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IMPACT OF WILDFIRE ON MOOSE MOVEMENTS

By
William C. Gasaway
Stephen D. Dubois
Rodney D. Boertje

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Job No.: 1.32R Job Title: Impact of Wildfire on Moose Movements

Period Covered: 1 July 1980-31 March 1985

SUMMARY

The initial response of 7 radio-collared moose (Alces alces) to wildfire was investigated to determine if moose were displaced from the burned portion of their home ranges. The long-term response of 14 radio-collared moose to the burned area was investigated to determine if, and how, moose modify their home ranges after a fire to take advantage of new browse. Home ranges of these moose either overlapped or were adjacent to a 500-km^2 fire that burned from 3 May-20 June 1980 in interior Alaska. Locations and home ranges of animals during May-August for the 2 years preceding the fire were compared to data during the year of the fire. The radio-collared moose were not displaced due to the fire and selected primarily unburned sites within the perimeter of the slow-moving fire as it burned. During the long-term study, none of the 6 moose with little or no prefire contact with the burned area altered postfire home ranges in a manner that increased use of the burn. In contrast, 6 of 8 moose with major prefire contact with the burned area increased their use of the burned area. Use of the burn increased during the 1st year and then remained relatively stable for 5 years. Age of moose was not related to changes in the frequency of use of the burn. Increased use of the burned area resulted from small home range shifts and changes in time spent in portions of home ranges. Our findings indicated the number of moose with major prefire contact governs the increase in moose abundance due to altered movements. Therefore, greatest postfire increases in moose abundance will occur where moose density is high and migrants are common.

Key words: Alaska, Alces alces, moose, wildfire.

CONTENTS

PREFACE

This report is organized in 2 phases: (1) the initial response of moose to wildfire, and (2) the long-term response of moose to a burned area. The initial response will be published in Canadian Field-Naturalist (Gasaway and DuBois 1985). That manuscript is reproduced here (in Canadian Field-Naturalist format) as a final report on the immediate effects of wildfire on moose movements and as background for the long-term study. Normally, a manuscript published elsewhere would be included as an appendix, but in this case the findings are an integral part of the entire study and the manuscript contributes an introduction, a study area description, and methods. By including the manuscript in the body of this report, we ensure readers are exposed to all facets of the study, while minimizing the rewriting of published material.

OBJECTIVES

Determine effects of wildfire on moose movements during and immediately after a burn.

Determine if, when, and how moose modify their traditional home range after a fire to take advantage of new browse.

Determine if moose population growth in burns occurs from immigration.

Incorporate findings into Alaska's fire management program so maximal rates of moose population growth follow fire.

INITIAL RESPONSE OF MOOSE TO A WILDFIRE IN INTERIOR ALASKA

This section is reprinted directly from a manuscript accepted by the Canadian Field-Naturalist (Gasaway and DuBois 1985).

The immediate effect of wildfire on wildlife is often perceived as animals fleeing from flames. Although some examples support this concept (Komarek 1969), little is known about the response of Moose to wildfire (Kelleyhouse 1979). Hakala et al. (1971) observed no Moose fleeing from approaching flames of a 348-km^2 fire on the Kenai National Moose Range, Alaska. Komarek (1969) indicated that large mammals usually escaped without panic along the sides and flanks upon determining the fire's direction. Conversely, Udvardy (1969, cited in Bendell 1974) reported a chaotic incident of Moose and other animals escaping wildfire by swimming across large rivers. In Manitoba, a large, fast-moving fire (809-km^2 in 8 hours) killed and scorched some Moose and other wildlife unable to escape (V. Crichton, pers. commun.).

Our objective was to determine if radio-collared Moose were displaced from the burned portion of their traditional home ranges during and/or shortly after a large wildfire in interior Alaska. This information will help Moose managers predict effects of wildfire on Moose, on postfire Moose population density, and on potential population growth. If most Moose are displaced from their home ranges either permanently or for many years, Moose population regrowth would be slow or highly dependent upon immigration. Where Moose density is low adjacent to the burn, immigration may not significantly contribute to population growth. Conversely, if Moose that traditionally used the burned area remained in their established ranges, then they could contribute substantially to population growth in the burn, and there would be less need for concern by wildlife managers, fire suppression personnel, and the general public about the welfare of Moose during and after wildfires.

Study Area

The interior Alaska study area, located on the Tanana Flats lowlands (Fig. 1), supports a mosaic of habitat types including herbaceous bogs, shrub-dominated seres following numerous wildfires, deciduous forest, and Black Spruce (*Picea mariana*) and White Spruce (*P. glauca*) forests (LeResche *et al.* 1974).

A 500-km^2 wildfire burned on the Tanana Flats from 3 May-20 June 1980. The fire burned an area of predominantly mature Black Spruce and Aspen (*Populus tremuloides*) forest, which supported a Moose density of approximately 0.1 Moose/km^2.

