HABITAT DIFFERENCES AND MOOSE USE OF TWO LARGE BURNS ON THE KENAI PENINSULA, ALASKA

Edward E. Bangs, Sally A. Duff and Theodore N. Bailey

U.S. Fish & Wildlife Service
Kenai National Wildlife Refuge
P.O. Box 2139
Soldotna, Alaska 99669

Abstract - Two large burns, one in 1947 (125,000 ha) and another in 1969 (35,000 ha), produced excellent moose (Alces alces) habitat believed responsible for up to 6.6 moose/km^2 on the Kenai National Wildlife Refuge, Alaska. The fire in 1969 burned during much hotter and drier conditions than the one in 1947. This resulted in a larger proportion of the forested habitat being consumed by fire and more, but smaller, remnant forest stands. Remnant forest edge (21-25km/km^2) and the percentage of burned forest habitat (71-75%) were similar in each burn. Areas within 1.6km of the 1947 burn boundary had less burned forest, more remnant forest, more forested edge, and larger stands than interior areas of the burn. The boundary and center of the 1969 burn were similar, apparently because it was a hot suppressed fire. Relocations of radio-collared moose, from 1980-84, indicated moose used water, bog, and burned forest significantly less and remnant forest significantly more than their proportion in each burn. Moose, using 1969 burned forest habitat, were located within 100m of forest edge (cover) 56% of the time. The activity of radio-collared moose was similar in burned forest, remnant forest, and bog habitats and in each burn. Moose were bedded on 60%, and traveling, feeding, or standing on 40% of the times located. Areas within 100m of the edge of forest edge appeared to be important to moose. However moose also frequently (44%) used burned habitat over 100m from the nearest cover.

Moose abundance in North America has been increased by forest fire and other habitat disturbances (Franzmann 1978). Fires usually increase browse quality and quantity (Oldemeyer and Regelin 1984), which enhance calf production and survival (Bangs and Bailey 1980, Schwartz and Franzmann 1980). Large wildfires in 1947 and 1969 on the Kenai National Wildlife Refuge (KNWR) and relatively mild winter weather on the Kenai Lowlands (LeResche et al. 1974, Bangs and Bailey 1980) have been associated with increasing moose densities (Spencer and Hakala 1964, LeResche et al. 1974, and Peterson et al. 1984), some of the highest in North America. We examined how past weather conditions and fire suppression efforts affected the fire-created habitats, and how fire intensity in the 1947 and 1969 burns affected habitat use by moose. Moose use of these burns was examined by comparing the activities and habitat selection of radio-collared moose to the composition of each burn. These findings could be useful to wildlife managers desiring to improve moose habitat.

STUDY AREA

The Kenai Peninsula, Alaska (60N 150W) previously has been described by Spencer and Hakala (1964), Oldemeyer et al. (1977), Bailey (1978), and Peterson et al. (1984). The western one-third of the peninsula is a mixed lowland boreal forest, interspersed in its northern portion with numerous lakes and bogs. Mature forest was primarily black and white spruce (Picea mariana and P. glauca), paper birch (Betula papyrifera), and aspen (Populus tremuloides). Understory included moss (Sphagnum spp.), lichens (Peltigera spp. and Cladonia spp.), lowbush cranberry (Vaccinium vitis-idaea) and forbs. Post-fire plant communities are dominated by regrowth of birch, willow (Salix spp.), and aspen, with grass, primarily Calamagrostis canadensis, fireweed (Epilobium angustifolium), and forb understory. During this study vegetation

burned in 1947 and 1969 was 3-5m and less than 2m in height, respectively. Browse density was greater in the 1969 burn than in the 1947 burn (Oldemeyer and Regelin 1984). Moose densities after the 1947 burn peaked in 1970 at 6.6 moose/km^2. In 1982, moose densities in the 1969 burn were 5.1 moose/km^2 while moose density in the 1947 burn had fallen to 1.5 moose/km^2 (Unpubl. data, Kenai NWR).

