A CASE STUDY FOR SPECIES REINTRODUCTION:

THE WOLF IN OLYMPIC NATIONAL PARK, WASHINGTON

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A Student Originated Study
funded by
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ABSTRACT

The gray wolf (Canis lupus) was eliminated in the early 1900's from the lands that now comprise the Olympic National Park, Washington, and surrounding area. This study sought to determine the biological feasibility of reintroducing the wolf to this habitat. Investigation of the ecological effects of such an action included study of the history of the wolf on the Olympic Peninsula; testing of the pellet-group count census method for estimating Olympic ungulate populations; and development of a computer model simulating a reintroduced Olympic wolf population in its former habitat. Historical evidence supports the fact that wolves did at one time exist in the Olympic Mountains and surrounding natural communities. It is shown that altered Olympic ecosystems would offer reintroduced wolves a biological advantage and that the Peninsula still has the capacity to support a stable wolf population. Results indicate that the pellet-group count technique of estimating large ungulate populations can be effectively modified for use in the Olympic Park wilderness. Determination of numbers of elk and deer could be made by combining other census methods with the pellet-group survey in the Park. Ten year runs of the computer model show that wolf predation would not be the major factor controlling numbers of Olympic ungulates. Results also show that after reintroduction, wolf numbers would increase very slowly. Reintroduction of the wolf to the Olympic National Park is biologically feasible. However, study of the desirability of such an action is necessary to determine the probable success of wolf reintroduction.

INTRODUCTION

The gray wolf (*Canis lupus*) was once one of the most widely distributed predators of large mammals in North America. Since the advent of white settlement on this continent, the wolf's range has steadily declined. Today the wolf survives in less than one percent of its former range in the conterminous United States, although substantial populations still exist in Alaska and Canada (Mech 1970). Figure 1 shows the former range of the wolf from which it has been extirpated.

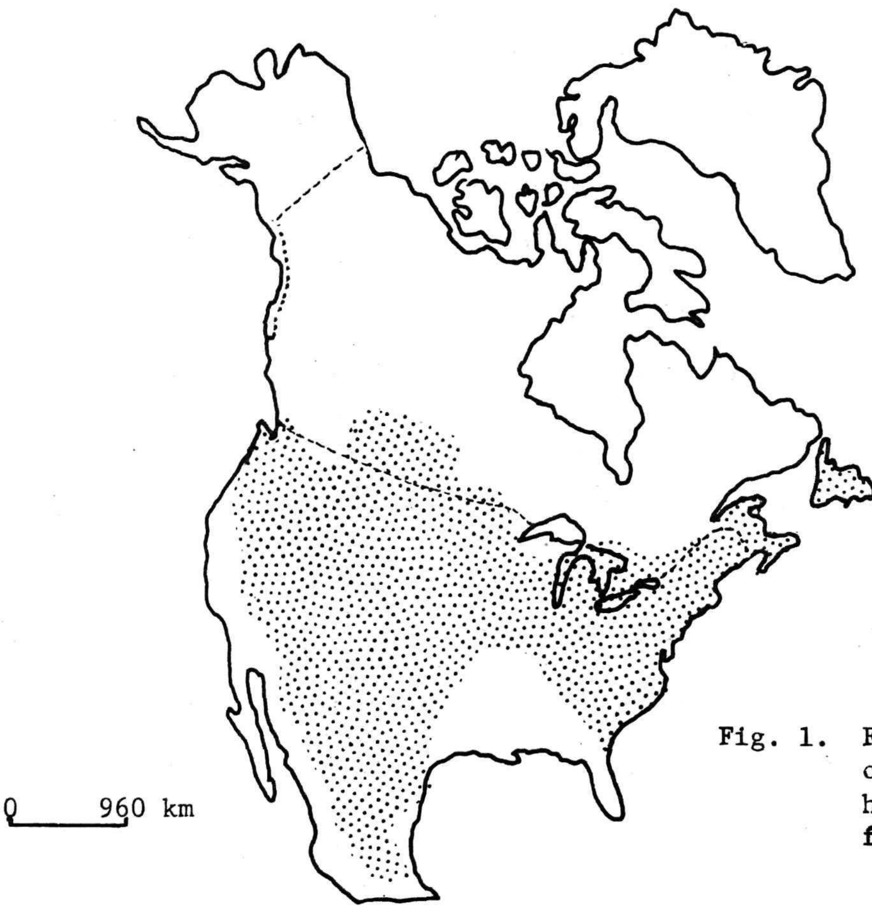


Fig. 1. Former North American range of *Canis lupus* from which it has been extirpated (modified from Mech 1970).

Within Washington State the Department of Game maintains that the wolf is nearly extinct (Game Management Division 1975). There is some evidence that a few wolves may inhabit mountainous areas near the Canadian border (Layser 1974; Nowak 1974), and occasionally wolves from more populated ranges in British Columbia travel into Washington. This appears to have been the case in January 1975 when a lone wolf was shot in Washington aproximately 112 km from the Canadian border. It was the first wolf shot in this state since 1951 (Dratch 1975). On the Olympic Peninsula it is believed that the wolf was exterminated prior to 1930 (National Park Service 1974a). In Washington State the wild wolf is classified as a "protected species", and unless the animal is damaging property it is illegal to kill, trap, or hold it in captivity.

Currently there is awakening interest in this country in re-establishing the wolf and other endangered or threatened species to habitats which they once utilized. However, substantial disagreement exists over the societal value of wolves. We believe that there are reasons to argue for the survival of the wolf as a species. Mech (1970) has examined the significance of the wolf in the biological community and explains that "...in addition to controlling or helping to control large numbers of plant eaters, the wolf also tends to cull out prey animals that are the most poorly adapted for survival. The significant contributions of the wolf to the stability of natural communities are of sufficient value that on these grounds alone man should spare the wolf from extinction wherever the animal does not seriously conflict with livestock interests.". Ethical, as well as biological considerations are important when debating the fate of a species. This is reflected in the International Union for the Conservation of Nature (IUCN) Wolf Mainfesto which in its first principle states: "Wolves like all other wildlife, have a right to exist in a wild state. This is in no way related to their known value to mankind. Instead, it derives from the right of all living creatures to coexist with man as part of natural ecosystems." (IUCN 1974).

Reasons exist to argue for the survival of the wolf as a species, and to insure that survival in the conterminous United States consideration must be given to re-establishing the wolf in suitable habitats. Our study sought to determine the feasibility of reintroducing the wolf to its former range in Olympic National Park and surrounding undeveloped lands.

We are not the first to suggest that consideration be given to reintroducing the wolf to the area. Noted biologist, Adolf Murie (1935), in recommendations submitted to the Park Service suggested; "That consideration be given to introduction of the wolf, which was a part of the fauna but is probably now extinct.". Again in 1937 J. C. Carpenter (1937), a sport hunter, proposed that, "...the introduction of a pack of timber wolves on the Peninsula would probably be the best conservation method at this time.". The National Park Service (1974b), in its Draft Master Plan for Olympic National Park, briefly considered the problems associated with a wolf reintroduction and concluded that serious study was needed to determine the adequacy of the area for sustaining a breeding population of wolves.

Goals

The research project, in an attempt to investigate the many aspects of this intricate biological question, had several broad objectives:

1) to collect data from the recent literature and develop from it a computer model to simulate a reintroduction of wolves to Olympic ecosystems.
2) to investigate the history of the wolf on the Olympic Peninsula.
3) to evaluate the feasibility of using the pellet-group count census for estimating populations of ungulates in Olympic National Park.
4) to evaluate the ecological effects of a wolf reintroduction on Olympic Peninsula ecosystems based on a computer model and pertinent literature.

Previous Reintroduction Attempts

Four documented wolf reintroductions have been attempted in this country. Three of the cases involved the transplantation of human raised or zoo wolves (Henshaw 1973, Mech 1966, Merriam 1964). In two of the cases, in Umiat, Alaska, and on Isle Royale, Michigan, the wolves were apparently attracted to human habitations and seven of the original nine released wolves were eventually recaptured or shot. In the third attempt in 1963 on 92 km^2 Coronation Island, Alaska, four captively raised wolves were released. These animals learned to prey on black-tailed deer (*Dama hemionus sitkensis*) and multiplied to create an abnormally high wolf density on the small island. By 1971 it was believed that no wolves remained on the island (Alaska Department of Fish and Game 1971). The most recent reintroduction attempt involved the transplantation of four wolves from northern Minnesota to northern Michigan (Weise et al. 1974). All four wolves were killed by humans within a year. Results of this study did indicate that wild wolves can be transplanted to a new range but that their initial wanderings may carry them beyond release zones. The researchers noted that the most important factor in the demise of the wolf was the accessibility of the area to humans and human attitudes towards wolves.

THE STUDY AREA

Size

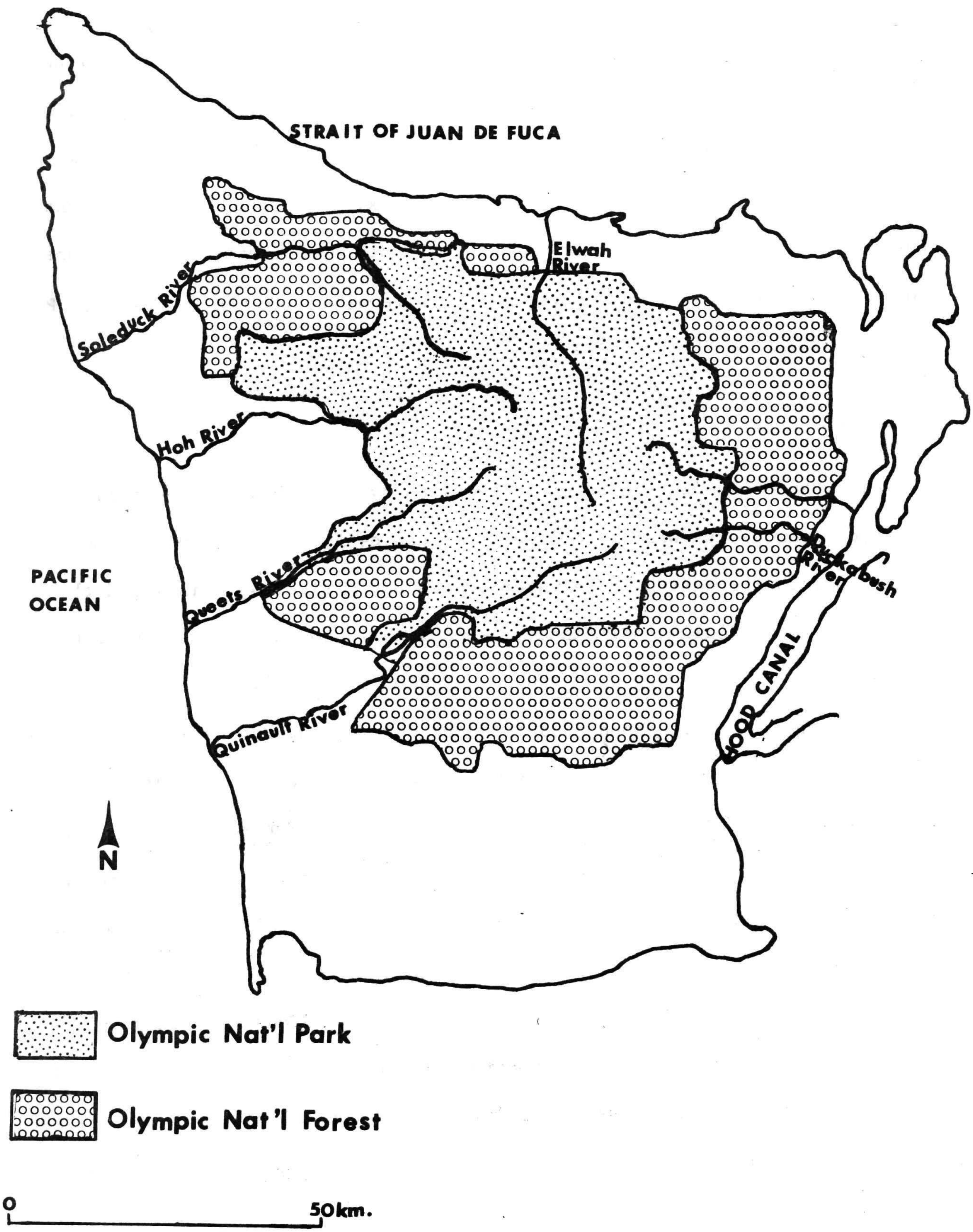
The 10,360 km^2 Olympic Peninsula occupies the extreme northwest corner of Washington State (47° N Latitude; 124 W Longitude). Large tracts of public wilderness and forest lands make up approximately 60% of the area on the Peninsula. This includes Olympic National Park, 3600 km^2; Olympic National Forest, 2360 km^2; and more than 500 km^2 of state owned lands. Large timber companies own a considerable portion of the remainder of the Peninsula. Public land ownership is shown in Figure 2.

Topography

The Peninsula is bounded on three sides by major bodies of water: the Pacific Ocean to the west, the Strait of Juan de Fuca to the north, and the Hood Canal to the east. These water bodies have effectively isolated the Peninsula biologically, politically, economically and socially from much of the state.

The rugged Olympic Mountains form the core of the Peninsula. They rise gradually from a narrow coastal plain to a height of 2390 m and drop more abruptly to a narrower plain to the north and east. The region has a complicated geologic history and the dissected topography reflects the forces of the most recent glacial activity upon the uplifted sedimentary and igneous rocks formed in an ancient shallow sea. Radiating from the interior mountains is a system of ten major rivers. On the west side of the mountains these river valleys display the characteristic broad U-shaped configuration typical of glaciated troughs. On the east and north sides the valleys have much steeper gradients and are narrower.

FIG. 2. **OLYMPIC PENINSULA**



Climate

The climate of the Olympic Mountains is noted for long periods of rainy and cloudy weather. Prodigious amounts of rain (80 to 200 cm per year) fall in the winter months, especially in the western valleys. Above approximately 750 m this precipitation occurs primarily in the form of snow ranging in depths from 18 cm to nearly 6 m. The snow levels to a great extent influence elk and deer movements and define wintering areas on the Peninsula.

Vegetation

The abundant precipitation and cool, moderate climate have contributed to the development of immense coniferous forests in most low lying areas of the Peninsula. Along the western coastal plain are forests representative of the lowland temperate forest zone, characterized by climax forests of western hemlock (*Tsuga heterophylla*) and western redcedar (*Thuja plicata*). On the floors of the major ocean facing river valleys grow one of the most unique forest ecosystems to be found on the continent, the temperate moist coniferous forest; predominately comprised of Sitka spruce (*Picea sitchensis*) and western hemlock.

River terrace development in these valleys is expressed in variations of vegetative type as one moves away from the river (Fonda 1974). Lower terrace zones support early seral stages of the climax forest including red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*), and vine maple (*Acer circinatum*). The river bottoms are extensively utilized by elk, especially as winter range (Schwartz 1939).

The montane forest ecosystem is found on higher slopes and on the leeward side of the mountains: Pacific silver fir (*Abies amabilis*), Douglas-fir (*Pseudotsuga menziesii*), and western hemlock are the primary species.

In all three of the described vegetative zones, understory species such as salmonberry (Rubus spectabilis), huckleberry (Vaccium sp.), sword fern (Polystichum munitum), and salal (Gaultheria shallon) serve as important food sources for ungulates (Skinner 1936).

The treeless alpine zone, which includes about 13% of the National Park, lies above about 1650 m. Short lived grasses, forbs, and sedges make this and the upper divisions of the montane zone primary summer range for migrating elk herds as well as deer, mountain goat and black bear.

Mammals

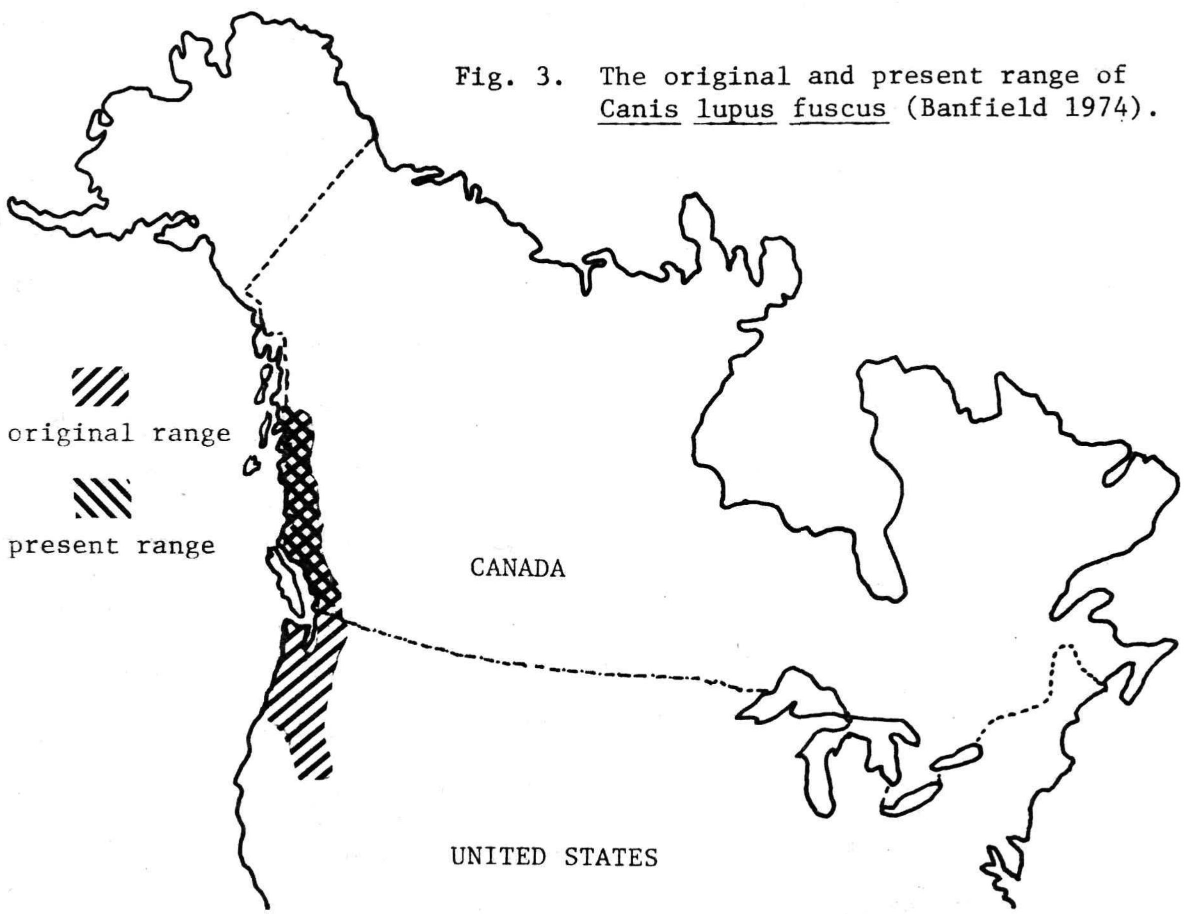
All of the described vegetative zones, as well as the logged areas surrouding the National Park, provide habitat for 54 species of mammals (Johnson and Johnson 1952). These include populations of black-tailed deer (Dama hemionus columbiana) and mountain goat (Oreamnos americanus). In addition, the Park and surrounding areas provide habitat for the largest population of Roosevelt elk (Cervus canadensis roosevelti) in the United States (Fagerlund 1954). Predators not exterminated with the wolf include cougar (Felis concolor), coyote (Canis latrans), bobcat (Lynx rufus) and black bear (Ursus americanus).