In that portion of the burn traditionally used by radio-collared Moose, about 75% of the area was moderately to severely burned, about 10% lightly burned, and about 15% unburned. Basal sprouting of willows (*Salix* spp.) occurred during summer 1980. An average of 58% ($\overline{SE}$ 8, *N* 7, range 20-76) of the 1980 home ranges occupied from 29 April-August were inside the fire perimeter.

Methods

We tested the following hypotheses: (H_o) wildfire does not displace Moose from burned portions of home ranges, (H_a) wildfire displaces Moose from burned portions of their traditional home ranges. A wildfire in May and June 1980 burned portions of home ranges of 5 radio-collared cow Moose and 2 radio-collared bulls. To determine if the fire displaced Moose, locations and home ranges of radio-collared Moose during 29 April-August 1980 were compared to similar data from the same Moose during 29 April-August of 1978 and 1979. The 1978 and 1979 Moose movements identify traditional home ranges and serve as controls for detecting effects of wildfire on home ranges. The number of relocations from 29 April-August for individual Moose ranged from 8-11 in 1978, 4-7 in 1979, and 4-6 in 1980 prior to and during the fire and 2-5 after the fire. Only 4 of the 7 Moose were radio-collared in 1978. Home ranges were drawn using the minimum home range method (Mohr 1947). Subjective visual comparisons between the 1978-79 and 1980 home ranges of each Moose helped to determine if displacement occurred. We realize the limitations of home range polygons drawn from a small sample of locations.

In testing the hypotheses, H_o will be rejected if: (1) a X^2 test shows significantly fewer ($P < 0.05$) relocations of Moose are found in the burn perimeter during 1980 than are expected, based on 1978 and 1979 relocations, and (2) a significantly ($P < 0.05$) greater percentage of 1980 home range polygon area is outside the burn perimeter when compared to percentages for 1978 and 1979; the test is Wilcoxon's signed ranks procedure (Hollander and Wolfe 1973). If we fail to reject H_o, we will inspect the data to determine if we want to make a heuristic argument for acceptance of H_o. If we reject H_o, inspection of data will be used to heuristically argue to accept H_a.

In 1980, Moose were recorded as being inside or outside the fire perimeter. If inside, the site selected by the Moose was recorded as burned or unburned. All relocations were made from fixed-wing aircraft and plotted on 1:63,360 maps.

To determine the percentage of radio-locations from 1978 and 1979 that were in the 1980 burn, each location was compared to a map showing the chronological advance of the fire perimeter. The Moose was determined to be in the area burned during 1978 or 1979 if the location was within the burn perimeter for that day in 1980. Therefore, when the burned area was small, a 1979 point could have been recorded out of the burn, yet later when the burned area had enlarged the same location could have been in the burn. The advance of the fire was monitored by the Bureau of Land Management and the Alaska Department of Natural Resources, Division of Forestry during fire suppression activities. Chronological advance of the fire's perimeter was drawn on 1:63,360 maps. The intensity of the burn, based on criteria of Viereck and Schandelmeier (1980), was assessed during aerial and ground level surveys.

Results

We accepted H_o because we did not statistically reject H_o and inspection of data provided no evidence that fire displaced Moose from the general area used 1-2 years prior to the fire. The number of relocation points inside the fire perimeter in 1980 did not decline ($P > 0.05$) compared with 1978 and 1979 (Table 1). The mean percentage of May-August home range area outside the burn perimeter was not greater in 1980 (42%, SE 7.7, $\underline{N}$ 7) than in 1978 and 1979 (57%, SE 8.6, $\underline{N}$ 11). In addition, May-August home ranges in 1980 overlapped 1978 and 1979 ranges by an average of 46% (SE 7, $\underline{N}$ 11). Visual inspection of these prefire and 1980 May-August home ranges shows nonoverlapping portions of ranges were spatially close and the long axes were generally parallel (Figs. 2, 3). These data indicate the fire had little effect on the shape and location of home ranges.

Moose showed no reluctance to use that portion of their range within the fire perimeter while the fire was burning and producing dense smoke (Fig. 4). Fifty percent of all June 1980 relocation points were inside the fire perimeter (Table 1) and, on 2 occasions, Moose were seen standing within 2 and 15 m of small flames. These 2 Moose appeared unconcerned about the flames.

When Moose were within the perimeter of the burn, they showed strong selection for unburned vegetation (X^2, $P < 0.01$). Although only approximately 15% of the vegetation remained unburned, radio-collared Moose were located in unburned sites 67% ($\underline{N} = 30$) of the time.

Discussion

Moose were not displaced from their traditional May-August home ranges when a portion of their range was altered by fire. Unburned vegetation apparently met their immediate food and cover requirements and may have been the main factor initially enabling them to remain within their ranges. Unburned vegetation outside the fire perimeter and as "islands" inside the fire perimeter was used (Fig. 4). Additionally, Moose had resprouting browse available in the burned area during summer 1980; therefore, their food base quickly increased.

Data in Table 1 appear to indicate that Moose were attracted to the burn area during June and July 1980, but we hesitate to draw this conclusion. Movements of each Moose viewed independently showed no clear shift of home range into the burn during 1980 as compared with other years.