Although the Kenai Peninsula has been repeatedly burned since the 1880s (Lutz 1960), few were naturally started. The 1947 fire was started by a road construction crew on June 3 and burned for 6 weeks before being extinguished by rain. Approximately 125,000 ha were within its perimeter. The Kenai Peninsula was then sparsely populated with little fire suppression. Fire suppression was instituted shortly after the discovery of oil in 1957 because the human population increased. However, a fire started by canoeists on August 3, 1969, burned for three weeks despite a $20 million control effort. The fire burned over 35,000 ha. and could not suppressed until weather conditions facilitated containment (R. Richey, Assistant Refuge Manager, Kenai NWR. pers. comm.). No major fires have occurred since 1969 probably because of helicopter-supported, initial attack, fire-suppression efforts. Fire control policy on the refuge was recently modified to restore fire as a desirable habitat alteration process and to reduce suppression costs in uninhabited areas (U.S. Fish and Wildlife Service 1985).

METHODS

Average monthly temperature and precipitation from May through September were examined from climatological data collected at the Kenai airport, since 1944, to evaluate potential fire intensity factors prior to the 1947 and 1969 wildfires.

Habitat classification in the 1947 and 1969 burned areas was conducted by examination of true color aerial photographs (1:15,840) taken in July 1975. Images of each burn were divided into 2.59 km^2 plots based upon section lines. Since moose were reported to be more numerous along burn boundaries (Neu et al. 1974), plots were classified as either (1) plots within the interior portion of the burn (center plots) or (2) plots within 1.6km of the burn boundary (boundary plots), to evaluate potential habitat differences. Some boundary plots included habitat outside of the burn perimeter because of the location of section lines; these habitats, including the forest edge created by the fire perimeter, were not sampled. The image of the 1947 burn was overlain by 479 plots, 280 in the center and 199 along the inside edge of the burn boundary; fifty-five plots were randomly sampled from its center and 45 from its boundary. The image of the 1969 burn was overlain by 156 plots, 81 center and 75 boundary; ten plots were randomly sampled from each. The 1947 burn was sampled with more plots because of its diverse topography.

A 10.16 cm by 10.16 cm transparency (representing 2.59 km^2 on an aerial photograph) was placed over each sampled plot. Stands of remnant mature forest, bogs (areas without trees or shrubs), and water bodies $\geq$0.1 ha. were outlined. These polygons were digitized and their areas calculated using a computer program (MAPDRAW). The perimeter of each sampled remnant forest stand was also measured and converted to kilometers. This sampling method was used to compare remnant forest stand numbers, size, and amount of edge. Since large remnant forest stands were often only partially in the sample plots, the number of remnant stands and the amount of edge was over-estimated while stand size was underestimated. Nearly 38% of the remnant forest stands in the 1947 burn went beyond the plot edge while only 18% of remnant forest stands in the 1969 did so. The total area of all outlined polygons (representing unburned habitat) was subtracted from 2.59 km^2 to determine the area actually

consumed by fire. Differences in 1947 and 1969 burn habitat were compared by Students t-test.

Fifty-eight moose (7 bulls and 51 cows) were radio-collared in November and December 1980 along the eastern edge of the 1969 burn and western edge of the 1947 burn (Figure 1) (Bangs and Bailey 1982). Moose were monitored by aerial tracking through May 1984 and most were located between 0900-1600 hours. The dominant habitat within a 1 km radius of the moose, the specific habitat each moose was in, and the distance from cover (vegetation over 2m in height) were recorded for each location. Habitats were initially classified as 1969 burn, 1947 burn, mature forest, bog, alpine, non-fire disturbed and other, but were further grouped into burned forest, remnant forest, bog, and water for analysis in this paper. Data were classified by season to evaluate diurnal habitat use patterns of moose within the burns. Bonferroni Z statistic was used to compare habitat use to the proportion of each habitat class in the burns (Neu et al. 1974). Moose activity was classified as bedded, standing, feeding, travel, and display.

