. Elk of North America: Ecology and Management. Stackpole, Harrisburg, PA. 698 pp.

Table 1.

## 1982 ELK POPULATION DATA - ELK HARVEST DATA

STATE OR PROVINCE	POST-HUNT POP. ESTIMATE	AVERAGE $\frac{\sigma}{100/\theta}$ *RATIOS $\frac{\sigma}{\theta}$	LONG RANGE OBJs.	TOTAL HARVEST	LICENSES SOLD Res.	LICENSES SOLD NonR.	SUB- SPECIES
Alberta, Canada	15,000	11/100/16	Increase to 30,000 by 1999	1,891	33,036	296	Rocky Mt.
British Columbia, Can.	2,700 21,910	22/100/32	3,500-4,000 20,000	127 2,764	221 14,866	0 648	Roosevelt Rocky Mt.
Ontario, Canada	-----NO SUMMARY-----						
Saskatchewan, Can.	5,100	121/100/46	Increase to 7,485 wintering population	334	3,720	0	Manitoban
Manitoba, Canada	*includes 4,090 6,650	Riding Mt. Nat. Pk. 32/100/53	4,000 excluding Riding Mt. Nat. Pk.	965	3,708	0	Manitoban
Yukon Terr., Canada	90/100 (introduced in 1951-54)	NO DATA	NO DATA	-----NO SEASON-----			Manitoban
Alaska	1,000	12/100/36	1,500-1,800	151	673	32	Roosevelt
Arkansas	-----NO SUMMARY-----						
Arizona	16,750	NO DATA	12,000-13,000	2,399	9,368	152	Rocky Mt.
California	-----NO SUMMARY-----						
Colorado	132,827	14.5/100/56.5	135,000	30,208	141,213	57,485	Rocky Mt.
Michigan	750	NO DATA	600-800	-----NO SEASON-----			Rocky Mt.
Minnesota	-----NO SUMMARY-----						
Montana	Stable to upward	Varies	Maintain	15,936	92,402	17,000	Rocky Mt.

DRAFT STATUS REPORT QUESTIONNAIRE - WESTERN ELK  
WORKSHOP - 1986

1. State or Province \_\_\_\_\_

2. Species of elk - please complete one form for each subspecies:

Rocky Mountain \_\_\_\_\_

Roosevelt \_\_\_\_\_

Tule \_\_\_\_\_

Manitoban \_\_\_\_\_

3. Population status - for purposes of standardization, data should be presented as follows:

A. Post-season population estimate:

1984 \_\_\_\_\_

Long-term objective \_\_\_\_\_

Discussion: \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

B. Population demographics - 1984 post-season data:

Bulls/100 cows =  $\bar{X}$  \_\_\_\_\_

Range \_\_\_\_\_ to \_\_\_\_\_

100 cows/calves =  $\bar{X}$  \_\_\_\_\_

Range \_\_\_\_\_ to \_\_\_\_\_

Discussion: \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

4. Harvest

A. Fill in where possible:

	<u>Antlered</u> 1984	<u>Antlerless</u> 1984	<u>Total</u> 1984
Rifle	_____	_____	_____
Archery	_____	_____	_____
Muzzleloading	_____	_____	_____
Total	_____	_____	_____

B. Licenses sold - 1984

- Resident \_\_\_\_\_
- Nonresident \_\_\_\_\_
- No. of hunters \_\_\_\_\_
- Hunter days/elk killed \_\_\_\_\_
- Percent success \_\_\_\_\_

C. How is data gathered? \_\_\_\_\_

5. Elk season structure - discuss how licenses are issued, opening and closing dates, season lengths, trophy areas, etc.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

6. Management problems and concerns: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

7. Short synopsis of ongoing research with references:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

7 (continued)

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8. Recent publications pertaining to elk. Please list titles and source:

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9. For more information, please contact:

Research \_\_\_\_\_

Management \_\_\_\_\_

PANEL DISCUSSION  
Commercial Husbandry of Elk

April 18, 1984  
Bob Hudson, Chairman



## ELK FARMING

R. J. HUDSON, Department of Animal Science, University of Alberta,  
Edmonton, Alberta, T6P 2P5

Current interest in game production is not a local phenomenon. It is part of an international wave endorsed by the IUCN/UNDP World Conservation Strategy. Internationally, the most promising candidates for commercial production are red deer and wapiti. This paper traces the development of the concept and its potential with special attention to Alberta where enabling legislation is pending.

### DEVELOPMENT OF THE CONCEPT

The modern origin of game production can be traced to western biologists working in Eastern and Southern Africa faced with the harsh reality that if wildlife were to survive, it must pay its own way. They were motivated by the perceived need to stem the replacement of wildlife by livestock and the resulting degradation of rangelands. The slogan was "conservation through utilization". Supply of protein was a justification rather than a goal.

#### Game Cropping

The earliest attempts were made to harvest free-ranging, sometimes migratory populations. Game cropping maintained the greatest degree of naturalness but economics required heroic campaigns launched against dense congregations of game. The scale of the operations was repugnant to the public while the pulsed supply created problems of meat distribution. Such operations had to be conducted by well-trained teams and did little to influence the behavior of landowners.

#### Game Ranching

Game cropping has been almost entirely replaced by game ranching on fenced properties. Although expensive, fencing is now recognized as a necessity. Fences clarify ownership and prevent crop damage on neighboring properties. By restricting migratory movements, fences serve to stabilize product supply, an essential requirement of market development.

### GAME RANCHING IN WESTERN CANADA

When the Alberta Wildlife Production Research Committee was formed in 1974, we wondered whether similar reasoning might apply in Western Canada.

Given the massive onslaught on the boreal forest at the time, it seemed as if much of northern Alberta would be developed for livestock production. We reasoned that the lesser of two evils would be to encourage production of native species. After all, wouldn't this serve the goal of landscape conservation?

Our local model was Elk Island National Park which has provided an impressive annual harvest simply in the process of controlling populations. Numerous studies have since documented this productivity and examined its ecological basis. The productivity of Elk Island exceeds that of the adjacent Blackfoot Grazing Lease which supports seasonal grazing by livestock.

The wisdom of hindsight now points to several problems with Elk Island as a model for the emerging game industry.

1. To be economically viable, game ranches must be large. Few people own large land bases and public lands are already heavily committed. This limits opportunities to Indian and Metis people with a communally-owned land base.
2. Breeding stock is scarce which means a long time to enter-prise maturity.
3. Regulations which protect the public wildlife resource (e.g. high fencing standards, tagging requirements) along with market competition which forces compliance with superior standards of meat hygiene, impose high material and managerial costs. This means that natural stocking densities tend to be lower than economic densities.

#### GAME FARMING

These forces, along with the requirement that game production must be conducted on private land, create a rather different future for game production than we originally conceived. Before, we saw the influence moving from the agricultural fringe outward. Now, we see it moving onto increasingly better agricultural land. This trend is very noticeable in New Zealand where sheep and deer have reversed roles.

Although new legislation will formalize conditions for raising a variety of wild species, only wapiti will join bison on farms in any numbers. Deer are too hard to contain, and moose do not thrive under intensive management. Production costs for moose are over \$850/yr. In general, only the Cervinae are resistant to disease, and the only representative we have is the wapiti. This is the only species with a long-term international market potential.

We should anticipate intensive management of wapiti to dominate the game farming scene. The purists cry that these animals will be raised like domestic livestock, and that we will be no further ahead. But there

is less motivation to replace natural vegetation, and game production is sufficiently economic to move onto croplands. There will be a net gain in habitats available for wildlife such as gamebirds, waterfowl, raptors, and even deer which move freely across game fences. Besides, game ranches will provide interesting variety to the agricultural landscape.

Wapiti provide an excellent opportunity for farmers to diversify their operations at a time when the vagaries of the beef price cycle have left many farm families destitute. Wapiti are surprisingly productive, easy to manage and quite profitable. They are suitable for farm families with small holdings so benefits need not only accrue to a small powerful elite.

#### CONTROLLING ILLEGAL DEALINGS

Although the viability of wapiti farming can no longer be questioned, we must be able to assure the public that the industry can be controlled. The Alberta Fish and Wildlife Division has drawn up a comprehensive set of effective and realistic controls which will be willingly accepted by prospective farmers. These regulations have been carefully studied following consultations with representatives of various nations with game industries. The essential features are:

- Only indigenous species can be raised.
- Only securely fenced private lands will be licenced.
- Animals must be tagged and registered.
- Animals will be slaughtered only with ante-mortem inspection at licenced plants.
- Meat will be cryopacked with a distinctive label. The seal will be broken immediately before use.
- Velvet antlers will be cut with the supervision of a veterinarian who will sign security documents.

These provisions will ensure the orderly development of an industry which will make an important contribution to rural development without threatening the traditional role of wildlife in the public domain.

## MIXED SPECIES GAME RANCHING ON METIS SETTLEMENTS

ELMER GHOSTKEEPER, Alberta Federation of Metis Settlement Associations,  
400 Dorchester Bldg., 1035 - 109 Street, Edmonton, Alberta T5J 1N3

I welcome this opportunity, as President of the Alberta Federation of Metis Settlement Associations, to address this workshop on Elk Husbandry. I'm sure it will be useful to briefly outline some general background about the Alberta Metis Settlements before addressing more specifically the issues at hand.

There are, at present, eight Metis Settlements in northwestern and northeastern Alberta. The names of the settlements are Big Prairie, Caslan, East Prairie, Elizabeth, Fishing Lake, Gift Lake, Kikino and Paddle Prairie, and in total they represent a land base of about one and one-quarter million acres. This is the only collectively held, legislatively established Metis land base in Canada. There are approximately 4500 Metis residents on the Settlements.

I would like to speak briefly on this historical establishment of the settlements, the structure of the self-governing body and the Metis settlements' economic development mechanism.

It was on the plains of western Canada in the late 18th century that the Metis nation developed. As generations passed, a unique lifestyle, culture and livelihood emerged.

As development of the country progressed, more and more eastern Canadian and European settlers moved westward and the Metis traditions and lifestyle were threatened. This resulted in the Metis resistances in the Red River settlement area in 1870 and in Batche and Duck Lake in 1885. The Metis, in an effort to preserve their traditional lifestyle, land and resources, and to avoid further conflict, moved farther west and north into what is now Alberta. During the depression of the 1930's, the Metis' living conditions deteriorated to such a degree that certain Metis leaders began lobbying the Provincial Government.

As a result of the pressure by the Metis, in December, 1934, the Alberta Government established the "Royal Commission Appointed to Investigate the Conditions of the Half-Breeds of Alberta" - commonly referred to as the "Ewing Commission".

The Ewing Commission held a number of discussions and consultations with Metis people of Alberta. It is interesting that the Commission was appointed to investigate the "Health, Education and General Welfare" of the Metis population and that there was no mention of a land settlement. Despite this, no one involved in the Commission seemed to doubt that the establishment of settlements for the Metis would be the main outcome of the Commission.

Following the recommendations of the Ewing Commission, the Metis Betterment Act was passed in 1938. It set aside land for Metis and provided for the establishment of Settlement Associations to occupy the land. The Metis Betterment Act, and the ten Alberta Regulations struck pursuant to it, have a great influence on the lives of the Metis settlers. Besides setting aside land for the Settlements, it also created a system of local government in the form of Settlement Association Councils. These Councils, which consist of five members democratically elected by the Settlement Association, have the power to enforce the rules and regulations in the Metis Betterment Act affecting land allotment, membership, hunting, fishing and trapping, timber, grazing, surface rights, and the administration of funds. In other words, the Councils make important decisions affecting Metis settlers on a daily basis.

The Federation of Metis Settlements was incorporated in May, 1975, to provide a unified political voice for the eight Metis settlements of Alberta. The Federation is governed by a twelve member Board of Directors consisting of the Chairman of each Settlement Council and four Executive Officers, elected at large for two year terms from the Membership of the Settlement Associations.

The economic development arm of the Metis settlements is also important in terms of developing an active and viable wildlife ranching industry. Settlement Sooniyaw Corporation is the economic and business development organization representing the eight Metis settlements in Alberta. The Corporation was conceived in the late 1970's and federally incorporated under the Canada Business Corporations Act in October 1980. It was officially launched in January, 1982, when the Settlements purchased share certificates and contributed start-up capitalization to the organization.

The overall objective of the Corporation is to encourage local economic development, control and self-reliance on the Metis Settlements. The more specific goals of the organization are as follows:

1. To support development of businesses that provide employment and ownership opportunities to residents;
2. To develop local capacity for self-directed sustained economic growth; and
3. To develop an independent system of capital assets and mechanisms capable of accessing traditional capital sources.

Over the past two years, Settlement Sooniyaw Corporation has become operational and has successfully launched a number of economic development initiatives.

The traditional "cultural economy" of the Metis nation and of the Metis on the Settlements has been one of hunting, fishing and trapping. The reliance on wildlife in that system is obvious. The Metis have a long history of relationships with elk and wildlife in general, as a means of subsistence. With the re-establishment of a Metis land base via the Metis Settlements in Alberta, the opportunities for farming, ranching and other

more sedentary methods of livelihood re-emerged. The lifestyle of the Metis on the Settlements improved, and we became established rural residents of the province.

With this modification in lifestyle, however, we saw no reason to abandon the means of livelihood that the Metis had relied upon and with which we had many years and generations of tradition and experience.

The Metis are, as you all know, an aboriginal or indigenous people of this country. The elk and other wildlife that were and are important in the cultural economy of the Metis are, of course, indigenous animals. There is nothing surprising in the fact that we have and do rely on these animals for subsistence and that in doing this, we have built up an expertise in the area. From obtaining food and clothing through hunting and trapping, we have experienced these animals in their natural habitat - from this we have - over a great deal of time - come to know their environment and other characteristics that are important for them to survive and flourish.

I would like to speak briefly about the ABORIGINAL RIGHT of the Metis to participate in their "cultural economy".

The Metis people are seeking constitutional recognition of their right to hunt, fish, trap and gather food according to our traditions. We are seeking affirmation of this right for the purpose of obtaining food and for the commercial development of such resources, through the Aboriginal constitutional process and through our participation in the review of the Metis Betterment Act and Regulations. Such a right would be subject to sound management of the resources and to conservation practices.

The Metis people do not want management and conservation practices to be arbitrarily set and enforced on us without our consent. To this end, we are striving for a constitutional right to be involved in the development of such management and conservation programs jointly with the level of government with jurisdiction on a given area. In the event that such programs require closed seasons, quotas or other restrictions on harvesting rights, the Aboriginal people want to receive first priority access to these surface resources.

The Metis who earn a livelihood from traditional economic activities resent the wildlife management systems imposed on them by the provinces and government biologists. As Aboriginal people, Metis believe they can manage wildlife resources more efficiently than government.

We feel strongly that government regulations must not hold back the return of Metis and Aboriginal peoples to means of livelihood from which we were historically displaced.

It is important to realize that we are suggesting that wildlife ranching is a contemporary manifestation of an Aboriginal right. For that reason and because it would take place on Aboriginals' lands, we recommend that Aboriginal people receive first priority access to wildlife ranching opportunities. We are not advocating any large scale or general policy to

allow private and/or crown land to be allocated for wildlife ranching. The Aboriginal people of Alberta relied on wildlife from their first days long before the Europeans settled in this province. Given the limited but real markets that are available for wildlife - particularly elk - and the right Aboriginal peoples have to continue their traditional cultural economy, we feel there are great advantages to providing legislative, regulatory and policy allowances for commercial wildlife ranching on Aboriginals' lands.

Many Metis Settlers are involved in employment opportunities that digress substantially from those of the "cultural economy". These are occupations that are associated with industries such as oil and gas exploration and exploitation. One primary advantage to an industry such as wildlife ranching is its renewable resource characteristics.

Because of this, well established and managed wildlife ranching operations are sources of livelihood that will enhance the lifestyle and well-being of the Metis for generations to come.

I would like now to address some of the current specific political issues that impact on Metis Settlement wildlife ranching.

As I have mentioned, the Metis Settlements were established and are administered under the Metis Betterment Act and Regulations which were passed in the Provincial Legislature in the late 1930's. At the present time, this legislation is in the process of being revised and the government has established, by order in council, a Joint Settlement/Government Committee to review the Act and Regulations. This is chaired by the Honourable Dr. Grant MacEwan, and its membership consists of John Thompson, M. L. A. & Chairman of the Cabinet/Caucus Committee on Native Affairs; Robin Ford, Assistant Deputy Minister of Municipal Affairs; Randall Hardy, Chairman of Kikino Metis Settlement, and myself. This Committee has agreed to recommend that Settlement Councils shall allocate the use and occupation of land on the Settlement and shall have management authority over hunting, fishing, trapping and gathering. The Joint Committee agreed that the principles should be implemented by efforts to have them recognized in legislation that is deemed appropriate.

The recommendations of the Joint Committee, and the other political process that the Federation is involved in, have the common aims of increased political self-determination and increased economic development for the Metis Settlements. We believe very strongly that the way of producing economic self-reliance is through increased political self-determination. Economic development should be pursued through a balanced approach between the Metis cultural economy and modern employment and business opportunities.

One piece of legislation that has been deemed appropriate in terms of recognizing Metis authority over Metis lands, and that is of issue in elk husbandry, is the Alberta Wildlife Act which is presently in the process of being revised and updated.

The Alberta Federation of Metis Settlement Associations has studied the government's discussion paper on proposed revisions to the Wildlife

Act which was issued in November, 1983, and the October, 1982, Alberta Energy and Natural Resources publication entitled "Fish and Wildlife Policy for Alberta".

We were pleased to note in the October, 1982 policy publication, a number of instances where the Alberta Metis Settlements were given specific consideration. Two cases are section 23 and 24 of the Wildlife Policy which say:

- 23) The Division will encourage an environment which fosters the development of a domestic wildlife farming industry on private land and Metis Settlements . . .
- 24) The Division will encourage an environment which fosters the development of a game ranching industry on private land and Metis Settlements . . .

Upon reviewing the more recent November, 1983 discussion paper, however, we noted that these particular items and others that pertained specifically to the Metis Settlements, were not included. We realize that not all of which is government policy may be included in legislation, but we do feel that the Alberta Metis Settlements represent a case where statutory inclusion is warranted. It is our belief that a new Wildlife Act should provide that fish and wildlife regulations on Metis Settlements are governed by principles similar to those of the (new) Metis Betterment Act and Regulations.

## ELK RANCHING - LEGISLATIVE CONTROLS AND ENFORCEMENT

J. R. NICHOLS, Standards and Operations Section, Alberta Fish and Wildlife Division, Main Floor, N. Tower, Petroleum Plaza, 9945 - 108 Street, Edmonton, Alberta T5K 2C9

I do not intend to speak specifically on elk ranching but instead will be directing my comments on game ranching in general. The comments and concerns expressed, however, will no doubt be applicable to elk ranching.

From an enforcement point of view, we are very concerned about the impact of game ranching on the wild resource. This material was not prepared to propose solutions or safeguards, but rather to raise the questions and suggest that if we are to proceed, it must be with caution.

The Fish and Wildlife Policy for Alberta provides that the Fish and Wildlife Division will encourage an environment which fosters the development of a domestic wildlife farming industry and a game ranching industry on private land and Metis Settlements. This objective is to be accomplished through:

- 1) the provision of a permit for the purpose of transporting and retaining wildlife;
- 2) the provision for capturing breeding stock from the wild under the authority of a permit;
- 3) the development of criteria for the conditions of captivity and sale of wildlife managed under farming or ranching licences.

In the broadest terms, there are three obstacles to the establishment of viable wildlife farms and ranches, and these might best be identified as philosophical, regulatory and enforcement.

Before providing detail in these regards, it might be best to consider the history of the current legislation, specifically the Game Bird Farm Regulations, the Big Game Farm Regulations and the Pheasant Shooting Ground Regulations.

Fish and Wildlife records indicate that there were few provisions with respect of wildlife farming prior to 1958 and those that did exist were made under the Game Act. In February of 1958, the Game Bird Farm Regulations came into being. These regulations dealt exclusively with game birds and provided mainly for their import, their being kept captive, released to the wild and export. In July of 1959, the Big Game Farm Regulations were passed and provided for, in essence, private zoos. Provisions for barter and exchange of animals were only made for licencees

or zoological gardens financed wholly or partly by public funds. September of 1965 saw the establishment of a Controlled Pheasant Shooting Ground Regulation.

Game bird farm regulations have been modified over time to provide for sale of table-ready pheasants. That, coupled with the advent of pheasant shooting grounds some years ago, suggests that commercialization of at least some forms of wildlife is acceptable to the general public.

Perhaps, this provides an appropriate lead-in to discussion of the philosophical barriers to wildlife farming in a true agricultural sense.

#### PHILOSOPHICAL CONCERNS

The philosophical barrier has, perhaps, five facets. The most significant of these, in my view, is the suggestion that farming and ranching of wild animals degrades wildlife. Large segments of the public subscribe to the belief that wildlife should remain wild.

The second aspect of the philosophical question is in respect of the right of property in wildlife. Alberta's Wildlife Act has provided and will continue to provide that the right of property in wildlife is vested in the Crown in the right of the province. Game farming and ranching cannot become viable industries unless the farmer or rancher owns the wildlife he produces. Therefore, provision is necessary to transfer the right of property in wildlife. This can be accomplished in various ways. Perhaps, we should legislate that wildlife collected from the wild remains the property of the Crown and that it be leased for breeding purposes. Further provision could then be made that progeny becomes the property of the producer.

Genetic matters are another element of the philosophical concern. These matters will, no doubt, be dealt with by others during this workshop. Suffice it to say that once the specifics of the matter are determined, legislation will have to be developed to provide against what is unacceptable.

While pheasant shooting grounds have not been vigorously opposed, much opposition to the concept of "paid hunting" of big game already exists. The Wildlife Policy for Alberta has addressed these concerns by supporting only the hunting of captively reared game birds. Conformity with that stated Policy is essential to gaining a measure of public support.

Finally, it would seem the hunting fraternity has some concerns respecting the possibility of trophy production from game farms and ranches. This is somewhat ironic as it represents the absolute opposite to a point that will be raised later as we discuss enforcement. The fear being voiced by the sportsman is that Boone and Crockett records may ultimately be held by those who procured their trophy through a game farm or ranch rather than by taking it under the fair chase concept.

The philosophical aspects of game ranching are, no doubt, much broader than those outlined above. The foregoing is a summary of the concerns voiced most often since the Fish and Wildlife Policy for Alberta was released to the public.

#### REGULATORY CONCERNS

The regulatory and enforcement issues might be somewhat difficult to separate. By "regulatory", I mean the creation of the legislation necessary to govern game farming and ranching while by "enforcement", I mean the application of that legislation.

At the outset, I paraphrased a portion of the Wildlife Policy of the Fish and Wildlife Policy for Alberta that indicated that these industries would be encouraged by providing authorization to hold wildlife on farms and ranches, providing for the capture of breeding stock, and permitting sale of produce. Unfortunately, that is an over-simplification of what needs to be done.

It is interesting to note that the Game Branch first came into being under the Department of Agriculture, and when it was separated from that Department, the Department of Agriculture retained the legislative and administrative authorities over fur farming. There is, therefore, a school of thought that game farming and ranching should be similarly arranged. It is worth noting here that fur farming is facilitated through provisions for collection of breeding stock made under the Wild Fur Industry Regulations which are made pursuant to the Wildlife Act.

The business of livestock production is one which is regulated by both federal and provincial law. Health of animals is, to a large degree, the responsibility of the federal government. The Animal Disease and Protection Act and its regulations are the responsibility of the federal government, and ultimately, these regulations will have to provide for wildlife that is produced on game farms or ranches. It is interesting to note that the Animal Disease and Protection Act provides an authority to make regulations in respect of health of animals for zoos and game farms. I am not aware that any such regulations have been made but suggest that they will be essential if significant game farming and ranching operations are developed within this province or elsewhere in Canada.

On the provincial side, statutes such as the Stray Animals Act and the Livestock and Livestock Products Act will have to be modified or regulations made under them will have to be amended to provide for and accommodate domestic ranching of wildlife. For example, it may be difficult to tell tame elk from the wild one unless they are clearly branded. Those producing wildlife on farms or zoos and for other display purposes will be reluctant to brand their animals.

Since the release of the Fish and Wildlife Policy for Alberta, the question of humane treatment of animals on game farms and ranches has been raised repeatedly. There are those that insist that special provisions in this regard must be incorporated in any regulations that we generate to

govern game farming and ranching while others maintain that provisions of this nature should be found in the Animal Protection Act and/or the Criminal Code of Canada.

The point I am trying to make, is that once game farms and ranches are established by the three initiatives set out at the outset, perhaps the remainder of the regulating should be left to those acts and regulations which generally provide for production of livestock and marketing of the products.

If that were to be done, and I'm not suggesting it would be a simple task, the Fish and Wildlife Division would then be left with the responsibility of developing legislation which would provide for conditions of captivity that would protect the wild resource, and provide for the sale of the wildlife produced in a manner that would assure that the wild resource would not be jeopardized by that activity.

That will be the most difficult task of all.

#### ENFORCEMENT CONCERNS

Current trends would indicate a lucrative market exists for utilization of big game species in a broader sense than is normally recognized by most Albertans. Because of our relatively short history in game management, the opinion is that wildlife's primary value is in its red meat. This, in fact, is not necessarily the case.

Recent experience in understanding and combating the illegal trade in animal parts for food, trophies and medicinal purposes has shed light on a growing demand here, as well as Europe and Asia. These demands far exceed supplies which can be provided through game farms, as they are beginning to adversely impact the far greater wild supply. The avenues to disperse the illegal trade are presently restricted. It may well be that by providing a legal avenue through which wildlife can pass, the flow from the wild populations will occur unhindered. It is not the concern of how domestically raised stock is dispersed but rather, the injection of those animals belonging to the Crown, that is repeatedly raised. It is impossible to differentiate meat or antlers raised on a farm from that taken legally or illegally from the wild. In an effort to adequately discourage elements from the wild population entering into the stream from producer to consumer, extensive and strict regulations would be required at a time when deregulation is being attempted.

Areas of trade that would be established, and regulations which would be required to adequately govern legalized trafficking, are as follows:

##### 1) Traffic in meat

Because game farms are for profit and not wildlife enhancement, the producer obviously will be offered a wide variety of potential markets. This would include over-the-counter sales, sales to retail food outlets and to restaurants or other service outlets. It would

be necessary to trace the origin of the meat back from the final consumer to the producer no matter how many hands it passed through. Acceptable documentation would be required at each level to account for each animal slaughtered pound by pound. Any weakness in this chain of accountability could and would be utilized by unscrupulous persons to inject undetectable volumes of illegal meat onto the market. Meat produced on a game farm, once it has been reduced to steaks and roasts, will be impossible to separate from wild meat.

2) Traffic in Animal Parts for Medicinal Purposes and Aphrodisiacs

Covert investigations in this country and the U.S. have proven time and again that an extremely lucrative market exists for these items, especially in Asia. So much so that persons buying these items have indicated they quite literally ask their own price and have no fear that demand will decrease or that competition will affect business. At this time, in Alberta, antlers in velvet are being sold for \$80 an ounce and a wide variety of items from hooves to penis bones fetch a variety of prices, though rarely under \$20. These were observed in stores, presently in business, openly being offered to mainly Asian clientele. To regulate the flow of these items, ranchers would be required to keep accurate records of age and sex of animals. Cropping antlers in velvet would require confirmation of poundage cropped and a proper trail to the consumer would be required to balance pounds legally produced and pounds resold. The same avenue for abuse as outlined in the meat section applies here.

3) Access to land for the purpose of hunting

This could be a natural outgrowth of game ranching. Whether or not this is an acceptable practice to the majority of Albertans, may be an issue here.

4) Growing of Trophies for Sale

At first examination, game ranchers may be in a position to provide large heads for mounting. The sale of mounted heads, though not expressly permitted by the Wildlife Act or Regulations, has been allowed to grow during the past few years. Experience would indicate, though, that the difficulty in acquiring a large trophy mount has a definite influence on the value placed on it. This being the case, a large trophy taken under adverse conditions from the wild would be more valuable than that domestically raised. A trophy purchased from a farm, however, could be utilized to cover up the sale of a more valuable item with little difficulty.

These examples are only a few and represent only the most basic way in which a system set up to facilitate legal traffic could be used to expedite the movement of illegal wildlife, not only Alberta's, but endangered species from other jurisdictions where more stringent protective legislation has interrupted its movement there as well.

The final point of concern is that of attempting to deal with those persons who operate in a manner outside the original purpose of game

ranching, that is to say, those who are in fact profiting from illegal trade. Fines would have to be sufficient to take the profit out of those ventures for however long the practice was taking place. Cancellation of the licence to operate a game farm, and avenues to preclude those persons from operating through someone else, would have to be implemented to be an effective deterrent.

In closing, I would like to suggest that we are not convinced that this enterprise represents a significant long term commercial opportunity. It might be advisable to have the economics examined before we rush in. I have heard the suggestion that the only money to be made in game ranching is on the ground floor supplying breeding stock. Once sufficient breeding stock is available, apparently markets dry up.

I think it is important to suggest that, if we are going into this, we should go into it carefully and slowly. Maybe only two or three species should be provided for in the initial regulations, perhaps elk, white-tailed and mule deer.

## A CRITIQUE OF GAME RANCHING IN ALBERTA

VALERIUS GEIST, Faculty of Environmental Design, The University of Calgary, Calgary, Alberta. T2N 1N4. 1985-01-15.

The intent by the Alberta ministries of Public Lands and Wildlife, and Agriculture, to establish game ranching has reached the stage that enabling legislation was passed on November 13, 1984, in the form of Bill 84. The debate about game ranching, however, is not subsiding. Some changes in position by the advocates of game ranching have taken place. They have now adopted the position that game ranching cannot be economically carried out on large tracts or relatively unproductive lands. Rather, game ranching will now be confined to small, intensely managed parcels of land. No longer will game ranching economically utilize "marginal lands" (although this part of their change of mind has failed to reach the Alberta ministries of Public Lands and Wildlife, and Agriculture, as seen from page 5, point IV, of the "Big Game Ranching Discussion Paper", October 30, 1984). No longer is game ranching a means of providing land for the landless, or for salving the uncontrolled access of native people to Crown land. However, should native communities indeed accept game ranching, and the advantages it offers them as described on page 4, then their land claims may indeed be weakened. Without any doubt, the argument for game ranching as now advanced by its proponents is more reasonable, more attuned to economics, than were the earlier promotions. Nevertheless, the chief argument against game ranching in the North American context is not weakened by the recent stance.

The problem with game ranching is that it creates a market for wildlife meat and products, as well as an infrastructure for the export of such products. Markets for wildlife, however, have led in North America to uncontrollable slaughter of wildlife, and were consequently stamped out -- though never entirely! In Europe, an intense policing effort is required to protect wildlife, a policing effort that far exceeds anything we normally envision. To understand this point it is necessary to look at how wildlife protection operates in North America.

The two pillars of wildlife conservation in North America are public ownership of wildlife, and equalitarian access to wildlife. Market forces have been pointedly excluded in the allocation of wildlife, just as they have been excluded in the allocation of water. These are two very important policies as they lead to concerned self-interest in those that desire a share of the wildlife harvest, to a willingness to sacrifice a little on behalf of wildlife, to refrain from killing outside the law, and to taking a dim view of those that flout the allocations. It is not at all surprising therefore that wildlife has not only a lobby in the large hunter associations, the naturalists, the societies dedicated to the conservation of waterfowl, bighorns, wolves, etc., but that wildlife is worthy of district ministries -- depending on jurisdictions. Granted this deep concern for wildlife, it is logical that wildlife laws are largely self policing, and that only a dwindlingly small number of wildlife guardians -- which go about their business unarmed -- is sufficient to provide fairly good protection. This self policing, cheap, very civil

system of wildlife protection is a great achievement of North Americans, an achievement envied abroad, and for good reason.

Germany has a rich tradition in wildlife management. It is this country that normally is referred to when reference is made to the "European" systems, and its way of managing and protecting wildlife is indeed very different from that of North America. It is a system that also "works", although by comparison with North America it is a system with a much poorer record in conservation and wildlife protection, and one based on an extraordinary effort in policing. There is a market for wildlife meat, and poaching -- of a much more sinister type than in North America -- has always been a problem. The problem has its roots in the fact that a legal market for wildlife meat attracts poachers that usually are hardened criminals. To cope with the policing problem the German system deputizes each of the hunters into police officers. To become an officially sanctioned hunter is a great honour reached only after preparation, exams and police clearance; part of one's preparation is to learn when, and when not, to use firearms in the task of wildlife protection. Poachers and hunters have been killed in shoot-outs. In Germany there is a great legal barrier to the acquisition of firearms.

Let us now look at some statistics that drive home the point of how terribly difficult it is to protect free-living wildlife. In West Germany, there were (in 1982) some 75,000 square miles of huntable land. To protect wildlife there are about 65,000 hunters that lease land for hunting, each one deputized as a policeman. In addition, about 1,000 hunters are professionally occupied managing and protecting private hunting preserves, while an unknown number are foresters protecting public, as well as private hunting areas. Furthermore, there are about 200,000 licenced, registered hunters, which, if they gain hunting privileges, may become deputized policemen. At a minimum there is thus one deputized wildlife protector per square mile of huntable land, as well as the regular police force that also plays a role in wildlife protection. Compared to Germany, Alberta, with a land area about 2.63 times greater than that of West Germany, employs a mere 100-odd game wardens. Granted that Germany's 260 'regiments' of actual or potential wildlife protectors are only on the job part-time, and may spend only two days per week or so on their hunting area, their policing effort is still several thousand-fold greater than ours! And, their wildlife protectors are armed; ours are not! How can we even hope to protect our wildlife against commercial poaching if we allow a market in wildlife meat to develop?

It is important that our arguments pro or contra game ranching not lose sight of established experience and facts. The New Zealand initiative in game ranching is based on circumstances quite different from ours in North America. They have no conflict between game ranching and the need to protect a stock of native wildlife. In fact, the contrary is the case. In New Zealand, deer are introduced, and justly treated as a pest on the land due to the great damage they have caused to the flora, fauna and soils. Anybody who can eliminate them strikes a blow for conservation, including those that gun deer from helicopters and sell their carcasses, skins, etc. The helicopter and automatic rifles, coupled to European and Oriental markets, have given New Zealand's native biota at least a small chance of recovery. Deer on public land there are a plague;

here they are an asset and a deeply cherished one. In New Zealand, a market for deer meat is a boon to conservation, here it has been an uncontrollable destructive agent on wildlife, and illegal markets continue to be so to the present.

Could not game ranching swamp the market with wild meat, making poaching uneconomical? In an ideal world, in fairy land, everything is possible. Not so in the real world. Long before the "swamping" could occur, our stocks of wildlife will be depleted or vanished. The market hunters of old did not have today's network of roads, fast vehicles, systems of electronic communication, night-sighting equipment, long-reaching rifles, or silencers. Given the God-given opportunity of a legal market to be infiltrated -- how is our unarmed, little handful of game guardians to protect wildlife, how will they carry out their mandate? How long before one of them, trying to do his duties against a gang of armed poachers, will loose his life? Even a modicum of understanding of the problems surrounding today's criminals that kill wildlife for the small, smouldering illegal markets, should make it evident that the above questions have a basis in stark reality.

The discussion paper on game ranching does envision park-like amenities on game ranches for the public. Unfortunately, the public and game ranching are not compatible. Should any game rancher let the public move through his stock of animals via ski trails or hiking trails he faces the legal consequences of one of his tame animals attacking a hiker, or -- if his stock remains shy -- he faces a loss in production due to the cost of excitement to the animals, and inefficient use of forage. There is no escape from this dilemma. We can safely assume that game ranchers will be even less pleased with trespassers than are cattle ranchers! Clearly, more thought and care in researching facts must be given before embarking on a promotion of game ranching.

Inadvertently, the discussion on game ranching raises a point not addressed: If game ranching can produce bountiful wildlife on "marginal" land, what has prevented the Fish and Wildlife Division from generating that bounty?

Is not the Minister aware of the market demand for wildlife-based recreation? This demand is staggering in North America, as so pointedly exemplified by the Texas system of leasing the shooting farms for game birds, the private hunting preserves stocked with exotics, etc.? Is not the Minister aware of the deep economic net tied to recreational wildlife that he is now endangering in Alberta? Any wildlife surplus that can be generated on "marginal lands" in Alberta would find, only too ready, a paying taker, increasing both the cash flow to government and affected municipalities. Those of us in wildlife management are aware that some increase in wildlife can be generated, provided the demand is recognized and channeled, and not abandoned and ignored as it is today. What of wildlife enhancement? Why is it not explored instead of game ranching?

TECHNICAL PAPERS



THE RESPONSE OF ELK AND MULE DEER TO FIREWOOD GATHERING ON THE MEDICINE BOW RANGE IN SOUTHCENTRAL WYOMING

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Abstract: More than 1,000 cords of firewood were removed by the public from the North Fork and Rock Creek Park area of the Medicine Bow National Forest during the summer and fall of 1980. Telemetered elk and their associates were disturbed by the presence of humans and preferred a buffer area of 800 m. Telemetered mule deer were more tolerant of the disturbance and continued to use the area although they generally stayed in the trees. Because firewood gatherers are so sporadic and scattered, it may become necessary to control their access in order to allow elk and mule deer to use their preferred habitat.

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INTRODUCTION

Studies on elk (Cervus canadensis) and mule deer (Odocoileus hemionus) behavior in relation to roads and traffic, recreation, and timber harvest have been conducted on the Medicine Bow Range of south-central Wyoming since 1974 (Ward 1976; Ward et al. 1976, 1980). A heart rate monitoring telemetry system was developed and used to collect both passive (animal alerted) and active (animal alerted and displaced) responses of elk and mule deer to various human disturbances on the Pole Mountain area east of Laramie (Ward and Cupal 1979, Ward et al. 1980). These studies showed that the response of hunted populations of elk and mule deer is quite consistent and fits a general pattern. Both species are more disturbed by people walking than by moving vehicles on roads and highways. Elk are more sensitive to human activities and prefer to stay at least 800 m from people walking and 400 m from the traffic on Interstate 80. Deer will tolerate people walking up to 200 m and use the habitat up to within 100 m of the traffic on Interstate 80. The distance of response becomes much greater (3,200 m for elk and 800 m for deer) on winter ranges where there are no conifer trees.

As this earlier data was being collected, there was a significant increase in firewood gathering activity in the forested areas of the elk and mule deer summer range, most likely because the high costs of heating fuels and the prospects for future energy use restrictions made people look to wood as another source of heat. This increase in firewood gathering by people living in nearby cities, such as Cheyenne and Laramie, was not very noticeable until the summer of 1979, when it was common to see pickups, trucks and trailers loaded with firewood coming out of the

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forest. A trip to the headwaters of the North Fork of the Little Laramie River or Rock Creek on a weekend was met with a parade of hauling equipment and the sound of chain saws.

Under the conditions that existed during the summer of 1979, the elk and mule deer were faced with a great deal of human activity, including firewood harvesting and the building of a new road associated with the Fallen Pines timber sale and an oil well drilling site. Personnel from the Medicine Bow National Forest and the Laramie District Office of the Wyoming Game and Fish Department expressed concern about the situation and wanted information on the impacts on the elk and mule deer and recommendations to alleviate or mitigate problems that may develop. This study started during the winter of 1979-80 and continued through the summer of 1980. Periodic observations of telemetered animals continued through the winters of 1980-81-82 and the summers of 1981-82.

#### STUDY AREA

The study area comprises part of the Laramie District of the Medicine Bow National Forest and the adjoining private property to the east

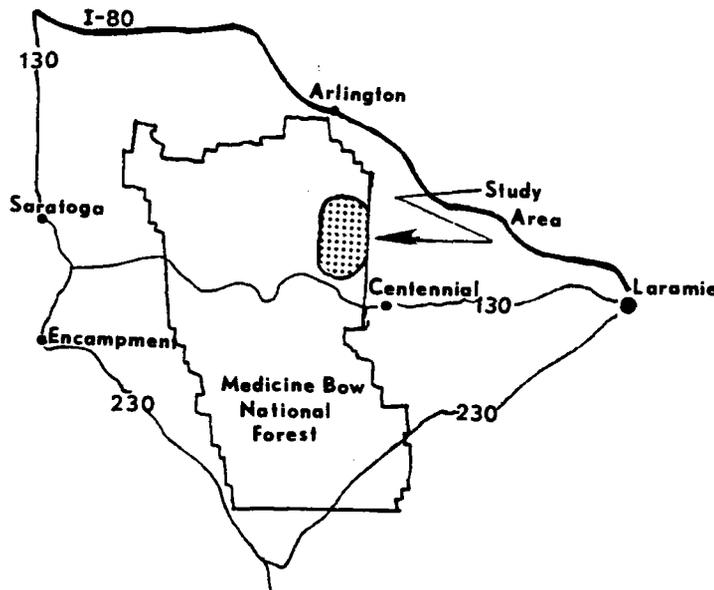


Figure 1. The study area where the response of elk and mule deer to firewood harvesting was investigated.

(Fig. 1). It is north of Wyoming Highway 130 and runs northeast of the Snowy Range along the hydrologic divide between the Medicine Bow River and Rock Creek and the North Fork of the Little Laramie River. The area includes both sides of Rock Creek Ridge from Bald Mountain on the south to Rock Creek near Arlington on the north. Elevation ranges from 2,500 to 3,658 m. Geological and vegetative characteristics are described by Wirsing and Alexander (1975).

Approximately 400 elk and 450 mule deer winter along the east slope of Rock Creek Ridge and use the area on the forest at the higher elevations during the summer. The elk population is being held in check by the issuance of cow permits during hunting seasons. During the 1979 season, the harvest, as estimated by the Wyoming Game and Fish Department, was 191 elk from this unit (89 cows, 19 calves and 83 bulls). The mule deer harvest was 154 (108 bucks and 46 does).

The following impacts were present on the study area during 1980. (Recreation and grazing remained the same through 1981 and 1982.)

#### Firewood Harvesting

Non-commercial - Entire area was open to free firewood gathering except within the Spring Creek and Fallen Pines timber sales and road building areas. (Both Spring Creek and Fallen Pines opened to firewood gathering in 1981 and 1982).

Commercial - An area covering all or parts of 13 sections on the west side of Rock Creek Park after crews piled slash from previous timber sales. Was opened in 1980.

#### Timber Sales

Partial cuts of the Spring Creek sale south of Rock Creek Park were completed.

#### Road Construction

Fallen Pines timber sale road of 9 miles (14.4 km) was completed along the east side of Rock Creek Ridge.

#### Recreation

All campgrounds were open and no new ones were under construction.

#### Minerals

Two exploratory drilling operations were under way at the north end of Fallen Pines road.

#### Grazing

There were 255 AUM's of cattle grazing the North Fork Allotment, including both sides of Rock Creek Ridge, from July to September 30.

## METHODS

During the winter of 1979-80, elk and mule deer were trapped in Clover traps baited with alfalfa hay and salt. All the animals, except two deer, were captured on the winter range west of Interstate 80 and east of the Medicine Bow Forest boundary. Two deer were captured with drugs near Rock Creek Park in August. Two elk and two deer were trapped near Bunker Hill on the south end of the area and four elk and 15 deer were trapped at Strouss and Manthos Hills on the north.

Five elk and four deer were fitted with telemetry collars and one bull elk and 13 deer were fitted with individually recognizable colored collars. Fixes of each telemetered animal were recorded at least once a week during the summer of 1980 and 1981. Check sheets were filled out showing location, weather, habitat type use, activity and distance from other domestic and wildlife and human activities. Most of the data were collected from ground tracking, but periodic aerial flights were made to determine the number and location of animals and human activity in the area. All elk and deer seen were checked for marked animals and classified when positive identification was possible.

Firewood gatherers and recreation activities were monitored by driving over all roads in the study area, periodically during the Friday to Sunday period each week, and sporadically during other weekdays. Location, type of activity, number in the party, and habitat type were recorded. Locations were marked on topographic maps and also recorded descriptively. During these same tours, all elk and mule deer either seen or fixed by telemetry were recorded. On a few occasions, specific tests were made using telemetered animals to determine disturbance parameters associated with cutting dead trees for firewood. Test animals were first vectored very carefully to determine their location and activity. At specific distances from the animal, a chain saw was used to cut down a tree and cut it up into firewood. While the work was being done, the telemetry signal was monitored to record animal activity and movement.

Traffic on the roads was monitored by either surveillance camera systems triggered by light sensors or microwave systems (Ward et al. 1980) or with pressure-hose traffic counters. The camera systems, particularly the microwave system, were found to be very accurate compared to the traffic counters. The light sensor unit worked very well during the day; at night, the microwave system tripped the camera to record the car lights on film. From the photographs of every vehicle using the road during daylight hours, the number of vehicles and amount of wood being hauled were determined. The date and time of day were also determined based upon shadows and light on the film. Even though there was more maintenance required, the surveillance camera systems were more accurate and recorded more useful data than the traffic counters, which gave erratic counts because of misses due to wet or icy conditions and multiple counts due to the changes in sensitivity.

## RESULTS

### Traffic and Firewood Harvest

Vehicular traffic and estimated firewood harvests, as observed from the surveillance camera photographs, are presented in Table 1. The volume of traffic varied from a high of 614 vehicles during the last week of August to 174 during the last week in October and the first two days of November. The highest number of vehicles carrying firewood (175) was recorded during the last week in August. This also corresponded with the high of 156.2 cords of firewood. The surveillance camera on the road along the east side of Rock Creek Park showed that 15% of the traffic used this road and 25% of the firewood came out of this area. Of the 754 vehicles photographed coming out of this area, 37% were carrying firewood. This was considerably higher ( $\chi^2 = 77.5$ ) than the 22% of the 4,240 vehicles that used other areas for firewood gathering and came out on the Sand Lake road.

Weekends were periods of heaviest traffic and firewood harvesting, when 67% of the firewood was hauled out. Labor day weekend showed the highest vehicle count of any two-day period; 408 vehicles were photographed leaving the area and 129 were hauling an estimated 115 cords of firewood.

During the archery hunting season in September and the deer hunting season during the first 14 days of October, the firewood harvest stayed high. There was a noticeable drop in firewood gathering activity during the elk rifle season from October 15 to 31, due mostly to deep snow and cold weather; however, a few elk hunters did take out a load of firewood.

Figure 2 shows the exact location of firewood gatherers and recreationists recorded on weekends during the June to October 1980 period in the Rock Creek Park area. Most people preferred to stay near the main well-drained and gravelled roads. Some used the arterial logging roads. The clearcuts in this area near the roads had received the pile and burn treatment to clean up the slash. In spite of this treatment, several parties were observed gathering slash for firewood from clearcuts.

Firewood harvesters were unpredictable in their selection of sites along the roads. The most consistent pattern was to select an area where dead wood was available. Turns, slopes and traffic did not appear to be deterrents. Individual parties were spaced widely enough to be safe, but they were often within sound or sight of each other. Since there were very few restrictions on areas of firewood harvest, the distribution patterns were scattered for Labor Day weekend. As the firewood became harder to find near the roads, the distribution patterns of harvesters changed.

The number of people in a firewood harvest party was usually either two or four (average 3.5). In the 38 parties observed, there were usually no more than two vehicles (average 1.4). Hunters and anglers were usually in one or two vehicles, with two people per vehicle.

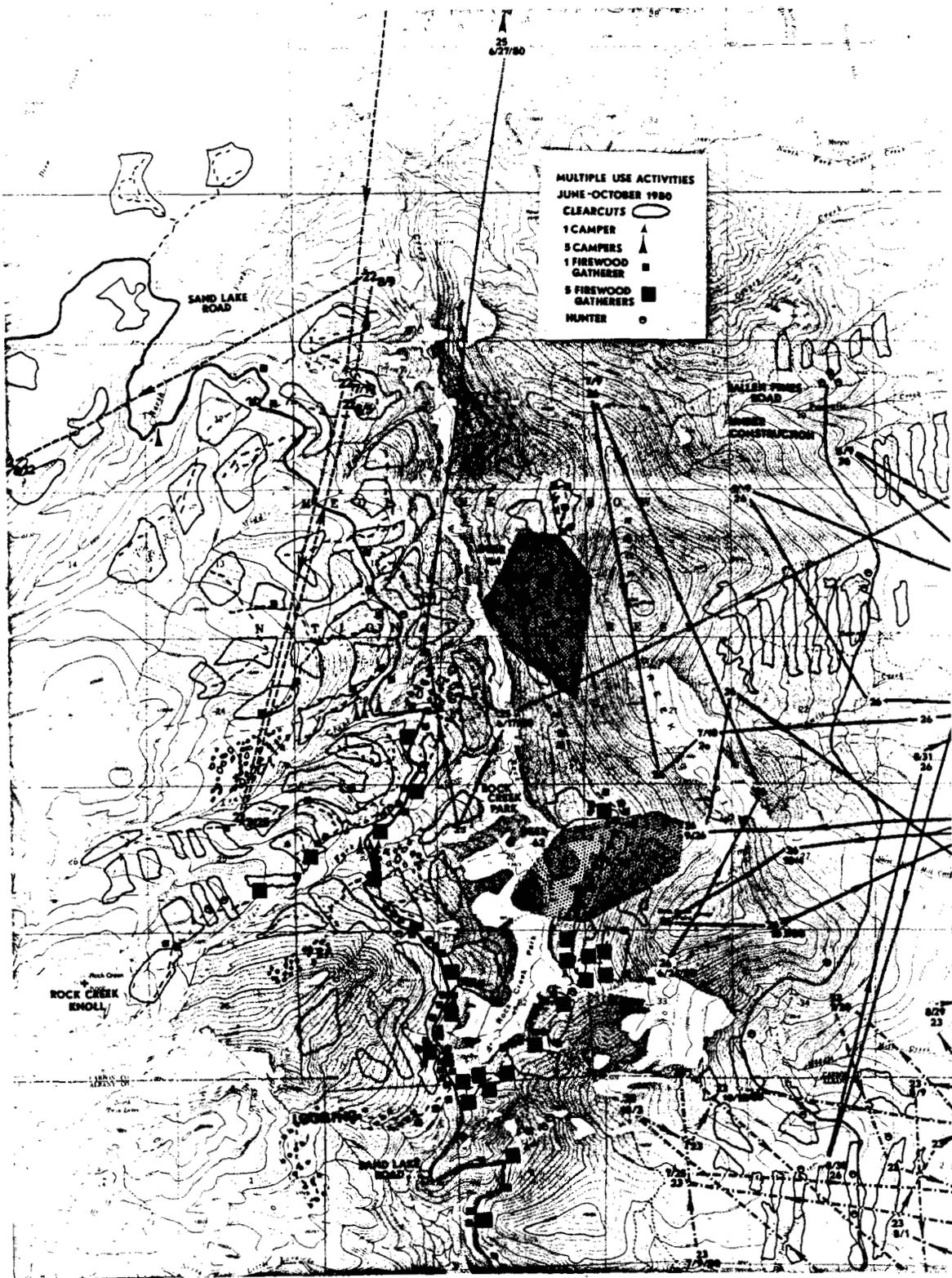


Figure 2. Firewood gathering, recreation activities, and telemetered elk and mule deer locations during summer-fall 1890 in the Rock Creek area.

Table 1. Firewood harvest determined from surveillance cameras at the south end of the Sand Lake road during the summer and fall, 1980.

Weekdays	Weekends	Total vehicles	Vehicles with wood	Number of cords
Aug. 11-15		319	35	28.8
	Aug. 16-17	208	58	51.5
Aug. 18-22		252	28	28.0
	Aug. 23-24	277	98	78.5
Aug. 25-29		206	46	41.2
	Aug. 30-31	408	129	115.0
Sept. 1-5		195	45	41.4
	Sept. 6-7	183	93	70.5
Sept. 8-12		165	23	20.0
	Sept. 13-14	191	105	83.0
Sept. 15-19		179	38	29.5
	Sept. 20-21	262	121	103.5
Sept. 22-26		233	44	37.5
	Sept. 27-28	206	81	62.5
Sept. 29-Oct. 3		150	30	27.5
	Oct. 4-5	198	81	52.5
Oct. 6-10		251	40	35.2
	Oct. 11-12	139	59	50.0
Oct. 13-17		333	34	31.0
	Oct. 18-19	142	3	1.0
Oct. 20-24		197	7	3.2
	Oct. 25-26	126	14	12.0
Oct. 26-31		146	8	7.5
	Nov. 1-2	<u>28</u>	<u>9</u>	<u>6.5</u>
Subtotals	60 Weekdays	2,626	378	330.8
	<u>12 Weekends</u>	<u>2,368</u>	<u>851</u>	<u>686.5</u>
Totals	84 Days	4,994	1,229	1,017.3

Recreationists were mainly associated with fish and/or hunting. Some anglers were found parked near small streams. Hunting parties were hard to locate. There are not many camps in this area because most of the hunters either drive out of the campgrounds down the North Fork or come out from town.

#### Animal Response

Elk have been monitored by telemetry in this area since 1974 (Ward 1976; Ward et al. 1976, 1980). Earlier results have shown the reluctance of elk to stay in the Rock Creek Park area when scattered timber harvest operations were in progress. Elk were still not using the area after the extensive logging operation had been completed. The logging roads were left open, leaving the firewood gatherers and recreationists good access to a very extensive area. Firewood gathering and recreation activities have been noted by the Forest managers to be increasing in amount and area affected.

Most of the useable data on elk and mule deer response to firewood gatherers and other human activities were based on the telemetered animals and their associates. Very few sightings of marked collars or ear tags were recorded. Some data were collected in the late summer of 1980 by making systematic searches into remote areas adjacent to the high impact human disturbance areas to record elk sightings and fresh elk sign.

The travels of the five telemetered elk (cow 22, 23, 26 and spike 25) and the two mule deer (doe 62 and buck 64) during the summer and fall of 1980 are shown in Figure 2. Only cow 23 and cow 26 consistently used the main core area where records of concentrated human activities were being monitored.

Cow 23 was tracked for 16 months. She was located 66 days while she was on the summer and fall range, when firewood gatherers and traffic were within her range, which was mainly in the national forest. Her summer range was mostly on the east face of Rock Creek Ridge at the south end where there was considerable traffic and human activity. During 1980, she was subjected to new road construction with restricted firewood gathering. During 1981, she had both firewood gathering and heavy traffic to contend with on her range. She was seen with from 11 to 39 (average 20) other elk during the summer of 1980-81. She was harvested in October 1982.

Cow 26 was tracked with telemetry for 42 months. Her summer and fall range was centered in the Rock Creek Ridge and Seven-Mile Creek area and was quite consistent for the 4 years. She and her 1 (calf) to 28 known associates (average 10) were located 96 days, during June to October of 1980 to 1983, while the human activity was being closely monitored. During the years, she had to contend with both road construction traffic on the Fallen Pines road and firewood gathering in the Rock Creek Ridge, as well as at least one oil drilling rig operating in the Four-Mile Creek drainage on the east side of Rock Creek Ridge. Traffic was always present when firewood was harvested. During the June to October periods of 1980, 1981, 1982 and 1983, she was located 46, 14, 18 and 18 days, respectively.

Cow 22 was in the Rock Creek Park area, but used the higher elevation range to the west which was over 1600 m from vehicle access. Spike 25 came into Rock Creek Park in mid-June before moving over Rock Creek Ridge away from the human activity in early July. Cow 27 was on the burn in Seven-Mile Creek above the Fallen Pines road in mid-June when her transmitter failed. These elk did not contribute much data to the study because of either the short duration of transmitter life or their short stay in the firewood road access area. All three were harvested near the Forest boundary on the east side of the ridge during the regular hunting seasons.

The number of times cows 23 and 26 were located within various distances of human activity associated with firewood gathering or traffic and road construction, is shown in Table 2. Both cows were approached twice within 400 m by researchers who simulated firewood harvest by sawing down a dead tree and cutting it up into firewood lengths. In all four cases, the elk displaced when human presence was detected. The 11 instances when elk were within 400 to 800 m of firewood gatherers, they were in areas where harvesting was along a major forest road and the elk were resting in good conifer cover. The two telemetered cows and their associates stayed at least 800 m away from people gathering firewood 91% of the days located. They were more than 1600 m from pedestrians 73% of the days. This is about the same relationship elk have shown to other pedestrians involved in timber harvest operations, recreation and live-stock operations on the Medicine Bow National Forest (Ward et al. 1973, 1976, 1980; Ward and Cupal 1976). The major difference with firewood gatherers is the unpredictable distribution and length of season.

The elk reacted less to traffic and road construction. Cow 26 did not move away when a motorbike passed within 50 m while she was resting in good conifer cover. Cow 23 and 26 were located within 200 to 400 m of moving traffic 12 days and within 400 to 800 m on 35 days and more than 800 m 114 days. Their high elevation summer range was mostly within 1600 m of a road. As in earlier studies on the Medicine Bow Forest and in Montana (Lyon 1979), elk show more tolerance for moving traffic than pedestrians, particularly on their summer and fall ranges where there are usually forested areas for cover (Ward et al. 1980).