Large wildfires in interior Alaska commonly burn mature or climax forests, which generally have low Moose densities (0.1-0.2 Moose/km^2; Gasaway and DuBois, unpub. data); therefore, few Moose will be associated directly with wildfires. Moose that are in contact with wildfires similar to the one we observed may not be adversely affected and probably will remain in their home range. In contrast, extremely hot, large, and fast-moving wildfires that leave few unburned inclusions may occasionally kill or temporarily force Moose to abandon their home ranges. These factors should be considered when planning prescribed burns or managing wildfire to benefit low density Moose populations. When Moose density is high adjacent to burns, type of burn is of lesser long-term importance because of the potentially high rates of immigration, as observed in Minnesota (Peek 1974). Additionally, burning in spring or early summer allows some forage regrowth in the same year, thus providing a widespread food source. Burning in late summer or fall in northern latitudes will delay vegetative regrowth until the following spring, which could be a factor in forcing Moose to abandon portions of their home range.

The consequences of home range abandonment and the resultant slowed population regrowth are significant to people dependent on Moose for food and recreation in interior Alaska and northern Canada. Moose density is currently low over much of the area, and this can have a bearing on the long-term response of Moose to burned areas. When Moose density is low and well below carrying capacity, there is neither a reservoir of Moose nor the competitive incentive for Moose to immigrate into burns. Therefore, growth of low density Moose populations may be primarily dependent on production by Moose that traditionally occupied the area (Gasaway et al. 1980). Under favorable conditions, Moose populations can double in 3-4 years (finite rate of growth = 1.2-1.25) (Gasaway et al. 1983, Keith 1983), hence the starting Moose density is an important determinant of future Moose densities and availability of Moose for use by humans.

LONG-TERM RESPONSE OF MOOSE TO A BURNED AREA

Background

The initial phase of our study demonstrated moose were not displaced by a slow-moving fire. Therefore, managers need not be overly concerned about slow-moving fires causing chaotic moose movements.

On the long term, moose often increase in numbers within burned areas that regenerate high-quality moose browse (Spencer and Hakala 1964), but how these increases occur is not clear. Two mechanisms can cause increased moose densities: immigration (Peek 1974) and improved calf production (Franzmann and Schwartz 1984). In this study, we investigated the role of immigration as a means of increasing moose density.

Methods

Fourteen radio-collared moose, each with a 1-3.5 year prefire movement history, were followed for up to 4.8 years after the 1980 fire. Seven of these moose had a close association with the fire during May and June and were used in the study of initial response of moose to fire. Another moose had major contact with the burned area during migrations and the other 6 moose lived near the burned area but had little or possibly no contact with it. Moose were located from a fixed-wing aircraft and positions were recorded on 1:63,360-scale maps and aerial photos. One moose (No. 8652) was located 20 times from October 1974 to July 1975. From August 1976 to April 1977, moose were located about 3 times. From May 1977 to April 1979, cows were located about 20 times per year, but there were some gaps of 1-3 months between locations. From May 1979 to October 1984, moose were located twice monthly, with the exception of a few months when only 1 flight was made, and from August 1982 to April 1983, when no moose were located. From November 1984 to March 1985, moose were located only twice. Home range polygons were drawn following Mohr's (1947) method. Migratory moose had home ranges consisting of 2 physiographic polygons, one in the uplands and in the lowlands. Moose were rarely observed during migration; therefore, no migration corridors were drawn to connect physiographic polygons.

Results

Contact with the burned area pre- and postfire varied widely among the 14 radio-collared moose (Table 2). Eight moose had major contact with the area both pre- and postfire. Moose having major contact migrated north-south across the burned area and some had portions of their nonmigratory home range in the burned area. The remaining 6 moose had contact with the burned area described as slight to unlikely (Table 2 and 3).

None of the 6 moose with slight to unlikely prefire contact with the burned area (Table 2) altered postfire home ranges in a manner that appeared to increase use of the burn. In fact, these moose were never observed within the burn perimeter postfire (Table 3) though some probably migrated through the burn (e.g., Fig. 5).

In contrast, 6 of 8 moose with major prefire contact with the burned area increased their use of that area postfire (Table 4). The 2 moose (No. 7754 and 8652) that decreased use of the area postfire lived much of the year along the jagged northern border of the burned area, both pre- and postfire. These moose were consistent in the area used among years; however, shifts in their major area of activity of just 1-2 miles made large differences in the percentage of locations in the burn. Hence, these 2 moose made no major home range shifts to avoid the burn.

Use of the burned area increased during the 1st postfire year for all 6 moose that increased burn use postfire; however, there was no consistent pattern among these moose after the 1st year (Table 4). Average use of the burn by the 8 moose with major contact remained relatively stable for 5 years postfire (Table 5).

Age of moose was not related to changes in the frequency of use of the burned area. Young and old moose showed a similar pattern of use regardless of their prefire contact with the burned area (Fig. 6).