THE HISTORY OF THE WOLF ON THE OLYMPIC PENINSULA

The Olympic Wolf

Before the onset of white settlement, _Canis lupus_ apparently inhabited most of the North American continent above 20° North Latitude (Goldman 1944), and except for tropical rainforests and arid deserts it made wide use of most habitat types (Mech 1970). According to Hall and Kelson (1959), 24 subspecies of wolves once existed in North America. Goldman (1944) concluded that the subspecies of wolf which inhabited the western coastal forests from northern California to southeastern Alaska was _Canis lupus fuscus_ Richardson 1839. The present range of this subspecies is apparently restricted to western coastal British Columbia and possibly some of the islands of southeastern Alaska (Figure 3).

Fig. 3. The original and present range of _Canis lupus fuscus_ (Banfield 1974).



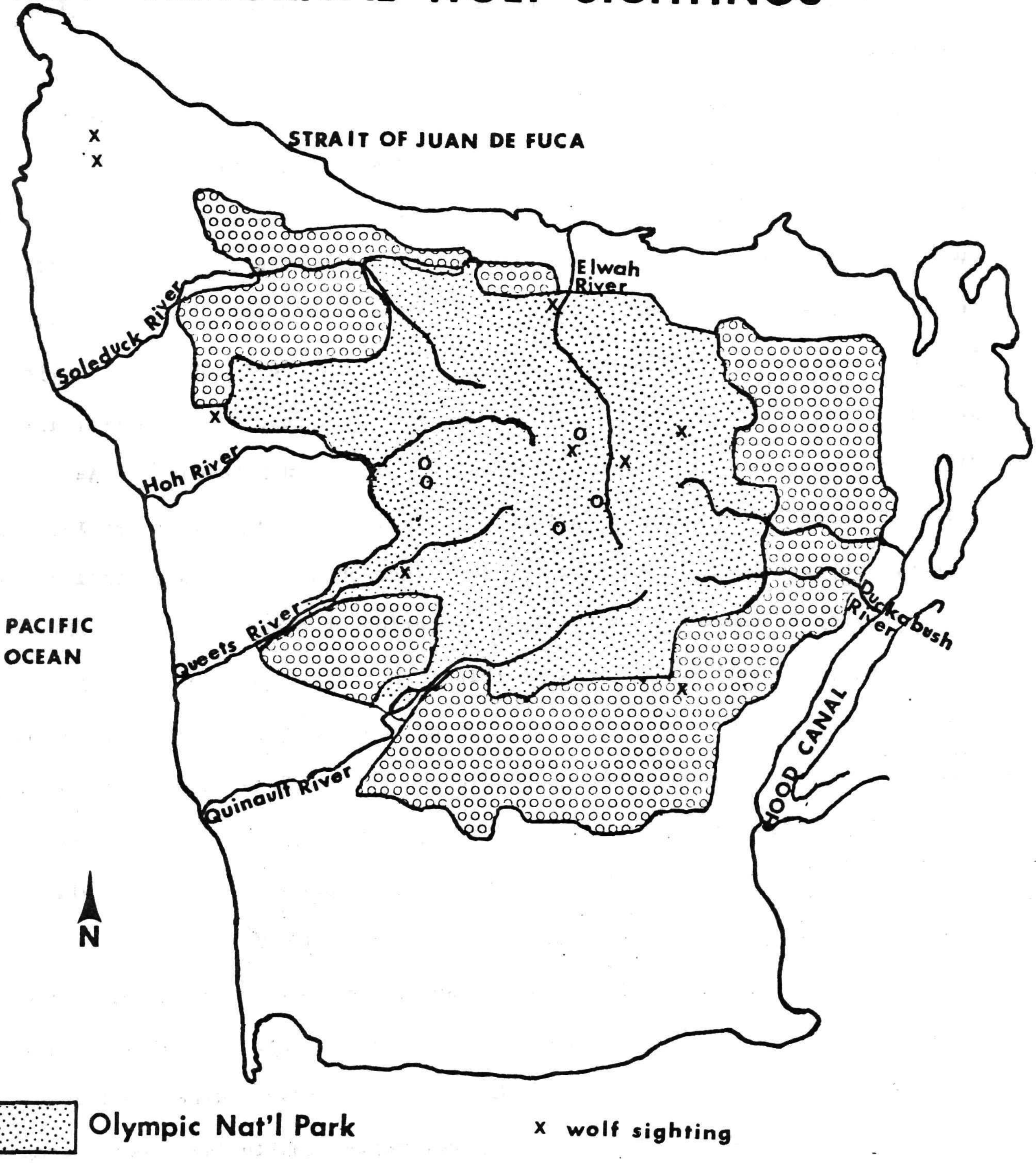
The classification of wolves of this subspecies is difficult however, especially at the interface between ranges where intergradations commonly occur. The wolf that existed on the Olympic Peninsula was described as Canis lupus fuscus based on two specimens taken from the Olympic Mountains in 1897 and 1920 (Scheffer 1946). Skulls of these specimens are presently catologed in the National Museum as numbers 93000 and 241614 (Setzer 1975, pers. comm.). The positive determination of the precise subspecies which inhabited the Olympics as well as the location of current populations that could serve as reintroduction stock is difficult to ascertain. The problem has been described by Klein (1975, pers. comm.) as follows: "...it is difficult to say whether C. l. fuscus is a valid subspecies, and whether it or C. l. ligoni occurs in southeastern Alaska. I suspect that there is not justification for distinguishing more than one subspecies within the area from the Olympic Peninsula to and including southeastern Alaska.".

Historically, subspecific classifications have been most often based on gross morphological characteristics . The distinguishing feature of C. l. fuscus seems to be its reddish pelage and its medium size (Goldman 1944, Scheffer 1946). Various persons who actually believed that they encountered wolves in the Olympics prior to 1920 characterized the medium sized animal as having distictly reddish legs, especially during the warmer summer months, and it was locally known as "red legs" (Richmond 1975, pers. comm.). However, there are other people who maintain that the animal was "...a huge grey wolf..." (Dalquest 1948), or "...the largest of his species..." (Adams 1946). One early trapper recounted his sighting of a black wolf to biologist Olaus Murie in 1917 (Murie 1917). It is likely that variations in morphology and seasonal differences in pelage might account for the disparity in these descriptions.

White settlement of the Olympic Peninsula did not occur in earnest until about 1890. Prior to this time coastal Indian tribe legends reflect the existence of wolves as important forces in the ecosystem (Morgan 1955, Young 1946, Ernst 1952). During the early white settlement of the region wolves were described as "numerous" or "very abundant" in the Olympic Mountains (Scheffer 1946). Between 1890 and 1920 the early settlers began an ambitious campaign to eliminate all predators from livestock producing areas: the wolf represented a real or imagined threat to their families, livestock and hunting success. Their use of traps, guns and strychnine-baited carcasses effectively reduced wolf and cougar populations in the area (Lewis 1975, pers. comm., Richmond 1975, pers. comm.). During this time numerous sightings of wolves, primarily in small groups or family units have been reported (Scheffer 1946, Mills 1975). A list of these sightings is included in Appendix A. As in all historical documentation, the factual reliability of these sightings is, to a degree, questionable. Plotting these sightings on a map gives an indication of wolf activity in the Olympics during this period of predator control (Figure 4). The estimates of wolf populations at this time suggest that 40 to 60 individuals existed in the Olympic National Forest Reserve (presently Olympic National Forest and Olympic National Park) in 1918 and 1919. These approximations were made by Chris Morganroth, Regional Forest Service Ranger, and the United States Biological Survey (Scheffer 1946). All existing data imply that, aside from human control, this population was a stable one.

In 1917, a United States Biological Survey employee, naturalist Olaus Murie, was sent to the Olympics to eradicate wolves. His journal indicates that few wolves existed in the Elwah Valley at that time and he was forced to offer his resignation due to lack of subject matter (Murie 1975, pers. comm.). Communications with some of the original pioneers in the area indicate that wolves were nearly eliminated by 1915 (Gwin 1975, pers. comm., Lewis 1975, pers. comm., Peterson 1975, pers. comm.). In 1920 the last documented wolf

FIG. 4 **HISTORICAL WOLF SIGHTINGS**



Olympic Nat'l Park

Olympic Nat'l Forest

x wolf sighting

o wolf tracks

1897 - 1937

0 50km.

killed in the Olympics was one which was trapped by Grant Humes on the Elwah River (Scheffer 1946).

It is entirely possible that small numbers of wolves continued to survive in the remote, relatively unexplored interior mountains for some time (Osborn 1975, pers. comm.). Little is known about the social effects of persecution on small, isolated populations of wolves . With what we know of wolf mortality in the wild, it seems likely that the very few surviving wolves roamed as loners or scattered pairs in the interior mountains and that a reproducing population was never again established. Another hypothesis presented by Dalquest (1948) is that the already decimated population was destroyed by a social disease such as rabies. Since 1930 there have been reports by various persons of wolf sightings in the Olympics, even as recently as ten years ago. These reports are included in Appendix B. Although there is a possibility that a few wolves still survive in the most remote sections of the Peninsula, it is generally believed that the wild wolf is extinct in the Olympics (National Park Service 1973).

During the time that an unpersecuted wolf population existed on the Peninsula the animals probably exhibited similar population characteristices as wild wolves in equally varied and rugged regions today. The primary prey species of the wolf was probably black-tailed deer and Roosevelt elk, both apparently common on the undeveloped Peninsula (Bailey 1911, Elliot 1899, Hult 1971) although the uncut climax forest did not sustain as large a population as is now supported by the vegetative communities resulting from intensive forestry management on the lands surrounding the Park (Newman 1954, Pimlott 1967). Until the early 1900's the prey populations probably fluctuated little, contributing to predator population stability as well. As settlers demanded more of the ungulate populations for food and trophy a rather severe stress was placed on the elk population, which in 1904 was estimated to number no more than 2000 (Jones 1953). At this time laws were enacted to protect the elk, both by banning hunting and by creating a refuge for them in the new Olympic National Monument. Elimination of predators was simultaneously encouraged as has been seen earlier, contributing in 1916 and 1917 to an overpopulation of elk on certain ranges. From 1917 to the mid-1930's the elk population exibited extreme fluctuations. In 1933 a hunting season was established on non-Park lands, thus providing an effective artificial control on elk populations in those areas.

Changes in Olympic Ecosystems

Major changes in the Olympic ecosystems have occured since the wolf's demise. First, logging of Olympic Peninsula forests has resulted in periodic increases in numbers of ungulates since 1920 (Graf 1955, Kuttel 1974, Schwartz and Mitchell 1945). Secondly, establishment of the Olympic National Park in 1938 resulted in the creation of a sanctuary for predators; artificial human control of predator numbers is presently prohibited within the National Park boundaries. Both of these changes have resulted in improved conditions for a potential wolf population. We believe that these altered ecosystems would offer the wolf a biological advantage, and would contribute to maintenance of wolf numbers in a naturally stable state.

PREY POPULATIONS

In order to determine the effects of wolf predation on the existing Olympic Peninsula ecosystems it was necessary to know something of the population dynamics of the primary prey species. As has been stated by Pimlott (1967): "Obtaining accurate data on the two basic variables, predator and prey densities, has proven to be the principle stumbling block to understanding the influence that wolves have on prey populations. It is mandatory, if we are to gain an understanding of the processes involved, that we continue our efforts to develop census methods that will provide accurate data at costs that are economically feasible."

Our study of ungulate populations took two primary directions.

1) In an effort to develop an efficient and feasible method of estimating ungulate populations within Olympic National Park, of which no recent studies have been done, we modified the pellet group census technique as described by Robinette et al. (1958) and tested it in the National Park.

2) We realized that the results of the pellet census, being necessarily limited by time and personnel available under this grant, would not provide us with estimates of ungulate populations in the 3600 km^2 Olympic National Park. For that reason we collected the most reliable qualitative estimates of Park ungulate populations as well. These estimates, coupled with population figures for lands surrounding the Park as based on hunter harvest data, provided the figures needed in the computer simulation.

The Pellet Census

Introduction The pellet group census has been described as, "...the process of estimating by fecal group counts the actual or relative numbers of big game animals, or their days of use on a given area" (Neff 1968). In using the

the method a study area is defined, and the density of pellet groups is determined for it from which an estimate of the total population can be calculated. The technique has been found useful in determining trends in and actual populations of deer and elk in various habitats throughout the United States (Dasmann and Taber 1955, Eberhardt and Van Etten 1956, McCain 1948). During the past five years the University of Washington has been conducting a pellet census on the Cedar River Watershed in western Washington and results have proven comparable to those obtained by aerial censuses and from the use of the Lincoln index (Taber 1975, pers. comm.).

The pellet census was chosen for this study for several reasons including: time, person-power, topography of the area, average sighting distances in the areas (limited observations possible), and funds available. Perhaps most importantly we chose the method in light of the recent proposal to include over 97% of Olympic National Park in the National Wilderness System. We believed that this technique would have little detrimental effect on the wilderness qualities of the area. It was our attempt to minimize the obtrusiveness of our study sites to Park visitors and wildlife that made this study unique.

Site Descriptions Within Olympic National Park three study sites were established (Figure 5) reflecting three distinct habitat types in the Park; moist temperate, montane, and sub-alpine. Descriptions of these sites are included in Table 1. Maps of the individual study sites can be found in Appendix C.

In the site selection for the pellet census, several criteria were considered important including; positive knowledge of elk and deer populations on the study area, ability to locate the area on a map, and accessibility by means of a trail. It was also advisable to locate the lowland sites along a section of river which displayed a consistant general trend thus maximizing the habitat variability.

