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GLACIER

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DRAFT ENVIRONMENTAL ASSESSMENT

FOREST FIRE MANAGEMENT
GLACIER NATIONAL PARK

West Glacier, Montana

Prepared by

Glacier National Park
Rocky Mountain Region
National Park Service
Department of the Interior

November 24, 1976

Recommended by: Phillip R. Iversen 11/24/76
Phillip R. Iversen date
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Lynn H. Thompson date
Regional Director

FIRE MANAGEMENT ASSESSMENT

GLACIER NATIONAL PARK

For any single forest the complex actions and interactions of plants, soils, animals, micro-organisms and men, together with all factors of climate, topography, lithology and history, must be studied separately and in synthesis.

The prosecution of such studies is no simple or short-term task; and a full understanding is unlikely to be gained by any individual student however competent. In this field of endeavour it is almost impossible to isolate a single, sharply defined problem from the tangled mass of inter-related problems producing, by diligent research, a polished memoir unassailable in fact and in logic. We must be satisfied if, aiming at the stars of final truth and complete comprehension, we can present what appears to be one aspect of the truth for consideration and evaluation by our critics and fellow students.

John T. Holloway in "Forests and Climate
in the South Island of New Zealand" Roy.
Soc. New Zealand Trans. 82(2) : 329-410,
illus., 1954.

DRAFT ENVIRONMENTAL ASSESSMENT

FOREST FIRE MANAGEMENT
GLACIER NATIONAL PARK

PREPARED BY FORESTRY TECHNICIAN JANE E. KAPLER

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0.0 ABSTRACT

0.1 Forest fires ignited by lightning are a force natural to Glacier National Park and even essential to the perpetuation of its wilderness character. Due to the dramatic power of fire to destroy, the National Park Service has attempted since the founding of the park to suppress all fires therein. Current policy (since 1974) recognizes the role of fire in Glacier's ecosystems. Glacier's managers are currently considering various approaches to fire management in order to perpetuate Glacier's wilderness, with the greatest safety for residents, visitors and non-park property.

0.2 This environmental assessment describes the Glacier Park environment in its relation to fire, and the changes which are taking place because of fire suppression. Potential effects are discussed for each of four possible approaches to fire management:

1. Total suppression of all fires to the extent possible under present technology.
2. Allowing all fires to burn without control measures.
3. Allowing some lightning caused fires to burn under prescribed conditions.
4. Introducing (prescribing) fire where need is demonstrated.

The table on the following pages summarizes these effects. (Note that Alternative 1 is divided into two parts: suppressing all fires while very small, which would be extremely expensive and may in fact be impossible; and suppressing most fires while small, which is closer to the current practice.) This table summarizes predictions from data which are themselves

very complex. The reader is therefore referred to the four sections of Chapter Three of the Fire Management Assessment, which correspond to these management alternatives for more detailed assessments of potential effects, and to the description of the Glacier environment (Chapter 2) for the relation of various areas of concern to the current fire management situation in Glacier.

COMPARISON OF PROBABLE EFFECTS FROM DIFFERENT FIRE MANAGEMENT PLANS

		Fire management plan				
		Alternative 1		Alt. 2	Alt. 3	Alt. 4
		Immediate suppression of all fires. <u>1/</u>	Suppression of most fires as Class A or B. <u>2/</u>	Allowing lightning caused fires to burn under some conditions. <u>3/</u>	Allowing lightning caused fires to burn under all conditions.	Introducing fire into areas where need is demonstrated.
Area of Concern	Area burned per decade	Decreasing.	Same or increasing.	Increasing.	Increasing considerably.	Little change.
	Diversity of cover types and wildlife habitat, naturally distributed.	Decreasing.	Redistributed into slightly larger uniform areas.	Young stands increasing slightly, many of them small in area.	Young stands increasing considerably.	Planned distribution of stand ages. May approach natural.
	Likelihood of large, continuous areas being affected by insects, parasites, windthrow or fire.	Increasing.	Increasing.	Decreasing slowly.	Decreasing.	Decreasing slightly, as planned.
	Nutrient availability in soil.	Decreasing.	Decreasing.	Increasing.	Increasing.	Increasing.
	Disturbance of soil, hydrology, fish populations.	Increasing slightly.	Increasing.	Little change.	Same or increasing locally.	Negligible.

(continued)

COMPARISON OF PROBABLE EFFECTS (continued):

		Fire management plan				
		¹ Total suppression, all fires.	¹ Most fires Class A or B.	² Some lightning caused fires.	³ All lightning fires allowed.	⁴ Introducing fire as needed.
Area of Concern	Risk of fire destroying historical resources.	Minimal.	Gradually increasing.	Increasing slightly.	Increasing considerably.	Decreasing.
	Opportunity for study of natural forces and interpretation of wilderness.	Decreasing.	Decreasing slightly.	Increasing.	Increasing.	Increasing, but in planned situations, not wild.
	Safety of back-country travelers from fires.	Minimal hazard.	Slowly increasing.	Increasing slightly.	Increasing.	Negligible hazard.
	Closure or disturbance of areas due to fires, suppression activity or ignition hazard.	Increasing.	Increasing.	Initial increase, then possible decrease.	Increasing.	Little change or decreasing.
	Frequency of fire spread onto land owned by persons or agencies other than Glacier Park. ^{4/}	Minimal.	Slowly increasing.	Increasing slightly.	Increasing considerably.	Little change.
	Days when scenic views are obscured by smoke.	Decreasing.	Increasing slightly.	Increasing.	Increasing.	Little change.
	Planning costs.	Increasing greatly.	Increasing.	Increasing.	No change.	Increasing.
	Fire monitoring costs.	Minimal.	Minimal.	Increasing.	Increasing.	Increasing.
	Fire suppression costs.	Increasing greatly.	Increasing.	Increasing initially.	Decreasing eventually.	Increasing slightly.