Increased use of the burned area resulted from small home range shifts and changes in time spent in portions of home ranges. Moose did not abandon previously used areas and subsequently move into the burn (Fig. 7 and 8). Rather, they increased use of burned portions of their home range that previously received little use. For example, prefire migrations were rapid, and moose were rarely observed in the area that burned (Fig. 7 and 8). Postfire, these moose spent several months in the area once used only for migration. The greatest home range shift is shown in Fig. 8, and Fig. 7 represents an intermediate shift.

Discussion

Moose abundance in burned areas has increased faster than would be predicted based solely on growth from reproduction (Spencer and Hakala 1964, Peek 1974). However, the mechanisms causing this growth are not well understood. The high observed rates of increase in some burns is clearly a result of moose altering their movement pattern. Alterations can potentially take many forms: (1) abandoning home ranges that were entirely outside the burn in favor of home ranges in the burn, (2) abandoning portions of the home range outside the burn in favor of the portion in the burn, (3) making small shifts in home ranges to increase the percentage that overlaps the burn, (4) maintenance of old home ranges but increase the time spent in the burn, and (4) expanding home ranges to include more burned area.

In our study area, 6 of 8 collared moose with major prefire contact with the burned area increased the time spent in the area postfire. That increase resulted primarily from increased time spent within the burned portion of their home range, and secondarily, from small home range shifts. We found no evidence that these moose abandoned the portion of home range outside the burn. Also, moose that had little or no contact with the burned area did not shift home ranges into the burn.

Our findings indicate the number of moose with major prefire contact governs the increase in moose abundance due to altered movements. Where moose respond similarly, the greatest postfire increases in moose abundance will occur where moose density is high and migrants are common.

Potentially, moose could alter home ranges in ways that produce faster rates of increase in burns than we observed. For example, moose could abandon most of their home range out of the burn because of relative availability of resources, i.e., animals living near carrying capacity when outside the burn, in contrast to our study, may make larger home range changes if the burn offers a nutritional advantage. To determine the additional mechanisms moose use to exploit newly created habitat, more studies of individual moose are needed.

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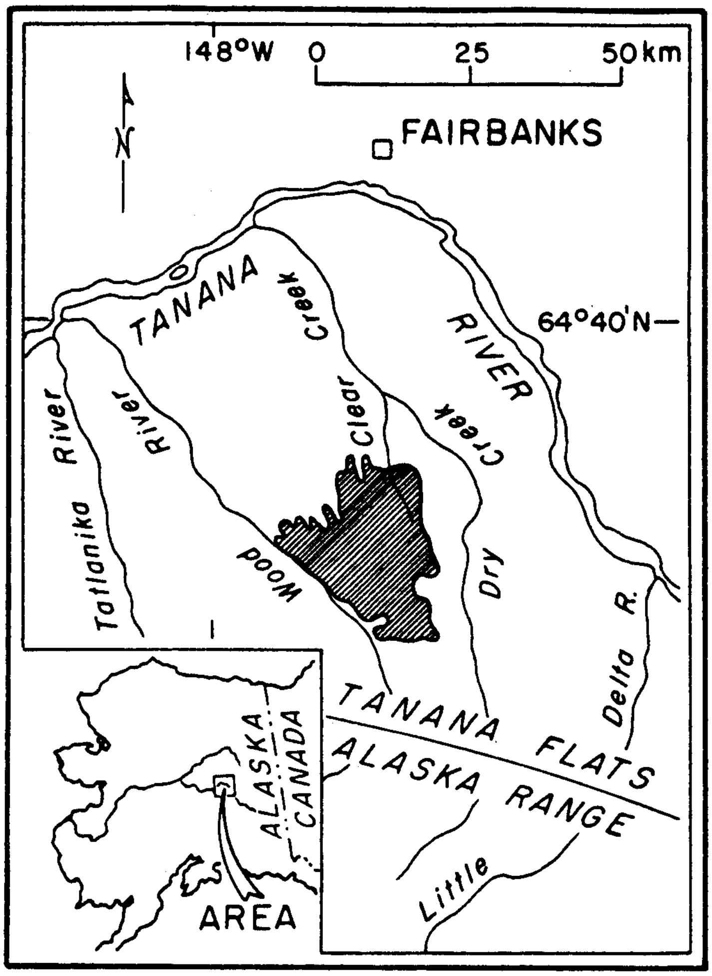

Fig. 1. Location of the 500-km^2 wildfire (shaded area) that burned on the Tanana Flats, Alaska from 3 May through 20 June 1980.