RESULTS AND DISCUSSION

Climate and Fire History

The 1947 fire occurred during different meteorological conditions than the 1969 fire (Table 1). Summer temperature (May-September) in Kenai from 1944-1982 averaged 9.7°C, average summer precipitation totaled 25.1 cm., and average monthly precipitation steadily increased from a low in May to a high in September. The summers of 1968 and 1969 were the hottest and driest on record. Furthermore, the winter of 1968-69 was one of the driest on record. These factors probably contributed to the severity of the 1969 fire (Bangs and Bailey 1980). In contrast, the summer of 1947 was normal as were the summer

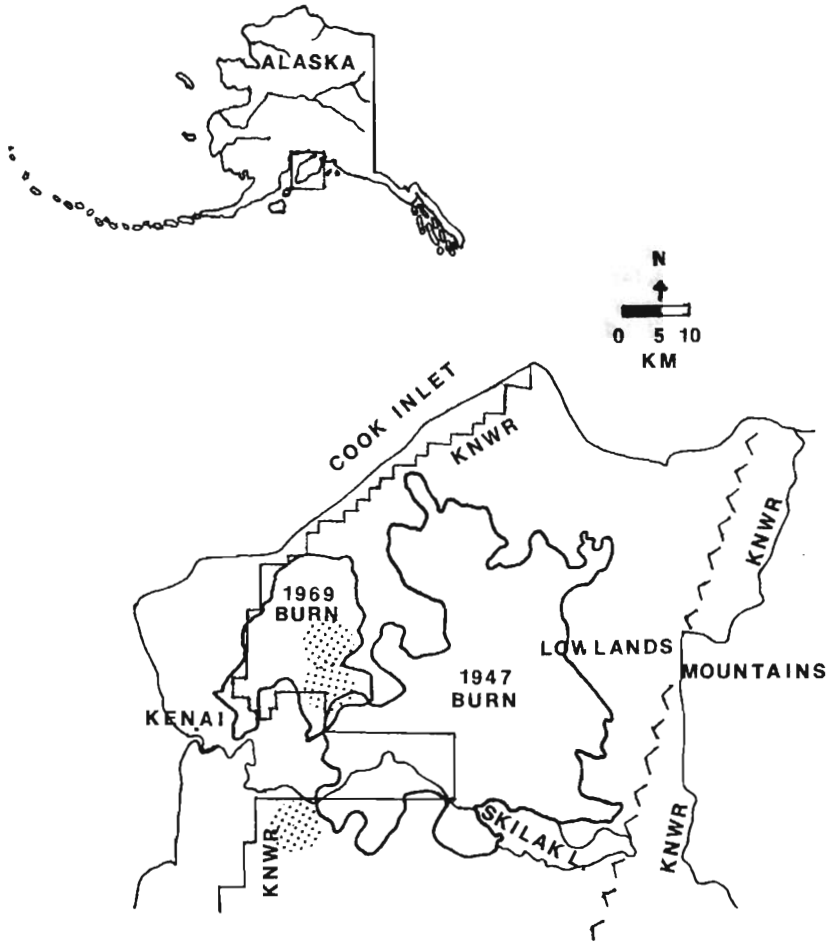

Figure 1. The location of the 1947 and 1969 burns within the northern portion of the Kenai National Wildlife Refuge, Alaska. Stippled areas represent areas where moose were radio-collared in 1980.

and winter prior to 1947. These factors made the summer of 1969 more favorable for a hot wildfire than the summer of 1947.

Table 1. The summer (May-September) precipitation (cm) and average temperature (C) recorded at the Kenai FAA station by month for the summers of 1947 and 1969, average, summer, and standard deviation from 1944-1982.

Year		May	June	July	August	September	Average Summer
1944-82	Precip	2.2	3.2	5.1	6.3	8.4	25.1
	SD	1.5	1.8	2.7	3.0	4.2	6.3
	Temp.	6.3	9.8	12.2	11.9	8.2	9.7
	SD	1.2	1.0	0.9	0.9	0.9	0.7
1947	Precip	2.1	1.6	5.8	5.2	10.0	24.7
	Temp	6.8	9.1	12.1	11.4	7.4	9.3
1969	Precip	1.8	1.6	4.2	1.8	1.7	11.1
	Temp	8.4	12.5	13.7	11.7	9.0	11.1

Different control efforts in 1947 and 1969 probably also contributed to differences in the resulting burn habitat. The perimeter of the 1969 burn was abrupt because bulldozer trails, roads, lakes, and bogs were used as suppression lines. The perimeter of the 1947 burn was less distinct and often feathered into lightly burned forest.

