FACTORS INFLUENCING FURBEARER POPULATIONS AND HARVEST ON THE KENAI NATIONAL MOOSE RANGE, ALASKA

THEODORE N. BAILEY, U.S. Fish and Wildlife Service, Kenai National Moose Range, P.O. Box 2139, Soldotna, Alaska 99669

ABSTRACT: Natural factors have influenced several furbearer populations on the 691,000 ha Kenai National Moose Range wildlife refuge in south-central Alaska. The 1964 earthquake which suddenly disturbed refuge hydrology, apparently caused a major decline in the refuge beaver (*Castor canadensis*) population. A history of wildfires appear related to the scarcity of marten (*Martes americana*) on the refuge and perhaps the relatively low beaver population. Browsing of aspen (*Populus tremuloides*) by high populations of moose (*Alces alces*) may also have influenced the refuge beaver population. A lynx (*Lynx canadensis*) harvest increase of 40 times between 1966 - 1967 and 1973 - 1974 apparently paralleled changes in snowshoe hare (*Lepus americanus*) abundance. Furbearer harvest on the refuge is related to fur prices, the local economy, trapper experience and technique, and mode of transportation. A "tracking" harvest strategy is recommended for harvesting certain furbearer populations on the refuge.

Two features of wildlife in the North are their general scarcity (Weeden 1978) and the fluctuations their populations undergo (Kendeigh 1961). Although scarcity appears to be the consequence of low annual plant production, fluctuations may be caused by a number of factors which appear related to environmental extremes caused by the northern climate. Furbearer populations are probably no exception to these generalizations. Although relatively little is known about the long-term population dynamics of many furbearers in Alaska, it is safe to assume that most furbearer populations fluctuate in response to changes in their major prey (Buckley 1954) or habitat. In this paper, apparent changes in several furbearer populations on the Kenai National Moose Range in southcentral Alaska are documented as well as some of the factors influencing furbearer harvests on the refuge.

MATERIALS AND METHODS

Two methods were used to document changes in furbearer populations levels and harvest rates. One was to compare annual furbearer harvests and success rates per trapping permit holder on the refuge and the other was to compare beaver population estimates for different periods and habitats on the refuge.

Harvest Reports

Trappers on the refuge after 1967 were required to possess a trapping permit which was issued annually to an unlimited number of trappers free of charge. Prior to 1967 the refuge was subdivided into trapping units with a fixed number of trappers per unit. All trappers on the refuge are required to submit annual harvest reports which are then used to determine annual minimum harvest. The annual harvest is a minimum figure because an estimated small percentage of trappers do not obtain permits, numbers of furbearers reported may be deflated, and all permit holders do not submit harvest reports. All permit holders do not trap and those that trap have a wide range of experience, use different trapping techniques, and have varying degrees of trapping success. However, in an attempt to reduce the annual reported harvest of furbearers to a common index for comparison, and with full realization of the problems involved, I expressed this index as an average harvest per permit holder. This value is lower than the actual average harvest per successful trapper because all trappers were not successful (an unknown for all trappers) and not all permit holders trapped (another unknown). However, the index does reduce the reported harvest of furbearers to a common unit based on the level of trapping interest on the refuge.

Beaver Population Survey

Beaver numbers were estimated on the refuge in the fall of 1977. To estimate numbers, the refuge was subdivided into 3 major habitats: 1) an 8-yr-old burn area; 2) a 30-yr-old burn area; and 3) the remainder which had not been burned in the past 30 yr. Lakes within these habitats were stratified according to size, with lakes less than 2 ha (5 acres) excluded. Lakes were then randomly selected within each strata. The total number of lakes sampled per strata was proportional to their occurrence in the habitat (Table 1).

Table 1. Beaver habitat and classification on the Kenai National Moose Range, 1977. Lakes less than 2 ha excluded.

Beaver habitat	Total area (km^2)	Size of lake (hectares)	Number of lakes In habitat	Number of lakes In sample
8-yr-old burn (1969 Wildfire)	337	2-40	117	44
		41-121	13	5
		122-243	1	1
		243+	0	0
30-yr-old burn (1947 Wildfire)	1,256	2-40	266	82
		41-121	29	8
		122-243	8	3
		243+	3	2
Unburned North of Sterling Highway	1,437	2-40	293	62
		41-121	29	9
		122-243	10	4
		243+	0	0
South of Sterling Highway	2,085	2-40	200	41
		41-121	11	3
		122-243	2	0
		243+	1	0
Total	5,115	2-40	876	229
		41-121	82	25
		122-243	21	8
		243+	4	2

To survey beaver, the shoreline of each sample lake was examined from a Piper PA-18 aircraft and the number of active lodges (those with a fresh food cache nearby) ascertained. Surveys were flown in the late fall (20 October - 4 November) when beavers cached food for winter. It was assumed there was an average of 4 beaver per active colony. In addition to the survey of beavers inhabiting lakes, another survey was flown over 19 streams totaling 368 km (230 mi) on the refuge. This survey was flown in a Cessna 185 on 31 October 1977 and the number of active lodges ascertained. It was recognized as reported by Boyce (1974) and Slough and Sadleir (1977) that aerial surveys probably underestimate the beaver population in stream habitat.

THE KENAI NATIONAL MOOSE RANGE

The Kenai National Moose Range was established as a wildlife refuge by executive order in 1941 to protect the habitat and breeding grounds of the giant Kenai moose and other wildlife values. This 691,000 ha (1.7 million acres) refuge is located on the western half of the Kenai Peninsula in southcentral Alaska. About 70 percent of the refuge is boreal forest comprised of black and white spruce (Picea mariana, P. glauca), paper birch (Betula papyrifera), aspen, willow (Salix sp.), and alder (Alnus sp.). The northern third of the boreal forest region is dotted with over 2,000 lakes, ponds, and bogs; the central third is dominated by gently, westward-sloping benchlands; and the southern third by upland and lowland terrain. Another 20 percent of the refuge is sub-alpine - alpine habitat in the Kenai Mountains which rise to a height of 1,820 m. Beyond the alpine zone is a zone of glaciers and permanent ice-fields which comprise about 10 percent of the refuge.

Furbearers on the refuge include the beaver, otter (Lutra canadensis), mink (Mustela vison), and muskrat (Ondatra zibethicus), lynx, coyote (Canis latrans), wolverine (Gulo gulo), and weasel (Mustela erminea). Red fox (Vulpes vulpes) and marten are rare. Wolves (Canis lupus) were extirpated from the Kenai Peninsula in the early 1900s but since the 1960s have recolonized the Peninsula and are found throughout most wolf habitat on the refuge (Peterson and Woolington 1979b).