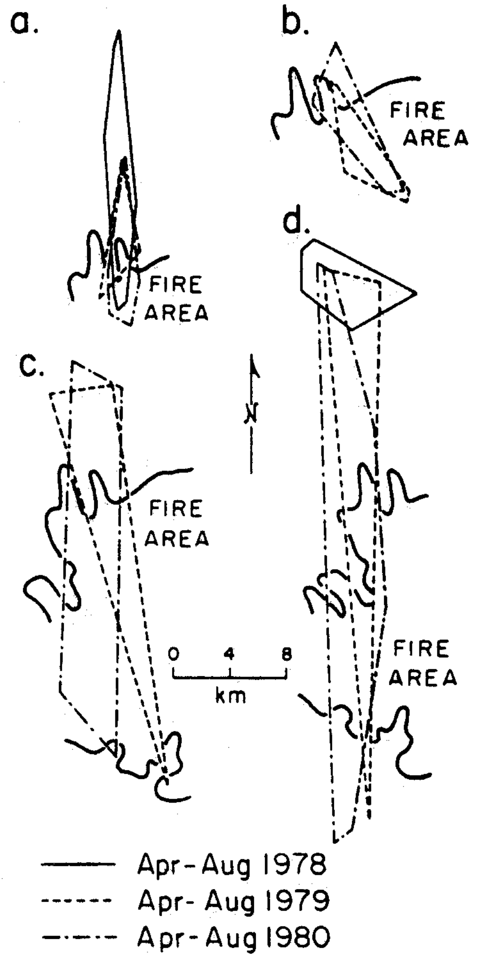

Fig. 2. Home range of 4 radio-collared moose for 29 April-31 August 1978, 1979, and 1980 in relation to a wildfire that burned from 3 May through 20 June 1980 on the Tanana Flats, Alaska.

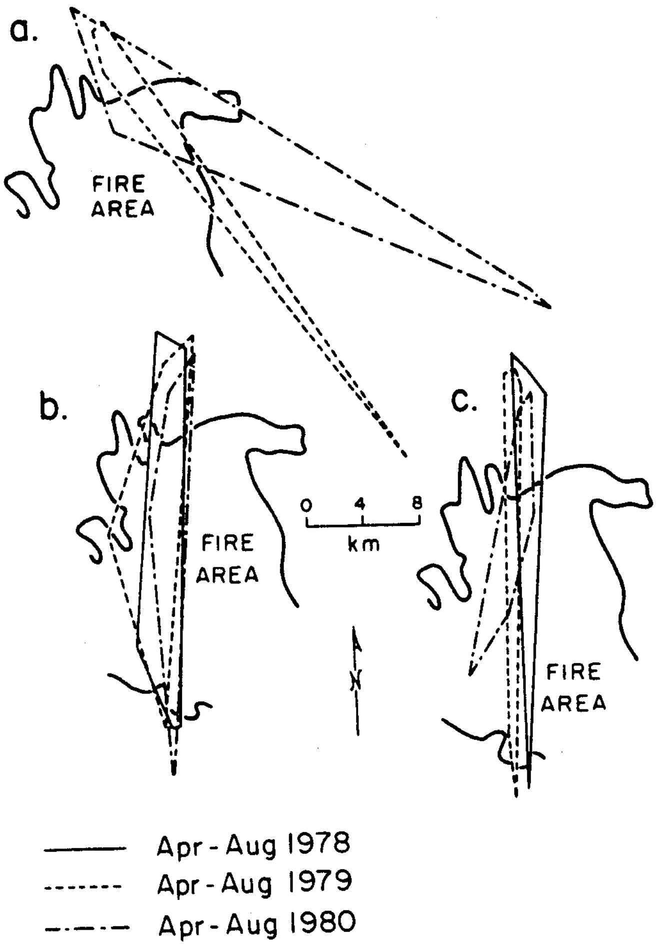

Fig. 3. Home ranges of 3 radio-collared moose for 29 April-31 August 1978, 1979, and 1980 in relation to a wildfire that burned from 3 May through 20 June 1980 on the Tanana Flats, Alaska.