^{1/} This practice would be extremely costly; its use is very unlikely.

^{2/} This is a more likely practice which would occur under continuation of current practice.

^{3/} Zones would be defined according to location, fuels and weather. Wherever natural fires would not be allowed, impacts would be as in Column 2, Suppression of most fires as Class A or B.

^{4/} Fire "trespass" will usually be accompanied by suppression costs and payment to owner for resource damage.

Chapter 1. DESCRIPTION OF THE PROBLEM

- 100. Forest Fires, a Management Problem in Glacier
- 110. Natural Fire Occurrence and Suppression Practice
- 120. Policy for Glacier National Park
- 130. Purposes of Assessment

100. FOREST FIRES, A MANAGEMENT PROBLEM IN GLACIER

Glacier National Park was established in 1910. In 1916, its administration was entrusted to the U. S. Department of Interior's National Park Service " . . . to provide for the enjoyment . . . (of the scenery and the natural and historic objects and the wild-life therein) . . . in such manner and by such means as will leave them unimpaired for the enjoyment of this and future generations."

1/ The Master Plan for Glacier National Park directs that "Park ecosystems will be managed to protect, preserve, or restore, where necessary, natural biotic relationships for the scenic, educational, and scientific benefit of the visiting public" 2/. Fulfillment of these fundamental purposes is impossible without the effects of naturally caused forest fires.

110. FIRE OCCURRENCE AND SUPPRESSION PRACTICE

111. Lightning-caused fires have affected the northwestern Rocky Mountains for thousands of years.3/ They have influenced the air, soil and water, and have in many ways determined the nature and distribution of the vegetative cover. This, in turn, affects the entire spectrum of animal species present.

1/ Anon. 1916: 1 (Founding Act for NPS)

2/ Glacier National Park 1975, Mar. 21:44

3/ Habeck and Mutch 1973: 410.

112. The traditional response to forest fires since the beginning of this century, however, has been total suppression as soon as possible. Fire suppression, increasingly effective in Glacier National Park since 1910, ^{1/} has altered the land noticeably in some areas. Development of a tall understory in ponderosa pine stands, lack of aspen reproduction in some areas, increase in old-age lodgepole pine, invasion of meadows by conifers and maturation of range for some ungulates, all evidence a trend toward homogeneity in landscape and reduction of some species from their natural distribution.* It is becoming evident that the traditional practice of total fire suppression has not been in keeping with the purposes of Glacier National Park.

^{1/} Singer (1975b:14) defines the period of effective fire suppression in the North Fork as beginning in the 1930s.

* Species will be referenced by common name throughout the text, according to Kessell 1974a, Shea 1971a and b. Appendix C contains catalog of scientific and common names.

120. POLICIES OF THE NATIONAL PARK SERVICE IN REGARD TO FIRE

121. Evaluation and revision of the policy of total fire suppression in the National Park Service may be dated from the "Leopold Report", submitted by the Advisory Board of Wildlife Management in the National Parks in 1963. This document pointed out that natural systems are in many cases maintained by occasional but powerful natural events, regarded as disasters because of the rapid changes they evoke and the threats they pose to human life and developments. Fire was mentioned as one such influence.^{1/} Since 1963, plans and policies at all levels of park administration have been studied and revised to implement the ideas developed in the Advisory Board's report.

122. The Department of the Interior Manual states that fires may be used to achieve approved resource management objectives. ^{2/} Consistent with this policy, the National Park Service recognizes lightning-caused forest fires " . . . as natural phenomena, which must be permitted to continue to influence the ecosystem if truly natural areas are to be perpetuated." ^{3/} Glacier's Statement for Management expresses the following:

Fire must be viewed as one of the most influential natural factors affecting the park's ecosystem. Fire is required for the perpetuation of most of the community types within the park. Any long-range planning for Glacier must include consideration of the restoration of fire as a natural factor in the environment.

^{1/} Leopold et al 1963.

^{2/} U.S.D.I. 1974 Nov. 1: 590.1.3b

^{3/} National Park Service 1975: 11

The operational policy for fire management and control in Glacier acknowledges that lightning-caused fires are essential elements of an unimpaired ecosystem and calls for the use of natural fires, provided that human safety and property are protected.

Ecosystem and habitat preservation is a major objective in Glacier National Park; management will make a positive commitment to this objective by establishing, implementing and developing a zone fire management system which recognizes and allows fire as a phenomenon essential to unimpaired ecosystem maintenance. Habitat preservation is interpreted to mean that a type will not be allowed to disappear, rather than that a particular geographic plot of land will be held unchanged. 1/

1/ Glacier National Park 1974 Jun 10: 233.200.