Access to trappers on the refuge include about 35 km of paved highway, 50 km of maintained dirt roads, and over 3,000 km of seismic trails and an unmaintained road. Aircraft are also permitted to land on the majority of lakes on the refuge during trapping season. Vehicle traffic is restricted to maintained roads but snow machines are permitted on most unmaintained roads and seismic trails.

RESULTS AND DISCUSSION

Factors Influencing Furbearer Populations

<u>1964 Earthquake</u>. The earthquake of 27 March 1964 apparently had an adverse impact on aquatic furbearers, particularly beaver, on the Kenai National Moose Range. Centered about 140 km northeast of the refuge, the earthquake, registering 8.4 - 8.6 on the Richter scale, had an impact on numerous lakes in the region. Lake and river ice was broken for distances of 720 km from the epicenter by seismic shock and seiche action, sediment-laden ground water erupted at the surface, ice-covered lakes and streams responded by seiching, the surging action temporarily dewatered some lakes, fissuring occurred which caused a loss of water in some lakes, and the sediment load in some streams during the April spring runoff appeared to be greatly increased over previous years (Waller 1966).

On the Kenai Peninsula, many lakes were perched above the seasonal water table at the time of the earthquake and thus were able to drain through seismic fractures in the frozen unconsolidated material. Some lakes were partially or completely drained and it required several days to several weeks before former levels were restored by snowmelt. The larger lakes showed the most extensive wave action and subsequent breakage of ice.

The earthquake apparently had a severe impact on the refuge beaver population. In 1965 (Kenai National Moose Range 1965) refuge personnel were <u>still</u> receiving reports of beavers killed during the 1964 earthquake. One person reported finding a beaver lodge that ice (from the earthquake) had pushed more than 9 m from the lake. The decline in the total reported harvest of beaver on the refuge and the average per permit holder before and after the earthquake was 96 and 93 percent, respectively (Figure 1). Beaver mortality presumably increased when lodges and bank dens were destroyed by the sudden movement of ice and water and when entrances to lodges or bank dens were left exposed as water levels dropped. Under such conditions, beaver may have been exposed to cold air temperatures moving to and from dens and to perhaps increased predation. Repairing of damaged lodges may have been impractical until spring thaw in early - mid-May.

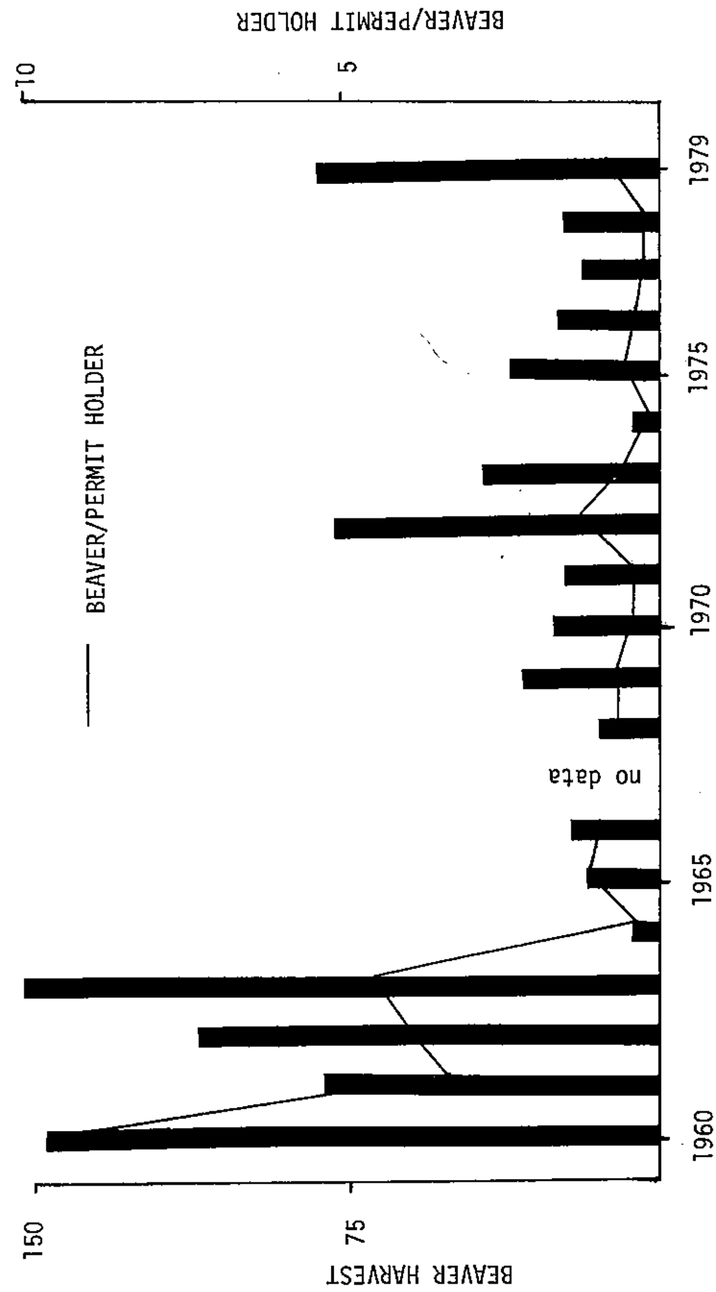

Figure 1. Beaver harvest and beaver per permit holder, Kenai National Moose Range, Alaska, 1960 - 1979.

Although beaver harvest on the refuge has never approached pre-1964 earthquake levels, factors other than the earthquake could also be responsible. These include fur prices, local economic conditions, and other changes in beaver habitat. Predation on beavers does not appear to be significant. Analysis of 542 summer wolf scats indicated beaver remains occurred only in 5 percent (Peterson and Woolington 1979a).

Results of 2 stream surveys on the refuge in 1962 and 1963, before the earthquake, suggest there may have been more stream beaver on the refuge during those years than in 1977 (Table 2). However, a number of reasons other than those associated with the earthquake could have been responsible for an apparent reduction in the refuge stream beaver population. Some active lodges may have been missed during the 1977 survey because freeze-up had already occurred at higher elevations, there was a light snow cover along some streams, and the speed of the aircraft was relatively high. Kenai Peninsula stream beaver densities (average 0.06 lodges per km) were much lower than those reported in Interior Alaska by Boyce (1974) where densities averaged 0.41 lodges per kilometer of streambed. Lake beaver densities on the refuge were also considerably less than those reported for boreal forest regions over much of Newfoundland (Bergerud and Miller 1977).

