Fire and Elk in Glacier National Park

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WILDFIRE is a natural phenomenon which historically exerted significant influence on terrestrial ecosystems of Glacier National Park (Ayres, 1900; Habeck, 1970a). Natural fire regimes have played a major role in maintaining the abundance and diversity of biota which currently inhabit the park. The frequency and importance of fire are also reflected in the varied adaptive features exhibited by many indigenous plants and animals. Suppression programs and more frequent unnatural ignitions have altered the historic role of fire during the past 60 years.

Responses of plant communities to fire have been widely documented in relation to structural and compositional changes along temporal gradients. In contrast, responses of wildlife and other consumers have been identified and defined in rather general terms. Resident species with narrow niche dimensions seem to respond dramatically to the effects of fire on their habitat. Those with broader dimensions and/or adaptive capabilities are less likely to exhibit intense population response. In either case, temporal succession of fauna undoubtedly follows that of plants as described by Row and Scotter (1973). An understanding of these relationships is requisite to the restoration of natural fires to altered park ecosystems.

Ecological investigations of wintering elk (*Cervus canadensis*) in Glacier National Park indicate that population response to fire may be relatively predictable. Early in the study it was recognized that most major elk herds wintered on sites that have burned during the past century. By comparison, the few populations which wintered in mature forests were relatively small and of marginal status. This paper evaluates these observations with respect to fire history, elk population trends, habitat relationships, and effects on associated species.

THE STUDY AREA

The study area included approximately 152,700 hectares of mountainous terrain in the southwest region of the park (Fig. 1). Comparable nature of topographic features and elk winter ranges aided in selection of area boundaries. Topography was glacial in origin and dominated by precipitous highlands, morainal deposits, and narrow valleys. Rapidly changing elevations ranged from 948 to 3095 meters above mean sea level. The numerous streams originating within the area formed headwaters of the Flathead River.

Vegetation was represented by a mosaic of alpine and coniferous forest communities (Habeck, 1970b). Coniferous forests occurred extensively below 2,000 meters and were of particular significance to this study. Forest composition reflected the combined influence of topography and fire history (Daubenmire and Daubenmire, 1968; Habeck and Mutch, 1973). Mature forests were dominated by alpine fir (*Abies lasiocarpa*), Englemann spruce (*Picea engelmannii*) and Douglas fir (*Pseudotsuga menziesii*). Seral forests were largely composed of lodgepole pine (*Pinus contorta*), western larch (*Larix occidentalis*), and Douglas fir. Outcrops, talus slopes, snowslides, and fires reduced or eliminated forest canopies in many areas. Shrubs such as mountain maple (*Acer glabrum*), western serviceberry (*Amelanchier alnifolia*), ceanothus (*Ceanothus spp.*), willow (*Salix spp.*), and mountain alder (*Alnus sinuata*) were abundant on these sites.

Study area climate is essentially continental with cold, moist winters and relatively warm, dry summers. Mean annual precipitation at West Glacier is 76 cm with about 50 percent falling as snow from November through April. Mean monthly temperature is 5.6C with extremes of −6.4C (January) and 17.5C (July). These conditions contribute to rapid growth and fuel accumulations on most forested