130. PURPOSES OF ASSESSMENT

Glacier National Park is at this time, contrary to policy statements, still committed in practice to total fire suppression. This practice has altered some of Glacier's ecosystems from their natural state; if it is continued, effects will become more widespread. This environmental assessment describes the natural role of fire and the problem of fire management in Glacier, and projects the effects of several alternative plans.

Its purposes are to describe the many aspects of the fire situation in Glacier (ecological, social, economic and historical), and to aid in the development of a fire management plan, which is in keeping with National Park Service policy and the fundamental purposes of Glacier National Park.

Chapter 2. DESCRIPTION OF THE ENVIRONMENT

Section 1. GEOLOGY AND SOILS

211. Geologic History

212. Present Features: Geology

213. Present Features: Soils

Map of Glacier National Park showing West Glacier, St. Mary, and locations of a few fires which are referred to in the assessment.

1	POLEBRIDGE
2	NORTH FORK FLATHEAD RIVER
3	FLATHEAD FIRE (1967)
4	HALFMOON FIRE (1929)
5	WEST GLACIER
6	FIREBRAND PASS
7	ATLANTIC FIRE (1973)
8	SUN FIRE (1969)
9	ST. MARY
10	HEAVENS PEAK FIRE (1936)
11	GLACIER WALL FIRE (1967)

GLACIER NATIONAL
PARK
FIGURE 211.1

211. GEOLOGIC HISTORY

211.1 In the landscape of Glacier National Park, an area of 4,100 square kilometers (1,013,000 acres) in northwestern Montana (Fig. 211.1) one may read a long history of geological and climatic events. Glacier's present rock formations show distinct layering and coloring, most apparent on the cliffs and peaks exposed to view above timberline. Almost all of these layers are limestones, shales and sandstones. They were deposited 1.3 billion to 900 million years ago in a narrow sea, which covered a belt of land from Alaska to Mexico.

Around 70 million years ago, the sediments deposited in the Belt Sea began to be uplifted. As the land west of the park rose higher than the eastern plains, segments broke away from the main block of the uplift and slid down toward the east. The mountains of Glacier and the Whitefish Range just west of the park are two such segments. This geological uplift and "overthrust" determined how major drainages would be aligned in western Montana, the channels and barriers, which would govern the weather patterns in the area.

211.2 The time of geological upheaval probably ended about 50 million years ago. Since then, erosional forces have dominated the land's history. By three million years before the present, only mountains, ravines and valleys remained from the great uplifted plain. Rivers and streams deposited perhaps as much as 700 - 1,000 meters (2,300 - 3,281 feet) of sediment in the North Fork Valley. 1/ During the last three million years, the glaciers of successive ice advances

1/ Alt and Hyndman 1973: 26.

have plucked away the sides of the mountains, leaving sharp ridges and peaks, and deep U-shaped valleys. 1/

- 211.3 Recent glacial processes have determined the most striking features of Glacier's geology, rapid changes in elevation and rugged physiography. But it is a long geological history, dating from the deposition of the Belt sediments a billion years ago 2/, which determined the orientation of Glacier's drainages and the composition of its soil -- two factors which affect the impact of lightning storms and fires in the park.

212. PRESENT FEATURES: GEOLOGY

- 212.1 Geological and climatic events have bequeathed to Glacier a wide variety of landscapes. Elevations range from 948 meters (3,110 feet) to 3,170 m. (10,400 feet). In a horizontal distance of 322 meters (1,056 feet), the north face of Mount Cleveland ascends nearly 1,219 meters (4,000 feet). Waterfalls roll out of high glaciated basins; Bird Woman Falls drops 149 m. (490 feet) in a horizontal distance of 101 m. (330 feet). In contrast to these rapid changes, a section of Camas Creek below Rogers Lake meanders across the floodplain for 9 km (5.6 miles) with a fall of only 13 m. (43 feet). Lakes up to 14 km. long (8.7 miles) and tiny mountain tarns are dammed by glacial debris. High country basins harbor approximately 50 small glaciers. 3/ Near-vertical cliffs, ledges and overhangs define the high slopes and mountain tops. Most hillsides are steep, 30 percent to 60 percent grades, even on forested slopes, but the flat valley bottoms contain swamps and rolling grasslands. A few high country parks overlook the valleys, remnants of a plain that was once continuous through the region. 4/

1/ Alt and Hyndman 1973: 28.

2/ Alt and Hyndman 1973: 1.

3/ Alt & Hyndman 1973: 29.

4/ Alt & Hyndman 1973: 39.

213. PRESENT FEATURES: SOILS

213.1 Soils, derived from parent rock and influenced by weather and the vegetation, which they support are complex, highly variable elements in Glacier's system of land and living things. Coniferous forests cover much of the park's area. Due to chemical properties of the litter deposited on the forest floor and to physiological properties of the trees themselves, soils in Glacier's coniferous forests are usually quite acidic.