The impact of the 1964 earthquake on other refuge aquatic furbearers was unknown, although harvest data indicated a substantial decline in the reported total harvest and average harvest per permit holder of otter and mink immediately after the earthquake (Figures 2 and 3). Total harvest declined 88 percent for otter and 82 percent for mink and average harvest per permit holder declined 75 percent for otter and 64 percent for mink after the earthquake. No information was available for muskrat. It is difficult to conceive how the effects of the earthquake could directly have influenced mortality rates of active carnivores like the otter and mink.

<u>Wildfires and Habitat Disturbances</u>. Boreal forest habitat on the Kenai National Moose Range has been influenced by periodic wildfires dating back to at least the mid-1800's (Spencer and Hakala 1964). These wildfires have been extensive, burning up to 1,256 km^2 or 25 percent of the

Table 2. Beaver lodges observed on streams during aerial surveys on the Kenai National Moose Range.

Drainage	Period of Surveys					
	Pre-Earthquake[a]				Post-Earthquake	
	1962		1963		1977	
	Length of streams (km)	Active lodges	Length of streams (km)	Active lodges	Length of streams (km)	Active lodges
Tustumena Lake-Kasilof River Drainage	83.2	1	118.4	5	48.0	3
Kenai River Drainage						
Russian River	16.0	0	17.6	0	-	-
Killey River	41.6	3	46.4	3	41.6	0
Funny River	36.8	0	41.6	1	36.8	1
Moose River	43.2	8	49.6	10	43.2	4
Beaver Creek	11.2	4	19.2	1	14.4	0
Other	16.0	5	19.2	4	22.4	3
Other Cook Inlet Drainages						
Chickaloon River	49.6	0	48.0	2	76.8	1
Pincher Creek	8.0	1	25.6	0	8.0	0
Bedlam Creek	6.4	0	9.6	0	6.4	0
Miller Creek	4.8	0	6.4	0	4.8	0
Swanson River	51.2	0	54.4	3	51.2	1
Bishop Creek	12.8	5	12.8	3	-	-
Seven Egg Creek	-	-	-	-	14.4	1
Total	380.8	27	468.8	32	368.0	14

[a]Data from J. Hout (Kenai National Moose Range 1964).

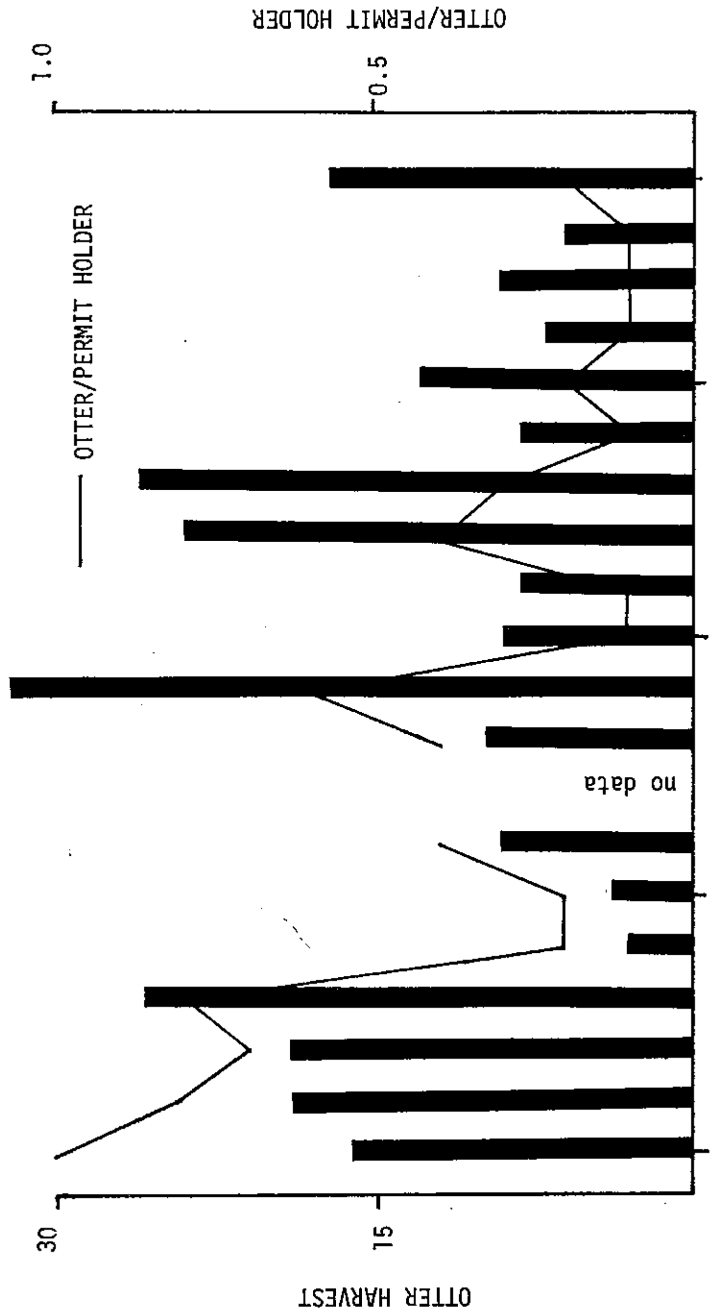

Figure 2. Otter harvest and otter per permit holder, Kenai National Moose Range, Alaska, 1960 - 1979.