Vegetative Data

LeResche et al.(1974) examined a 2.5km^2 area believed to be representative of the 1947 burn and estimated that 46% of the area was left as remnant forest with nearly 40km of remnant forest edge/km^2. Because of this habitat diversity the 1947 burn was reported as "the most productive large area of moose habitat known". Analysis of an adjacent 120 km^2 area by Smith (1984) indicated the 1947 burn was 32% remnant forest, 46% burned forest, 15% bog, and 15% water. Although our habitat sampling methods did not use as many habitat classifications as those used by LeResche et al. (1974) or Smith

(1984), we sampled a much larger area of the burn. Our data suggest that their findings were more representative of the upland northern portions of the 1947 burn than the entire burn area.

The 1947 fire produced significant differences in the habitat configuration between boundary and center plots within the burn (Table 2). The center of the burn had more burned forest ($t=4.1$ $P<0.01$, 98df), less remnant forest ($t=3.0$ $P<0.01$, 98df), less remnant forest edge ($t=2.3$ P 0.05, 98df), and smaller average remnant forest stand size ($t=2.6$ $P<0.01$, 98df) than areas near its boundary. In the burn's center 13.4% of the forest present was unburned while along the boundary 28.4% of the forest remained unburned. Although the center of the burn had less bog, less water, and slightly more remnant forest stands than the boundary, the differences were not significant.

Table 2. The composition of the center and boundary areas within the 1947 and 1969 burns expressed as the percentages of area burned. The number, average size and km edge of remnant forest stands are also provided for each category.

	1947 Burn			1969 Burn		
Habitat Class	Center (N=55)	Boundary (N=45)	Total Area (N=100)	Center (N=10)	Boundary (N=10)	Total Area (N=20)
% Burned	80.8	67.0	75.1	71.1	71.9	71.5
% Remnant Forest	11.0	19.0	14.2	6.6	9.7	8.1
% Bog	3.0	5.9	4.2	17.1	9.2	13.3
% Water	5.3	7.9	6.4	5.2	9.1	7.1
% Forest Habitat Burned	86.6	71.6	84.0	90.71	86.6	90.0
# Remnant Forest Stands 0.01 ha/km^2	27.0	24.7	26.2	37.6	36.3	36.7
Remnant Forest Edge/ km^2	21.6 km	29.7 km	25.1 km	17.4 km	26.6 km	21.6 km
$\bar{x}$ Remnant Forest Stand Size	4.0 ha	7.7 ha	5.4 ha	1.8 ha	2.7 ha	2.2 ha

In contrast, the 1969 burn did not exhibit significant differences in habitat configuration between its boundary and center plots (Table 2). The center of the 1969 burn had less remnant forest, less remnant forest edge, and smaller average remnant forest stand size than its boundary. Although these differences were not significant, they followed the same pattern as those in the 1947 burn. This probably occurred because the 1969 fire was actively suppressed and was a relatively hot fire. In the 1969 burn's center only 9.3% of the forest present was unburned while along its boundary 13.4% of the forest remained unburned. Equal numbers of stands occurred in boundary and center plots. Smith (1984) examined vegetation types in the 1969 burn and reported that his 120km^2 study area was 8% remnant forest, 67% burned forest, 14% bog, and 11% water which was very similar to our analysis (Table 2).

A comparison of the 1947 and 1969 burns showed the acreage of burned forest/km^2 was similar in both burns (71-75ha/km^2) but the 1947 burn had significantly more remnant forest ($t=2.3$ $P<0.05$, 118df) than the 1969 burn. The 1947 fire burned 75% of the total area and 84% of the forested habitat, while the 1969 fire burned 71% of the total area and 90% of the forested habitat. The 1969 burn had more remnant forest stands ($t=2.3$ $P<0.05$, 118df), but they were smaller ($t=2.4$ $P<0.05$, 118df) than those in the 1947 burn. The amount of remnant forest edge was not significantly different between the burns, although the 1947 burn had more (25km/km^2) remnant forest edge compared to the 1969 burn (22km/km^2). The amount of water was similar in each burn (6-7%) but the 1969 burn had three times more bog ($t=4.6$ $P<0.01$, 118df) than the 1947 burn. This gave a false visual impression that the 1969 burn had more burned forest than the 1947 burn.