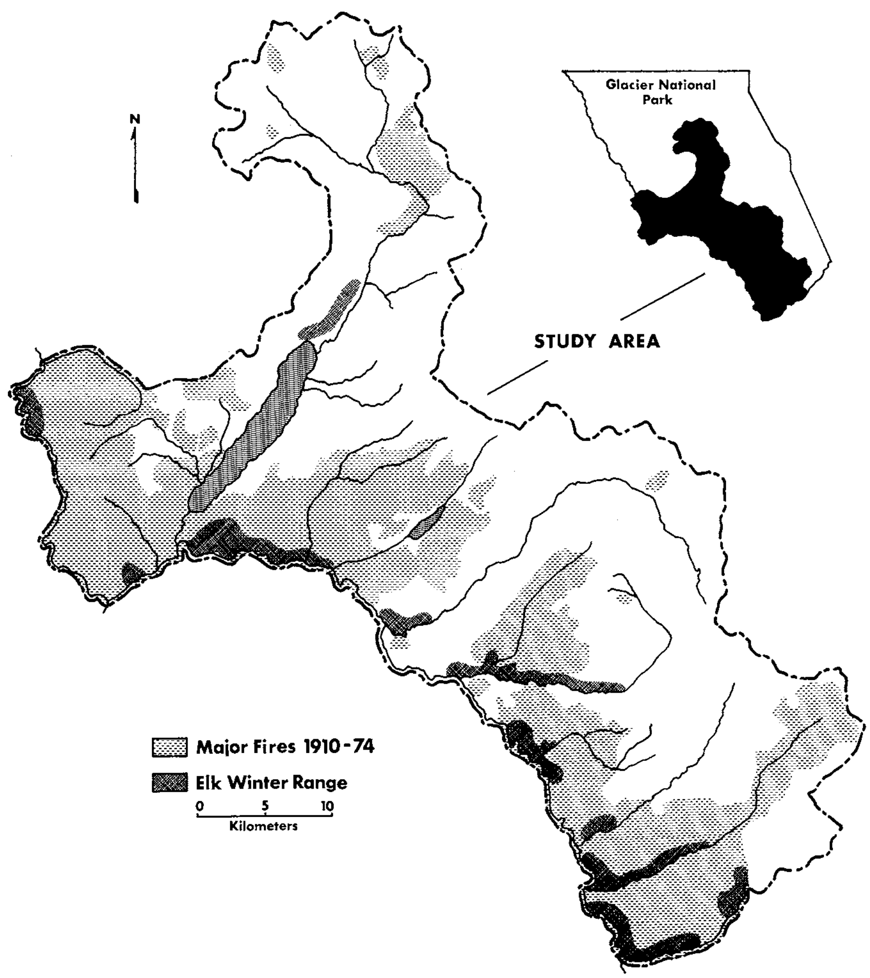

Fig. 1. Extent of major fires and distribution of wintering elk on the study area.

sites. The combination of warm, dry weather, ample fuels, and lightning storms provide excellent conditions for fire starts during most summer months.

STUDY PROCEDURES

Evaluation of fire history considered the extent and frequency of fire as measurable parameters of ecological significance. Geographical extent of major fires from all ignition sources was compiled from the park fire atlas. Distribution, frequency, and size class of successful lightning ignitions were tabulated from individual fire reports. Unnatural ignitions which did not contribute to major fires were excluded as they were generally not ecologically important to wintering ungulates.

Elk population trends were studied from wildlife sighting records and annual reports. Records prior to 1930 were limited to occasional comments on elk numbers and locations. Winter counts from 1931-38 provided general information on elk numbers within the study area. Counts were intensified to a formal biennial census of winter range units from 1946-66. Count data represent minimum population estimates with population trends best reflected by periodic high values.

Current status and ecological relationships of wintering elk were studied in the field from 1967-74. Locations of wintering elk were determined and numbers estimated from late winter aerial and/or ground counts as opportunity permitted. Winter ranges were delineated on topographic maps, recently burned areas identified, and sizes determined. Evaluations of elk population trends, habitat relationships, and plant succession following fire were aided by intensive studies on the Belton Hills winter range.

FIRE HISTORY

Fire has been a prominent feature in the development of landscape patterns on the study area (Fig. 1). An estimated total of 60,000 hectares burned from 1910-74 of which 12,200 hectares (20%) were multiple burns. Thirty-eight fires of 40 or more hectares each contributed to nearly all of the area burned during the 64 year period. Particularly large fires occurred in the southern half of the area in 1910 and 1919 while northern portions burned extensively during 1926, 1929, and 1967.

Approximately 31 percent of the study area has burned one or more times since 1910. Forest habitats were the focal point of significant fire activity, with about 44,900 of 117,000 coniferous forest hectares (38%) having burned. At the same time, only 2,900 of 35,700 alpine/subalpine hectares (8%) were influenced by fire. Unfavorable fuel and moisture conditions apparently restricted fire expansion into alpine habitats. The presence and extent of these natural firebreaks contributed to the distribution pattern of major fires in the study area (Fig. 1).

Ignition source of the 38 major fires included 10 caused by man, 13 by lightning, and 15 of undetermined origin. Fire perimeters generally expanded eastward with several of the larger fires known to have been ignited outside the study area. A number of additional fires spread from the study area to the east and north. The potential for occasional conflagration was clearly demonstrated regardless of ignition source.