1/ High acidity inhibits bacterial decomposers, the most efficient soil-forming organisms, and leaves this activity to the fungi. 2/ Fungi not only decompose litter more slowly than bacteria, but also weave it into a mat-like cover that rests on mineral soil but does not grade into it. Acidic soils have limited ability to absorb and hold water. 3/ Studies in young Douglas-fir stands in the North-west indicate that nitrogen deposited in litter may return to the soil so slowly that the supply available in plants is depleted in about 125 years. 4/ The coniferous forest floor may be nutrient-rich, but if this wealth in essential minerals and compounds is not returned to the soil for re-use, vegetational development may be retarded.

1/ Smith 1966: 247; Habeck 1970b: 118.

2/ Behan 1970: 13.

3/ Smith 1976: 247-248.

4/ Behan 1970: 28.

- 213.2 Glacier's grassland soils are characterized by high calcium content and by lower acidity than the soils under coniferous stands. Soils in bottomland and deciduous stands, especially those in riparian communities, also are less acidic than those in coniferous forests. 1/ Because more organic materials are produced on bottomlands and grasslands, the soil here may be deeper than middle-elevation soils.
- 213.3 Soils in alpine areas vary even more than those in low elevation communities. Very dry, shallow soils and retarded chemical activity due to the short growing season and severe climate will occur on one site, but an adjacent depression may harbor deposits of deep, moist organic soils. 2/ Like many other processes in the high country, soil formation and accumulation is slow. Disturbance of the soil usually has longer-lasting effects than at lower elevations. Lichens may take as long as 50 years to return to a burned site. 3/
- 213.4 Fires usually have little effect on the physical structure of the soil and its chemical properties. 4/ However, under very dry conditions in pockets of dense, large fuels, heat output from a fire can be intense enough to produce measurable effects on the soil. Under clumps of heavy fuels, soil particles in the top 2 - 3 cm. (1 in.) of soil may fuse together, decreasing soil wettability, increasing susceptibility to erosion and causing subsequent nutrient and moisture stress on vegetation. 5/ Even these effects are variable. In California, very

1/ Duff 1972 May 31: 3; Habeck 1970b: 118.

2/ Habeck 1970b: 119.

3/ Lutz 1956: 86.

4/ Agee 1974: 32-33; Striffler and Mogren 1971: 29-32.

5/ Agee 1974: 63; Ahlgren & Ahlgren 1960: 486-487.

intense heat output from a fire burning in some shrub species will increase soil wettability, but an even more intense fire reverses this effect. 1/ Changes in soil structure rarely reach more than 5 cm (2 in.) beneath the surface. 2/

- 213.5 Soil movement as evidenced by soil creek is a natural process readily observable throughout the park, in forest and shrub stands of all ages. Fires, particularly frequent reburns over an area, may accelerate this natural process. 3/ Studies on coarse mountain soils in Colorado have recorded only slight downhill displacement of soil after a fire which removed most of the soil's covering. 4/ On ponderosa stands in California, erosion has been attributed to fire control measures, but not to prescribed burning. 5/ On the Flathead Fire of 1967 in Glacier, approximately 75% of litter was removed, exposing soil in many locations. During the next year, general downslope movement of the soil, deterred by patches of unburned vegetation occurred, but noticeable erosion was not observed. 6/

1/ Satterlund 1972: 76, referencing DeBano et al 1967.

2/ Austin and Bainsinger 1955:277.

3/ Agee 1974: 32-33; Anderson 1976.

4/ Striffler & Mogren 1971: 29.

5/ Biswell & Schultz 1957: 374.

6/ Martinka 1969b: 4.

Chapter 2. DESCRIPTION OF THE ENVIRONMENT

Section 2. CLIMATE AND FIRE WEATHER

- 220. Introduction to Climate
- 221. West Side Climate
- 222. East Side Climate
- 223. Air Purity
- 224. Fire Weather Cycles
 - 224.1 Fire Season
 - 224.2 Fire Days
 - 224.3 Diurnal Cycle
- 225. Weather Extremes: Drought

220. INTRODUCTION TO CLIMATE

With its highest peaks delineating the Continental Divide, the Rocky Mountain Range constitutes a formidable weather barrier in this region. Glacier, being part of that barrier, is split into two quite different environments. Glacier's western half is generally moist, characterized by heavy snows during winter, and rain and snow during spring and fall. Continental air masses influence the climate east of the Divide with colder temperatures and less precipitation.

221. WEST SIDE CLIMATE

221.1 Glacier's west slope inherits moisture-laden storm tracks from the Pacific coasts of Washington and British Columbia. Annual precipitation is relatively high, ranging from 60-75 cm. (24-30 in.) at elevations between 900 and 1050 m. (2952 and 3445 ft.), to 200-250 cm. (79-98 in.) at higher elevations, mostly in the form of snow.

1/ Moisture, however, is not constant as one moves north and south along the park's west side. Average annual precipitation at Polebridge is 55 cm. (21.7 in.), while that at West Glacier, 40 km. (25 mi.) to the south, is 75 cm. (29.5 in.). 2/

221.2 Temperatures vary at West Glacier from 37 degrees Celsius (98 degrees F.) to -21 degrees C. (-37 degrees F.). 3/ During winter months sunshine may occur during less than 20% of daylight hours, a cloud cover pattern similar to that of Seattle, Washington. 4/ Occasionally air masses originating east of the Continental Divide spill over to the west slope with severe low temperatures and clear skies. During spring and early

1/ Glacier National Park 1973 Jul 23.