Differences between the two burns suggest that hotter fires burn a higher percentage of the forest, leave more but smaller remnant forest stands, but create about equal amounts of forest edge compared to cooler fires. Differences between the boundary and center of the 1947 burn suggest fires burn cooler along their boundary and that naturally extinguished fires have significantly more remnant forest in fewer but larger remnant forest stands. It thus appears unlikely that fires on the Kenai Lowlands could burn so hot that moose would not have adequate cover to utilize the burn area. However, total suppression programs will probably result in habitat being burned only during extreme weather conditions. This will result in different habitat characteristics than would occur from fires during average summer weather conditions or from unsuppressed fires.

Moose Habitat Use in the 1969 and 1947 Burns

Moose relocations in the 1947 and 1969 burns indicated that moose used burned forest, bog, and water habitats less and remnant forest stands more than the relative area of each habitat in the burns (Tables 3 and 4). These data should be interpeted with caution since our discussions did not address potentially different habitat use by resident or migratory moose. Also, portions of the 1969 and 1947 burns were not used as frequently, or in some cases not at all by radio-collared moose. As LeResche et al. (1974), Hauge and Keith (1981), and Thompson and Vukelich (1981) similarly reported - moose in the 1969 burn used burned forest habitat most often in the fall and winter (Oct-March). Remnant forest and bogs were used most frequently in the spring and summer (April-Sept.). Moose in the 1947 burn used burned forest and remnant forest habitat most frequently in winter. Bog habitat was used, by

moose in the 1947 burn, most often during the spring; a finding also reported for moose in Alberta by Hauge and Keith (1981). Moose in the 1947 burn used bogs in the spring more frequently than moose in the 1969 burn, perhaps because less food was less available in forest habitats in the 1947 burn.

Table 3. The percentage of radio-collared moose locations, 1980-1984, habitats within the 1969 burn, by season, compared to the proportion of each habitat.

Habitat Class	% 1969 Burn	Total % Moose Observations ± 95% CI[a]	N	% Observations by Season Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
Burned Forest	71	61 ± 7.3[b]	452	66	46	48	68
Remnant Forest	8	33 ± 4.3[b]	248	28	43	40	31
Bog	13	5 ± 2.0[b]	39	5	8	11	1
Water	7	1 ± 0.4[b]	4	1	1	1	0

[a] 95% Confidence Interval, Z=2.5, Neu et al. (1974)
[b] $P < 0.05$

Table 4. The percentage of radio-collared moose locations, 1980-1984, habitats within the 1947 burn, by season, compared to the proportion of each habitat.

Habitat Class	% 1947 Burn	Total % Moose Observations ± 95% CI[a]	N	% Observations by Season Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
Burned Forest	75	49 ± 10.4[b]	70	50	47	37	56
Remnant Forest	14	40 ± 10.2[b]	58	45	32	37	43
Bog	4	10 ± 6.2	14	5	17	21	0
Water	6	2 ± 0.04[b]	2	0	2	5	0