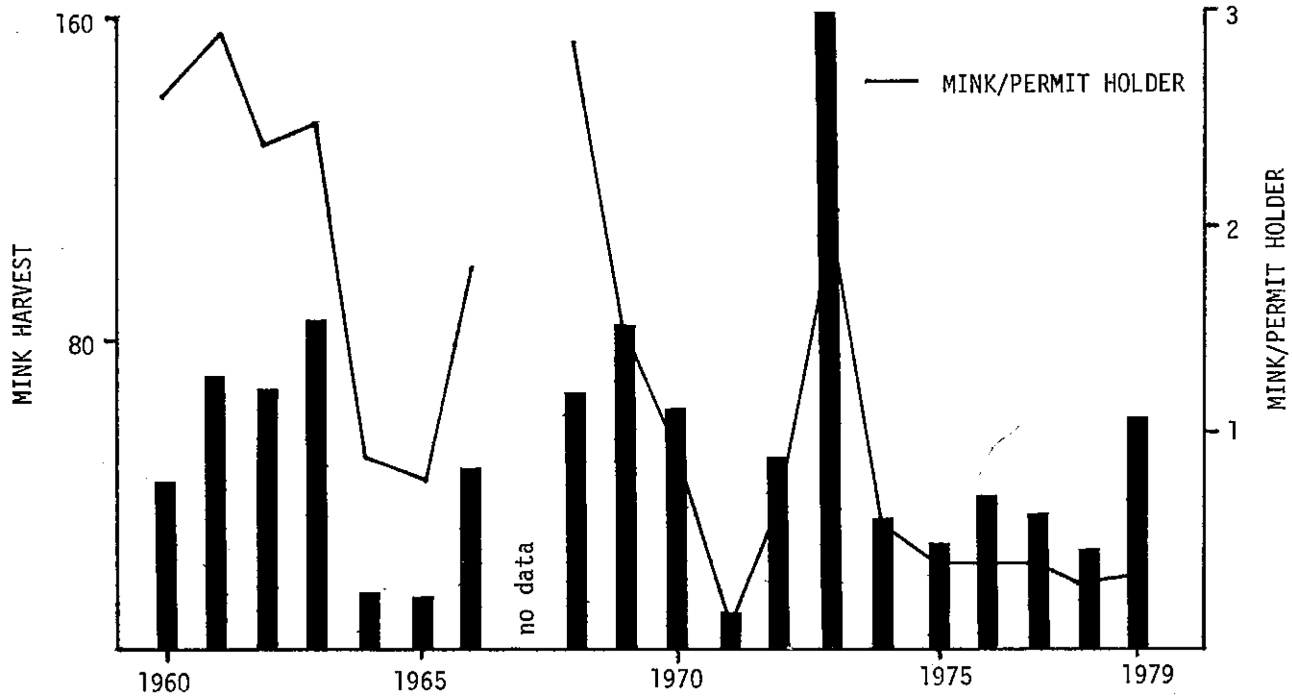

Figure 3. Mink harvest and mink per permit holder, Kenai National Moose Range, Alaska, 1960 - 1979.

refuge boreal forest habitat in a single fire. The vegetation following wildfires and its impact on moose has been the subject of long-term and continuing investigation on the refuge (Spencer and Hakala 1965, Oldemeyer et al. 1977), but little is known about the influence of fire on other species on the refuge.

During the 1977 beaver survey, estimates of lake beaver densities were obtained for the major beaver habitats on the refuge (Table 3). The data suggested that lake beaver densities may have been the highest in the 30-yr-old burn, were greater in the 30-yr-old burn than the 8-yr-old burn despite the fact that there were more lakes in the 8-yr-old burn, and were the lowest in the unburned area south of the Sterling Highway. Beaver densities would be expected to be much lower in the latter area because there are fewer lakes, the elevation is greater, and the forest has not been disturbed by major fires in over 80 yr. Elevation appeared to be a limiting factor perhaps only because few lakes occur over 120 m (400 ft), the streams have a steeper gradient, and lakes remain frozen longer throughout the year. Although active beaver colonies were not observed at elevations over 120 m during the beaver survey, some beaver are known to occur above that elevation on certain portions of the refuge. Lake size appeared to influence beaver numbers. Most lake beaver (64 percent) inhabited lakes less than 40 ha in size and few (2 percent) inhabited lakes over 243 ha in size.

The most significant lake variables influencing beaver colony sites in northern British Columbia were those quantifying food, particularly length of nonproductive brush and swamp shoreline and transformed length of aspen shoreline (Slough and Sadleir 1977). Aspen, because it is only a temporary occupant of lake shorelines, depends primarily on fires for its colonization (Graham et al. 1963). Since aspen is a preferred beaver winter food, Slough and Sadleir considered prolongation of the lifetime of aspen stands the most powerful beaver management tool and recommended the use of fire for the purpose of aspen reforestation.

After the 1947 wildfire on the Kenai National Moose Range, aspen became one of the most dominant hardwood species in the burn area largely through root suckering and later through seedling stock (Spencer and

Table 3. Lake beaver population statistics for the Kenai National Moose Range, 1977.

Beaver Habitat	Estimated Lake Beaver Density: Area (km^2)	Average number of beaver	Density (km^2 per beaver)	Estimated Lake Beaver Distribution: Average number lakes per km^2	Lake size (ha)	Average number of beaver	Percentage of total population
8-yr-old burn (1969 Burn)	337	25.2	13.4	0.39	2-40	10.8	43
					41-121	10.4	41
					122-243	4.0	16
					243+	0	-
30-yr-old burn (1947 Burn)	1,256	112.2	11.2	0.24	2-40	51.9	46
					41-121	43.5	39
					122-243	10.8	10
					243+	6.0	5
Unburned North of Sterling Highway	1,437	111.2	12.9	0.23	2-40	75.6	68
					41-121	25.6	23
					122-243	10.0	9
					243+	0	-
South of Sterling Highway	2,085	58.4	35.7	0.10	2-40	58.4	100
					41-121	-	-
					122-243	-	-
					243+	-	-
Total	5,115	307.2	16.6	0.19	2-40	196.8	64
					41-121	76.6	26
					122-243	24.8	8
					243+	6.0	2

Hakala 1964). Although aspen was estimated to supply about 96.5 percent of the standing shrub biomass 5 years after the fire (Spencer and Chatelain 1953), by 1967 it apparently decreased to less than 1 percent (LeResche et al. 1974) primarily because of heavy moose browsing and plant competition (Spencer and Hakala 1964). By the mid-1970's, paper birch was estimated producing over 80 percent of the annual browse production (Oldemeyer et al. 1977).

If the northern British Columbia findings apply to the Kenai refuge beaver population and if aspen is a key component of beaver habitat, those factors reducing the lifespan of aspen on the refuge may be responsible for the relatively low numbers of beaver. Fires, moose, and perhaps snowshoe hare may play an important role in aspen-beaver ecology on the refuge. A major problem in aspen reforestation to benefit beaver is keeping out beavers and ungulates during reforestation to allow aspen to become established (Gese and Shadle 1943). The extremely high densities of moose on the Kenai National Moose Range following the 1947 wildfire (LeResche et al. 1974) and their impact on the lifespan of aspen could therefore have been a major factor influencing the refuge beaver population.