The survey into remote areas to document elk presence and use in late September 1980 showed the following:

<u>Area</u>	<u>Estimated Elk Present</u>
Rock Creek Knoll west of Rock Creek Park	40 to 50
Rock Creek Ridge	20 to 30
Corner and Bald Mountain to the south	20 to 30
Cooper Creek north to Three-Mile Creek	200 to 250

All of these areas are at least 800 m from centers of human activity, and access is only possible by walking, horseback, or in few cases, by four wheel drive and motorbike vehicles. Cow 22 was with the group around Rock Creek Knoll. Spike 25 moved from Rock Creek Park in mid-June to the less accessible area north of Cooper Creek.

Table 2. Number of days telemetered elk were located within various distances of human activity.

Elk	Distances (m)	Firewood Harvest	Traffic and Road Construction
Cow 23	within 200	0	0
	200 to 400	2 <sup>a</sup>	8
	400 to 800	5	15
	800 to 1600	13	16
	over 1600	46	27
	Total	66	66
Cow 26	within 200	0	1 <sup>b</sup>
	200 to 400	2 <sup>a</sup>	4
	400 to 800	6	20
	800 to 1600	16	26
	over 1600	72	45
	Total	96	96

<sup>a</sup>Field test with chain saw while elk were resting in the conifers.

<sup>b</sup>Motorbike passed within 50 m.

#### Mule Deer

Doe 62 and buck 64 were mule deer captured with a dart gun just off the road on the east side of Rock Creek Park at the height of firewood gathering in August 1980. Their activities were monitored by telemetry during the survey trips to record firewood gathering activity. Doe 62 was followed periodically from August 14, 1980 to June 9, 1983. She returned to the same summer range (shown in Figure 2) for the two additional years monitored. Buck 64 came back to the same summer range in 1981, but was harvested during the hunting season in early October.

Both of these deer were seen with one to five associates during each summer. Doe 62 was never seen nursing fawns. These deer arrived on their summer range in late June and stayed until the cold stormy weather in late October.

Table 3. Number of days telemetered deer were located within various distances of human activity.

Mule Deer	Distance	Firewood Harvest	Traffic
Doe 62	within 100	0	3
	100 to 200	0	3
	200 to 400	10	9
	over 400	10	8
	Total	20	23
Buck 64	within 100	3 <sup>a</sup>	7
	100 to 200	1 <sup>a</sup>	8
	200 to 400	14	14
	over 400	17	24
	Total	35	53

<sup>a</sup>Field test with chain saw while deer were resting in the conifers.

The deer response to firewood gathering and traffic is shown in Table 3. They were fixed or seen within 200 m of firewood gatherers only 7% of the 55 days when harvest activity was noted in the area, and on those four occasions, specific tests were being conducted to determine their reaction when dead trees were sawed for firewood. If the deer were lying down in conifer cover, neither deer showed displacement response to people operating chain saws within 100 m. They would spook at greater distances when feeding in openings and approached by pedestrians. They were fixed or seen within 100 m of traffic on 13% of the 76 days traffic was noted in the area. They were within 200 m of traffic 28% of the days and within 400 m 58% of the days. Most of their summer ranges were within 800 m of the road since it passed through about the middle of their summer range. Each year the deer stayed within their previously used summer range in spite of human activity. Adjacent areas away from human disturbance had similar habitat, but deer did not move to them.

## CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Hunted populations of elk and mule deer are affected by human disturbances associated with multiple uses on our public and private lands (Thomas and Toweill 1982, Wallmo 1981). They are more disturbed by people engaged with out-of-vehicle activities than by traffic or equipment (Ward et al. 1973, 1976, 1980; Ward 1976; Ward and Cupal 1979). Elk are by far more sensitive than mule deer and can be displaced from good elk habitat if human disturbances are frequent and scattered (Ward 1976, Lyon 1979). Mule deer have a high tolerance for disturbance and will stay within their known range if adequate security cover is available (Geist 1971, Kramer 1973, Ward et al. 1980). The animals in this study showed the same response to human activities associated with firewood gathering.

People engaged in uncontrolled firewood gathering activities on the Medicine Bow Range predictably collected wood near roads and in a scattered pattern. As a result, the heavily used areas were those along the edge of the best roads and within the shortest distance to a hard-surfaced highway. This pattern is bound to change as the wood supply is harvested. Eventually, people will move into the more poorly roaded areas and collect wood farther away from the roads.

In the area of this study there has been little effort made by the Forest Service to close existing roads. There were, however, some access roads closed to firewood gatherers, but used by loggers, oil drillers and road construction crews. The area of greatest elk displacement was the approximately 41.4-km<sup>2</sup> area surrounding Rock Creek Park where firewood gathering and recreation activities were continuous from mid-July to the end of October. Some elk came into the area about mid-June but moved out to the more remote and inaccessible areas when the people came. Others stayed in the area but kept a buffer area between themselves and people.

This study shows the importance of managing widespread human activities to allow elk use of their range. Not only are the elk displaced, but they move to other areas that are already occupied. In this case, there were remote areas available with adequate food supplies. This may not always be the case. New access routes with no control of traffic are the most serious problems. Roads are needed and will continue to be constructed in order to use the renewable and nonrenewable resources, but without a program of road closures for control of human activities, there is definite threat to hunted populations of elk and possibly mule deer. A long-range program of scheduled human use areas with adequate refuge areas for elk is needed. Data from studies in south-central Wyoming and other areas in the Rocky Mountains suggested human activities be confined to one drainage or about a 13 km<sup>2</sup> area at one time with an 800 m buffer of trees or ridges to separate people and elk. Elk have demonstrated they will return after human activity stops, so the use can be rotated (Ward 1976). In a heavily timbered area such as the Medicine Bow Range, there is little danger of depleting the tree cover under the present management programs. On other areas, with less tree cover, plans will be needed to make certain the security of the elk.

Mule deer, as a result of the type of disturbance observed in this study, are not being displaced. The easy access and hunting pressure, along with periodic tough winters, are controlling the populations.

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ROOSEVELT ELK AND BLACK-TAILED DEER RESPONSE TO HABITAT CHANGES RELATED TO OLD-GROWTH FOREST CONVERSION IN SOUTHWESTERN OREGON

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Abstract: We studied the effect of old-growth forest liquidation on Columbian black-tailed deer (Odocoileus hemionus columbianus) and Roosevelt elk (Cervus elaphus roosevelti) populations in the southern Coast Range of Oregon. Deer and elk densities were estimated in 18 drainages that contained varying proportions of old-growth habitat and younger seral stages. Elk densities decreased in a curvilinear fashion ( $r^2=0.89$ ,  $p<0.05$ ) as the proportion of old-growth forest decreased in each drainage, which indicated that elk carrying capacity was directly associated with the amount of old-growth habitat. Unlike elk, deer densities were not correlated ( $P>0.05$ ) with old-growth or any seral stage past 12 years old, but responded positively ( $r^2=0.77$ ,  $P<0.01$ ) to increasing proportions of new clearcuts 0-12 years of age.

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INTRODUCTION

Forage and cover requirements of Roosevelt elk are not well-known in the Pacific Northwest (Jenkins 1980, Witmer 1981). Although they prefer old-growth Douglas-fir (Pseudotsuga menziesii) as a habitat type (Witmer 1981) and use it to survive during heavy snowfall (Newman 1956, Harper and Trainer 1969, Janz 1980), the impact of old-growth forest liquidation (Juday 1976) upon elk populations is not clearly understood.

Conversely, information on forage and cover needs of black-tailed deer is available but contradictory. Most early studies (Cowan 1945, Brown 1961, Hines 1973) associated highest deer densities with peaks in forage production 10-20 years after clearcutting. These studies, however, have been questioned (Schoen et al. 1981) and more recent studies (Jones 1974, Hebert 1979, Rochelle 1980) have clearly demonstrated the importance of old-growth stands to deer during periods of heavy snowfall.

Our principal objective was to provide information on the relationships of Roosevelt elk and black-tailed deer to the seral stages and stand conditions in southwestern Oregon. Our second objective was to evaluate the possible reasons for the relationships noted.

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## STUDY AREA

Our study was conducted in 18 drainage systems in Coos and western Douglas counties, Oregon. The study was conducted on lands administered by the Coos Bay District Bureau of Land Management and immediately adjacent private lands (Figure 1). Each drainage was a 3rd or 4th order system that encompassed 810 - 2,430 hectares (2,000-6,000 acres). Elk and deer are common throughout the region. Herds are non-migratory and typically occupy the same drainage on a year-round basis (Witmer 1981).

Douglas fir - western hemlock (Tsuga heterophylla) associations dominate the District. Intensive logging has transformed the area from predominantly old-growth forest (Juday 1976) to progressively younger age classes, and more managed stand conditions, which is reflected in the wide variety of seral stages present in the 18 drainages (Table 1). Four of the drainages are dominated by grass-forb and shrub stages (Figure 2a); five are dominated by sapling and pole stages (Figures 2b and 2c); and nine others are dominated by old-growth stands (Figure 2d; Table 1).

The study area is heavily roaded, and it is difficult for animals to get more than 2/5 - 4/5 km (1/4 - 1/2 mile) from a logging road. Clearcutting is the common type of cut to instigate forest regeneration. Most clearcuts on public lands are 8 - 24 hectares (20 - 60 acres) and are usually interspersed in a patchwork of older seral stages. Some clear cuts on private lands are 121 - 243 hectares (300 - 600 acres) in size. Public and private lands are usually interspersed in a checkerboard ownership. Generally, every other section (2.59 square km) is public land.

Topography is steep and rugged; approximately 15% of the land area is characterized by slopes of 80% or greater, and slopes less than 30% are uncommon. Elevations range from 152 - 853 m (500 to 2,800 feet). Climate is relatively mild, with temperatures above 35°C (95°F) and below 2°C (35°F) uncommon. Annual precipitation averages 203 cm (80 inches), most of which occurs as winter rain. Snowfall is usually light and melts quickly, but severe winters occurred in 1968-69, 1955-56, and 1948-49 (Harper and Trainer 1969, Oregon Game Commission 1956, Oregon Game Commission 1949). Our research was conducted during three consecutive mild winters when rain and 4°C - 10°C (40°C - 50°F) temperatures were common.

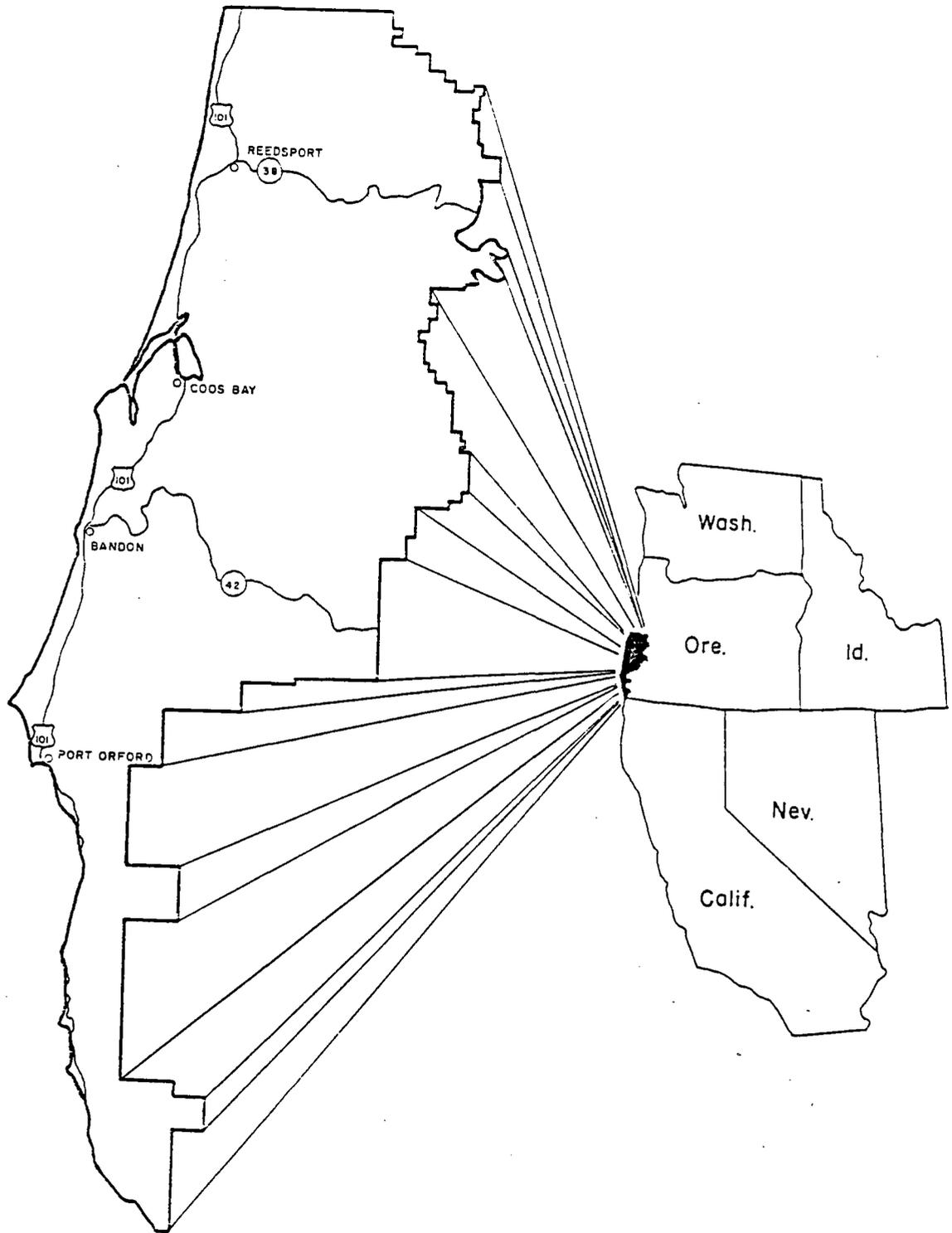


Figure 1. Location of the Coos Bay District of the Bureau of Land Management in southwestern Oregon.

Table 1. Deer and elk densities, forest seral stages, and road area.

Transect	Density Sq. Kilometer (Square Mile)		% Area in Each Age Class					Kilometers Rd. Sq. Kilometer (Miles Road) (Square Mile)
	Deer	Elk	0-12	12-35	35-80	80-160	160 +	
Oxbow	21.9 (56.8)	0.2 (0.4)	88.1	10.6	—	0.4	0.9	1.9 (3.1)
Paradise	13.8 (35.8)	0.3 (0.9)	40.9	26.0	7.7	4.3	21.1	1.5 (2.4)
Windy Herb	5.9 (15.3)	0.0 (0.0)	32.9	28.4	5.2	5.1	28.4	2.0 (3.2)
Vincent/Scare	2.6 (6.8)	0.4 (1.0)	32.0	30.8	5.1	4.7	27.4	1.1 (1.8)
Soup Creek	1.2 (8.3)	0.0 (0.0)	24.6	37.3	17.2	—	20.9	1.9 (3.0)
Lower Camp	7.3 (18.8)	0.8 (2.0)	23.2	24.3	9.3	8.8	34.4	1.4 (2.2)
Upper Camp	7.3 (18.9)	2.4 (6.2)	31.2	10.1	5.0	—	53.7	1.6 (2.5)
Blue Ridge	3.0 (7.8)	0.1 (0.3)	14.0	12.3	60.7	10.5	2.5	2.1 (3.3)
S. Fork Coos	3.1 (8.1)	1.4 (3.7)	27.8	17.5	9.5	—	45.2	1.6 (2.6)
N. Fork Coquille	6.9 (18.0)	8.5 (21.9)	35.7	—	—	—	54.3	2.1 (3.3)
Alder Creek	3.1 (8.0)	4.0 (10.3)	16.3	35.6	0.9	—	47.2	1.8 (2.9)
Shotgun	6.5 (16.8)	0.1 (0.3)	42.9	25.0	1.1	—	31.0	2.4 (3.9)
Cherry Creek	3.0 (7.7)	2.4 (6.3)	20.4	31.1	6.7	1.4	40.4	1.5 (2.5)
Brummet Creek	6.5 (16.9)	3.2 (8.3)	28.9	11.3	11.4	2.0	46.4	1.6 (2.6)
Vaughn's	3.8 (9.9)	12.5 (32.4)	23.4	12.9	—	—	63.7	1.4 (2.3)
Tioqa	3.3 (8.6)	0.4 (1.0)	31.3	35.5	5.5	—	27.7	1.8 (2.9)
Yankee Run	4.0 (10.3)	0.0 (0.0)	10.8	62.1	13.8	3.8	9.5	1.8 (2.9)
Camas Creek	4.7 (12.2)	1.2 (3.2)	20.6	51.8	3.7	0.5	23.4	1.9 (3.1)

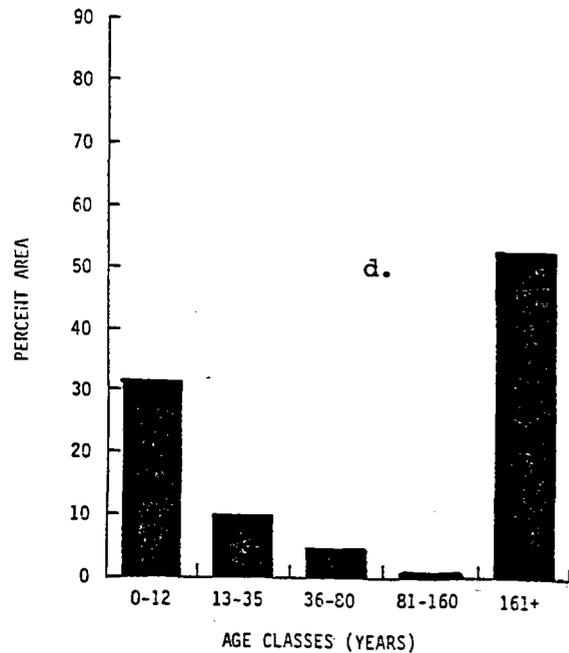
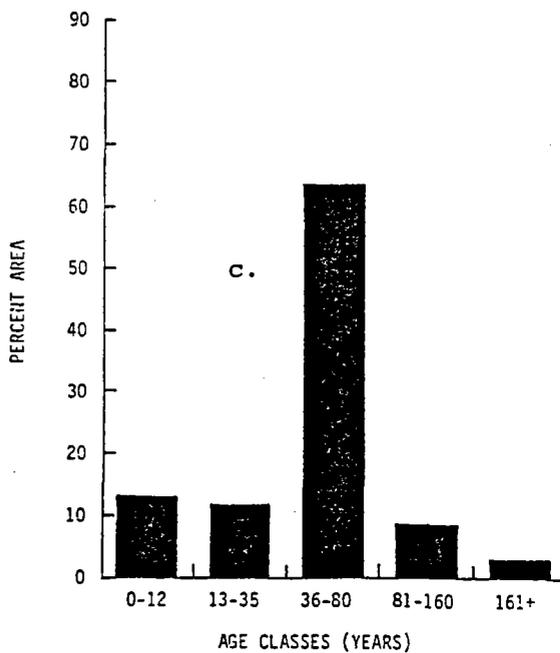
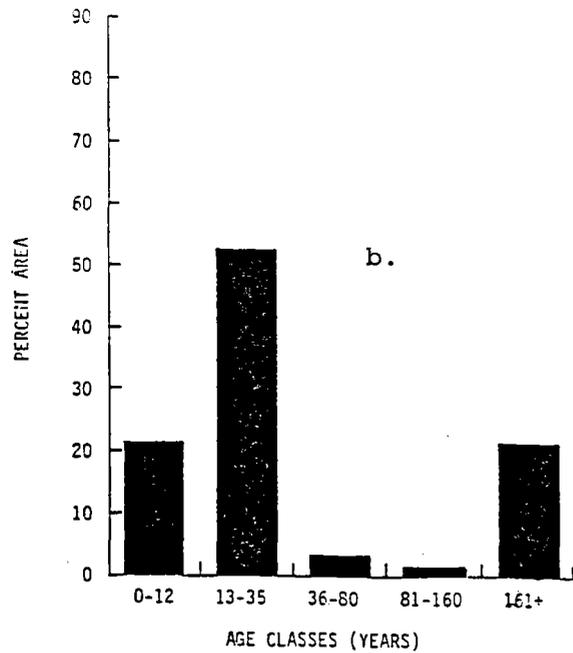
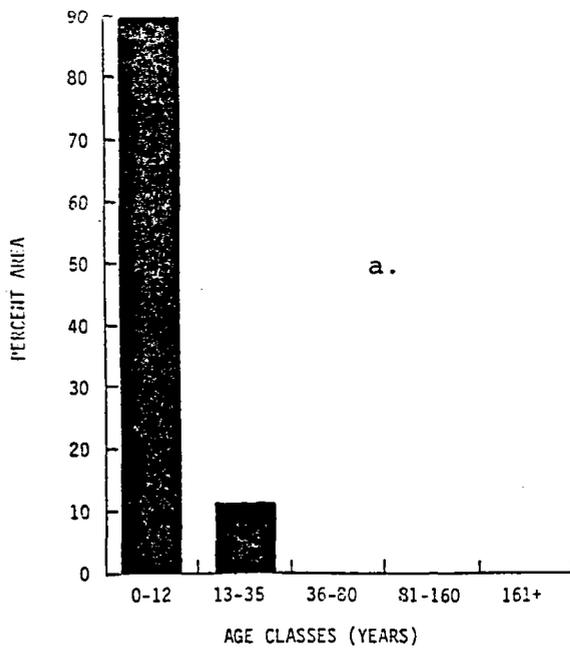


Figure 2. Examples of drainages dominated by:

- a. the grass/forb/shrub stage (0 - 12 years old),
- b. the sapling stage (13 - 35 years old),
- c. the pole stage (36 - 80 years old),
- d. the old-growth stage (161+ years old).

## METHODS

We counted deer and elk in each drainage at night by using spotlights while driving along permanent road transects (Harestad and Jones 1980). Transects were usually located on unpaved, secondary roads because elk avoided habitat adjacent to heavily travelled primary roads (Witmer 1981). Transect lengths were 8 - 32 km (5 to 20 miles); this depending on drainage size and the desired sampling intensity. A total of 12 repetitions were conducted on each transect during the winters of 1978-79, 1979-1980, and 1980-81.

We estimated deer and elk densities for each drainage by: 1) measuring the distance that animals could be spotlighted along each side of the transect, by measuring visibility with a rangefinder at 3/10 km (1/5 mile) intervals, 2) making additional measurements between these intervals wherever dramatic changes in visibility occurred that corresponded to changes in habitat type or topography, 3) calculating the total area of visibility enclosed by the distance measurements and 4) dividing the number of animals observed by the area of visibility. This technique corresponds to the variable width method described by Smith (1981). Our density estimates were probably conservative because an unknown percentage of deer and elk were missed, but this was assumed to be comparable across drainages.

According to Dealy (1966), the limitations of spotlighting for deer as a technique are: 1) observations from areas of low population density seem erratic, 2) comparing areas of markedly different cover characteristics is limited and 3) it is indicative of general trends rather than precise estimates.

Our variable width transects were designed to offset the second concern expressed by Dealy (1966) by accounting for differences in visibility between different habitat types. Because the study area is heavily roaded (Table 1) and elk herds non-migratory, the spotlight technique has more value in this study area as an index of elk numbers than under other circumstances (e.g. migratory herds and/or few roads). Increased repetitions increase the reliability of the relative numbers of animals among transects.

To screen the variables for further analysis, stepwise multiple regressions (Sokal and Rohlf 1968) of deer and elk were calculated on proportions of area in several seral stage classes, even though independent variables were not truly independent. The following variables were examined:

1.  $Y$  = deer or elk density
2.  $X_1$  = proportion of area 0 - 12 years old (grass-forb/shrub stage)
3.  $X_2$  = proportion of area 13 - 35 years old (sapling stage)
4.  $X_3$  = proportion of area 36 - 80 years old (pole stage)

5. X4 = proportion of area 81 - 160 years old (mature stage)
6. X5 = proportion of area 160 years or older (old-growth stage)
7. X6 = density of roads in each drainage

Ninety percent of the X5 age class is over 200 years old, and nearly all of this age class meets the definition of old-growth described by Franklin et al. (1981). The 160 year break-off is a standard forestry recording system used by BLM; it has no particular relationship to wildlife ecology.

The X1 through X5 age classes were selected to reflect various stages of succession that presumably might have influenced deer and elk densities. Relative proportions of these age classes were computed for each drainage by using the dot grid technique. Because of concerns about the accuracy of the census technique, and the lack of independence of the seral stage proportions as variables, a Spearman's coefficient of rank correlation test (Johnson 1976) was done one variable at a time and results compared with the multiple regression. The X6 variable was secondary gravel roads basically, with occasional short stretches of primary paved roads on a given transect.

## RESULTS AND DISCUSSION

### Elk/Successional Stage Relationships

The regressions indicated that elk densities decreased in a curvilinear fashion as the proportion of old-growth habitat in each drainage decreased (Figure 3); this relationship ( $r^2=0.89$ ) was significant ( $P<0.05$ ), indicating that elk density was closely associated with the amount of old-growth forest present. A cubic equation provided the best fit for predicting elk densities: number elk/square km =  $-0.013633 + 0.1007918$  (% area in old growth age class)  $- 0.00583$  (% old-growth)<sup>2</sup>  $+ 0.000001$  (% old-growth)<sup>3</sup>. Correlations between elk and seral stages younger than the old-growth stage, and between elk and road densities, were not significant ( $P>0.05$ ).

The results of a Spearman's rank correlation test indicated a positive correlation between elk density and old-growth habitat ( $P<0.01$ ), but no positive correlation with other seral stages ( $P>0.05$ ). The rank correlation indicated no correlation between old-growth stands and roads ( $P>0.05$ ). The rank correlation indicated a negative correlation between elk density and road density ( $P<0.05$ ). The regression of elk density and road density was not significant ( $P>0.05$ ).

The negative rank correlation between elk density and road density may well indicate some road avoidance. However, since road densities are very similar in most cases (Table 1), it is not clear how meaningful this is. Lyon (1979) indicated that once road density reaches about 1.6 - 1.9 km per square km (2.5 - 3.0 miles per section) in heavily forested areas, elk response to roads levels off. Road densities in the study area

average 1.7 km per square km (2.8 miles per section) (Table 1). We think that roads were a minor factor influencing elk density in this instance.

Our results are surprising in two respects; one is that early studies (such as Harper and Swanson 1970, and Nelson 1974) stressed the importance of increased forage production (through clearcutting or fire) to increased elk density; the other is that few studies have demonstrated a positive relationship between elk populations and old-growth forest, mainly because it has not been the subject of extensive research. A probable explanation for this is that many of these early studies were done when old-growth forest was more abundant. As the amount of old-growth habitat decreases, what is left may become more important (Witmer 1981).

The fact that we found no correlation of elk densities with other seral stages or stand conditions, underscores an important relationship to old-growth habitat. However, this does not mean that other important relationships do not exist. We think our results represent elk response to conditions where thermal cover primarily in summer, rather than forage, was the principal limiting factor. The curvilinear relationship of increasing elk densities to greater amounts of old-growth forest would be expected to plateau beyond 70% and then decline as 100% old-growth forest is approached (Figure 3). The expected decline would reflect conditions similar to those found in the earlier studies where forage was limiting, such as Harper and Swanson (1970) and Nelson (1974). We did not have areas in excess of 70% old-growth forest to study and therefore, must speculate.

Hiding cover characteristics as defined by Thomas et al. (1979) are generally well developed by the time a stand reaches the pole-sapling stage. The trees are tall enough and dense enough to conceal elk from the view of a human only a few meters away. There are an abundance of stands in the pole-sapling stage or older (Table 1). If hiding cover is a limiting factor, we would expect a correlation to cover types younger than old-growth forest.

A number of recent studies documented elk preference and use of old-growth forest, although few of these studies clearly defined the specific functions that old-growth provided as a habitat (Janz 1980, Witmer 1981, H. M. Zahn pers. comm. 1984). Witmer (1981) monitored movements of cow elk on the Coos Bay BLM District and found that they either preferred old-growth forest or used it according to its availability during all seasons. He speculated that old-growth habitat provided important relief from heat stress during hot summers in the interior southern Coast Range.

H. M. Zahn (pers. comm. 1984) determined habitat use for an introduced herd of Rocky Mountain elk (*C. elaphus nelsoni*) on their summer range in the northern Cascades of western Washington. (The area was historically occupied by Roosevelt elk.) Old-growth forest was highly preferred as habitat and functioned as thermal cover during periods of heat stress. Adjacent 50-year-old timber received little use. Elk typically fed and rested within old-growth stands from mid-morning through mid-evening, when solar radiation or high ambient temperatures discouraged their use of forage in clear cuts. Because old-growth was the only

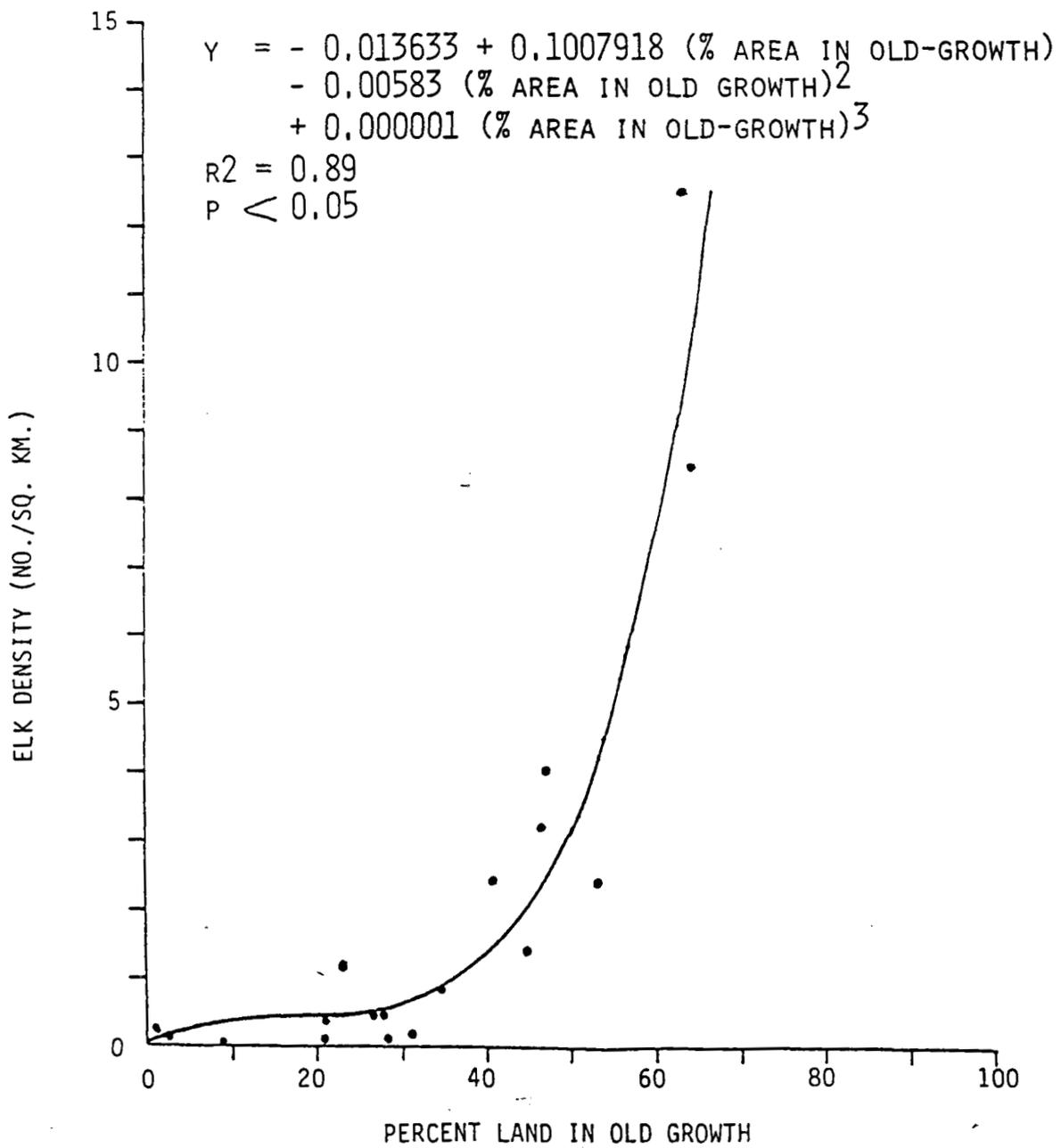


Figure 3. Relationship of elk density with percent of land in old-growth.

habitat that provided forage and thermal cover needs within the same stand, Zahn (pers. comm. 1984) concluded that it functions as optimum thermal cover for elk under a wide range of climatic conditions. The option to feed both day and night in a thermally comfortable environment could result in elk coming off summer range in better condition.

Zahn's study area, the watershed for Seattle, is closed to public entry. Our study area in contrast is heavily roaded and open to the public. Harassment as well as thermal influences may contribute to elk use of forage within old-growth stands in our study area.

The value of old-growth structure for survival under severe winter conditions, from Alaska to southern Oregon, has been documented by several authors (Newman 1956, Batchelor 1965, Harper and Trainer 1969, Janz 1980). Old-growth stands intercepted snow and provided essential forage in the form of litterfall lichens and groundlevel shrubs (Janz 1980).

#### Deer/Successional Stage Relationships

Deer densities increased linearly with increasing proportions of new clearcuts 0 - 12 years of age, grass forb/shrub stage, (Figure 4); this relationship ( $r^2=0.77$ ) was highly significant ( $P<0.01$ ). Unlike elk, deer numbers were not correlated ( $P>0.05$ ) with old-growth forest or any other seral stage past 12 years old. The equation for estimating deer density was: number deer/square km =  $- 2.34 + 0.2627$  (% area in 0 - 12 year age class). The results of the Spearman's rank correlation test showed a positive correlation between deer density and the grass-forb stage ( $P<0.10$ ), but no positive correlation to any other seral stage ( $P>0.05$ ), or to roads ( $P>0.05$ ). That we found no correlation with other seral stages does not mean relationships do not exist, but it does reinforce the importance of the grass-forb/shrub stage.

These results are similar to previous studies conducted in other Pacific Northwest areas where mild winters are common, especially areas that lack extended periods of heavy snowfall. Black-tailed deer are principally forage dependent, and presumably reach peak numbers when forage quantity and/or quality peaks after clearcutting (Cowan 1945, Brown 1961, Hines 1973).

Conversely, our results are different from studies conducted in areas where severe winters occur regularly. Under such conditions, black-tailed deer are directly dependent on old-growth forest for snow interception, modification of cold temperatures, and provision of forage in the form of litterfall lichens and ground-level shrubs (Jones 1974, Rochelle 1980). The last severe winter in our study area was 1968-69. Deer populations have had the chance to recover. It is probable that deer would suffer great losses during a severe winter if old-growth structure is scarce.

#### Deer vs. Elk: Habitat Response

In contrast to elk, deer have a high surface/volume ratio. Heat dissipation is rapid, which allows deer to remain cool during hot weather. Because heat dissipates quickly, however, deer are subject to cold stress (Raedeke and Taber 1979). Elk have a much lower surface/volume ratio than

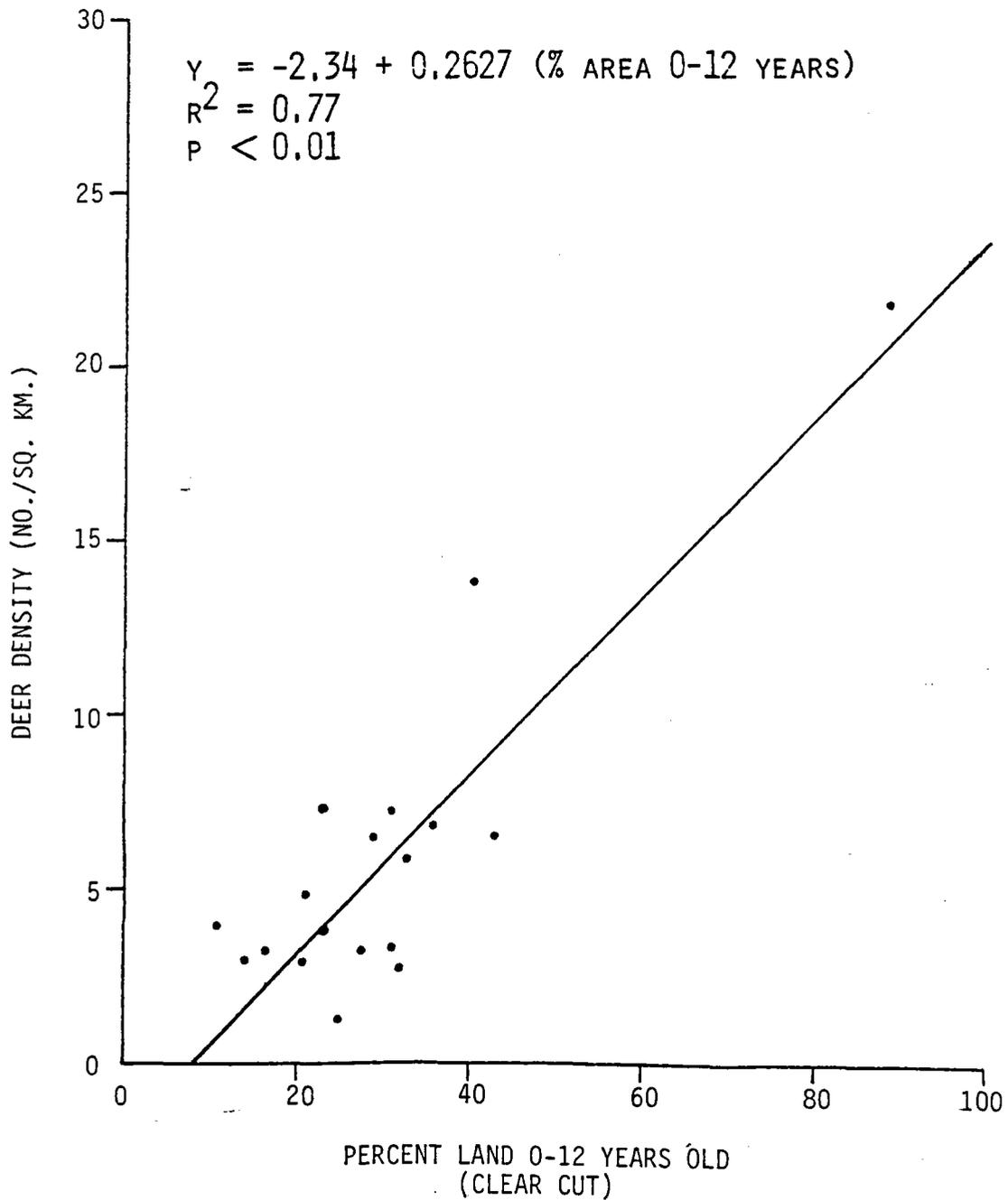


Figure 4. Relationship of deer density with percent of land clear cut (0 - 12 years old).

deer. Heat retention is superior, which allows elk to remain warm during cold weather. However, increased heat retention also means they are more susceptible to heat stress (Raedeke and Taber 1979, Zahn pers. comm. 1984).

In general, Bergman's rule suggests an advantage to large body size in cold climates and small body size in warm climates. It is worth noting, however, that deer in direct sunlight would absorb heat faster than elk because of the high surface/volume ratio. Nevertheless, deer, because of their small size and relative lack of herding behavior compared to elk, have more flexibility in the use of microhabitats and small vegetative patches for thermal cover.

Deer and elk adjust their feeding and resting activities to minimize thermal stress (Moen 1973). Habitats are sought that allow continuous feeding until temperatures become either excessively hot or cold; alternative habitats are then sought that best modify temperature extremes (Beall 1976). In the southern Coast Range, forage in clear cuts may not be continuously usable due to lack of thermal cover (Witmer 1981). Sapling, pole, and mature stands provide thermal cover but little forage (no thinning), or abundant forage but poor quality thermal cover (thinned stands). This is particularly true for managed stands. Old-growth forest, however, has structural characteristics (Franklin et al. 1981) which provide both forage and thermal cover needs within one stand (H. M. Zahn pers. comm. 1984).

Temperatures in the southern Coast Range commonly reach 29° - 35°C (85° - 95°F) throughout the summer. These temperatures exceed the "thermal-neutral zone" 4° - 21°C (40° - 70°F) of ungulates (Blaxter 1962; Leckenby 1977), and can place high metabolic demands on elk because of their susceptibility to heat stress (Zahn pers. comm. 1984). Metabolic rate increases rapidly with effective temperatures outside this "comfort zone" (Blaxter 1962; Leckenby 1977). Growth could be inhibited and fat reserves would be used to meet increased energy demands, which could result in less energy available for reproduction and reduced herd sizes. In contrast, winter temperatures rarely dip below 2° - 4°C (35° - 40°F). These mild temperatures rarely dip below 2° - 4°C (35° - 40°F). These mild temperatures place little stress on deer despite their susceptibility to cold weather (D. Leckenby, Oregon Dept. Fish & Wildlife, pers. comm. 1981).

We believe these differences in deer and elk physiology, combined with local climatic factors and the structure of old-growth forest, best explain our results. Logically, the climate of the southern Coast Range places greater stress on elk during summer (heat stress) than on deer during winter (cold stress). One would expect a different response reported from deer in colder climates (Jones 1974, Rochelle 1980). One would also expect a different response from elk in areas with milder summer climates such as Clatsop County, Oregon, where the fog belt sitka spruce zone extends greater distances inland (Juday 1976) or as reported in the redwood fog belt (Mandel and Kitchen 1979).

## MANAGEMENT CONSIDERATIONS

Franklin et al. (1981) emphasized the difference in forest structure of old-growth and naturally regenerated (unmanaged) mid-age forest as opposed to managed stands (tree farms). In the Pacific Northwest, deer and elk are subject to a variety of climates that may cause thermal stress. Several authors have stressed the importance of thermal cover for elk (Raedeke and Taber 1979, Witmer 1981, Zahn, pers. comm. 1984), which might be a causative factor for the correlation between numbers of elk and old-growth forest. We believe old-growth forests provide the optimum thermal cover. Naturally regenerated mid-age forest may provide a reasonable substitute, if the stand structure parallels old-growth structure closely enough. This has yet to be demonstrated, however, and further research is needed.

The structural characteristics which we believe are needed in a thermal cover stand, for significant elk response where high summer temperatures prevail, include a mosaic of small openings less than 1/20 hectare (1/8 acre) in a multi-story canopy where the dominant canopy is about 70 - 80% closed. These openings allow filtered sunlight to the forest floor and the development of a substantial ground and shrub layer for foraging. The sub-canopy probably aids in creating a cooler, more moist, microclimate in summer. In winter, it could help retain heat in the stand. On the other hand, all that is needed for hiding cover, in our opinion, is vegetation tall enough and dense enough to hide animals from view. If management for high densities of elk, relative to local site potential, is an objective, then retention of adequate amounts of old-growth forest, or perhaps, management of a substitute with similar structure, will be necessary.

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## ELK CONCENTRATIONS IN AREAS CLOSED TO HUNTING

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Abstract: A study designed to assess elk (*Cervus elaphus*) habitat use relative to timber management activities, inadvertently documented the development of an elk concentration in an area closed to hunting. Between 1977 and 1983, 2,643 aerial locations were collected from 59 radioed cow elk. The elk concentration developed from a few animals in 1980 to approximately 70% of the herd in 1982 and 1983. Security from hunting, forage quality and quantity, and home range fidelity were the factors responsible for the concentration. Three management problems resulted from this concentration: loss of hunter opportunity, loss of forage, and fence damage. The management options of hunting, herding, and intensive ranching operations are discussed relative to biological, social, and political constraints.

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### INTRODUCTION

Since the turn of the century, elk have shown a marked increase in both distribution and density in response to management programs. This increase has resulted in elk occupying nearly all suitable habitat available under current land use constraints. In addition, elk densities in many of these areas are at or near carrying capacity.

This "success story" has resulted in widespread land management problems that deal primarily with damage to agricultural and forestry crops, where elk concentrate in high densities (Lyon and Ward 1982). Hunting pressure often causes elk to concentrate in areas closed to hunting, which not only creates the usual gamut of depredation problems, but may result in a marked decrease in hunter opportunity. The purpose of this paper is to outline the development of an elk concentration in an area closed to hunting, and to examine the causative factors and management options.

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### STUDY AREA

The study area (Fig. 1) lies in the northern Garnet Mountains of western Montana, 56 km east of Missoula. Approximately 85% of the area is forested to some extent, and these areas fall within the Douglas fir

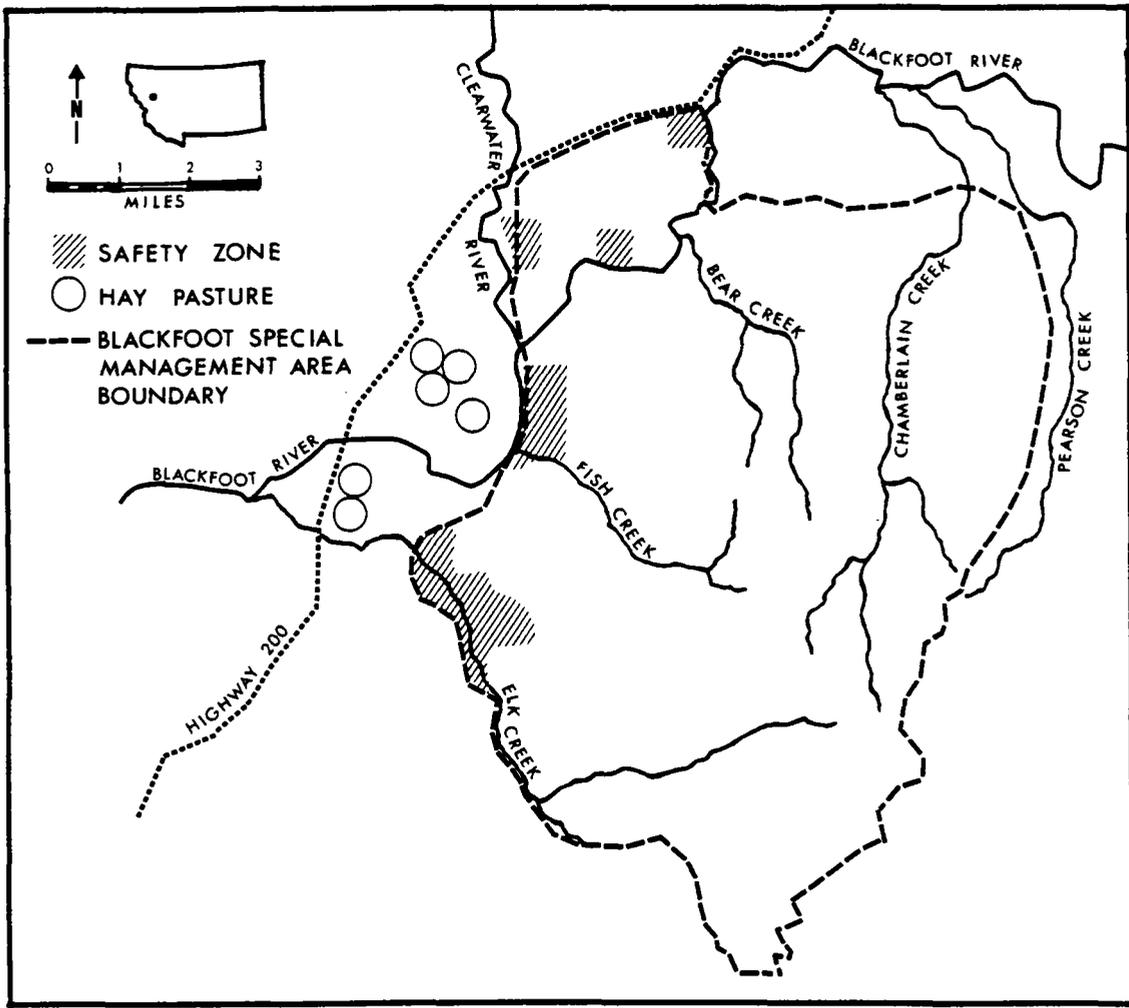


Figure 1. Study area and Blackfoot Special Management Area in Western Montana.

(Pseudotsuga menziesii) and subalpine fir (Abies lasiocarpa) climax series of the Montana Forest Habitat Types (Pfister et al. 1977). Pastures and hayfields, natural meadows, clearcuts, brushy riparian areas, water, roads and scree account for the remainder of the study area. Elevations range from 1,160 to 2,090 m. The Blackfoot River borders the study area to the north and west and state Highway 200 runs along the north and western edge of the study area. Scott (1978) and Lehmkuhl (1981) described the study area in detail.

Timber management is the principle land use, and much of the study area has been extensively logged within the last 50 years. The western and northern portions of the area are grazed by horses and cattle respectively between June and October. Big game hunting in the fall is the main recreational activity.

Most of the study area lies within the Blackfoot Special Management Area (BSMA), an area created by cooperative agreement between the Montana Department of Fish, Wildlife and Parks, the Bureau of Land Management, Champion International Timber Company, Plum Creek Timber Company, Lubrecht Experimental Forest, and local landowners. The BSMA was designed to encourage elk use in areas which had been roaded and logged, where security cover was limited, to provide a walk-in hunting area and improve the quality of hunting, to gain hunting privileges on private lands which were previously closed to the general public, and to prevent vehicle damage to soils and vegetation (McDaniel 1975). The area is closed to vehicular traffic from September 1 to December 1. Safety zones, closed to hunting, were established near human habitation and livestock concentration areas within the BSMA.

The area north of the Sunset Hill road, west of the BSMA and east of Highway 200 (Fig. 2) is closed to hunting. This area contains 6 circular-pivot irrigated hay-pastures, ranging from 40 to 80 ha in size. These are fertilized, seeded to alfalfa (Medicago sativa) and orchard grass (Dactylis glomerata), and cut during July then grazed by cattle, or simply grazed.

## METHODS

Elk were trapped in corral-type traps which were baited with alfalfa from December through April, and salt from March to September. A 150-151 MHz radio inserted in a PVC-pipe collar (Pedersen 1977) was placed on each animal. Elk were located weekly using a Piper Super Cub or a Cessna 182 from mid-May to December, and locations were marked on aerial photographs and transferred to topographic maps. Yearly population trends were established using aerial spring counts of marked and unmarked elk.

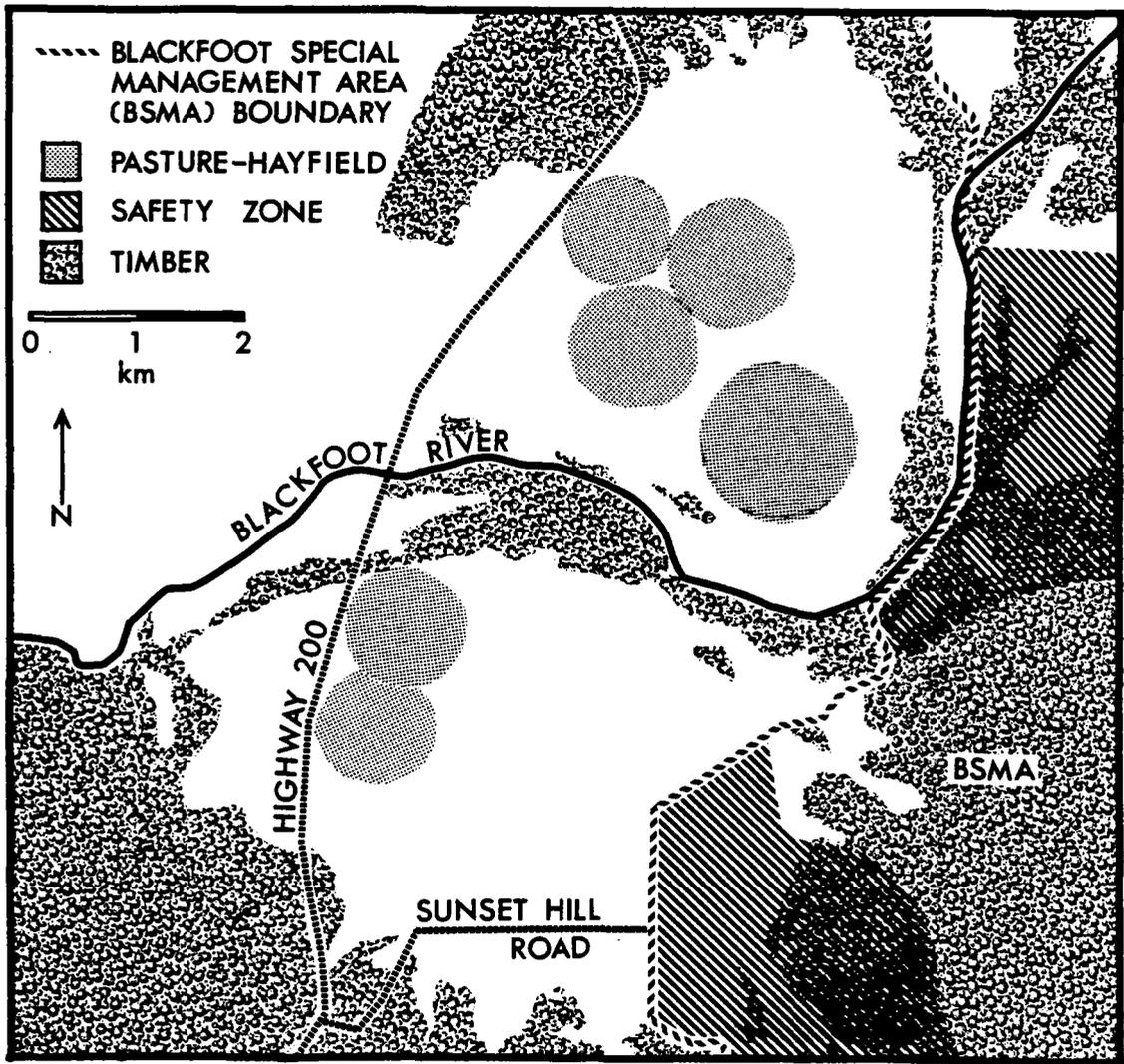


Figure 2. Area closed to hunting where elk concentrated during the falls of 1980 to 1983.

## RESULTS

Between 1977 and 1983, 2,643 aerial locations were collected from 59 radioed cow elk. These elk were trapped from 3 trap-sites, and constituted 2 distinct herds. The animals of interest in this paper are referred to as the Lindbergh herd, believed to be a stable to slightly increasing population based on yearly spring censuses. Although surveys indicated that an area closed to hunting, west of the BSMA, was used by a few elk on an annual basis, 3 years of radio tracking data prior to 1980 showed no evidence the area was used by the Lindbergh herd. The Lindbergh elk began using the area during fall 1980. Movement to the area occurred between mid-September and mid-October each year. The total number of elk and the number of radio-collared elk using this area increased to a high in fall 1982 (Table 1). The transmitter of the only collared elk using the closed area in 1980 failed before the concentration occurred in 1981. However, a high degree of traditional use was demonstrated by the radioed elk returning in subsequent falls. Both collared elk using the area in 1981 returned in 1982 and again, in 1983. Of the 10 collared elk using the closed area in 1982, one was illegally killed on the area, one transmitter failed, and one did not return to the area in 1983; the remaining 7 used the area again in 1983.

Table 1. Annual concentrations of elk in an area closed to hunting.

Year	Fall Elk Counts <sup>a</sup>	Number of Radios	Percentage of All Radios <sup>b</sup>	Duration of Stay
1980	13	1	11	< 7 Days
1981	34	2	33	25 Days
1982	112(148) <sup>c</sup>	10	77	45 Days
1983	92	8	73	51 Days <sup>d</sup>

<sup>a</sup>Maximum number of elk observed during duration of stay.

<sup>b</sup>Percent of all radioed elk in Lindbergh herd.

<sup>c</sup>Ground count of total elk.

<sup>d</sup>period includes 3 attempts to move elk off property.

## DISCUSSION

We believe that 3 factors contributed to the concentration of elk in this particular area. The concentrations in 1980 and 1981 apparently were the result of elk selecting for security from hunting. During 1980, the elk arrived immediately after opening of the general hunting season. These animals stayed in a timbered area within 250 m of Highway 200 for less than 1 week before returning to the BSMA. During 1981, the elk arrived several days after the hunting season opened and remained on the area throughout the season. Changes in elk distributions due to hunting is well documented in the literature. Lieb (1981) reported that these elk restricted their use to portions of the study area outside the areas of intensive hunter use. In Idaho, elk densities were greater in roadless areas than in roaded areas during the hunting season (Thiessen 1976). Ward et al. (1980) found that hunting activity in Wyoming created a zone of influence of 800 m. Lyon (1979) noted a movement to less accessible areas during the hunting season in Montana. Elk also move from more preferred areas to areas of extensive continuous timber (Irwin and Peek 1979). Marcum (1975) reported a substantial increase in elk use of areas greater than 1.6 km from an open road during the hunting season. Security during the hunting season is apparently influenced by hunter pressure, independent of other factors. The closed area used by elk in our study area is close to both open roads and human habitation. Elk habitat use of this area is approximately proportional to the availability of each habitat component, with the pasture hay fields and grass-sagebrush components receiving the majority of use.