[a] 95% Confidence Interval, Z=2.5, Neu et al. (1974)
[b] $P < 0.05$

Moose using burned forest, within the 1969 burn, were less than 100m from remnant forest stands (cover) during 56% of their locations. When using remnant forest, moose were within 100m of remnant forest edge during 89% of the times located (Table 5). Moose were farthest from forested edge while utilizing bog habitats. The use of cover by moose has been suggested as predator avoidance (Stephens and Peterson 1984), thermal protection (VanBallenberghe and Peek 1971), and avoidance of deep or crusted snow (McNicol and Gilbert 1980, Welsh et al. 1980, and Brusnyk and Gilbert 1983). Since moose used remnant forest stands more frequently in summer than winter and Schwartz and Franzmann (1980) reported black bear predation on moose calves to be low in open habitats, we suggest that these remnant stands were important for thermal protection or other reasons. The distance moose move into openings from cover is apparently related to snow depth (Welsh et al. 1980 and Brusnyk and Gilbert 1983). One hundred meters has been suggested as a maximum distance that moose would move from forest edge in deep snow conditions (Hamilton et al. 1975). Moose movements from forest edge have also varied in the same area dependent on snow depth and the level of human harassment (Tomm et al. 1981). Moose utilizing the 1969 burn on the KNWR are not subject to much human harassment because of restrictions on motorized access and snow depths rarely approach depths reported in other studies (Bangs and Bailey 1980). We suggest, as did Oldemeyer and Regelin (1980), that the relatively high proportion of moose locations (44%) beyond 100m from forest cover should not be considered unusual for the Kenai lowlands. We recognize that cover may be most important to moose during severe winter weather or in areas that receive high levels of human use.

Table 5. The percentage of locations, in each habitat within the 1969 burn, that radio-collared moose were 10m, 10-100m, 100-1000m, or farther than 1000m, from the edge of remnant forest.

Habitat moose located in	N	Percent of Locations: Distance to remnant forest edge 0-10m	10-100m	100-1000m	+1000m
Burned Forest	418	18	38	32	11
Remnant Forest	247	50	39	9	2
Bog	39	26	18	51	5
Water	4	25	50	25	0

The activity of radio-collared moose in both the 1947 and 1969 burns did not vary with habitat. Moose were found bedded during 60% and standing, feeding, or traveling about 40% of the times located (Tables 6 and 7). The activity pattern of moose in the two burns was very similar to the activity of all radio-collared moose, in all habitats, from November 1980 thru January 1982 (Bangs and Bailey 1982). These levels of activity (40%) were different from Alberta moose which were active about 60-70% of the time (Hauge and Keith 1981). Peek et al. (1974) reported that moose activity was related to habitat use. Our data may be different than reported elsewhere because; (1) Aircraft disturbance, while tracking, may have affected moose behavior prior to our observations; (2) The Kenai Lowlands have mild winters and much of our data were recorded during the winter of 1980-81--the mildest winter recorded (Bangs and Bailey 1982); (3) The sightability of moose can be affected by a combination of activity and habitat selection (Gasaway et al. 1978); (4) Moose on the Kenai feed extensively on lowbush cranberry (LeResche and Davis 1973) and may thus forage in remnant forest stands where lowbush cranberry was abundant (Smith 1984); and (5) timing of our observations missed moose activity peaks which occur at dawn and dusk (Best et al. 1978).

Table 6. The percentage of observed activity of radio-collared moose in each of four habitat classes within the 1969 Burn.

Habitat Class	N	Activity: Bedded	Standing	Feeding	Travel	Display
Burned Forest	362	58	21	12	8	1
Remnant Forest	159	62	26	7	4	1
Bog	27	63	22	15	0	0
Water	4	0	75	0	25	0
Total	552	59	23	10	6	1

Table 7. The percentage of observed activity of radio-collared moose in each of four habitat classes within the 1947 Burn.

Habitat Class	N	Activity: Bedded	Standing	Feeding	Travel
Burned Forest	47	64	13	17	6
Remnant Forest	37	76	19	5	0
Bog	13	31	38	31	0
Water	1	0	0	0	100
Total	98	63	18	14	4

Our data suggested that moose were often within 100m of remnant forest stands in the 1969 burn, used remnant forest stands more than expected in both burns, and used remnant forest stands for a variety of activities. Since moose within the 1969 burn were within 10m of the forest edge 50% and within 100m of edge on 89% of the times they were located, it appears that moose use remnant stands that are relatively small or that they often select to be near the edge of remnant forest stands. We maintain as have others (Spencer and Hakala 1964, LeResche et al. 1974, Oldemeyer et al 1977, and Bailey 1978), that burned forest was the major habitat important to and selected by moose in the large burns because of the quality and quantity of food. However, bog habitat apparently becomes more important when food abundance or quality declines in the early spring or as a burn matures.

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