2/ Habeck 1970b; U.S.D.C. 1974: 4.

3/ Dightman 1967.

4/ Habeck 1970b.

FIGURE 221.2 Annual precipitation patterns,
Glacier National Park

West Glacier weather station data taken from Dightman (1967),
29 years of weather records; St. Mary data from 15-year
record 1957-1972.

summer, the entire park usually experiences a wet period, but drier conditions develop during July and August. Then lightning storms occur, sometimes accompanied by little, if any, rainfall. Some of these storms ignite forest fires.

222. EAST SIDE CLIMATE

222.1 Glacier's east slope does not have elevations as low as those on the west side. The elevation at West Glacier (see map, Fig. 211.1) is 945 m. (3100 ft.); elevation at St. Mary weather station is 1372 m. (4500 ft.). Higher elevation combines with a continental weather pattern akin to that of Alberta to produce a more severe climate on Glacier's east side. The minimum temperature recorded at St. Mary is -47 degrees Celsius (-53 degrees Fahrenheit). Maximum summer temperature recorded is 36 degrees C. (96.8 degrees F.), 1/ slightly lower than that of West Glacier. The east side is almost constantly buffeted by winds, frequently of high velocity, while the western slopes have a comparatively less windy climate.

222.2 The east side receives much less rainfall than the west. Average precipitation from June 1 through August 31 at St. Mary is 1.07 cm. (0.42 in.), compared to an average of 11.61 cm. (4.57 in.) for the same period at West Glacier. Although the east side is generally drier than the west, its annual precipitation pattern is similar, as shown in Figure 221.2. May and June are usually the wettest months and are followed by hot, dry summer weather during July and August. Occasional lightning storms sweep through the valleys. These are not as frequent and ignitions from this cause are not as widespread as on the west side, 2/ but drier conditions and high winds may spread fire over a large area. 3/

1/ Glacier National Park 1973 Jul 23. 3/ Habeck 1970a: 20.

2/ Colony 1974 May 8.

223. AIR PURITY

- 223.1 For many summer visitors, Glacier's weather is a mixture of clean air, brilliant sunshine and capricious storms. But even without fires, the particles which produce the "piney" smell of the forest contribute to an occasional haze over the landscape. 1/ Particles of smoke from fires within the park, controlled burning in neighboring areas and fires as far away as Idaho occasionally spread through the park. A line of haze often obscures the mountains during periods of burning in August and September.
- 223.2 The principal components of wood smoke are carbon dioxide, water and particles of carbon and ash. It is the concentration of particulates in wood smoke which causes the greatest concern. 2/ Concentrations of particulates in Glacier in 280 observations since 1966, have not surpassed 100 mcg/m^3 , and have exceeded 90 mcg/m^3 only twice. 3/ (Particulate concentrations in cities are to be kept at or below 80 mcg/m^3 , according to Environmental Protection Agency standards. 4/)
- 223.3 Concentrations of wood smoke particles even as close as 50 m. (164 feet) from a forest fire do not pose a serious health hazard. 5/ Like other products and effects from forest fires, smoke particles have a place in the earth's natural cycles. Distributed through the atmosphere, they contribute to the formation of ice crystals and raindrops. 6/ However, particulate levels have been recorded in Glacier during which

1/ Beaufait 1971: 9.

2/ Beaufait 1971: 8-9.

3/ U. S. Environmental Protection Agency 1976 Jun 6.

4/ Ward and Lamb 1970: 136.

5/ Komarek 1970: 169; Murphy 1972: 105; Hall 1972: 39.

6/ Komarek 1970: 146.

visibility may be reduced to 6 km. (3.72 mi.) 1/ Despite the fact that this level of smoke concentration does not endanger human health, temporary interference with views in the park affects visitors and residents throughout the area. This effect is a natural variation of air quality, not a change caused by man's activity. It therefore cannot be considered pollution. 2/

"We speak of "clean air" as an achievable reality, once having existed, fowled by man, and to be returned to its original condition. In truth, our knowledge of geology and biology teaches us that clean air, all made up of nitrogen, oxygen, and rare gases, never existed and probably never will until the ultimate transformation of the earth to a cold body devoid of all life." 3/ Smoke from slash fires in the area is regarded as a nuisance, and smoke from natural fires will meet with the same response from those who do not understand the important nature of fire in Glacier's ecosystems.

- 223.4 Emissions of gaseous and particulate pollutants from industries located outside the park have invaded the park's air and biota in recent years. 4/ Flathead County, which includes the west slope of the park, has recorded fluoride, suspended particulates and dustfall above state standards. Low windspeeds and frequent nighttime inversions make the Flathead Valley susceptible to periods of severe air pollution. 5/ The inversions are usually brief and dissolve in the frequent, sometimes daily, weather changes characteristic of mountainous areas. 6/ But it is possible that

1/ Spirtas & Levin 1970: 89; Beaufait 1971: 9.

2/ McClelland 1968: 60.

3/ Hall 1972: 14.

5/ Wake 1972: 36.

4/ Spirtas & Levin 1970: 11.