A second factor contributing to the elk concentration in this area is forage availability and preference, which apparently resulted in the large concentrations during 1982 and 1983. The Lindbergh Cattle Company, which owns most of the closed area, has been attempting to sell the property since 1982; therefore, during 1982, the circular hay-pastures were fertilized and irrigated, but were not cut, and only lightly grazed by cattle during mid-summer. The elk responded to this abundant and highly palatable forage by moving onto the area 3 weeks prior to the opening of the hunting season. Towards the end of the hunting season, elk used the hay-pastures within 300 m of Highway 200 throughout the day. This high visibility resulted in 3 hunters trespassing and illegally killing 4 elk, which in turn drove most of the elk back into the BSMA. The 1982 use, therefore, appeared to be a function of a highly abundant and palatable forage supply in an area that was secure from hunter pressure. Use of the area in 1983 followed a similar pattern to 1982, with elk again arriving before the opening of hunting season.

Forage quality or quantity was felt to be a factor in elk use of clearcuts (Lyon and Jensen 1980). Collins (1979) reported that elk in Utah forage in areas where they obtain the most forage over time. Mackie (1970) stated that "Vegetational complexes and the availability of preferred forage as influenced by general range conditions, annual vegetational growth, and prior use appeared to be the primary determinants of seasonal distributions . . ." Elk in our study area use relatively mesic, high elevation sites during August and much of September, and move to more xeric lowland sites in late September or early October. These

movements correspond to the advent of frost in high areas which apparently results in a decrease in forage palatability.

The third factor contributing to this elk concentration is home range fidelity. Craighead et al. (1973) and Irwin and Peek (1983) report strong home range fidelity for non-migratory elk herds. Elk may also show strong fidelity to distinct seasonal ranges (Brazda 1953, Knight 1970, Hershey and Leege 1982). Because of transmitter failure, we are unable to assess this factor from 1980 to 1981. Since 1981, however, a high degree of fidelity to the closed area has been observed in the radioed elk; once there, forage and security apparently determine duration of the stay. Hershey and Leege (1982) reported that cow elk demonstrate home range fidelity regardless of disturbance, phenological conditions or changing weather.

Two management problems result from this concentration of elk. Forage depredation and fence damage is undoubtedly occurring, but the current landowner has not issued a complaint. However, the property is for sale and future landowners may be forced to make depredation complaints to the Montana Department of Fish, Wildlife and Parks. In addition, 1983-84 was the first winter in which elk concentrated in the closed area, setting the stage for an annual problem of greater duration than the 2 or 3 fall months.

A second, and more important, management problem is the loss of hunter opportunity. If the ratio of observed radios to total radios in the Lindbergh herd is assumed to be proportional to the portion of the herd using the area, then between 70-80% of the herd was unavailable to hunting during 1982 and 1983. This represents a major loss in hunter opportunity since the Lindbergh herd is one of 2 major herds in the BSMA.

#### MANAGEMENT RECOMMENDATIONS

Upon assessing the behavioral, forage and security factors leading to the elk concentration, we offer the following management recommendations in order of probability of success in solving the problem. However, we recognize that because of social and political constraints the probability of success does not equate to the probability of implementing such management recommendations.

1. Allow hunting within the closed area. Hunting is currently prohibited in the area by the landowners, not by BSMA agreement. We feel that even a very limited hunt would greatly reduce the number of animals using the area. However, there are various problems associated with implementing this recommendation which will probably relegate it to being the final solution attempted. Hunting the closed area could result in a limited number of hunters shooting at a large group of elk, which in turn could result in large number of elk being driven toward a concentration of hunters within the BSMA. There are serious public relation problems associated with such "slaughter" situations. Because the landowners are cooperators in the BSMA agreement, they would undoubtedly receive a high degree

of criticism because of their decision to hunt the area, as well as their choice of who are the "lucky hunters". The major landowner of the area has several personal reasons for using hunting as a last resort. First, because the area is in the middle of his ranch, and has always been closed to hunting, he does not wish to set a precedent for hunting the area. Second, the other landowner, north of the river, is adamant against hunting the area. Third, the primary landowner feels that the first hunt will undoubtedly result in extensive fence damage due to stampeding elk. Finally, because the ranch is for sale, he feels that other methods should be attempted first because any future owners may prefer to allow hunting on the area. Should this solution be attempted, the hunt should be conducted early in the week when there would be a minimum number of hunters within the adjacent BSMA. Should the landowners wish to have the Montana Department of Fish, Wildlife and Parks take responsibility for the hunt, the department could issue special permits as to time and place. This would allow a small number of hunters to hunt the closed area prior to opening of the general hunting season. This option would require a lag period of 1 year for the special hunt to be approved by the Fish and Game Commission.

2. Attempt herding prior to periods of heavy hunter pressure in the BSMA. Three attempts to drive the animals off the property were made in 1983, with limited success. The first 2 attempts resulted in the elk returning within a day or 2. The third, made on a Thursday, allowed two groups of hunters to successfully kill elk on Saturday near the western border of the BSMA. Both groups independently reported a "large" group of elk moving toward the western border of the BSMA. We therefore feel that herding attempts should be made just prior to opening day or weekends, when the BSMA receives the heaviest hunter pressure. This would prevent elk from being driven into hunters waiting on the boundary, but at the same time, make hunters available shortly thereafter in order to prevent the elk from returning to the closed area. Herding, in general, will prove to be ineffective unless the elk are prevented from returning to the closed area.
3. Cattle grazing in the area closed to hunting should be initiated during late summer or early fall and maintained at the highest level possible under "wise use" constraints. Human use of the area should be intensified, along with an increase in livestock grazing. It is impossible to tell if the large concentrations observed in 1982 and 1983 would have occurred under "normal" ranching operations. Cattle were only lightly stocked in the area during 1982, and only moderately stocked after the elk arrived in 1983. The potential for social intolerance and direct competition for forage (Nelson 1982) due to cattle use of the area offers the best first approach to solving the problem. If this solution proves to be ineffective, then herding and hunting could be attempted later in the season.
4. Safety zones in the BSMA (Fig. 1) should be monitored during the hunting season to prevent them from becoming reservoirs for elk. Should this problem arise, the safety zones within the BSMA, or the basic agreement, may need to be redefined. Safety zones that are

designated because of close proximity to human habitation could be opened to hunting by the nearest resident. Those zones created for protection of livestock concentrations could be hunted provided the livestock are removed. However, redefining the safety zones within the BSMA will require the agreement of all cooperators and would probably be a lengthy process.

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ELK MANAGEMENT IN THE EAST KOOTENAY SUB-REGION OF BRITISH COLUMBIA VIA  
HUNTING REGULATIONS AND LIMITED ENTRY SEASONS

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Abstract: Rocky Mountain elk (Cervus elaphus) have been steadily increasing in the East Kootenay Sub-Region of British Columbia, from approximately 7,900 elk in 1974 to approximately 19,000 elk estimated post-winter population in 1984. The dramatic increase in population has been attributed to maintenance of the sex ratio despite (a) increased pressure on bull elk hunting through the implementation of specific antler regulations; (b) the use of Limited Entry Hunting (LEH) seasons on antlerless elk including calf-only permits; (c) a series of mild winters in the late 70's and early 80's; and (d) an increase in spring, summer and fall elk habitat through new logging practices and improvements in livestock grazing systems on Crown land. However, the gradual loss of winter range through forest succession, industrialization and human settlement, and the competition for winter forage with other ungulates both domestic and wild, require the implementation of management techniques to ensure that elk numbers do not exceed the carrying capacity of the major winter ranges. Thus, an increase to 6,800 calf-only L.E.H. permits and 2,255 cow/calf-only L.E.H. permits have been proposed for the 1984 hunting season in order to slow the increase and to begin stabilizing the East Kootenay elk population at approximately 25,000 elk.

COLORADO'S EMERGENCY WINTER FEEDING OPERATION, 1983-84

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Big game in Colorado has periodically suffered from severe winters. As human populations have increased and land use patterns changed, a significant amount of big game living space has been lost to man's recreational, agricultural and industrial uses. The result is increased conflict between wildlife and people. This is especially true on big game winter range where human development has forced the animals into less space and has increased the damage to crops and increased the animals' vulnerability to severe winters. Because Colorado has such liberal game damage laws, damage payments and costs for prevention of damage have been significant drains on Division of Wildlife resources.

Emergency winter feeding as a viable tool for wildlife management was thoroughly tested during the winter of 1983-84. Feeding's potential to reduce or prevent game damage and reduce winter mortality was established, but feeding is not a panacea and has potentially dangerous side effects. It must be considered a drastic action to be implemented only under extreme conditions when other actions have failed or were found to be inappropriate. Additionally, it must be supported by a strong policy, carried out in accordance with implementation plans, and justified by a thorough evaluation in relation to the population objectives of the species involved.

Winter wildlife feeding programs have traditionally had high appeal to the public and low appeal to wildlife professionals in North America. Both prejudices have been based upon incomplete understanding of the winter ecology of big game species. The public has not understood that big game animals are well adapted to winter severity and food shortages, and that big game ruminants will decline in body weight every winter and, consequently, will look alarmingly undernourished even during moderate winter conditions. The public has not understood that big game animals suffer significant winter-caused mortality even during mild winters. Wildlife professionals have opposed winter food supplementation because they generally believed it was ineffective in reducing big game population losses and because they believed a precedent set by feeding in any situation compelled feeding in every situation. In fact, most past efforts to feed deer have failed or may even have increased deer mortality.

Emergency winter feeding operations in Colorado were designed to meet two general goals:

- A. To reduce or prevent game damage.
- B. To reduce severe winter-caused mortality.

Both goals were met when evaluated herd by herd, but efforts lose significance when viewed statewide. During 1983-84, the Division fed less than 1% of the post-season statewide deer herd, but in areas hard hit by winter as high as 90% of the affected populations were supplementally fed and positively affected. Animals causing damage were targeted for feeding to hold them away from the damage-causing situations. These efforts were generally successful.

By the first week in January, the Southwest and Northwest Regions were receiving pellets from two mills which were building pellets to our specifications (Table 1). The regions began to buy hay for elk feeding and also equipment. Personnel took on temporary assignments. We inventoried and then gathered up all our snow equipment, leased some, and bought some to get us through. Two helicopters from our contractors were moved to Gunnison (this was ultimately reduced to one). As we established more and more feeding areas, it quickly became clear we were rapidly going to go beyond our supplies and our ability to deliver. Not only were more and more areas getting critical, but more and more animals were coming to established feed sites.

At its peak, we were feeding 68,000 deer, elk, antelope and bighorn sheep daily. This cost a great deal of game cash funds, manpower and time. It was the largest big game feeding effort ever embarked upon in Colorado. In fact, it was probably the largest operation of this sort ever embarked upon in the U.S. The cost to the Division over and above the daily operation of the agency: 3.8 million dollars.

What did we accomplish with a 3.8 million dollar price tag? We were successful in reducing damage, but paid record damage claims. We were successful in saving animals on feedgrounds, but were unable to feed all the animals in many areas where high mortality occurred. Most importantly we learned from the experience. An Emergency Winter Feeding Policy has been developed (Attachment 1), an implementation plan drafted, and a thorough evaluation was conducted (Carpenter et al. 1984).

#### FEEDING PROGRAM GUIDELINES

Winter feeding can be and has been used to reduce or prevent game damage and to mitigate the effects of severe winter on big game survivability.

##### A. Winter Feeding to Reduce or Prevent Game Damage

Feeding animals to hold them away from situations in which they cause damage to crops or cropland will be used only as a last resort. It will be implemented only after other actions to prevent damage have failed or are determined to be unworkable. Winter feeding will be considered on a site-by-site basis with the consequences of incurring and paying for damage weighed against the total cost of purchasing feed and delivering feed to reduce or prevent that damage. Prevention type feeding will not start unless damage has occurred or is imminent. Pre-planning will focus

Table 1. Composition and chemical analysis of pelleted supplemental diet for deer and elk.

INGREDIENT	WEIGHT %
Wheat middlings	43.0
Brewers dry grain	25.0
Cottonseed hulls	15.0
Suncured alfalfa pellets	7.0
Dehydrated alfalfa	5.0
Corn starch	3.0
Molasses, cane	2.0
Vitamin A, D, E premix	0.002
Trace mineral package (Mg, Zn, I, Fe, Co, Cu)	0.005
<u>Analysis</u>	
Dry matter	86.8
Ash	9.5
Crude protein	23.3
Neutral-detergent fiber NDF	32.7
Acid-detergent fiber	20.6
Lignin ADL	5.2
Gross energy kcal/g	4.3
Hemi-cellulose	12.1
Cellulose	15.4
Apparent in vivo dry matter digestibility	
Mule Deer	58.2
Elk	42.7
In vitro digestible dry matter	70.5
Apparent in vivo digestible energy kcal/g	
Mule Deer	2.75
Elk	2.13
Apparent in vivo metabolizable energy kcal/g	
Mule Deer	2.33
Elk	1.81

Table 2. Mean ad libitum intake for mule deer and elk consuming pelleted supplemental diet. Mean body weight for deer and elk in these trials were 59.6 and 231.8 kg, respectively.

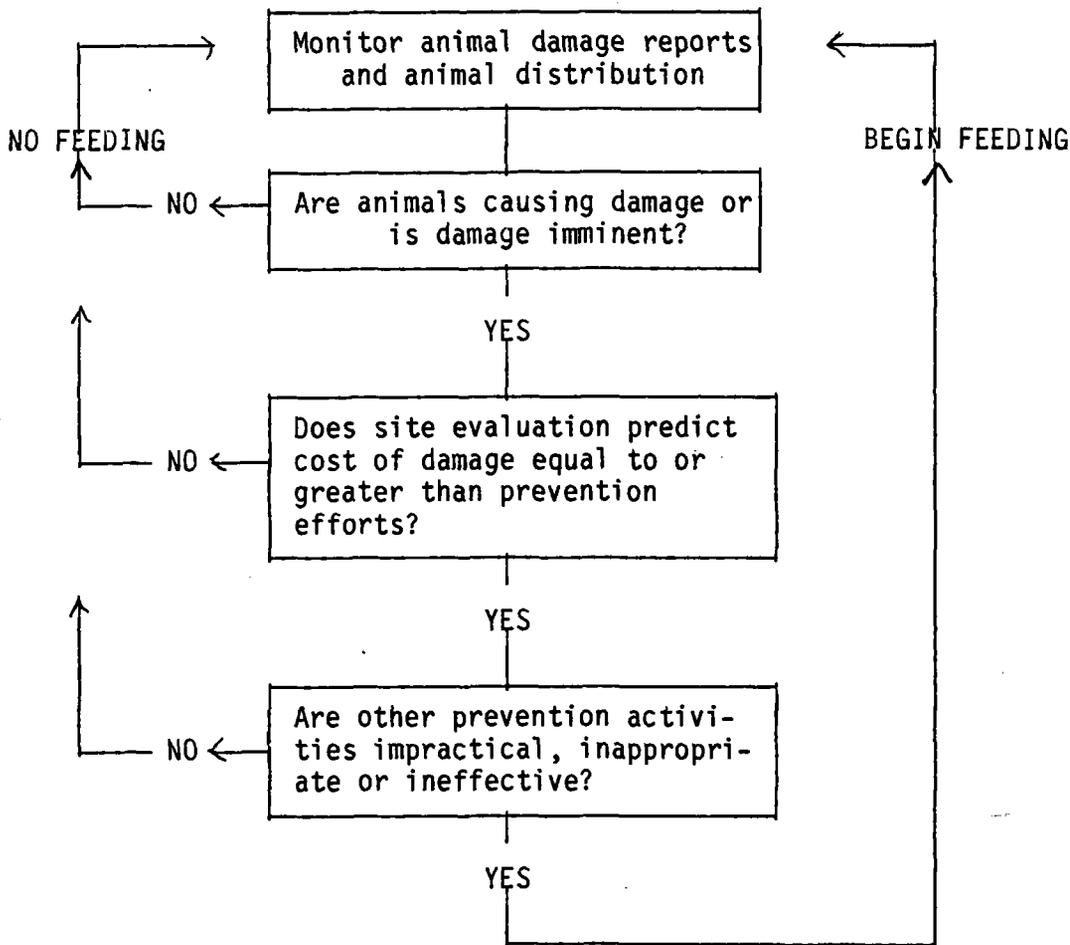
Average Dry-matter and Energy Intake	Species			
	Mule Deer		Elk	
	$\bar{x}$	se	$\bar{x}$	se
g/day	1991.0	182.0	6956.7	780.7
g/kg BW/day	29.7	2.2	29.8	1.7
g/kg BW <sup>.75</sup> /day	84.8	6.3	117.1	8.3
kcal DE/day	5482.0	502.4	14821.2	1663.3
kcal DE/kg BW/day	81.8	6.1	63.5	3.49
kcal DE/kg BW <sup>.75</sup> /day	233.5	17.4	248.1	17.3
kcal ME/day	4659.7	427.0	12598.0	1414.0
kcal ME/kg BW/day	69.5	5.2	54.0	3.0
kcal ME/kg BW <sup>.75</sup> /day	198.5	14.8	210.9	14.6

Table 3. Apparent in vivo digestibilities for mule deer and elk consuming a pelleted supplemental diet.

Apparent digestibility %	Species			
	Mule Deer		Elk	
	$\bar{x}$	se	$\bar{x}$	se
Dry Matter	58.2	0.03	42.7	0.22
Organic matter	59.7	0.03	46.2	0.13
Energy	63.3	0.03	49.0	0.22
NDF	60.3	0.03	43.5	0.01

where damage potentially may occur, using comprehensive site plans. Adequate expertise exists within the Colorado Division of Wildlife to estimate probable game damage at site specific resolution. Likewise, we have the expertise and experience to estimate total prevention costs. The decision to feed or not to feed big game ungulates (elk, deer, etc.) is largely a matter of which is most cost effective - to pay for damage or to prevent the damage. However, experience has shown that under certain conditions, purely financial considerations are overshadowed by other considerations such as animal visibility and the ability of landowners to tolerate the damage. Every effort will be made to keep any damage-preventative feeding program cost effective.

Figure 1. Flowchart of decisions necessary to initiate emergency supplemental feeding to prevent or reduce game damage.



B. Emergency Winter Feeding to Reduce Winter Mortality

The use of emergency winter feeding to reduce winter mortality will be considered for big game ungulates.

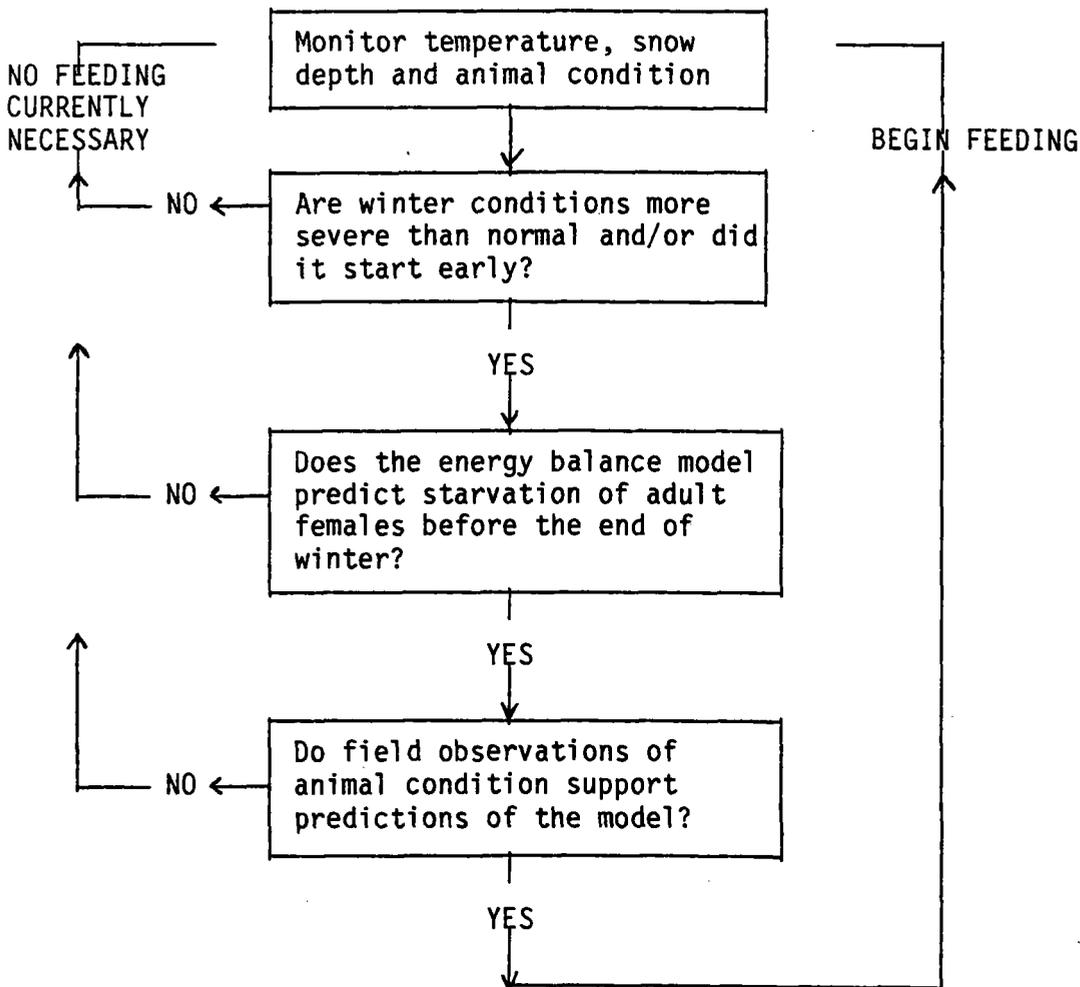
Two criteria listed below must be met before feeding operations will be considered:

1. To have a significant impact on long-term animal populations, a minimum of 25% of the population must be fed. This implies that 25% of a post-season Data Analysis Unit population, or some major sub-population within a Data Analysis Unit, is located so that it is feasible to feed.

2. Evaluation indicates a probable adult female mortality of 30% or more if no feeding occurs.

Supplement feeding of big game herds may be initiated during winters when abnormally high mortality is probable in the absence of supplementation. Adult females are used as indicators because they are numerous, valuable and less variable in physiological characteristics than other sex and age classes. Because they represent the reproductive capital of many years of management investment, they are difficult to replace in the event of severe mortality. Probability of mortality will be based on 3 criteria: 1) measures of winter severity, 2) simulation modeling of animal conditions, 3) field observations on animal condition.

Figure 2. Flowchart of decisions necessary to initiate and terminate supplemental feeding of big game herds for animal survival.



Emergency Winter Feeding Site Plans - The Emergency Winter Feeding Site Plan is designed as a planning document for developing area, regional and statewide feeding plans in a uniform manner. The information is tied to the Wildlife Commission Policy Statement and baseline data to be used for determining when feeding should begin. Site plans establish area and regional responsibility and will be used to set priorities for limited resources. The appropriate area supervisor will complete the site plan, monitor conditions that lead up to feeding operations, and make recommendations for feeding to the regional manager. The regional manager will carry that recommendation to the Director of the Division. This will allow for a graduated feeding program. Winter conditions and animal distribution will not be uniform throughout the State so the Division must, through the prioritization method, limit commitments of resources by area so that our ability to react at a later date in another area is not jeopardized.

#### LITERATURE CITED

Carpenter, L.H., R. B. Gill, D. L. Baker, and N. T. Hobbs. 1894. Colorado's big game supplemental winter feeding program, 1983-84. Unpublished report, Colorado Division Wildlife, Denver. 98 pp.

ATTACHMENT 1

STATE OF COLORADO  
WILDLIFE COMMISSION

POLICY NO. C-4

November 15, 1984

SUBJECT: EMERGENCY WINTER FEEDING

Emergency winter feeding of big game ungulates may be used as a last resort to prevent damage to private property or to reduce unusually severe winter-related mortality.

Feeding may be initiated when winter conditions in any area are such that the estimated cost of damage to private property will exceed the cost of feeding to prevent that damage and other preventive measures have been ruled impracticable, inappropriate or ineffective, or if the predicted winter-related mortality exceeds thirty percent (30%) of the adult female segment of a major big game population. The decision of where and when to feed will be made by the Director of the Division of Wildlife considering site-specific, quantified information about the anticipated costs of feeding versus the consequences of not feeding.

If the anticipated feeding activity will require the redirection of resources equivalent to fifty percent (50%) or more of the Division's appropriation for game damage prevention for any fiscal year, a supplemental appropriation will be sought through the State's budget process in consultation with the Executive Director of the Department of Natural Resources. In each case, the Division will consider whether Wildlife Cash or the General Fund is the most appropriate source for the supplemental request. The feeding activity will be structured so that Wildlife Cash and General Fund expenditures do not exceed the amount of such funds provided in a supplemental appropriation.

An evaluation of methods, costs and administrative procedures for any emergency winter feeding program funded by a supplemental appropriation will be provided to the Wildlife Commission and the Executive Director of the Department of Natural Resources.

## IDAHO ELK POPULATION STATUS/DEPREDAATION PROBLEMS

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Abstract: Elk (*Cervus canadensis*) in Idaho have increased since 1976. These population increases have been followed by increased tag sales, hunter harvest and elk damage complaints from landowners. Attempts to resolve depredations have included special depredation hunts, haystack paneling, scare devices and hazing, baiting and feeding, and issuing kill permits.

Impromptu depredation hunts were totally unsuccessful while one scheduled depredation hunt was successful. A law was passed in 1984 increasing each elk, deer and antelope tag by \$1.50 with the income earmarked for depredation and emergency winter feeding.

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### HISTORY AND STATUS

Idaho has long been a major elk-producing state and populations have increased substantially during the past 6-8 years. Wildlife managers are very aware that sportsmen frequently refer to "the good old days". I suggest that in Idaho, 1984 is "The Good Old Days".

Historically, either-sex hunting was the rule statewide with seasons in many areas extending into early December. In 1975, general hunts south of the Panhandle were changed to bulls-only and have remained under this rule to date with the exception of controlled hunts.

The highest elk harvest recorded statewide was 17,064 animals in 1968 (Figure 1). That total included 8,708 bulls and 8,356 cows. In 1958, 1960 and 1961, the harvest exceeded 16,000 animals each year. There were 7,909 (48%), 7,280 (44%) and 8,392 (51%) cows in the harvest, respectively, during those years.

In 1976, the statewide harvest bottomed out at 4,135 animals and included only 827 cows. In 1983, there were 13,076 total animals harvested. This included 10,143 bulls (77.6%) and 2,933 cows (22.4%). This is more bulls than has ever been taken in any previous year.

Since 1976, the year following initiation of bulls-only hunting, statewide harvest has increased significantly. The Department developed overall policy plans in 1978 with the following three goals: 1) rebuild elk numbers to approximately 1965 level; 2) rebuild allowable harvest to approximately 1965 level; and 3) meet 1990 demand at greater than current success rate. Historic estimates were that the 1965 statewide elk population was 81,000 and in 1975, we estimated 50,600 elk statewide.

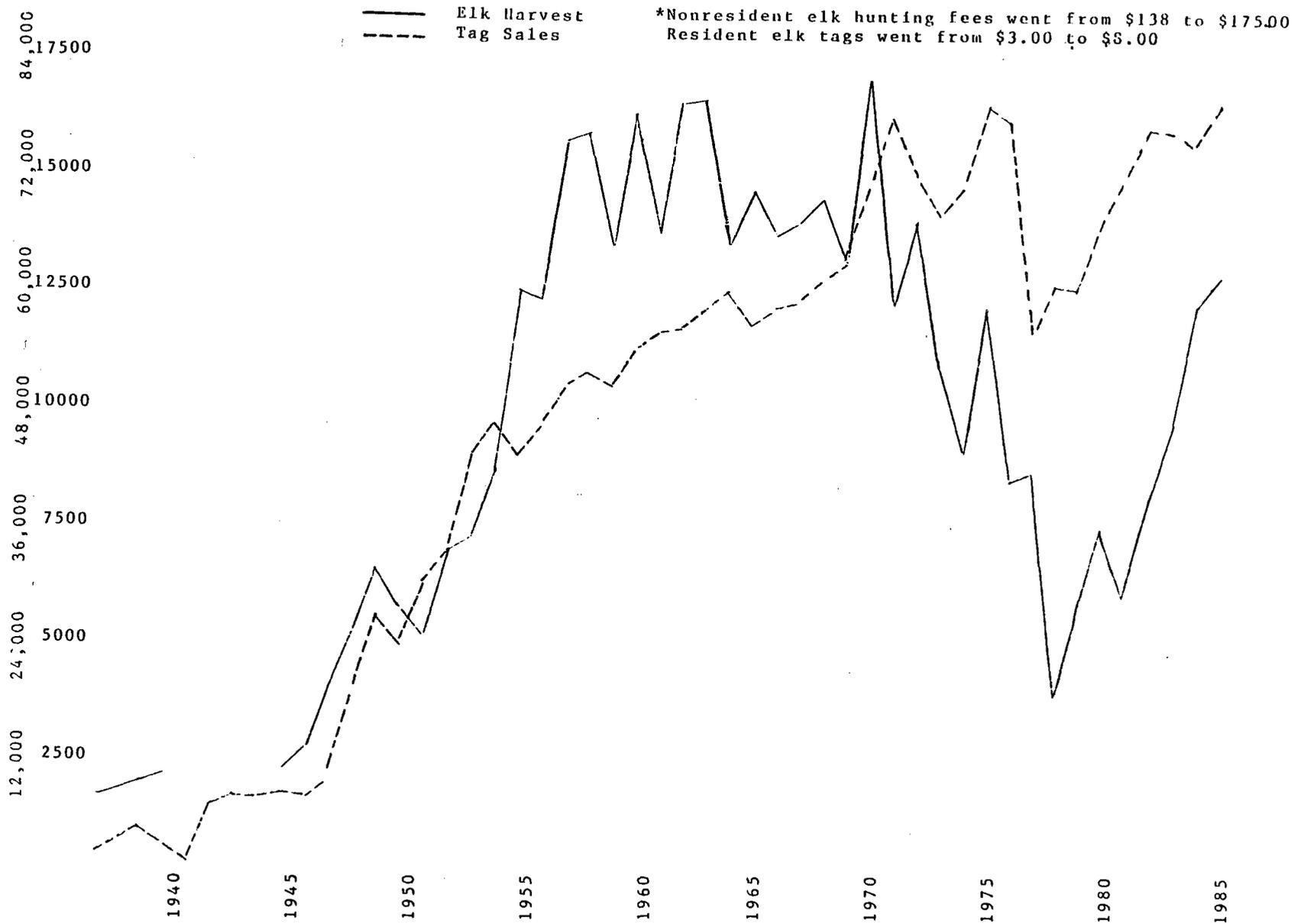


Fig. 1. Tag sales and harvest levels for Idaho elk populations, 1935 - 1983

## MANAGEMENT PLANS

In 1981, we developed the "Elk Species Management Plan - 1981-1985" and in that document, the estimated 1981 statewide population was 90,325 and the projected 1990 population was 109,635 with a harvest of 8,165. These numbers, which were larger than 1975 estimates, were probably a result of it being a second effort at estimating populations and because better information was available in some areas.

The 1983 harvest of 13,076 elk was about 60% above the 1990 goal. The Species Plans will be rewritten in 1985 for the 1986-1990 period.

The outlook for continued increases is good-to-excellent if we can permanently resolve the problems associated with depredations as populations increase. There were many problems this winter which our regional personnel did an excellent job of resolving. The Department uses panels or fences to protect hay stacks; hazes animals; baits animals; and has tried depredation hunts. Even with the timely job our personnel did this winter, there was legislation proposed to force us to pay for depredations. This legislation failed to pass.

## DEPREDATION PROBLEMS AND ACTIONS

During November, 1983, we received numerous depredation complaints from landowners who grow winter wheat in our management unit 11A. Within one week, we were able to develop season structures for 15 consecutive 6, 7 or 8-day controlled either-sex depredation hunts with 20 permittees in each hunt beginning November 19, 1983 and ending March 2, 1984. We advertised for applicants for 13 days, received 5,154 applications and conducted the drawing on November 9. The Commission waived the two-year waiting period for receiving a controlled hunt permit. A numerical list was developed as names were drawn and individuals were called to notify them when and where to pick up controlled hunt permits and where the hunt area was located. Names and phone numbers of landowners who would allow hunting were also furnished each permittee.

Two major problems developed prior to the hunt opener. The landowners decided their problems were not adequate to allow hunters to trespass, and Nez Perce Indians in the area began to hunt elk in the area in response to publicity about the hunts. The Indians probably were the major influencing factor on the landowners as several confrontations regarding trespass were reported.

During the first seven-day hunt segment, 15 permittees took part and harvested one adult cow elk. All subsequent hunts were postponed on the basis that the landowners would contact us where problems with elk depredations developed; we would then call the next group (designated number) of people on the hunt list to go hunting. The landowners demanded they be able to pick the hunters and that no more than five hunters be allowed at one time. We agreed on the reduced number of permit hunters but did not consider anyone not drawn for the permit hunt list. We did

not hear from any landowner through the March 2 closing of the hunt so, in effect, all hunts were cancelled after the opening segment.

During normal 1983 big game seasons development and setting Region 1 personnel requested an elk hunt with 25 either-sex permits in management unit 1 adjacent to the Canada boarder. This hunt was proposed specifically to curtail elk damaging winter wheat fields. The hunt was set for December 1-31 and limited to private property only in a small portion of management unit 1. Permittees harvested 19 animals of which there were 15 bulls and 4 antlerless animals. Ten of those 15 bulls were five point or larger. Although the hunt turned into somewhat of a trophy hunt, there have been no complaints about the hunt nor subsequent elk damage complaints.

Region 1 has recommended 50 antlerless elk permits for the same area for December 1984 in an attempt to stabilize the population and to help remove the depredation problem. Recommendations for antlerless-only permits in many other units are being recommended in an effort to stabilize or reduce populations in many other management units.

Beginning in December, 1983, heavy snows fell across all of the state south of the Salmon River. By the first of January, elk had moved to low elevation areas and began causing depredations on haystacks, livestock feeding areas, ornamental vegetation, and some winter wheat. We tried to scare elk away from problem areas with Zon guns, repellent mixtures, helicopter and snowmobile hazing. We also used hay to bait animals away from public areas. Haystacks and stack yards were protected with wood panels, wire panels and fences.

In some areas, feeding sites were developed and elk were hazed from problem areas to these sites. The animals were fed until snow conditions allowed them to return to natural food sources which was as late as mid-April in some areas.

High voltage electric fences were tried in some areas with no success. Groups of elk would simply force the lead animals in a group through the fence.

There were about 30 thousand panels placed around haystacks in the winter of 1983-84.

Two individuals who have established tree nurseries in wooded areas in north Idaho made numerous complaints this winter about both elk and deer eating their trees. After many attempts to resolve the complaints, the Department issued a kill permit to an individual. This is the first time a kill permit has been given to an individual and it is not known what problems this precedent will cause in the future. Another request has been received from a neighbor of this individual. During the first two weeks, he killed one spike bull.

The Department has also issued kill permits to our personnel but few or no animals have been killed to date.

Feeding to eliminate depredations has caused problems - road kills, train kills, fence damage, harassment by snowmobiles and cross-country skiers, dog and other predator problems.

The Department spent about \$540,000 from December 1 through April on feeding and depredations. The total directly related to depredations was about half that amount.

A bill to increase the price of all elk, deer and antelope tags was passed, effective 1984. This money (about \$350,000 per year) is earmarked for emergency winter feeding and depredation control. It will provide our Department with a source of funding to alleviate depredations.

Another law enacted by the 1984 legislature provides that the Director may establish depredation hunts without Commission approval.

During the past five years, as elk populations increased, depredations on crops on private property have also increased. The winter of 1983-84 was one of the most severe on record in the southern one-half of the state and depredation problems rose to an all-time high. Department personnel were able to resolve most complaints quickly and most landowners involved were satisfied with our effort. The Department is also developing a statewide depredation plan. When this is completed with input from virtually every group of landowners and sportsmen plus as many individuals as possible in conjunction with the new revenue source, we hope to continue to increase elk populations and eliminate the depredation problems they cause.

# AN ALBERTA ELK HUNTER SOCIOECONOMIC PROFILE<sup>1</sup>

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## INTRODUCTION

Elk in Alberta are held in trust by the provincial government on behalf of society at large. Consequently, management of this big game species is a public endeavour. They are an integral part of our natural ecosystem and serve as a source of enjoyment and study by members of society both consumptively (hunting) and nonconsumptively (viewing and study). The focus of this paper is on consumptive use (sport hunting) or, more specifically, consumptive users (hunters).

Hunting has long been recognized as a wildlife management tool. Much of the value associated with wildlife such as elk originates with hunting activities. These values or benefits are for the most part not registered in the market place. License fees which are the market component of elk hunting values constitute only a small part of such values or benefits. This situation leads to a dilemma. Management of elk is largely a public endeavour whereas the use of elk, including hunting, is a private one. Public management decisions must reconcile the provision of elk on the one hand, with the demand for its use on the other. The importance of this reconciliation process is magnified by the increased competition for elk habitat from alternate, displacing land uses. It is our view that public wildlife policy and management decisions can be enhanced by knowing more about wildlife users - their characteristics, activities, motivations, expenditures and wildlife values.

The course of this paper begins with a biographical sketch of elk hunters active in Alberta in 1981 and continues with a profile of elk hunting activity. An examination of hunter expenditures and benefit estimation models follows. The paper concludes with a look at hunter demand, harvest and habitat relationships.

Data used in this paper originated from a survey of resident and nonresident Alberta elk hunters in 1981 by the authors and funded by the Alberta Fish and Wildlife Division (Adamowicz 1983; Phillips 1983; Phillips and Adamowicz 1983). A sample of 500 out of approximately 32,500 resident elk hunters (1.54 percent) were randomly selected and asked to respond to a resident mail questionnaire. Unopened returns reduced the

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<sup>1</sup>Portions of this research were funded by the Fish and Wildlife Division, Alberta Energy and Natural Resources Department.

effective sample size to 480. There were 266 responses (55.4 percent). A sample of 209 out of 310 nonresident elk hunters (67.4 percent) were randomly selected. The effective sample size was 201 of which 137 (68.2 percent) responded. There was no evidence of non-response bias.

#### HUNTER CHARACTERISTICS, ACTIVITY AND EXPENDITURE PROFILES

A typical resident elk hunter is 37 years of age, male, a high school graduate with an income of \$32,000 per year and 18 years big game hunting experience (Table 1). His nonresident counterpart is older at 46 years of age, male, and has 13 years formal education. The nonresident hunter has a higher income (\$39,100) and more big game hunting experience (23 years). Both categories of hunters rate elk hunting in Alberta "good" to "very good". The resident hunter holds five different Alberta hunting licenses, the nonresident hunter only two. Both were raised in rural areas (Table 1).

Resident hunters indicated reasons for hunting in order of importance to be: outdoor enjoyment, meat, exercise, companionship, and trophy. Hunting for enjoyment and for meat reasons are nearly twice as important as are the latter three reasons. Non-resident hunters indicated that hunting for trophy is their most important reason followed by outdoor enjoyment, meat, companionship and exercise reasons.

Table 1: Socioeconomic Characteristics of 1981 Elk Hunters in Alberta

Characteristics	Resident Hunters		Nonresident Hunters	
	Average	Std. Dev.	Average	Std. Dev.
Age (years)	36.6	12.1	46.1	12.4
Percent Male	97.4		100.0	
Family Size (No. of persons)	3.4	1.5	3.1	1.5
Annual Income (median dollars)	32,029.0		39,184.0	
Education (No. of years)	12.3	2.9	12.8	3.4
Big Game Hunting Experience (years)	17.7	13.1	23.0	11.9
Mean Rating (5-point scale: 1 excellent, 5 very poor)	2.6	1.1	2.7	1.4
Alberta Licenses Held (number)	5.0		1.9	
Percent Raised in Rural Area	58.5		55.4	
Percent Raised in Small Town	22.3		24.1	
Percent Raised in Urban Area	19.2		20.4	

The resident elk hunter takes three elk hunting trips per season involving a total of 12 days. He hunts with two companions (Table 2). The nonresident hunter makes one elk hunting trip to Alberta involving 13 days and three companions. Success rates for both resident and nonresident hunters were approximately 11 percent. Resident hunting trip expenditures total approximately \$430 per season of which nearly half is travel costs and about 20 percent is food costs (Table 3). In addition, capital costs (e.g. equipment) amount to about \$580 per year. The nonresident elk hunter in 1981 spent \$2,250 to hunt elk in Alberta, most of which was spent in Alberta (\$1,825). Guiding costs amount to about 40 percent of the total and travel costs are about 15 percent.

The time and income devoted to elk hunting in Alberta by hunters suggests that consumptive use of that species is significant. There were 29,000 active resident elk hunters and 310 nonresident.<sup>2</sup> In total, hunters in Alberta spent 357,000 hunter days and 13 million dollars (exclusive of capital costs) to hunt elk in 1981.

#### BENEFIT ESTIMATES

Hunting benefits which are largely extra-market can be estimated either in terms of willingness to pay (WTP) or in terms of willingness to accept compensation (WTAC). Benefits measured in dollars associated with gains in satisfaction from elk hunting activity are referred to as WTP; benefits measured in dollars but associated with losses in satisfaction from denied elk hunting opportunities are referred to as WTAC. Which concept of benefits is appropriate depends on circumstances. If there is a reduction in elk habitat and hence elk population for a particular area, then WTAC may be appropriate, particularly if the reduction in benefits is also viewed as a violation of rights associated with initial resource use levels (Knetsch 1980). Otherwise, WTP is appropriate.

Because of the absence of market prices associated with elk hunting and other forms of outdoor recreation activities, numerous techniques have been developed and modified during the past three decades to estimate extra-market benefits. Only a few survived as acceptable on economic grounds (Dwyer, et al. 1977; Adamowicz and Phillips 1983).

One of these techniques is the direct or contingent valuation method in which hunters (a) indicate the amount of dollars they are willing to pay over and above expenditures to engage in hunting to reveal WTP; and (b) indicate the amount of dollars they must receive in order not to

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<sup>2</sup>Although 32,500 Albertans purchased elk licenses, only 29,000 actually hunted.

Table 2: Hunting Activity of 1981 Elk Hunters in Alberta

Item	Resident Hunters		Nonresident Hunters	
	Average	Std. Dev.	Average	Std. Dev.
Number of Trips per Season	3.3	2.2	1.1	0.5
Number of Days per Season	12.2	25.8	13.0	2.9
Miles Travelled One-Way per Season	428.3	572.2		
Days per Trip per Hunter	4.5	9.8	11.4	28.9
Miles per Trip per Hunter	146.9	214.8		
Party Size per Trip per Hunter	3.0	3.7	4.1	8.6
Percent of Hunting Time Spent in Alberta			43.9	34.1
Success Rate (Percent)	11.80		11.0	

Table 3: Average Expenditures of 1981 Elk Hunters in Alberta

Item	Resident Hunters	Nonresident Hunters	
		Total Trip	Alberta Portion
Travel Costs	\$199.91	\$569.84	\$286.81
Lodging Costs	18.15	140.76	109.70
Food Costs	84.28	118.19	104.53
Beverage Costs	21.37	30.74	28.53
Rental Costs	0.69	11.57	11.57
Guide Costs	7.85	870.68	835.02
Ammunition Costs	28.74	13.75	13.07
Service Costs	34.65	173.18	118.50
Other Costs	33.08	27.04	19.56
Total Variable Costs--Average	428.74	2,248.00	1,823.18
Total Variable Costs--Std. Dev.	500.00	2,448.00	2,335.00
Total Capital Costs <sup>1</sup> --Average	582.26		
Total Capital Costs--Std. Dev.	2,048.00		

<sup>1</sup>Capital costs are determined by multiplying the total spent on an item by the proportion of time that the item is used for hunting in the season. If a vehicle cost \$10,000 and was used for hunting 5 percent of the time, then the capital cost is  $.05 \times \$10,000 = \$500$ .

engage in the activity to reveal WTAC. Benefit estimates from resident Alberta elk hunters for 1981 are on average \$63.00 WTP per day and \$66.82 WTAC per day. For nonresident hunters, the average amounts are \$61.50 and \$42.99 respectively (Table 4). WTAC estimates are lower than WTP for nonresident because of the availability of substitute sites and a lesser infringement upon the ability to hunt. Since nonresidents have a variety of alternate hunting areas available to them, they do not require as much compensation for a reduction in hunting days in Alberta.

Two indirect methods are also commonly used: the travel cost method (Hotelling-Clawson method) and the hedonic price method (Hotelling 1949; Clawson 1959; Clawson and Knetsch 1966; Bockstael and McConnell 1981). The travel cost method employs travel cost information (Table 3) as a proxy for price of hunter days or trips (Table 2) to develop demand schedules and obtain benefits. A schedule of hypothetical user fees is introduced in which participants are assumed to react to the fee increases in terms of reduced hunter days in a manner similar to increases in travel costs. An estimate of WTP benefits using this technique is \$14.50 per day (Table 4).

Table 4: Extra-Market Benefit Estimates by 1981 Elk Hunters in Alberta

Type of Value	Resident Hunters	Nonresident Hunters
Willingness to Pay per Day (Direct)	63.00	61.50
Compensation per Season (Direct)	813.17	316.01
Compensation per Day (Direct)	66.82	42.99
Marginal Value per Day (Hedonic)	61.53	n/a
Average Value per Day (Travel Cost)	14.50	n/a

The hedonic price method uses a household production function approach (Becker 1966; Lancaster 1966) whereby the utility of outputs, that is, days of elk hunting, is produced by combinations of inputs, that is, travel cost, ammunition, public habitat and elk populations, in a consumer's (hunter's) production function. Data requirements are not difficult to meet and there is considerable flexibility in the functional form used in a simultaneous "supply-demand" framework. Quality characteristics (habitat, success rates, etc.) are easily incorporated. Hedonic price method estimates for a marginal day of elk hunting is \$61.50 for resident hunters (Table 4).<sup>3</sup>

<sup>3</sup>In order to derive the hedonic estimates, a selected sample was chosen. This slightly smaller sample included all respondents with the data essential to the hedonic technique. Those respondents with missing essential information were removed.

The benefit estimates provided by the hedonic technique are of a slightly different nature than those presented earlier. Hedonic estimates provide marginal values which are estimates of the benefit of an additional hunting day. The direct and travel cost techniques provide estimates of the benefit of an average hunting day.

Elk hunter benefit estimates can be expressed in terms of the aggregate hunting benefits derived from the resource. The approximately 29,000 active elk hunters spend an average of 12.2 days hunting and received an average of \$63.00 of extra-market benefit per day for a total of \$22,289,400 of benefit. The 310 active nonresident hunters spent 13 days on average and received \$61.50 of extra-market benefit per day for a total of \$247,845 of benefit. In total, the elk hunting resource accounted for over \$22.5 million of extra-market benefits or approximately \$6,500 per elk harvested in Alberta. These figures represent value magnitudes which clearly show the importance of elk resources to society, and particularly to Albertans.

#### THE ROLE OF SOCIOECONOMIC ANALYSIS IN ELK MANAGEMENT DECISIONS

The economic information above is useful only if it is incorporated into planning, decision making and wildlife management. This paper concludes with an outline of some areas in which socioeconomic analysis can be used in the wildlife policy process.

Wildlife management has primarily relied on biological information for policy formation. A low population count results in a closed season or a limited number of tags sold. Hunting activity, on the other hand, is driven by socioeconomic variables. If incomes rise, more time is available for hunting. Economic analysis can provide input into wildlife management by indicating the effect of a change of socioeconomic variables on hunting activity and harvest rates. The hedonic technique described above is an example of such economic analysis. The estimation of extra-market benefits first requires the estimation of the importance of various hunting activity variables (days, harvest, quality) on the expenditures incurred. Just as the expenditure for a house can be broken down into the number of square feet, the number of bathrooms, etc., hunting expenditures can be determined by the number of days, harvest and hunting quality. From this result, the change in expenditures can be determined for an additional bathroom on a house, or a day or harvest in hunting. This added expenditure results in the "price" of an additional day or additional harvest. Use of these "prices" in an equation called a demand function provides an estimate of important relationships involved in hunting activity. For example, a demand curve for elk hunting may appear as:

$$\text{Days} = f(\text{Income, Education, "Price of Days", Harvest, Quality})$$

where the "Price of Days" variable is the marginal expenditure required to provide an additional day of hunting. Estimation of this relationship could provide forecasts of hunter days for changing economic, social and biological conditions.

Hunter days, however, is only one part of management information. The effect of hunter days on the wildlife stock through harvest rates is likely more important. Estimation of a function such as:

$$\text{Harvest} = f(\text{Days, Miles Travelled, Cost ...})$$

may provide forecasts of changing harvest rates dependent on changing hunter activity and motivation levels. Harvest rates are an important policy variable linking wildlife management with demand. Estimation of relationships between socioeconomic variables and biological factors can provide the "a priori" knowledge necessary for effective wildlife policy.

A major concern among economists is the proper representation of wildlife habitat values in social decision making and land use planning. Reduced wildlife habitat will result in either fewer hunting days or lower hunting quality. The former will decrease benefits by the number of days lost times the willingness to accept compensation while the latter will result in lower estimates of WTP and WTAC. In either case, economists can help to bring wildlife habitat values on the same base as agricultural expansion, drainage or some other monetarily well defined activities. Work is proceeding currently to evaluate the loss of habitat for waterfowl in the U.S. and Canada (e.g. Miller and Hay 1981).

Finally, the changing social and economic conditions may also play an important role in future wildlife management. As mentioned earlier, the majority of elk hunters were raised in rural areas. What will be the effect of urbanization on the demand for wildlife resources? Urban individuals are generally more non-consumptive-use oriented, therefore, we may expect a decrease in demand for consumptive use. Secondly, urban hunters appear to be younger and less experienced than rural-raised hunters. How will the new type of hunter affect the wildlife resource? Will a change in wildlife policy be necessary?

These are questions which require further research. In particular, ongoing continued analysis of socioeconomic variables is required in order to predict changes in resource use and to aid in policy decision-making.

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## HABITAT UTILIZATION BY EAST KOOTENAY ELK POPULATIONS

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Abstract: Habitat selection and utilization by elk was investigated within biophysical inventories covering the coal properties of Crows Nest Resources Limited in the Upper Elk River Valley of the East Kootenays. Habitat use was assessed through three years of pellet group counts and browse surveys, sighting records, a comprehensive radiotelemetry program, and a nutritional fecal analysis on a seasonal basis.

The results suggest that the study area supports two elk populations loyal to their respective winter ranges. From spring to fall, habitat selection becomes less pronounced. Seventeen habitat types were defined and investigated for the study area based on dominant plant communities as related to soils, aspects, moisture regime and elevation. Overall, elk densities were highest in "Douglas Fir" habitats. In summer, the "Alluvial Complex", "Riparian Meadows", and "Subalpine Meadows" showed preferred use.

Seasonal distribution of elk by aspect showed overall preference for the east-southeast aspects, with a positive selection of east-southeast aspects by the northern population in winter. The southern population overwinters on Grave Lake Prairies and Elk River Flats. Calving habitats and rutting areas seemed to be unspecific. Habitat selection by elevation indicated preference for high elevations in summer with a range from 1600 - 2200 metres.

Fecal analysis showed substantially less use of graminoids on the southern winter range, where it was substituted through conifers. The overall winter diet for the northern population was dominated by graminoids, and for the southern population by conifers. From spring to summer, use of graminoids and forbs increased dramatically for both herds, and conifers almost disappeared from the diet. The results suggest opportunistic feeding behaviour by elk in the study area.

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### INTRODUCTION

The approximately 200 square kilometre study area is located in the East Kootenays of British Columbia within the Front Ranges of the Rocky Mountains, a region characterized by a strong north-south alignment of major ridges parallel to the strike of westward slipping thrust faults and sedimentary strata (TAESCO 1983). It forms part of the Dry Interior Region in the rainshadow of the Interior Ranges. It is typified by the Interior Douglas Fir Zone at lower elevations and the Subalpine Engelmann Spruce-Alpine Fir Zone at higher elevations. Elevations range from 1375 to 2575 metres. The study area has a distinct fire history.

It supports six ungulate species of which elk is the most abundant, followed by Rocky Mountain bighorn sheep, deer, moose and mountain goat. According to historic records, elk populations in the Elk River Valley increased dramatically in numbers as a result of large scale land clearing and logging in the 1930's. Current elk populations in the Elk Valley may be in excess of 4000 animals (TAESCO 1983), and seem to be expanding as a result of favorable habitat modifications (i.e. clearcut logging, burning, land reclamation, establishment of "No Shooting Zones"), and a series of mild winters.

The current study forms part of Biophysical Inventories conducted by TAESCO on behalf of Crows Nest Resources on their coal lease lands in the Elk River Valley. The intensive research program commenced in 1980 and will terminate in 1985.

## MATERIALS AND METHODS

Seventeen major habitat types were defined and analyzed based on dominant plant communities as related to soils, aspects, moisture regime and elevation. Information from 170 vegetation plots was used for the differentiation between habitat types through a computer-assisted tabular analysis as described by Ceska and Roemer (1978). The percentage area covered by each habitat type was calculated through a Summagraphics Intelligence Digitizer.

Elk habitat use by season, elevation and aspect was identified through 2444 browse-pellet circular sample plots on 153 line transects, proportionately representing the 17 vegetation types. Principal analytical methods consisted of cross tabulation using the SPSS (Statistical Package for the Social Sciences) program for the analysis of habitat use and browse production.

Movements of elk were monitored since 1982 through survey flights and from the ground using 15 radio-collared cow elk instrumented in 1982 and 1983. Relocations were recorded on UTM grid co-ordinates.

Composite fecal samples served to investigate seasonal diet composition and plant species preference as described by Davitt and Nelson (1980).

## RESULTS

Preliminary analysis of three years' tracking records of radio-collared elk reveals that the study area supports two distinct populations with winter, and to a lesser degree, summer range fidelity. Both herds of approximately 500 animals each are migratory with up to 100 km distances between seasonal home ranges for individual animals. Availability of winter range seems to be critical for both populations.

The northern herd overwinters on south, southeast facing Subalpine slopes and in the lower montane forests, whereas the southern population

utilizes the floodplain of the Elk River and the adjacent fluvial terraces. On the average, snow depth on the northern winter range is significantly higher than on the southern winter range. The telemetry data show that elk calve in the Elk River floodplain and at the timberline in the northern section. However, calving grounds are generally unspecific, suggesting that they are not population limiting.

A reverse habitat use pattern emerges when comparing both populations by season. After spring dispersal, part of the northern herd seems to drift south towards the winter range of the south herd. At the same time, the southern herd moves up-valley, bypassing the winter range of the northern herd. The spring dispersal commences as early as February, depending on snow conditions. The elk return to their respective winter ranges by October/November. Rutting activities seem to occur enroute to the winter ranges.

A 1:20,000 biophysical ungulate habitat map was produced identifying seventeen major vegetation cover types, of which the Engelmann Spruce-Subalpine Fir (ESSF) showed the greatest abundance, followed by Engelmann Spruce-Lodgepole Pine (ESPI), and Sub-alpine Meadows (SM). Riparian Meadows (RM) and Engelmann Spruce Riverbottom types (ESR) are rare (Table 1).

Table 1. Habitat types measured in hectares.

Habitat Types <sup>1</sup>		North <sup>2</sup>	South <sup>3</sup>	Total
Alpine Tundra	(=AT)	187.59	33.86	221.45
Sub-alpine Meadow	(=SM)	1106.87	660.17	1767.04
Alpine larch	(=AL)	116.95	203.52	320.47
Engelmann spruce sub-alpine Fir	(=ESSF)	1349.98	1614.67	2964.65
Engelmann Spruce Lodgepole Pine	(=ESPI)	1604.66	848.48	2487.00
Lodgepole Pine	(=P1)	208.14	448.54	656.68
Douglas Fir	(=DF)	252.31	111.40	363.71
Riparian Meadow	(=RM)	57.52	2.52	60.04
Engelmann Spruce River Bottom	(=ESR)	79.77		79.77
Alluvial Complex	(=A)	298.70	141.20	439.90
Slide Area	(=SA)	356.99	394.50	751.49
Burned	(=B)	749.71	11.67	792.36
Logged	(=L)	196.82	733.00	929.82
Disturbed	(=D)	96.56	451.89	548.45
Talus	(=T)	9.04	35.33	44.37
Non-vegetated	(=NV)	4.10		4.10
Rock	(=R)		5.25	5.25
			Total	12,436.75

<sup>1</sup> Habitat types used synonymously with vegetation cover types.

<sup>2</sup> Northern Section of study area.

<sup>3</sup> Southern Section of study area.