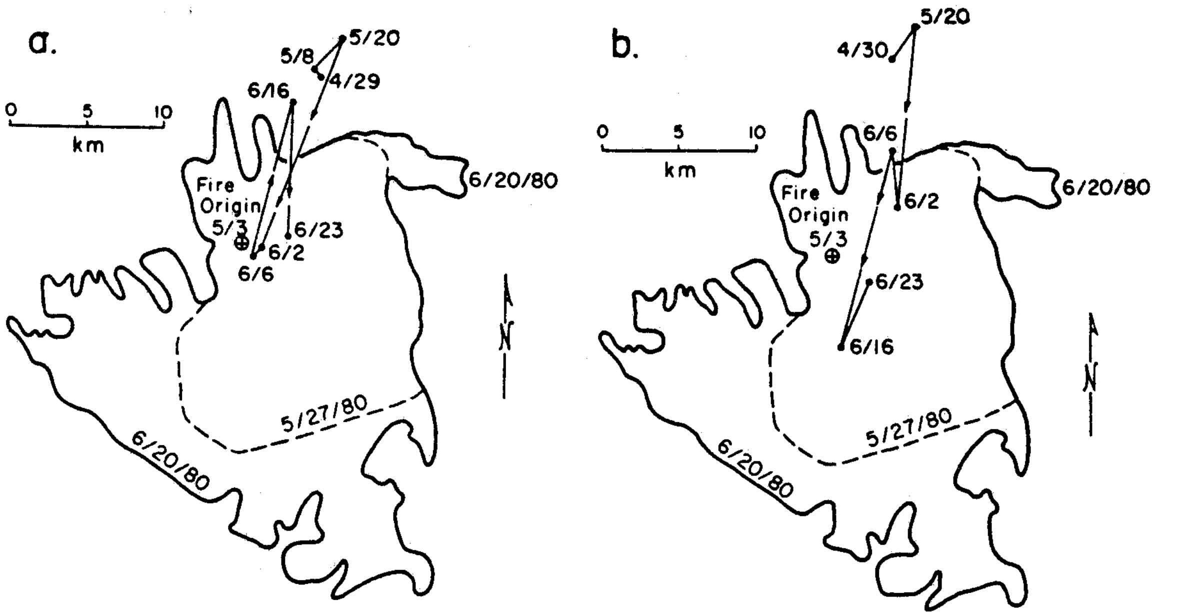

Fig. 4. Movements of 2 radio-collared moose from 29 April through 23 June 1980 in relation to a wildfire that burned from 3 May through 20 June 1980 on the Tanana Flats, Alaska. Intermediate (dashed line) and final fire perimeter (solid line) are shown.

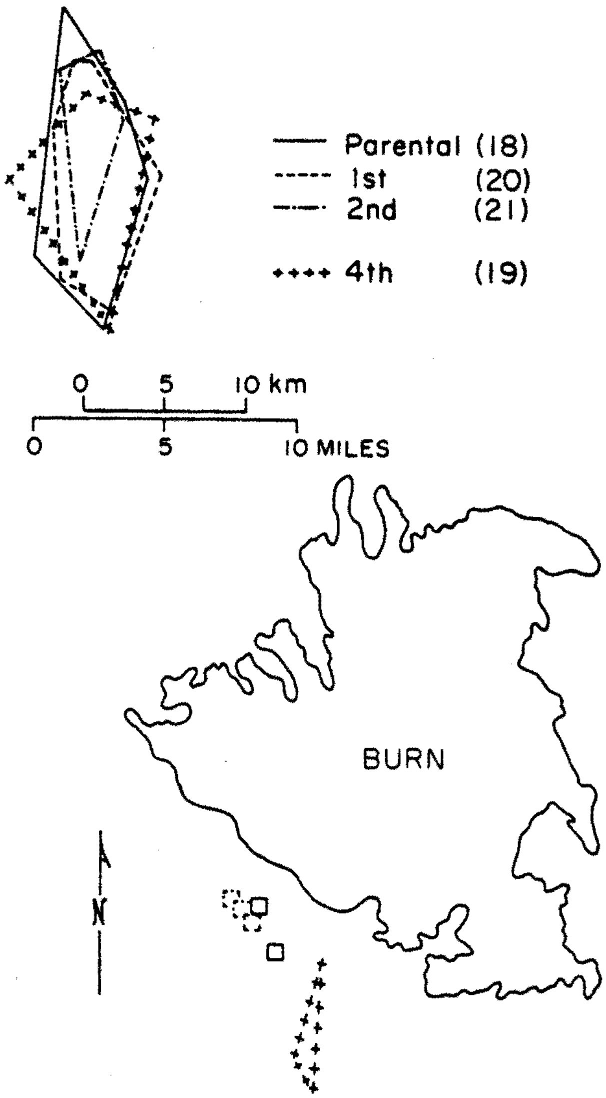

Fig. 5. Home ranges of moose number 7770 in relation to a burned area on the Tanana Flats, Alaska, May 1979-May 1984. Parental range (when accompanying its mother) was prefire, whereas ranges for 1st-4th independent years were postfire. This moose annually migrated between southern and northern portions of its home range and likely had pre- and postfire contact with the burned area. Squares indicate single locations. Number of locations is in parentheses.

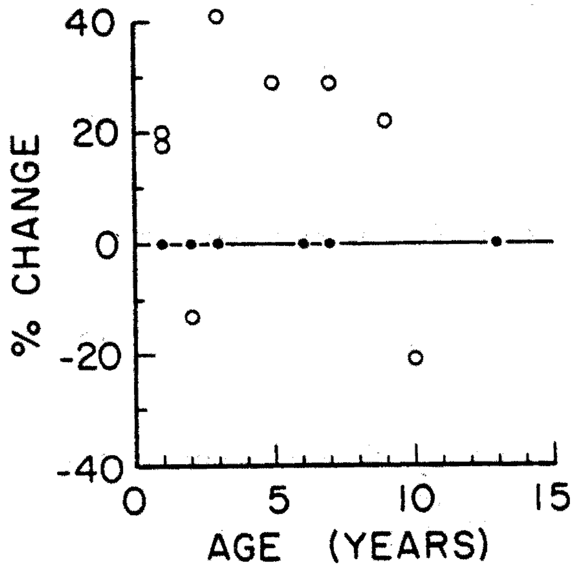

Fig. 6. Age of moose in relation to their mean postfire change in percentage of locations within the perimeter of a burn, Tanana Flats, Alaska, May 1980-March 1985. Indicated age was age during fire, May 1980. Postfire use by individuals was calculated from all postfire locations in Table 4. Moose with major and slight to unlikely prefire contact are indicated by "O" and ".", respectively.