Lightning storms caused a minimum total of 306 natural fire ignitions from 1910-74 (Table 1). Fire starts occurred at a mean annual rate of 4.8 with none recorded during 13 years and 10 or more during 9 years. Periodic changes in ignition rates were significant but small

Table 1. Frequency and size distribution of lightning fires on the study area from 1910-74.

	No. of Fires			Percent of Total Number by Hectare Class		
Period	Total	Range	Per Year	0-0.1	0.2-40.0	40.1 plus
1910-19[1]	5	0-2	0.5	0	80	20
1920-29	50	1-16	5.0	68	26	6
1930-39	63	1-21	6.3	77	19	4
1940-49	86	1-27	8.7	93	7	0
1950-59	26	0-11	2.6	96	0	4
1960-69	51	0-12	5.1	76	20	4
1970-74	25	3-10	5.0	88	12	0
1910-74	306	0-27	4.8	81	16	3

[1]Data are incomplete for this period.

sample size precluded correlation with regional trends (Komarek, 1967). Individual fire sizes ranged from less than 0.1 hectare to nearly 11,400 hectares. Eighty-one percent were less than 0.1 hectare while only 3 percent expanded to greater than 40 hectares. Increasingly effective suppression programs undoubtedly contributed to the predominantely small size of lightning fires.

ELK WINTER RANGES

Elk populations wintered on at least 11 sites distributed along the western periphery of the study area (Fig. 1). Winter ranges were lo-

Fig. 2. Typical pattern of seral shrub and coniferous forest habitat on an elk winter range in southwestern Glacier National Park.

cated on modeı ately steep south to west exposures below about 1500 meters elevation (Fig. 2). These topographic features produced snow conditions which permitted elk to access and forage in both shrub and forest habitats. Winter ranges were generally considered ecologically complete with elk populations regulating their own numbers (Cole 1971; Martinka 1969).

Most elk winter ranges were situated within the zone of extensive fires (Fig. 1). Average estimated size was 794 hectares with a total of 8,734 hectares representing 5.7 percent of the study area (Table 2). Nine winter ranges which burned between 1910 and 1967 had a mean of 89 (44-100) percent of their area influenced by fire. The remaining two are not known to have burned extensively during recent history.

Winter range vegetation was distinct in relation to fire history and successional patterns (Table 2). Mature forests were generally dominated by Douglas fir on xeric sites with spruce and alpine fir abundant in the canopy of mesic locations. Recently burned forests were rapidly replaced by shrubfields variously dominated by mountain maple, western serviceberry, redstem ceanothus (*Ceanothus sanguineus*), evergreen ceanothus (*C. velutinus*), and snowberry (*Symphoricarpos spp.*). Shrubfields persisted for relatively long periods

Table 2. Location, size, fire history, and habitat composition of 11 elk winter ranges on the study area.

Winter Range Location	Estimated Size (Hectares)	Most Recent Fire		Habitat Composition (%)		
				Coniferous Forest		
		Year	Percent of Area	Mature	Seral	Shrubfields[1]
Elk Mountain	680	1910	100	0	60	40
Bear Creek	760	1910	99	1	50	49
Ole Creek	863	1910	91	8	54	38
Park Creek	242	1910	95	7	61	32
Double Mountain	895	1910	100	0	66	34
Coal Creek	1623	1958	44	56	14	30
Nyack Creek	573	Unknown	0	98	0	2
Belton Hills	1571	1929	76	24	41	35
McDonald Valley	689	Unknown	0	88	0	12
South Apgar	222	1929	100	0	78	22
North Apgar	616	1929	92	0	8	92

[1]Includes burns, snowslides, and talus areas.

on xeric sites but were rapidly replaced by combinations of lodgepole pine, western larch, and Douglas fir under more mesic conditions. Interspersions of seral habitats occurred in relation to moisture gradients and varied according to the topography of each winter range. Mature forests were represented on most recently burned areas as isolated remnants or as stands contiguous with adjacent forests.