6/ Beaufait 1971: 10.

particulate concentrations greater than 400 mcg/m³ caused by smoke from forest fires, which is held in the lower valleys, could combine with industrial pollutants to endanger human health and life. 1/

224. FIRE WEATHER CYCLES

The course of weather follows many cycles in addition to seasonal patterns. The smallest changes in which temperature and humidity may be altered even by changes in cloud cover, have little effect; the dramatic diurnal cycle governs many aspects of our lives, but we often are unaware of its more subtle effects. Floods and droughts combine rare occurrence with extreme power to alter the land. Although their causes are largely unknown, they may also belong to complicated, centuries-long cycles.

224.1 FIRE SEASON

224.11 Conditions most favorable for forest fire ignition and spread are seasonal in Glacier. While temperatures rise during July and August, a period of little precipitation occurs. 2/ Relative humidity is quite low, often 20% or less during daylight hours. (Fig. 224.11). This causes vegetation to dry out, the smaller dead particles most rapidly. 3/ Live annual vegetation begins to "cure out" during late July or August, adding dead fuels to the forest's store.

224.12 The fire season in Glacier has been defined as a 100-day period beginning June 13 and ending September 20. This season is bordered by an occasional fire at earlier or later dates. 4/ During the fire season, weather is recorded and the condition of vegetation is studied, in order to estimate the current fire hazard using the National Fire Danger Rating System. 5/ An indicator of the amount of effort, which would be needed to contain a forest fire, is a Burning Index, which is calculated. Burning Index increases in response to dry weather conditions, as do fire ignitions and large-fire frequencies which are shown in Fig. 224.12.

1/ Beaufait 1971: 9-10.

2/ Dightman 1967.

3/ Gaylor 1974: 87. 5/ Deeming et al 1972.

4/ Colony 1975 Nov. (pers. com.).

Table 224.11 Days during Fire Season with Relative Humidity
less than or equal to 20 % *

Glacier National Park

		1 Pct. of days RH $\leq$ 20%	Maximum		Minimum		Sample Size	
			2 %	3 Season	4 %	5 Season	6 Days	7 Years
Weather Station	West Glacier	14	53	1973	0	1963	705	9
	Polebridge	28	57	1967	5	1964	793	12
	St. Mary	17	46	1973	2	1972	635	9
	Belly River	8	27	1967	0	1964	796	12

* Taken from weather records 1960 - 1975.

FIGURE 224.12 Number of lightning fire ignitions in ten-day periods, 1910-1968, from O'Brien(1969).

*Solid line shows total number of lightning ignitions, dashed line shows number of fires Class B and larger (0.1 hectares and larger, or 0.25 acres and larger). Fire size classes are listed in Appendix B .

224.2 FIRE DAYS

- 224.21 Within a fire season not every day has an equal potential for fire ignition. Glacier has an average of five days per summer, "fire days", when lightning strikes ignite flammable fuels to begin at least one forest fire. 1/ The storms which accompany major weather changes usually come with the prevailing winds from the west, 2/ where thunderstorm conditions develop two or three times each month during the fire season. 3/ But winds and storms from the west alternate with other weather patterns in Glacier. "Chinooks" flow along the eastern Rocky Mountain ranges with high-velocity winds, raising temperatures and lowering humidities, 4/ and may drop lightning on both sides of the Continental Divide. In addition to variable large-scale weather patterns, local mountain air currents often change wind and other weather conditions rapidly. Shifts in wind direction of 180° have occurred on several fires in Glacier.* Wind patterns near the Continental Divide are extremely variable.
- 224.22 A single lightning storm may generate several fires. Twenty-six fire starts have been recorded in Glacier from one storm.** The frequency of multiple fires from a single storm is shown in Figure 224.22. It is not uncommon for a frontal passage to start fires over the entire northwestern Rocky Mountain area. There were 1,500 fires started in U.S. Forest Service Region One (Montana, northern Idaho and northeastern Washington) during a ten-day period

1/ Deeming et al 1972: 15.

3/ U.S.D.A. 1941: 966.

2/ Colony 1975 (pers. comm.)

4/ Komarek 1967: 28.

* 1969 Sun Fire, 1936 Heavens Peak Fire, 1973 Atlantic Fire (Frauson 1976, pers. comm.)

** 25 fire starts (22 Class A, 2 Class B, 1 Class D) are recorded for August 25, 1945. (See Appendix B for fire size class definitions.)