Wildfires undoubtedly have played a significant role in influencing other furbearer populations on the Kenai National Moose Range. Marten are extremely scarce on the refuge and the western half of the Kenai Peninsula where wildfires have periodically occurred over the past 100 yr. Only 2 marten have been reported taken on the refuge by trappers since 1960 even though marten are taken by trappers in forested valleys on the mountainous eastern side of the Kenai Peninsula. Since mature forested stands were a necessary component of winter marten habitat in Idaho (Koehler and Hornocker 1977) and marten are generally associated with climax forest communities (deVos 1952), the frequency and extent of wildfires on the refuge may have been detrimental to marten or may have prevented sufficient numbers of marten from dispersing through several narrow valleys from the eastern to the western side of the Peninsula. Some stands of mature forests and an abundant food supply on the refuge appear to provide some remnant but scattered marten habitat.

Wildfires have probably influenced numbers of other furbearers such as lynx on the refuge. The sudden removal of most of the cover in 1,256 km^2 and its impact on the prey population of lynx undoubtedly influenced lynx numbers. If lynx densities on the refuge are similar to those in Alberta (Brand and Keith 1979), the 1,256 km^2 wildfire could have been a temporary loss of habitat for up to 120 lynx depending on snowshoe hare abundance. Similar temporary losses of habitat would be experienced by other furbearers such as coyote, wolverine, and weasel. Later, following vegetative succession, prey densities, and furbearer populations are probably higher than they would have been had the fire not occurred. Since prime habitat of wolverines on the refuge appears to be along the more rugged mountainous forest edges and alpine areas, fires probably have not significantly influenced wolverine habitat.

Prey Populations. A most significant prey of medium-sized furbearers, especially lynx, on the refuge is the snowshoe hare. Hare populations were high on the refuge in the early 1970s with lynx harvest peaking in 1973 - 1974 and 1974 - 1975 (Figure 4). Reported harvest was also high for coyote (Figure 5) and weasel on the refuge at this time, but weasel harvest was probably related to lynx trapping since most weasels were probably accidentally captured in lynx sets. Since coyotes are not often captured in lynx sets and since relatively few trappers captured coyotes, the trend in coyote harvest was believed to reflect a change in the refuge coyote population. Because wolverine harvest has remained relatively stable on the refuge since 1960 (1-14 wolverine per yr) despite marked changes in the snowshoe hare population, wolverine numbers on the refuge may not be as closely related to hares as lynx and coyote numbers. Wolverine harvest on the refuge did peak during the winter of 1971 - 1972 (14 wolverine) when a major die-off of moose occurred and moose carcasses were widespread and available as carrion. An increased food supply may have either increased survival of young wolverines during this period or merely concentrated wolverine in moose winter habitat where they were easily trapped.

Lynx harvest has been shown to parallel changes in lynx numbers, accurately indexing highs and lows but not the amplitude of the fluctuations (Brand and Keith 1979). On the Kenai National Moose Range, total lynx

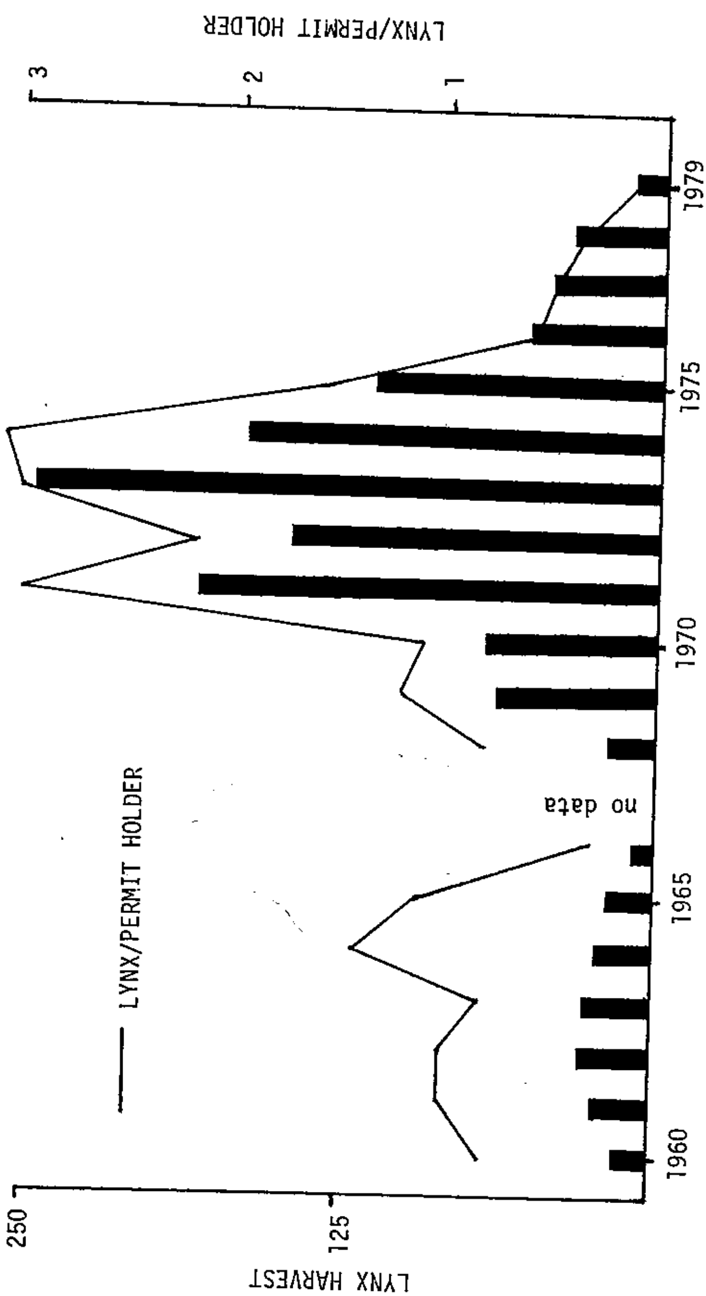

Figure 4. Lynx harvest and lynx per permit holder, Kenai National moose Range, Alaska, 1960 - 1979.