The pellet group counts indicated that the Douglas Fir habitats (DF) received the highest overall use by elk (Fig. 1). Subalpine Meadows (SM) ranked second in use intensity, followed by Burned Areas (B). The least used habitat types were Rocks (R) and recently Logged sites (L) which are characterized by seral lodgepole pine. Although logged areas within the first 10 years after cutting may provide elk with good quality forage in summer, escape cover is generally poor, and snow conditions in winter are mostly unfavorable.

The habitat types are used differently by season. In summer, the Alluvial Complex and Subalpine Meadow habitats show the highest density of elk pellets, whereas the use of forested areas such as meadows with trees and Engelmann Spruce types increase in winter (Fig. 2). Overall, the areas classified as being summer and winter habitat for elk have the highest pellet group densities. This would indicate that the summer populations are more dispersed and that elk are restricted by available winter range. Since only a few transects were established in areas classified as prime elk winter range, conclusions from the pellet group analysis about seasonal range use are limited. However, good quality data on seasonal distribution are available through other sources (TAESCO 1983; B.C. Research 1978).

Figure 1. Overall distribution of elk by habitat type.

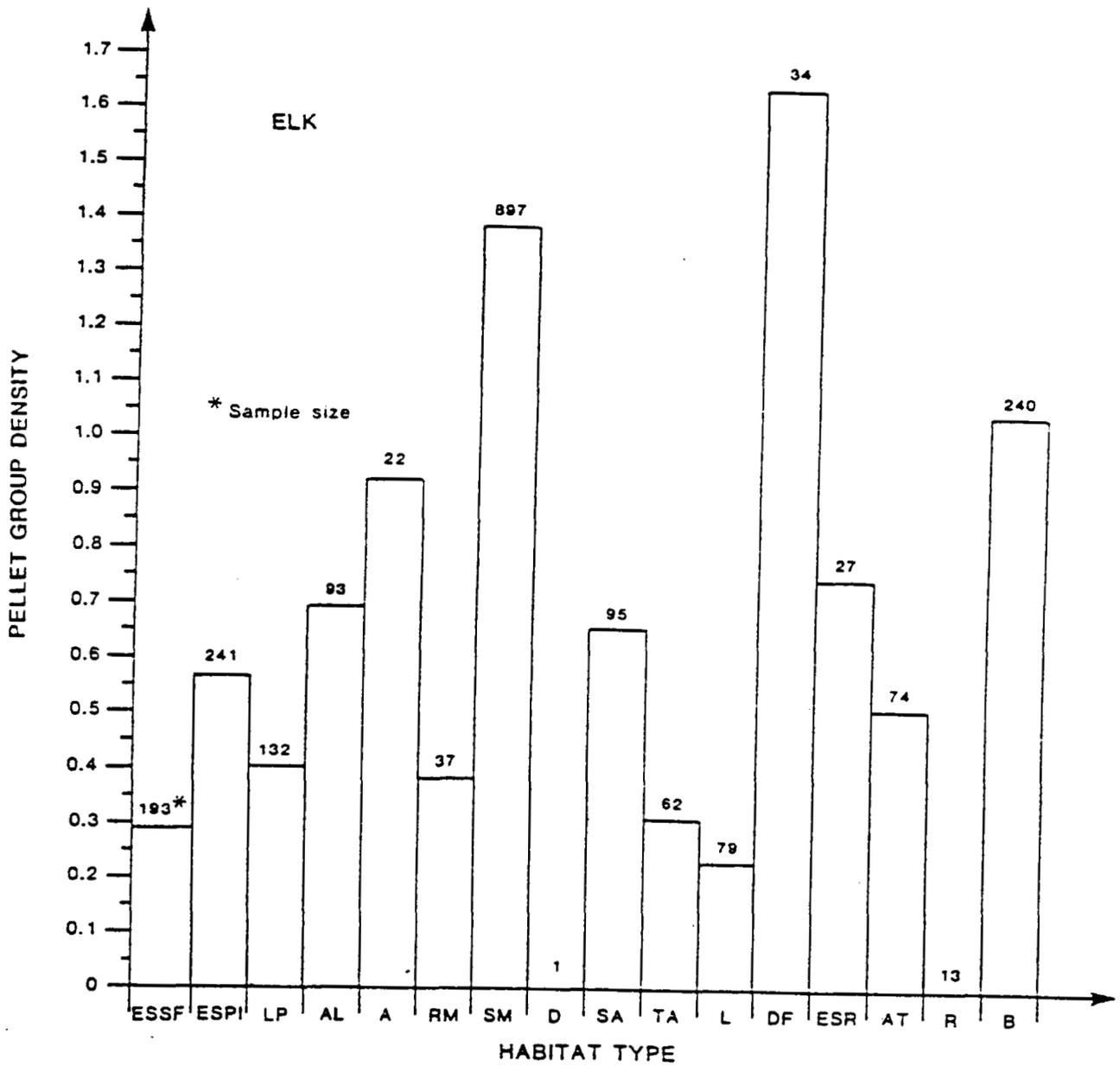
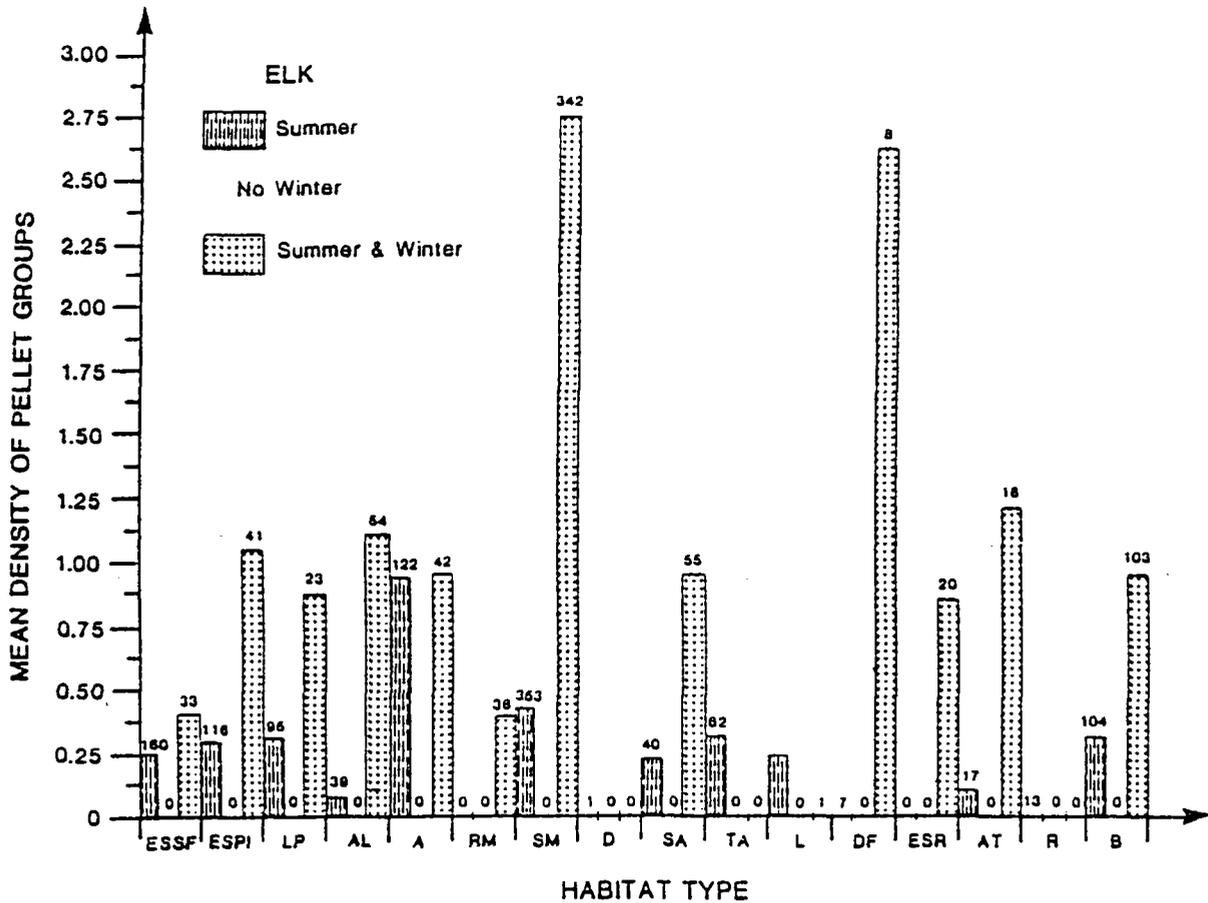


Figure 2. Seasonal distribution of elk by habitat type.



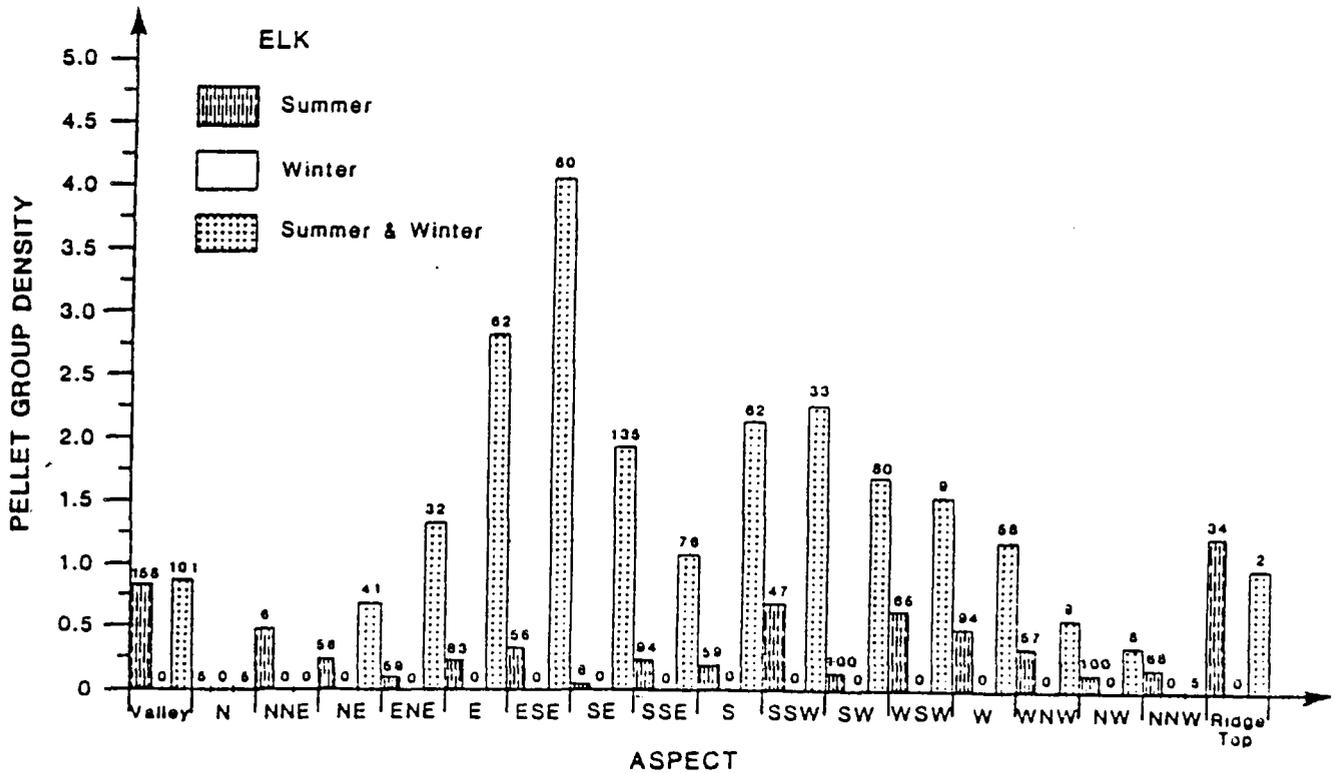
An analysis of the overall use frequency of different aspects revealed a distinct preference by elk for east-southeast facing slopes (Table 2) and low use of northern exposures. Lower elevation ridge tops are used by elk in winter and by bull elk in summer, when ventilation is needed for thermo-regulation (Gossow and Schuerholz 1974). Since no sample plots were located in exclusive elk winter ranges, the seasonal use analysis is restricted to summer and summer/winter range. The most commonly used aspects by elk in summer and winter are east-southeast, east, and south-southwest (Fig. 3).

Table 2. Distribution of deer, elk, moose and sheep by aspect

Aspect	No. of Plots	Deer		Elk		Moose		Sheep	
		g*	d*	g*	d*	g*	d*	g*	d*
Valley	324	6	0.02	277	0.85	63	0.19	3	0.01
N	66	0	0	43	0.65	6	0.09	8	0.12
NNE	9	0	0	3	0.33	1	0.11	0	0.00
NE	131	2	0.02	53	0.40	5	0.04	8	0.06
ENE	93	2	0.02	50	0.54	8	0.09	6	0.06
E	147	1	0.01	207	1.41	6	0.04	25	0.17
ESE	119	0	0	265	2.23	2	0.02	140	1.18
SE	240	2	0.01	259	1.08	8	0.03	218	0.91
SSE	245	5	0.02	187	0.76	6	0.02	70	0.29
S	148	6	0.04	173	1.17	8	0.05	76	0.51
SSW	126	18	0.14	131	1.04	3	0.02	59	0.47
SW	200	16	0.08	184	0.92	9	0.04	43	0.27
WSW	90	6	0.07	125	1.39	0	0.01	26	0.29
W	179	12	0.07	146	0.82	7	0.04	14	0.08
WNW	68	5	0.07	25	0.37	9	0.13	1	0.01
NW	109	4	0.04	18	0.16	3	0.03	5	0.04
NNW	83	1	0.01	17	0.20	16	0.19	11	0.13
Ridge Top	64	0	0	45	0.70	0	0.00	77	1.20

g\* Number of pellet groups.  
d\* Mean density of pellet groups.

Figure 3. Seasonal use of aspect by elk.



Elk seem to select slopes of 0-5 degrees in summer and 21-35 degrees on summer/winter range (Fig. 4). According to the radiotelemetry data, the northern elk population overwinters in the flood plain of the Fording River and along the south, southwest facing slopes of the low elevation Todhunter and Imperial Mountains. The southern population winters on the Grave Lake prairies and Elk River flats.

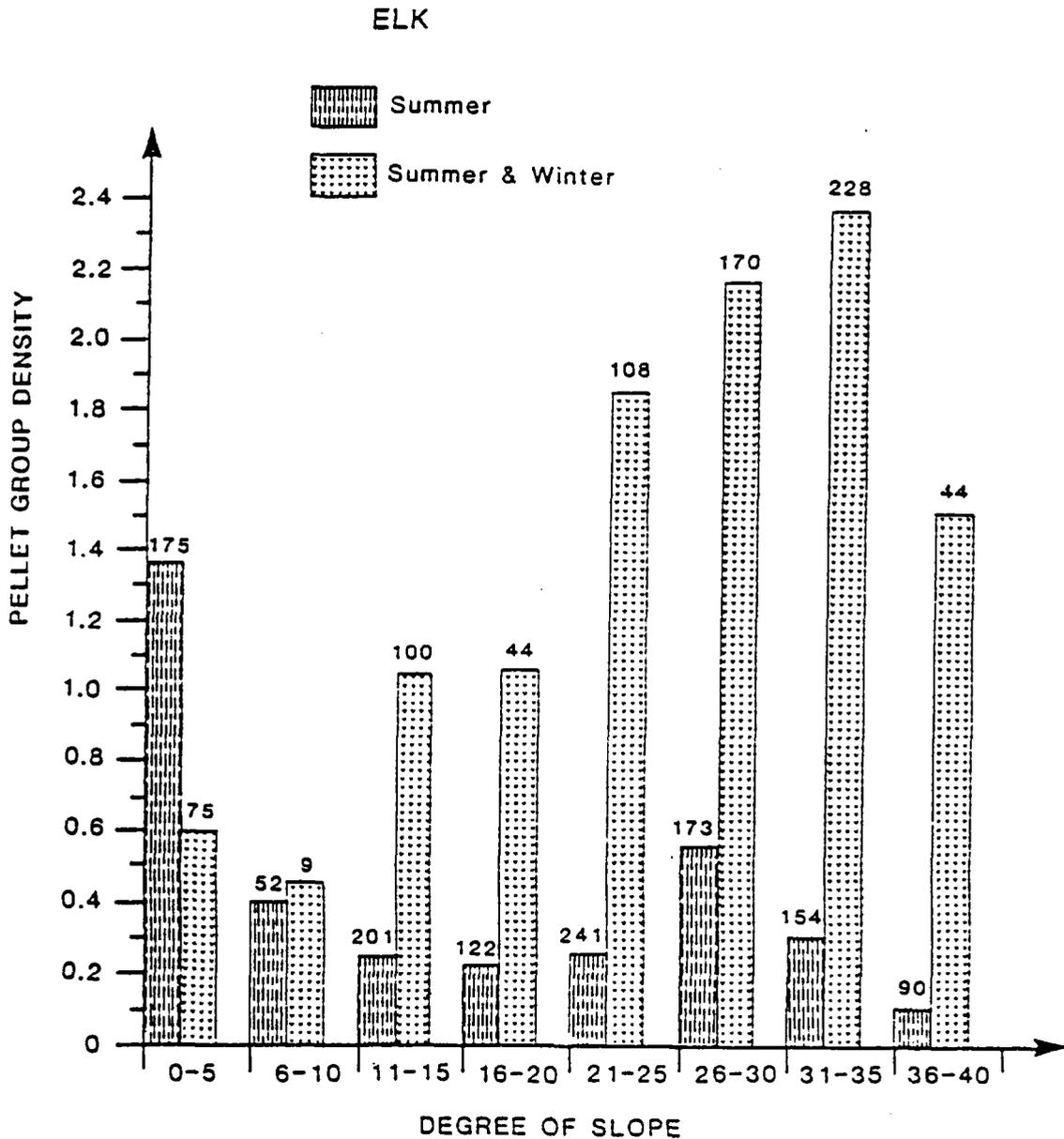


Figure 4. Seasonal distribution of elk by slope.

The overall distribution of elk by elevation shows highest fecal pellet group density between 1200 - 1400 metres (Fig. 5), with summer range at higher elevations than winter range. Occasionally, elk venture into high elevation ranges about 2400 metres in winter, usually when trapped by snow (Schuerholz 1982).

The browse survey was limited to 23 species of perennial plants and nine conifer species considered to be important forage for ungulates in the study area (Table 3). Relative browsing pressure was estimated by assigning a form class to each plant species on the plot. The results show that the most commonly occurring plants were birchleaf spiraea (32.7%), *Rosa* spp. (28.6%), russet buffaloberry (25.4%), rusty menziesia (17.2%), *Ribes* spp. (15.9%), willow (15.5%) and Utah honeysuckle (15.1%) The data show that the most common species are not the most heavily used. Further, the browse species are generally not showing extreme degrees of browse pressure, suggesting diet composition favouring grasses and forbs.

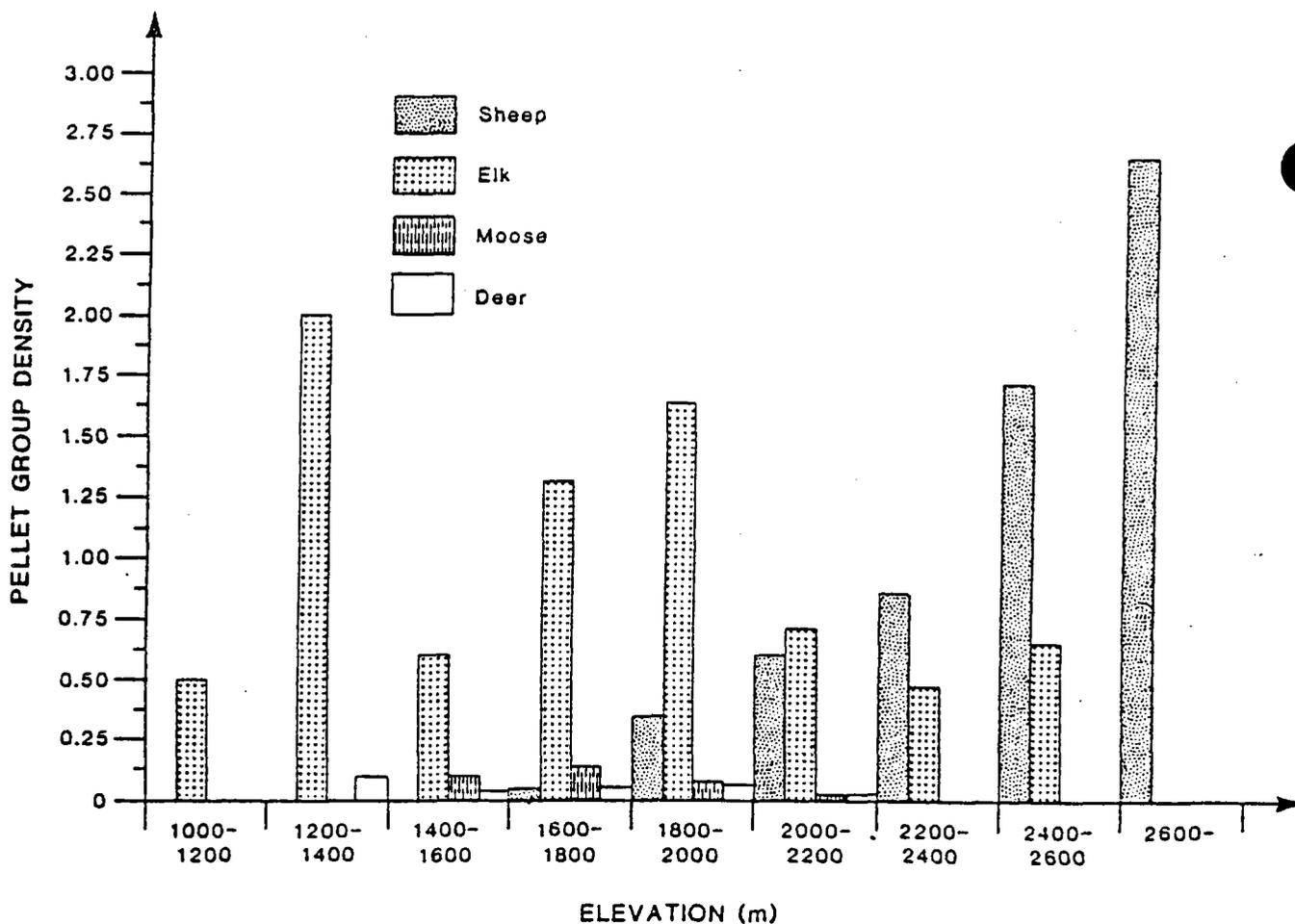


Figure 5. Distribution of ungulates by elevation.

Table 3. Summary of plant species frequency on browse plots and degree of utilization, as measured by the form class ratings.

SPECIES	FREQ <sup>1</sup>	% <sup>2</sup>	RANK <sup>3</sup>	AVE. FC <sup>4</sup>	FC RANK <sup>5</sup>
Rocky Mt. maple	6	5.9	24	2.0	7
Mountain alder	40	3.9	18	1.3	12
Sask. serviceberry	164	6.7	22	1.4	11
Bog birch	15	1.4	28	1.5	10
Red-osier dogwood	1	<0.1	28	3.0	1
Silverberry	1	<0.1	28	1.0	15
Bearberry honeysuckle	89	8.8	12	1.7	8
Utah honeysuckle	52	5.1	16	1.4	11
Rusty menisiesia	77	7.6	13	1.2	13
Trembling aspen	96	9.5	11	2.5	4
Black cottonwood	2	<0.1	26	2.0	7
Bitter cherry	5	.5	25	3.0	1
Common choke-cherry	16	1.6	22	2.6	3
Ribes spp.	161	15.9	5	1.7	8
Rosa spp.	290	28.6	2	1.6	9
Rubus spp.	52	5.1	16	1.3	12
Willow	157	15.5	6	2.8	2
Elderberry	21	2.1	21	2.2	5
Russet buffaloberry	257	25.4	3	1.2	13
Birchleaf spiraea	331	32.7	1	1.5	10
Green Mt. ash	2	<0.1	26	1.0	15
Snowberry	21	.8	24	1.4	11
Vaccinium spp.	137	13.5	9	1.5	10
Douglas fir	58	5.7	.14	2.1	6
Lodgepole pine	155	15.3	7	2.0	7
Juniper	129	12.7	10	1.1	14
Grand fir	7	.7	23	1.6	9
Spruce spp.	153	15.1	8	1.1	14
Subalpine fir	175	17.2	4	1.4	11
Whitebark pine	57	5.6	15	1.1	14
Five needled pine	25	2.5	19	1.2	13
Larch	22	2.2	20	1.4	11

<sup>1</sup>Number of plots where plant is present.

<sup>2</sup>Percent of total plots with the species present.

<sup>3</sup>Numerical rank order of species.

<sup>4</sup>Average form class (0 to 3) for all occurrences of the species.

<sup>5</sup>Numerical rank of the species with respect to form class.

The relative browse volume and the volume of preference plant species by habitat type are presented in Figure 6. The plants selected for the latter were willow, trembling aspen, Rocky Mountain maple, *Ribes* spp., and bearberry honeysuckle. Although bitter cherry and red-osier dogwood showed the highest form class, they were the least abundant and therefore not chosen as the most representative preference plants. To meet the selection criteria as a preferred browse, the species had to occur on more than 5% of all sampled plots. For this reason, common chokeberry (1.6%) and elderberry (2.1%) were not included, although they had higher form classes than trembling aspen and Rocky Mountain maple.

Douglas fir and lodgepole pine ranked third and fourth in the degree of browsing. Both species were excluded, because they are classified as "trees" rather than "shrubs".

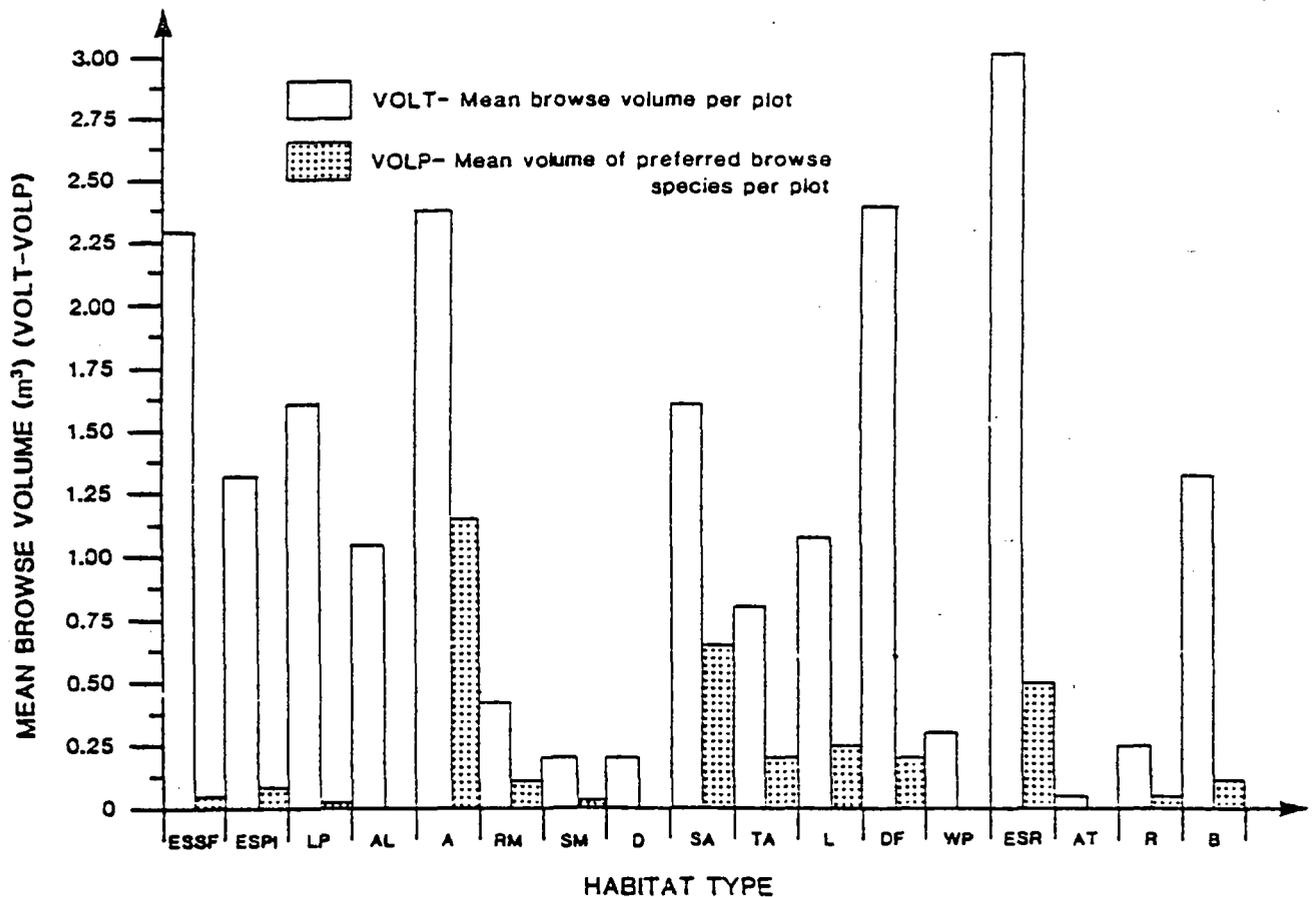


Figure 6. Browse production by habitat type.

The volume calculated for the preference plants (VOLP) incorporates the information on species abundance and utilization in order to determine relative amounts of preferred forage per habitat type.

The most productive habitats in terms of total browse volume are in decreasing order: Engelmann Spruce-Riverbottom, Alluvial Complex, Douglas Fir and Engelmann Spruce-Subalpine Fir. These types are followed by Slide Areas, Pine forests and Burned areas. The least productive habitats, in terms of browse, are the meadows. Low browse production in meadow habitats can be expected because they are "grassland" communities. In general, all forested habitat types seem to be highly productive browse areas, when all browse species are considered. However, when only the preferred browse species are included, the forested habitat types have a low browse productivity. The most important habitats for production of preferred browse are the Alluvial Complex, Slide Areas, Engelmann Spruce-Riverbottom, and Logged Areas. The least productive types for preference browse species are stands of alpine larch and whitebark pine.

For overall browse production by aspect, the north-northeast facing slopes are by far the most productive. They are followed by west-northwest, northwest, northeast aspects, and valley bottoms. The lowest values were recorded on ridge tops, west-southwest and north facing slopes.

Overall and preference browse production compared to slope show the highest value for almost level terrain (0-5 degrees) in valley bottoms and on terraces. A trend occurred toward lower production with increasing slope inclination.

Overall and preference browse production compared to elevation shows that in elevations below 1200 metres the production is low. It is highest between 1200 and 1800 metres and decreases progressively with increasing elevation. No preference browse plants were found above 2400 metres.

To test how ungulates in the study area respond to browse abundance, correlation coefficients were calculated for all ungulate species by comparing different habitat types with respect to browse production. All correlations are weak. With respect to preferred browse plants, elk are positively correlated with browse abundance. This confirms the data base from the pellet group surveys.

Fecal analysis was used to identify diet composition and plant species preference by elk related to season. For this analysis, the Grave Lake Prairie winter range was included.

Nutritional requirements and food habits of Rocky Mountain elk have been reviewed by Nelson and Leege (1982). Food habits of elk are extremely variable, as these animals utilize many different vegetation types. Nelson and Leege found evidence indicating that elk prefer to graze, yet large herds are found where browse constitutes a major portion of the diet. It is commonly accepted that grass is the most important

forage class during spring greenup months, usually constituting more than 85% of the diet. This was confirmed through the current studies (Figure 7).

Elk using the lower montane forests and river floodplains in spring and mid-summer, utilize less (15.2%) graminoids than elk in the Subalpine habitats, and less (24.3%) forbs on the Subalpine range than in the lower elevations. The spring/early summer diet on Subalpine ranges shows highest utilization of graminoids, followed by shrubs, forbs and conifers. For the lower montane forests and floodplains, the ranking is graminoids, forbs, shrubs and conifers. *Festuca scabrella* was used significantly more on both ranges than any other grass species (Table 4). The data for the summer/fall diet show a distinct shift in dietary composition in favour of forbs and shrubs. Although graminoids still dominate in the overall diet (37.7%), they are balanced by shrubs (35.4%) and forbs (21.6%). The shift in dietary composition is explained through "dryness" of grasses with maturation in the late summer/early fall. This makes graminoids less attractive to elk than forbs and woody plants which have nutritious leaves and twigs at this time.

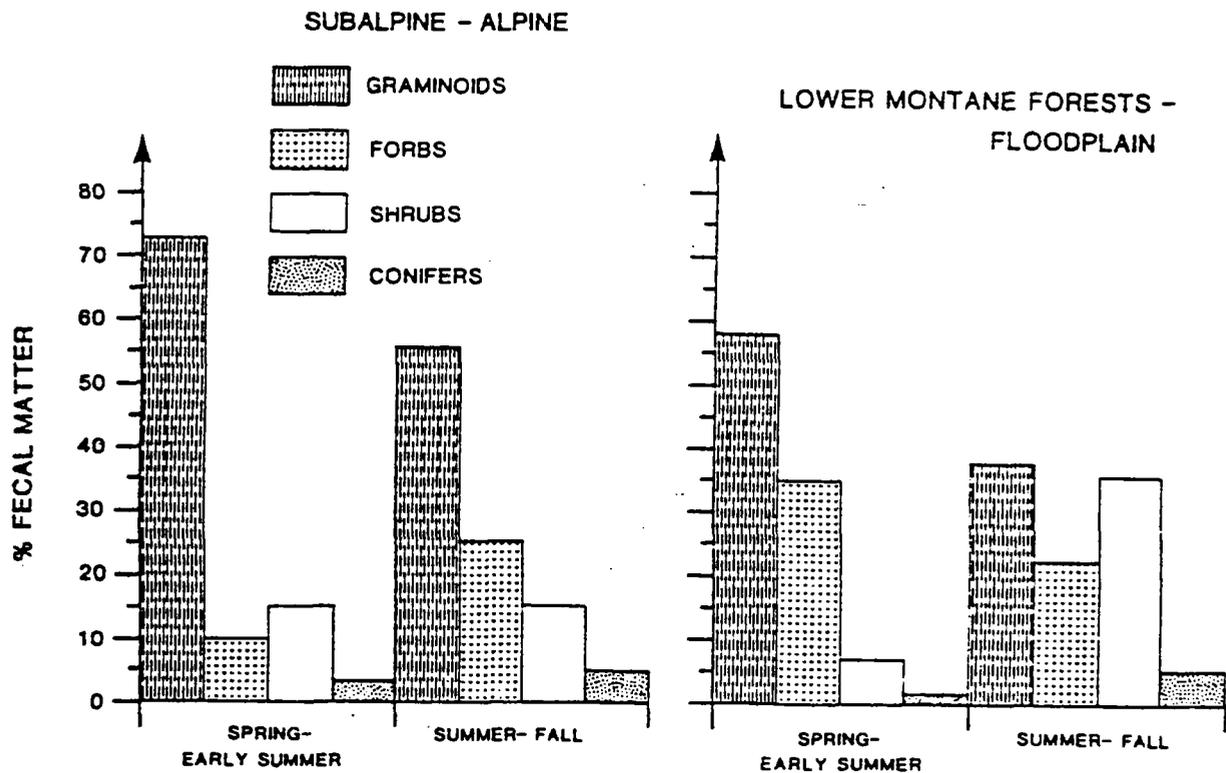


Figure 7. Seasonal diets of elk by range.

Table 4: Spring-early summer diet of elk by elevational range.

Lower Montane Forests-Floodplain			Subalpine-Alpine		
	Species	% Diet	Species	% Diet	
GRAMINOIDS	<i>Festuca scabrella</i>	33.3	<i>Festuca scabrella</i>	33.3	
	<i>Poa</i> spp.	6.5	<i>Poa</i> spp.	11.2	
	<i>Elymus</i> spp.	6.3	<i>Elymus</i> spp.	7.6	
	<i>Carex</i> spp.	4.3	<i>Carex</i> spp.	5.8	
	<i>Festuca</i> spp.	2.8	<i>Festuca</i> spp.	11.5	
	Other graminoids	4.7	Other graminoids	3.7	
			<u>57.9</u>		<u>73.1</u>
FORBS	<i>Epilobium angustifolium</i>	8.6	<i>Epilobium angustifolium</i>	3.4	
	<i>Cornus canadensis</i>	3.0	Other forbs	6.4	
	<i>Astragalus</i> spp.	1.4		<u>9.8</u>	
	<i>Hieracium</i> spp.	4.8			
	Other forbs	16.3			
		<u>34.1</u>			
SHRUBS	Other shrubs	6.6	<i>Vaccinium</i> spp.	8.2	
		<u>6.6</u>	<i>Shepherdia canadensis</i>	2.9	
			Other shrubs	3.7	
			<u>14.8</u>		
CONIFERS	Other conifers	1.4	Other conifers	2.3	
		<u>1.4</u>		<u>2.3</u>	

Some researchers have found that forbs constitute almost all of the summer diet (Rouse 1958, Knowles 1975, Singer 1975). Others report a greater importance of shrubs (Hash 1973, Bohne 1974). Elk summering in the Subalpine-Alpine ranges of the study area utilize the vegetation in a different pattern. Although the use of graminoids decreases by approximately 20% compared to the spring/early summer, the overall use is still high (55.2%). This may be caused through the late phenological development of high elevation vegetation which is still highly palatable to elk when grasses in lower elevation have dried up (i.e. four weeks difference in phenological development between Elk River Flats and Upper Ewin Ridge).

The winter diet is strongly influenced by forage availability as affected by snow conditions. Elk move to ranges where snow depth is minimal, and exist on whatever forage is available (Nelson and Leege 1982). Nelson et al. (1982) found that on ranges in Montana which are dominated by grass, elk eat primarily grass in winter. However, on woody plant dominated ranges, such as northern Idaho, elk diets consist principally of woody plants. Where both grasses and shrubs are available,

elk usually prefer grasses. At times when these grasses become less available due to utilization and/or deep snow, shrubs become prominent in the elk diet (Claar 1973; Singer 1975).

When snow further limits the availability of shrub, elk increase the consumption of conifers (Hash 1973). The data from the study area seem to support these findings.

The pattern of winter diets differs significantly between the two herds. In the study winter, when the fecal samples were collected from the Grave Lake Prairies, graminoids were mostly under snow cover and available only along the exposed banks of the Elk River, the steep slopes parallel to the railroad bench and the south-facing slopes of the mountain terraces. This forced the elk to shift their diet to available browse which was dominated mostly by conifers (46.3%) and shrubs (20.3%) until dormant graminoids became available with decreasing snow in late winter. Feeding craters were pronounced along reclaimed slopes, seeded with grass and forb mixtures, indicating the preference by elk for graminoids (and forbs).

The northern herd, which overwinters along the slopes of Imperial Ridge, Todhunter, Mid-Ridge, Short and Pine Ridges, shows approximately 70% graminoid content in the diet. In mild winters, the corresponding south and southeast facing slopes are mostly free of snow, making the grass layer readily available to elk. On this herd's range, conifers contributed 14.4% to the diet.

In summary, seasonal forage preferences by elk seem to be mostly influenced by forage availability and phenology. Except for the Grave Lake Prairie winter range, the diets of the two elk herds wintering in the study area are dominated by graminoids. Where grasses are not available due to snow, the diet shifts to conifers and shrubs. From spring to fall, forbs may contribute a substantial part of the diet, independent of altitudinal range. In winter, the utilization of forbs is low.

Relative importance of plant species is presented on Table 5. The "values" may not reflect dietary preferences, but rather the availability of plant species. However, the "values" are indicative of the relative importance of a single species or species group when compared by range and season. The table shows the highest overall mean value for graminoids and low overall mean values for the other plant groups. The highest species value was found for Festuca scabrella on all ranges and for all seasons, followed by Elymus spp. for winter ranges.

Table 5: Relative forage values.

Species Name	Relative Forage Values*1									
	Winter			Spring-Early Summer			Summer-Fall			Overall
	F*2	G*3	x*4	F	G	$\bar{x}$	F	G	$\bar{x}$	$\bar{x}$
<b>GRAMINOIDS</b>										
Festuca scabrella	+		+	+	+	+	+	+	+	+
Elymus spp.	+	+	+	0	0	0	0	0	0	0
Poa spp.	0	-	-	+	0	0	0	0	0	0
Carex spp.	+	-	0	0	-	0	0	0	0	0
Agropyron spicatum	-	-	-	-	-	-	-	-	-	-
Festuca spp.	-	-	-	+	-	0	-	-	-	-
Other graminoids	-	0	-	-	-	-	0	0	0	0
<b>FORBS</b>										
Epilobium angustifolium				-	0	0	0		-	0
Equisetum telmateia							0	0	-	-
Cornus canadensis					-	-	0		-	-
Astragalus spp.					-	-			-	-
Hieracium spp.					-	-			-	-
Bryophyta spp.										
other forbs	-	-	-	0	+	+	+	+	-	0
<b>SHRUBS</b>										
Sambucus spp.								+	0	-
Vaccinium spp.				0		-	0	-	0	-
Shepherdia canadensis		-	-	-		-		-	-	-
Salix spp.									-	-
Populus tremuloides								0	-	-
Linnaea borealis									-	-
Juniperus communis		+	0							-
Other shrubs	-	0	-	-	0	0	-	0	0	-
<b>CONIFERS</b>										
Abies spp.	-		-						+	-
Pinus spp.	0	+	+							-
Pseudotsuga menziesii		+	+							-
Other conifers	-	-	-	-	-	-	-	0	-	-

\*1 Symbols used for relative forage values are:  
+ highly valuable (over 10% of diet)  
0 valuable (5-10% of diet)  
- low value (less than 5% of diet)

\*2 Fording - Alpine - Subalpine Ranges

\*3 Grave Prairie - Elk River Flats, Lower Montane - Floodplain

\*4 Statistical Mean

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THE ASSESSMENT OF THREE ELK WINTER RANGES  
IN ALBERTA: AN APPRAISAL.

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Abstract: In 1982, the Alberta Fish and Wildlife Division supported a detailed study of three elk (Cervus elaphus) winter ranges in the eastern slopes of the Rocky Mountains. The project involved classification of vegetation at a plant community level, elk distribution and plant community utilization, food habits, forage quality, range and soil condition, and fire history. Grasses, particularly fescue species, were found to be a major component of elk winter diets. The contribution of willow species was marginal. Forage was found to be phosphorus, nitrogen and selenium deficient. Elk selected for dry grassland communities that represented less than 30% of the apparently available ranges. The utilization of plant communities was found to be related not only to their foraging or cover value, but also to their proximity to other plant communities or site-specific features (mineral licks, game trails, etc.). Pellet group counts were not adequate to detect local distribution patterns. The absence of baseline information on range plant composition and trends limited the assessment of range condition and potential productivity. Several management recommendations were submitted. Even though such detailed studies can provide valuable information, their value for management is limited when ecology, behavior and movements of regional elk populations are not known.

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INTRODUCTION

In Alberta, in the Eastern Slopes Region north of Calgary, there are several grass-shrubland ranges that traditionally overwintered large herds of elk (Alberta Fish and Wildlife files). At the present time, in spite of restrictions on elk hunting for the last 13 years, most of these ranges appear to support fewer animals than in the past. In order to provide insight into the factors affecting elk distribution in winter and to evaluate the need for range improvement, in 1982 the Alberta Fish and Wildlife Division retained Wildland Resources Consultants Limited to assess the value of three selected elk winter ranges along the east slopes of the Rocky Mountains. The main objectives of the study were to assess range utilization, to evaluate the need for range improvement, and to determine the potential of the areas to support higher elk densities. The results of the study were summarized in an extensive report submitted to the Alberta Fish and Wildlife Division in the fall of 1983 (Morgantini and Russell 1983) (copies available from E. Bruns). The objective of this

paper is to outline some major findings and to relate them to the management of elk and their habitats throughout the province.

#### STUDY AREAS AND METHODS

The three study areas (Figure 1) are open, predominantly treeless valleys surrounded by continuous forest.

Harrison Flats, located along the Clearwater River approximately 10 km east of Banff National Park, extends over 156.4 hectares (386.5 acres) of rolling ground, of which about 30% is covered by forest, 23% by shrubs and 47% by native grassland (Figure 2). Its elevation ranges between 1680 m and 1720 m.

The area enjoys relatively mild winter conditions. Prevailing westerly airflows and frequent warm chinook winds that funnel along the Clearwater River valley limit snow accumulation and maintain the open grassland largely snowfree.

The second study area, Ribbon Flats, is located within the Red Deer River drainage, 2 km south of the Ya Ha Tinda Ranch, one of the most important elk winter ranges in Alberta. The study area extends over 171.4 hectares (423.5 acres) of which 17.9% is covered by forest, 39.1% by shrubs, 27.3% by muskegs and wetland, and 14.8% by grassland (Figure 3). Elevation ranges between 1700 m and 1740 m.

The third study area is located along George Creek, a tributary to the Blackstone River (Figure 4). The area consists of 82.7 hectares (204.4 acres) of which 75% is covered by birch-salix shrubland, 15% by a vegetational complex on river alluvium, and 10% by open meadows.

Ribbon Flats and George Creek have a cordilleran climate, with warm chinook winds ameliorating colder, continental winter temperatures. Due to their north-south orientation, the two areas are not significantly affected by strong westerly winds. Hence, snow tends to persist and accumulate through the winter.

The vegetation of each winter range was classified into plant communities, i.e., plant assemblages of similar species composition, physiognomy and habitat. Elk use of plant communities was determined by pellet group counts along transects established in representative sites within each community type. In view of the limitations of the pellet group count technique (Collins and Urness 1979), numerous, long (50-200 m) and wide (3 m) transects were used. Pellet counts were then interpreted on the basis of the location of each and every transect within the study area, and compared to field observations of animal movements and distribution and herbage removal data.

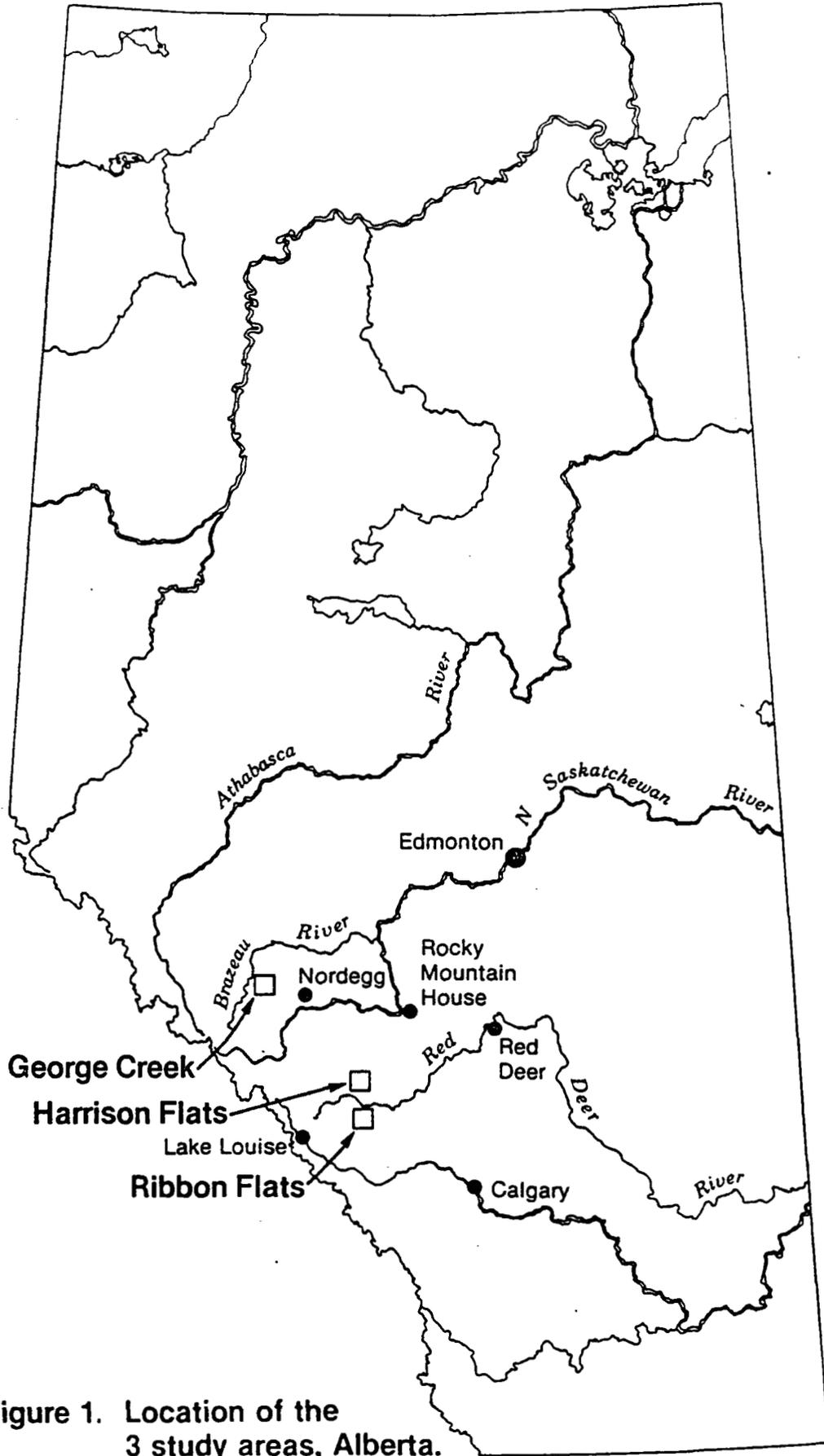


Figure 1. Location of the 3 study areas, Alberta.

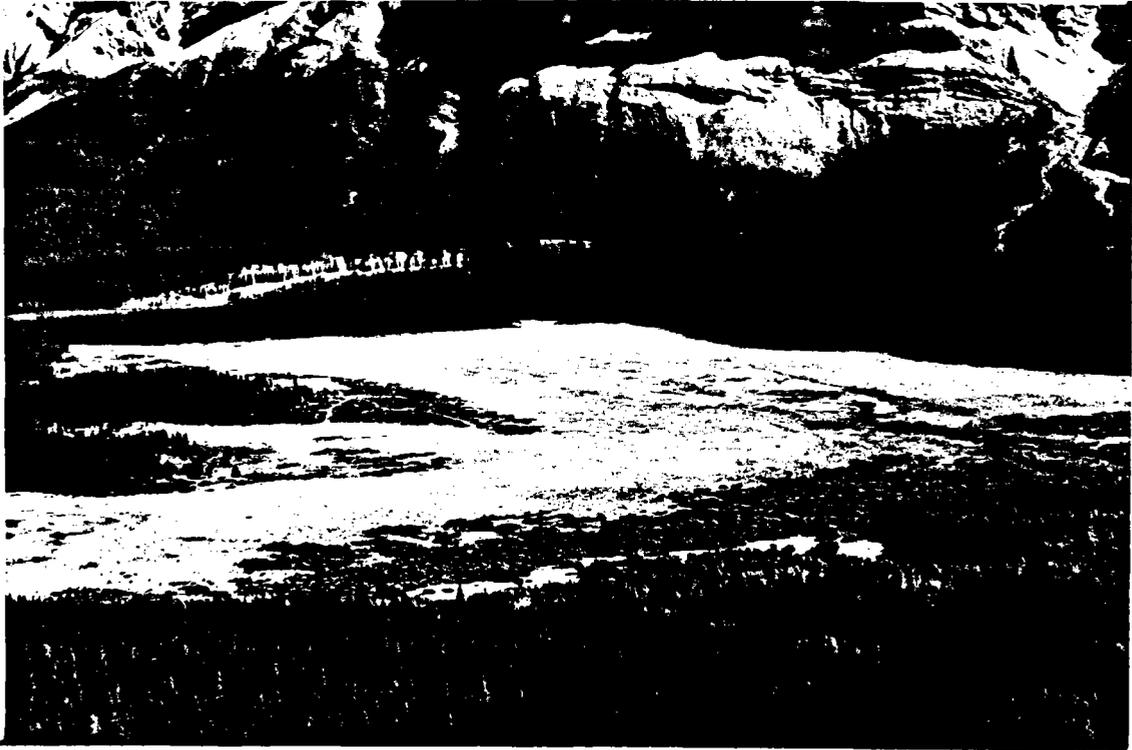


Figure 2. Harrison Flats along the Clearwater River.

Figure 3. Ribbon Flats. The Ya Ha Tinda Ranch elk winter range can be seen in the background (upper right).





Figure 4. George Creek meadow.

Forage availability in late fall was assessed by clipping 10 plots randomly established within each plant community. Overwinter herbage removal was determined by late spring clipping of 10 additional plots randomly established within each plant community and by subtracting spring standing biomass from the standing biomass in the fall.

Elk monthly food habits were determined by identification of plant cuticular fragments in the feces (Todd and Hansen 1973).

Major forage species were collected in the fall and analyzed for crude protein, phosphorus, calcium and selenium according to procedures described by A.O.A.C. (1965). Acid Detergent Fibers (ADF) were determined by the procedures summarized by Bailey and Ulyatt (1970).

#### RESULTS AND DISCUSSION

The three study areas differed in environmental conditions, in level and patterns of elk utilization (Table 1), and in their value to regional elk populations.

Thirteen plant communities were classified on Harrison Flats, 16 on Ribbon Flats and 7 along George Creek. Based on pellet group counts, elk selected for fescue and wheat grass communities. The Potentilla/Festuca/Geum, Festuca/Helictotricon/Oxytropis and the Agropyron/forb grassland communities on Harrison Flats recorded the

highest average pellet group densities (.299 pellet groups [pg]/m<sup>2</sup>, .232 pg/m<sup>2</sup>, and .202 pg/m<sup>2</sup>). On Ribbon Flats, the highest average densities were recorded in the Festuca-Agropyron x Elymus (.186 pg/m<sup>2</sup>) and in the Deschampsia/Agropyron (.182 pg/m<sup>2</sup>) communities. The use of George Creek meadows was marginal and largely restricted to the Agropyron community (.022 pg/m<sup>2</sup>) located on a small ridge.

Table 1. Number of transects, total length, and number of pellet groups covered in the study areas (1982-83).

	Transects		Pellet Groups	
	No.	Total Length (m)	Total Number	Density (/m <sup>2</sup> )
Harrison Flats	59	6,092	2,698	.148
Ribbon Flats	47	6,319	1,466	.077
George Creek	31	4,520	93	.007

Pellet counts along individual transects within each plant community showed widely ranging values (e.g. between .113 and .513 pg/m<sup>2</sup> in the Potentilla/Festuca/Geum community on Harrison Flats). This variation reflected the position of each transect within the study area, irrespective of the plant community in which it had been established and its location in relation to other plant communities. The utilization of plant communities was found to be related not only to their foraging or cover value, but also to their position within the vegetational mosaic, their proximity to other plant communities or to site-specific features (mineral licks, game trails, etc.).

Overall, the preference by elk for fescue and wheat grass communities, as apparently indicated by pellet group counts, was consistent with overwinter herbage removal and food habits data. However, in spite of a high sampling intensity, pellet group counts were not adequate to detect local distribution patterns and habitat use for the purpose of habitat management. In this study, pellet group count results were verified and compared to herbage removal and food habits data. These data, and field observations of animal behavior, helped interpreting local variations of pellet counts within each plant community. The absence of such data and/or any longer sampling intensity would have led to erroneous conclusions.

Grasses were the dominant component of the winter diet in all three study areas. Consumption of fescue species averaged 69.5% of the diet on Harrison Flats and 57.5% on Ribbon Flats. Sedge and browse species contributed to 14.2% and 7.1% of diet on Harrison Flats, and 20.6% and 11.2% on Ribbon Flats. The marginal use of the George Creek study area by elk restricted the collection of fecal samples. Based on only two months

data, December and March, winter diet averaged 37.5% grasses, 27.4% sedges and 25.4% browse. In view of the limited use of this area, these values are believed to reflect elk diet in the surrounding ranges.

Forage quality was similar in all the study areas. Major plant species were found to be nitrogen, phosphorus and selenium deficient. From the cured stage through winter, native grasses of the rough fescue association are known to contain levels of crude protein and phosphorus below maintenance requirements for livestock (Bezeau and Johnston 1962). Crude protein of willow was above maintenance requirements. However, willow species contributed only a minor portion of the diet. Elk preference for grasses, mostly rough fescue (*Festuca scabrella*), in spite of their low nitrogen content, has been explained as due to higher digestible energy content (65% in grasses vs. 48% in willow; Morgantini and Hudson 1985).

In view of the importance of phosphorus intake for the reproductive performance of livestock (Maynard et al. 1979), phosphorus deficiency on winter ranges was considered a factor affecting the productivity of elk populations in the study areas.

On the basis of fall standing biomass and overwinter herbage removals, an attempt was made to assess the carrying capacity of the study areas and the level of utilization overwinter.