Elk utilized winter range habitats from December through April most years. Differential use of shrubfields and forests occurred in response to accumulated snow depths. Depths of less than about 60 centimeters permitted relatively extensive use of shrubfields while greater depths caused nearly exclusive use of forested areas. Forest canopies altered snow conditions and moderated temperature extremes to lessen energy drain during critical winter periods. Elk utilized seral and mature conifer stands in apparent relation to geographic location rather than vegetation composition.

Wintering elk were primarily browsers with trends in forage use reflecting species preference, local availability, and habitat use. Redstem ceanothus, evergreen ceanothus, mountain maple, and western serviceberry were major forage species on shrubfields. Forest stands provided palatable conifers, including lodgepole pine and Douglas fir, in addition to deciduous species. Production of preferred foods correlated with the successional status of habitat types (Lyon, 1971). The greatest variety and volume were present in young conifer stands. Shrubfields were less productive although elk browsing tended to maintain comparatively high annual twig production (unpublished data). Mature forests were least productive in both variety and volume of preferred forages.

ELK POPULATION TRENDS

Historical records contain frequent references to elk on the study area. Accounts from 1890 to 1910 suggest that elk were sufficiently plentiful to provide hunting opportunities in southern portions. Later reports further suggest that these populations expanded from 1910-30. In contrast, scarcity of elk in northern areas was emphasized by an attempt to establish a herd near West Glacier in 1912. Marginal status of elk in northern regions apparently continued until at least 1930.

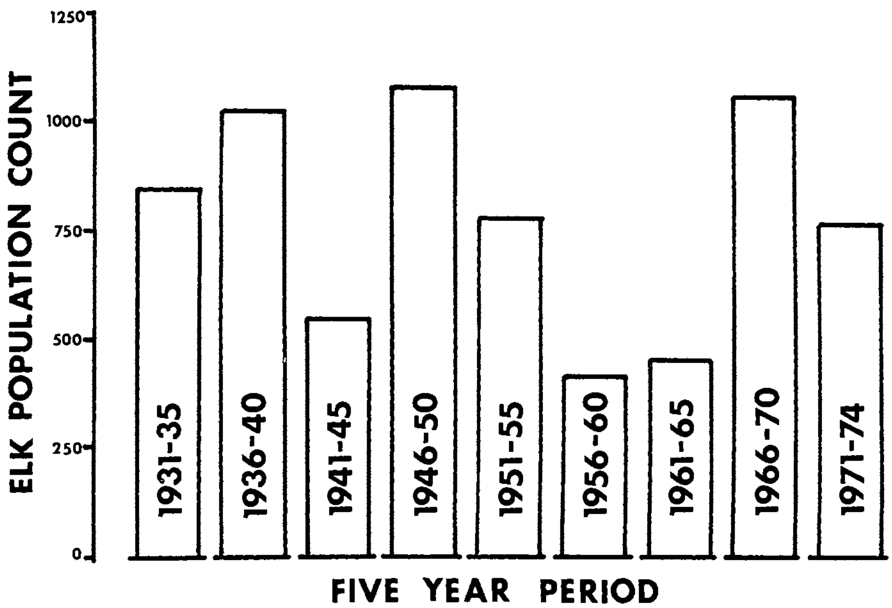

Fig. 3. Elk population trends on the study areas as determined from maximum counts during 5-year periods, 1931-74.

Periodic winter counts from 1931-74 revealed significant changes in elk population levels (Fig. 3). Expanding populations reached a peak in about 1935 followed by an apparent decline from 1941-45. Reduced census effort appears to have been partially responsible for the low count as the estimate rapidly increased to 1074 elk in 1946-47. The period from 1946 to 1967 seems to represent a population cycle during which a major decline and recovery occurred. Specific cause of the decline is not known but several severe winters and extended hunting seasons adjacent to park winter ranges were potential contributing factors. Recovery to earlier population levels required nearly 12 years between 1955 and 1967.

Evaluations of certain individual winter ranges indicated relatively distinct trends in elk populations during postfire years. Elk populations apparently expanded to peak numbers within 25 years of a major fire. High population levels were maintained on winter ranges where shrubfields persisted in association with young conifer stands. However, population expansions were followed by rapid declines where shrubfields were extensively replaced by conifers. A dramatic decline was also observed following a 1967 fire which eliminated most of the existing conifer habitat on a winter range. These trends suggest that development of maximum elk population levels was primarily related to partial reinvasion of conifer stands on burned winter ranges.