FIG. 5 **STUDY SITES FOR PELLET - GROUP CENSUS**

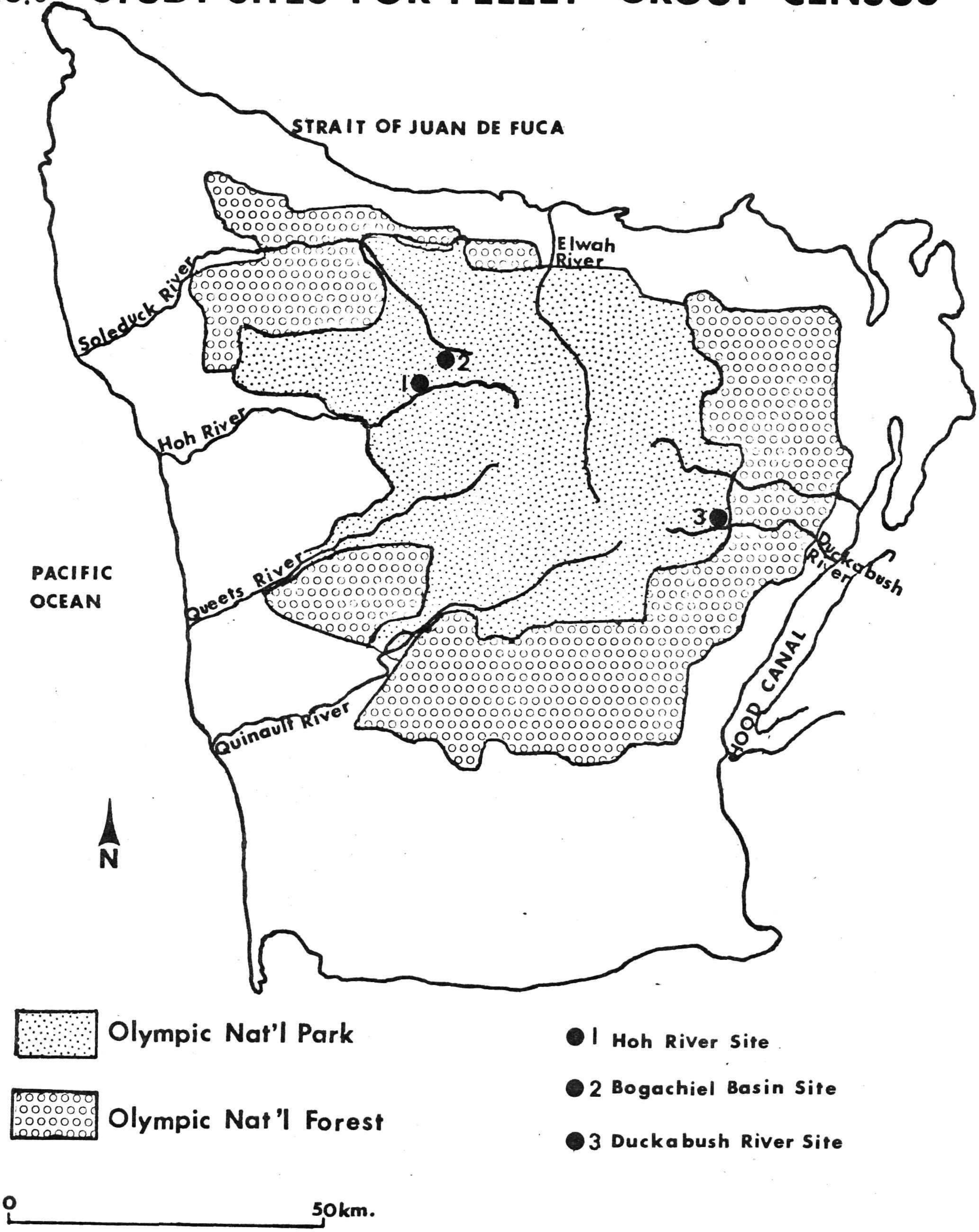


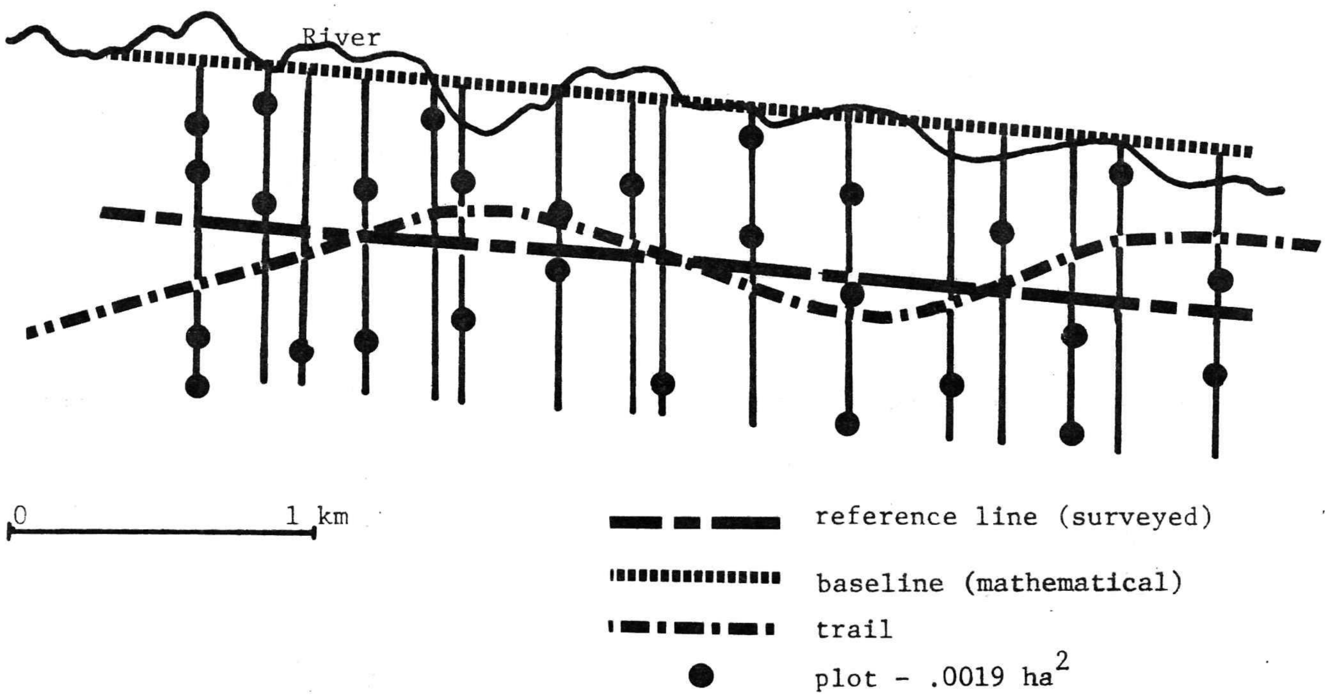
Table 1. Descriptions of the three pellet group census study sites

FEATURE	HOH RIVER	DUCKABUSH RIVER	BOGACHIEL BASIN
Location	T27N,R9W sec. 1 and 2 (parts)	T25N, R4W	T28N, R9W
Access	Hoh Trail	Duckabush Trail	Soleduck Trail
km from trailhead	12 km	14 km	9.6 km
Side of river	north	north	headwaters
Elevation	210 m	360 m	1290 m
Size	150 ha	100 ha	50 ha
Topography	broad valley	narrow, steep-walled valley	high elevation basin
Vegetative zone	moist temperate	montane	sub-alpine (upper montane)
Average annual precipitation	350 cm	225 cm	unknown
Site established	8/12/75	7/20/75	9/9/75

Methods The sizes of the study sites were calculated by using the number of person-hours available while considering the density of plots needed for the desired accuracy. Both the Hoh and Duckabush River Sites were mapped using the pace and compass technique (Greenhood 1951). The existance of an adequate USGS topographic map for the Bogachiel Basin Site made this unnecessary.

In our study sites we established a 2-stage random sampling system (Poole 1974), the primary unit being the randomly spaced transects, the second stage involving sub-sampling plots along the transects. Figure 6 illustrates the basic sampling system used in all three sites.

Figure 6. A schematic diagram of the sampling system used to establish three pellet group censusing sites in the Olympic National Park.



The baselines from which transects were extended were established parallel to the general trend of the river. Due to the topography and thick vegetation of the areas along the river, the beginning point of each transect (point closest to the river) was derived mathematically from a reference line established near the access trail. It was surveyed by pairs of researchers using tripod-held Bruntin compasses and meter tapes. Computer generated random points through which the 16 transects were extended were marked and the distance to the trail and to the river edge measured. The transects, varying in length from 500 to 750 m, were approximately perpendicular to the contours of the area for maximum variability in sampling((Robinette et al. 1958). Numbered stakes were driven into the ground within two meters of the hiking trails at the point of intersection by the transects. Descriptions and measurements of transect trail crossings were recorded for relocation (Appendix D).

The beginning point of each transect (baseline) was mathematically established using the reference-line-to-river and reference-line-to-trail distance. In this way the beginning point of each transect was placed as close as possible to the river while still enabling the precise measurement of the study area. Circular plots with a 2.5 m radius (.0019 ha^2) were randomly located on the transects utilizing computer generated random numbers, hand held compasses, and meter tapes. Pacing was used when the use of the tape was not feasible. The density of the plots was dependent on several factors including:

1) the density and distribution of pellet groups
2) the size of the area to be sampled
3) the size of the sample plots
4) the sampling accuracy desired (Robinette et al. 1958).

In the center of each plot a 30 to 45 cm wooden stake with an attached metal tag was driven into the ground. Minimal red and blue overhead flagging, in keeping with the low impact aspects of the study, was used to mark the plots for relocation. An explanation of the specific sampling system used in each of the three sites is included in Table 2. At the time of establishment of the census area, recently deposited pellet groups, when encountered, were placed in various habitats, measured, and described to provide a reference to pellet group deterioration. Each circular plot was cleared of pellets in a manner described by Fairbanks (1975, pers. comm.). Coverage of vegetative species as well as surrounding vegetative community types were recorded for each plot for future reference. Signs of wildlife use (browse, game trails, tracks, old pellet groups) were noted.

The sites were revisited during leaf fall 10 weeks after establishment. Plots were checked for new pellet groups according to the searching process used by Rogers et al. (1958), to minimize observer bias. Boundary groups or scattered groups were included in the count if more than one half of the group fell within the boundary (Robinette 1958). A group was only counted as such if more than five similar pellets were found together (Bowden 1969). All pellet groups were identified by species and recorded. The time necessary to relocate each plot was noted.

Table 2. Sampling system used in the three Olympic National Park study sites.

FEATURE	HOH RIVER	DUCKABUSH RIVER	BOGACHIEL BASIN
Area of site	150 ha	100 ha	50 ha
Length of baseline	2 km	2 km	1 km
Direction of baseline	N70 E	N65 E	N70 W
Length of transects	750 m	500 m	500 m
Direction of transects	N20 E	N25 W	N40 E
Number of plots	65	65	33
Percent of site sampled	.08%	.12%	.13%

Results Population Estimates: Population estimates from pellet group data were calculated using the formula (Harris 1959):

1. $\frac{\text{pellet groups/hectare * total hectares in site}}{\text{defecation rate/day}} = \text{number of animal-days-of-use on site}$

2. $\frac{\text{number of animal-days-of-use on site}}{\text{number of days animals were on site}} = \text{average population on the site during the given time period.}$

The second calculation is reliable only if the number of days the animals were on the range is known. A 70% confidence limit with a 10% standard error was tolerated (Robinette 1958). The defecation rate for elk was taken as 12.5

pellet groups per day (Neff 1965). The defecation rate used for deer was 12.7 pellet groups per day (Bennet et al. 1940, Eberhardt and Van Etten 1956, Smith 1964). Results of the analysis of the Hoh and Duckabush River sites are included in Table 3. Inclement weather made returning to the Bogachachiel Basin site impractical this year. In calculating the average total population of ungulates on each site during the given time period we assumed that elk were present on the Hoh site for 76 days (time between pellet counts) based on direct observations and animal sign. On the Duckabush site the number of days the elk were on the range is difficult to ascertain. The average total population figures presented here assume the elk migrated on to the lowland site early in September. Much more reliable estimates could be obtained if a comprehensive ungulate movement study was initiated.

Table 3. Results of the pellet census for the Hoh and Duckabush River sites, cf= .70, df=1

SITE	SPECIES	PELLET GROUPS FOUND	PELLET GROUPS/ PLOT	TIME PERIOD	UNGULATE DAYS-OF USE	ASSUMED UNGULATE TIME ON RANGE	AVERAGE TOTAL POPULATION
Hoh River	Elk	23	.35	76 days	2162±229	76 days	28±3
Hoh River	Deer	1	.02	76 days	94±1.5	76 days	1
Duckabush River	Elk	1	.02	108 days	63±1.0	30 days	2

Person-hour Efficiency: The remote location of the study sites and our commitment to minimize observable field equipment are factors differentiating this study from others. Because of this we were interested in evaluating the person-hour efficiency of establishing and relocating the study plots.

Time necessary to survey, map, establish the reference line and plots,and record vegetative factors was combined in our initial establishment of 163 plots. Total time needed by the research group for this purpose was 764 person-hours. An approximate breakdown of the time needed to perform the different aspects of the site establishment is outlined in Table 4. Disregarding the initial reconnaissance and design phases, approximately 1.7 hours was used to establish each of the 163 plots, and an additional 1.4 hours per plot was needed to survey the reference line. Time needed in the Hoh to establish a site, disregarding reconnaissance time, amounted to two hours per hectare. Later in the summer more "experienced" personnel were able to establish the Duckabush site using only 1.5 hours per hectare.

Table 4. Time considerations in establishing the pellet group census sites. All numbers shown indicate person-hours spent in that activity.

FACTOR	HOH SITE	DUCKABUSH SITE	BOGACHIEL SITE
Reconnaissance (mapping)	112	80	40
Installing reference line	144	80	8
Establishing plots	156	70	56
Time needed to establish reference line and plots per hectare	2hrs./ha	1.7hrs./ha	1.2hrs./ha

Time needed to relocate and clear plots of new pellet groups in the fall was substantially lower than that needed to establish the sites (Table 5.). All plots were located without difficulty by persons, who in 47% of the cases, had no familiarity with plot locations.

Table 5. Time considerations in relocating and searching pellet group census sites in the fall.

FACTOR	HOH SITE	DUCKABUSH SITE	BOGACHIEL SITE
Number of persons rechecking site	4 in pairs	2 individually	not rechecked
Number of person-hours required to locate and search plots	64	24	----
Number of person-hours per hectare to relocate and search	.42hrs./ha	.24hrs./ha	----

Deterioration of Pellet Groups: No quantifiable relationship between precipitation and pellet deterioration was made. The several pellet groups marked and revisited during the summer and fall showed some deterioration but were identifiable as pellet groups. Few difficulties in identifying new pellet groups on the study plots were encountered.

Low Impact Techniques: Criteria for evaluation of low impact technique effectiveness is difficult to quantify. The 16 wooden stakes placed along hiking trails to identify transects are virtually undetectable during summer and early fall deciduous cover when 70% of the visitors use the trails. Flagging is rarely visible from the trail and observation has shown that very few persons venture off the trail in the forested areas of the Park. The effect of the study sites on wildlife is impossible to discern. Several wooden stakes and pieces of plastic flagging were found chewed upon, possibly due to the attractiveness of salt from human handling (Doherty 1975, pers. comm.). Our field teams had a chance to subjectively evaluate their disruption of the wilderness qualities of the Park and concluded that the use of unobtrusive personal equipment and low impact techniques was effective in that the wilderness experience of other visitors was respected.

Conclusions: Results from this preliminary pellet group survey suggest that the method is feasible for use in the Olympic National Park between the months of July and November. The low impact method appears to present no initial problems in relocating the plots soley by the pace and compass technique. Person-hour considerations indicate that the time required to establish sites decreases with experience but that this method is more time consuming than that used by Ryel and Bennet (1964) with the Michigan Department of Conservation. Once the plots are established, relocation times are comparable to those documented for other study areas where extensive flagging and trail systems are employed. Between the months of July and November in the Olympics, pellet groups do not appear to deteriorate beyond recognition. No determination of total Park ungulate populations can be made from this preliminary survey. More extensive investigations of ungulate movements within the Park would make determination of total populations from this technique more reliable.

Ungulate Populations Based on Estimates

A complete quantitative evaluation of ungulate populations in Olympic National Park is not available at this time. For this reason we turned to qualitative estimates by Park personnel and biologists for the data needed in our computer simulation. The most recent estimate by a knowledgeable source was used. The assumed populations for the National Park were then coupled with data obtained from the Washington Department of Game (Game Management Division 1975) for lands outside of the Park.

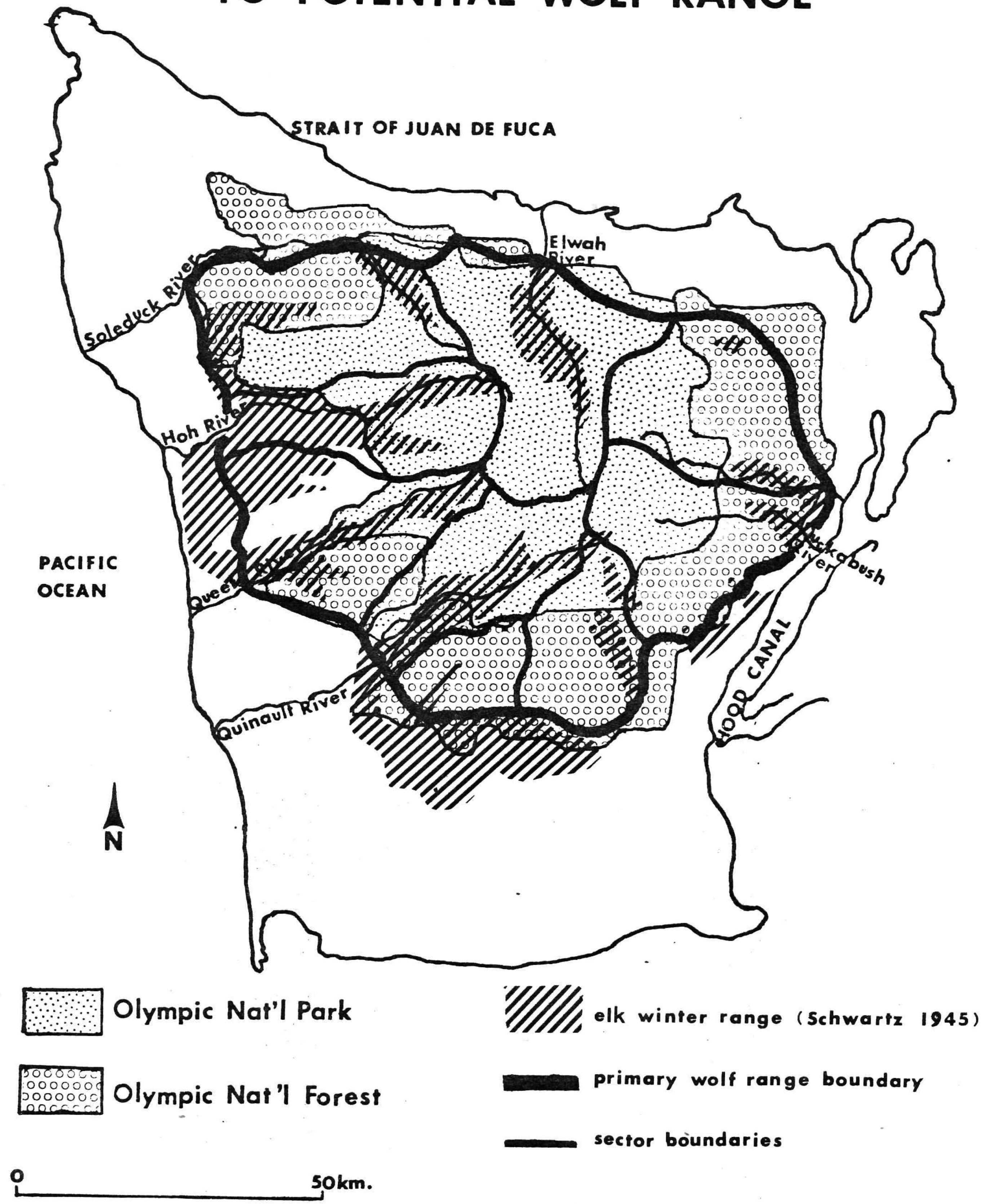
For our estimates, watershed areas on the Peninsula were calculated (Richardson 1962). Winter range for elk according to Schwartz and Mitchell (1945) was juxtaposed with watershed areas and land uses on the Peninsula. A boundary (Figure 7.) was then drawn which: 1) included most of the winter range for elk and 2) marked the interface between contiguous wilderness and/or timber lands and privately owned lands used for other purposes (farms, towns, homes etc). The 6400 km^2 of land within this boundary were defined as "primary wolf range", for purposes of the computer model. In this way the model can detect when wolf populations could be expected to come into conflict with presumably incompatible land uses. This matter will be discussed in later sections. Within the primary wolf range the watersheds were grouped into nine sectors.