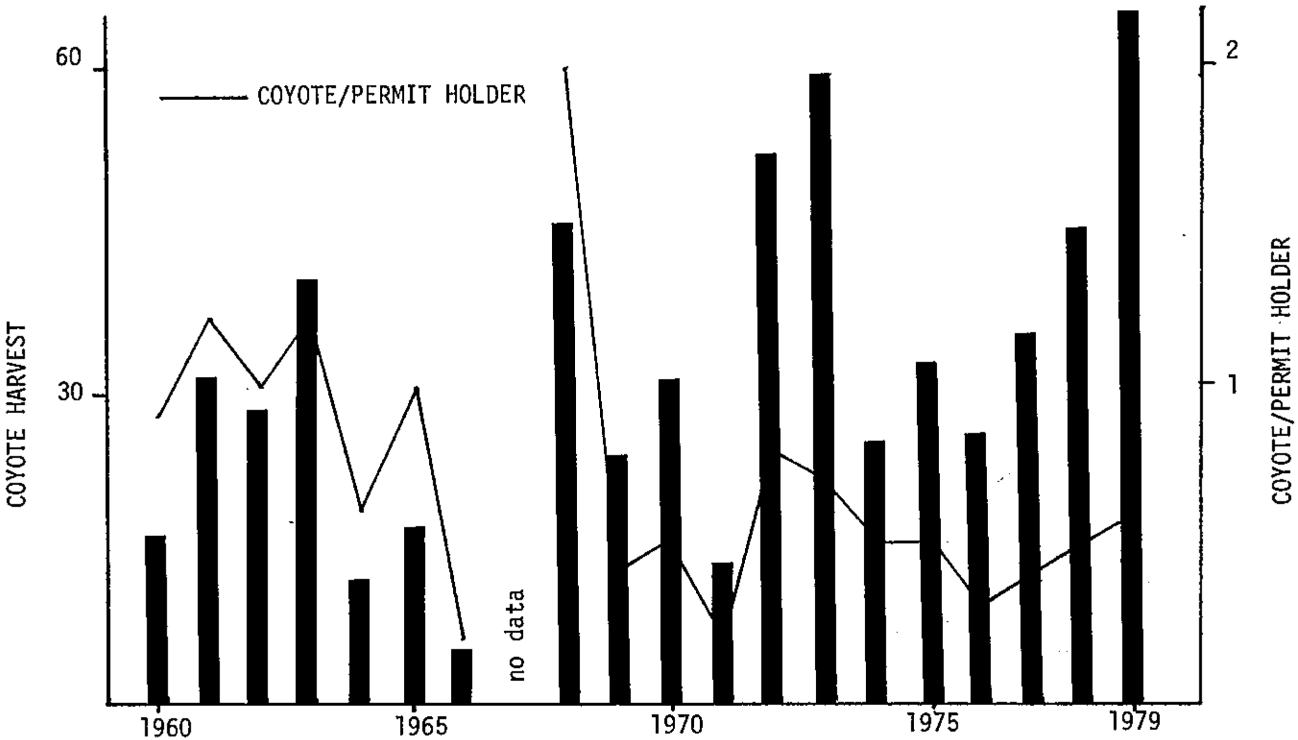

Figure 5. Coyote harvest and coyotes per permit holder, Kenai National Moose Range, Alaska, 1960 - 1979.

harvest was at an extreme low in 1966 - 1967, reached a peak in 1973 - 1974, and has continued to decline in 1979 - 1980. This suggests a periodicity of 6 - 7 yr between highs and lows or 12 - 14 yr for a complete cycle. The magnitude of the lynx harvest change was about 40-fold between 1966 - 1967 and 1973 - 1974. The magnitude of the change in harvest for coyote and weasel for the same period was 12x and 14x, respectively.

Coyote harvest trends on the refuge did not parallel lynx harvest trends. This suggests that factors other than snowshoe hare abundance may influence coyote populations and harvest. Coyotes are probably more adaptable to changes in food supply than lynx because they can scavenge on carrion and hunt small rodents under the snow. Coyote abundance may also be related to wolf abundance on the refuge (R. Peterson, pers. comm.).

Other Factors. Although wolves were apparently once common on the Kenai Peninsula, they were extirpated in the early 1900's perhaps because of the extensive use of poison and unregulated hunting and trapping (Peterson and Woolington 1979b). Although occasional lone wolves were seen on the Peninsula after that period, breeding packs of wolves did not become established until wolves were protected throughout Alaska and wolves dispersed on to the Kenai Peninsula.

Population growth was apparently rapid during the late 1960's and early 1970's probably because of an extremely high refuge moose population. The dynamics of the refuge wolf population and moose-wolf relationships have been the subjects of an intensive research effort on the refuge since 1976. Preliminary findings suggest an early winter, pre-harvest wolf population of between 80-90 wolves on the refuge (Peterson and Woolington 1979a). Wolf trapping on the refuge began in 1974, over 30 percent of the estimated refuge wolf population was taken by trappers in 1978 and harvest declined in 1979 (Figure 6).

Factors Influencing Furbearer Harvest

Economics. Economic factors influencing the rate of furbearer harvest on the refuge include fur prices, the local economy, and energy costs. Although long-term fur prices for Kenai Peninsula furs were not available, it was evident that the price of long-hair furs over the past several years has contributed to increased interest in lynx, coyote, wolverine, and wolf trapping. High fur prices probably contributed to the high proportion of unexperienced trappers who obtained refuge trapper permits in 1977 - 1978 (Bailey 1981). With high beaver prices, beaver harvest on the refuge suddenly increased 3.6 times between 1978 - 1979 and 1979 - 1980. Otter harvest is probably directly related to beaver harvest since many otter are caught in beaver sets. The nearly 3-fold increase in otter harvest between 1978 - 1979 and 1979 - 1980 parallels the increase in beaver harvest and supports this view.

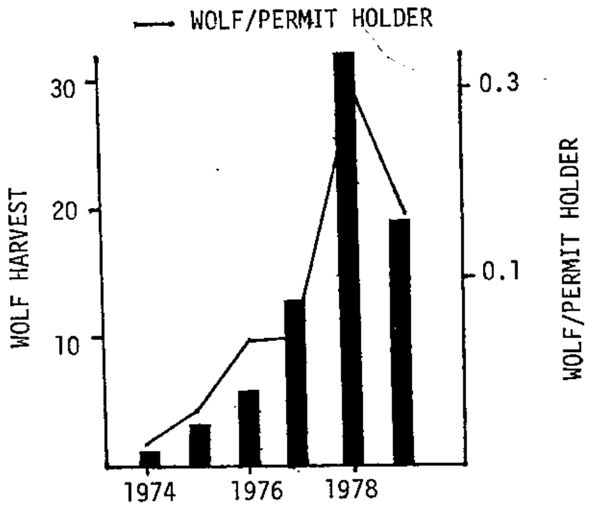

Figure 6. Wolf harvest and wolves per permit holder, Kenai National Moose Range, Alaska, 1960-1979.