Three different winter carrying capacity values were obtained. The first assumed a 65% uniform utilization of all grass and sedge species. The second was based on a 65% utilization of only the plant communities that were used by elk during the winter of study. The third carrying capacity value was obtained by removing from the second carrying capacity the contribution of some plant communities whose utilization was site specific and could not be generalized to the entire study area. With regard to Harrison Flats, for instance, it was estimated that the area could support about 161 adult elk cows (average weight 236 kg) for a 5 month period (Table 2). This figure assumed an average monthly intake of 173 kg of forage (22.9 g daily/kg body weight) (Thorne et al. 1976, Mereszcak et al. 1981). However, such a stocking rate did not allow for the differential use of plant communities based on their forage palatability and value. For example, it was highly unlikely that 77 elk could overwinter within the *Deschampsia* community (H11) on a diet of tufted hairgrass (*Deschampsia caespitosa*). If that had been their only choice on Harrison Flats, it is reasonable to assume that the animals would have searched for more palatable forage on other ranges. A more correct estimate of the potential stocking rate of Harrison Flats was obtained by considering only the plant communities that received some use during the winter of 1982-83. Based on herbage removal data, the area supported about 74 animals a month for 5 months. Increasing the utilization of the same communities up to 65% of their total winter forage biomass, and including the highly palatable fescue forage available in the *Betula/Fescue* community whose utilization was not detected by grazing enclosure cages and clip plots, the stocking rate increased to approximately 98 elk a month for 5 months. In this estimate, herbage removal from the *Deschampsia* community (H11) was arbitrarily left to the same percentage observed during the study since the utilization of the

community was site specific and related to human harassment. However, in view of the minimal contribution of tufted hairgrass to elk diet ( $\bar{x}=1.0\%$ ), it is also questionable whether the heavy grazing observed around three grazing exclosures in the hairgrass community in one location should be used to estimate the elk utilization of that community wherever it occurs. Removing the contribution of the Deschampsia community (H11), the potential stocking rate decreases to some 63 animals a month for 5 months. Although this figure is significantly less than the stocking rate initially calculated, it is still based on two assumptions: 1. uniform grazing of plant communities throughout the area; 2. availability of palatable forage in all the plant communities considered, up to 65% of the total forage biomass.

The same reasoning was applied to estimate the carrying capacity of Ribbon Flats and George Creek study areas.

Assessment of range condition involves determining site-specific climax vegetation, which is difficult and requires long term studies. With regard to species composition, the same species that may be an increaser ("undesirable") as a result of heavy grazing in one area, can be a decreaser ("desirable") in another. Further, it should be noted that, on native ranges not grazed by livestock, climax condition may not be preferable. Vegetation in subclimax condition may be more productive of palatable wildlife forage than it would be at its climax stage. In this study, because we did not know climax vegetation of the winter ranges and its response to grazing, range condition analysis was restricted to a mostly subjective assessment of plant communities. On the basis of plant vigour, height and cover, and standing biomass, all study areas were considered in good-to-excellent condition.

Based on 1982 forage production, all of the study areas could have supported higher elk densities. The low utilization of Harrison Flats was related to regional movement patterns and a low density of elk along the Clearwater River. Differently, the limited use of Ribbon Flats was explained in terms of its proximity to a major winter range, the Ya Ha Tinda Ranch, with good forage, milder winter weather and less snow cover. Ribbon Flats was considered a secondary winter range. In contrast, no conclusion could be reached about the study area along George Creek. In the absence of some understanding of elk movement, behavior and range availability in the region, the factors underlying the low use of George Creek could not be determined.

As a result of the project several management recommendations were submitted, such as experimental phosphorus supplementation, prescribed burning and road closures.

Table 2. AUM and stocking rates for Harrison Flats.

Plant Comm.	Hectares Per AUM <sup>1</sup>	5 months stocking rate <sup>2</sup>	1982-83 stocking rate <sup>3</sup> (5 months)	Potential stocking rate (5 months)
H1	.64	1.9	2.3	1.9
H2	.43	7.7	0.0	7.7
H3	.20	7.9	4.6	7.9
H4	.16	22.0	16.4	22.0
H5	.09	9.6	7.1	9.6
H6	1.08	8.6	0.0	0.0
H7	.13	13.5	9.0	13.5
H8	.36	5.2	0.0	0.0
H9	.58	3.3	0.0	0.0
H10	.13	1.4	0.0	0.0
H11	.07	77.1	35.3	35.3
H12-H13	.09	3.3	0.0	0.0
	Total	161.5	74.6 (39.3)	97.9 (62.6)

1 =  $\frac{\text{Average monthly forage intake by elk}}{\text{Available forage per hectare} \times .65}$

2 =  $\frac{\text{Total \# of hectares per community}}{\text{AUM} \times 5 \text{ months}}$

3 =  $\frac{\text{Forage utilization per hectare} \times \# \text{ of hectares}}{\text{Average monthly forage intake} \times 5 \text{ months}}$

( ) Stocking rate when the contribution of the Deschampsia community (H11) is removed.

- H1 *Festuca scabrella* - *Helictotrichon hookeri*/*Oxytropis campestris*
- H2 *Betula glandulosa*/*Festuca scabrella* - *Kobresia bellardii*
- H3 *Potentilla fruticosa*/*Festuca scabrella*/*Geum triflorum*
- H4 *Potentilla fruticosa*/*Agropyron subsecundum*/*Geum triflorum*
- H5 *Agropyronx Elymus*/forb
- H6<sup>1</sup> *Pinus contorta*/*Sheperdia canadensis*/*Elymus innovatus*
- H7 *Agropyron subsecundum*/forb complex
- H8 *Salix* spp. - *Betula glandulosa* shrubland complex
- H9 *Salix* spp. - *Betula glandulosa* thicket complex
- H10 *Salix* spp./*Juncus balticus*/moss
- H11 *Deschampsia caespitosa* - *Carex aquatilis* - *Poa pratensis*
- H12 *Carex pseudo-cyperus* - *Deschampsia caespitosa*
- H13 *Carex aquatilis* - *Calamagrostis neglecta*/moss

## CONCLUSIONS

This elk winter range assessment study, the first ever carried to such a detailed level in the province of Alberta, provided valuable information on vegetation composition and nutritional quality, and on elk ecology, food habits and movements. It also underlined the limitations of directly applying range management concepts and practices, largely developed in the livestock industry, to wildlife and habitat management.

The results of this study have several implications for the management of elk populations and their habitat. Often, wildlife biologists refer to open meadows along the foothills of the Rocky Mountains as potential elk winter ranges. The presence of some elk activity is taken as an indication that the range could support higher elk densities, when the low animal density may simply reflect limited resource availability. The recent development and application of an ecosystem approach to wildlife habitat assessment further confound the issue, insofar that an entire open meadow may be erroneously considered a single land unit potentially available to elk. As shown in this study, dry grasslands supporting fescue and wheat grass communities, selected by elk, represented only 28.7%, 30.6% and 9.6% of the total range apparently available on Harrison Flats, Ribbon Flats and George Creek, respectively.

The results of this study and the management conclusions cannot be taken out of context and applied to other elk ranges.

Proper elk management requires an understanding of individual elk populations, their movements, behavior, habitat availability, forage preference and availability, and a knowledge of the impact of weather conditions, human activities and other land uses. As stated by Skovlin (1982): "To plan for habitat alterations to benefit elk, the specific habitat requirements must be recognized...Inadequate habitat assessment or worse - no assessment at all - requires that vital decisions be made without adequate information, to the possible detriment of elk and their habitats".

Future assessments of elk winter ranges in similar detail may not be financially or practically feasible. Nonetheless, if such assessments were possible, they should be conducted as part of more extensive studies on regional elk populations. With regard to this project, it should be noted that the value of range assessment on Harrison and Ribbon Flats was greatly enhanced by the available knowledge of elk populations along the Clearwater and Red Deer River valleys. In contrast, the absence of regional information on elk limited the value of range assessment along George Creek, even though the study provided previously unavailable data.

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## MODELING ELK HABITAT USE BY PROBABILITY

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Abstract: Wildlife management and research has historically operated in a descriptive mode, whereas now, with a myriad of demands on nearly all the natural resources and with the advent of the computer, we are challenged to operate in a more predictive mode. Although population dynamics modeling is in vogue, little has been done with synthesizing elk distributional data relative to the environment via a mathematical model to help the manager predict elk-habitat use as affected by management prescriptions and habitat characteristics. In this presentation I will present some results from the Long Tom Creek Phase of the Montana Cooperative Elk-logging Study that describes the use of such a working model. Since these results were excerpted from the final report of this study which is currently in preparation and pending publication, only a summary is being presented.

This model was developed using a stepwise regression approach to emulate a log linear regression and was based on transect data collected during June through November from 1972 through 1980 in southwestern Montana. It does not predict elk numbers, but predicts the probability of elk use when given values for certain habitat parameters that were determined to be important for each of 5 time periods; June, July, August, September and Fall (October-November). Three classes of independent variables were used to develop the model: dynamic and site specific (e.g. cattle use), static and site specific (e.g. % slope), and static and site adjacent (e.g. surface area of wet meadow within a 12.4 ha circular area surrounding the center of each transect). A total of 33 variables were determined to be statistically important ( $p < .05$ ) for predicting elk use in the overall model, but not for every time period. The predictive accuracy of the model ranged from 61% for September to 74% for the fall months. Predictive accuracies for the other months were 66%, 68% and 70% for June, July and August, respectively. Although these accuracies are not exceptionally high, they still provide the manager with some quantitative insight as to what the intensity of elk use of an area might be or how management prescriptions of the habitat might affect elk use, e.g. road construction, logging, cattle grazing, road closures.

This approach in describing elk use of an area also demonstrates how variables change in importance over time and how this change can be from important to unimportant and vice versa or from a negative to a positive correlation and vice versa. When using a model such as this one, the manager will quickly realize the dynamics of a situation and how the effects of various management activities on elk are time dependent and often subtly interactive.

# A CONCEPTUAL MODEL OF ELK HABITAT SELECTION AND USE

By the Participants in a Workshop on Elk Habitat Selection and Use

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## INTRODUCTION

On February 1-3, 1984, a small group of invited participants met at Lubrecht Experimental Forest, University of Montana, to discuss and, if possible, develop a model of habitat selection and use by elk. The participants were invited on the basis of their past experience working with elk and elk habitat, or because of their experience with modeling logic and procedures. This was the first workshop ever conducted in the new Forestry Center of the Lubrecht Experiment Forest and, as far as we can determine, the first one on elk in which a primary objective was the development of a habitat selection model using a temporal framework to describe year-round, integrated habitat use.

None of the 12 participants in the workshop have illusions that they managed to develop a definitive model for elk habitat selection and use. Most were disappointed, but not surprised, that we ran out of time just when it appeared that success might be possible. The conceptual model we produced is still in the early stages of development and could prove to be a dead end. At the same time, we believe we accomplished something worthwhile, and that a written summary of workshop results can serve two useful purposes. First, we suspect that similar workshops on habitat use

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might be beneficial in other geographic areas or possibly on other species of wildlife. Toward that potential, we offer this review of the way the Lubrecht Workshop was organized and conducted. Although it was far from perfect, all the participants reported it an excellent experience and a concept that could lead to even greater progress in the future. Second, although this workshop did not yield a functional model of elk habitat selection and use, we believe the conceptual model is worthy of further consideration and peer critique. We are particularly interested in presenting the tentative model to other research and management biologists with the hope that critical feedback will enable us to build a model to be appropriately tested during the next 2 to 5 years.

## CONDUCT OF THE WORKSHOP

### Selection of Participants

The first and possibly the hardest task for the workshop sponsors was the selection of participants. A workshop can serve for either teaching or brainstorming, but we decided that it could not do both. Thus, every participant had to be carefully selected on the basis of expected potential contribution, and the group had to be small enough that all contributions would be heard. Given the objective of the workshop--to develop a habitat selection and use model for elk--we tried to select wildlife biologists who had worked on both population dynamics and on habitat use. We wanted a preponderance of research biologists to assure that abstract concepts would dominate, but we also felt that abstraction should be tempered by management biologists. Finally, we selected two participants with strong backgrounds in model construction and design. Neither had worked specifically on elk prior to the workshop.

In the planning stages, we had hoped to limit the workshop to 10. We finally invited 12 to get a full selection of the various lines of expertise. As events during the workshop proved, the appropriate working group size is probably less than 10. If a larger number is involved, it will almost certainly become necessary to break into units of five to seven at some time during the workshop.

### Physical Environment

Not surprisingly, it helps if the workshop environment is comfortable, participants are well fed, and any major distractions either contribute to, or at least don't detract from, the work. The Forestry Center at the Lubrecht Experimental Forest seemed particularly well suited. We were able to use a small, well-lighted conference room with a fireplace for most of the meetings, and there were other laboratory, dining and sleeping areas readily available.

In the first evening session we held a field trip to view parts of the Chamberlain Creek Elk Study area and the Lubrecht Forest. This was a short trip and was repeated each evening for those interested in seeing elk. We were also entertained by a demonstration of Lonner's habitat probability program run on a Kaypro portable microcomputer. The

potential demonstrated by this program and the equipment was high. If several demonstrations of equipment and recent results were available, they would be an exciting addition to any workshop.

### Preparation

When used as a learning experience, workshops normally have some kind of prework to bring all participants to the same starting point before the first meeting. For this workshop, we asked each participant to suggest possible prework materials, but received no suggestions. We believe this was fortunate. As it turned out, each participant brought his own individual expertise but without any preprogramed ideas on the way the workshop should proceed or the form the model should take.

### Building the Initial Framework

As a starting point for discussions during the three days, each participant presented his perception of what he expected the workshop might accomplish. This was a worthwhile exercise, because it brought out several ideas not previously recognized, and it established a framework on which we could recognize both the ultimate goal and the complexity of the problem. Among the more important concepts mentioned were that the model should:

- describe habitat selection and use in at least monthly intervals
- treat behavior of individual animals rather than populations
- be capable of demonstrating effects of land management activities on individual animals and populations
- identify specific carrying capacity in numbers of elk per acre
- demonstrate importance of individual components of habitat; that is, identify the key variables
- integrate habitat requirements and behavior in a logical and useful way
- be a functional management tool using existing data bases

Following this discussion, each participant described his recent work and his perception of the applicability of that work to the objectives of the workshop. Possibly, the most significant observation from this discussion was that the majority of participants have been using or developing habitat utilization models of some kind and that the major problem with existing models is failure of extrapolation. Even when the biologist had a functional model for a specific study area, he was uncertain that it could be used on any other area.

One point we did not develop in this initial discussion was the specific form the final model could take. Instead, several participants obviously avoided any suggestion that an existing model should be used as a format. Later events probably show that this was an oversight. A few

minor decisions at this stage would probably have led to a higher level of accomplishment than was actually attained. Certainly, if a form had been described, the major disagreement of the workshop could have been avoided, and we might not have spent so much effort straying away from the primary objective.

### Aiming at the Primary Objective and Resolving Disagreements

In a workshop with a limited amount of time, all participants need to concentrate on the primary objective and to resolve any disagreements quickly. This was not easy because habitat use by elk is an abstract concept, and the abstraction was not identical for everyone. Methods for maintaining continuity of progress included frequent summarizations. When a persistent failure of agreement occurred, we tried approaching the problem from a different direction. When it appeared this was inadequate, we divided the participants into two groups so that discussions could continue along apparently different lines.

#### Summarize at frequent intervals

At the beginning of the workshop, we hoped that frequent summarizing with status reports would enable us to keep all participants on the same track. We started the second day, for example, by asking Clark to summarize, from his viewpoint as a modeller, what he thought of the existing situation and the potential. We got the following checklist of items any elk model must satisfy to be useful (note the complexity, even before discussions started):

- treat individual animal, by sex and age classes
- generalized (can be extrapolated beyond one study area)
- must solve the spatial resolution problem
- preferences should be related to requirements
- habitual use must be recognized in the model
- people influences and disturbances are significant
- several kinds of responses will require stochastic control
- phenology must be modeled and included
- energy budget might be a model denominator
- lag variables need consideration (summer condition influences value of the winter range)
- scaled variables should be related to carrying capacity, density . . .

- model needs to work realistically at the limits
- is it possible to have controls for testing?

From these points, Clark concluded that the areas most likely to create significant problems in development of a functional habitat model were:

- philosophy: system state or dynamic pattern model?
- scale: how big an area? bigger is harder, is it better?
- time steps: daily, weekly, monthly?
- tying the model to existing data bases to save time and money
- who are the users? is there a break between useful and valid?
- validation and sensitivity testing, "what if" games

The discussions that followed, and the initial attempts to outline a form for a potential model of elk habitat use, demonstrated that Clark was right. After an hour or two of circling the problem, the workshop was obviously degenerating into two defenses of specific viewpoints rather than a single discussion moving toward a solution of the problem. At this point, we decided to break up into two smaller groups and continue with the hope that eventual model construction, even if initiated from two different formats, would lead toward the same end product.

Separate into smaller discussion groups

When the two separate groups with their different approaches to modeling were allowed to work independently, each produced a flow diagram and a basic concept in less than two hours. At first, it was not clear if this achievement was an evidence of progress. When the two groups reconvened, they apparently had produced two different models. However, as we will show later in this paper, the differences were not as great as first perceived. The starting point for one group involved density (number of elk per square mile), while the starting point for the other group involved instantaneous physical needs of a single animal. The first group tied population density to population characteristics through a condition index for each individual animal, while the second group tied animals to habitat units with the intent that a movement submodel would establish densities by default. When the two models were reviewed, there was less than overwhelming agreement that they could be combined or even reconciled. At that point, it appeared we had reached a permanent impasse that might prevent any further progress.

Try a different approach

Rather than continue an apparently fruitless discussion, we changed directions and tried to come at the objective from a different viewpoint or on a different scale. Although this particular impasse was somewhat greater than others, we used this technique on several occasions when

temporary differences of opinion did not seem substantial enough to require separation into smaller discussion groups.

In preliminary discussions we had agreed that time would be a required variable in the final model, so we changed directions and worked on a listing of the most important variables affecting elk habitat use by monthly periods. Again, we ran into some discussion problems, but this time we backed away from the main problem far enough to see that all variables seemed to fit into one of three categories depending on the way they influenced the condition or requirements of elk: security, thermal regulation, and food. Within the context of this agreement, we ranked each variable for importance during six periods of the year as follows:

Periodic List of Influencing Variables

Variable	Jan-Mar	Apr-Jun	Jul-Aug	Sept-Oct	Nov	Dec
Security <sup>1</sup>		1c	3	2	1	
Thermal (warm) <sup>2</sup>	1	2 3	4		2	1
Thermal (cool) <sup>2</sup>			2			
Food <sup>3</sup>	2	1	1	1	3	2

<sup>1</sup> Habitat variables influencing security include roads, hiding cover, social interaction with cattle, topography, elevation, slope, and in some seasons, darkness.

<sup>2</sup> Habitat variables influencing thermal regulation include timber cover, topography, moist sites, elevation, aspect, and group relationships.

<sup>3</sup> Habitat variables influencing food revolve around seasonal characteristics of openings, shrub fields, and forests.

The second time we decided to diverge from a straight path to the objective, we had begun to agree on some similarity between the two prototype models, but were still badly hung up on the concept of animal movement from one place to another. Pfister suggested that maybe we should forget about movement momentarily and try to develop a "habitat model" that would eventually relate to a movement model. He suggested an ecosystem x successional stage framework under which each cell could be linked to a real land area by mapping. A diversity index would take care of juxtaposition problems, and a prototype model could then be developed and tested. A side result of this discussion was that Banaugh was able to determine an apparently logical way to construct a movement submodel using the suggested habitat model as a driver. A second side product was the recognition by Escano that the available information on elk habitat use was probably adequate to allow development of habitat suitability index (HSI) models in a form usable by management.

#### The "Black Friday" solution

One approach to the resolution of disagreements that we did not try but has been used in other workshops was described by Banaugh as the

"Black Friday" solution. In large laboratory situations, this is simply an arbitrary selection, usually by the laboratory chief, of one of the two competing answers. Selection is usually made on Friday so the losers will have the weekend to recover from disappointment and come back ready to work on the selected answer. In a small workshop, if the participants are willing, it could as well be done by random drawing to pick a participant to make the decision.

### Workshop Preliminary Results

The two diagrams, here, are from the display sheets of the working subgroups. Neither diagram is intended to be a definitive description, and neither is expected to be of direct use to anyone not present for the discussions. These are the preliminary, working hypothesis models for the workshop, and all participants will object to any misuse implying that they are more than preliminary sketches. (See Figure 1).

### Summary and Followup

On the final day, Banaugh addressed the status of the proposed models and the areas of needed emphasis. One clear point was that the Movement submodel (in the Discrete Step Model) was a specific deterrent to any immediate integration of the two diagrammatic models. At the same time, most of us conceded that the state variables, "condition index," and "animal needs" might only be different expressions of about the same thing.

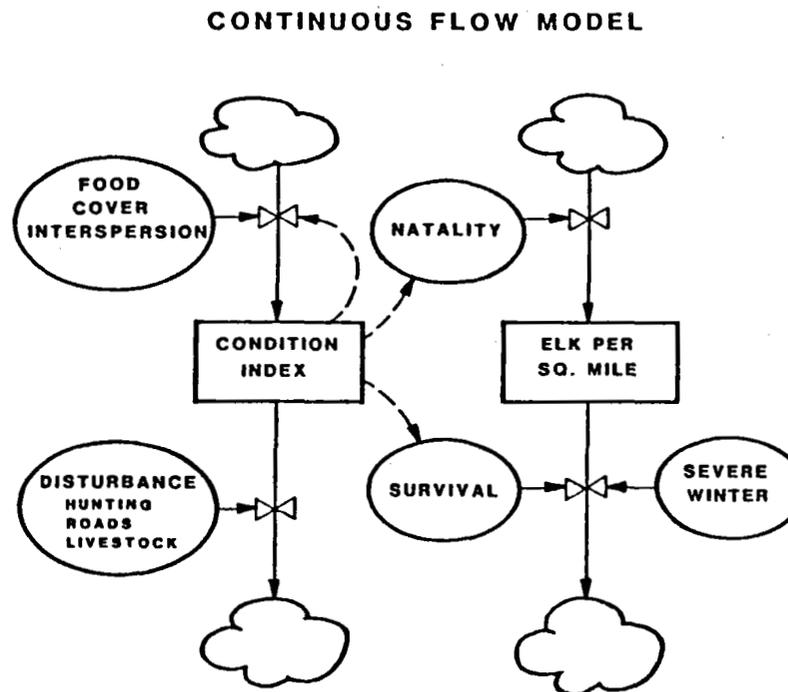
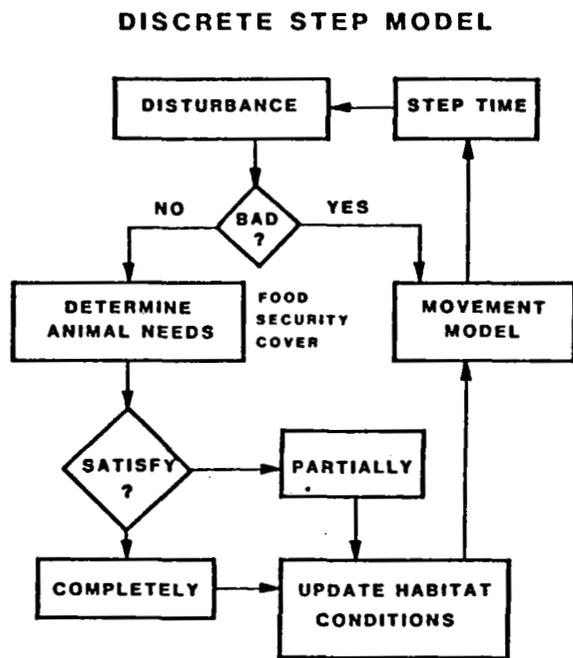
Our most important realization was that the "periodic list of variables" compiled on the second day of the workshop expressed the central core for a functional habitat use model. All of the variables listed contain a single idea: that the day-to-day behavior of elk revolves around a constant attempt to maintain a positive energy balance.

Wrap-up included an overview statement from each participant regarding the significance of the discussions and an evaluation of accomplishments. Most of the participants by then recognized that a workable framework for a habitat selection model had been developed. Lyon volunteered to attempt the integration of the two models, and Banaugh indicated a desire to develop the model to at least an initial computer program stage. Other participants, especially those involved in developing new research, indicated that such a program could be immediately subjected to field testing and modification.

## INTEGRATION OF THE PRELIMINARY MODELS

Integration of the two models started with examining those functions that appeared to be common to both models and those that were present in only one. This was an interesting exercise in several ways. First, it was rewarding to find that all of the functions listed as desirable by the workshop participants are present in one or the other of the two models. Second, many of the listed functions do appear in both models and are recognizable even though not necessarily interchangeable. And finally,

Figure 1. The two preliminary working hypothesis models.



most of the functions found in only a single model are easily understood and noncontroversial.

From the standpoint of attempted integration, most of the apparent differences between the models are associated with the method of expression rather than the underlying concept. In one model, a "happening" is controlled by a valve that determines how much influence gets through to the elk. Flow through the valve, even when limited, is continuous. In the other model, the valve is replaced by a question, usually dichotomous, regarding the probable result of the "happening". Such questions are always presented in a diamond-shaped box that is clearly the equivalent of the valve except that the result becomes a discrete event. For purposes of this discussion, the two models shown earlier are called the "continuous" model and the "discrete" model.

### Common Functions

At the heart of both models is a single descriptive variable expressing the status or "condition" of an individual animal. The continuous model considers this a condition index expressing both the physiological and behavioral conditions applicable to each animal in the population. The discrete model expresses this same variable as a question of animal needs for food, thermal cover, or security. Integration of the two models, as the participants recognized on the final morning of the workshop, might be accomplished if this variable was expressed as the cumulative daily energy balance for each animal. The balance could be reduced each day by the energy required for maintenance, and any food eaten would replace the losses. Intake in excess of the daily maintenance requirement would contribute to a positive energy balance. At the same time, inadequate food, cover, or security for any period, would result in a negative balance. The energy balance at any specific time would be an expression of condition for the animal.

The discrete model lists habitat conditions in what appears to be a submodel for maintaining and updating status. Access to the influences of habitat are controlled by the question, "Is the environment available to an animal adequate to satisfy needs?" On the other hand, the continuous model expresses the influence of habitat as a control on energy flow to the condition index from the variables food, cover, and interspersion. Even though expressed in somewhat different ways, these are clearly the same concept.

The influences of disturbance on elk use of habitat also seem to represent similar concepts in both models although neither model appears able to provide a clear explanation of the effect on elk. In the continuous model, disturbances are shown as modifying the condition index, which implies that some energy cost is involved. In the discrete model, disturbances are seen as causing activation of the movement submodel. Movement, viewed as a method of compensating for environmental change, also has energy costs. Either version should reduce the energy balance for the animal and at the same time lead to selection of a different habitat in which energy drain is reduced.

Finally, both models contain a treatment effect for variations in winter severity. The continuous model takes the direct approach of allowing a severe winter to reduce population density, while the discrete model treats winter as one of several seasons in which the energy requirements of an animal could potentially exceed availability.

### Unique Functions

One of the items workshop participants listed on the first day, as a desirable attribute for the model, was an expression of carrying capacity or population density. The continuous model includes such a variable, and it also includes the life-table parameters, natality and survival. When they gave their presentation, the discrete model group had not addressed population density, but some members of the group thought that a properly scaled behavioral and habitat quality model would probably provide a density estimate if allowed to run through several cycles. Neither group was certain if it would be necessary to carry a complete population structural table within the final model, but such information would likely be produced whether or not it is essential to the needs of the users of the model. In either version, it is clear that individual animals must be specifically identified if condition or need is to be determined.

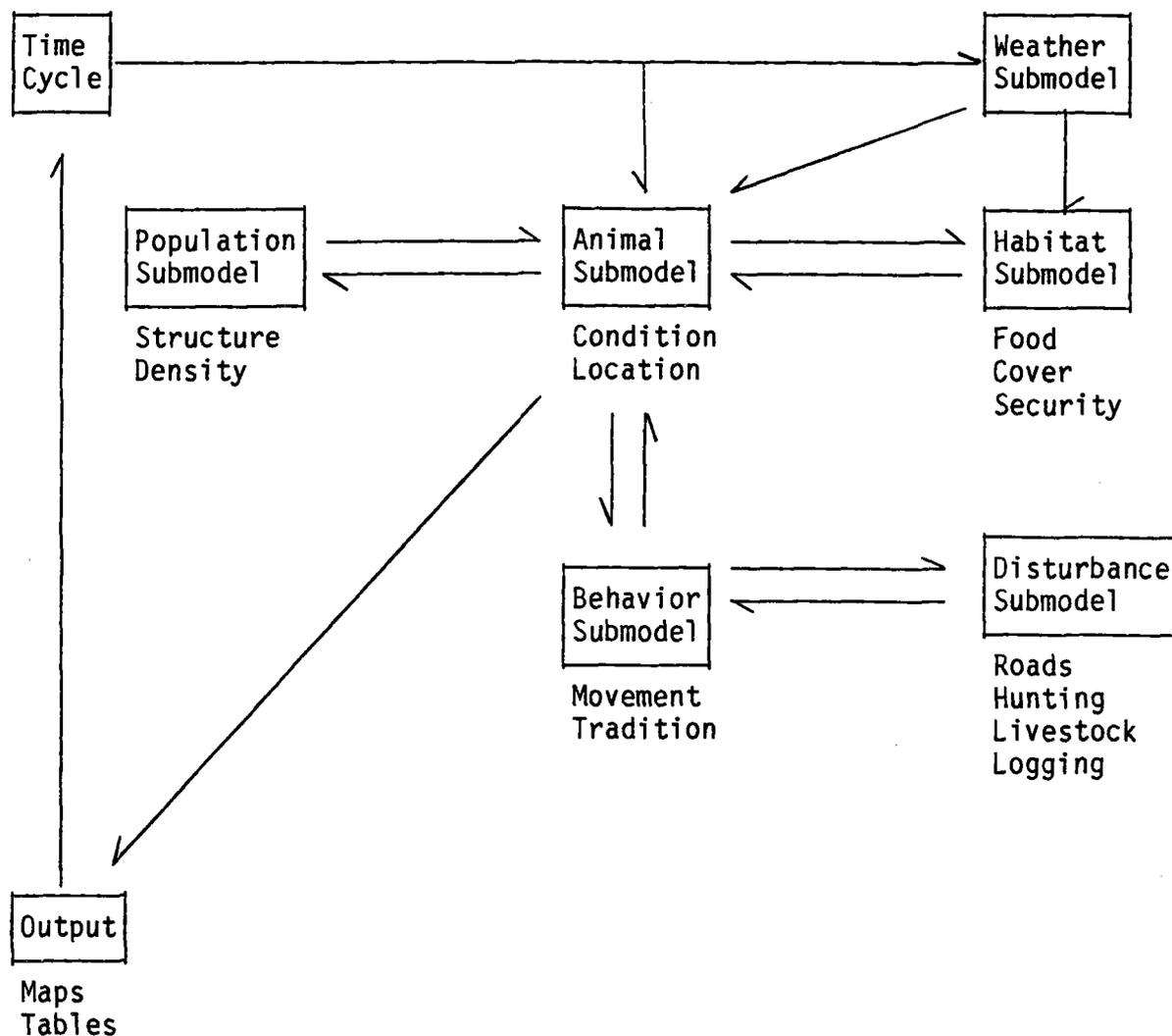
The discrete model included two concepts that were unique, although one of them, the time step, was certainly implied in the continuous model by the flow through condition for individual animals and through density for the population. However, the concept of movement was completely unique to the discrete model and became a subject of some controversy. Again, however, the real difference between the models may be the way the results of a "happening" are expressed rather than the basic concept underlying the influence of the event. In either model, disturbance has quantifiable consequences in energy cost, in the condition index, and in the habitat selection strategy of the individual animal. The major difference appears to be the way the habitat selection strategy might be expressed in the output. The discrete group, through the movement model, has introduced a concept foreign to the way the majority of models have previously been constructed. Specifically, this group has assumed that program function in the model will be designed to use a study area map as the base on which habitat values are recorded and individual elk are tracked.

### A Revised Working Hypothesis

Based on this initial comparison of the functions of the two preliminary models, we present here a consolidated model in which all functions from both previous models are expressed. This flow chart (Figure 2) purposely avoids both the continuous and discrete expressions, at least in part because several of the variables in this chart represent submodels of some complexity. Movement, as suggested by the discrete group, is a part of the proposed model, and we have attempted to maintain the parallel development of population densities and individual animal condition as suggested in the continuous model. A number of concepts have been consolidated into separate submodels within the diagram while "weather" and "output" have been indicated as separate units. The only

specific assumption not shown by the flow chart is that this model is visualized as a base map on which individual elk move, much as checkers are moved around on a checkerboard. Descriptions follow for each of the eight units of this chart.

Figure 2. Conceptual model of elk habitat selection and use.



**TIME CYCLE:** The stepping sequence and the starting point for program flow. In the end, this variable will be a measure of the sophistication of the model. Much of the recent radio location work with elk indicates a considerable amount of movement within a restricted daily home range. A model capable of relating this daily movement to the hourly energy balance and behavioral patterns of elk, would indeed be sophisticated. However, in the initial version of the program, a daily cycle may be adequate to incorporate most of what is known about elk habitat selection and use.

**WEATHER SUBMODEL:** Daily variations in weather, or even hourly variations if that degree of precision is needed, can be programmed through tabular listings of real data or set up as a stochastic model of real data summaries over periods of years. In the long run, this should be a

stochastic subprogram, but initial program design might be better served if one to four known, predictable weather patterns could be selected.

**HABITAT SUBMODEL:** Whether this unit should be designed as a functioning submodel, or simply as a complicated tabulation system, is not clear. Primary input to the unit is weather data, which converts to a continuously updated phenological record for all vegetation on the base map. Each habitat unit is related to elk in terms expressing the value for maintenance of energy balance: food, abundance and quality; thermal cover, effectiveness; and security, including cover, topography, isolation, or any other factor that produces security for elk.

**DISTURBANCE SUBMODEL:** Closely related to the habitat submodel is a continuing record of those events that might cause security loss. In the initial model, disturbance will include roads, the hunting season, live-stock grazing, and timber harvest.

**ELK SUBMODEL:** In this unit, the daily energy balance of individual animals is determined. Input from the weather and habitat submodels will make possible estimates of daily energy requirement and the probability of obtaining that requirement in the readily accessible habitat. This submodel also maintains the location for each elk on the base map and produces movement from one location to another when required for physiological reasons (food or cover, not security).

**POPULATION SUBMODEL:** This unit may prove to be no more than a continuing summary of all the individual animals in the elk submodel. In this capacity, it could be used to maintain life tables and summaries of population structure and density. However, as it is developed, the population submodel can be driven by animal condition and behavior in a way that will make it possible to evaluate carrying capacity by allowing the population to expand until negative energy balances begin to cause "starvation".

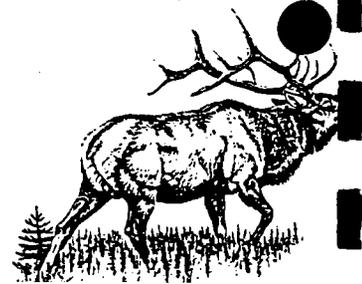
**BEHAVIOR SUBMODEL:** This submodel provides a second evaluation of the daily energy balance for individual animals, but it does so primarily by adding on the costs associated with output from the disturbance submodel. This submodel is also capable of producing movement from one location to another, but it does so as a response to behavioral processes. In addition to movement required because of disturbance, the behavior submodel is intended to control annual migration and any limitation on movement related to traditional behavior.

**OUTPUT SUBMODEL:** Considering the variety of parameters required in one or more of the previous submodels, output can be comprehensive or relatively simple. At first, selected parameters from other submodels, such as "condition" in the elk submodel, might be examined on a monthly basis. Population structure and density tables could also be printed at selected intervals. In the degree that the habitat, animal, behavior, and disturbance submodels can be made to function realistically, output could include summaries of habitat selection and use during short periods. Reruns on the same areas with revised habitats could be used to demonstrate effects of management and the importance of different variables. It should be possible to program a CRT to display a study area

map with locations of individual elk on a daily basis. This model could eventually be programed to satisfy all seven concepts listed in the beginning framework of the workshop, including the variable some of us considered least possible, carrying capacity.

#### CONCLUSIONS

This paper was presented to elk biologists at the Western States and Provinces Elk Workshop, April 17-19, 1984, in Edmonton, Alberta, Canada. We had hoped for more suggestions than we received, but we were grateful that all comments were positive. We plan to start on a few of the sub-programs during summer 1984. Depending on unforeseen complications, we hope to be able to describe a minimum-function program sometime in 1985. Written comments and suggestions will be gratefully received by any of the workshop participants at any time.



# FORAGING ECOLOGY OF WAPITI IN THE BOREAL MIXED-WOOD FOREST, CENTRAL ALBERTA

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**Abstract:** Forage selection by wapiti (Cervus elaphus nelsoni) in the boreal mixed-wood forest of central Alberta was examined in five habitat types: poplar forest, willow, upland grassland, lowland grassland, and sedge meadow. Diets were sampled from October (1980) to August (1981) using the bite count method. Significant differences in the use of forage classes (grass, browse, forbs) occurred among seasons and among habitats ( $P < .001$ ). Grasses dominated the grassland and sedge meadow diets for much of the year, though forbs were important components in the summer. Forbs remained important in the winter diet in the lowland. Browse generally dominated diets selected in poplar forests. Fallen leaves formed a significant proportion of the fall and winter diet. Use of grass in this habitat was greatest in spring and fall, and forbs were important in the spring and summer diets. In the willow habitat, browse was the major component of the diet during winter and summer, while grasses, mainly green sedge shoots, dominated the diet in spring and fall.

Phenology and availability of forage items appeared to be major factors influencing use by wapiti. Forage quality, based on crude protein, was significantly greater in spring and summer than in fall and winter ( $P < .05$ ). Forbs generally contained more protein than other forage classes, except in summer when no differences were evident. Digestibility of winter forage samples ranged from 35-45%, while summer samples ranged from 60-75%. Forbs tended to have the highest overall digestibility. Dietary crude protein followed seasonal trends similar to that of forages. It was significantly greater in the spring and summer than fall and winter. Dietary crude protein ranged from 4.5% in the sedge meadows during winter to 25.3% in the lowland grassland in summer. Dietary crude protein was considered to be sufficient to meet requirements of wapiti throughout the year, except in the sedge meadows in winter.

Foraging rates (bite rate, consumption rate, rate of movement) varied among sex and age classes, habitats, and seasons. Foraging rates were generally greatest in summer, when forage abundance and quality was higher, and lowest in winter. Within a season, rates tended to be the lowest where selection was the greatest, in areas of high species and structural diversity. Intake rates on grassland areas during snow free periods tended to exhibit increases with increasing biomass. Bite size appeared to be an important factor in determining consumption rate during these periods.

DIGESTIVE EFFICIENCY OF WAPITI WITH VARIATION IN DIET: A COMPARATIVE APPROACH

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Abstract: Rate of fermentation and digestion of three diets of fistulated wapiti (Cervus elaphus nelsoni), moose (Alces alces) and cattle were studied during mid-summer. The animals were fed diets of alfalfa/grass hay, alfalfa and alfalfa/aspen, in 12 day trials, spaced 3 weeks apart. The rate of digestion of grass and hay and aspen in nylon bags suspended in the rumen of wapiti was higher than in moose and cattle. The potential digestibility of the alfalfa dry matter, in wapiti, was 6.3% and 14.5% higher than the grass hay or aspen diets, respectively. Wapiti appear to obtain this asymptotic level more rapidly than moose or cattle.

## METHODOLOGY FOR THE DETERMINATION OF DAPA IN FECES OF LARGE RUMINANTS

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Abstract: A standardized technique has been developed for monitoring DAPA (2,6 diaminopimelic acid) in feces from elk and other large ruminants for use as an index of herd nutritional well-being. The method is efficient and relatively inexpensive compared to existing methods which require elaborate equipment and become costly if DAPA is the only amino acid to be analyzed. The method modifies several ion exchange column procedures described by Czerkowski (1974); utilizes the acid ninhydrin reagent method of ElShazly and Hungate (1966) to determine concentrations of DAPA spectrophotometrically; and develops laboratory apparatus for sample filtration/purification and column elution. A stepwise description and validation of the procedure is presented as follows: (1) fecal sample preparation, (2) acid hydrolysis, (3) purification/filtration and concentration, (4) ion exchange column elution, (5) ninhydrin reaction and spectrophotometry. Analysis problems encountered thus far and future verification studies are discussed including: (1) determining effects of weather, storage, and handling of fecal DAPA samples, (2) evaluation of optimum fecal pellet group sampling size for DAPA analysis, (3) testing alternative methods for expressing DAPA and (4) effect of possible inhibiting organic compounds. This improved fecal DAPA method should significantly reduce cost, increase the number of samples processed concurrently and make the nutritional monitoring of big game herds more practical for the big game manager.

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### INTRODUCTION

In order to provide for the biological needs of big game animals, the well-being of the herd is usually monitored through various herd structure, composition and condition indicators. Although useful, indicators such as kidney fat index (Riney 1955), bone marrow color or compression (Cheatum 1949, Greer 1968, Hunt 1979, Peterson et al. 1982), ovarian analysis and fetal counts (Robinette et al. 1977), blood urea (Warren et al. 1982), and combinations of indicators, evaluate animal productivity and condition after the fact and require the death of the animal. Direct methods for evaluating the current nutritional status of animals involve analysis of rumen content for crude protein (McBee 1964 cited by Moen 1973:312) or volatile fatty acid production (Mansfield et al. 1975). However, direct methods require much time and expense to obtain statistically adequate samples and involve the live capture of big game animals.

Although fecal nitrogen is related to dietary crude protein intake of ruminants, fecal nitrogen indices do not seem to have broad application in estimating some measure of the digestibility of ingested forages. Holloway et al. (1981) point out that the relationship between fecal nitrogen and digestibility or intake varies both seasonally and between forage plant species. They sought to improve fecal nitrogen estimates of digestibility by including other fecal constituents into their model (fecal cell wall content, ether extract, and dry matter content). Obviously, there was no simple and reliable technique for measuring diet quality for ruminants grazing over expansive areas (Gates and Hudson 1979, Holloway et al. 1981). A new method of monitoring the nutritional status of a herd was needed.

A standardized method for evaluating current herd nutritional well-being has been developed for measuring fecal DAPA (2,6 diaminopimelic acid). The method is direct, inexpensive and does not require the death or live capture of animal subjects. DAPA analysis as a nutritional monitoring device is based on the relationship between DAPA (a unique amino acid residue of rumen bacterial fermentation) and diet quality. This residue passes unabsorbed through the digestive tract of ruminants with no measurable loss and passes out in the feces. DAPA exhibits the same cyclical pattern as shown by seasonal changes in diet nutritional quality of big game animals (high when diet quality is high and low when diet quality is low). The apparent reliability of DAPA as an indicator of diet digestible energy and the low cost of the method lends itself well as a valuable tool for monitoring the nutritional well-being of big game herds.

A variety of methods and equipment exist for determining levels of fecal DAPA including: (1) paper chromatography (Work 1951, Cummin and Harris 1956, Hoare and Work 1957); (2) thin-layer chromatography (Sen, Somers and O'Brien 1969); (3) a spectrofluorometric method (Rogers, Chambers and Clarke 1967); (4) gas chromatography (Sen, Somers and O'Brien 1969); (5) auto amino analyzers (Ibrahim et al. 1970, Hutton, Bailey and Annison 1971, Mzik et al. 1978, Dufva et al. 1982); and (6) ion exchange column chromatography (ElShazly and Hungate 1966, Mason 1969, Mason and White 1971, Hutton, Bailey and Annison 1971). Although these other methods can detect low levels of fecal DAPA, they require elaborate equipment, are often slow, or become expensive when DAPA is the only amino acid to be analyzed. Furthermore, early ion exchange methods were relatively slow since collection fractions were obtained from large chromatographic columns (15-100 cm. in length). Czerkowski (1974) improved the ion exchange method by reducing the column length to about 5 cm and thus reducing sample elution time and the need for elaborate equipment. He adopted the acid ninhydrin method of ElShazly and Hungate (1966) since: (1) the acid ninhydrin reagent itself is stable; (2) the yellow color produced when reacted with DAPA is very stable unlike the blue color produced with ninhydrin at pH 5; (3) there is an absence of color interference by atmospheric ammonia; and (4) proline is the only amino acid likely to be found in the ruminant digestive tract which produces a similar reaction with acid ninhydrin, but it is removed by the ion exchange column earlier in the procedure (citrate buffer pH 3.4).

An overview of the DAPA procedure developed by these authors is given below (Figure 1). A more detailed description of ion exchange theory, lab equipment, and reagent preparation is available elsewhere (Davitt and Nelson 1984).

## METHODS

### Sample Collection and Storage

Since DAPA levels should be representative of the herd, it is recommended that a minimum of 15 pellet groups be sampled per herd per collection period (e.g. monthly). Collect about 3 pellets from each pellet group and combine them into a composite sample for that herd and collection period. If fresh pellet groups can be easily obtained from an area, then less material may be collected from each pellet group (e.g. 2 pellets from each of 30 groups). The entire pellet group need not be saved. Fecal samples should be collected as fresh as possible to ensure that pellets represent the desired collection period. Samples can be stored in plastic bags, labelled with the herd name and collection period, and frozen as soon as possible. If there are no freezer facilities available within a few days access, then dry the pellets thoroughly. Spread the pellets out in a thin layer in an area of good air circulation so that they dry without molding. If a laboratory oven is available, dry the samples at about 55°C for 24 to 48 hours. Samples which are to be shipped to a laboratory for analysis should be placed in plastic bags (if frozen) and packed in a cardboard box about twice the size of the frozen material. Surround the frozen samples with some sort of insulating material such as newspaper or styrofoam peanuts. Dried samples may be placed in envelopes or small containers and shipped in a carton. Care should be taken to avoid decomposition of fecal samples through bacterial degradation. Although DAPA appears to be unaltered, results are reported per gram of fecal dry matter, and fecal material must not change in composition after collection.

### Hydrolysis

A 250-300 mg oven-dry sample is weighed to the nearest 1/10 mg, hydrolyzed in 10 ml of 6N hydrochloric acid in a 50 ml test tube with a teflon-lined screw cap for 16-18 hours in a 105°C oven.

It was found that approximately 3 ml of hydrochloric acid is needed for each 100 mg of feces for proper hydrolysis. Czerkawski (1974) selected 105°C since he observed DAPA loss at 120°C. Our results were similar, with a volume loss from the test tubes at 120°C. Teflon-lined screw caps on 50 ml test tubes prevented leakage at 105°C. Although a range from 10 to 20 hours appeared to be sufficient time for hydrolysis in a 105°C oven, a 16-18 hour period is convenient for overnight preparation.

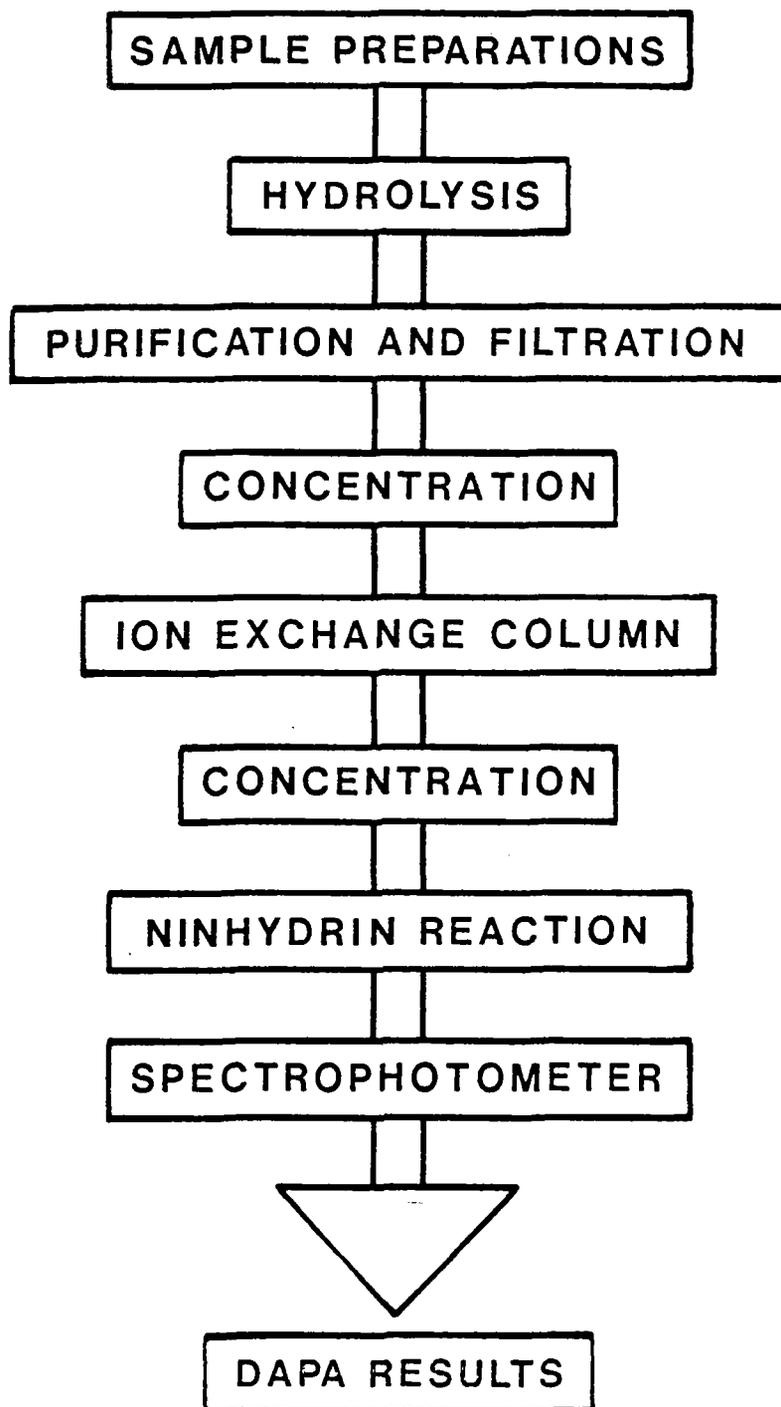


Figure 1. A diagram illustrating major steps in procedure for fecal DAPA analysis.

## Filtration/Purification

A 30 cc plastic disposable syringe is packed to the 5 cc level with a layer of glass wool below, and a layer of Celite filter-aid (diatomaceous earth) above. A luer-lock filter assembly attaches to the syringe tip and a .2 micron membrane filter is positioned inside the filter assembly. The hydrolyzed fecal sample is removed from the oven, and approximately .25 gm. of activated charcoal is added to the test tube and stirred. The fecal sample, acid and charcoal are poured into the plastic syringe and forced through the Celite, glass wool and micropore filter assembly by applying either pressure or vacuum to the apparatus. The test tube is rinsed twice with 4 ml of 20% ethanol in distilled water and the washings are poured into the syringe and filtered as before. Finally, the syringe is washed with 4 ml of distilled water and filtered. The filtered sample and washings are collected in a 50 ml test tube.

Fecal samples which were not purified in this manner clogged the columns and increased elution time. Unpurified samples which were not reacted with ninhydrin still resulted in optical density readings on the spectrophotometer. This "background" reading was equal to 15 to 30 percent of the ninhydrin reaction reading for unpurified samples but only 1 to 3 percent for purified samples.

## Concentration

The test tube containing the filtered sample and washings is placed in a sample concentrator consisting of aluminum heating blocks and a rack of needles to force a stream of air into the test tube. The sample is dried at 100°C, washed twice with about 5 ml of distilled water and dried again to remove most of the HCl before column elution. The sample is greatly clarified from a dark brown to a pale yellow solution and suspended particles have been removed.

Both steam baths and dry block heaters (with air stream) were effective in concentrating the sample, however, the sample concentrator reduced the drydown time to less than half that required by the steambath. Samples were tested to determine the degree of dryness necessary to drive off most of the HCl and concentrate the sample. Samples were dried to within .5 ml, to complete dryness, and 15 minutes beyond dryness. No significant differences were found in DAPA recovery. It was determined that two washings of 4 to 5 ml of distilled water after first dryness was sufficient to remove most of the HCl. These washings were in turn brought to dryness on the concentrator.

## Ion Exchange Column Chromatography

Amberlite CG120 resin is prepared by washing three times in 0.2N HCl, twice in 0.2N NaOH and storing in pH 2.0 citrate buffer. Fine particles are decanted following each washing after resin has settled for about 10 minutes. Polypropylene 1X5 cm columns are filled to the neck with resin, a filter paper disc is placed on top of the resin bed (to prevent disturbance of the bed), and about 5 ml of pH 2.0 citrate buffer is run through the columns. The concentrated sample is suspended in 1 ml of the same buffer and transferred quantitatively to the column. The columns are

eluted with 100 ml of pH 3.4 citrate buffer and eluant is discarded (proline is removed at this point). DAPA is eluted by 40 ml of pH 4.2 citrate buffer and collected in 50 ml test tubes. The sample is dried on a sample concentrator as described above and brought up to volume in a 10 ml volumetric flask with distilled water.

A larger column (7 ml capacity) is being tested in efforts to increase the fecal sample size and decrease sampling error. This should prove useful for samples with either very low or very high concentrations of DAPA. Columns larger than this would increase elution time beyond optimum efficiency with little increase in sample recovery.

### **Spectrophotometry**

DAPA concentrations are determined using the acid ninhydrin method described by ElShazly and Hungate (1966). A 2 ml sample is reacted with 4 ml of acid ninhydrin reagent and heated to boiling for 5 minutes in either a water bath or in a dry heating block (sample concentrator without using the air stream). Test tubes should be capped to prevent evaporation. Samples are rapidly cooled in cold water and the optical density is determined at 425 nm on a spectrophotometer. Samples are read against distilled water blanks and corrected for reagent effects. Standard solutions of various DAPA concentrations are prepared, reacted with acid ninhydrin as above, and a standard curve of DAPA concentration versus optical density is plotted. The resulting linear relationship is used to calculate samples of unknown DAPA concentration when read on the spectrophotometer.

DAPA samples reacted with acid ninhydrin were read on the spectrophotometer 1 hour, 24 hours and 48 hours after the reaction to test the stability of the resulting product, with no significant difference in optical density. Samples left for more than a few hours after reaction with ninhydrin should be capped and refrigerated to prevent evaporation.

### **Experimental Apparatus Development**

Equipment selection and development to aid in efficiency of analysis, including column racks, sample concentrators, vacuum micro-filtration units, column resin bed preparation, vortex stirrers, and micro-flow cell sampling spectrophotometer, have increased the number of samples run simultaneously and reduced procedure time several fold. Batches of 36 or 72 samples can be run concurrently in contrast to 8 to 16 samples run a year ago.

## **RESULTS AND DISCUSSION**

### **Validation of Procedure**

(1) Sample Size Bias: Sheep fecal samples were analyzed for DAPA using 100, 200, 300, 400 and 500 mg samples with no significant difference in mg of DAPA per gm fecal dry matter. Sheep fecal samples plus a "spike" of pure DAPA of known concentration were analyzed for increasing sample size (100 through 500 mg as above) each with two different levels of DAPA

"spikes" (77 and 95 ug). Mean recovery of DAPA for these tests were  $96.5 \pm .99$  percent and  $95.1 \pm .81$  percent respectively (Figure 2).

(2) % Recovery: Samples of pure DAPA of various concentrations (75, 100, 150, 200, 250, 300 ug) were run through the entire analysis procedure giving a mean recovery of  $97.2 \pm 1.65$  percent. Deer feces with increasing "spikes" of DAPA (0, 25, 50, 75, 100, 125, 150, 175 ug) gave a mean DAPA recovery of  $99.97 \pm 1.54$  percent (Figure 3). Proline (which also reacts with acid ninhydrin to give a yellow colored product) was added to samples but was effectively removed by the procedure as stated by Czerkowski (1974) and did not interfere with observed levels of DAPA.