Estimates by Bruce Moorhead, Olympic National Park Research Biologist, were used for both deer and elk populations within the Park. He recently estimated that there were approximately 3000 elk in the National Park (broken into watersheds accordingly) (Mills 1975). This is a conservative estimate compared to the 5500 elk estimated to be in the Park by Coleman Newman (1954). For deer, Moorhead's estimate of 4 deer per 2.5 km^2 is used in our calculations. This compares favorably to the estimate by Taber (1962) of 1 to 5 deer per 2.5 km^2 in western coastal climax coniferous forests. Using these figures we obtained an estimate of 5,000 deer in the National Park. Combining these estimates with those calculated from hunter harvest data collected by the Game Department, we estimate that there are approximately 7,000 elk and 15,000 deer in the "primary wolf range". In the remaining areas of the Peninsula there are an additional 28,000 deer and 10,000 elk, according to the Game Department. Calculated deer and elk population densities are shown in Table 6.

Table 6. Deer and elk densities (animals/km^2) in 9 "primary wolf range" sectors.

	1 HOH	2 BOGACHIEL SOELDUCK	3 ELWAH	4 GRAYWOLF DUNGANESS	5 DOSEWALIPS DUCKABUSH	6 SKOKOMISH SATSOP	7 WYNOCHEE	8 QUIN-AULT	9 QUEETS CLEAR-WATER
Elk	1.4	1.8	.41	.27	.42	1.0	1.7	1.0	2.1
Deer	2.7	4.0	2.0	5.0	4.0	4.7	5.4	3.0	3.0
Area	657km	657km	839km	790km	656km	580km	408km	685km	899km

FIG. 7 ELK WINTERING AREAS IN RELATION TO POTENTIAL WOLF RANGE



COMPUTER SIMULATION

We developed a computer simulation based on a compilation of data extracted from studies in wolf ecology and behavior and ungulate ecology. The model is actually a system of sub-models that simulate natural dynamics of wolf and cervid populations, in addition to simulating important aspects of wolf and cervid behavior. It is an attempt to simulate speculated wolf-prey relationships in the Olympics. From this model we have been able to see some projected effects of an introduced wolf population on the present Olympic ecosystems.

Unlike the analog model of a three trophic level predator prey system that Tykiel and Kuensel (1971) used to model the wolves of Isle Royale, the present model attempts to follow the fate of individual wolves. It is a stochastic model in that it realizes that the predator occurs in a small population that can be drastically depleted or eliminated by chance events. The program is written in BASIC and was developed and run on The Evergreen State College's IBM 2000C Time Shared System.

Development

The development of the model shows a gradual narrowing of scope and comprehensiveness. The data in the literature concerning wolves and prey are limited in terms of quantifiable cause and effect relationships. We realized that in many cases we were dealing with hypothetical systems and interactions but for the sake of simplicity, assumptions were made. Schematic models designed a set of relationships that could be tested in field situations in the future. We first proposed to build the model around a plant component, an ungulate component, and a wolf component. The first of these proved to be the most difficult and in the final model it has been included only as a small negative feedback mechanism.

We proceeded with the devlopment of an empirical model of elk and deer reproduction and mortality by estimating the ungulate populations present in the nine sectors defined in the preceding section. We slightly altered the basic surviorships from the literature in order to maintain nearly stable populations of the two prey species. The elk on the Peninsula have a history of periodic population fluctuations which may have been caused by a number of factors (Schwartz 1939, Washington Department of Game 1939). The evidence seems to suggest that the succession of population crashes was due to range deterioration, but, the recent stability of the populations has led us to assume that the populations would remain more or less stable during the period it would take to establish a wolf population. In the case of deer, the estimates are more qualitative. We again used a steady population.

Four aspects of wolf behavior were effectively modeled: wolf reproduction, hunting, pack structure and local movements. Reproduction is one of the more well documented elements of wolf ecology and data assimilated from recent studies were used in the model. Wolf predation on Olympic prey species is simulated by letting a random number algorithm in the program allow each pack to fulfill its monthly meat needs on a random selection basis.

The two most difficult things to model proved to be pack splitting and pack formation and the dynamics of wolf pack movements. In converting the information on pack dynamics as expressed in the literature into the explicit language of the computer, we developed a mathematical, and therefore somewhat rigid model which accounts for all anticipated permutations of wolf pack structure. The wolf movement model is very simplified in that it is only iterated monthly. Nevertheless, it effectively controls the number and size of pack that would be able to coexist on the "primary wolf range". The assumptions which were used in the course of constructing the computer model are explained and cited in Table 7.

Table 7. COMPUTER MODEL ASSUMPTIONS

ASSUMPTIONS	SOURCES
Reproduction Subroutine	
1. Wolves in Olympic National Park would breed March 1.	Joslin 1966, Pimlott 1968, Mech 1966
2. Wolves would give birth May 2 (63 day gestation period).	Brown 1936, Woolpy 1968
3. An average of one litter is born per pack.	Schenkel 1947, Rabb et al. 1967
4. The average number of pups born is six.	Cowan 1947, Murie 1944, Pimlott et al. 1969 Rausch 1967, Stenlund 1955
5. Wolf sex ratio is even.	Rausch 1967
Cervid Mortality and Natality Subroutine	
1. Deer survivorship curves show high initial mortality in lower age classes. 75% of total population dies in first 10% of life span.	Kormondy 1969, Taber and Dasmann 1957
2. Elk survivorships are similar to that evidenced by deer.	McCullough 1971 (Only available life tables were for Tule elk)
3. Deer have an average of 1.5 fawns/female/year.	Lauckhart 1948
4. Elk have an average of 1 calf/ female/year.	Kuttel 1974
5. Deer and elk populations have been more stable in recent years due to rotational forestry practices.	Kuttel 1974
6. Deer and elk populations are estimated to be those calculated in Figure 6.	Mills 1975, Game Management Division 1975
7. Ungulate survival rates are affected by overpopulation of range (negative feedback)	Schwartz 1939, Taber 1957
8. Females make up approx. 75% of total ungulate age classes.	Schwartz 1939, Taber 1957

ASSUMPTIONS	SOURCES
9. Ungulate fecundities are neg. affected by overpopulation and/or poor range conditions.	Harper 1971, Taylor 1961
10. In the Olympics, ungulate young are born in June.	Newman 1954

Hunting Subroutine

ASSUMPTIONS	SOURCES
1. Wolf pups require 1.6 kg of prey per day.	Van Ballenburghe and Mech 1975
2. Wolf adults require 6 kg of prey per day.	Mech 1966, Kolenosky 1972
3. Fawns make up approx. 50% of total wolf-killed deer in winter, spring, fall.	Mech 1970, Pimlott 1975, Pimlott et al. 1969
4. Calves make up approx. 50% of total wolf-killed elk in winter, spring, fall.	Same as above
5. Fawns and calves make up 60% of wolf-killed ungulates in summer.	Same as above
6. Approx. 20% of the wolf's annual diet consists of other small food items.	Cowan 1947, Mech 1966, Pimlott et al. 1969
7. One adult elk weighs 305 kg	Graf 1955, McCullough 1969
8. One elk calf weighs 91 kg	Same as above
9. One adult deer weighs 69 kg	Same as above
10. One deer fawn weighs 27 kg	Same as above
11. Wolves are opportunists, take advantage of certain age classes and types of prey.	Mech 1970

Wolf Aging Subroutine

ASSUMPTIONS	SOURCES
1. Wolf survivorships in Olympics similar to those in wild wolf populations elsewhere.	Mech 1970 (Apparent survival rates calculated from figures in the literature)

ASSUMPTIONS	SOURCES
1. By vaccinating and giving vitamins to wolves, good health would be insured upon release into the reintroduction zone. (Optional input)	Weise et al. 1975

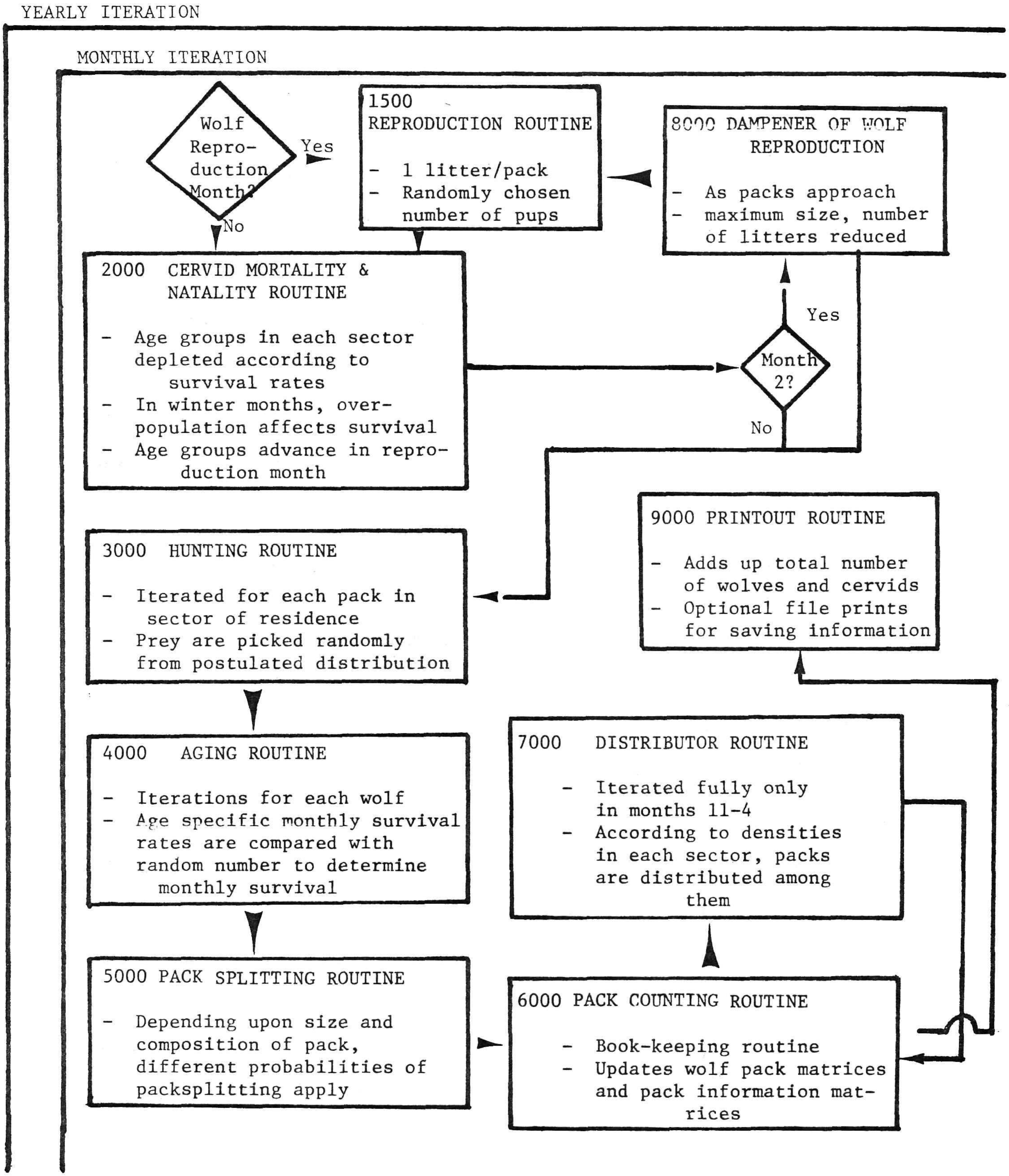
<u>Pack Splitting Subroutine</u>

See Figure 10 for probabilities of pack splits occurring in a pack consisting of a breeding pair and several other adult wolves.	These % probabilities reflect our attempt to mathematically define wolf pack splitting as observed by Burkholder 1959, Jordan et al. 1967, Mech 1966, Murie 1944 and as summarized by Mech 1970

<u>Wolf Distributor (Movement) Subroutine</u>

1. Wolf pack activity is centered around a den or rendezvous site from April through Sept.	Joslin 1967, Murie 1944, Pimlott 1967, Pimlott 1975
2. Movement and distribution of wolves are influenced by the distribution and density of the most important prey animals.	de Vos 1950
3. When the predator-prey ratio is less than 350 ungulates per wolf, some wolves leave the sector. If another adequate food source is not found they may leave the primary wolf range.	Based on Cowan 1947
4. When the wolf population reaches an equilibrium level of 50 individuals, surplus animals emigrate to the peripheral range.	Size of a stable Olympic wolf population based on historical documentation (Scheffer 1946, Mills 1975)
5. Population density and availability of prey influence annual increment in wolf numbers.	Mech 1970, Singer 1975
6. Biomass of one elk equals that of four deer, based on weight.	Calculated from Schwartz and Mitchell 1945, Skinner 1936, Taylor 1956

Fig. 8.
FLOW CHART FOR "FINAL1": A MODEL OF A WOLF REINTRODUCTION



Structure

This model was constructed subroutine by subroutine. There are ten different subroutines in the final simulation, modeling the processes of reproduction, cervid mortality and natality, hunting, aging of wolves, pack splitting, pack movements, and print outs (Figure 8). The entire program can be run indefinitely, but in the interests of computer time consumption, our runs have been confined to ten years. It presently takes nearly four hours for a single ten year run on the time-shared system.

Because of the wide variety of information and information types that the program must use in order to carry out the various subroutines, we have relied extensively on matrices. The model and a description of the basic matrices can be found in Appendix E. The respective wolf pack matrices are stored on different records. When making iterations, the information about a wolf pack is brought into the model from a file and placed in Matrix W, a 20 by 3 matrix with wolf "ID" numbers, sexes, and ages of wolves in months. The second important matrix is the 8 column Matrix G which stores information about the respective packs, including the number of adult wolves, their sexes, the number of wolf pups and the number of yearlings. The E Matrix and D Matrix are 10 by 9 matrices that store the sector by sector age distribution of elk and deer respectively. The rows correspond to the ten different age groups for deer and elk. Matrices B and F are both 10 by 2 matrices which contain surviorships and fecundities by age group for the two species of ungulates. Matrix C contains the estimated ungulate carrying capacity for the nine sectors, and the sector area. Matrix S includes information about the average proportions of deer and elk and other prey species in the wolf's diet according to season. Other matrices in the program perform book keeping chores. Files are used throughout the model to store constantly changing information.

The Routines

Except for month five when wolf reproduction takes place, the first routine to execute is the Cervid Mortality and Natality Subroutine. This subroutine is divided into three main divisions according to whether it is a winter month, a reproduction month, or a normal month. During the months 12 through 4 the program checks the total number of elk and deer in the respective sectors to obtain the total ungulate population. This is then compared to an estimated carrying capacity for the sector. Excess populations result in a factor that causes a reduction in survival rates, a phenomenon that has been observed on overpopulated ranges by Schwartz and Mitchell (1945) and by Taber (1962). During non-winter months each age group is decreased according to basic survival rates. During month six, ungulate reproduction month, the program determines the number of young being born according to the basic fecundities. The program then advances the members of the age groups 1 through 9 to the next age groups to make room for the young produced. As in the Leslie Matrix (Poole 1974), the remaining number in the final age group is eliminated.

The Wolf Reproduction Subroutine occurs in month five. This subroutine models the reproductive patterns of the wolf packs, assuming that one litter of pups will be born per pack. A random number is used to pick a number of pups from a multinomial distribution. Random numbers are also used to determine the sex of each pup born.

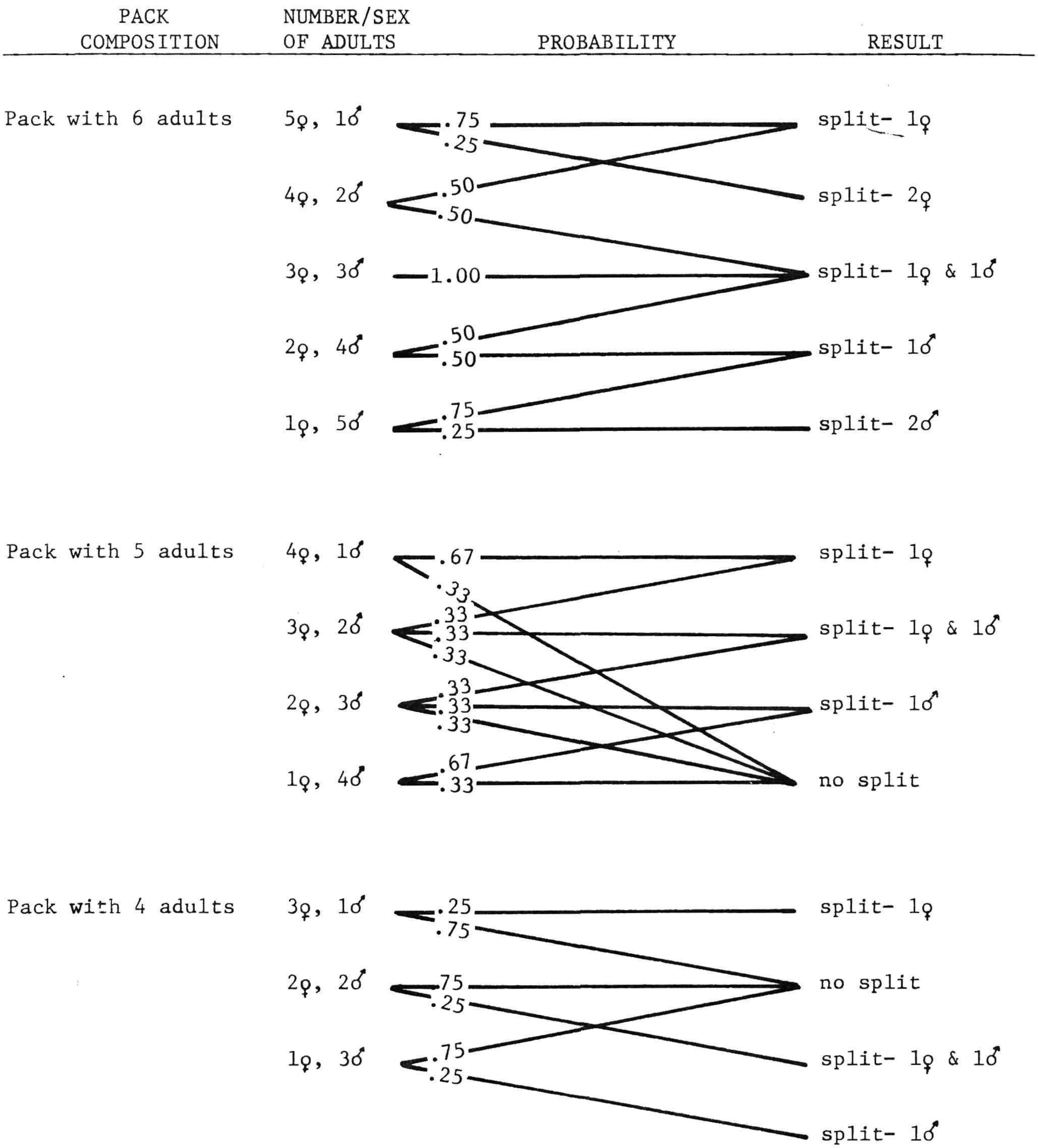
The Hunting Subroutine defines the food habits of each pack. The meat needs of each wolf pack are determined according to the size and composition of the pack, and the wolves hunt randomly among the deer, elk and "other" until their meat needs are satisfied. The program performs a simple random number algorithm that determines whether the deer or elk caught is a fawn or calf, and if not, what age group the animal is from. In all of these cases the pack's monthly meat quota is calculated in accordance with the weight of the prey caught (Mech 1970).