Figure 224.22

Ignition Frequency Tables
Glacier National Park
West Glacier, Montana

All fires 1910 through 1973

NUMBER OF FIRES RECORDED WITH NO DATE	=	0
NUMBER OF FIRES RECORDED WITH DATE	=	583
FIRE RECORD SEARCHED	1910 - 1973	= 583

NUMBER IGNITIONS	FREQUENCY	PROBABILITY	CUMULATIVE PROBABILITY
1	206	0.6777	0.6777
2	50	0.1645	0.8422
3	21	0.0691	0.9113
4	8	0.0764	0.9377
5	2	0.0122	0.9509
6	8	0.0099	0.9608
7	1	0.0033	0.9642
8	0	0.0000	0.9642
9	2	0.0066	0.9708
10	3	0.0099	0.0907
11	2	0.0066	0.9873
12	1	0.0033	0.9907
13	0	0.0000	0.9907
14	1	0.0033	0.9940
15	1	0.0033	0.9974
16	0	0.0000	0.9974
17	0	0.0000	0.9974
18	0	0.0000	0.9974
19	0	0.0000	0.9974
20	0	0.000	0.9974
21	0	0.0000	0.9974
22	0	0.0000	0.9974
23	0	0.0000	0.9974
24	0	0.0000	0.9974
25	0	0.0000	0.9974
26	1	0.0022	1.0000

in July 1940. 1/ If conditions are ripe for the spread of lightning-caused fires, the likelihood that man-caused fires will occur is also very high. Such a situation can generate a sudden massive drain on fire management resources throughout the area, compounding the complexity of fire monitoring, control and management.

224.3 DIURNAL CYCLE

Lightning fires usually are ignited during major weather changes, but their behavior is governed in part by the familiar diurnal cycle of daytime warming and nighttime cooling. Upslope and up-valley winds caused by the sun's warming of the land surface during the daytime are replaced by nighttime down-slope, down-valley winds, which usually bring cool, dense air to the valley bottoms and cause temperature inversions. 2/ It is suspected that these nighttime inversions create three elevation zones characterized by different humidity patterns in some of Glacier's drainages. Valley bottoms become cool and may reach nearly 100% humidity each night during the fire season, lowering the likelihood of rapid fire spread. At mid-elevations, the warm air and low humidity characteristic of an upper layer of an inversion may create conditions more favorable to fire spread at night than during mid-day. Down-slope winds frequently occur in the mountains at night. Low humidities at the same time may account for the rapid downhill spread of fires, which sometimes occur at night. Mountain ridges and peaks form the highest humidity zone, with temperature, humidity and corresponding fire danger at levels between the extremes of the bottom and middle elevation zones. 3/

1/ Brown and Davis 1973: 141.

2/ Mason 1975 (pers. comm.).

225. WEATHER EXTREMES: DROUGHT

- 225.1 Climatic extremes are at least as important as summer weather patterns to fire occurrence and behavior. According to Brown and Davis, dry summers in the Nation's forests occur approximately three summers out of every ten. 1/ A wildfire and ungulate study by Francis J. Singer in the drainage of the North Fork of the Flathead River showed an average of about five years between fire years and a sixteen-year interval between important fire years.*
- 225.2 Large fires were not unknown prior to European travel and settlement in this area; the report of H. B. Ayres to the U. S. Geological Survey in 1900 describes several large areas burned during the 1800s. 2/ Severe droughts are well remembered in fire records. In 1910, fires burned 12,000 square kilometers (3 million acres) in Idaho 3/ and 400 square kilometers (100,000 acres) in brand-new Glacier National Park. 4/ The same year was marked by severe burns in Minnesota as well, evidence of a drought which affected a large part of the continent. 5/ Vegetation which is observed on the west side by visitors on the Going-to-the-Sun Road has been largely determined by four fire years: 1926, 1929, 1936 and 1967. The dry season of 1967 caused two lightning-caused fires to burn 4800 hectares (12,000 acres) in Glacier.

*A fire year occurs when at least one fire is recorded in the study area; during an important fire year, at least one-tenth of the study area (71 sq. km., or 18,000 acres) burned (Singer 1975b: 13).

1/ Brown & Davis 1973: 115.

2/ Habeck 1970a: 18-22.

3/ Brown & Davis 1973: 24.

4/ Bowers (no date, rec'd. 1975): 117.

5/ Heinzelman 1973: 351.

225.3 Drought weather conditions and large fires are important natural events and may belong to a very long cycle which we do not now understand. 1/ Certainly they are vital contributors to the dynamics and natural beauty of Glacier's vegetative patterns. But they may also threaten human inhabitants and their property. Minimizing the dangers posed by drought conditions to visitors and residents is one of the tasks of a fire management plan. 2/

1/ Brown & Davis 1973: 115.

2/ Everhart 1975 Mar 13.

230. INTRODUCTION TO GLACIER'S LIVING ENVIRONMENT

230.1 Complexity is the dominant features of Glacier's living environment.

More than 1,000 species of vascular plants have been recorded in the park, including eighteen tree species. 1/ Lakes and streams are used by sixteen native species of fish. 2/ Fifty-nine species of mammals inhabit the land, 3/ including the endangered Northern Rocky Mountain timber wolf and the threatened grizzly bear. 4/ More than 200 species of birds live in Glacier or pass through the park on their migrations. 5/ Less obvious but equally important to this natural system are diverse populations of insects and micro-organisms.

230.2 The experience of Glacier's natural environment is so valued that 3754 square kilometers (927,550 acres, or 92% of the park's total area) have been proposed for protection by the National Park Service 6/ under the Wilderness Act of 1964. 7/ Because Glacier harbors an ecological system largely unaffected by human influence, the park has been designated as an International Biosphere Reserve for ecological study by the United Nations. 8/ These designations recognize the value of a natural system for its unique species and associations and also for the internal forces, largely unknown to us, which determine its natural condition. Both of these qualities will become more valuable as man exercises more and more influence over his environment, altering the effects of natural forces.