### Further Verification and Problem Solving Studies

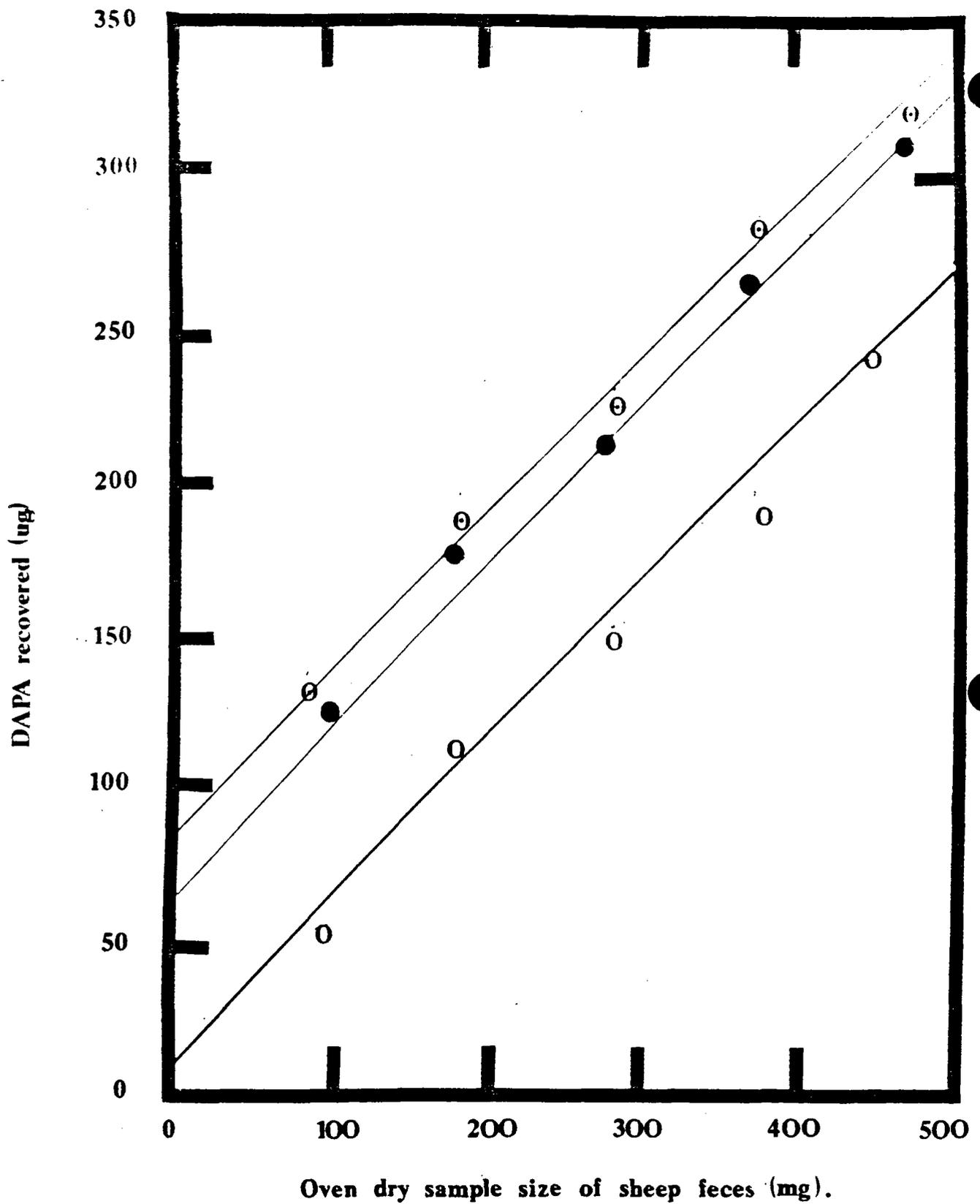
**OBJECTIVE 1: Determine effects of weathering, storage and handling of fecal samples on DAPA levels for big game species.**

Studies will be initiated in the winter of 1984. Fresh fecal samples will be subsampled and exposed to various field conditions and sites (ambient temperature, rainfall levels, snow and bare ground contact, overstory canopy coverage) to determine their effect on DAPA levels in the feces. Subsamples will be exposed to these regimes for 0, 1, 3, 7, 10, 15, 20, 30, 45 and 60 days after defecation and will be subsequently analyzed for DAPA. Fecal pellet group deterioration will be observed since leaching of soluble materials, bacterial degradation or contamination, heat/cold damage, or molding processes acting upon the feces may effect either the DAPA levels or the chemical composition of the feces over time.

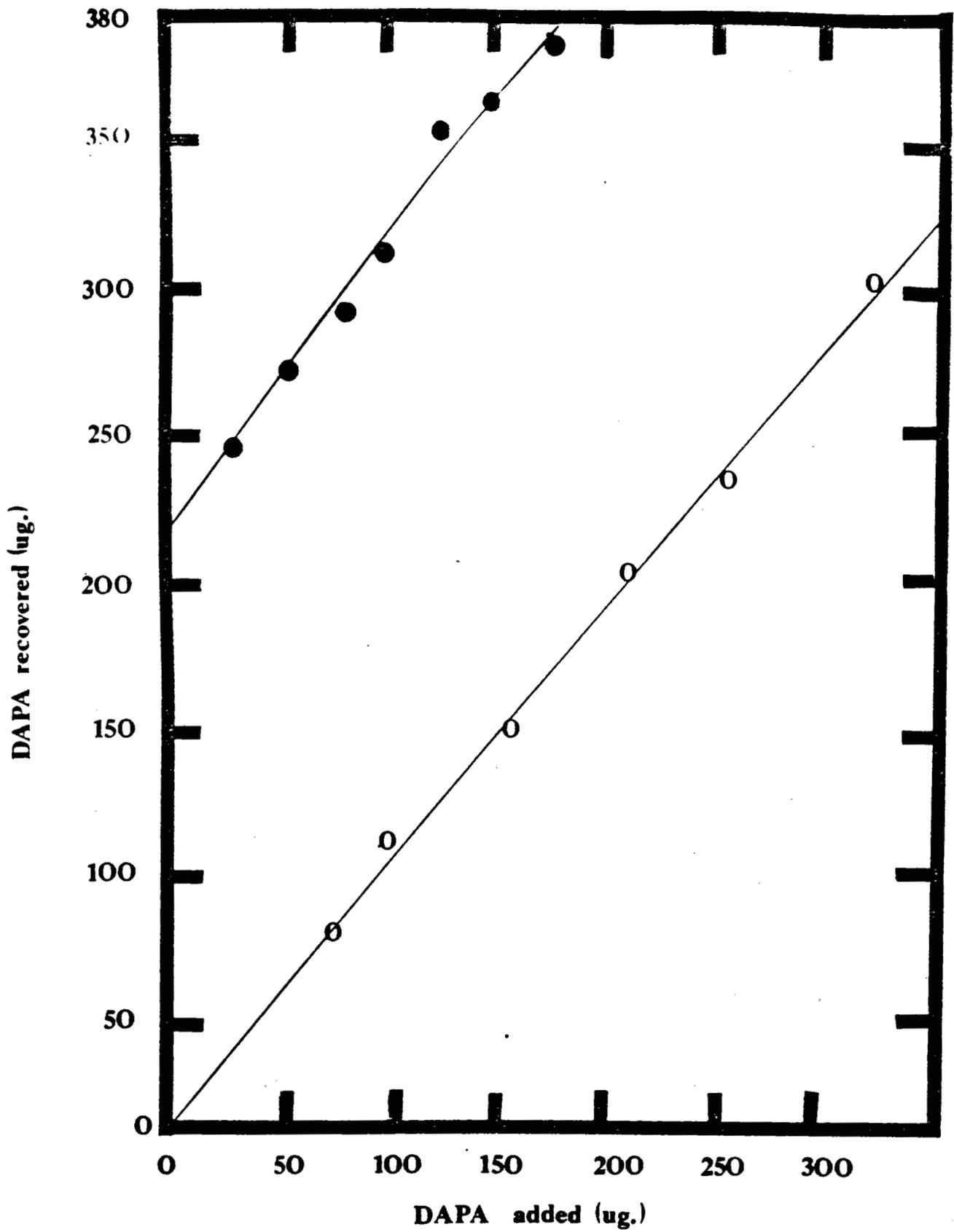
Sample storage methods such as freezing, air drying, and oven drying at  $55^{\circ}\text{C}$  will be examined to determine any significant differences in subsequent DAPA determinations. Sample handling in the lab (grinding, homogenizing, and subsampling) will be examined and be more closely defined.

**OBJECTIVE 2: Evaluate pellet group DAPA variability to determine optimum sampling intensity for major big game species.**

Fecal DAPA can vary significantly even among individual animals on the same diet. Therefore, if a precise estimate of a free-ranging herd's fecal DAPA level is to be made, the sample must be large enough to account for this variation. It is anticipated that variation among animals of the same herd would be the highest during periods of rapid plant growth (rapid changes in nutritional quality) and the least during winter, especially if plant availability is restricted by snow depth. Nelson et al. (1984) estimated that 7-8 pellet groups were sufficient to attain 5% sampling error for fecal DAPA estimates with control-fed domestic sheep (Figure 4A). A free-ranging herd would obviously require larger samples. Haussaman and Barnett (1983 unpublished) collected fecal DAPA samples from 26 individual mule deer from each of two herds in New Mexico during spring when deer diets were changing from dried herbage and browse to succulent herbs. Much color variation was observed among pellet group samples (ranging from green to dark brown) which suggested some animals were feeding heavily on new green forage and others were not. Sampling errors



**Figure 2.** Recovery of DAPA, using described procedure, from sheep feces of increasing sample size (O) with two levels of pure DAPA "spikes" 77.04 ug. (●) and 94.56 ug. (⊙).



**Figure 3.** Recovery of DAPA by described procedure. Various concentrations of pure DAPA (lower) and deer feces "spiked" with increasing amounts of DAPA (upper).

of only 6-7% were obtained for fecal DAPA estimates from these herds with only 15 pellet group samples from each (Figures 4B, 4C). Preliminary results (T. Leege 1983) suggest that only a 7-10 pellet group sample is needed for 5% herd DAPA sampling error on elk winter range in northern Idaho.

In order to further characterize fecal DAPA within-herd variation, samples of individual pellet groups, rather than composited samples, will be collected from free-ranging big game herds and analyzed for DAPA. Sampling error vs. sample size relations will be determined on a monthly basis for each selected herd. It is anticipated that six elk and six mule deer herds will be studied for at least two years.

### OBJECTIVE 3: Test alternative methods for quantifying fecal DAPA.

DAPA will be variously expressed on the basis of fecal dry matter, NDF, ADF, ADL, nitrogen or some combination of these parameters in order to determine the method most suitable for field collected samples. Due to possible effects of weather or site conditions on fecal pellet deterioration, some factor which reflects fecal fiber (non-leachable portion) may be useful in expressing fecal DAPA. For example DAPA/fecal NDF or DAPA/fecal ADF is less susceptible to weathering than DAPA/fecal dry matter. Figures 5 and 6 illustrate the relationship between DAPA vs. % Digestible Energy and DAPA/fecal NDF vs. % Digestible Energy, respectively for control-fed sheep. However, these fecal samples were from a controlled feeding trial and thus, were not subjected to various field conditions.

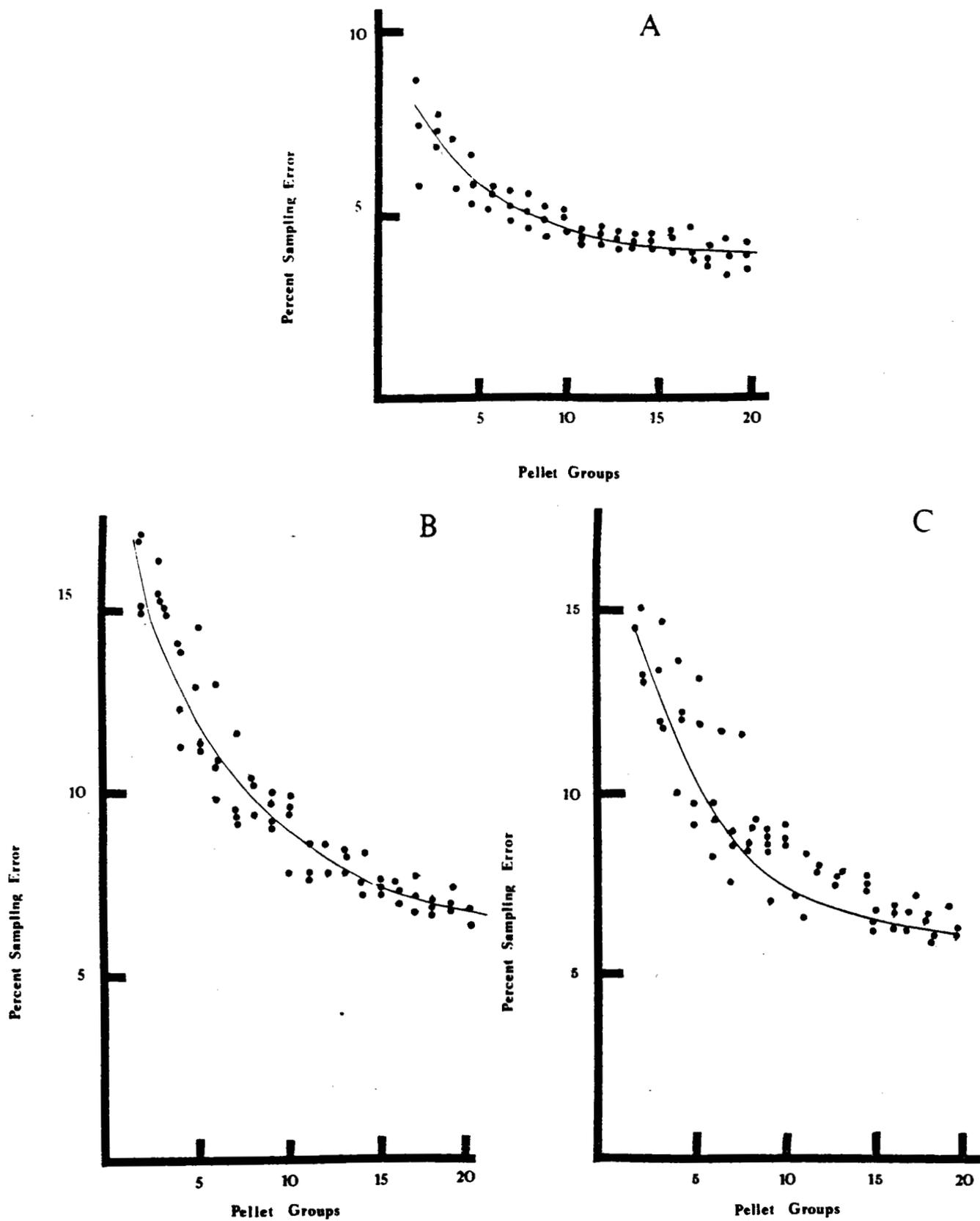
### OBJECTIVE 4: Examine the possibility of "inhibiting" compounds in certain forages effecting DAPA recovery from the ion exchange column.

Diets of big game herds may, within a certain area or portion of the year, contain plant chemical compounds which when in sufficient concentration, may inhibit the ion exchange process of the column. Diets comprised of plants with high levels of "phenolics" will be examined to determine any effect on DAPA recovery. Present purification steps should be adequate to prevent such interferences, but special extraction or purification steps may need to be established if "inhibition" is found to occur using the present procedure.

## CONCLUSIONS

The fecal DAPA technique should be viewed as a potentially valuable index for extensive monitoring of the nutritional well-being of big game herds. The method is rapid, relatively inexpensive, does not require animal disturbance, live-capture or sacrifice, and should prove practical for the big game manager.

The fecal DAPA technique is based on the relationship between DAPA (a unique amino acid residue of rumen bacterial fermentation) and diet quality. DAPA passes unabsorbed through the digestive tract with no measurable loss and passes out in the feces. DAPA exhibits the same



**Figure 4.** Relationship between number of pellet groups sampled and percent sampling error for DAPA estimates, based on 52 individual pellet group samples of the Guadalupe (B) and McGregor (C) mule deer herds (New Mexico) and 25 fecal samples from control-fed domestic sheep (A). Figures B and C were derived from Haussman and Barnett (1983).

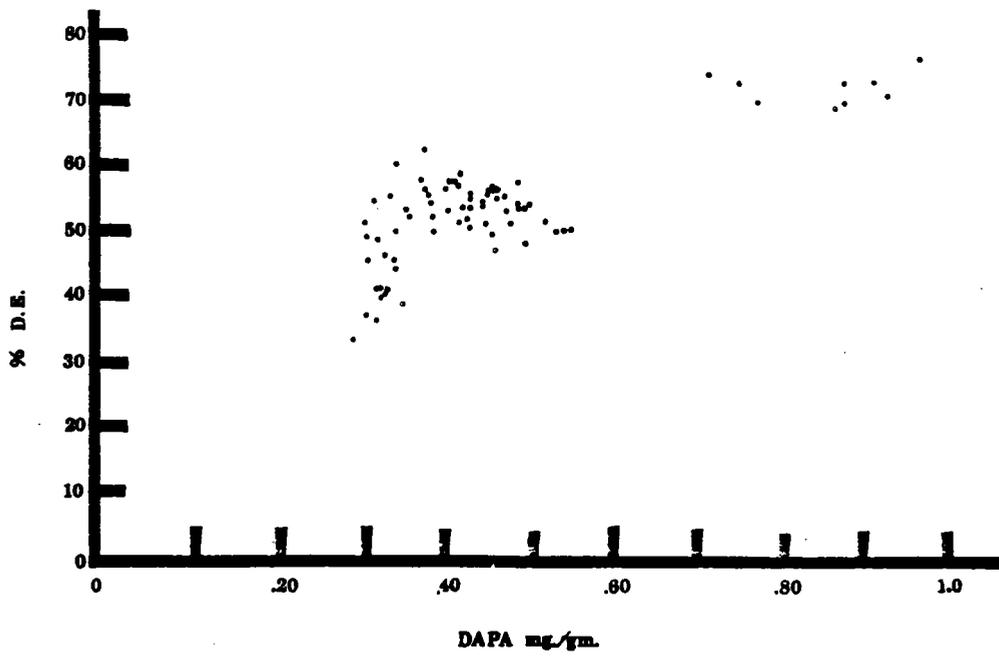


Figure 5. Relationship of DAPA (mg. per gm. fecal dry matter) and Percent Energy Digestibility for control-fed sheep on rations of various levels of nutrient quality.

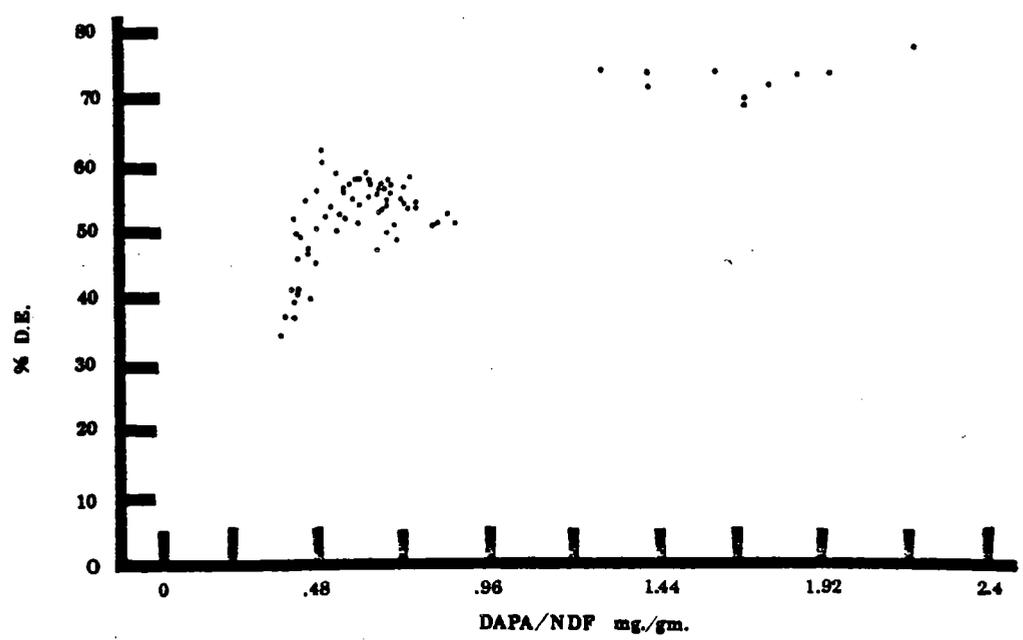


Figure 6. Relationship of DAPA (mg. per gm. fecal NDF) and Percent Energy Digestibility for control-fed sheep on rations of various levels of nutrient quality.

cyclical patterns as shown by seasonal changes in diet nutritional quality (high when diet quality is high and low when diet quality is low).

It is not anticipated that this technology should supplant traditional population monitoring methods, but it could, indeed, be very complementary to them. DAPA profiles for various big game herds in a region might be useful in evaluating: (1) habitat suitability or (2) manipulation effectiveness, (3) interspecific competition on a nutritional basis, and possibly, as an animal criterion in (4) long-term big game range condition and trend studies. With additional data, fecal DAPA patterns might become useful in (5) predicting herd productivity and mortality.

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A REGIONAL COOPERATIVE DAPA RESEARCH AND DEVELOPMENT PROGRAM

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Abstract: Levels of amino acid residue of rumen fermentation (DAPA-diaminopimelic acid) recovered in feces of elk and other large ruminants may be a useful criterion for rapid and inexpensive monitoring of the nutritional well-being of these animals. This residue (DAPA) passes unabsorbed through the digestive process with no measurable loss, and passes out in the feces. Like the seasonal changes in diet digestible energy which it reflects, fecal DAPA follows an annual cycle: low when diet quality is low, such as in winter, and high when diet quality is high, such as early in the forage growing season. Due to the method's simplicity and relative low cost its greatest application may be in extensive monitoring programs for identifying herds with apparent nutritional problems. A cooperative research program has been initiated to coordinate investigations of DAPA's potential in this regard. Objectives include: (1) documentation of relationships between diet energy digestibility and fecal DAPA levels for the major North American wild ruminant species, and (2) development of regional fecal DAPA profiles for these species, using samples submitted by state and provincial cooperators. Recent unpublished results from cooperative state efforts and controlled feeding studies of penned animals are presented and discussed.

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The DAPA method (Nelson et al. 1982, Davitt and Nelson 1984) may be useful in extensively evaluating the nutritional well-being of wild ruminant populations. The method monitors a unique fecal amino acid, 2,6 diaminopimelic acid (DAPA), which is correlated with dietary protein and digestible energy (DE) in domestic sheep (Nelson et al. 1983), and exhibits seasonal patterns (profiles) in mule deer and elk like DE (Nelson et al. 1982, Davitt and Nelson unpublished). DAPA is found in the cell walls of rumen bacteria and eventually in the ruminant's feces, because it is neither digested nor absorbed by the ruminant.

The North American cooperative DAPA research and development project was initiated to coordinate investigations of DAPA as a criterion for monitoring the nutritinal well-being of big game herds. The project was approved for funding by the North American Association of Fish and Wildlife Agencies in September, 1983, and was cooperatively funded by the

U. S. Fish and Wildlife Service and Washington Agricultural Research Centre in March, 1984. Objectives of this project have been to:

1. initiate and coordinate a cooperative research effort to
  - a. document relationships between diet digestible energy and fecal DAPA levels for at least the major North American wild ruminant species through controlled feeding studies.
  - b. develop regional fecal DAPA profiles for these species, using field collected samples submitted by cooperating resource agencies.

Quantity and quality of food is generally considered the principal constraint of big game herd productivity (Connolly 1981, Nelson and Lege 1982) and subsequent harvestability, and much research and management effort has been focused on this subject area. In spite of this, all too frequently we remain ignorant of the animal's nutritional needs. Standards for the nutritional requirements of wild ungulates are as yet only crude approximations drawn heavily from the livestock literature.

Many, including these writers, have accepted available nutritional standards as adequate and have evaluated how well the habitat provides for the protein and energy needs of the animal (e.g., Schommer 1978, Gibbs 1978, Davitt 1979, Hobbs 1979, Hobbs et al. 1981, Baker and Hobbs 1982). Some have proceeded even further by estimating carrying capacity on a nutritional basis (Wallmo et al. 1977, Hobbs et al. 1982). However, this requires accurate determination of food habits and digestible protein and energy, either on a forage species-by-time or diet mixture-by-time basis. All methods for quantifying food habits continue to have serious technical and logistic problems (Medin 1970, Rice 1970, Ward 1970, Wallmo et al. 1973, Bartmann and Carpenter 1982, Nelson and Lege 1982). Even with accurate food habits data, it is necessary to express them in terms of digestible nutrients. This is an expensive procedure, even when using the least expensive methods; vis., food habits determined by fecal analysis with forage samples in diet mixture subject to in vitro digestion of crude protein and gross energy. At best, current methods for evaluating big game food habits on a nutritional basis are expensive and only marginally reliable.

Many biologists favor animal indicators for monitoring the well-being of big game populations because they are more direct than the usual diet quality approach and simpler, with less opportunity for technical errors to bias results and their interpretation. Some of the more commonly used indicators include ovarian analysis and fetal counts (e.g., Robinette et al. 1977), bone marrow color (Cheatum 1949, Hunt 1979, Peterson et al. 1982) or compression (Greer 1968), kidney fat index (Riney 1955), blood urea (Warren et al. 1982), and combinations of indicators (Ransom 1965). Although useful, these indicators evaluate productivity and animal condition after the fact and require the death of the animal. Direct methods for evaluating current nutritional well-being which have been used involve nutrient analysis of the rumen for crude protein (McBee 1964 cited by Moen 1973:312) or volatile fatty acid (VFA) production (Mansfield et

al. 1975). These methods also require the death of the animal, unless a trocar is used on darted and drugged animals.

A unique fecal amino acid, that of undigestible portions of bacterial cell walls, shows strong promise of being closely correlated with diet quality (Nelson et al. 1982). The compound, 2,6 diaminopimelic acid (DAPA), is found in most anaerobic bacteria and blue-green algae but not in higher plants and animals. The ratio of DAPA to total bacterial nitrogen in a mixed rumen bacteria population has been shown to be rather consistent. Because of this, DAPA has been used as a marker for determining nitrogen flow to the lower tract of ruminants (Hogan and Weston 1970, Hutton et al. 1971, Lindsay and Hogan 1972). Once diet nitrogen is combined into DAPA, it passes through the animal undigested and unabsorbed (Hutton et al. 1971). Since at least 80% of a grazing ruminant's digestible energy is derived from bacteria-produced VFA and digested bacterial constituents (Weller 1969) and, since DAPA comprises an indigestible proportion of the bacterial mass, it follows that fecal DAPA could be strongly correlated with diet digestible energy.

DAPA was first isolated from Corynebacterium diphtheriae by Work (1951) and has subsequently been found in cell walls of most rumen bacterial species tested, as well as blue-green algae (Work and Dewey 1953, Synge 1953, Hoare and Work 1957, Purser and Buechler 1966). It has not been found in other algae, fungi, plant viruses, protozoans, and higher plants (Larsen and Norris 1976), except as bacterial contamination (Rhuland 1960, Czerkawski 1974). Theurer (1982) found DAPA levels in protozoa and higher plant material which were too high to be explained by bacterial contamination but might have been due to elution of unknown amino acids with DAPA. All three possible stereoisomers of DAPA have been isolated from bacteria, but the meso- and LL-forms are most prevalent (Hoare and Work 1957).

Following the early efforts of Weller et al. (1958), DAPA has been most commonly used as a criterion for separating bacterial nitrogen from undigested forage residue nitrogen in the upper GI tract (El-Shazly and Hungate 1966, Freitag et al. 1970, Mason 1969, Dufva et al. 1982, Verma and Srivastava 1980). For DAPA to be used to predict rumen bacterial content, concentrations of DAPA in bacteria must be constant or its variation be understood and predictable. Some workers have assumed a constant DAPA-nitrogen in the bacterial nitrogen fraction and Hutton et al. (1971) showed that the DAPA/nitrogen ratio was constant for a constant feeding regime.

Since DAPA concentration in the upper GI tract could be used to estimate average net bacterial biomass growth to about 5% accuracy (El-Shazly and Hungate 1966), subsequent workers have used DAPA concentrations in undigested forage material throughout the GI-tract (including feces) to evaluate diet quality. Freitag et al. (1970) and Virtanen (1966), working with cattle, found significant increases in DAPA concentrations when diet quality was enhanced with urea supplements. Mason (1969) found significant variation in fecal DAPA concentration among sheep fed a variety of forages and supplements. DAPA concentration was not correlated with diet crude protein, however.

Czerkawski (1974) found significant changes in rumen bacterial numbers and types with varying levels of linseed oil supplemented to sheep diets, as well as corresponding changes in rumen DAPA and total nitrogen content. DAPA increased with increased oil supplement to mid-levels, then decreased. He attributed DAPA increases to bacterial mass increases. Above mid-level oil supplementation, Selenomonads and other large bacterial species increased disproportionately, with resulting decreases in DAPA concentration.

Nelson et al. (1982) were first to examine relationships between fecal DAPA and digestible energy (DE) in the diet. Using sheep fed a variety of high quality feeds with concentrates, they showed that fecal DAPA was directly related to diet DE. Additionally, using a DE estimator derived from this sheep study, they found that fecal DAPA might be useful in estimating diet DE for elk and other wild ruminants and suggested that DAPA profiles (fecal DAPA values over time) could be an important tool in monitoring the nutritional well being of free-ranging wild ungulates. They called for cooperative research among the state and federal agencies to investigate this possibility.

#### METHODS

Wildlife nutritionists from the United States and Canada will collaborate in documenting relationships between diet digestible energy and fecal DAPA. Controlled feeding studies of subject species will be carried out in digestion metabolism stalls or other appropriately designed structures in which quantity of feed and water consumed and total feces and urine voided can be monitored. Rations fed should contain varying amounts of natural, high fiber forage of varying quality to simulate as closely as possible diets of free-ranging animals. Consumption levels and forage quality should be closely controlled, but varied. Each treatment should be replicated at least twice.

In a controlled feeding study with domestic sheep, Nelson et al. (1983, unpublished) varied both consumption rate and forage quality. They found that, not only was forage quality reflected in the fecal DAPA levels, but that DAPA levels were also influenced by consumption rate. Highest correlation ( $r = .980$ ) was shown between fecal DAPA level and total daily digestible energy intake (Figure 1).

Further method validation research will be initiated with cattle feeding experiments during the summer of 1984 and with mule deer in the spring of 1985. At present, facilities for the mule deer controlled feeding trial are being constructed. Fawns are being halter-trained to accustom them to confinement in pens and metabolic crates.

Chopped, native forages will be fed ad libitum in mixtures which will simulate mule deer winter diets in central Washington. Diet digestible energy, protein, and fiber fractions will be compared to DAPA and other fecal parameters for each feeding trial.

State game management agencies scattered throughout the ranges of the subject animals will be solicited for their cooperation in this study.

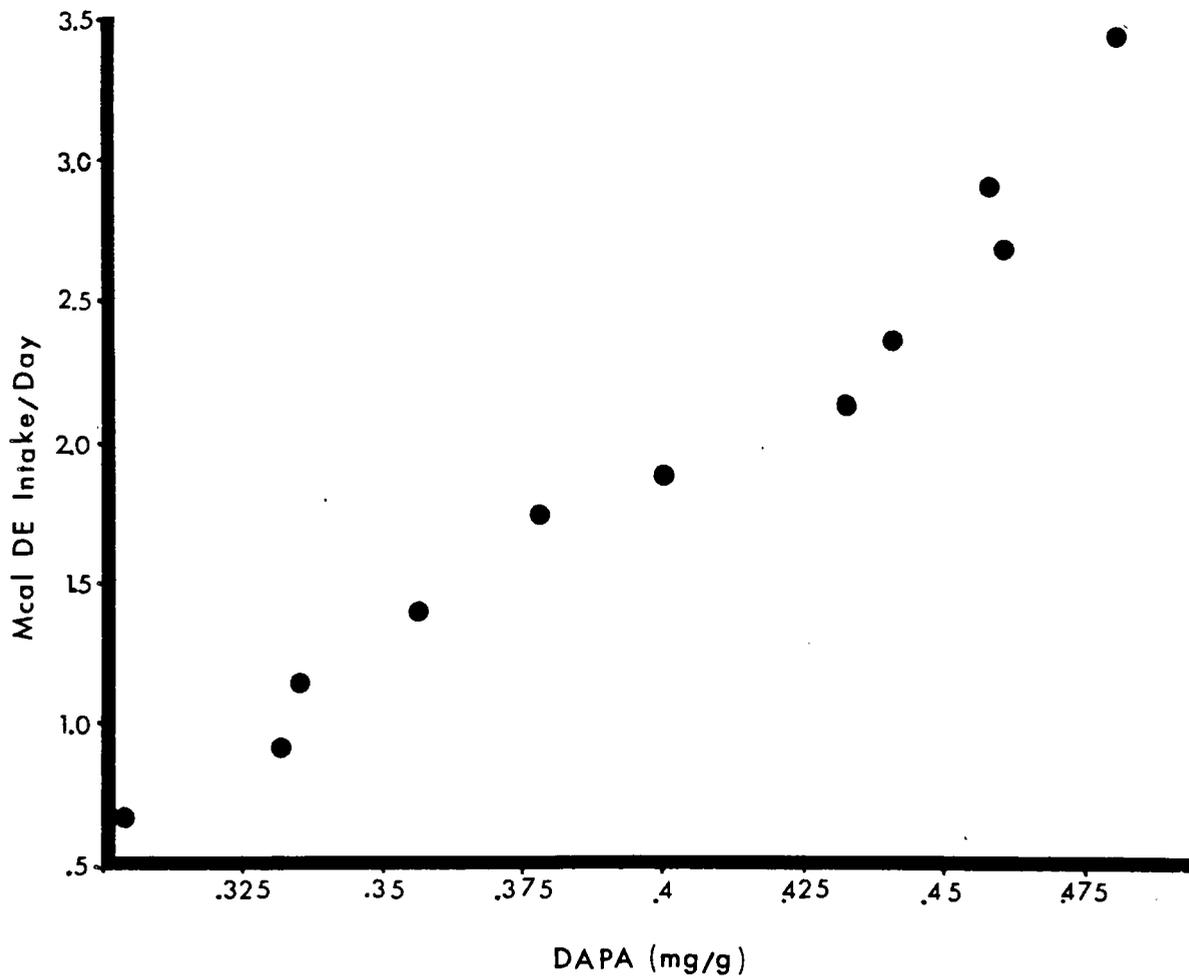


Figure 1. Relationship between digestible energy intake vs. fecal DAPA for sheep. Data from Nelson et al. (1983).

They will be asked to participate for at least three years, the anticipated minimum time needed to sample for variations in amplitude and wavelength expected among annual DAPA profiles for a herd.

Fecal DAPA profiles will be monitored on at least a monthly basis for herds of subject animal species with contrasting nutritional planes. Ideally, paired herds could be selected from within a limited geographic area to minimize variation associated with geographic and climatic differences: one herd which, in the opinion of local specialists, has near optimal nutritional conditions, the other in poor to fair nutritional circumstances. Of course, paired herds will not be required when more than two herds with contrasting nutritional background are selected from the same general area. Herd selection will be entirely up to the discretion of the cooperating agencies.

## RESULTS AND DISCUSSION

Fecal DAPA monitoring has begun for 74 wild ruminant herds, including 12 white-tailed deer herds (on for Columbian whitetail), 18 mule deer herds, 10 black-tailed deer herds, 10 Rocky Mountain elk herds, 8 Roosevelt elk herds, and 6 California bighorn sheep. Others include Tule elk, moose, Stone sheep, pronghorn, barrenground caribou, woodland caribou, Sanbar deer (Guam), and water buffalo (Guam). This effort is being carried out by 35 cooperators in 16 states and Canadian provinces.

To date, a limited number of herds have been monitored for a year or more for fecal DAPA, most of them have been elk herds. Results, however tentative, reinforce our earlier (Nelson et al. 1982) suppositions that herd fecal DAPA levels (1) are cyclic, at least for northern herds, being low in winter when diet quality is expected to be low, and high in late spring and early summer when diet quality is expected to be high; (2) vary in pattern between years, (3) vary among animal species, and (4) vary within species.

Elk. Fecal DAPA patterns have been monitored for 5 elk herds for over a year in Idaho, Washington, and California. The Northwestern herds are Rocky Mountain subspecies, and the California herd is Tule elk. In Washington, the Mt. St. Helens (R. Tabor unpublished) and Yakima (W. Meyers unpublished) herds showed similar DAPA profiles in late 1982 and through 1983 (Figure 2A). DAPA levels remained consistently high from May through August for both herds and were lowest in December. The most obvious difference between habitats of these herds is that the Yakima herd winters at lower elevations where the range is more herbaceous in nature and is free of snow most of the winter. The Yakima herd's better winter range and access to winter feeding facilities may be reflected in their higher winter DAPA levels.

Figure 2B compares the 1982-1983 fecal DAPA profile of a Blue Mountain, Washington, elk herd (W. Meyers unpublished) with that of two composited northern Idaho elk herds (T. Leege unpublished). Both herds summer in mixed-conifer habitat, but the Washington herd winters in open sagebrush/bunchgrass to semi-open ponderosa pine mostly below 2000 feet, while the Idaho herd winters in coniferous forest and seral brush fields

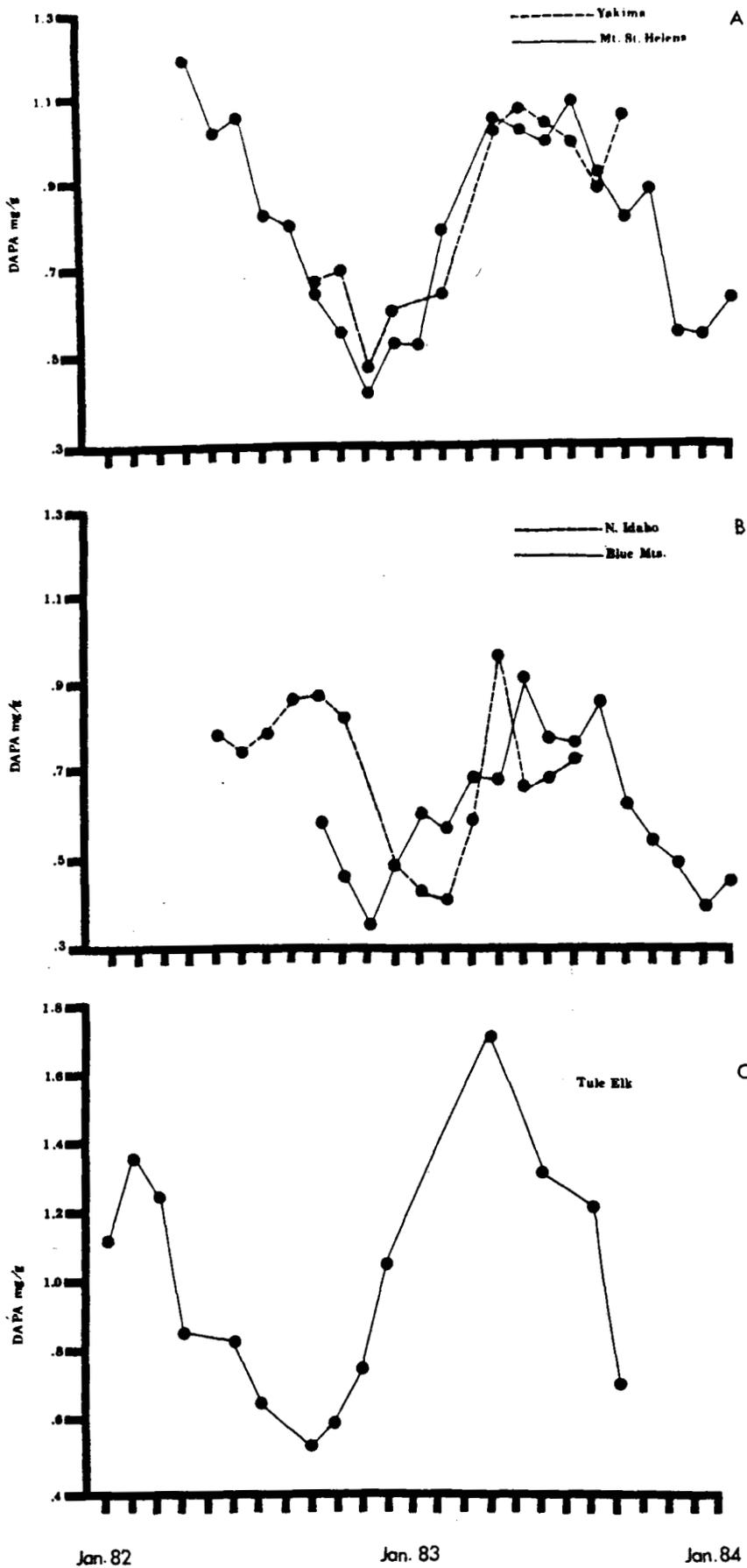


Figure 2. Fecal DAPA profiles for selected Rocky Mountain elk herds in Washington and Idaho as well as Tule elk in California. Unpublished data credits: Blue Mountains and Yakima herds, W. Meyers; Mt. St. Helens herd; R. Tabor; North Idaho herds, T. Leege; Tule elk herds, M. Hanson.

above 3000 feet elevation. Spring greenup and, subsequently, improved forage quality frequently begins in March on the Blue Mountain herd's winter range, but is delayed until May for the Idaho elk. This appears to be reflected in the DAPA profiles for the two herds.

Tule elk (M. Hanson unpublished) in Monterey County, California, have shown the most remarkable, yet not unexpected, DAPA profile for elk (Figure 2C). This small subspecies of elk showed higher DAPA levels than the larger subspecies, ranging from a low of about .6 mg/g to highs of nearly 1.4 mg/g in 1982 and 1.7 mg/g in 1983. These DAPA levels are more similar to white-tailed and mule deer than they are to other subspecies of elk. Lowest DAPA levels were observed in September and October, the end of summer drought in that region; highest were observed in winter and spring, their period of active plant growth.

No Roosevelt elk herds have been monitored long enough to characterize their DAPA profiles. Results of analyses conducted on fecal samples from this species suggest that their DAPA levels will be similar to those of the Rocky Mountain elk.

Mule and Black-tailed Deer. Nearly all cooperators working with these two subspecies initiated field work late in 1983 or in 1984. Consequently only two black-tailed deer herds (Kie and Burton 1984) have been sampled for a full year. These deer largely summer in coniferous forest and migrate down to oak-brush and lower elevational coniferous forest in winter. These workers found distinct monthly variation in both fecal nitrogen and DAPA levels (Figure 3) but no significant DAPA differences between the two herds. Highest DAPA levels were observed in June; lowest occurred in late fall and winter. A secondary DAPA peak was observed in December for both herds, which the authors attributed to acorn consumption. Kie and Burton recommended further study to related seasonal range use and food habits to fecal nitrogen and DAPA.

White-tailed deer. The Florida Game and Fresh Water Fish Commission, beginning in October, 1982, has the longest tenure of cooperation with this project of any of the white-tailed deer cooperators, as well as being the only cooperator with at least one year's field study. Five herds were sampled (F. Smith unpublished), although DAPA analysis is incomplete at this time. DAPA profiles for 1982-1983 for four herds are presented in Figure 4. The Edward Ball and St. Regis herds, located in the Florida Panhandle region, showed lower DAPA levels for spring and summer than the Osceola and Ocala herds which were located in the Central Highlands. The St. Regis herd has historically been the more productive of the two Panhandle herds and showed a higher spring and summer DAPA level. The Highlands herds have shown similar productivity through the years, but the Osceola herd shares its range with 1,650 head of cattle.

Although only winter months were sampled on four white-tailed deer areas in western Montana (C. Seeley unpublished), preliminary data from this study have merit for presentation here, because they demonstrate a different use for fecal DAPA monitoring studies. Seeley sampled fecal DAPA on two areas currently being logged, and two unlogged areas, from December, 1983, to March, 1984, as well as determined monthly white-tailed deer food habits on the same areas, using fecal analysis technique. DAPA

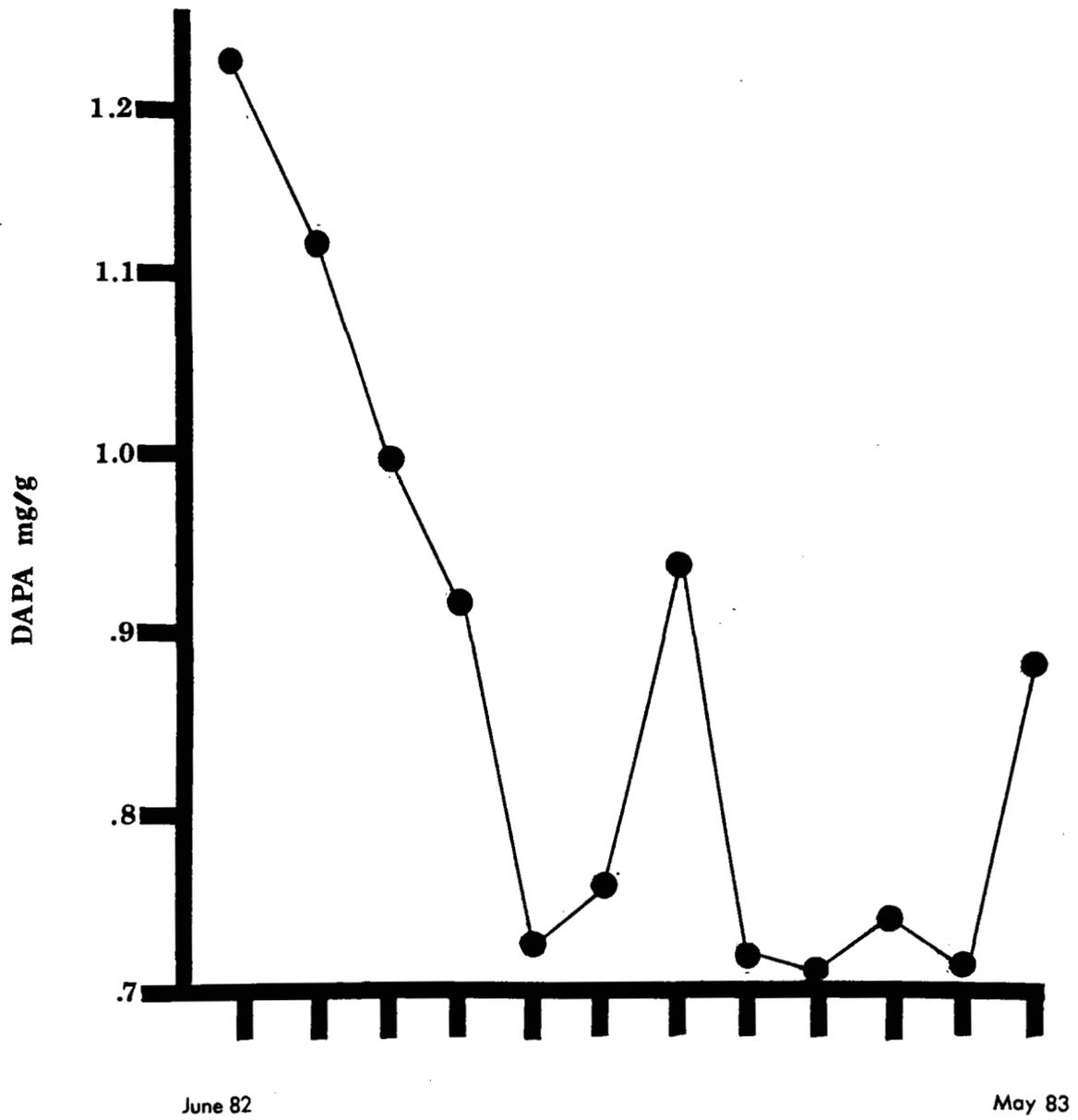


Figure 3. DAPA profile for black-tailed deer from Trinity County, California (Kie 1983).

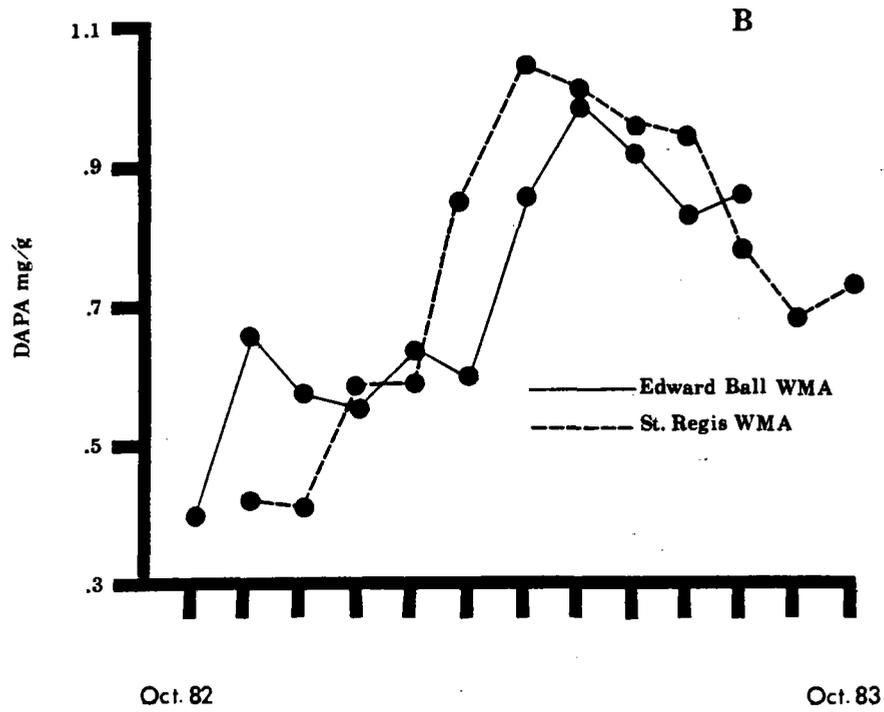
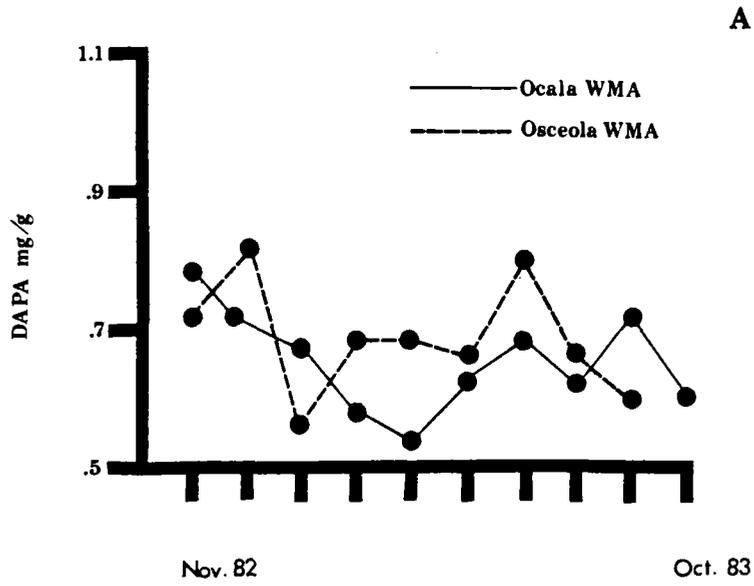


Figure 4. Fecal DAPA profiles for white tailed deer in (B) Northwestern and (A) Central Highland Regions of Florida for the period beginning November, 1982, and ending September, 1983 (F. Smith unpublished.)

content of feces collected on the four areas during the 1983-1984 winter are presented in Figure 5. Deer concentrated in the logged areas, feeding on tops of felled trees. Food habits results showed no significant differences in diet composition between logged and unlogged areas in December and January. Conifer browse, mainly Douglas-fir, comprised 30 to 50 percent of the diets in all areas. Quality of the conifer browse differed, however. Tree-top Douglas-fir browse averaged a full percent higher (6.3 vs. 5.3) in crude protein than that from lower branches. In addition, logged areas afforded earlier spring greenup, and this resulted in greater green herbage consumption in February and March in those areas. Winter DAPA profiles for the four areas reflect the expected diet quality differences.

Desert Bighorn Sheep. G. Miller (unpublished) compared bighorn food habits, forage quality, and various other habitat evaluation parameters for three bighorn populations in Arizona, as well as monitored fecal DAPA. Range area size, forage composition, and water availability were similar for the three areas. The Dome Rocks herd, having the lowest population and occupying what Miller felt was the poorest range area, showed the lowest DAPA profile (Figure 6). Of the two remaining herds, North Plomosa has been generally larger than the New Water Herd, 125-200 vs. 80-150 sheep. The New Water herd consistently showed higher fecal DAPA through the 1982-1983 sampling period than the North Plomosa herd. Herd productivity statistics for 1983-1984 have not yet been made available.

#### CONCLUSIONS

Fecal DAPA follows an annual cycle, reflecting the seasonal change in diet digestible energy: low when diet quality is low and high when diet quality is higher. Due to the methods simplicity and relative low cost, the greatest application of DAPA analysis may be in extensive monitoring programs for identifying big game herds with apparent nutritional problems.

Efforts will continue to collaborate with other researchers which have initiated DAPA method validation research (feeding trials), and to seek to enlarge the number of big game species being studied. Feeding trials using mule deer will be conducted by these authors to document the relationship between DAPA and diet digestible energy, protein and fiber fraction.

Currently, fecal DAPA monitoring has begun for 74 wild ruminant herds being carried out by 35 cooperators in 16 states and Canadian provinces. New cooperators are anticipated and encouraged to join these cooperative research efforts. Although only a limited number of herds have been monitored for a complete year to date, results reinforce earlier suppositions that herd fecal DAPA levels (1) appear cyclic, (2) may vary in pattern between years (plant phenology, climatic conditions), (3) may vary among animal species, and (4) may vary within species.

Ongoing studies include determining the effects of weathering, storage, and handling on DAPA levels in selected wild ruminant fecal samples; to evaluate pellet group DAPA variability to optimize sampling

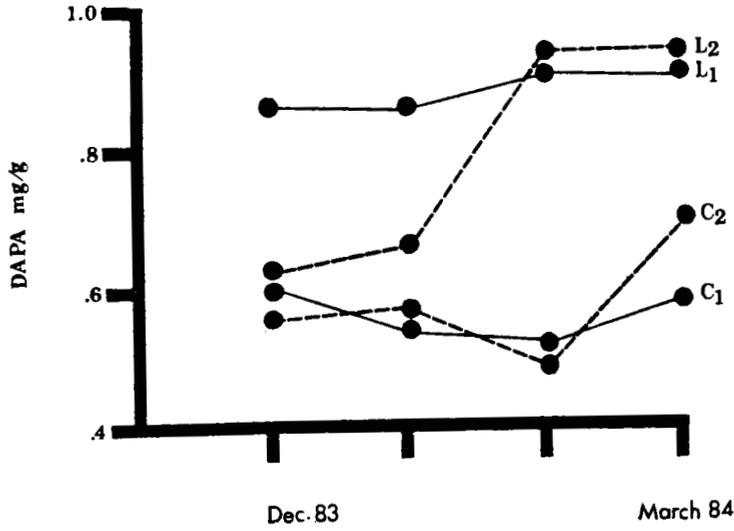


Figure 5. Fecal DAPA profiles for wintering white-tailed deer on two areas currently being logged (L) and two unlogged control (C) areas in western Montana (Seeley unpublished).

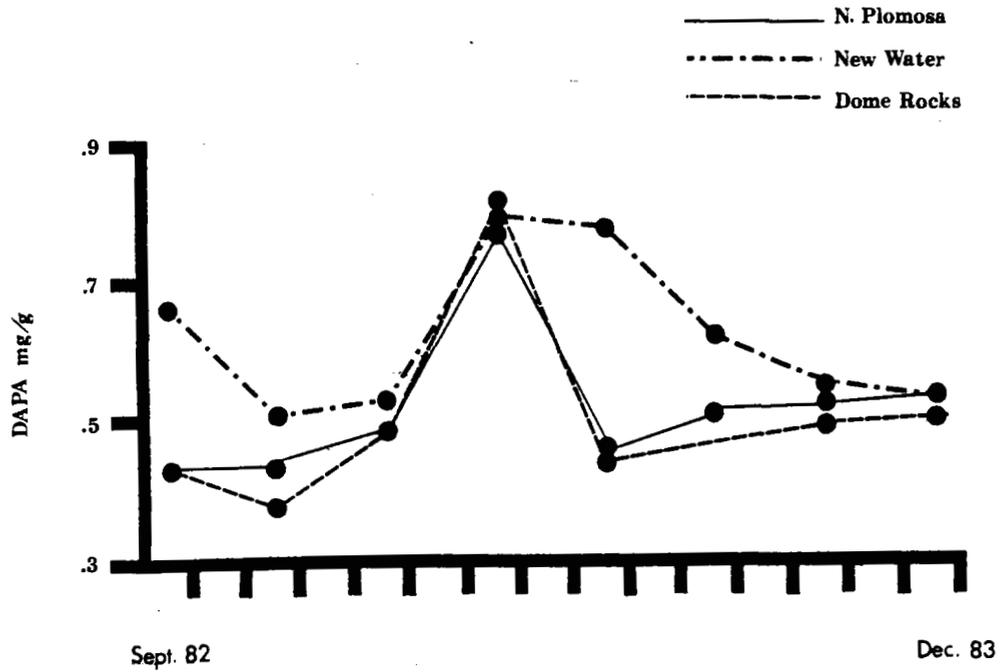


Figure 6. Fecal DAPA profiles for three desert bighorn sheep herds in Arizona (G. Miller unpublished).

intensity for major big game species; and to test alternative methods for quantifying fecal DAPA (Davitt and Nelson 1984).