The Aging and Mortality Subroutine models the age specific mortalities of wolves. Depending on the animal's age, a probability is assigned which is compared with a random number and if the random number is greater than this probability then the wolf is eliminated.

The phenomenon of pack splitting is modeled in a subroutine that effectively limits the size of each pack to six adult animals. A number of alternatives are provided depending on the number of adult wolves present and the proportions of sexes in the pack. Random numbers are used to determine which of the various alternatives occur. The possibilities are outlined in Figure 10.

The last subroutine is the Distributor or Movement Subroutine, occurring during the months when the pack is not confined to a home range centered around the den or summer rendevous site (Joslin 1967). This subroutine most likely departs considerably from the reality of the extreme mobility of wolves, however it serves to distribute the effects of wolf predation throughout the Peninsula's "primary wolf range". The routine first evaluates the density of cervids in the sector, then applies a weighting factor to the deer. From these densities, probabilities are assigned that the valley would be chosen by a wolf pack. Each time the program ascertains whether the total number of wolves in a valley would exceed the postulated 1 to 350 ratio of ungulates to wolves as described by Cowan (1947). This ratio effectively prevents large packs from entering certain sectors, and causes packs that are too large to leave the wolf range. Another control on wolf populations is provided in the Dampener of Wolf Reproduction Subroutine (Natality Reducer) which reduces the number of pups born if the population of wolves approaches the threshold for the sector.

Fig. 10. The probabilities of packs splitting based on the number and sex of adult wolves (older than 22 months) present in each pack.



Results

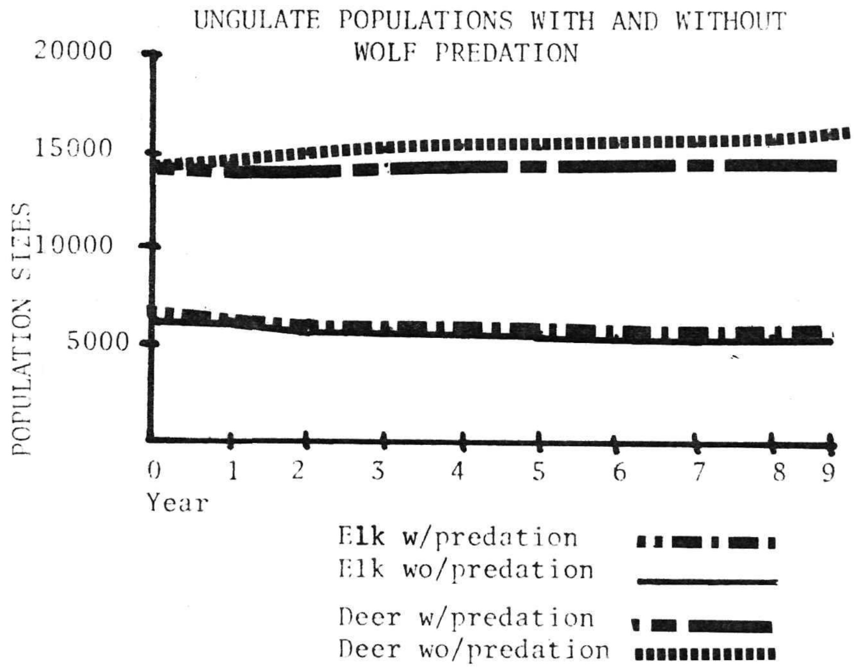
The results of successive runs of the computer model are extremely variable, but they provide a good test of the hypothesis developed in the course of the study. The model, in its printouts, provides the user with information on:

1) the number, age, and sex of each wolf present
2) the number, size, composition and location of each wolf pack
3) the number of new packs formed each month or year
4) the number of lone wolves produced each year
5) the number of packs that are forced out of the primary wolf range due to insufficient prey
6) the type, number, and age of prey taken by each pack monthly
7) the number of ungulates and wolves born each year.

Time has limited our exploration of the effects of wolf predation to manipulating only several of the many variables. Successive runs of the model have shown that wolves would not be the major controlling influence on prey species in the Olympics. Figure 11. shows the effects of ten years of predation by four wolves and their offspring on deer and elk populations as compared to populations not experiencing predation. While we realize that several significant prey responses to predator pressure have been omitted, this gives an idea of the changes in prey populations that could be expected to occur under wolf predation pressure. Given the assumptions in the model, a reintroduced population of eight wolves could be expected to take about 65 fawns, 50 adult deer, 65 calves and 45 adult elk, as well as about 70 "other" prey species in one year in the Olympics.

The model also indicates several surprising things about wolf population growth that could be expected in the Olympics. When four wolves are reintroduced

Fig. 11. The effects of wolf predation on ungulate populations as generated by the computer model.



(two adults, two yearlings) there is a good possibility that all four animals and their offspring will die within ten years. Reintroduction of four adult animals or two packs of four animals each, increases the chance that a wolf population will become established.

Given the probabilities calculated for pack splits, the occurrence of pack splitting is frequent, even in small populations. Also, occasional runs of the computer model create situations where individual wolf packs become too large for any sector to support, due to the presence of pups and yearlings. Presently the model removes the pack from the program, simulation their movement off of the primary wolf range in search of a more suitable habitat. In all of the ten year runs to date, wolf populations have never exceeded 20 animals - well below the postulated carrying capacity of 50 wolves.

Conclusion

The model itself is a dynamic system; continual refinements bring it closer to the actuality of ecosytem dynamics as presently interpreted in the literature. Present runs of the model for ten years show it to be a good test of the hypothesis developed in the course of this study. Given the mortality rates of wild wolves, we believe wolf populations in the Olympics would, if reintroduced, increase very slowly, and that wolf populations as presently generated by the computer, would not be the major control on the number of ungulates in the study area. Other influences of wolf predation on prey population dynamics and behavior was beyond the scope of this model. Furthermore, we believe that this model could serve as a basis for similar reintroduction studies.

DISCUSSION AND CONCLUSIONS

In order to define the parameters used in modeling a stable population of Canis lupus in the Olympic National Park ecosystems, we reviewed classic and current literature dealing with studies of wolf ecology and behavior in the wild. After compiling data from these studies, we speculated on the role of the wolf in Olympic ecosystems. To facilitate this speculation we chose to extrapolate from data gathered in research areas that are similar to the Olympic Mountains in ruggedness of terrain, variety and distribution of prey species, and climatic and vegetative variability. These study areas included the Canadian Rocky Mountain National Parks, southeast Alaska, parts of British Columbia, and Glacier National Park. Our computer simulation then utilized these parameters in a simplified form, as it was impractical to model many of the more intricate aspects of naturalistic wolf behavior. This discussion is aimed toward a further synthesis of our assumptions: it is hoped that the following conclusions will contribute to an understanding of why, biologically, a stable wolf population could exist once again in the Olympic National Park and surrounding lands.

Wolf-Prey Interrelationships

Examination of the availability of a food source is a necessary step in evaluating survival probability of any reintroduced species. Availability of Olympic ungulate species was particularly investigated because in all the areas where it has been intensively studied in North America, the wolf has exhibited an exclusive dependence on large ungulates for its winter food (Pimlott 1975). The Olympic Peninsula provides habitat for two and possibly three ungulate species that could serve as prey for the wolf: the Roosevelt elk, the Columbian black-tailed deer, and potentially, the mountain goat. Elk and deer have been shown to be preyed on by wolves in other wilderness areas (Carbyn 1974; Cowan 1947, Mech 1970). In the Canadian Rocky Mountain National Parks wolves demonstrated a marked proclivity for elk as a food source: the annual diet of wolves there consisted of 80% large ungulates, with elk contributing 47% (Cowan 1947). Deer was the primary prey of wolves in Algonquin National Park in Ontario, having a frequency of occurrence in the wolf's diet of 80% (Pimlott et al. 1969). We considered data from all the above sources in speculating on selection of prey by wolves in The Olympic National Park.

In an attempt to determine possible relative occurrence of elk and deer in the wolf's Olympic Peninsula diet, we evaluated social and physical characteristics of each of the two species that might contribute to greater protection from or susceptibility to wolf predation. Studies by Stenlund (1955) and Pimlott et al. (1969) showed that when two or more large prey species inhabit the same area, wolves apparently concentrate on the smallest or easiest to catch. And, not only do they "...concentrate on <u>species</u> of big game that are easiest to hunt and kill, but they also rely more on the <u>individuals</u> that are most easily caught," (Mech 1970). The solitary and smaller black-tailed deer might present an easy opportunity for wolf predation. In Cowan's study of wolf predation in Jasper National Park (1947), it was suggested that wolves might have been selecting for deer: deer apparently contributed to the diet in greater proportion than they represented in the population. We also examined at this point the theory of co-evolution of a social prey with its social predator. "There appears to be a subtle reciprocal evolution between prey and predator, the predator being adapted physically and socially to a particular...prey." (Fox 197). The social prey in the Olympics, the Roosevelt elk, might actually appear to have greater defense mechanisms inherent in its herd organization, larger size, and localized migration patterns, but its very size and herd formation might serve as a powerful wolf attractant (large groups of prey being easier to locate by direct scenting and chance encounter). Due to lack of more specific data on wolf-elk and wolf-deer interactions we can only speculate that prey selection by the Olympic wolf would be similar to that in the Rocky Mountain National Parks, where elk and deer "appear in the diet in fairly close relation to their relative abundance..." (Cowan 1947).

There is evidence that mountain goats contributed to the wolf's diet in Jasper and Banff National Parks (Cowan 1947). Although there are no documented historical accounts of this occurring in the Olympics, we speculated on the possibility of wolf-goat interactions in the context of altered Olympic ecosystems. Mountain goats were introduced to the Peninsula in the early 1920's, just as the wolf population was approaching extinction, thus it seems unlikely that wolf-goat encounters would have occurred. Goats in the Olympics are presently not restricted to traditionally typical mountain goat habitat because they are under little predator pressure at this time (infrequent predation by cougar has been known to occur, according to Poelker 1975, pers. comm.). Mountain goats "...are apparently better equipped to escape the wolves than are the forest game species..." and ordinarily "the preferred terrain of goats seems to render them almost immune to attack by wolves." (Cowan 1947). Because the increasing Olympic mountain goat population is often utilizing habitat that would not afford it much protection from wolf predation, the goats might initially and/or temporarily serve as prey for wolves in the advent of a reintroduction of this predator.

Mech (1970) commented on the occurrence of smaller prey items in the wolf's diet: "...when viewed in the total perspective of the wolf's food habits, predation on small animals is seen to play only a minor role in the life of the wolf." Smaller species, when they are abundant, may at times serve as prey for wolves when large ungulates are less available. In the Olympics, this prey class might consist of smaller mammals such as marmots (Marmota olympus), beaver (Castor canadensis), snowshow hare (Lepus americanus), mountain beaver (Aplodontia rufa), and other miscellaneous foods which might seasonally act as secondary prey species. By taking other studies into account, we postulate that in the Olympics less than 20% of the wolf's annual diet would consist of these smaller food items (Mech 1970).

The wolf, as a species, is very adaptable in locating and attacking a wide variety of prey. The two most probable primary prey species for the wolf in the Olympics (elk and deer) depend on their alertness and speed for their defense (Mech 1970); even though, in certain cases, a single wolf can successfully prey on one individual, both have effectively evolved "defense mechanisms that allow a fraction of the population to avoid being eaten." (Murdoch and Oaten 1975). Wolf predation efficiency on deer in Algonquin National Park was relatively low (25% and 63% in two different years, the difference being attributed to varying snow conditions) and there was selection for older animals which indicates that most deer encountered by wolves escape. Mech (1970) mentions that because of its large size the elk probably is almost as difficult for wolves to safely attack as are moose. Isle Royale figures show a predation efficiency of 7.8% in wolf-moose interactions (Mech 1966). No doubt most attacks on elk in the Olympics would be just as unsuccessful. The above data suggest that, as in other wilderness areas, wolf predation in the Olympics would not result in abrupt depletion of the ungulate population.

Coexistence of Sympatric Predators

In examining the possibility of certain non-prey animals being competitive with the wolf in The Olympic National Park it was important to compare niche utilization by the sympatric Olympic predators. In doing so, we evaluated selection of prey and method of hunting by the wolf (Canis lupus), cougar (Felis concolor), bobcat (Lynx rufus), coyote (Canis latrans), and black bear

(Ursus americanus). Differences in prey selection by Olympic predators were illuminated by study of the results from research on five sympatric predators in the Serengeti area in East Africa. Studies have shown that the five species of carnivores (including both Canids and Felids) show considerable overlap in their diets, but with striking differences. Wherever they prey on the same species, they select and hunt their prey in different ways (Kruuk and Turner 1967). Schaller (1972) also noticed basis differences in selection between coursers and stalkers:

> The age, sex, and health of prey that is killed depend in part on the hunting method used by the predator, especially in areas where several species use the same resource. Coursers...select a specific individual and chase it, usually selecting the one that is easiest to catch. Consequently, coursers kill a disproportionately large number of young and sick animals. While stalkers also capture such prey, they quite often depend on those that select against themselves by becoming vulnerable in some way...and because of this stalkers tend to kill more randomly from a population than do coursers.

Available data on the habits of the large predator species in the Olympics allowed us to compare their predation patterns to those of the sympatric Serengeti predators. Table 8 shows considerable overlap in the diets of the Olympic predators (including the wolf), but wherever they prey on the same species they select or hunt the prey in different ways. The black bear is not represented in the table because competition between the wolf and North American bear species for a food source is of a more direct sort. Documented wolf-bear interactions are limited to direct confrontations at wolf dens and kill sites, with these interactions involving bear predation on wolf pups and scavenging by bears on wolf kills. As is also true for the aforementioned predator species, wolf-bear encounters are rare and can only be evaluated in terms of individual animals' behavior patterns due to lack of sufficient data on the species level.

Two additional sources have examined sympatric predator species: Fox (1975) described predation patterns common to members of Canidae and Felidae and

Table 8.

Sympatric Predator Food Habits & Niches

	WOLF	COUGAR	BOBCAT	COYOTE
SOCIABILITY	social	solitary	solitary	solitary, social
HUNTING METHOD	courser	stalker	stalker	stalker, courser
MAIN PREY	ungulates	ungulates & lagomorphs	lagomorphs & grouse & ungulates	lagomorphs & rodents & ungulates
PREY SELECTION	selects young, old, sick	random	random, young	random, young

discussed socio-ecological relationships between predators, and Rosenzweig (1966) explained that physical size difference contributes to coexistence of predators that use similar hunting methods, as do social differences such as hunting cooperatively or solitarily. But "...social and ecological dynamics between sympatric species remain to be evaluated, especially in terms of conservation and possible imbalance..." (Rosenzweig 1966). Evaluation of these dynamics is especially needed with regard to Olympic predator species and their postulated relationship to the wolf. Poor reproductive success and small pack size in the Glacier National Park wolf population might have been related to lowered availability of prey caused by interspecific competition for the resource. Singer (1975) cited evidence implying that the cougar and coyote might have an advantage over wolves in the exploitation of ungulates. Other data suggest, however, that the varying hunting strategies of Olympic predators and the social organization of these species contribute to different habitat utilization and would therefore aid in minimizing interspecific competition. We agree with Singer (1975) that "more data on the food habits and niches of the large predators is needed to determine the extent of overlaps in the exploitation of species of prey..." by the wolf and its possible sympatric predator species in the Olympics.

Influence of Wolf Predation on Prey Species

Wolf predation is generally selective in that it results in the culling of biologically inferior individuals from a population. Actual research has not answered the question of to what degree this culling benefits the ungulate population, but it is agreed that this selective pressure helps to maintain the protective properties of the prey species. There is the possibility, as expressed by Murdoch and Oaten (1975), "...that natural predator-prey systems may owe much of their stability to a long-shared evolutionary history: the prey species we see are those that have evolved sufficient defense mechanisms for some individuals to survive in each generation, while the predator species likewise have characterisitics that assure some individuals an adequate harvest of prey." And, as Schaller (1972) said so eloquently about the Serengeti prey species, "...their fleetness and grace, their vital tension, are the evolutionary products of a constant predator pressure that has eliminated the stolid and slow...to survive in all their vigor and abundance, the prey populations need predators."

The question of whether wolf predation exerts a major control on the size of prey populations has been frequently examined. The prevalent theory at this time is that ungulate populations are controlled by their range and that wolf predation is inconsequential in determining ultimate numbers of ungulates. "While predation may be a major control on the size of a prey population, the ultimate factor is habitat, the food supply." (Schaller 1972). Under the circumstances where there is little human interference with either the predator or prey populations "...the effect of predation as a depressant on the population is minimized..." (Pimlott 1975).