The local economy has also had impacts on furbearer trapping on the refuge. A decline in the number of trapping permits issued in 1964 -1965 and 1965 - 1966 paralleled the greatest decline in annual borough population growth rates since 1960 (-5.3 percent and 0.7 percent, respectively) (Kenai National Borough 1980). Another decline in the number of trapping permits issued in 1974 - 1975 followed another decline in annual borough population growth rates (-3.5 percent to 2.4 percent). The decline in number of trapping permits issued in 1974 - 1975 also appeared related to a decrease in the unemployment rates from 15.7 percent in 1974 to 8.7 percent in 1975. These trends suggest that the number of trapping permits issued declines as population growth declines in the surrounding area. It also suggests that the greater the employment rate, the fewer the people that obtain trapping permits. The local economy appears closely related to energy (gas and oil) exploration and development on the Kenai Peninsula and elsewhere in Alaska. Economic conditions also determine how many trappers can afford to purchase and operate vehicles, snow machines, and aircraft.

Rising energy costs will probably influence trapping on the refuge as the cost of gasoline reduces the margin of profit from the sale of furs. Since most trappers on the refuge apparently trap for the outdoor experience rather than to supplement their incomes (Bailey 1981), the overall impact of this variable on trapping effort may be slight under current conditions.

Trapper Experience and Techniques. Information from refuge trapping permit holders after the 1977 - 1978 and 1978 - 1979 trapping seasons indicated only 50 and 44 percent, respectively, of the respondents successfully captured at least 1 furbearer on the refuge. Thirty-four and 27 percent of the respondents in 1977 - 1978 and 1978 - 1979, respectively, indicated they did not trap and the remainder either did not catch a furbearer or did not trap. According to a 1977 - 1978 survey (Bailey 1981), about one-fourth of the permit holders did not have previous experience trapping furbearers in Alaska and about 45 percent had not previously trapped on the refuge. This information suggested that since a substantial proportion of the trapping permit holders on the refuge were unfamiliar with trapping conditions on the refuge and with trapping in Alaska, they were unsuccessful capturing furbearers at least during their 1st year of trapping on the refuge. However, since populations of land furbearers on the refuge were very low from 1977 - 1980, trapping success would be low regardless of trapper experience.

The techniques used by refuge trappers would also influence their trapping success. The experienced trappers on the refuge trap in remote areas where competition with other perhaps less-experienced trappers, is less. More-experienced trappers are also more familiar with the refuge habitat and movements and behavior of furbearers than less-experienced trappers. Since experienced trappers use snares more frequently (Bailey 1981), and coyotes and wolves appear easier to snare than to capture in foot traps, they are captured more frequently by the more experienced trappers.

Some refuge trapping permit holders locate furbearers from aircraft and then land and shoot the furbearer. Wolves under certain snow conditions are particularly vulnerable to this form of "aerial trapping" as are otter under certain snow and ice conditions. The number of permit holders on the refuge which attempt this form of "aerial trapping" is unknown but relatively low. However, their impact on certain species may be significant at times. For example, of 32 wolves taken by trapping permit holders on the refuge during the 1978 - 1979 season, at least 13 (41 percent) were taken by 2 permit holders using the land-and-shoot method.

<u>Transportation</u>. The mode of travel used by trappers influences trapping success on the refuge. The number of permit holders using aircraft increased the past several years (1976 - 1977 = 14 percent, 1977 - 1978 = 24 percent, 1978 - 1979 = 30 percent) and the number of potential landing locations in the form of frozen lakes is at least several hundred on the refuge. Trappers using aircraft usually are more successful taking certain species than trappers using ground transportation. Because beaver lodges are readily observed from aircraft and trappers can land on frozen lakes, trappers using aircraft have an advantage trapping beaver over non-aircraft-using trappers. For example, the percent of aircraft trappers successfully capturing beaver on the refuge in 1978 - 1979 was 64 percent compared to about 20 percent for non-aircraft trappers.

Trappers using aircraft can also account for a high proportion of wolves, otter, and wolverine taken on the refuge in certain years. During the 1977 - 1978 season, reporting trappers using aircraft took 75 percent of the wolverine, 56 percent of the otter, and 25 percent of the wolves on the refuge. During the 1978 - 1979 season, 83 percent of the reporting trappers using aircraft captured otter and 50 percent captured wolves.

Snow and ice conditions greatly influence the success of trappers using aircraft. If lake freeze-up is late or breakup is early, this limits their ability to land on lakes. If snow cover is light or if the snow has a hard surface crust, tracks of furbearers or the furbearers themselves are difficult to see from the air.

From 30 - 40 percent of the refuge trappers use snowmobiles on the refuge. These trappers during 1978 - 1979 took the majority of wolverine, coyote, lynx, and muskrat on the refuge and 25 percent of the wolves. Trappers using other modes of transportation (primarily wheeled vehicles) took the majority of mink and weasel and 25 percent of the wolves on the refuge. Trappers dependent on wheeled-vehicle transport only are limited to trapping adjacent to the relatively few winter-maintained roads on the refuge.

CONCLUSIONS

Although little is known about the population ecology of furbearers on the Kenai National Moose Range, trends in harvest data and information on habitat disturbances and prey populations suggest periods of abundance and scarcity for several species. Marten may have been eliminated from, or prevented from recolonizing marten habitat on the refuge because of periodic wildfires dating back to the mid-1800s. Periods of furbearer scarcity and abundance may range from 6 - 7 yr for lynx to over 20 yr for beaver. Reestablishment of wolves on the refuge appeared to be related to the health of wolf populations in Alaska north of the Kenai Peninsula.

Trapping effort and success has also varied considerably on the refuge. Because of fur prices, human population growth, and economic conditions, trapping may be the greatest when furbearer populations are lowest. Lynx trapping on the refuge is one example of intensive trapping pressure on a furbearer during a period when lynx were already naturally declining or at a low in their population cycle. Trappers also appear capable of harvesting substantial numbers of wolves on the refuge.