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## ARTIFICIAL BREEDING OF CAPTIVE WAPITI

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### INTRODUCTION

Interest in the artificial breeding of captive wapiti and red deer (*Cervus elaphus*) has stemmed from three different viewpoints. In the first, semen was collected, evaluated, frozen and used for the insemination as a scientific exercise (Krzywinski & Jaczewski 1978). The second has arisen from the interest of New Zealand deer farmers in the use of semen from Canadian wapiti in the breeding programs of farmed deer. This was especially intended for the upgrading of their wapiti type animals. These animals have emerged over the last 70 years from the interbreeding of a small number of wapiti introduced from the U.S.A. in 1908 and red deer introduced over many years. The third has been the fairly recent enlightened interest among members of the zoo community in the breeding of captive species without further depletion of wild resources. As the gene pool of many species in captivity is small, and the risks and cost of moving animals from one zoo to another may be great, it has been recognized that artificial breeding offers a genuine alternative as a means of captive propagation. Limited success has been reported in these efforts (Haigh, in press). Although wapiti and red deer cannot be classed as endangered, it may be that information acquired while studying them will be applicable to other species.

### SEMEN COLLECTION

Semen has been collected both by the use of an artificial vagina (A.V.) (Krzywinski & Jaczewski 1978) and by electroejaculation (E-E) (Jaczewski & Jasiorowski 1974; Haigh, Glover, Cates and Rawlings 1984).

Both methods have advantages and disadvantages relative to one another. Collection by A.V. involves the use of either very tame (halter trained) females, or the use of dummies sprayed with estrous urine to simulate the female in estrus. In either case, a specially designed A.V. is used (Krzywinski 1976). One of 4 stags in the Polish studies could not be collected by this method due to excessive aggressiveness (Krzywinski 1976).

Although no estrous female is required to collect stags or bulls by E-E, not all wapiti bulls can be satisfactorily collected by this method without resorting to immobilization. Immobilization offers an alternative for the occasional collection of semen from a given individual, and has been widely used in zoos for semen collection of many different species (Seager et al. 1980); however, it is not a suitable method for the long term collection of semen due to its disruptive nature. Two of 12 animals

studied in our tests proved to be impossible to handle in chutes and could not be trained for E-E.

A disadvantage of E-E, no doubt due to the non-physiological nature of the method, is that occasionally one fails to collect a good quality semen sample from a bull wapiti even in the midst of the rut. A subsequent collection within a few minutes, or the following day, may yield a satisfactory sample.

For wapiti, the E-E method offers a reasonably reliable and safe method of collection for both the animal and the handler, provided that the chute facilities are of an adequate standard of design and construction.

It is likely that semen will have to be collected in adverse weather conditions (by whatever method) and means must be devised to protect the semen from thermal shock (Krzywinski & Jaczewski 1976; Haigh 1982).

Semen quality reaches a peak in the late summer or early autumn, just before the onset of the rut. The quality remains high for about six months, although there are variations from one collection to another. In the northern hemisphere, no sperm are present in ejaculates from about mid-April until mid-July (Fig. 1).

#### SEMEN EVALUATION

Evaluation of semen at the time of collection is based on colour and motility. Semen smears are also stained with a vital stain at this time. They can subsequently be used for the examination of sperm morphology and an estimation of the proportion of live sperm in the ejaculate.

Colour of an ejaculate is graded according to its relationship with the colour of milk. This provides only a crude estimate of the density of the sample. A more accurate estimate of ejaculate density is made in the laboratory with a hemocytometer.

In cattle, it is considered that semen collected by A.V. is denser, but of a lesser volume than that collected by E-E (Ball 1980). Comparison of the data from red deer and our own data shows that this may not be the case with Cervus. The difference between the two methods may lie in the proportion of samples that are of poor quality with E-E. Densities of samples collected by both methods fluctuated widely. The most dense of the red deer semen samples contained 3.95 billion cells/ml (Krzywinski & Jaczewski 1978). The densest wapiti sample contained 5.61 billion cells/ml. The single most important indicator of the potential of the ejaculate as a candidate for use in A.I., especially for freezing, is its initial motility. Standards are based on those described by the Society for Theriogenology (Ball 1976). Samples with very vigorous, swirling motion, containing rapidly forming and vanishing dark eddies are classed as "very good". Samples classed as "good" exhibit less vigorous swirls, with some eddies. Samples exhibiting some degree of wave motion with no eddies and obvious individual motility of sperm are classed as "fair". In "poor" samples, there is no evidence of wave motion; movement of individual sperm

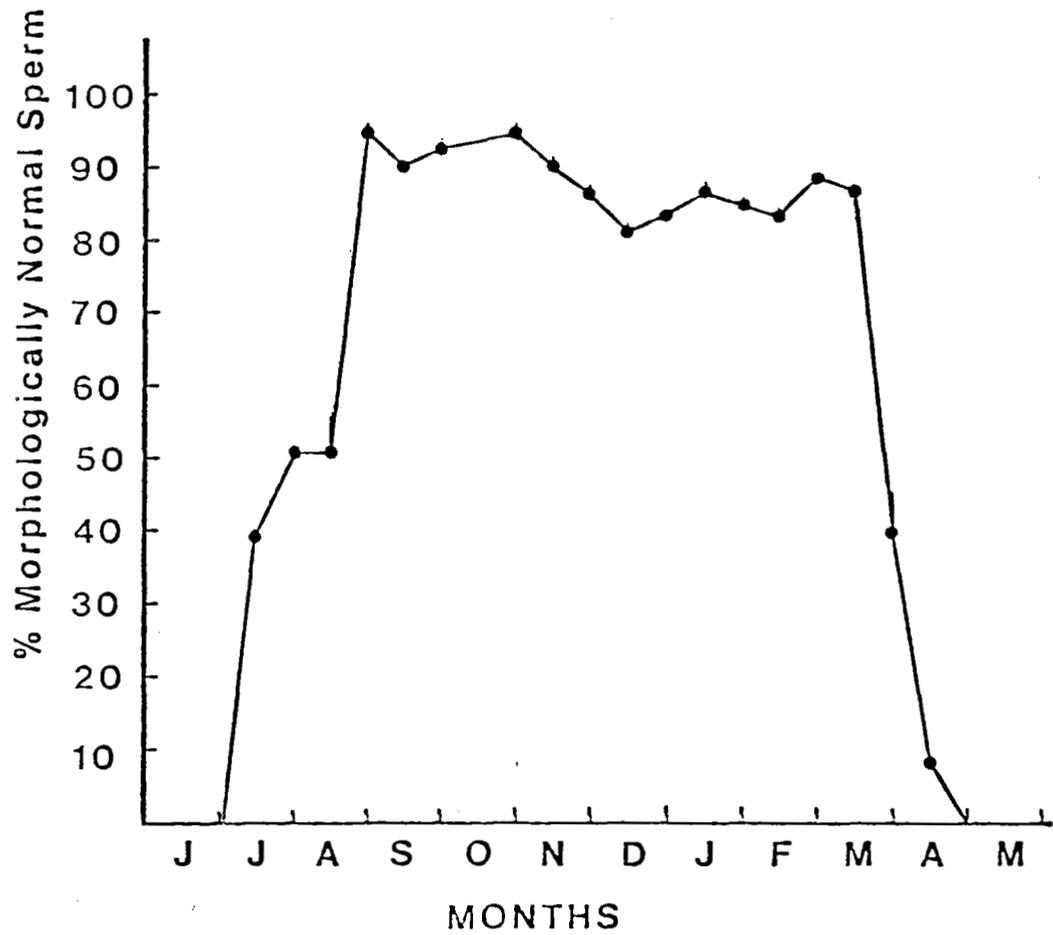


Figure 1. Percentage of morphologically normal sperm in ejaculates of wapiti (*C. elaphus*) in the northern hemisphere over a calendar year. (From Haigh 1982.)

can be seen, but they are making very little forward progress. When no motility of sperm is evident, samples are classed as "nil".

Fig. 2 illustrates the distribution of nine categories of ejaculate motility over two periods of one collecting season. The first period (1st September to 12th November) corresponds to the period when most breeding occurs in the wild. The second period (26th November to 30th April) follows the first and continues up until the time that sperm could no longer be found in ejaculates. The proportions of the various categories are similar which indicates that when collections are made twice a month, semen with good motility can be collected for over six months consecutively.

There are differences among bulls in their ability to produce good quality semen when electro-ejaculated. Sixty and one-half percent of 233 ejaculates collected from 8 wapiti bulls between 1st September and 1st March during 3 consecutive years were judged to have initial motility that was good or better (Haigh unpubl.).

We have initiated the semen extension process only in those ejaculates which were judged to be of the colour of milk, or thicker, and have had an initial motility rated good or better.

Examination of semen morphology is an essential step in ejaculate evaluation. In wapiti bulls of 3 years of age and older, the greatest percentage of morphologically normal sperm are present in ejaculates collected between 1st September and 15th March (Fig. 1) (Haigh 1982). One bull in our study group consistently produced semen with a high proportion of defective sperm.

An important step in the evaluation process is the estimation of the percentage of individually motile sperm and their rate of progression. This is carried out on extended semen prior to initiation of the freezing process. The rate of progression scale is defined as follows: 0 = no sperm movement, 1 = slight tail undulation without forward motion, 2 = slow tail undulation with slow, or stop and start, forward motion, 3 = forward progression at a moderate speed, 4 = rapid forward progression, 5 = rapid progression in which cells are difficult to follow visually.

Semen extenders for wapiti and red deer that have been successfully tested are yolk-citrate, with or without fructose, and skimmed milk. Glycerol has been used as the cryoprotectant. The process for extension in our laboratory has closely resembled that for bull semen.

Our criteria for extension and freezing of wapiti ejaculates are as follows:

- minimum density,  $0.5 \times 10^9$  cells/ml.
- minimum percent normal sperm 80%
- minimum individual motility 80%
- minimum rate of progression 3

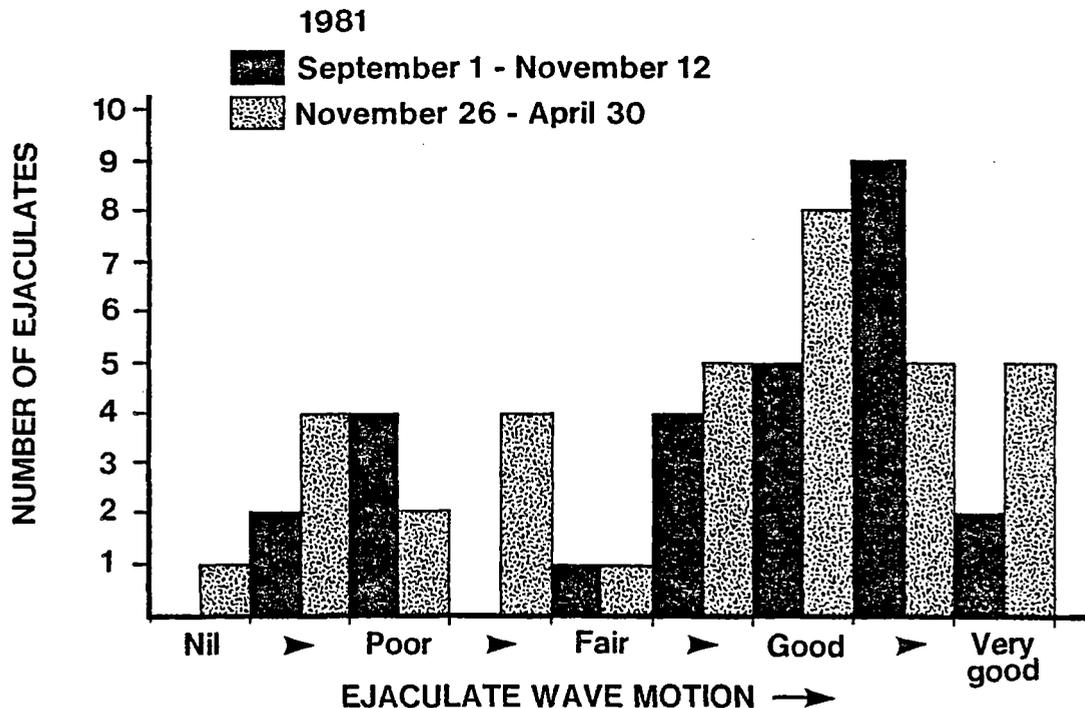


Figure 2. Distribution of ratings of ejaculate wave motion of ejaculates collected twice monthly for 8 months from wapiti bulls. The period was divided into that covering maximum breeding activity (Sept. 1 - Nov. 12) and the rest of the period when rutting had ceased. (From Haigh, Barth, Cates, and Glover 1984.)

We have extended semen to 20-30 million live normal sperm per dose before freezing with the intent to provide at least 10 million live sperm after thaw. Similar figures were used in Polish studies (Kryzwinski & Jaczewski 1978). Our figure was empirically based upon the normal figures for cattle and the limited successes that were achieved with initial attempts at A.I.

Wapiti/red deer semen has been frozen either in pellets on dry ice which were then transferred to liquid nitrogen (Kryzwinski & Jaczewski 1978), or in liquid nitrogen vapor using 0.5 ml straws (Haigh, Barth, Cates, and Glover 1984). The latter method has considerable advantages, especially in regards to the subsequent identification of the specimen.

Evaluation after thawing involves examination of the semen for motility and the percentage of intact acrosomes. Samples are rated "satisfactory", "questionable" or "unsatisfactory". The tests are conducted as soon as the semen has been thawed and after a two hour incubation of the semen at 37°C. Minimum standards for a satisfactory rating as established by our laboratory were:

Minimum motile cells/dose 10 million (time 0)

TIME 0        25% motility (rate of progression 3/5)  
                 50% intact acrosomes

TIME 2 HR.    15% motility (2/5)  
                 35% intact acrosomes

We have frozen semen between 15th September and 15th December for 3 years. Of the 59 ejaculates frozen, 32 (56%) were rated good or better.

### The Estrous Cycle

Female red deer and wapiti are, like the males, seasonal breeders; they come into estrus at the time of the rut, and if not bred, will continue to cycle for almost six months. In red deer, the cycle is about 18 days in length (Guinness et al. 1971; Kelly et al. 1984). In wapiti, the cycle is slightly longer, about 20 days (Glover 1984).

The hormonal events of the estrous cycle of these sub-species have recently been reported. It has been found that progesterone is not always low on the day of estrus, and that estrogen levels are from four-to-ten fold higher than those of other polyestrous ungulates (Kelly et al. 1984, Glover 1984).

If the females are to be artificially bred, either a close watch must be kept on them so that insemination is carried out at estrus, or the cycle must be synchronised with one of two types of hormone treatment regime.

Polish workers used observation and mating at natural estrus and achieved 3 pregnancies in 12 hinds (Krzywinski & Jaczewski 1978). The same method was tried in New Zealand with two hinds of 20 becoming pregnant (Kelly & Moore 1981).

Estrus synchronisation involves either the use of progestogens or prostaglandins.

Progestogens have been administered by subcutaneous or intravaginal implant. They block ovulation and suppress estrus. They are administered for a period of time sufficient to allow for natural regression of the corpus luteum (CL). After progestogen withdrawal, follicular development resumes followed by synchronised estrus and ovulation.

There is little information on the use of either type of implant in wapiti or red deer. In one small trial conducted in our laboratory, results were inconclusive, and these materials need further testing (Glover 1984). The use of intravaginal devices has not proved entirely satisfactory because a proportion of them are removed by the females, apparently by pulling the string attached to the device. Even in cases where the string has been cut off, either close to the vulval lips or deeper in the vagina they have sometimes not been retained. Certain types were retained better than others. In a trial conducted in New Zealand,

the use of intravaginal devices successfully synchronised estrus in 9 of 11 wapiti type females (Sanderson pers.comm.). It was determined by rectal palpation that ovulation occurred between 48 and 72 hours after removal of the devices in 7 of the 11. In 2 other cases, estrus occurred after 72 hours. It was not possible to be sure how many of them conceived to A.I. as they were joined with a bull the day after insemination.

Estrous synchronisation has been attempted in wapiti using the synthetic prostaglandins (PG). A 500 mg dose of "Estrumate" (ICI, Mississauga, Ontario) was luteolytic after the 8th day of the estrous cycle. Only transient declines in serum progesterone concentrations were recorded if the PG was administered 8 days or less after ovulation (Glover 1984). In a trial carried out on commercial deer farms in New Zealand, 39 cows on 10 farms were synchronised using a regime of two injections of "Synchrocept B" (Syntex Labs, NZ.) 13 days apart. Inseminations were carried out at 48, 72 and 96 hours after the second PG injection. Sixteen cows (41%) subsequently delivered calves (Haigh, Shadbolt, & Glover 1984).

It is possible that pregnancy rates could be improved upon if inseminations were conducted when wapiti were observed to be in estrus. Success rates in domestic cattle (Bos taurus) have been reported to range from 33 to 69 percent when timed inseminations were used (Donaldson 1980; Young & Henderson 1981; King et al. 1983), however, it has been shown that timed inseminations were less successful than those done after observation of estrus (Manns 1983).

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GAME FARMING FEDERAL AND PROVINCIAL LAWS: MANITOBA

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(Author unable to attend.)

In Manitoba, there are no specific regulations for game farms. They are regulated through the provisions of the Manitoba Wildlife Act. The applicable sections are:

**Possession of live wild animals**

Section 45 'Except as may be otherwise permitted by this Act or the regulations, no person shall capture alive, or have possession of any live wild animal.'

**Property in live wildlife**

Section 86(2) 'Subject to this Act and the regulations, where a person has possession of any wildlife that is live under a licence or permit that authorizes him to keep the wildlife, he has all property, rights, title and interest in and to the wildlife, and he continues to have the property, rights, title and interest as long as he complies with the provisions of this Act and the regulations.'

**Disposal of live wildlife**

Section 87(2) 'The minister may dispose of any live wildlife in captivity that is the property of the Crown, by selling, donating, killing and destroying the wildlife or setting it free'.

And finally,

**Regulations by Minister**

Section 90 'For the purpose of carrying out the provisions of this Act according to their intent, the minister may make such regulations as are ancillary thereto and are not inconsistent therewith and every regulation made under and in accordance with the authority granted by this section has the force of law; and without restricting the generality of the foregoing, the minister may make such regulations, not consistent with any other provision of this Act, (gg) regulating the sale of wild animals raised and

kept in captivity on wildlife farms, or brought into the province to stock wildlife farms or private shooting preserves, or brought into the province for sale in restaurants or food stores;

(hh) respecting the licencing of, and regulating the operations of, shooting preserves and wildlife farms, and regulating the keeping, raising and propogation of wild animals therein or thereon, and the taking of wild animals therein or thereon;'

#### PRESENT DEPARTMENTAL GUIDELINES

#### FOR GAME FARMS AND HOLDING WILDLIFE IN CAPTIVITY

This permit is issued subject to the following terms and conditions.

1. A certified veterinarian must be in attendance during the handling of wildlife.
2. All drugs given to wildlife must be administered by a certified veterinarian.
3. Wildlife killed or injured must be reported to the Dept. of Natural Resources of the Province of Manitoba (hereinafter referred to as "Natural Resources") within 24 hours.
4. This permit may be suspended following investigation of the cause of death of any wildlife.
5. Wildlife must be treated humanely and in accordance with the standards set out in 'Ethics of Animal Experimentation', Canada Council on Animal Care, a copy of which is attached hereto.
6. Wildlife transported must be securely contained in a manner that will protect the public and the wildlife from injury.
7. A Conservation Officer or a certified veterinarian must be available during the time any wildlife are loaded and unloaded from any vehicle.
8. The operator shall cooperate with Natural Resources so that the department can effectively assess and evaluate all matters related to wildlife under the terms of this permit.
9. The operator shall not sell any wildlife or its progeny without the prior written permission of the Minister.

10. The wildlife and its progeny shall not be used for hunting purposes, for meat or exploited for exotic products such as antler velvet.
11. The wildlife or its progeny shall not be exported from Manitoba unless a separate export permit specifically authorizing such export is issued.
12. The operator shall annually provide Natural Resources with a written report on the status of the wildlife.
13. The operator shall be solely responsible for the protection, care and maintenance of the wildlife and their progeny, as long as they are legally in his possession.
14. The operator shall maintain public liability insurance in an amount not less than one million dollars protecting himself from liability for any injury or death or loss or damage to property, due to or arising out of the possession of the wildlife under the terms hereof.
15. The staff of Natural Resources shall have the right of access to the game farm at all times.
16. The operator shall have wildlife and their progeny, marked with a visible ear tag and tattoo as soon as is deemed reasonable in consultation with the Wildlife Branch.
17. A pedigree stock record book shall be maintained by the operator.
18. This permit may be cancelled by the Minister or a person designated by him, at any time, by notice in writing either given to the operator or mailed to him by registered mail. If the permit is cancelled then the operator shall forthwith give up possession of the wildlife and their progeny and turn those animals over to the staff of Natural Resources. He shall cooperate with the staff of Natural Resources so that the transfer of possession of the animals is carried out as expeditiously as possible without risk to the animals or the public.

If the operator refuses to give up possession of the wildlife, then Natural Resources or its agents shall have the right at any time to enter upon any lands or premises where the wildlife is kept and may break and force open any locks, bars, bolts, fastenings, hinges, gates, fences or enclosures for the purpose of taking possession of and removing the wildlife.

19. This permit shall not be assigned.
20. In accordance with Subsection 86(2) of the Wildlife Act, during the term of this permit, the operator shall have all property, rights, title and interest in the wildlife and its progeny in his possession and shall be solely responsible for them. However, such property, rights, title and interest shall terminate upon the cancellation of this permit.

XYLAZINE IMMOBILIZATION OF WAPITI: ANTAGONISM WITH YOHIMBINE AND 4-AMINOPYRIDINE

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Abstract: Trials were conducted to assess the effectiveness of yohimbine and 4-aminopyridine as an antagonist for xylazine sedation in wapiti. Treatments consisted of xylazine immobilization followed by unantagonized recovery, and xylazine immobilization followed by antagonist administration. Eight wapiti were paired according to sex, age, weight and behavior. Each animal was randomly assigned a treatment order according to a modified latin square design (treatment x sex). Treatments were generally separated by a 6-7 day interval.

Tame and tractable cows were immobilized by hand syringe injections of 0.65 mg/kg of body weight of xylazine (IM). Wild, free-ranging bulls required dosages of up to 2.18 mg/kg of xylazine, administered intramuscularly by a Cap-Chur gun, for effective immobilization. Xylazine-immobilized wapiti were sternally recumbant for periods ranging from 178 to 265 minutes. Generally, short induction times and prolonged immobilization were observed among the more tractable animals.

In antagonist treatments, xylazine-sedated wapiti were given concurrent intravenous injections of 0.15 mg/kg of yohimbine and 0.30 mg/kg of 4-aminopyridine. Wapiti receiving reversal drugs were standing and ambulatory within 1.9 to 47 minutes from antagonist injection. Walking times differed significantly between treatments ( $P < 0.005$ ), and four of the eight animals were walking within 3 minutes of antagonist injection.

No mortality or complications resulted from the trials. Relapses to profound xylazine sedation did not occur. The yohimbine-4-aminopyridine combination appears to be a safe and effective antagonist of xylazine in wapiti.

## VISIBILITY BIAS IN AERIAL SURVEYS

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Abstract: The management of animal resources requires information on important population parameters, such as density, age ratios, sex ratios, and their changes over time. Aerial surveys are probably the most widely used means of estimating these population parameters for North American ungulates. However, available evidence indicates that aerial surveys provide underestimates of animal density.

In order to improve aerial survey estimates, it is necessary to determine the number of animals missed during surveys. The failure to observe all animals is called visibility bias and is generally held to be a major cause of inaccuracies in aerial surveys. The magnitude of visibility bias depends upon numerous variables, including animal behavior and dispersion, observers, weather, vegetation cover types, and equipment.

Radio-collared elk in north Idaho have been used to assess the importance of a variety of factors in determining visibility bias. A non-linear regression approach was used to evaluate these factors and to assess their impact on sightability. Preliminary results showed that group size had a major influence on the sightability of elk during winter surveys. Vegetation cover and animal behavior also have significant influences. The estimated sightability function for group size was used to predict corrected population size with confidence intervals and corrected age and sex ratio estimates. Survey counts averaged 85% (range 80-91%) of the corrected counts over a 9 year period for an open vegetation type. Observed bull-cow ratios were consistently below their respective corrected ratios. Observed calf-cow ratios were usually above the corrected ratios.

PRECISION OF AGE AND SEX RATIOS: A CLUSTER SAMPLING APPROACH

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Abstract: Herd classification counts have become a routine part of ungulate management and research projects. The objective of such counts is to determine population proportions, age ratios and sex ratios. These data are used as indicators of reproductive success and population recruitment or to set and evaluate harvest strategies.

The usual procedure in sampling is to classify as many animals as possible in order to improve the precision (or reliability) of the observed ratios. Since these ratios involve variation in both the numerator and denominator, appropriate procedures for calculating variance and confidence limits are not straightforward. Previous studies have emphasized two sampling plans for estimating ratio variances. The area method divides the study site into quadrats which are randomly sampled. Classified animals within each quadrat are assumed to be true estimates and the variance is calculated between quadrats. A second, more popular method, surveys the entire area and treats individual animals as the sampling unit. This approach assumes that individuals are independently and randomly sampled from the population.

We propose an alternative approach which is known in the statistics literature as cluster sampling. Applied to wildlife surveys, cluster sampling treats groups of animals as the sampling unit. This approach assumes that groups are independently and randomly sampled from the population. Treatment of individuals is shown to be a special case of cluster sampling applicable only under limited conditions. These conditions occur when groups consist of a single animal or when groups are both of constant size and homogeneous with respect to the ratio being estimated. The precision of simple random sampling estimates will be biased for most wildlife surveys. Cluster sampling produces reliable estimates of precision. Comparison of the methods are made using ground surveys of deer and aerial surveys of elk.

A complementary approach to achieve improved reliability is to conduct repeated, but independent surveys of the population. This procedure has been advocated for mark-recapture surveys and may also be extended to classification surveys. The ratio estimate is simply the ratio of the total of animals classified during all surveys. Weighted variance estimates may be used to pool the variances from the individual surveys. These pooled estimates will generally reduce the variance by the square root of the number of surveys conducted. Repeated surveys of deer indicate that pooling may have a substantial influence on the reliability of fawn-doe and buck-doe ratios.

Because animals are typically found in groups that are likely to be relatively homogeneous and variable in size, the notion that single animals are randomly and independently sampled is fallacious. As a result, the determination of reliability of ratio estimates using a simple random sampling approach will give biased results. In many cases, it appears that our judgements on the precision of the relative abundance of age and sex classes may be grossly overstated. This mis-estimation of reliability applies to management decisions and research evaluations. In addition, the estimation of abundance via techniques such as the change in ratio method will be biased if simple random sampling is used. In the usual situation, where animals naturally congregate, the application of cluster sampling should provide more realistic estimates of our knowledge of the relative population abundance from herd composition surveys.

## SCABIES AND ELK MORTALITIES ON THE NATIONAL ELK REFUGE, WYOMING

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**Abstract:** During winter 1982-83, mortalities from the Jackson Hole elk herd, wintering on the National Elk Refuge, were located and biological data regarding age, sex and condition were recorded. A total of 170 mortalities occurred: 101 (59.4%) adult bulls, six (3.5%) spike bulls, 29 (17.1%) cows, 29 (17.1%) calves and five (2.9%) antlerless (either cows or calves). The percent of adult bulls among the mortalities was significantly ( $P < 0.001$ ) greater than their percent composition (19%) of the winter herd. The mean age of male mortalities (excluding calves) was 7.35 years ( $N=89$ ). The mean age of female mortalities (excluding calves) was 11.86 years ( $N=22$ ). At least 63 of the adult bull mortalities during winter 1982-83 showed clinical signs of scabies or psorotic mange. The presence or absence of scabies could not be confirmed in another 32 carcasses because little or no hide remained. Two old ( $\bar{x}=16.0$  years) adult cow mortalities had scabies but scabies was not evident on calf or spike mortalities. The incidence of scabies, evidenced by alopecia, during winter 1983-84 was 27.8% of adult bulls, 9.6% of spikes, 33.3% of cows, and 1.0% of calves. The percent of bulls among total winter mortalities is significantly correlated ( $P < 0.05$ ) with the percent of bulls in the winter herd over the past 15 years. A herd reduction program, initiated in 1977, increased the overall bull:cow ratio of the Refuge herd. Field observations indicate that the high bull:cow ratio is unique to the herd segment that summers in Grant Teton National Park. The rising bull:cow ratio may have predisposed more bulls to scabies as a result of debilitation during the rut.

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### INTRODUCTION

The purpose of this study was to determine age and sex of winter elk mortalities on the National Elk Refuge (NER), Wyoming, and the incidence of scabies, psorotic mange, among mortalities. Winter losses are an expected occurrence among ungulates of northern latitudes in the United States and Canada, and in fact, were instrumental in the creation of the NER (Wilbrecht and Robbins 1978). Although winter losses can escalate in severe winters, their contribution to annual losses among hunted populations of elk existing on sufficient habitat, is usually far less than the hunter harvest.

In situations where available winter range has been reduced due to usurpation by man, as is the case of the Jackson Hole elk herd, winter feeding of elk has dampened the effects of adverse winter conditions on natural mortality rate (Murie 1951, Anderson 1958). Winter mortality on the NER during the past 45 years has averaged about 2% of the wintering herd, although an effort was not generally made prior to 1968 to locate and record all mortalities.

Data collected during the winter of 1982-83 from winter elk mortalities are discussed in relation to the complexity of the management of the Jackson Hole elk herd.

I thank the staff of the National Elk Refuge and G. Roby of the Wyoming Game and Fish Department for assistance with locating mortalities and collection of teeth. I also thank T. Moore and other personnel at the Wyoming Game and Fish Laboratory in Laramie for their efforts to age the teeth.

#### HISTORICAL PERSPECTIVE

Jackson Hole, Wyoming, was historically a wintering area for elk. Cole (1969) wrote that "The 1887 to 1911 estimates of 15,000 to 25,000 elk in the Jackson Hole herd, with highest numbers reported during severe winters, should establish the fact that the area was a historical wintering (ground)." In 1884, the first settlers arrived in Jackson Hole and homesteaded lands where elk had wintered. By 1909, homesteaders and ranchers had settled large areas of the elk's winter range. Conversion of the land for livestock use, "tusk" hunting, and several severe winters, resulted in heavy elk losses during the winters of 1889, 1890, 1891, 1909, 1910 and 1911. These losses, and depredation by elk on ranchers' haystacks, resulted in appeals from residents of Jackson Hole that brought national attention to the elk situation. During the winter of 1910, the Wyoming State Legislature appropriated \$5,000 to purchase hay to feed the elk. But the amount was inadequate, and hundreds of elk died that winter (Wilbrecht and Robbins 1978). During the severe winter of 1911, elk losses were conservatively estimated at 2,500 and 75% of the calves died before spring arrived (Brown 1947). That same year, the U.S. Congress appropriated \$20,000 for the purchase of hay and conducting of studies to determine what should be done to alleviate the situation (Anderson 1958).

As a result of the studies, Congress appropriated \$50,000 in 1912 and 1913 to purchase land for the production of feed for elk. From its initial size of 1,760 acres in 1912, the Refuge has increased - through federal acquisition of homesteads and a 1,760 acre donation by the Izaak Walton League - to its present 24,300 acres.

Supplemental feeding of elk has been necessary 63 out of the 72 years of the Refuge's existence. Although the Refuge produces about 13,000 tons of herbaceous forage (Anon. 1984), deep, crusted snow generally limits the availability of forage by February and necessitates supplemental feeding. Since 1912, the average duration of supplemental feeding has been 75 days. The 5,000 to 9,000 elk which winter on the Refuge are split up and fed on three to five separate feedgrounds on the Refuge. Hay was fed to the elk, either in loose (up to 1938) or baled form (1938-1974). In 1975, a change was made to pelleted alfalfa hay. Feeding trial studies, conducted from 1971 through 1973, showed that the elk readily accepted the pelleted feed and weight changes were similar to those in control groups of elk fed stem hay. Additional studies were conducted from 1972-74, to observe the acceptance and behavior of free-ranging elk fed alfalfa pellets on one or more of the Refuge feedgrounds, before the conversion to alfalfa pellets was made.

Winter losses of elk and other North American ungulates are often difficult to assess. On the National Elk Refuge, where elk are concentrated on about 12,000 acres from December through April most years, mortalities can readily be located and tallied.

Murie's (1951) studies of the National Elk Refuge elk during the 1920's and 1930's outlined several causes of winter mortality, of which necrotic stomatitis was the most prevalent. This disease still exists in the NER herd but to a much lesser degree than in the past. Murie (1951) found that the parasitic condition known as scabies, or psoroptic mange, was a factor of somewhat lesser importance among mortalities. Scabies continues to afflict a percentage of the Refuge herd.

Since Murie's studies, investigation of mortalities on the Refuge has been limited. Several important management changes, occurring during the past 35 years, have affected the summer distribution of elk wintering on the NER and hunting pressure experienced by the various herd segments. The most important of these may be the addition of the valley (eastern portion) of Grand Teton National Park (GTNP) to the existing mountainous portion of the Park in 1950 (Fig. 1). Following the expansion of the Park, a summering herd segment developed in the expanded area of GTNP. The GTNP elk are harvestable only east of the Snake River in the Park (as detailed in Public Law 787) and on the NER. As a result, elk which summer in GTNP, experience less hunting pressure than elk on the National Forest summer ranges in the Teton Wilderness (TW) and Gros Ventre (GV) drainage and elk that summer in southern Yellowstone National Park (SYNP) which must migrate through National Forest lands each fall.

## METHODS

During winter 1982-83, an attempt was made to locate every elk mortality on the NER. Searches from the feedtrucks, Thiokol (over-snow vehicle), horseback and on foot were conducted from late October 1982 through June 1983 to locate carcasses. Once located, each carcass was classified as adult bull (branch-antlered), spike bull, cow, or calf; sex was determined on calves; calves and yearlings were aged based upon tooth eruption and replacement techniques (Taber 1969:391); both incisors 1 were pulled to age animals older than yearling; and a gross examination was made of the carcass for external maladies or injuries. In particular, I tried to determine if the animal was afflicted with scabies. The incisors were sent to the Wyoming Game and Fish Department Laboratory in Laramie for decalcification, sectioning and cementum annuli reading.

## RESULTS

### Age and Sex of Mortalities

Results of the annual mid-winter classification count on February 23, 1983, showed that 5,878 elk were on the NER. Between the time when the earliest fall migrants arrived in late October 1982 and the last of the herd migrated north in May 1983, 170 elk mortalities occurred on the

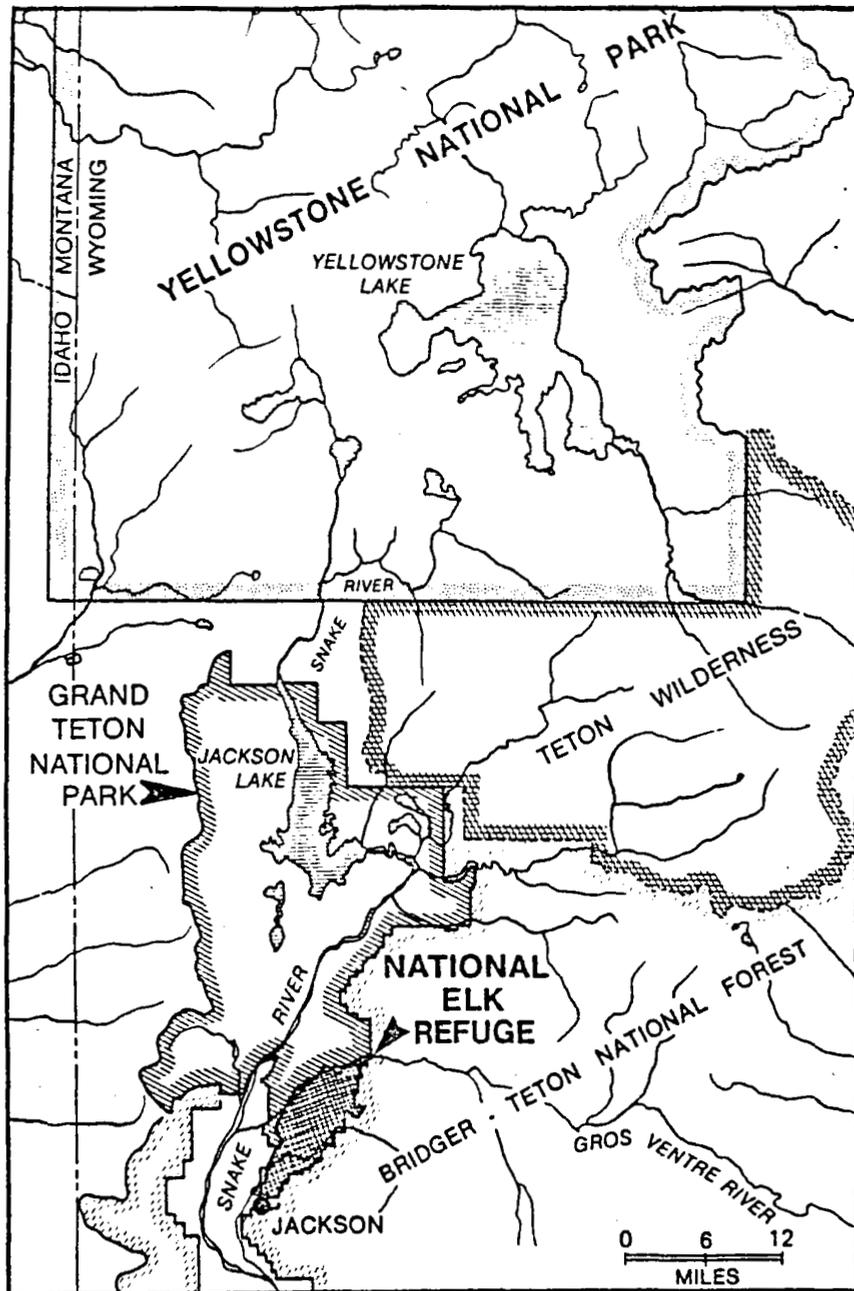


Fig. 1. Area used by the Jackson Hole elk herd (from Robbins et al. 1982:481).

Refuge. Of those, 165 were examined and classified (101 adult bulls, six spike bulls, 29 cows and 29 calves). Five antlerless animals (cow or calf) were not examined. The percent composition of each class among total mortalities compared to the percent composition of each class in the winter herd, is shown in Table 1. There was a significant difference ( $\chi^2=121, df=3, P<0.001$ ) between the observed mortality rates by class compared to the expected mortality rates (based upon composition of each class in the winter herd). Sixty-one percent of 165 classified mortalities were adult bulls, although only 19% of the winter herd was adult bulls.

One hundred forty of the carcasses were aged (Table 2). Excluding calves, the mean age of male mortalities was 7.35 years and that of females was 11.86 years. Five of 22 cows were 18 1/2 to 27 1/2 years of age. One bull mortality was 18 1/2.

Sex was recorded for all adult mortalities examined but for only four of 29 calves (one male, three females) because of scavenging by coyotes, ravens, magpies, bald and golden eagles. Scavengers quickly find and begin feeding on the carcasses of elk mortalities in winter. The flesh and entrails are sometimes completely consumed within 48 hours, particularly in the case of calves.

#### Mortalities with Scabies

Scavenging precludes the possibility of determining cause of death of most mortalities on the NER. However, a gross examination was made of 165 carcass remains during winter 1982-83 to detect any superficial maladies, particularly scabies. Scabies, or psoroptic mange, in elk is caused by the mite Psoroptes equi var cervinus (Thorne et al. 1982). The mite lives out its life cycle on its host but is readily transmitted by direct contact from one host animal to another. With the exception of bighorn sheep (Ovis canadensis), P. equi var. cervinus is host specific to elk

Table 1. Percent composition of the winter herd and percent composition of total winter mortalities of each age/sex class of elk, winter 1982-83.

	Bulls	Spiques	Cows	Calves
Percent of Herd	19	8	56	16
Percent of Mortalities	61	4	18	18

Table 2. Age/sex composition of 140 elk mortalities aged by tooth eruption/replacement and cementum annuli examination techniques on the National Elk Refuge during winter 1982-83.

Age	Male	Female	Sex Undetermined	Total
Calf	1	3	25	29
1 1/2	6	2		8
2 1/2	1			1
3 1/2	3	1		4
4 1/2	4	1		5
5 1/2	16	1		17
6 1/2	14	1		15
7 1/2	10	2		12
8 1/2	14	1		15
9 1/2	7	2		9
10 1/2	5	1		6
11 1/2	3	1		4
12 1/2	2			2
13 1/2	1			1
14 1/2	1	1		2
15 1/2		2		2
16 1/2	1	1		2
17 1/2				
18 1/2	1	1		2
19 1/2		1		1
22 1/2		1		1
23 1/2		1		1
27 1/2		1		1
Adult - Not Aged	18	7		25
Antlerless - Not Aged			5	5
TOTAL	108	32	30	170

(Thorne et al. 1982). Because of the large number of animals wintering on NER (an average of 6,980 elk in 1912 to present), it is likely that most if not all the elk wintering on the NER are hosts of the scabies mite. Murie (1951:166-168) reported that scabies was prevalent in the NER elk in the 1920's and 1930's and that it was reported among the elk as far back as records go. He wrote that severe cases of hair loss were chiefly associated with mature bulls although "quite a few adult cows are at times afflicted." Scabies was rare in younger animals and calves. Murie speculated that rutting activity and scanty feeding by adult bulls during the rut tended to lower their vitality, increasing susceptibility to

scabies. In this weakened condition of lowered resistance, a mite population may increase on an elk and the clinical signs of "scabbing" and alopecia become manifest. The adverse weather conditions of late fall and winter may aggravate the condition of scabied elk and create a negative energy balance.

Figures 2 and 3 show the distribution of cow and bull elk mortalities by month. The most striking difference is the earlier onset of mortalities in bulls and the number which had died prior to the start of supplemental feeding on February 3. More bull mortalities occurred in January, the coldest month of the year, than any other month.

Of the 101 adult bulls which died on the Refuge, at least 62% (63) showed clinical signs of scabies. Another 32 may have had scabies, but there was insufficient hide among the remains to make a determination. Only two of 29 cow elk mortalities (7%) had scabies, and no spike bull or calf mortalities were scabied.

Among males (yearling and older), age of mortalities with scabies was similar to mortalities that either did not have scabies or in which presence or absence of scabies could not be determined (Fig. 4). However, the mean age of scabied male mortalities (7.9) was greater than in non-scabied mortalities because no yearling and two-year-old males were scabied. The two cow mortalities with scabies averaged 16 years old.

#### Incidence of Alopecia in the Herd

During winter 1983-84, a census of alopecia among elk on the Refuge's feedgrounds was conducted. Standard criteria were used by observers to classify the severity of hair loss on each elk. Alopecia generally begins at the base of the neck and then spreads along the back and shoulders. For elk, having alopecia extending no further than 1/4 the distance along the length of the back or having only a limited patchy loss of hair, alopecia was recorded as "light". For elk in which alopecia extended more than 1/4 the distance along the back from the base of the neck, or elk in which alopecia extended less than 1/4 the distance along the back but hair loss was also evident on the neck and/or face, the condition was recorded as "severe". Table 3 shows that alopecia is most prevalent on adult bulls (27.8%) followed by spike bulls (9.6%).

#### Relationship of Mortalities to Herd Composition

Although quantitative information regarding the past incidence of scabies in the NER elk herd is not available, the percent composition of bulls among total winter mortalities was recorded in previous years. Figure 5 shows a significant positive correlation ( $P < 0.05$ ) between the percent of bulls in the winter herd and the percent bulls among total winter mortalities over the past 15 years. Figure 6 shows the degree of correlation increases when spikes are added to the percent of bulls in the winter herd. Logic might dictate that, as a class of animal becomes proportionately more abundant in the herd, likewise it would become proportionately more abundant among mortalities. However, the body size

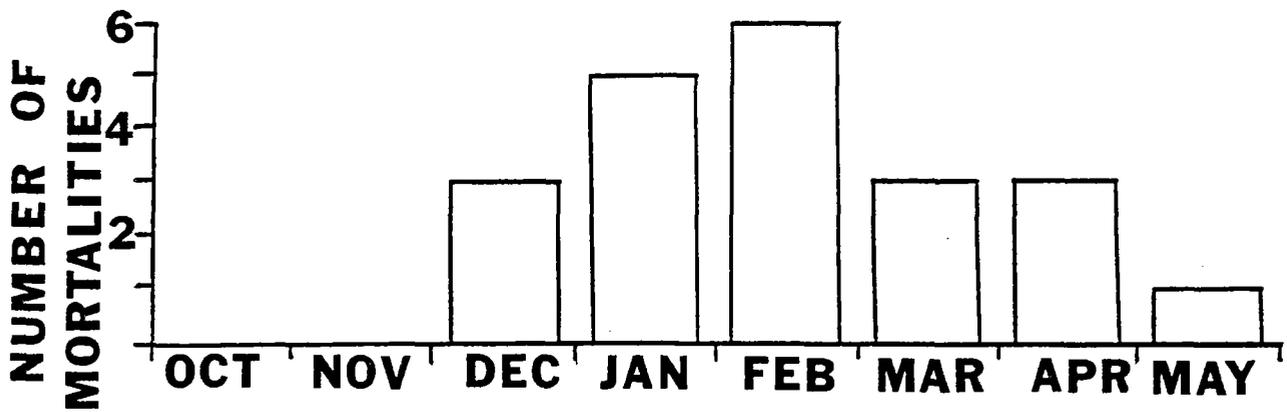


Fig. 2. Distribution of cow elk mortalities by month, winter 1982-83.

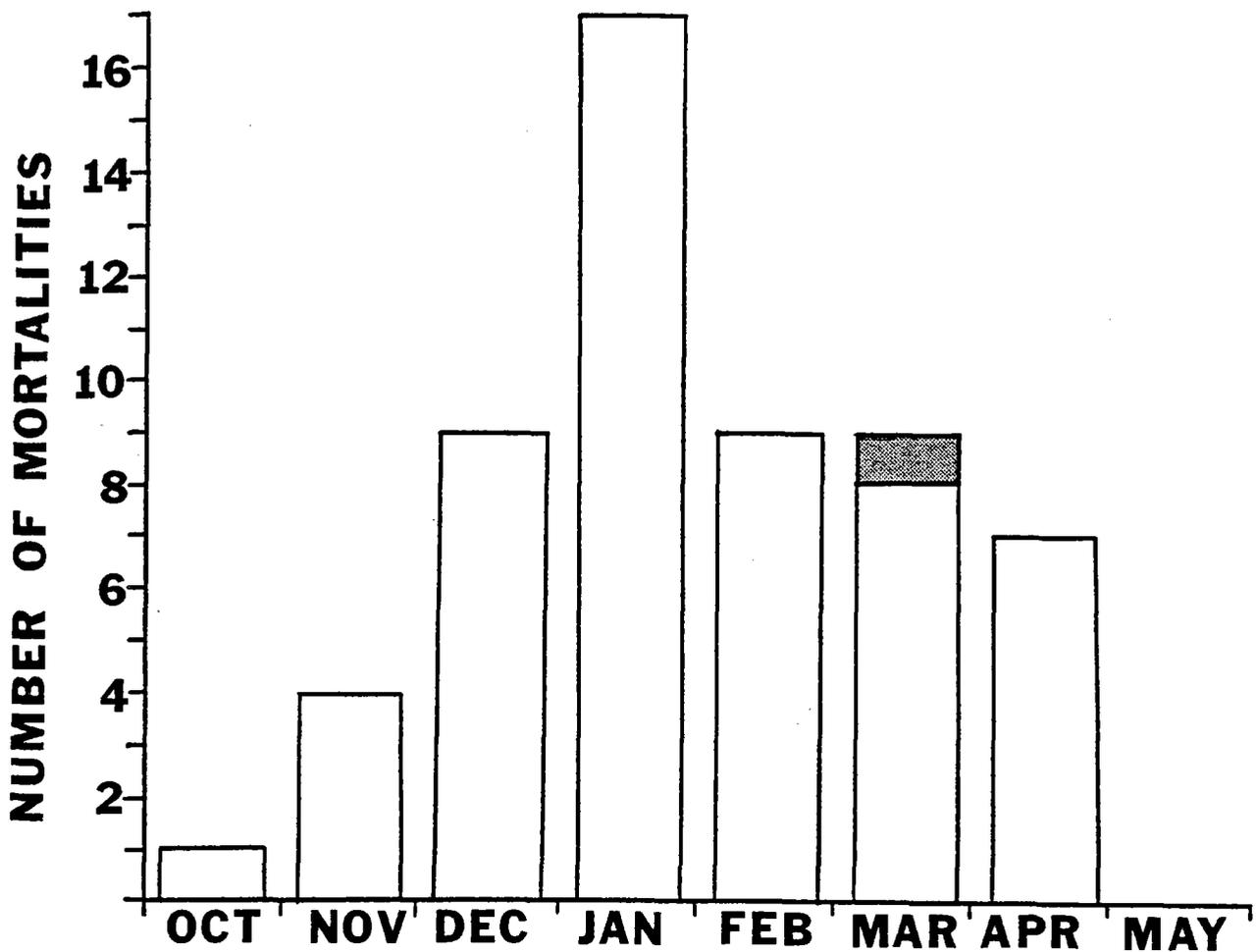


Fig. 3. Distribution of adult bull and spike bull (shaded) elk mortalities by month, winter 1982-83.

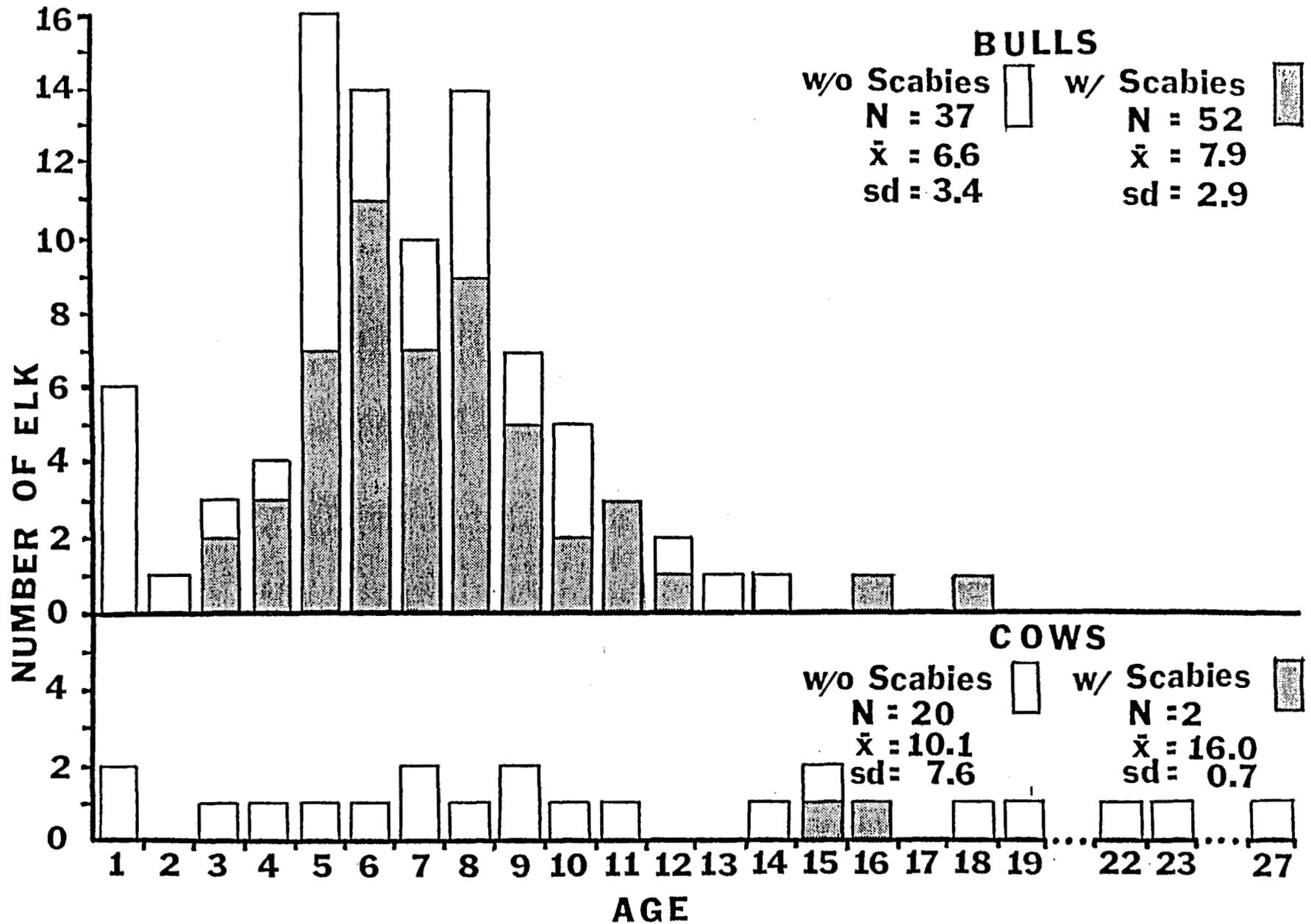


Fig. 4. Age of elk mortalities with scabies and without scabies (includes 25 bulls in which insufficient hide remained to make a determination) on the National Elk Refuge winter 1982-83.

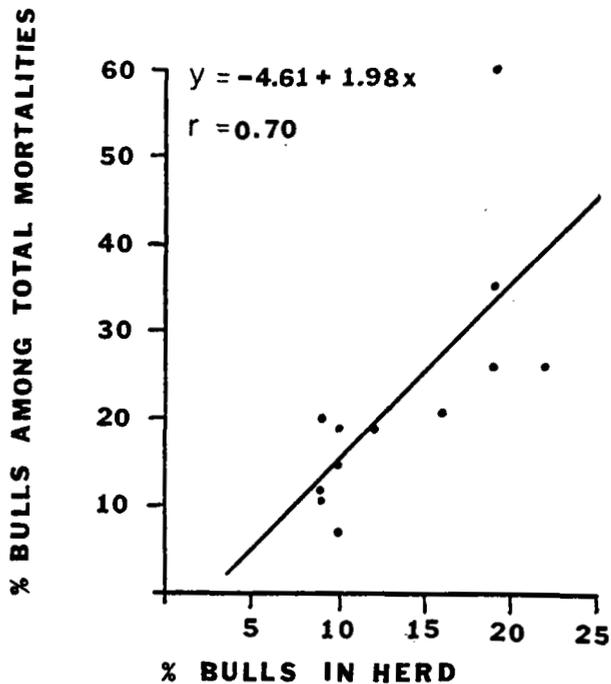


Fig.5. Relationship between percent composition of bulls in wintering herd and percent bulls among total winter mortalities 1969-83 (n=12).

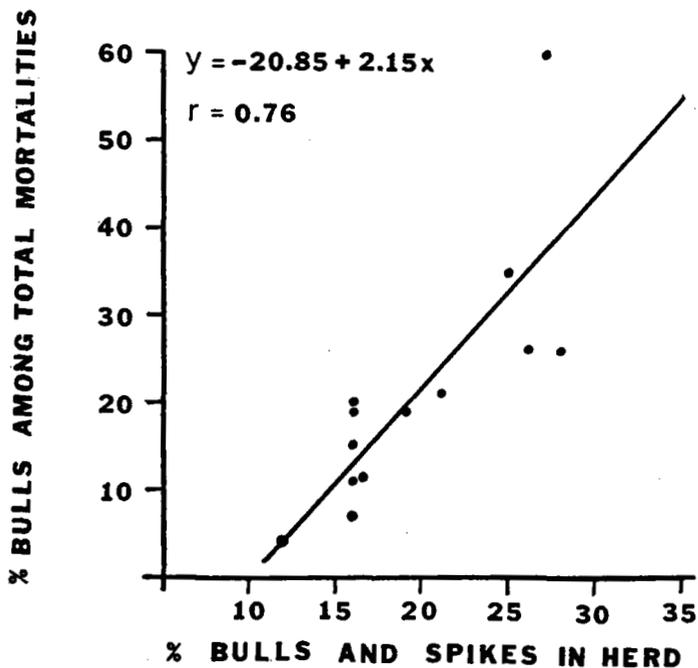


Fig.6. Relationship between percent composition of bulls and spikes in wintering herd and percent bulls among total mortalities 1969-83 (n=12).

and antlers of adult bulls enhance their competitive status on the Refuge winter range and supplemental feed lines. Thus, competition for food should not affect the survival of bulls during winter. There were not significant correlations between percent of bulls among total mortalities (1975-83) and 1) the number of days in the supplemental feeding period ( $n=7$ ,  $r=0.364$ ), or 2) the average number of pounds of supplemental feed/elk/day fed ( $n=7$ ,  $r=-0.303$ ). More likely, adult bulls arrive on the winter range in poorer condition than the other classes due to a decline in body condition associated with rutting behavior. Bulls that are lean and have alopecia are among the earliest arrivals to the Refuge in the fall. Hunters on the Refuge and in GTNP kill scabied bulls each year in November and Wyoming Game and Fish Department personnel are aware of only two elk killed in recent years on National Forest lands north of Jackson that had scabies (T. Toman, pers. comm.). Ground and aerial monitoring of the fall migration and radio-telemetry locations of elk (unpubl. data, NER files) reveal that in most years, many elk from GTNP summer ranges migrate to NER in advance of elk from the Gros Centre, Teton Wilderness and southern Yellowstone National Park herd segments (Fig. 1). Refuge classification counts have shown that among the early migrants, there is a high percent of bulls. For example, on November 19, 1982, 1,350 elk had migrated to the south end of NER. Of those, 650 (48%) were males (388 branch-antlered and 162 spikes). At that time, scabies was evident on quite a number of bulls, although the number was not determined. On November 22, 1982, there were 1,700 elk on the south end of the Refuge and 971 (57%) were males (775 branch-antlered and 196 spikes). Only 43% were cows and calves. Only in GTNP could such a high proportion of males occur in the population due to limited hunting pressure exerted on those elk, and regulations aimed at reducing the antlerless segment in recent years.