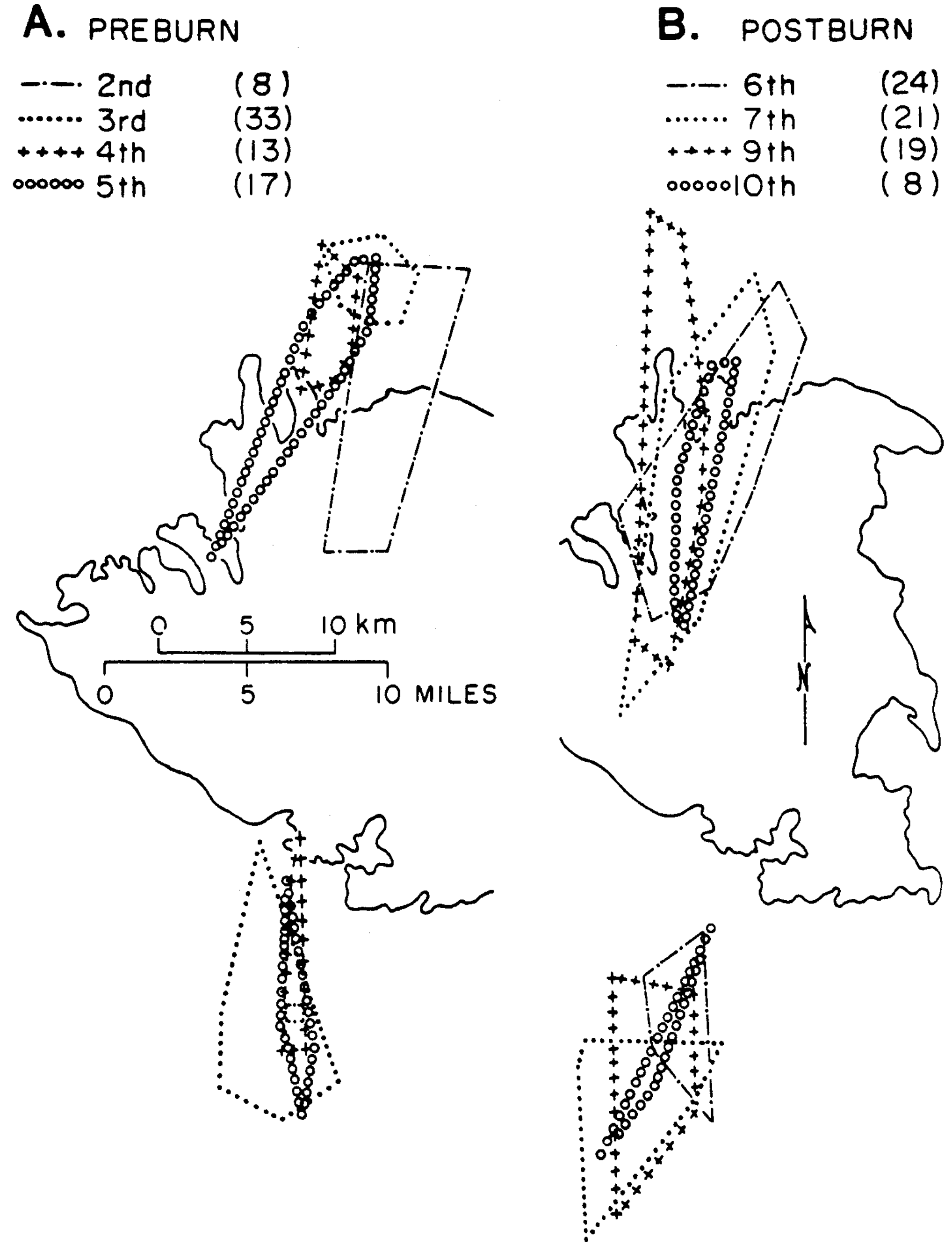

Fig. 7. Preburn (A) and postburn (B) home ranges of moose number 7709, Tanana Flats, Alaska, August 1976-March 1985. Year of independence from its mother is indicated for each home range. Number of locations is in parentheses.