Current furbearer harvest strategy on the refuge does not consider the problem of harvesting certain furbearer populations in a fluctuating environment. The current harvest strategy for all furbearers is basically a mean strategy which assumes a degree of stability in populations that does not appear to exist for all species on the refuge. The refuge environment appears to be similar to an environment where wildlife densities and resources are seldom balanced and one cannot be predicted with confidence from the other (Caughley 1977). As Caughley pointed out, a mean or average harvest strategy works well when the amplitude of fluctuation in wildlife populations is not too great and the average time between fluctuations is not too long. Since a mean strategy requires considerable information, it is considered an unwise choice when little is known about the magnitude of environmental fluctuations or about the population's dynamics.

A tracking strategy is considered safer when little information is available about a population and its environment. It is the only workable strategy, according to Caughley, when environment fluctuations are substantial and when their mean periodicity exceeds about 5 yr. A tracking strategy tracks the population, changing as the population changes. The rate of harvesting is increased as the population's rate of increase rises and harvesting is curtailed or suspended when the rate of increase is negative.

Because some furbearers on the Kenai National Moose Range appear to occur in relatively low numbers (wolverine, otter, wolf) or meet 1 or more of the requirements for a tracking harvest strategy (substantial natural or man-caused fluctuations, long-term periodicity between fluctuations, fluctuating environment) a tracking harvest strategy is recommended for lynx, beaver, otter, wolf, and perhaps wolverine populations on the refuge. Beaver can be censused from aircraft, the wolf population could be monitored by the use of radio telemetry, and it may be possible to obtain an index of the abundance of otter and wolverine by aerial observations of tracks in the snow in representative or preferred habitats in the winter. Lynx population trends may be predicted by indices obtained from snowshoe hare abundance (Brand and Keith 1979). Regardless of the harvest strategy used, more information will be needed to properly harvest furbearers on the refuge without adversely effecting their populations or the vital role they play in the refuge's ecology.

ACKNOWLEDGMENTS

Many individuals were responsible for maintaining data on furbearers captured on the Kenai National Moose Range wildlife refuge since 1960 including J.B. Hakala, W.A. Troyer, J.B. Monnie, R.A. Richey, R.K. Seemel, and J.L. Filio of the U.S. Fish and Wildlife Service. I am also grateful to E. Bangs, J. Woolington, and W. Jakubas for assembling data and V. Berns for flying the 1977 beaver survey.

LITERATURE CITED

BAILEY, T.N. 1981. Characteristics, trapping techniques, and views of trappers on a wildlife refuge in Alaska. Proc. Worldwide Furbearer Conf., 3 - 11 Aug, 1980, Frostburg, Maryland.

BERGERUD, A.T. and D.R. MILLER. 1977. Population dynamics of Newfoundland beaver. Can. J. Zool. 55:1480-1492.

BOYCE, M.S. 1974. Beaver population ecology in Interior Alaska. M.S. Thesis. Univ. Alaska, Fairbanks, Alaska. 161 pp.

BRAND, C.J. and L.B. KEITH. 1979. Lynx demography during a snowshoe hare decline in Alberta. J. Wildl. Manage. 43:827-849.

BUCKLEY, J.L. 1954. Animal population fluctuations in Alaska - a history. Trans. 19th N. Am. Wildl. Conf. 19:338-357.

CAUGHLEY, G. 1977. Analysis of vertebrate populations. John Wiley and Sons, New York, New York. 234 pp.

deVOS, A. 1952. The ecology and management of fisher and marten in Ontario. Ontario Dept. Lands Tech. Bull. 90 pp.

GESE, E.C. and A.R. SHADLE. 1943. Reforestation of aspen after complete cutting by beaver. J. Wildl. Manage. 7:223-228.

GRAHAM, S.A., R.P. HARRISON, JR., and C.E. WESTFALL, JR. 1963. Aspen-phoenix trees of the Great Lakes Region. University of Michigan Press, Ann Arbor, Michigan.

KENAI NATIONAL MOOSE RANGE. 1965. Annual narrative reports: Kenai National Moose Range. 1964 and 1965. Kenai National Moose Range, Soldotna, Alaska.

KENAI PENINSULA BOROUGH. 1980. Situation and prospect: Kenai Peninsula Borough. Planning Dept., Kenai Peninsula Borough, Soldotna, Alaska.

KENDEIGH, S.C. 1961. Animal ecology. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. 468 pp.

KOEHLER, G.M. and M.G. HORNOCKER. 1977. Fire effects on marten habitat in the Selway-Bitterroot Wilderness. J. Wildl. Manage. 41:500-505.

LERESCHE, R.E., R.H. BISHOP, and J.W. COADY. 1974. Distribution and habitats of moose in Alaska. Naturalist Can. 101:143-178.

OLDEMEYER, J.L., A.W. FRANZMANN, A.L. BRUNDAGE, P.D. ARNESON, and A. FLYNN. 1977. Browse quality and the Kenai moose population. J. Wildl. Manage. 41:533-543.

PETERSON, R.O. and J.D. WOOLINGTON. 1979a. Wolf-moose investigations on the Kenai Peninsula, Alaska. Dept. Biol. Sc., Michigan Tech. Univ., Houghton, Michigan. Qrtly. Rep. No. 13. 7 pp.

____________________. 1979b. The extirpation and reappearance of wolves on the Kenai Peninsula, Alaska. Proc. Portland Wolf Symp., 12 - 16 Aug, 1979, Portland, Oregon. 19 pp.

SLOUGH, B. G., and R.M.F.S. SADLEIR. 1977. A land capability classification system for beaver (*Castor canadensis* Kuhl). Can. J. Zool. 55:1324-1335.

SPENCER, D.L., and E.F. CHATELAIN. 1953. Progress in the management of the moose in south central Alaska. Trans. N. Am. Wildl. Conf. 18: 539-552.

____________________, and J.B. Hakala. 1964. Moose and fire on the Kenai. Tall Timbers Fire Ecol. Conf. 3:11-23.

WALLER, R.M. 1966. Effects of the March 1964 Alaska earthquake on the hydrology of southcentral Alaska. U.S. Geol. Surv., Prof. Paper No. 542, Supt. of Doc., U.S. Gov't. Print. Off., Washington, D.C. 28 pp.

WEEDEN, R.B. 1978. Alaska: promises to keep. Houghton Mifflin Co., Boston, Massachusetts. 254 pp.