Table 3. Incidence of alopecia observed in the National Elk Refuge wintering elk herd, winter 1983-1984.

Class	Number	Number (%) Lightly Alopecia	Number (%) with Severely Alopecia	Total Number (%) with Alopecia
Calf <sup>a</sup>	706	7 (1.0)	0	7 (1.0)
Cow <sup>a</sup>	2,886	92 (3.2)	2 (0.1)	94 (3.3)
Spike <sup>a</sup>	345	33 (9.6)	0	33 (9.6)
Bull <sup>b</sup>	1,050	240 (22.9)	52 (5.0)	292 (27.8)
TOTAL	4,987	372 (7.5)	54 (1.1)	426 (8.5)

<sup>a</sup>From February 6 count

<sup>b</sup>From January 31 count

## Chronology of Bull Mortalities

Scabied bull carcasses were discovered as early as October 26, 1982 on the Refuge and at least 15 had died by December 31. Another 13 had died prior to the initiation of feeding on February 3, 1983. Another 17 scabied bull carcasses, found north of the Jackson National Fish Hatchery in April, died prior to February judging by the weathering of hide and skeletal remains. Thus, 45 of the 63 scabied bull mortalities occurred before supplemental feeding was necessary.

## DISCUSSION

The Wyoming Game and Fish Department and U.S. Fish and Wildlife Service work under a cooperative agreement to manage for an average of 7,500 elk on the NER in winter. During winter 1975-76, there were 7,858 elk on the Refuge. The following fall and winter were mild and snow-free and the lightest elk harvest in recent years was obtained on the Jackson Hole herd. A total of 1,176 elk were harvested in 1976 compared to about 3,000 in most years (G. Roby, pers. comm.). Liberal seasons were implemented in the fall of 1977 and hunting regulations in GTNP and NER shifted harvest pressure to females with antlerless-only permits issued for much of the season. A harvest of 3,756 animals was obtained. The NER classification count for winter 1977-78 totalled 8,491 elk. Regulations to reduce elk numbers, particularly females in GTNP, continued through fall of 1983. The harvest averaged 3,413 elk from fall 1977 through 1983 (Table 4). The NER classification count for winter 1983-84 totalled 5,010 elk. During the reduction period, the adult bull segment was reduced 23% but the number of cows in the population was reduced 44%.

Table 4. Annual elk harvest from the Jackson Hole elk herd 1976-1983.

	1976	1977	1978	1979	1980	1981	1982	1983
Total Elk Harvested	1,176	3,756	2,880	3,321	3,740	4,290	3,548	2,355

Note: Data are for the Jackson Herd which includes elk wintering on the National Elk Refuge, the Gros Ventre State feedgrounds, and on native winter range north of Jackson. Data obtained from G. Roby, Wyoming Game and Fish Department.

Harvest statistics from GTNP show that the percent of bulls harvested from 1974-79 that were 4+ years of age was 9% compared to 19% 4+ years of age from 1980-83. Cows in the 4+ category remained at 42% of those harvested (R. Wood, GTNP unpub. data). Thus, the herd reduction resulted in a larger percent of the NER wintering herd being comprised of adult bulls (12% prior to 1977, 21% in 1984), and the age structure of the bulls being shifted toward older animals. As the percent of bulls in the winter herd increased, so did their percent composition of total winter mortalities on NER. This relationship suggests that despite what extrinsic factors exist, bull mortalities (relative to total mortalities) are a function of competition or stress between bulls - probably during the rut. Haigh (1984) stated that for captive breeding purposes, bulls with the largest volume and highest percent motility of sperm are those with the largest scrotal circumferences. These tended to be seven year-old bulls. Thus, the mean age of 7.35 years for bull mortalities appears to coincide with the age of greatest reproductive potential and possibly sexual activity.

As discussed earlier, the high bull:cow ratio appeared to be associated with the GTNP summer herd segment where the sex ratio during fall 1982 may well have approached 1:1. Competition for females under such circumstances, and associated inter-male rivalry and sparring, would serve to increase the contamination of other animals with psoroptic mites and drain energy reserves of males. Thus, alopecia, leanness, and occasionally emaciation were already evident in November.

For many of the bulls that died, the days prior to death were often spent in areas conducive to thermoregulation. This was true even during the period of supplemental feeding when wandering 1 km or more from the Refuge's four feedground locations to lee hillsides or areas of dense sagebrush and chokeberry stands often meant missing out on the daily feeding of alfalfa. Carcasses were often found in places with maximum solar and minimum wind exposure. In their last days, some scabied animals showed little or no responsiveness to the supplemental feeding operations, apparently favoring to conserve energy and remain in those areas less exposed to the wind than the feedground locations. Malnutrition/starvation or hypothermia may ultimately bring on death although such weakened animals may be predisposed to opportunistic diseases or parasites as well (Murie 1951:168). Worley (1979) noted that elk with heavy tick and mite infestations also tended to have heavy internal parasite loads. Bergstrom and Robbins (1979) found that elk in the valley portion of GTNP had a 30 to 40% incidence of lungworm (Dictyocaulus viviparus) during summer/early fall compared to a 13-16% incidence among elk along Wolverine Creek and Big Game Ridge of southern Yellowstone Park and the northern Teton Wilderness. Both summer herd segments winter on NER.

Regarding the years 1968-1980, Robbins et al. (1982:505) stated that "about 10-20 scabby elk die on the Refuge each winter; most are mature bulls but mature cows are sometimes lost." Thorne et al. (1982:247) related the appearance of clinical scabies to the nutritional intake and physical condition of elk. Murie (1951:169) believed the best precaution for reducing scabies was the avoidance of overstocking to maintain good, productive elk range.

Stress-related nutritional deficiencies precipitated by a rising bull:cow ratio in GTNP may have increased the incidence of scabies in bulls and mortality of bulls recently. Unfortunately, quantitative data on the incidence of scabies on the NER or in other elk herds have not been recorded in the past. Colwell and Dunlap (1975) reported scabies in a single bull elk in northern Idaho and Houston (1982:192-193) reported its occurrence in the Northern Yellowstone elk herd. Houston (pers. comm.) felt the incidence of alopecia among elk in that herd might approach the percentages I described from the NER.

Although it apparently predisposes a number of elk to die each winter on the NER, scabies is not a density dependent population control because it does not cause significant losses of females or young. However, it is possible that the conditions under which scabies manifests itself may lead to poorer overall health of the elk herd. If in this manner reproductive success or survival of offspring are affected, there may be a mechanism at work dampening the rate of increase of the herd.

There are many unanswered questions concerning scabies in the Jackson Hole elk herd. Winter nutrition has been suggested as one cause of scabies. In that case, one would expect all of the summer herd segments that winter on the Refuge to be afflicted with scabies. It is noteworthy that most of the bull mortalities with scabies have large heavy antlers. The elk generally do not leave the Refuge winter range until May. Antler growth recommences in April prior to migration. How then do those bulls grow such massive antlers if prior to and during early antler growth they are undernourished? Arrival of scabied bulls on the Refuge in October and November suggests that malnourishment or physiological stress is encountered prior to the fall migration (probably between completion of antler development in August and migration). Another possibility is that clinical scabies is cyclic in individual elk.

Research is needed to answer these and other questions regarding scabies. Dusting or dipping elk with a topical insecticide could theoretically control psoroptic mites. However, effective treatment of 7,000 elk twice in a 10-14 day period (the incubation period of eggs which would not be killed by an initial treatment) appears neither practical nor logistically possible. Systemic insecticides have been used to control parasites in livestock and may hold promise for treating scabies in elk. Experimental testing of the pharmacological effects of such insecticides on elk should precede field administration.

Investigation of the cause-effect relationship of scabies in the Jackson Hole elk herd is also needed. Identification of the conditions which lead to the initial debilitation of elk, allowing mite colonies to multiply, may disclose management options for a long-term solution to the problem.

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FACTORS AFFECTING THE SURVIVORSHIP OF MALE ELK IN SOUTHWESTERN  
MANITOBA

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Abstract: Factors causing low bull:cow ratios in the Spruce Woods-Shilo elk population of southwestern Manitoba are under investigation. Preliminary results of seasonal range use, range size and dispersal of radio-transmitted male elk suggest that immature (1 1/2 - 2 1/2 year) male elk have larger seasonal ranges than mature elk. Mature male elk use traditional seasonal ranges. Immature males are known to disperse long distances from the area. Many elk observed in outlying areas are bulls. No significant hunter harvest of males occurs. Native harvest of male elk is significant. The level of illegal harvest of male elk is unknown. The combination of native and illegal harvest plus natural dispersal appears to be the greatest reason for the loss of male elk from this population.

## WAPITI IN THE PEACE RIVER REGION - LIMIT OF THE SPECIES RANGE

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Abstract: A review of observations made almost 200 years ago is provided to give an indication of the numbers and types of wildlife along the Peace River prior to settlement and exploration. Populations of elk declined rapidly to a point in the 1920's when efforts were made to reintroduce elk into Alberta. Several introductions of elk have been made in different parts of the Peace Region between then and as recently as 1982. The present distribution of elk includes most parts of the south and extends locally as far north as Fort Vermilion. Depredation by elk on agricultural products occurs where elk exist adjacent to developed land.

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### INTRODUCTION

Relatively little is known even today about the northern distribution of elk. In western Canada, elk have existed and still do exist in small isolated bands with a tenuous existence. Not infrequently single bulls or cows are found in unusual locations far from established elk herds. The Peace River region of Alberta is an administrative and management area for wildlife and other resources. The northern limit of elk distribution is included in this region. Management of these animals for the best public benefit requires an understanding of the present distribution and numbers but also requires some idea about potential numbers and distribution within the limits of the habitat and present land uses.

In preparing this report, I wished to review information about elk within the regional boundary from any reliable sources that were available. The original observations of Alexander Mackenzie provide an indication of the pristine conditions against which to compare the present distribution and numbers of elk. Information about elk transplants had not previously been summarized but was contained in numerous departmental files.

We have begun to conduct winter surveys specifically for elk in this region in recent years and that has added to our knowledge about the species. Future management options should be based upon a clear understanding of objectives and sound knowledge of the potential that elk might have in the north.

I thank Ron Bjorge who reviewed this manuscript and made useful comments, and Reg Arbuckle who helped to compile the data.

## STUDY AREA

The northwestern part of Alberta is the Peace River Region and includes 93,000 square miles, about one third of the province in area. The Peace River is the main drainage, flowing from British Columbia into Lake Athabasca and the Mackenzie drainage system. The Wapiti, Smoky, Simonette, Little Smoky, Notikewin and Wabasca are major tributaries of the Peace System in this region. Utikuma, Wabasca and Peerless Lakes are also part of the Peace drainage. Lesser Slave Lake is part of the Athabasca system, but is included in the regional boundary. The resident population of the region is less than 100,000 with Grande Prairie and Peace River being the major settlements. The area provides land based recreation including hunting and non-consumptive wildlife oriented activities to residents of Edmonton and other major centers.

Topographically, the region varies from Rocky Mountain foothills in the southwest to boreal forest in the north interspersed with large muskegs. Major topographic relief includes the Swan Hills, Saddle Hills, Clear Hills, Buffalo Head Hills and the Caribou Mountains. Precipitation in the region is moderate to high except locally in parts of the Peace River valley where near desert conditions prevail thus supporting a small species of prickly pear cactus. Winters are cold and summers are cool. Long daylight periods during summer months result in rapid growth of forage plants.

Elk have been and still are an important resource in many parts of this region.

## HISTORICAL REVIEW

In 1792, western Canada was unexplored and unsettled country. In October of that year, a 29-year-old partner of the North West Fur Trading Company, Alexander Mackenzie, left the company post at Fort Chipewyan with a crew of 10 and one canoe on a voyage up the Peace River that would take him to the Pacific coast. They travelled up the Peace to a point just beyond the confluence with the Smoky River where they established Fort Fork and spent the winter (Figure 1). The voyage commenced again in May of 1793.

Through Mackenzie's journal, we have a limited record of the fauna of that time, and we can see that it was quite different from what we would see today in the same locations. Here are some extracts from Mackenzie's journal (Lamb's edition) which reflect the fauna that Mackenzie saw and hunted.

Quotation from page 242 of Lamb's edition, (a general reference to the Peace River valley downstream from Fort Fork).

"On either side of the river though invisible from it, are extensive plains, which abound in buffaloes, elks<sup>6</sup>, wolves,

foxes and bears. At a considerable distance to the Westward, is an immense ridge of high land or mountains, which take an oblique direction from below the falls, and are inhabited by great numbers of deer..."

<sup>6</sup>Here as elsewhere the wapiti is meant. (Footnote from Lamb's edition.)

Quotation from page 252 of Lamb's edition (date of entry is March 22, 1793 at Fort Fork).

"...a wolf was so bold as to venture among the Indian lodges and was very near carrying off a child."

Quotation from page 255 of Lamb's edition (no date given, entry made at Fort Fork).

"An Indian in some measure explained his age to me be relating that he remembered the opposite hills and plains, now interspersed with groves of poplars when they were covered with moss and without any animal inhabitant but the reindeer. By degrees he said the face of the country changed to its present appearance, when the elk came from the East and was followed by the buffalo; the reindeer then retired to the long range of high lands that at a considerable distance run parallel with this river."

(This must surely be a fanciful explanation as it is difficult to comprehend the transformations described occurring in a single lifetime.)

Quotation from page 258 and 259 of Lamb's edition (entry made on May 10 shortly after departure from Fort York).

"...the young men landed when they killed an elk and wounded a buffalo.

...groves of poplars in every shape vary the scene and their intervals are enlivened with vast herds of elks and buffaloes, the former choosing the steeps and uplands, and the latter preferring the plains. At this time, the buffaloes were attended with their young ones who were frisking about them and it appeared that the elks would soon exhibit the same enlivening circumstance."

Quotation from page 260 of Lamb's edition (entry made on May 12).

"We killed an elk and fired several shots at animals from the canoe."

Quotation from page 262 of Lamb's edition (entry made on May 13).

"Here the land lowered on both sides with an increase in wood and displayed great numbers of animals.

...we perceived along the river tracks of large bears, some of which were nine inches wide and of a proportionate length. The Indians entertain great apprehension of this kind of bear which is called the grisly bear."

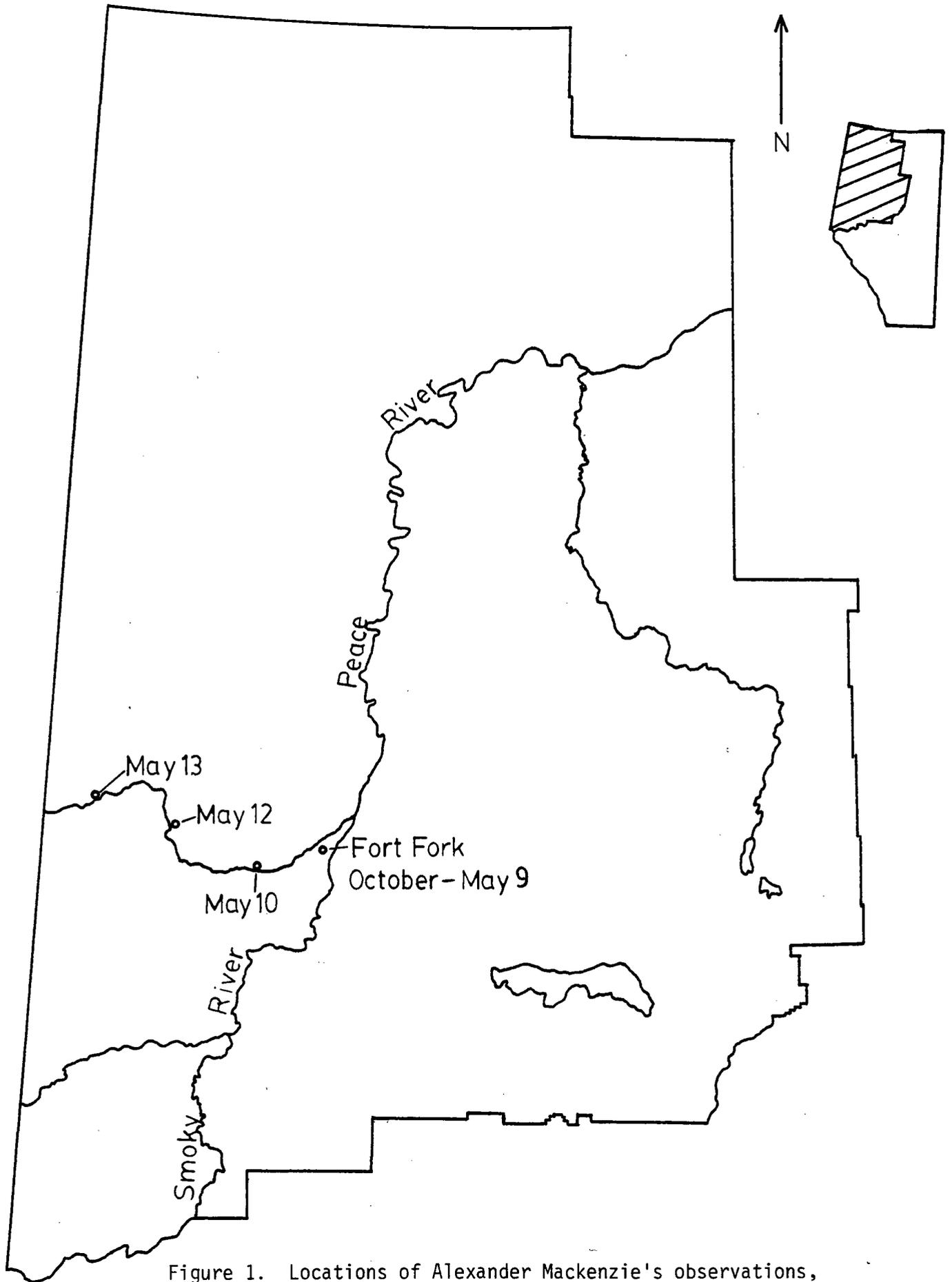


Figure 1. Locations of Alexander Mackenzie's observations, October 1792 - May 1793.

After Mackenzie explored the Peace River, there was a flood of explorers, trappers, missionaries and prospectors. Each camp would hire professional hunters responsible for supplying fresh game meat. Elk and bison were an easy mark for the musket in the Peace valley. Between 1825 and 1850, most bison in the valley of the Peace were gone and it is very likely that elk numbers declined with equal rapidity. John Stelfox (1964) reported that a series of severe winters contributed to the general decline of elk herds in the province between 1810 and 1913.

#### REINTRODUCTIONS

It was believed that in the 1920's and 1930's elk had been virtually eliminated from most of Alberta, and there were several attempts to reintroduce stock to historic range of elk. Some data (Table 1 and Figure 2) suggest that elk may not have been as uncommon as they were thought during the first part of the century. Observed rates of increase reported for several transplanted herds were greater than the potential rate of

Table 1: Elk Transplanted to the Peace River Region to 1984.  
(Information from regional Fish and Wildlife files).

DATE	LOCATION	MALE	FEMALE	TOTAL	ORIGIN
Dec. 19, 1964	White Mountain/ Saddle Hills (77-99-W6)	10	16	26	Banff Nat. Park.
Summer 1965	Saddle Hills			28	Banff (Stelfox, pers. comm.)
Feb. 19, 1972	Meikle River			28	EINP (Elk I. Nat. Park)
Feb. 1972	East Lovet Creek (92-2-W6)			18	EINP
Feb. 10, 1973	Fisher's Millsite (92-2-W6)	7	7	14	Jasper Nat. Park
Feb. 13, 1973	Fisher's Millsite		mostly female	20	Jasper
Mar. 3, 1973	87-3-W6			20	EINP and Jasper
Feb. 8, 1982	Pelican Mountains (22-77-W4)	6	15	21	EINP
Feb. 15, 1982	Pelican Mountains	11	18	29	EINP

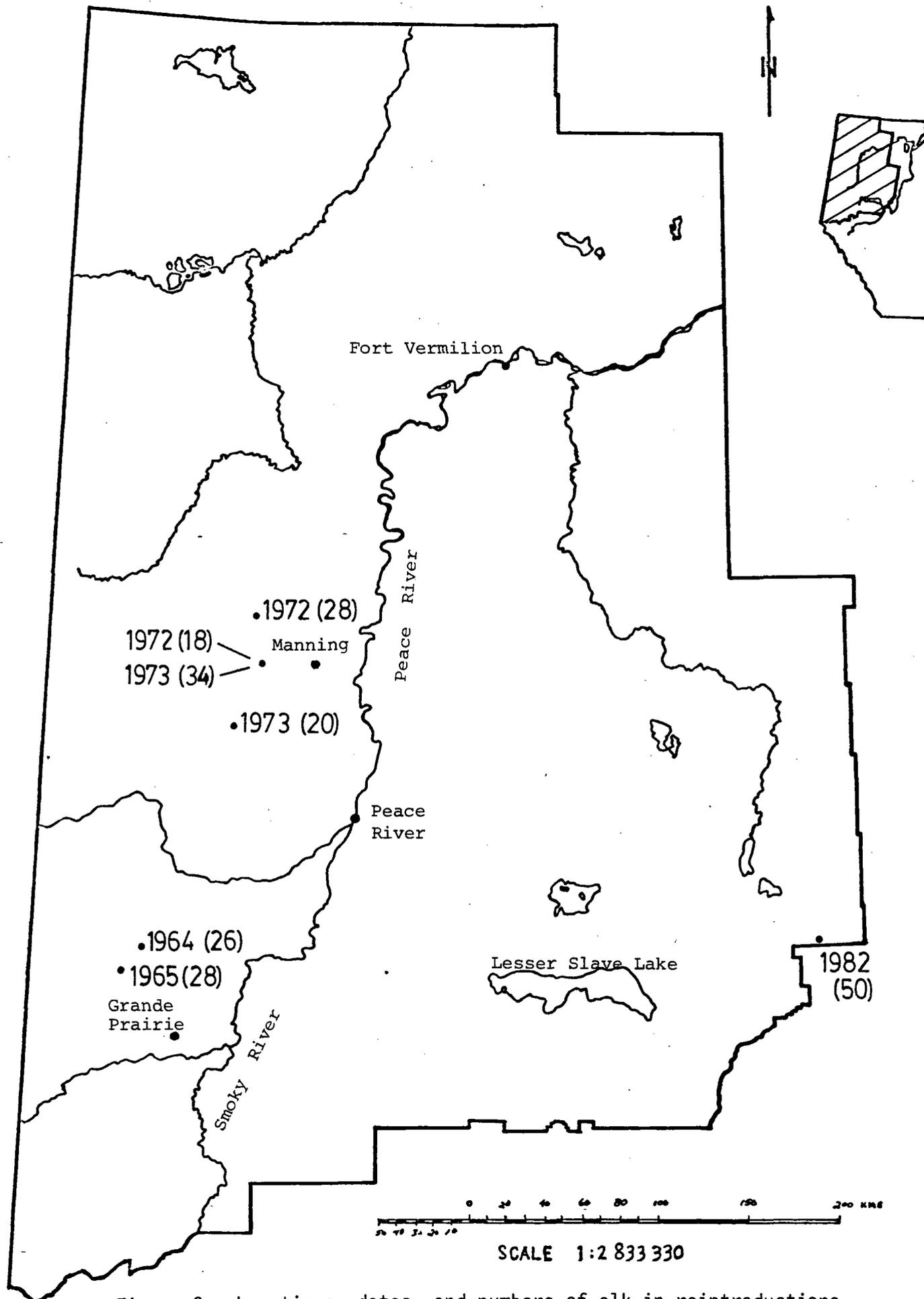


Figure 2. Locations, dates, and numbers of elk in reintroductions, 1964 - 1982.

increase or certainly very close to it. For example, Stelfox (1964) reported that a reintroduction of 88 elk in Jasper National Park in 1920 yielded 1000 to 1200 head by 1926. A 50% annual increment to that herd would yield 1002 animals in six seasons with no mortality. If it was true that elk numbers had dwindled to nothing prior to reintroductions in Jasper, it would seem likely that reintroduced herds were supplemented with native stock perhaps naturally dispersing from British Columbia.

In 1964 and 1965, 54 elk were released in the Saddle Hills northwest of the city of Grande Prairie. Although it was reported that no elk were present prior to reintroduction, Lungle (1972 - departmental memo) reported that the herd had grown to 150-200 head by the fall of 1967 (an annual increment of 45-53% over 3 years). It seems likely in this case that native stock was present prior to reintroduction or that the introduced animals were supplemented with native animals from British Columbia by immigration.

In 1972 and 1973, 100 head of elk were released northwest of Peace River over a wide area between the Meikle River and the Whitemud River. Based upon sighting reports, it is evident that dispersal from those releases was very rapid and occurred in several directions. There do not appear to be any survivors of those transplants at the release sites; however, there is a herd of elk southwest of the town of Manning that is probably derived from these releases.

In 1982, 75 head were released in the Pelican Mountains. The known survivors of that release number 14 (as of February 1983) and have taken residence south of Wabasca Lake. It is still questionable whether that introduction will result in the establishment of a permanent herd.

#### PRESENT DISTRIBUTION AND ABUNDANCE

Figure 3 shows the present distribution of elk in northwestern Alberta. In addition to the area depicted here, small numbers of elk are regularly observed in the hills south of Lesser Slave Lake east to the Athabasca River. Elk are occasionally reported along the upper and lower sections of the Peace River. At Fort Vermilion in 1977, a farmer reported the most northern occurrence of elk in Alberta. He had two herds of elk on his grazing lease. In total, he counted 18 elk including mature bulls, cows and calves. In March (1984), I contacted that farmer (Mr. Bittman) who told me that he had not seen the elk in about 5 years, although they had been on his lease for 2 or 3 years. Further south, we have received unconfirmed reports of elk at various locations along the Peace River but only in very limited numbers.

Parts of the region have been surveyed specifically for elk, and we are gaining data on distribution and numbers on winter range. Today the largest elk populations occur in the Saddle Hills and south of Grande Prairie along the Smoky, Wapiti and Simonette Rivers.

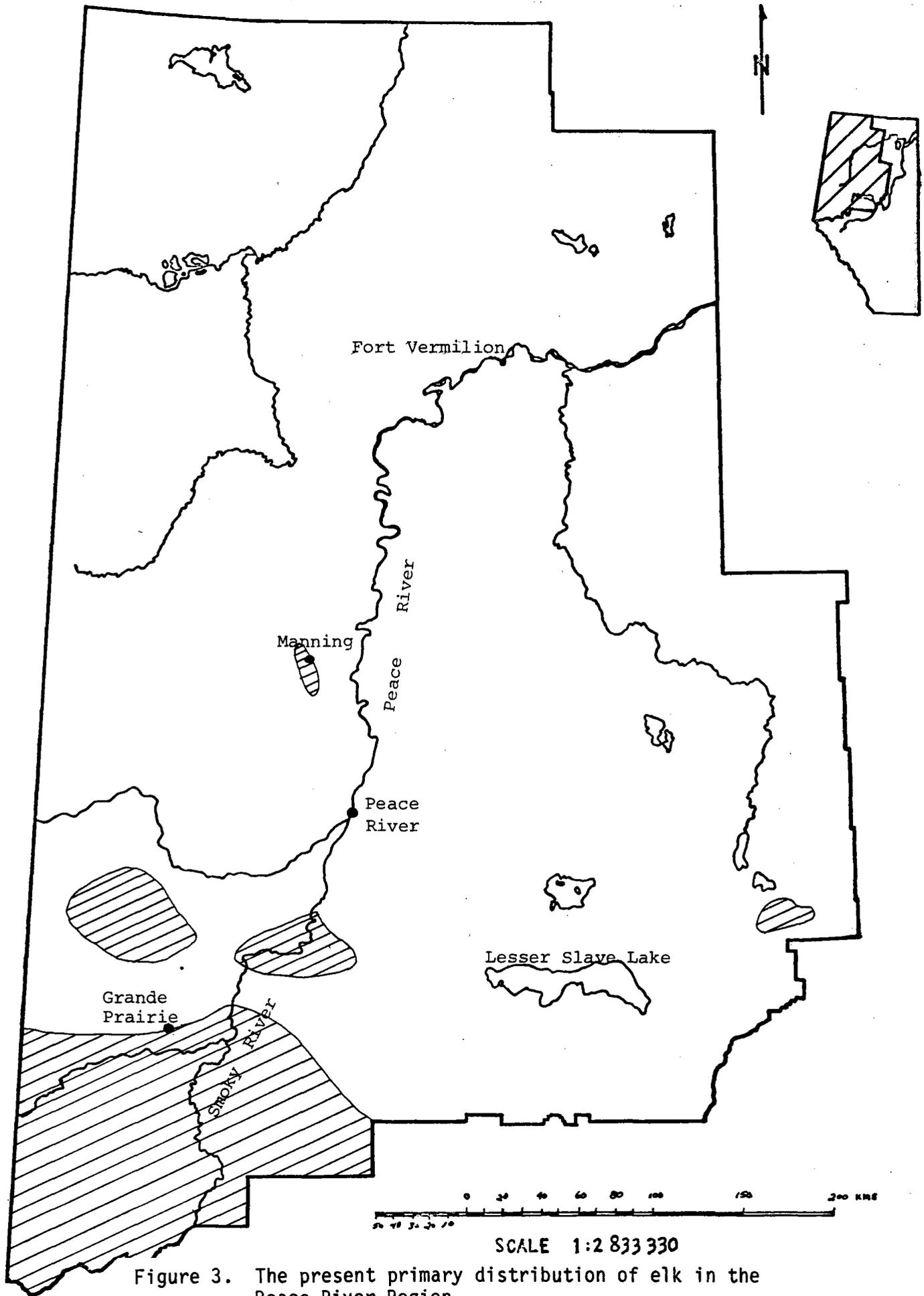


Figure 3. The present primary distribution of elk in the Peace River Region.

In northwestern Alberta, elk favour habitat with significant topographic relief such as major watercourses or large hills. Mixed stands of aspen and conifer are typical preferred range. These areas are usually associated with treeless slopes and small meadows. Rippin (1983) referred to elk using open bog areas in mid-winter in northwestern Alberta. It is unlikely that this happens extensively in the Peace Region with the possible exception of the introduced elk at Pelican Mountains where Rippin was working. Some of the elk range in this region is adjacent to developed agricultural lands leading to depredation on stacked hay or cereal grains.

#### HARVEST HISTORY

Until 1975, elk hunting for both sexes in this region was under general open seasons. Antlerless seasons were limited to certain areas and to about five days or less while general male elk seasons have been up to three months in length. In 1975, authorizations were instituted for antlerless elk allowing an extension of the season to two months. In 1976, additional areas were opened for antlerless elk authorizations with further expansion of the antlerless elk authorization in 1977. Elk seasons have remained static since that time except for a later opening date on the antlerless authorizations.

Registration of legal elk kills began in 1975 in the Peace Region. During the first years of compulsory registration, the numbers registered were low (about 40/season) but since 1978, the numbers registered have been about 90-120. An improvement in compliance with the requirement for registration may account for the sudden increase in the number of elk registered. Since 1981, we have issued 100 authorizations for antlerless elk in each of three management units. Hunter success rate for those antlerless authorizations has ranged from 4% to 22% in different management units.

#### FUTURE MANAGEMENT

Divisional questionnaires have established that elk are a popular species among hunters and non-consumptive users in Alberta. About 30,000 hunters purchase elk tags annually to harvest 2000 of the estimated 15,000 elk in Alberta. Elk are listed as number four among native wildlife species in the "like to see" category and number six in the "like to see more of" category in a random survey of Alberta residents in 1976. Therefore, there has been much pressure to establish additional elk populations and the north is seen by many as the place for this type of expansion. We face the dilemma, however, of opposing interests in trying to provide a recreational resource and avoiding the damages that elk frequently cause to private property.

Over the next years, our goal will be to look for a resolution to that conflict and to continue to protect established elk herds in this region. This fall, we expect to have a more liberal elk season than we

have had within the past 10 years in this region. New areas will be opened for a general bull elk licence and antlerless elk authorizations will be available throughout the zone. I expect that we will attract more elk hunters to the region with only a slight increase in harvest but perhaps a better distribution of harvest.

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## LEGAL AND ETHICAL ASPECTS OF REDDEER HUSBANDRY IN CHILE

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Abstract: The introduction of exotic Reddeer (Cervus elaphus) to Southern Chile in 1952 was made possible through a special bylaw granting wealthy landowners the right to breed Reddeer in captivity. By 1960, red deer enclosures had become popular throughout the Valdivian Precordillers. Political upheavals, land reforms, lack of law enforcement and changing attitudes in the following years led to the destruction of most enclosures and the accidental and deliberate release of their occupants. Favourable climate and generally excellent forage conditions favoured the rapid expansion of the prolific Reddeer, noted for its aggressive colonization potential. Currently, the geographic range covers all of the Valdivian forests. Reddeer are found from sea level to the high Cordillera where it is believed to have connected with Argentinian populations.

The free-ranging Reddeer are sympatric with the two native deer species (Hippocamelus bisulcus and Pudu pudu), classified as "vulnerable" and "endangered". There is reason to believe that the rapidly expanding Reddeer populations have led to competitive exclusion with native cervids. Further, range use and vegetation studies indicated adverse impacts of Reddeer on the endemic flora. In high density areas, grazing pressure results in decreased plant species diversity and range deterioration.

The ecological, ethical and related legal problems have increased dramatically. The landbarons defend their right to ownership, and lobby for protective hunting laws although Reddeer are found on government and private land alike. The underprivileged subsistence farmers suffer from damage to their crops. Intensive forest management, with a focus on fast growing exotic conifers, proves to be incompatible with Reddeer. Economic losses through damaged seedlings and saplings are substantial.

The complex problems request an urgent legal review and well defined practical management decisions. Some options under debate are discussed in this paper.

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### INTRODUCTION

The controversial introduction of Reddeer to Chile took place in the early 1950's. The original breeding stock of 30 animals was imported from the neighbouring Argentinian provinces of Neuquen and La Pampa where twenty Reddeer were first introduced prior to World War One from Austria and Hungary.

The historic development of the Chilean Reddeer populations proceeded similar to the development in Argentina. Several small groups of five to fifteen animals were kept in enclosures by land owners in Central and Southern Chile. Subsequently, accidentally escaped and deliberately released animals established free ranging populations which today can be found throughout the Valdivian forest from sea level to the high Cordillera. The rapid expansion and the dramatic population increase (i.e. total free-ranging population exceeds several thousand animals) were made possible through (a) favorable climatic conditions typifying the Valdivian forests, (b) an almost unlimited high quality forage supply in terrain with diversified cover, (c) legal protection against hunting, and (d) the absence of predators.

According to the Chilean law, the owner of an enclosure had to be officially registered as a certified breeder before Reddeer could be purchased for husbandry. The law is still in effect, but the ownership of free-ranging animals on public and private lands remains undetermined.

Damage by Reddeer to crops and forest plantations is increasing and has resulted in considerable economic losses. The problems are aggravated through research findings which may indicate that the expanding Reddeer populations may contribute to the decline of native cervid populations. Adverse impacts on the native flora have been documented (Eldridge 1974). Several management alternatives have been proposed but with little success (Schuerholz 1975, 1976b).

#### LEGAL ASPECTS

The establishment of enclosures for Reddeer husbandry conformed to a special bylaw passed by the Ministry of Agriculture in response to import applications in the early 1950's. This bylaw granted the importers sole ownership and the right to keep the animals in captivity; it did not specify or restrict utilization. Reddeer husbandry fell under a category similar to livestock ranching. Meat and by-product marketing (i.e. skins, antlers, etc.) were regulated in the same fashion as for beef cattle. The only legal requirement for Reddeer husbandry was official registration as a breeder. The bylaw did not provide a contingency clause for animals which escaped from enclosures, but it prohibited deliberate release.

Political upheavels, ignorance by government agencies, poor law enforcement, and irresponsible Reddeer breeders are accountable for the current dilemma. Revolutions connected with agrarian reforms caused the destruction of many enclosures and the deliberate release of Reddeer into the Valdivian forests of the Central Chilean Precordillera.

Meanwhile, free-ranging Reddeer populations got out of control, compounding legal problems. Although Reddeer are found on public and private lands, the ownership of free-ranging animals has not been defined. In contrast to rabbits, Californian quail, and European hare, which were officially introduced to Chile to enrich the native fauna, this was not the original concept for the introduction of the exotic Reddeer, at least

not an admitted objective. For this reason, the current hunting regulations and the Wildlife Acts do not apply to Reddeer, although hunting is permitted on properties of registered Reddeer breeders. The irony of the current situation is that the registered breeders continue to be legally protected, although they are responsible for the problems outside their property boundaries.

Currently, the management of wildlife resources in Chile is a dual responsibility of CONAF (Corporacion Nacional Forestal), a Government Forestry Corporation, and of the Ministry of Agriculture which is also in charge of law enforcement (Schuerholz and Mann 1979). Chilean wildlife biologists are afraid to recommend "game" status for Reddeer, since this would imply recognition of free-ranging populations. On the other hand, they are afraid to recommend total eradication of the species which would likely result in a strong confrontation with politically powerful landbarons of the south. The lack of a clear policy statement on the issue by the government has caused international concern since competitive exclusion of native cervids by Reddeer and an impoverishment of the native flora in densely populated areas is suspected.

#### THE GAUS PRINCIPLE

Based on the hypothesis that free ranging Reddeer in Chile may cause a threat to the native Huemul (Hippocamelus bisulcus) and the native Pudu (Pudu pudu), a complex research program on all three species was conducted between 1974 and 1978. Emphasis was placed on autecological studies of Pudu and Huemul for which very little information was available. These studies were linked to investigations with respect to the ecological habitat requirements by Reddeer, and Reddeer colonization strategies in undisturbed forest ecosystems where Pudu and Huemul may still occur. The extremely low population density of the endangered Huemul caused substantial constraints. The Pudu and Reddeer projects progressed successfully until policy changes in 1978 abruptly brought the studies to an end. Unfortunately, there has not been a follow-up and the pre-project 1974 status quo option is still in effect, providing Reddeer with the continuing opportunity to expand ad libitum.

The preliminary findings indicate that competitive excusion of Pudu by Reddeer is unlikely due to distinctly different habitat partitioning. The Pudu, one of the smallet cervid species in the world, seems to have evolved closely with bamboo thickets which characterize the moist Precordillera hardwood forests of Central Chile. Bamboo grows best in forest clearings, but may be found as undergrowth in higher elevation Nothofagus forests which are dominated by deciduous trees. Bamboo is a very prolific seral species which is rapidly established after land clearing and burning, suppressing all other plant growth. These thickets provide Pudu with cover and forage (i.e. staple diet of Pudu). A complex tunnel network characterizes the home ranges of the territorial males. Although Reddeer make some use of bamboo for cover and forage, bamboo thickets severely limit Reddeer movements, and therefore are usually avoided. There is little reason for Pudu to ever leave the shelter of

bamboo, consequently competition with Reddeer for space and/or forage seems to be negligible. The Pudu's highly specialized ecological adaptation to bamboo and its high vulnerability outside of bamboo thickets predestines its extirpation following increased land alienation. Its only native predator is the mountain lion, but feral dogs take their toll.

Historic records show that the Huemul occurred in good population densities between 33 degrees North and 54 degrees South latitude in Chile until the turn of the century (Schuerholz and Rottman 1974). The current populations may have dwindled to a low of 200 animals distributed over the entire range of the original geographic distribution. Ruthless killing for sport and meat, heavy persecution on livestock ranges, susceptibility to exotic diseases introduced and spread by livestock, and the large scale destruction of forests may have been responsible for the rapidly declining population. Taber (1974) suggested that the establishment of free ranging Reddeer populations may have contributed to the decline. The preliminary data from the mid-1970's research seem to support the hypothesis of competitive exclusion of Huemul by Reddeer. Both species may occupy the same habitat and may utilize the same forage and other requisites. However, Reddeer were not established in Chile prior to 1950 when extremely low population densities of Huemul were first noticed. The major population crash may have occurred concurrent with the introduction of Aftosis (foot and mouth disease) in the early 1930's.

In brief, although Reddeer may not be directly responsible for the low Huemul populations, they will place additional stress on the few remaining animals in all habitats shared by both species. If this stress factor could be eliminated, and simultaneous efforts be made to maintain and enhance suitable Huemul habitat without unreasonable economic sacrifices, it would be prudent to pursue this matter. If not, Huemul will be just another species to become extinct as a result of human interference.

#### THE ECOLOGICAL NICHE SYNDROME

In defending the introduction of exotic species, a commonly used argument in the Americas is that in, comparison to Africa, many ecological niches are unoccupied. This may be supported through prehistoric findings which provide evidence that America sustained a large species diversity prior to the post Pleistocene mass mammal extinctions. This suggests that not sufficient time was available for more species to evolve in order to replace the species which disappeared during the Pleistocene. Therefore, why not fill the unoccupied niches? This may theoretically be a viable option, but it requires intensive baseline research prior to introductions in order to prevent ecological catastrophies as well as documented for many parts of the world.

The "vacant niche" is widespread in Chile and it takes much educational effort to prevent influential politicians and wealthy land owners from introducing prominent trophy animals. Suggestions have ranged from moose and bighorn sheep to African plains animals. Little

consideration is given to native species, which are classified as less attractive. Camelids and native cervids could well be doomed to extinction simply because they do not grow impressive antlers or roar like lions during the rut.

The introduction of an exotic species is not condemned per se, but it is prudent to obtain a species which will not compete with native fauna for the same living space. If competition could result in the displacement of native species, the original motives are unethical. Given the right conditions, exotics can enrich the native fauna and may become a source of food and pleasure in areas with poor representation of native species. This may apply in particular to heavily altered habitats (i.e. agricultural lands and pasture) which become unsuitable for native species, but favorable for those exotic animals which might have evolved in closer relationship with humans. The free-ranging Reddeer populations in Chile may fit this category to the extent that they are able to utilize almost any available habitat, be it climax forest, seral communities, and agricultural or pasture lands; but as indicated previously, they may displace their native counterpart, the Huemul and they may have a detrimental effect on the native flora in areas with high densities. Since Reddeer seem to have poor abilities to self-regulate their numbers, active population management becomes essential.

#### ECONOMIC CONSIDERATIONS

At the 1971 international hunting exhibition in Budapest, the unofficial world record trophy Reddeer came from Argentina. Since then, world class trophies with over 200 International Nadler points have been harvested in Argentina and Chile.

As indicated earlier, favorable climatic conditions (i.e. mild snow-free winters and long growing season with ample well-distributed precipitation) and high quality forage seem to be responsible for the thriving Reddeer populations. Reddeer in Chile is highly prolific and calf:cow ratios of 80 calves:100 females are common for most populations. Natural mortality is low. Predation by mountain lion is negligible since predators are heavily persecuted in all livestock areas. Due to the excellent quality of forage, antler development is astounding. Three point yearlings are common and four to six-year old stags with antlers reaching 180 to 200 Nadler points have been reported from several areas.

Due to the climate, the ecological carrying capacity of Pre-Cordillera habitats exceeds by far the prime European Reddeer areas, where winter is population limiting and where forage quality and availability in winter determines antler growth.

The international demand for trophy stags is high and still increasing. The present demand can only be met with greatest efforts by principally East European countries. The conditions for trophy hunting in Chile are excellent. Although not fully commercialized, landbarons of Southern Chile who are officially registered as Reddeer breeders have

provided international hunting clientele with excellent hunting opportunities. It is not unusual that the same client harvests up to five trophy stags within one trip. The economic returns frequently exceed annual profits from crops and livestock, especially with depressed agricultural markets. The price range for trophies is not as sophisticated as in Eastern Europe, and the price tag is up to the discretion of the respective landowner. Compared to Europe, Chilean trophies are still a bargain.

European traditions in South Chile are strong, the hunting conditions and natural settings are attractive, and hunting success is guaranteed. These ideal pre-requisites for the trophy hunter and the much needed foreign currency are strong arguments for rational Reddeer management.

Breeding Reddeer for meat production and by-products (i.e. velvet antlers for aphrodisiac and hides for fashionable leather clothing) has become popular, especially on fresh-water islands in the south. It has been estimated that Reddeer produce considerably more biomass on native range than livestock due to more efficient forage utilization. Meat prices are higher than for beef, and a local market is readily available in population centres. It is evident that a financially attractive industry could be developed with a well controlled and regulated Reddeer management scheme.

#### NON-COMPATIBLE LAND USE

At present, the only beneficiaries of Reddeer in Chile are the generally wealthy breeders, who can manage Reddeer on their own properties without restrictions. Most of the breeders are cattle and/or dairy ranchers owning large tracts of land. The majority of the rural populace either works for wages on the large ranches and farms, or survive off "minifundos" at a subsistence level. The damage which can be inflicted by Reddeer to agricultural crops is well known. If the crop damage occurs on minifundos, the problems are compounded. In a situation where agricultural crops such as cereal, beets, and rape are intensively managed on minifundos surrounded by extensively managed latifundos with high Reddeer densities and comparably less attractive forage, damage levels have resulted in economic catastrophies for the subsistence farmers.

The subsistence farmer, or any landowner who is not a registered Reddeer breeder, has neither the right to destroy the nuisance animals, nor an entitlement to compensation because the ownership of the free-ranging Reddeer is not determined. This unfortunate dilemma has caused much grief and many conflicts.

Large scale reforestation for wood fibre production with fast growing exotic conifers in Central Chile proved to be incompatible with high Reddeer densities. With short rotations of 15 years, tree crops do not tolerate growth retarding browse pressure in young age classes. Further, any deer-caused mortality of manually planted seedlings is costly and

economically intolerable unless the plantation owner is permitted to either destroy or properly utilize Reddeer on his property. This indicates the urgent need for a proper management and legal solution which has to take all land use forms and proprietorships into account.

#### MANAGEMENT IMPLICATIONS

The current management of Reddeer in Chile is left to the registered breeders although the populations are not kept in enclosures any longer. Poor biological-ecological understanding has led in some areas to densities which, by far, exceed levels of ecological carrying capacities (i.e. most evident on islands); in other areas, sex ratios are unbalanced, or stags are shot too young, leaving insufficient numbers for breeding. In most instances, there is still a noticeable hesitation in culling cows and calves to reduce populations.

To overcome some of the problems, Reddeer breeders and owners of adjoining properties formed an association in the late 1960's to discuss problems of mutual interest, especially with respect to Reddeer populations utilizing seasonal ranges on different properties. Informed members of the association teach newcomers basic rules of management, hunting, handling of harvested animals and the marketing of meat. The structure of the association is adopted from West Germany, where huntingblock lease-holders are required to form a management association. The associations specify lease-specific annual harvest by sex and trophy size.

The Chilean Reddeer Association should be treated with some skepticism. Because it is mostly composed of wealthy landowners with political clout, the association can lobby its interests much more effectively than non-members and owners of minifundos who are less organized and do not have the political clout.

It would be desirable that the interests of both groups be equally represented in reform attempts. As a first step, Reddeer should receive "game" status. This would identify public ownership and would place the species under government management jurisdiction. In this fashion, hunting pressure on public and private lands could be manipulated as necessary. In a second step, rights for economically attractive trophy hunting on public lands should be defined. As a third step, detailed management guidelines should be developed with contingency plans for potentially conflicting land use forms. The overall authority for Reddeer management should be assigned to a capable government agency to be assisted by private individuals or associations.

In summary, the sooner the legal status of Reddeer in Chile is identified, and the sooner a clear policy concept on the future management of the species can be defined, the easier inherent problems can be overcome. It is apparent that the chaos is aggravated with steadily increasing Reddeer populations.

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1984 ELK WORKSHOP SUMMARY

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I have approached this job with some level of reluctance. I have not formally summarized a conference before; I think I now know why, having spent the last hour trying to summarize about twenty-five pages of notes. I am not sure that taking notes over the last two days was really the proper approach to trying to summarize the results of a conference, or "workshop", of this nature.

Certainly, it is impossible for me, within an hour, to summarize for you the things we have learned in the last two days. I think that has to be left for each of you to do on your own, and I am sure you all will. We have dealt with a vast array of topics, something which is different from the usual concept of a workshop where there is a more common and specific theme to the presentations. That causes me some degree of difficulty in trying to summarize what has happened, but on the other hand it provides a breadth of experience and information we could not get from a more singular thematic type of workshop.

We have had excellent papers presented to us! I have been to many conferences over the last 20 years or so; as a group these papers were some of the better ones I have heard anywhere. I say that as a congratulatory message to the various authors. You have done an excellent job in your presentations, and as has been mentioned by the chairmen of the sessions, all within your time allotment as well.

Just as a quick review of some of the things we have talked about - these are, perhaps, groupings or highlights that I have picked out:

Depredation is a major issue, obviously, to almost all jurisdictions which are managing elk today. There was a statement, which came from the audience, that we should all remember: somebody stood up and said "Feeding is a disease". I can assure you, all of you who are from outside of Alberta, that Alberta is showing symptoms of that disease as well. I have serious doubts that feeding is really a long term solution to depredation problems or a solution that we want to get heavily into. It is certainly one which is open-ended in what it can lead to, in terms of cost, in terms of dealing with other species besides elk, and so on.

We have had a number of papers on topics which can be grouped as habitat issues. Much of the work which we do in managing elk is trying to maintain the critter in the face of development of many kinds and magnitudes. All jurisdictions feel these pressures. In talking to some of you about everything from golf courses and ski developments, to condominiums and just plain urban sprawl, I detected that everywhere elk

populations face permanent damage from developments which are basically just part of the growth of society and growth of industry and growth of human populations. Many of the papers which were presented also dealt with these issues. I am pleased to see that the data on which we have to base our opinions and our positions are improving. Every time I come to a conference of this nature somebody else has more detailed information about the impact of various levels of development or activity, be it from roads, logging activities or human harassment. Harassment is one issue which is of particular concern to me. It has become an obvious problem in the last few years and it is encouraging to see that people are beginning to work on it now. We are getting more details about how much of these sorts of things can be tolerated by elk populations. These are extremely important facts especially for habitat biologists who are often dealing with industrial interests in trying to work out compromises that will allow elk populations to survive in particular areas.

We had some intriguing presentations on the use of computers for habitat evaluation. I can see this as an excellent future tool for habitat biologists. They can plug in several of these criteria and get out an answer that will help predict responses of animals to a particular development. A major step forward!

Economics. Again, from discussions I have had, and from at least one paper presented here, I would like to remind you (although I suspect I really don't need to) that it is very very clear that the value of the resources that we are charged with managing is phenomenal. The actual figures - in Alberta we are looking at about a \$22 million value assigned to elk hunting alone. When I listen to some of the statements of representatives from Colorado and Idaho where they are talking about elk populations in excess of 100,000, those economic values are just unreal. The point I want to leave you with is that we shouldn't have to take a back seat to hardly any development, hardly any activity, when it comes to the economic value of our resources. That is just one species, ladies and gentlemen. It is also a renewable thing, that is a value which goes on year after year after year. Very often the things that we are competing with are not renewable resources.

Interesting papers on artificial insemination, and improvements to census techniques. We have had many insights into problems in other areas. I was especially intrigued with a presentation on red deer in Chile. Every time I come to a conference of this nature I always look forward to perhaps one highlight paper, one which "catches my fancy" more than any other. I think that that paper in this conference - it was actually two papers - dealt with DAPA. Mr. Davitt, congratulations, you did an excellent job of presenting difficult material and you took us through it step by step very nicely. It is a new technique for the future which excites me considerably.

Our guest speaker at last night's banquet, Valerius Geist, always delightful. Well, exhausting! Every time I talk with you, Val, I end up exhausted by the experience. It was a little easier to sit back in an audience and just listen. I have nothing more to say about the

presentation other than that it exemplified Wishart's suggestion that this man has "fast neurons".

The panel discussion which Bob Hudson set up did a fine job of probing the issues surrounding game ranching. A challenging panel, an enlightening panel. They covered many aspects of game ranching, another issue which is sitting on our doorsteps and about which all of us should become familiar.

I certainly was not aware of everything to do with this subject and I found the panel to be a very useful three hours.

The detailed discussion generated by the individuals on the panel and from the crowd afterwards exemplified the type of discussion which we should be trying to capture in all aspects of the workshop. I'm not sure that we were always successful in doing that, perhaps because of lack of time for questioning from the audience and for interchange with the speakers. I would challenge future workshops to try to capture that detailed discussion for all papers.

In conclusion, a few thoughts which came to mind as I was listening to papers and presentations over the last few days. I asked myself the following questions:

What is the purpose of a workshop such as this? What do we want to get out of it? And were we successful in doing it?

The first thing I put down was - a recharging of my brain. It has been about twenty years since I was in University, and it gets a little slow and rusty at times. This is one of the few opportunities that I have to again sit down and listen and apply my mind to scientific papers being presented. I certainly appreciate that, as I think most everyone else does. It is a chance to go back to school, a short-term sabbatical.

I often wonder why it is difficult for some people to get to these things, or why agencies don't send more than one or two people to them, particularly the home agency. I can't think of a better investment in terms of recharging biologists than a meeting such as this where in quick order they can be refreshed about, in this case, elk, and be brought up to date on the current thoughts, concerns and issues surrounding that species.

This workshop provides an opportunity to meet and talk with people from many jurisdictions which manage elk populations. That is another thing I consider of major importance from a workshop. Again, we have been successful. That opportunity has been presented, and has been taken advantage of. To all of those people I have spoken with, when I wasn't taking notes, I thank you for your time and just the opportunity to speak with you. It is amazingly refreshing, amazingly educational. If anything by way of criticism, I would say perhaps there was not enough time in this workshop for that kind of communication on a one-to-one basis.

Some things that come through loud and clear are the similarities of problems that are being faced by jurisdictions from all over North America. It is interesting that the problems of elk depredations in Colorado, Idaho, Oregon, Wyoming, and Alberta are in many ways the same, and reassuring that our approaches to solving those problems are also very much the same. It also came through loud and clear that while there are many similarities there are also many differences, and we have to be awake to those differences - that certain things which apply in a warm climate, for example, may be totally irrelevant in a climate such as we have here in Edmonton. Again, a reminder to all of us that in biology the exception is the rule.

As professionals we should not be too quick to jump on a bandwagon, no matter what that bandwagon might be. I noted the word "bandwagon" relative to several presentations through this meeting. One of them was the concept of winter feeding. Another was the game ranching issue. It is important for a gathering like this, for a workshop, to be an opportunity to probe ideas, to discuss them in detail, to argue about them if we will. Some of the best arguments may come three or four hours from now over a bottle of beer in the lounge, but that part of the program is very very important. It concerns me somewhat when I see biologists getting too quickly onto a bandwagon, because this is a new thing found just yesterday, the latest idea, this is IT. Let me remind you that it isn't always IT. It takes time before things are in fact proven, before we can be certain we are in the right track. If we look critically at our history we can find many situations in which we have oversold issues by jumping on bandwagons too quickly and pushing them too hard, only to find out down the line that we weren't right after all. There are two examples that come to mind; winter feeding and predator control. The opinions and views that are being discussed now are very different from the things we were talking about ten or fifteen years ago. When I went to school I was generally brainwashed that neither should be considered at all. We are now beginning to see that maybe that wasn't totally correct. I'm just suggesting that you don't flip-flop too far, too fast, without some considerable thought put into it.

I suspect all of us have been put into the situation of defending a position with which we don't agree, but because of our position, our employment, we are forced into perhaps writing a letter or attending a meeting to defend a position which is most unpopular to us. It is a difficult situation to be in, but what frightens me is that after doing it two or three times you find yourself believing those positions yourself - you climb on the bandwagon. During this meeting I've talked to a number of people and found them basically defending positions which I am sure, if they sat back and thought about them, that they don't believe, themselves. So again, it is important for us not to be too quick to jump on the bandwagon. Let's keep an inquisitive mind and always ask the question - is this really correct, or is it not? Our purpose as biologists, as professionals, as scientists, is primarily to seek out the truth, not necessarily to sell a political viewpoint that happens to be popular at any point in time.

The next elk workshop has been awarded to ... taken by ... accepted by ... the state of Oregon. I wish the best of luck to our Oregon colleagues in their efforts to put on a top notch elk workshop two years down the line.