The possible effect of wolf predation on present elk and deer populations in the Olympics can best be examined in the light of studies on these particular species in areas where wolf predation is an actuality. Research by Klein and Olson (1960) on black-tailed deer in southeast Alaska clarified possible effects of wolf predation on the similar Olympic subspecies. They speculated that the populations of <u>Dama hemionus sitkensis</u> were actually benefiting from predation by wolves: the population increased rapidly and had light winter mortality from starvation and the winter range remained in fair to good condition. These areas also supported a greater annual hunter harvest of deer per unit area. (Areas where wolves were absent had heavy winter mortality in the deer population and exhibited severely deteriorated winter ranges.) Cowan, in his 1947 study in Jasper National Park, concluded that wolves were not detrimental to the Park game herds and that their influence was definitely secondary to what he referred to as "welfare factors", the most important of which was the absence of sufficient winter forage. The research results expressed above support our conclusion that wolf predation would not be disadvantageous to Olympic ungulate populations.

Mech (1970) discussed the question of control of ungulate numbers by wolf predation in detail and summarized by concluding that it is the major controlling mortality factor only when the predator-prey ratio is 10,900 kg of prey per wolf or less. At higher ratios wolf predation becomes just one of several factors that contribute to mortality of the prey species and is not the primary control. We estimated the total biomass of large ungulates in The Olympic National Park and surrounding forest lands to be about 23,000 animals per 6,400 km^2. This can also be expressed as approximately 67,600 kg of prey per wolf, using a hypothetical population of fifty wolves (as suggested by historical documentation). This significantly exceeds the controlling predator-prey ratio as given by Mech (1970). Based on these data, we submit that total predation by a fifty-member wolf population would not be the major mortality factor influencing ultimate numbers of ungulates in the Olympics. Results from our computer simulation also support this conclusion. In addition, we submit that the ungulate biomass could support up to approximately three hundred wolves without their predation exerting a major control on Olympic ungulate numbers.

Stability in an Olympic Wolf Population

Wolf numbers in the wild are controlled naturally (Mech 1966, Merriam 1964, Pimlott et al. 1969) and in order to simulate this natural regulation we tried to determine the probable size of a stable Olympic wolf population. We looked at currently popular approximations of wolf-ungulate ratios that are needed to sustain a population of Canis lupus in dynamic equilibrium with an ecosystem, and in addition, we examined past estimates of numbers of wolves in our study area. Probable wolf numbers and distribution patterns were particularly difficult to ascertain as a result of the uniqueness in physical character of The Olympic National Park and because of the scarcity of available data on local elk and deer numbers and movements. We additionally examined wolf density per unit area and possible limitations on wolf social structure that could be imposed by the rugged topography of the study area.

The biological reasoning behind suggesting size of a stable Olympic wolf population was first based on predator-prey ratios. Cowan (1947) calculated that predator-prey ratios in Jasper National Park were three to four hundred ungulates per wolf. Jasper, as a wilderness area, compares favorably to the Olympics in ruggedness of terrain and variety of prey species, and for this reason we suggest a size limit for wolf population stability in the Olympics based on wolf population size in Jasper. Using a predator-prey ratio like Cowan's, we postulate that a stable Olympic wolf population could consist of 60 to 80 individuals.

Approximations of high wolf densities were summarized by Mech (1970) and Pimlott (1967). They concluded that average wolf densities do not exceed one wolf per 25.9 km^2 except during periods of exceptionally high prey concentrations. Letting this figure represent a threshold for normal wolf density, we conclude that the area we have defined as primary wolf range could support up to 250 wolves without having an abnormally high population density. This is considerably more individuals than were reported by Forest Supervisor R. E. Benedict in the Olympics in 1910, when the area at that time supported about 115 wolves in an apparently stable state (Scheffer 1946). This suggests the possibility that altered Olympic ecosystems might currently be able to support a larger population than once existed. But we realize that this estimate reflects rapidly declining wolf numbers and is therefore a conservative evaluation of the carrying capacity for wolves in the Olympics.

We speculated on space utilization by wolves in the Olympics by investigating studies of wolves that were carried out in areas with similar physical ruggedness. Even though wolf population densities cannot be expected to be uniformly similar from region to region we used data from several wolf-inhabited areas to assist us in making some assumptions about Olympic wolf spatial relationships and local migrations. Perhaps even more important to consider are behavioral parameters when evaluating survival probability of a social predator such as the wolf. Data were extrapolated from several studies to show the postulated influence of Olympic ecosystems on a component of wolf social behavior that most directly relates to survivorship: social stress.

Studies by Cowan (1947) and Carbyn (1974) both dealt with social organization in the wolf population existing in Jasper National Park. Jasper's comparability with The Olympic National Park lies in its river valley-ridge structure which, in Jasper, constitutes natural boundaries for wolf movements. A study by de Vos (1950) on the Sibley Peninsula in Ontario took into account the influence of topography, prey animal distribution, and seasonal climatic changes in its interpretation of wolf movements. We also looked at Singer's (1975) study of wolves in northern Glacier National Park where an east-west physiographic, climatic, and vegetative division occurs in similar fashion to the Olympics. Research results from the above sources indicate that the physical character of the Olympics would not result in restriction of normal wolf social behavior, as summarized by Mech (1970), although topographical features, i. e. mountainous terrain, and the distribution of the Olympic prey source might determine distribution of wolf numbers and ultimately define territorial boundaries. The available data suggest that the above mentioned parameters, as represented in Olympic ecosystems, would contribute to maintenance of a "well organized, well functioning" wolf population (Mech 1975).

On the basis of all the above data, we submit that Olympic Peninsula ecosystems still have the capacity to support a population of 40 to 60 wolves in dynamic equilibrium with surrounding natural communities. However, we realize that ultimate numbers reached by a wolf population are primarily determined by food supply and would expect wolf population fluctuations to accompany changes in Olympic prey numbers. Our computer simulation of wolf reproduction and predation shows the annual increment in wolf numbers to be slight, implying that attainment of this equilibrium level by a reintroduced wolf population would be a very gradual process.

SOCIAL AND POLITICAL CONCERNS OF A WOLF REINTRODUCTION

Even though it was the main focus of our research, the way in which the wolf interacts within a natural community cannot be the only concern of a wolf reintroduction study. In addition, we also felt a need to examine wolf interactions with human communities and, after extrapolating from data gathered elsewhere, we looked at the possibility of this type of interaction occurring in the Olympics.

Mech (1975) suggested that the minimal size of a zone for establishing a "well organized, well functioning natural population of wolves" would be from 10,000 to 13,000 km^2. He based this on his work with natural wolf packs in mortheastern Minnesota. The area of the entire Olympic Peninsula is just barely 10,000 km^2 and, as has been suggested by a noted local biologist, probably 90 to 95% of the Peninsula could serve as wolf habitat (Scheffer 1975, pers. comm.). This means that a relatively greater density of wolves in the primary wolf range (due to minimal unit area size) might result in more frequent wolf-human interactions in the peripheral range.

Studies, including the recent effort in Michigan to re-establish a wolf population, have indicated that a rural human density of between 6 and 12 persons per 2.5 km^2 is the critical threshold for wolf survival. Densities on the Olympic Peninsula approach ten persons per unit area, implying that wolf survival might be somewhat tenuous. However, Mech (1974) also pointed out that wolves <u>can</u> live in close proximity to people where they are not persecuted and where suitable prey is sufficiently abundant. The sanctuary of The Olympic National Park wilderness might therefore be essential in that it could provide the wolf with both sufficient prey and protection from human persecution. Zimen (1975) described the problem of high human density in or around a relocation zone by saying the following: "in general, wolves need to be where the human population is the lowest density. However, people are not the most critical problem. Most important is that there be no domestic, grazing animals." He saw this as presenting an enormous public relations and economics problem.

We found that land used for livestock ranching is minimal on the Peninsula: only about 9% of the total area is farmed, 65% of the Peninsula is classified by the USDA as less than suitable for grazing purposes, and the total number of livestock in the study area is less than 13,000 head. There are two areas of livestock concentration, the northeastern coastal plain and the southern river valleys, but the bulk of the domestic population is found widely scattered on small private farms. Most wolf research supports the concept that wolves with a well organized pack structure would have few encounters with livestock in this peripheral range. However, lone wolf dispersal to the surrounding area, i.e., peripheral range, can take place and usually results in the persecution or killing of these individual animals by local residents or predator control programs (Mech 1974).

Examination of a unique type of interspecific coexistence has been undertaken by several researchers in the course of work with naturally existing wolf populations. Mech (1975) discussed his view that recreational back country users in wolf range are no problem, i.e., limitation of their activities is not necessary in order to insure normal wolf social behavior in the wilderness area. Wolves usually exhibit an avoidance of Homo sapiens (Mech 1970). Furthermore, wolves in other national parks exhibited avoidance of roads or maintained park trails (Singer 1975) or restricted their use of these potential travelways (Peterson and Allen 1973). There is evidence that public interest in wolf conservation has been stimulated by the promotion of wolf-related tourist activities, such as the wolf-howling program in Algonquin National Park (Pimlott 1967, Pimlott et al. 1969) and this suggests that a wolf population in the Olympics might act to attract potential Park users. Even with increased tourist and hiker use, Isle Royale, Mount McKinley, Glacier, and Algonquin National Parks have exhibited a true compatability between wolves and National Park users (Haber 1975, Peterson and Allen 1973, Pimlott 1967, Singer 1975).

Another important matter of attitude is that of the sport hunter, the human predator on the large ungulate species in our study area. The biological arguments discussed previously show that wolves would not significantly reduce numbers of deer and elk. Wolf predation has even been shown to increase prey numbers and resulted in increased hunter harvests in southeast Alaska (Klein and Olson 1960) and Minnesota (Mech 1970). Mech (1970) discussed current data supporting his conclusion that in most of its North American range the wolf does not compete significantly with the human hunter, "despite strong claims to the contrary from certain vocal segments of the public." (Mech 1970). We therefore submit that hunters and wolves would be compatible species on the Olympic Peninsula.

Public sentiment is perhaps the most important factor of all when discussing a wolf reintroduction. While we made no attempt to systematically collect impressions regarding the desirability of such an action, feelings were nevertheless expressed to us. Vast areas of the Olympics remain wilderness and those people that live on its fringes still view the world from the perspective of pioneers. Thus, enmity toward predators, with which these pioneers once had to compete for a food source, is still prevalent. A common attitude concerning a wolf reintroduction is perhaps best summarized by quoting old-timer Charlie Lewis (1975, pers. comm.), who said to us, "Anyone who'd put back wolves is a crazy!"

RECOMMENDATIONS FOR FUTURE STUDY

This study, in its attempt to investigate a complex biological question, has built a foundation on which more focused investigations can and should be based. The suggestions that follow are our recommendations for future studies, presented in a descending order of priority.

1) Public attitudes regarding the desirability of a wolf reintroduction on the Peninsula should be systematically obtained and evaluated.

2) Quantitative data on postulated wolf-prey interrelationships should be obtained. A comprehensive study of Olympic ungulate population dynamics should be initiated, including censusing of the populations, determination of movements, and influence of other types of predation on their numbers.

3) Additional evaluation of social and ecological requirements of sympatric predator species in the Olympics is needed to determine the possibility of interspecific competition between the wolf and these other predators.

4) An intensive public education campaign to promote an understanding of wolf ecology and the benefits of a wolf population is needed.

5) Study of Canis lupus populations in British Columbia and southeast Alaska should be undertaken to determine the dynamics of a wolf population which could serve as reintroduction stock should a decision be made to re-establish the wolf on the Olympic Peninsula.

6) The Olympic National Park, in its interpretive program, should prepare a display on the wolf's historical role in Olympic National Park ecosystems. This would help to promote an understanding of the wolf by Park visitors.

7) Another preliminary study is needed to examine strict scientific wolf management policies and to speculate on the application of these to the Olympic Peninsula, should a decision to reintroduce wolves be made.

SUMMARY

Historical evidence supports the fact that wolves did at one time exist in the Olympic Mountains and surrounding natural communities. On the basis of this past documentation and after evaluation of changes that have taken place in Olympic ecosystems since the wolf's demise, it was shown that these altered ecosystems would offer reintroduced wolves a biological advantage. The Olympic Peninsula still has the capacity to support at least forty to sixty wolves in dynamic equilibrium with surrounding natural communities.

Ten year runs of the computer simulation tested the above conclusions mathematically and the results support the contention that wolf predation would not be the major mortality factor controlling ungulate numbers in the Olympics. After reintroduction wolf numbers would increase very slowly and would stabilize naturally.

The pellet group count technique of censusing large ungulate populations was shown to be effective in The Olympic National Park in terms of feasibility. Additional census methods used in conjunction with the pellet count census would further facilitate determination of trends in and actual numbers of deer and elk in the Olympics.

We submit that a reintroduction of the wolf to its former range surrounding and including The Olympic National Park is biologically feasible. However, study of the desirability of such an action is needed to determine probable success of a wolf reintroduction.

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This study could not have happened without the help, encouragement, and cooperation of many people in many places. We wish we could thank you all personally.

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APPENDIX A

WOLF SIGHTINGS OR ESTIMATES BETWEEN 1890 - 1930

DATE	SIGHTINGS OR ESTIMATE	LOCATION	REFERENCE
1890	two wolves seen	Elwah River bank	(Mills 1975)
1894	"you'd see 8-9 wolves month"	Quinault River	(Olson 1975 pers. comm.)
1897	skin with skull collected	"base of Olympics"	(Scheffer 1946)
1898	one wolf shot	Quinault River	(Olson 1975, pers. comm.)
1900	one wolf sighted	Hoko River	(Mills 1975)
1909	"practically extinct"	Olympic Peninsula	(Scheffer 1946)
1910	wolf killed several sheep	Hoko River area	(Mills 1975)
1910	115 wolves estimated	Olympic Nat'l Forest	(Scheffer 1946)
1912	one wolf trapped	Queets River	(Gwin 1975, pers. comm.)
1916	wolf tracks - one set	Elwah River	(Murie 1917)
1916	wolf tracks - two sets	Hayes River	(Murie 1917)
1916	wolf tracks - one set	Press Valley	(Murie 1946)
1917	wolf tracks - one set	Lost River	(Murie 1917)
1917	wolf feeding on carcass	Press Valley	(Murie 1917)
1917	42 wolves sighted	Lost Creek	(Scheffer 1946)
1918	50 wolves in "pairs or scattered families"	Olympic Mountains	(Scheffer 1946)
1919	one wolf trapped	Upper Cameron Ck.	(Scheffer 1946)
1919	40-60 wolves estimated	Olympic Peninsula	(Scheffer 1946)
1920	one wolf trapped	Elwah River	(Scheffer 1946)
1920	one wolf sighted	Forks	(Mills 1975)
1929	one wolf sighted	Snow Creek	(Scheffer 1946)

APPENDIX B

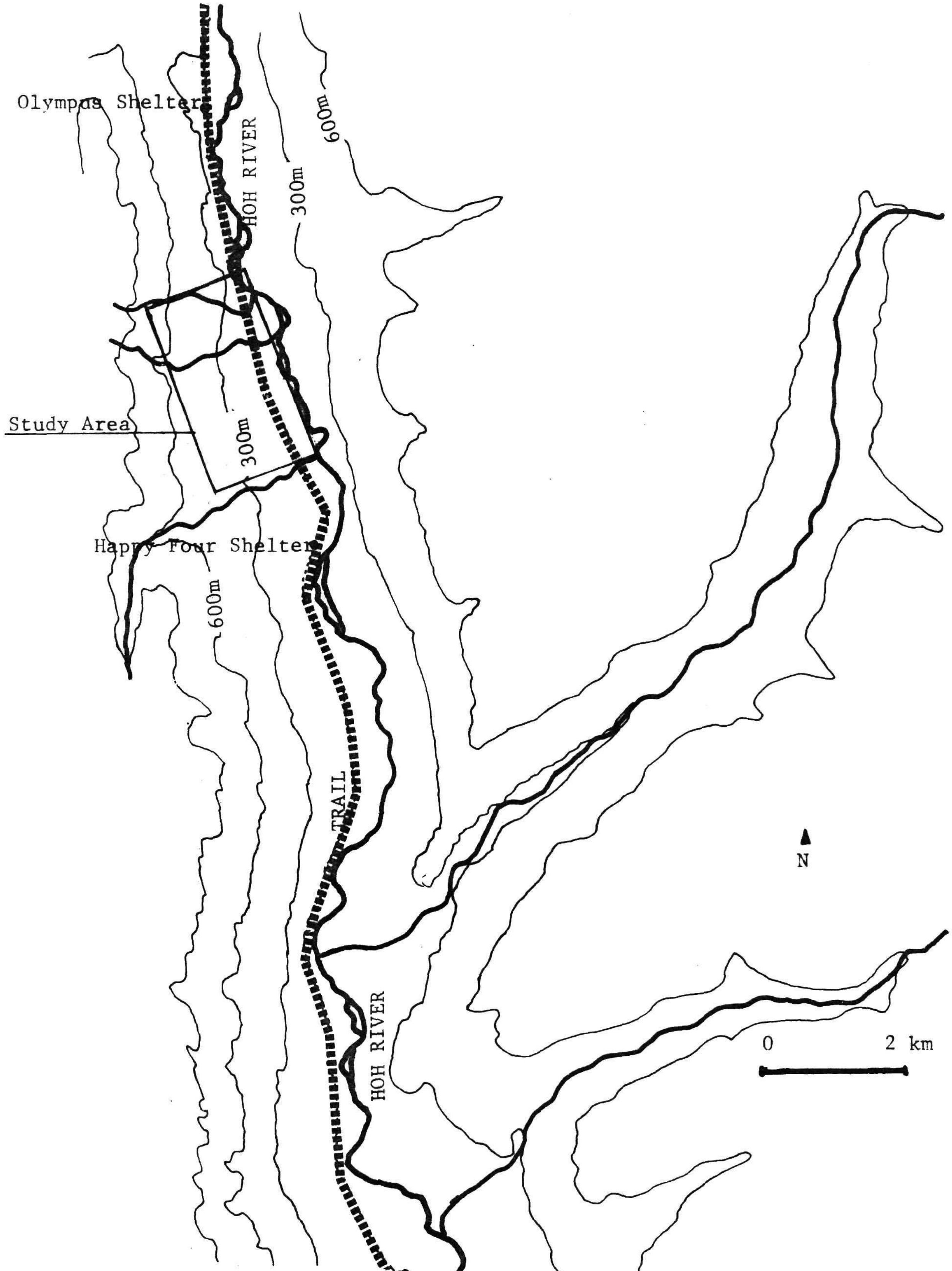
WOLF SIGHTINGS OR ESTIMATES 1930 - 1975

DATE	SIGHTING OR ESTIMATE	LOCATION	REFERENCE
1930	one wolf sighted	Snow Creek country	(Scheffer 1946)
1932	wolf howl heard	S. side Hoh Valley	(Mills 1975)
1932	wolf tracks - one set	Olympus Ranger Station	(Mills 1975)
1930	"wolf"tracks	Soleduck River	(Peterson 1975, pers. comm.)
1946	"wolf" tracks	Greywolf River	(Scheffer 1946)
1946	"wolf attack" on man	Elma	(Scheffer 1946)
1972	wolf tracks	N. Fork Quinault River	(Osborn 1975, pers. comm.)