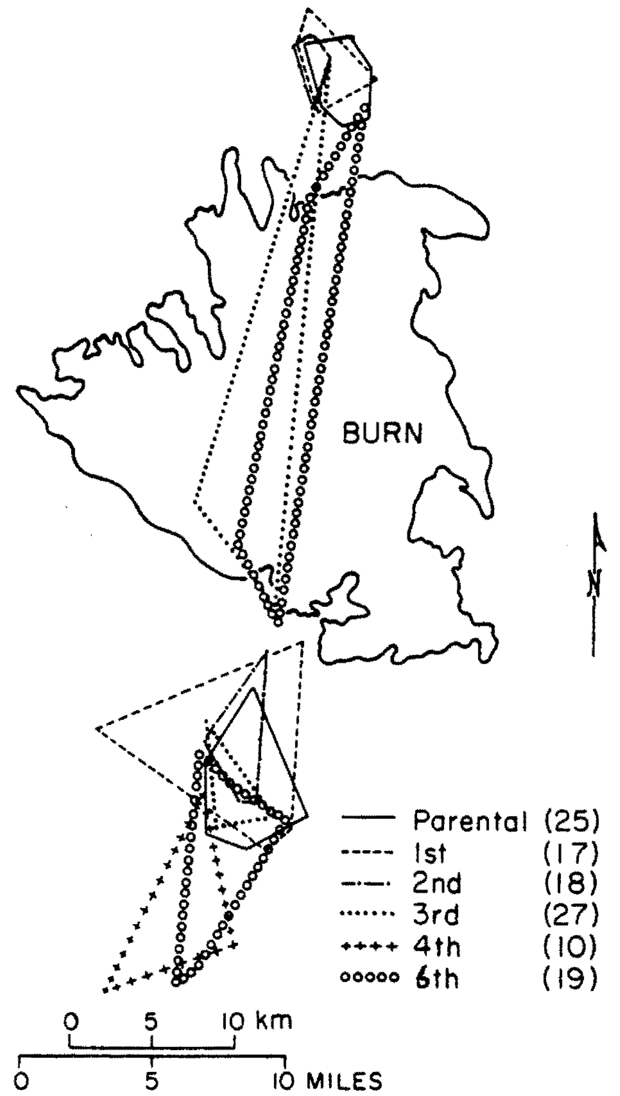

Fig. 8. Home ranges of moose number 7703 in relation to a burned area, Tanana Flats, Alaska, May 1977-May 1984. Prefire ranges include the parental (when accompanying its mother) through 2nd year of independence from mother; postfire ranges include 3rd-6th years. Number of locations is in parentheses.

Table 1. Percentage of relocations for 7 radio-collared moose within an area burned on the Tanana Flats, Alaska.

Month	1978-79 (preburn) N	1978-79 (preburn) %	1980 N	1980 %	Status of fire
May	37	11	11	9	Burning
June	17	12	20	50	Burning
July	6	17	8	75	Postburn
August	8	63	9	78	Postburn
Total or mean of means	68	26	48	53	

Table 2. Pre- and postfire contact of 14 radio-collared moose with an area burned in 1980, Tanana Flats, Alaska, October 1974-March 1985. Individual moose identification numbers are shown. Moose classed as "likely" or "unlikely" were never observed in the burned area (see Table 3).

Prefire contact / Postfire contact: Major / Major	Slight / Likely	Likely / Likely	Unlikely / Unlikely
7703	7722	7734	7742
7709	7739	7770	7758
7724			
7745			
7754			
7763			
7766			
8652			

Table 3. Description of contact 6 radio-collared moose had with an area burned in 1980 by wildfire on the Tanana Flats, Alaska, August 1976-March 1985. Remarks apply to pre- and postfire periods unless qualified.

Moose No.	Contact class prefire / postfire	Moose age at time of fire (years)	Remarks on distance from burn	Closest observed point from burn (km) pre-fire	post-fire
7722	slight / likely	7	Prefire straightline movement route intersected edge of burned area, but not seen in burn.	1.0	0.6
7739	slight / likely	3	Probably migrated through burned area while accompanying its mother (8652) 2-3 years prefire. Lived adjacent to burn as nonmigratory adult.	in burn	0.2
7734	likely / likely	13	Straight line migration route did not intersect burn but was close (1.3 km).	2.6	2.9
7770	likely / likely	1	Straight line migration route intersected edge of burn (Fig. 5).	2.8	3.0
7742	unlikely / unlikely	$\geq$6	Straight line migration route did not intersect burn.	3.5	3.2
7758	unlikely / unlikely	2	Straight line migration route did not intersect burn.	4.0	4.8

Table 4. Percentage of locations within the perimeter of an area burned for 8 radio-collared moose having major pre- and postfire contact with the burned area, Tanana Flats, Alaska. Prefire, moose migrated through the burned area and some had a portion of their nonmigratory home range within the burned area. The fire burned from 3 May-20 June 1980.

Moose No.	Moose age at time of fire	Prefire 1974-80		Postfire 1980-81		Postfire 1981-82		Postfire 1983-84		Postfire 1984-85	
		%	N	%	N	%	N	%	N	%	N
7703	3	0	61	53	15			37	19	33	9
7709	7	3	64	33	21	26	19	20	20	43	7
7724	9	0	70	5	20	5	21	20	20	56	9
7745	5	7	14	30	23	37	19	17	18	62	8
7754	2	59	29	45	20	47	19				
7763	1	7	14	30	23	25	20	21	19	25	8
7766	1	8	12	15	20	40	20				
8652	10	57	49	55	20	35	20	33	21	20	10

Table 5. Mean percentage of pre- and postfire locations within the perimeter of a burned area on the Tanana Flats, Alaska. Pre- and postfire means were calculated using the same moose.

Years post-fire	No. moose	Prefire (1974-80)			Postfire (1980-85)		
		$\bar{x}$	SD	No. of locations	$\bar{x}$	SD	No. of locations
1	8	18	25	313	33	18	162
2	7	20	26	252	31	14	138
4	6	12	22	272	25	8	117
5	6	12	22	272	40	17	51