Current densities of wintering elk reflect the combined effects of fire history and habitat interspersions (Table 3). Low densities occurred on the extensive shrubfields of early succession and in continuous forests of later stages. Intermediate conditions permitted densities to approach or exceed those on productive bunchgrass winter ranges (Houston, 1974). These observations further support the hypothesis that wintering elk derive maximum benefit from developing shrub/forest mosaics following fire.

DISCUSSION

Environmental conditions for frequent fire ignition and occasional conflagration have been inherent to study area ecosystem development during the postglacial period (Hansen, 1948). Conditions for extensive burning may have occurred in relation to major climatic

Table 3. Elk population densities on 11 study area winter ranges as estimated from maximum counts from 1967-74. Winter range size shown in Table 1.

Winter Range Location	Estimated Winter Elk Population	Number of Hectares per Elk
Elk Mountain	100	6.8
Bear Creek	100	7.6
Ole Creek	150	5.6
Park Creek	40	6.1
Double Mountain	175	5.1
Coal Creek	100	16.2
Nyack Creek	25	22.9
Belton Hills	200	7.9
McDonald Valley	25	27.6
South Apgar	30	7.4
North Apgar	10	61.6

fluctuations with interim periods permitting development of extensive forests (Heinselman, 1970). Current habitat relationships of wintering elk reflect both adaptability and responsiveness to the spectrum of vegetation change associated with a fire regime. However, study area population trends indicate that elk largely occupy an intermediate position in postfire faunal succession.

Wintering elk populations responded to fire by expanding population levels but at a rate less than biological potential. Expansions correlated with improving forage conditions and apparently required forest cover for maximum densities. Young conifer stands provided an important food and reduced environmental stress during critical periods. Contrastingly, extensive shrubfields or continuous forest canopies did not support high densities of wintering elk. It is becoming increasingly apparent that habitat structure complements the forage base to provide optimal wintering conditions for elk in areas of deep snow.

The large size and gregarious nature of elk required special survival habits under deep snow conditions. Most significant was substantially reduced group size as compared to populations wintering on bunchgrass ranges. In addition, productivity occurred at a comparatively low rate with only minimal response to variations in winter severity (unpublished data). These attributes interact with climatic fluctuations to provide relative population stability and prevent excessive forage utilization. Winter forage species have evolved with and are well adapted to the effects of both fire and elk.

Elk winter ranges were also inhabited by mule deer (*Odocoileus hemionus*) which responded differently to the effects of fire. Population levels seemed favored by extensive shrubfields of early postfire succession. Smaller body size, dispersed groups, and ample forage production permitted shrubfield use in the absence of forest cover and elk. Mule deer were gradually excluded from certain sites as elk populations expanded following fire. In contrast, whitetails (*Odocoileus virginianus*) were important inhabitants of forested areas where topography was not limiting. This species was seldom observed in shrubfields. Moose (*Alces alces*) and mountain goats (*Oreamnos americanus*) also inhabited the study area but their relationships to fire are at best poorly understood.

In conclusion, elk appear well adapted to cope with and respond to fire in their environment. Efficient use of a variety of seral habitats suggests evolutionary adaptation to fire through genetic diversity. Exclusion of fire through suppression programs will tend to compress genetic diversity and reduce responsiveness of populations to dramatic environmental change. Such an effect will undoubtedly jeopardize the natural status of elk in forested habitats of northwestern Montana.

SUMMARY

Data and observations from ongoing studies were utilized to discuss ecological relationships between elk and fire in Glacier National Park, Montana. The study area included 152,700 hectares of mountainous terrain in the southwest region of the park. Approximately 47,800 hectares have been burned by lightning-or man-caused fires since establishment of the park in 1910. Elk winter ranges were located on relatively steep southern and western exposures below 1,500 elevation with 9 of 11 having been partially or completely burned since 1910. Secondary succession following burning of winter ranges has been characterized by developing mosaics of shrub and conifer communities in apparent relation to moisture gradients. Elk population trends suggest that development of young conifer stands enhanced habitat carrying capacity for elk and permitted maximum densities to utilize winter ranges. The status of elk relative to postfire succession was discussed.

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