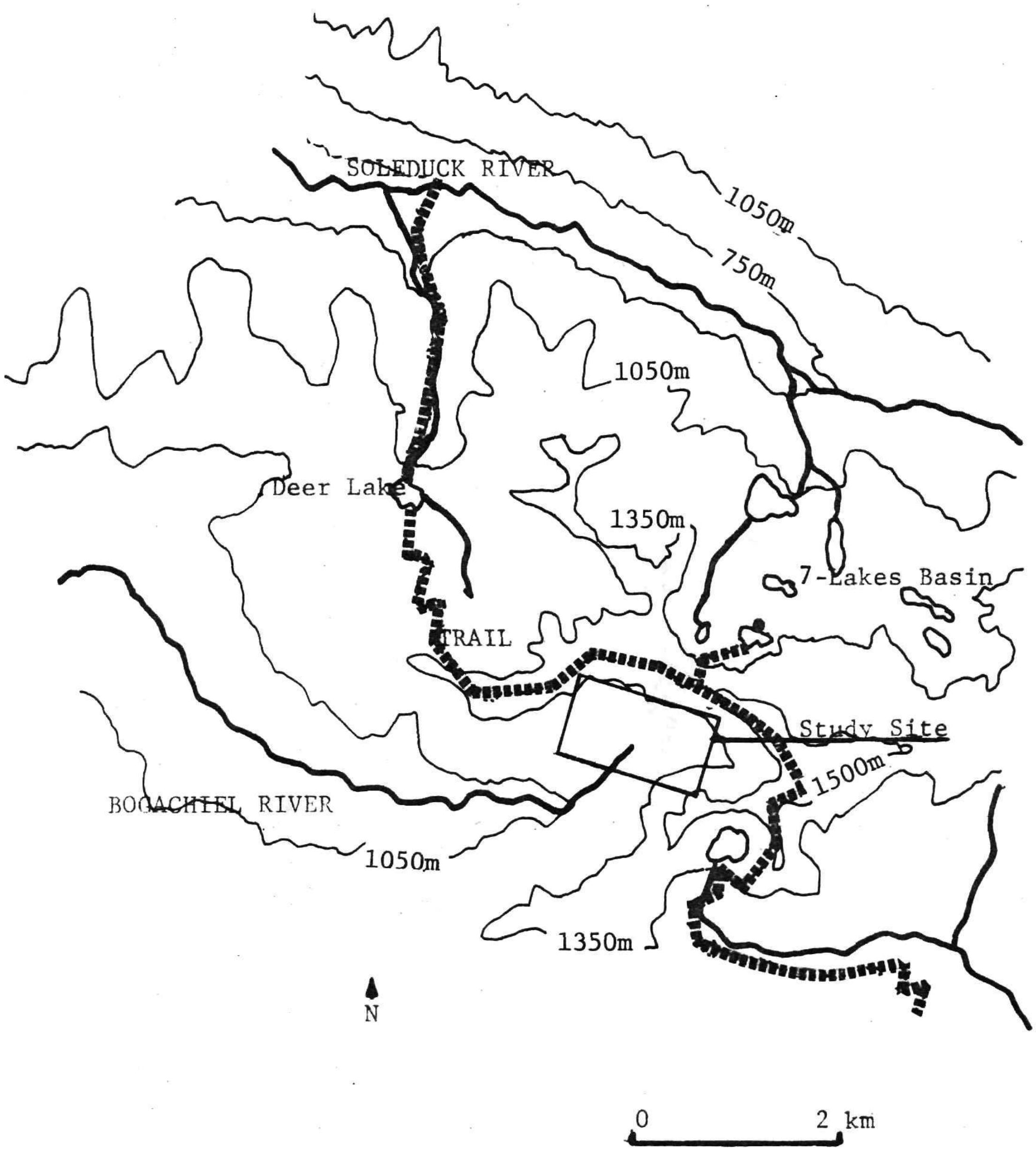
APPENDIX C

STUDY SITE MAPS

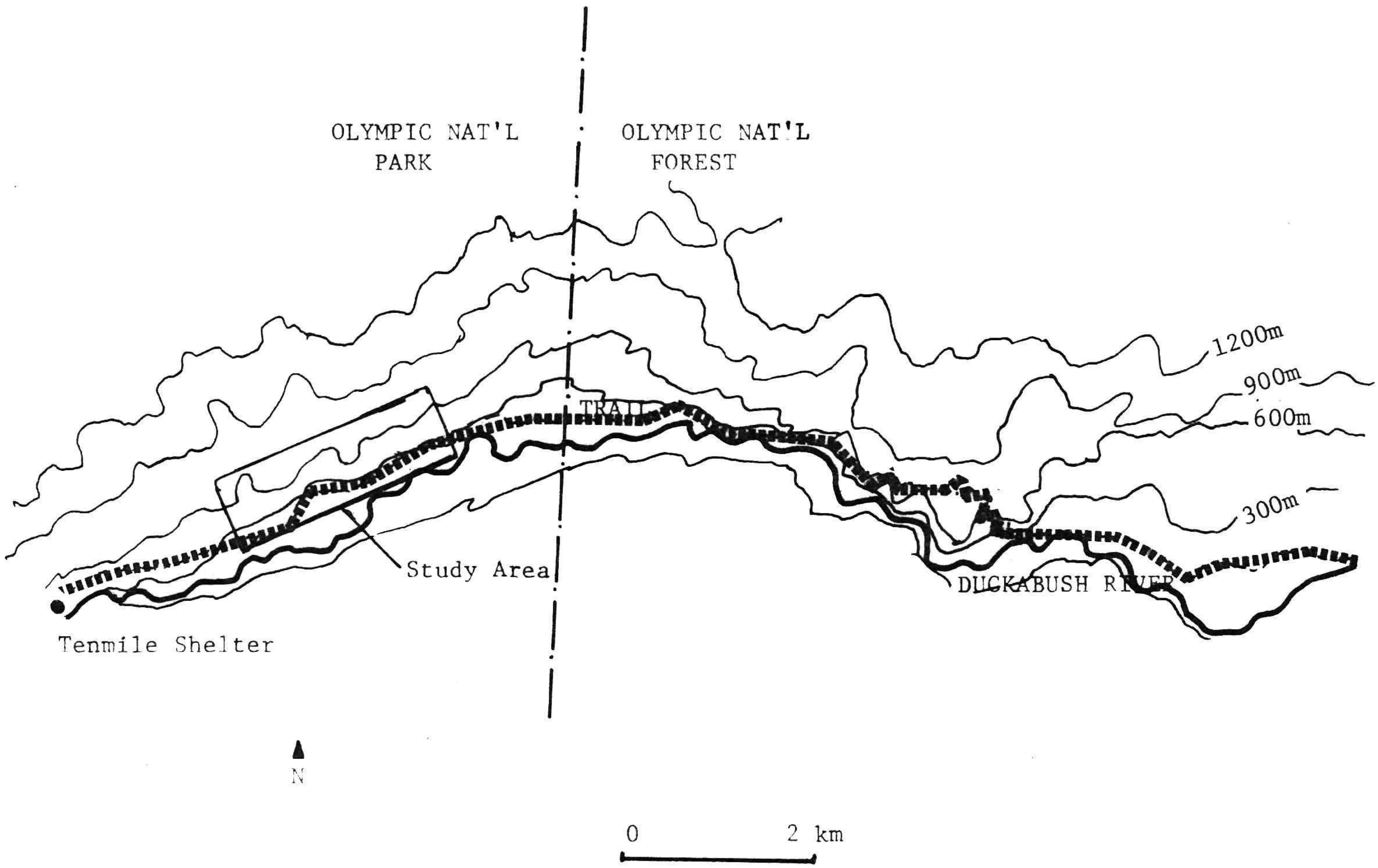
1) MAP OF THE HOH RIVER AND VICINITY



2) MAP OF THE BOGACHIEL BASIN SITE AND VICINITY



3) MAP OF THE DUCKABUSH RIVER SITE AND VICINITY



APPENDIX D

DISTANCES BETWEEN THE TRANSECTS

HOH SITE		DUCKABUSH SITE		BOGACHIEL SITE	
Transect	m. to next transect along trail	transect	m. to next transect along trail	transect	m. to next transect along baseline(no trail)
1*	97	17**	273	33***	20
2	511	18	12	34	10
3	42	19	87	35	120
4	147	20	232	36	40
5	22	21	96	37	20
6	218	22	182	38	50
7	51	23	48	39	50
8	183	24	29	40	120
9	76	25	5	41	10
10	386	26	122	42	160
11	201	27	394	43	10
12	7	28	112	44	120
13	88	29	282	45	140
14	32	30	261	46	40
15	6	31	285	47	10
16	end	32	end	48	end

* Transect No. 1 is approximately 800 m east of Happy Four Shelter and 100 m east of a 2 m diameter log through which the trail passes.

** Transect No. 17 is approximately 130 m west of the second puncheon boardwalk encountered about 2.5 km west of the Olympic National Park boundary.

*** Transect No. 33 lies off the trail approximately 100 m below and to the south of the Deer Lake-Bogachiel Peak Trail, S 70°E of Bogachiel Peak

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 1   COM X,F,F1,E8,Z8,Z9,U9
 10  REM-THIS PROGRAM LAST UPDATED ON DEC. 17,1975
 20  FILES PACK4,PKINF4,CERVID,RSLTW4
 100 DIM E[10,9],D[10,9],W[20,3],B[10,2],F[10,2],C[9,2]
 110 DIM H[9],S[4,3],G[20,8],T[9,3],P[9,3]
 111 DIM Y[9,3],Z[6]
 112 DIM A$[1],B$[1],C$[1]
 114 DIM L[9]
 117 DIM M[9,3],Q[20],X[20,3]
 500 PRINT "DO YOU WANT TO REINTRODUCE HEALTHY, VACCINATED WOLVES";
 510 INPUT D$
 515 U9=0
 517 IF D$="Y" THEN  U9=1
 520 PRINT "YEARLY ITERATION INSTEAD OF MONTHLY";
 530 INPUT A$
 540 PRINT "DO YOU WANT THE RESULTS PUT ON A FILE";
 550 INPUT B$
 555 PRINT "DO YOU WANT TO SEE THE CERVID DISTRIBUTION";
 556 INPUT C$
 560 F=1
 570 F1=0
 575 E8=1
 580 IF A$="Y" THEN  F=0
 590 IF B$="Y" THEN  F1=1
 595 IF C$="Y" THEN  E8=0
 600 PRINT "HOW LONG RUN";
 610 INPUT X
 620 PRINT "HOW MANY RUNS";
 630 INPUT Z8
 640 Z9=0
 645 Z9=Z9+1
 650 IF Z9>Z8 THEN 9999
 655 CHAIN "PUTIN4"
 660 MAT H=CON
 661 MAT Q=CON
 663 Z=0
 680 MAT B=ZER
 700 MAT F=ZER
 710 MAT C=ZER
 720 READ #3,11
 730  IF  END #3 THEN 750
 740 MAT  READ #3;B
 750 READ #3,10
 760  IF  END #3 THEN 780
 770 MAT  READ #3;F
 780 READ #3,6
 790  IF  END #3 THEN 810
 800 MAT  READ #3;C
 810 MAT  READ S
 815 MAT  READ V
 820 DATA .5,.5,.2,.5,.5,.2,.6,.6,.2,.5,.5,.2
 830 DATA 5.65E-05,.00131,.0159,.0988,.333,.666,.911,.9997
 831 DATA .99995,1
 840 RESTORE
1011 REM K1 IS SET TO 2, FOR 2 PACKS
1012 K1=2
```

```
1013  Z=0
1020  FOR Y=1 TO X
1030    FOR M=1 TO 12
1032      Z=Z+1
1033      IF  NOT F THEN 1035
1034      PRINT "MONTH"M,"YEAR"Y
1035      IF M#5 THEN 1055
1037      PRINT LIN(2)
1041      GOSUB 1500
1055      GOSUB 2000
1056      IF M=2 THEN  GOSUB 8000
1060      GOSUB 3000
1070      GOSUB 4000
1080      GOSUB 5000
1085      GOSUB 6000
1090      GOSUB 7000
1095      GOSUB 6000
1100      GOSUB 9000
1120    NEXT M
1130  NEXT Y
1140  GOTO 645
1150  STOP
1500  REM-REPRODUCTION ROUTINE*********
1550  FOR I1=1 TO K1
1555    READ #1,I1
1560    MAT W=ZER
1570    IF  END #1 THEN 1590
1580    MAT  READ #1,I1;W
1581    A1=2
1585    IF G[I1,1]=0 THEN  A1=A1-1
1587    IF G[I1,2]=0 THEN  A1=A1-1
1589    IF A1<2 THEN 1790
1590    N1=1
1595    IF F THEN  PRINT "PACK"I1"IS HAVING PUPS"
1600    FOR I2=1 TO N1
1602      T=RND(0)
1604      FOR I3=1 TO 10
1606        IF T>V[I3] THEN 1610
1608        N2=INT(I3*Q[I1])
1609        GOTO 1620
1610      NEXT I3
1620      G3=G[I1,3]
1630      K=0
1640      FOR I3=G3 TO G3+N2-1
1650        W[I3,1]=G[I1,4]+K
1670        W[I3,2]=INT(RND(0)+.5)
1680        W[I3,3]=0
1700        K=K+1
1710      NEXT I3
1720      G[I1,3]=I3
1730    NEXT I2
1740    G[I1,4]=W[I3-1,1]+1
1770    READ #1,I1
1780    MAT  PRINT #1,I1;W
1782    GOSUB 4500
1790  NEXT I1
```

```
1900  RETURN
1999  REM-CERVID MORTALITY AND NATALITY *******
2000  IF Y#1 OR M#1 THEN 2050
2002  MAT D=ZER
2004  MAT E=ZER
2006  FOR I1=1 TO 2
2007    READ #3,I1
2008    FOR I3=(I1*5)-4 TO (I1*5)
2010      FOR I2=1 TO 9
2012        IF  END #3 THEN 2020
2014        READ #3;E[I3,I2]
2016      NEXT I2
2018    NEXT I3
2020  NEXT I1
2022  FOR I1=1 TO 2
2023    READ #3,I1+3
2024    FOR I2=(I1*5)-4 TO (I1*5)
2026      FOR I3=1 TO 9
2028        IF  END #3 THEN 2036
2030        READ #3;D[I2,I3]
2032      NEXT I3
2034    NEXT I2
2036  NEXT I1
2050  IF M#6 THEN 2060
2056  D9=E9=0
2060  FOR I3=1 TO 9
2070    IF M=12 THEN 2090
2080    IF M>4 THEN 2250
2090    D1=E1=0
2100    FOR I4=1 TO 10
2110      D1=D[I4,I3]+D1
2120      E1=E[I4,I3]+E1
2130    NEXT I4
2140    D2=D[1,I3]
2150    E2=E[1,I3]
2160    D3=C[I3,1]/(D1+D2+E1+E2)
2170    D3=D3↑(1/5)
2175    IF D3>1 THEN  D3=1
2200    H[I3]=D3
2205    FOR I4=1 TO 10
2210      D[I4,I3]=INT(D[I4,I3]*B[I4,1]*H[I3])
2220      E[I4,I3]=INT(E[I4,I3]*B[I4,2]*H[I3])
2230    NEXT I4
2240    GOTO 2410
2250    IF M#6 THEN 2370
2260    D1=E1=0
2270    FOR I4=9 TO 1 STEP -1
2290      D1=D1+INT(F[I4+1,1]*D[I4+1,I3]*H[I3]*.75)
2300      E1=E1+INT(F[I4+1,2]*E[I4+1,I3]*H[I3]*.75)
2310      D[I4+1,I3]=INT(B[I4,1]*D[I4,I3])
2320      E[I4+1,I3]=INT(B[I4,2]*E[I4,I3])
2330    NEXT I4
2335    D9=D9+D1
2337    D[1,I3]=D1
2340    E9=E9+E1
2350    E[1,I3]=E1
```

```
2360    GOTO 2410
2370    FOR I4=1 TO 10
2380      D[I4,I3]=INT(B[I4,1]*D[I4,I3])
2390      E[I4,I3]=INT(B[I4,2]*E[I4,I3])
2400    NEXT I4
2410  NEXT I3
2500  IF  NOT F THEN 2900
2600  IF M#6 THEN 2780
2610  PRINT "UNGULATE YOUNG BROUGHT INTO THE WORLD THIS MONTH:"
2620  PRINT D9"FAWNS;"E9"CALVES"
2780  IF E8 THEN 2900
2790  PRINT "MAT E AT Y="Y"AND M="M"IS"
2800  MAT  PRINT  USING "9(5D)//";E
2849  PRINT "MAT D IS"
2850  MAT  PRINT  USING "9(5D)//";D
2900  RETURN
2999  REM- HUNTING ROUTINE****************
3000  IF Y#1 OR M#1 THEN 3070
3010  MAT G=ZER
3011  READ #2,1
3015  FOR I1=1 TO K1
3020    FOR I2=1 TO 8
3025      IF  END #2 THEN 3040
3030      READ #2;G[I1,I2]
3033    NEXT I2
3035  NEXT I1
3040  GOTO 3070
3070  S1=INT(M+5)/4
3080  FOR I1=1 TO K1
3090    C5=C6=C7=C8=0
3091    C9=C0=0
3100    G4=G[I1,8]
3110    C1=G[I1,7]*4
3120    C2=C1+G[I1,6]*5.5
3130    C3=C2*30
3140    C4=C3-C5
3160    IF C4 <= 0 THEN 3651
3170    GOSUB 3670
3180    GOSUB 3750
3190    T1=1-(S[S1,3])
3195    D4=D3/4
3200    T2=D4+E3
3210    T3=D4/T2*T1
3220    T4=T3+(E3/T2*T1)
3230    R1=RND(0)
3240    IF R1<T3 THEN 3280
3250    IF R1<T1 THEN 3450
3260    C5=C5+10
3265    C6=C6+1
3270    GOTO 3140
3280    T1=1-S[S1,1]
3300    R1=RND(0)
3310    IF R1>S[S1,1] THEN 3350
3320    D[1,G4]=D[1,G4]-1
3330    C5=C5+27
3335    C9=C9+1
```

```
3340    GOTO 3140
3350    K3=Ø
3360    FOR I3=2 TO 1Ø
3370      K3=D[I3,G4]+K3
3380      K4=K3/D1*T1+S[S1,1]
3390      IF R1<K4 THEN  GOTO 341Ø
3400      GOTO 344Ø
3410      D[I3-1,G4]=D[I3-1,G4]-1
3420      C5=C5+69
3425      C7=C7+1
3430      GOTO 314Ø
3440    NEXT I3
3450    T1=1-S[S1,2]
3470    R1=RND(Ø)
3480    IF R1<S[S1,2] THEN 35ØØ
3490    GOTO 353Ø
3500    E[1,G4]=E[1,G4]-1
3510    C5=C5+91
3515    CØ=CØ+1
3520    GOTO 314Ø
3530    K3=Ø
3540    FOR I3=2 TO 1Ø
3560      K3=E[I3,G4]+K3
3570      K4=K3/E1*T1+S[S1,2]
3580      IF R1<K4 THEN 36ØØ
3590      GOTO 364Ø
3600      GOTO 361Ø
3610      E[I3,G4]=E[I3,G4]-1
3620      C5=C5+3Ø5
3625      C8=C8+1
3630      GOTO 314Ø
3640    NEXT I3
3651    IF  NOT F THEN 3668
3652    PRINT "NUMBERS OF PREY TAKEN BYPACK"I1" IN SECTOR"G[I1,8]
3653    PRINT C9"FAWNS;"C7"ADULT DEER"
3654    PRINT CØ"CALVES;"C8"ADULT ELK"
3655    PRINT C6"OTHER PREY"
3668  NEXT I1
3669  RETURN
3670  REM-DEER COUNTER$$$$$$$$$$$$$
3680  D1=Ø
3690  FOR I2=2 TO 1Ø
3700    D1=D1+D[I2,G4]
3710  NEXT I2
3720  D2=D[1,G4]
3730  D3=D1+D2
3740  RETURN
3750  REM-ELK COUNTER$$$$$$$$$$$$$
3760  E1=-Ø
3770  FOR I2=2 TO 1Ø
3780    E1=E1+E[I2,G4]
3790  NEXT I2
3800  E2=E[1,G4]
3810  E3=E1+E2
3820  RETURN
3999  REM-AGING AND MORTALITY****************
```

```
4000  FOR I1=1 TO K1
4001    READ #1,1
4002    MAT W=ZER
4003    IF  END #1 THEN 4010
4004    MAT  READ #1,I1;W
4010    FOR I2=1 TO 20
4014      IF W[I2,1]=0 THEN 4110
4020      P2=W[I2,3]
4030      IF P2 >= 0 AND P2<7 THEN  R2=.923
4040      IF P2 >= 7 AND P2 <= 19 THEN  R2=.936
4050      IF P2>19 AND P2 <= 34 THEN  R2=.98532
4055      IF P2>34 THEN  R2=.991
4057      IF U9 THEN  U8=1
4058      IF Y#1 THEN  U8=0
4059      IF U9#1 THEN  U8=0
4060      IF U8 THEN  R2=R2*1.01
4061      R1=RND(0)
4070      IF R1>R2 THEN 4100
4080      W[I2,3]=W[I2,3]+1
4090      GOTO 4110
4100      W[I2,1]=0
4110    NEXT I2
4115    MAT  PRINT #1,I1;W
4120  NEXT I1
4140  RETURN
4500  REM-MAT W PRINT OUT ROUTINE*********
4505  IF  NOT F THEN 4590
4507  PRINT "CURRENT WOLF PACK STATUS"
4510  FOR J1=1 TO 20
4520    IF W[J1,1]=0 THEN 4590
4530    FOR J2=1 TO 3
4540      IF J2=3 THEN 4560
4550      PRINT  USING 4555;W[J1,J2]
4555      IMAGE #,3D
4559      GOTO 4570
4560      PRINT W[J1,J2]
4570    NEXT J2
4580  NEXT J1
4590  RETURN
4600  REM-MAT G PRINT ROUTINE***********
4605  IF  NOT F THEN 4690
4607  PRINT "CURRENT WOLF PACK STATISTICS"
4610  FOR J1=1 TO K1
4620    FOR J2=1 TO 8
4630      IF J2=8 THEN 4660
4640      PRINT  USING 4650;G[J1,J2]
4650      IMAGE#,3D
4655      GOTO 4670
4660      PRINT G[J1,J2]
4670    NEXT J2
4680  NEXT J1
4690  RETURN
5000  REM-PACKSPLITTER***************
5005  K2=0
5030  FOR I1=1 TO K1
5031    G=G[I1,1]+G[I1,2]
```

```
5032    H=ABS(G[I1,2]-G[I1,1])
5033    IF G<4 THEN 5994
5035    MAT W=ZER
5040    READ #1,I1;W
5045    IF  END #1 THEN 5070
5050    MAT  READ #1,I1;W
5070    IF H=G THEN 5700
5075    P1=RND(0)*4
5080    GOTO G-3 OF 5100,5200,5300
5100    REM-CASES OF TWO SUBORDINATES
5105    IF P1<3 THEN 5994
5110    GOTO G[I1,1] OF 5400,5500,5600
5200    REM- CASES OF THREE SUBORDINATES
5205    IF P1<4/3 THEN 5994
5210    S=0
5215    N=1
5220    IF H#1 THEN 5230
5225    IF P1>8/3 THEN 5500
5230    IF G[I1,1]>G[I1,2] THEN  S=1
5235    GOTO 5800
5300    REM-CASES OF FOUR SUBORDINATES
5305    N=2
5310    S=2
5315    IF H=0 THEN 5800
5320    S=0
5325    GOTO H/2 OF 5330,5360
5330    IF P1>2 THEN 5500
5335    IF G[I1,1]>G[I1,2] THEN  S=1
5340    GOTO 5800
5360    IF P1<3 THEN  N=1
5365    IF G[I1,1]>G[I1,2] THEN  S=1
5370    GOTO 5800
5400    S=0
5410    N=1
5420    GOTO 5800
5500    S=2
5510    N=2
5520    GOTO 5800
5600    S=1
5610    N=1
5620    GOTO 5800
5700    REM-CASES OF ONE SEX COMPLETELY MISSING
5710    N=1
5720    S=1
5730    IF G[I1,2]>G[I1,1] THEN  S=0
5740    GOTO 5800
5800    REM-KICKOUT ROUTINE*************
5803    IF M>4 AND M<11 THEN 5998
5805    IF  NOT N THEN 5990
5807    MAT Z=ZER
5810    K2=K2+1
5813    I=-1
5815    IF S=2 THEN 5880
5820    FOR I2=20 TO 1 STEP -1
5825      IF W[I2,1]=0 OR W[I2,2]#S OR W[I2,3]<22 THEN 5870
5826      I=I+1
```

```
5830      N=N-1
5835      FOR I3=1 TO 3
5840        Z[I3+I*3]=W[I2,I3]
5850      NEXT I3
5865      W[I2,1]=0
5868      IF  NOT N THEN 5872
5870    NEXT I2
5872    READ #1,K1+K2
5873    PRINT #1,K1+K2;Z[1],Z[2],Z[3],Z[4],Z[5],Z[6]
5875    GOTO 5990
5880    REM
5885    FOR I2=20 TO 1 STEP -1
5892      IF W[I2,1]=0 OR W[I2,2]=I OR W[I2,3]<22 THEN 5940
5893      I=I+1
5895      N=N-1
5900      FOR I3=1 TO 3
5905        Z[I3+I*3]=W[I2,I3]
5910      NEXT I3
5915      W[I2,1]=0
5920      IF  NOT N THEN 5945
5940    NEXT I2
5945    READ #1,K1+K2
5950    PRINT #1,K1+K2;Z[1],Z[2],Z[3],Z[4],Z[5],Z[6]
5990    READ #1,I1
5992    MAT  PRINT #1,I1;W
5994  NEXT I1
5995  K1=K1+K2
5996  REM
5998  RETURN
5999  REM-MISCELLANEOUS INFO PROCESSOR*********
6000  REM
6020  FOR I1=1 TO K1
6030    MAT W=ZER
6040    IF  END #1 THEN 6052
6050    MAT  READ #1,I1;W
6052    REM
6060    G[I1,1]=G[I1,2]=G[I1,5]=G[I1,6]=G[I1,7]=0
6070    FOR I2=1 TO 20
6080      IF W[I2,1]#0 THEN 6180
6110      FOR I4=1 TO 3
6120        FOR I3=I2 TO 19
6130          W[I3,I4]=W[I3+1,I4]
6140        NEXT I3
6150        W[20,I4]=0
6160      NEXT I4
6170      IF W[I2,1]=0 THEN 6300
6180      IF W[I2,3]<10 THEN 6250
6190      IF W[I2,3]<24 THEN 6230
6200      IF W[I2,2] <> 0 THEN 6270
6210      G[I1,2]=G[I1,2]+1
6220      GOTO 6290
6230      G[I1,5]=G[I1,5]+1
6240      GOTO 6290
6250      G[I1,7]=G[I1,7]+1
6260      GOTO 6290
6270      G[I1,1]=G[I1,1]+1
```

```
6290      G[I1,6]=G[I1,1]+G[I1,2]+G[I1,5]
6300    NEXT I2
6310    FOR I2=1 TO 20
6320      IF W[I2,1] <> 0 THEN 6350
6330      G[I1,3]=I2
6331      IF I2=1 THEN  GOSUB 8500
6332      IF K1#0 THEN 6351
6333      PRINT "ALL WOLVES DECIMATED OR LEFT"
6334      GOTO 1140
6350    NEXT I2
6351    REM
6352    GOSUB 4500
6355    READ #1,I1
6360    MAT  PRINT #1,I1;W
6361  NEXT I1
6500  GOSUB 4600
6899  RETURN
7000  REM-DISTRIBUTOR*********************
7009  MAT P=ZER
7050  D=E=0
7055  FOR I1=1 TO 9
7060    D1=E1=0
7065    FOR I2=1 TO 10
7070      E1=E1+E[I2,I1]
7075      D1=D1+D[I2,I1]
7080    NEXT I2
7085    T[I1,1]=E1
7090    T[I1,2]=D1
7100    D=D+D1
7110    E=E+E1
7115  NEXT I1
7120  IF M>4 AND M<11 THEN 7610
7123  Q1=4
7125  REM Q1 IS THE RATIO OF PREFERENCE  OF ELK TO DEER
7130  D=D/Q1
7132  P=0
7135  FOR I1=1 TO 9
7140    D2=T[I1,2]
7145    D1=D2/Q1
7150    E1=T[I1,1]
7155    U1=D1+E1
7160    A1=U1/C[I1,2]
7165    P=A1+P
7170    T[I1,3]=D2+E1
7173    P[I1,1]=P
7175  NEXT I1
7180  FOR I1=1 TO 9
7185    P[I1,1]=1/P*P[I1,1]
7190  NEXT I1
7199  K3=0
7200  FOR I1=1 TO K1
7205    MAT L=ZER
7207    L=0
7210    P1=RND(0)
7220    FOR I2=1 TO 9
7230      IF P1>P[I2,1] THEN 7400
```

```
7240       C=I2
7260       IF L[I2] THEN 7280
7270       GOTO 7290
7280       L=L+1
7285       IF L >= 15 THEN 7800
7287       GOTO 7210
7290       L[I2]=1
7300       C1=P[I2,2]+G[I1,6]+G[I1,7]
7305       IF C1>0 THEN 7310
7307       PRINT "WOLF PACK #"I1"IS COMPLETELY DECIMATED"
7308       GOTO 7500
7310       IF T[I2,3]/C1 <= 350 THEN 7210
7320       P[I2,2]=C1
7330       G[I1,8]=I2
7340       GOTO 7500
7400     NEXT I2
7500   NEXT I1
7600   K1=K1-K3
7610   RETURN
7800   K3=K3+1
7805   IF  NOT F THEN 7820
7810   PRINT "PACK #"I1"WITH"(G[I1,6]+G[I1,7])"WOLVES CANNOT BE";
7811   PRINT "      SUPPORTED BY THIS SECTOR AND HAVE LEFT AREA"
7820   READ #1,I1
7830   MAT W=ZER
7840   MAT  PRINT #1,I1;W
7849   GOTO 7600
8000   REM-NATALITY REDUCER************
8005   FOR I1=1 TO K1
8007     FOR I2=1 TO 9
8010       M[I2,1]=0
8015       M[I2,2]=0
8020       FOR I3=1 TO 10
8025         M[I2,1]=D[I3,I2]+M[I2,1]
8030         M[I2,2]=M[I2,2]+E[I3,I2]
8035       NEXT I3
8040       M[I2,3]=M[I2,1]+M[I2,2]
8050       M9=0
8055       FOR I3=1 TO I2
8060         M9=M9 MAX M[I2,3]
8065       NEXT I3
8070     NEXT I2
8073     Q[I1]=1
8075     IF M9/375<G[I1,6]+G[I1,7] THEN  Q[I1]=.44
8080   NEXT I1
8095   RETURN
8500   REM-PACK MOVES TO DIFFERENT RECORDS******
8505   IF K1-1#0 THEN 8515
8507   K1=0
8510   GOTO 8900
8515   READ #1,I1+1
8517   MAT X=ZER
8520   IF  END #1 THEN 8530
8530   MAT  PRINT #1,I1;X
8532   FOR P6=1 TO 8
8534     G[I1,P6]=G[I1+1,P6]
```

```
8536  NEXT P6
8540  IF K1 <= I1+1 THEN 8600
8542  FOR P5=I1+1 TO K1-1
8543    MAT X=ZER
8545    READ #1,P5+1
8550    IF  END #1 THEN 8560
8555    MAT  READ #1;X
8560    MAT  PRINT #1,P5;X
8565    FOR P6=1 TO 8
8570      G[P5,P6]=G[P5+1,P6]
8575    NEXT P6
8580  NEXT P5
8600  K1=K1-1
8900  RETURN
8999  REM-PRINTOUT ROUTINE********************
9000  F3=0
9001  IF F THEN 9019
9010  IF M#12 THEN 9030
9011  F=1
9012  F3=1
9014  PRINT "END OF YEAR #"Y
9015  FOR I1=1 TO K1
9016    GOSUB 4500
9017  NEXT I1
9019  IMAGE 10X,"SECTOR",4X,"ELK",7X,"DEER",6X,"WOLVES"
9020  IMAGE 10X,"------",4X,"---",7X,"----",6X,"------"/
9023  IMAGE 10X,3D,5X,5D,5X,5D,5X,5D
9024  PRINT  USING 9019
9025  PRINT  USING 9020
9030  FOR I1=1 TO 9
9040    IF M<5 OR M>10 THEN  Y[I1,1]=P[I1,2]
9050    Y[I1,2]=T[I1,1]
9060    Y[I1,3]=T[I1,2]
9070    IF F THEN  PRINT  USING 9023;I1,Y[I1,2],Y[I1,3],Y[I1,1]
9090  NEXT I1
9500  Z7=Z6=Z5=0
9510  FOR I1=1 TO 9
9520    Z7=Z7+Y[I1,1]
9530    Z6=Z6+Y[I1,2]
9540    Z5=Z5+Y[I1,3]
9550  NEXT I1
9555  IMAGE 19X,"-----",5X,"-----",5X,"-----"
9557  IF F THEN  PRINT  USING 9555
9560  IMAGE 10X,"TOTALS",3X,5D,5X,5D,4X,5D
9570  IF F THEN  PRINT  USING 9560;Z6,Z5,Z7
9600  IF  NOT F1 THEN 9900
9610  P9=INT((Z-1)/40)+1
9613  O1=X*12-Z
9615  GOTO P9 OF 9620,9640,9660
9620  GOTO 9621
9621  IF Z=1 THEN  READ #4,(3*Z9-2)
9622  IF  NOT O1 THEN  PRINT #4;Z7,Z6,Z5, END
9623  IF  NOT O1 THEN 9900
9625  PRINT #4;Z7,Z6,Z5
9635  GOTO 9900
9640  IF Z=41 THEN  READ #4,(3*Z9)-1
```

```
9645  IF  NOT 01 THEN  PRINT #4;Z7,Z6,Z5, END
9648  IF  NOT 01 THEN 9900
9649  PRINT #4;Z7,Z6,Z5
9650  GOTO 9900
9660  IF Z=81 THEN  READ #4,(3*Z9)
9665  IF  NOT 01 THEN  PRINT #4;Z7,Z6,Z5, END
9668  IF  NOT 01 THEN 9900
9670  PRINT #4;Z7,Z6,Z5
9900  IF F3 THEN  F=0
9950  RETURN
9999  END
>
```

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