1/ Kessell 1974a.

2/ Glacier Natural History Association (no date).

3/ Shea 1971b.

4/ Public Law 93-205, Section 4.

5/ Shea 1971a.

6/ H. R. 5823 Apr 9, 1975 and S. 1079.

7/ Public Law 8-577.

8/ Purkerson 1975.

231. LIGHTNING FIRE OCCURRENCE

- 231.1 Of the total 852 fires that were reported in Glacier from 1910 through 1968, 525 (62%) were lightning-caused and 327 (38%) were man-caused. 1/ Man-caused ignitions are most prevalent near areas of greatest use. The distribution is quite different for lightning-caused fires, which are concentrated by topography and weather patterns near Lake McDonald and the Apgar Mountains. 2/ According to a 1969 summary of lightning fire reports, the area west of the Continental Divide (63% of the total park area) had 90% of the lightning fire ignitions between 1910 and 1969. The Lake McDonald Subdistrict (21% of the park's area) has accounted for approximately 50% of all the lightning fires reported in the park. 3/
- 231.2 Fire size in Glacier seems to be independent of cause, general location and aspect, 4/ but is determined mainly by climatic conditions and the presence of forest fuels. West-side fires usually occur between the lowest elevation (945 m., 3100 ft.) and 2438 m. (8000 ft.), with all Class F and G fires (greater than 400 hectares, 1000 acres) occurring below 177 m. elevation (5800 ft.). East-slope fires, like east-slope forests, have a more limited elevation range; 97% occur between 1250 m. (4100 ft., the lowest elevation) and 1920 m. (6300 ft.).5/

1/ O'Brien 1969: 1.

2/ Colony 1974 May 8.

3/ O'Brien 1969: 4.

4/ O'Brien 1969: 5, 8, 10.

5/ O'Brien 1969: 6.

232. FOREST FUELS

- 232.1 The process of photosynthesis converts the sun's energy into vegetation. As the forest ages, minerals essential to plant growth become bound up in standing vegetation and dead matter, and unavailable to new growth. 1/ The decomposition of dead vegetation can release the nutrients and minerals to the soil, but in Montana's climate, one of cold nights and brief summers, and on the acidic soil typical of conifer forests, organic decomposition cannot match vegetation's productivity until a stand becomes perhaps 500 - 1000 years old. 2/ Under the natural fire regime, forest fires rapidly and dramatically break down these tied-up nutrients on a periodic basis, returning much of this material to the soil in the form of ash. 3/
- 232.2 In order to estimate potential fire spread and effects in an area, forest fuels are measured. They are categorized into different size classes according to their susceptibility to drying. The categories most susceptible to drying and where most ground fires spread are "litter", the loose debris which forms the top layer of the forest floor, and the standing dead herbs and twigs. According to fuel measurements conducted in Glacier during 1974 and 1975, litter accumulates and declines in a distinct pattern as a site "ages" from open meadow-shrubfield to closed forest after fire. Figure 232.21 shows litter accumulation after fire, calibrated from 0 to 8 metric tons per hectare (mT/ha - - 0 to 0.16 lb/sq ft). Dead leaves, twigs, and pine needles accumulate rapidly during the first 20 - 40 years

1/ Behan 1970: 12, 15.

2/ Beaufait 1971: 8.

3/ Lyon & Pengelly 1970

Figure 232.2| Fuel Loadings of Litter according to Stand Age *

* from preliminary fuel report by Collin Bevins (1975 Jun 1), Gradient Modeling Inc.

Figure 232.22 Forest Fire Spread Potential

Fire spread rates are predicted for forest stands of four ages, 25 years (shrubs and early forest succession) to 200 years (mature forest). Three sets of weather conditions are used, all taken from weather records kept at Polebridge Ranger Station. Days are ranked according to conditions which affect fire spread (Burning Index 1/). The first weather set uses the five days on record with the highest burning index; second weather set uses the day with 10th-highest burning index. Third set uses 20th-highest burning index. Fuel and wind conditions used are specified in Appendix E. Slope of 10 degrees is used.

		Maximum Ground fire spread rates in meters/minute in fuels typical of four stand ages 2/			
		1 25 years	2 50 years	3 100 yrs.	4 200 yrs.
Rank of Burning Index	1st to 5th highest	21.83	4.31	5.71	13.67
	10th highest	12.31	2.38	3.15	7.46
	20th highest	1.46	1.11	1.26	1.22

1/ Deeming et al. 1972.

2/ Fuel measurement and loadings completed by Gradient Modeling Inc., 1975-1976 (Kessell 1976). Fuel from preliminary report by Bevins, 1976 Jun 1. Fire spread predictions according to three-strata model by Bevins 1976, which uses equations from Rothermel (1972).

following fire, the time when herbs and shrubs are flourishing on the site. More than 6 mT/ha (0.12 lb/sq ft) may be measured within 20 years after fire. As herb and shrub cover is replaced by young forest, litter declines slightly. But while this young forest matures, 60 - 100 years after fire, litter increases again to loadings around 7 mT/ha (0.14 lb/sq ft). The rapid buildup of fine fuels during this period coincides with fire's suspected natural periodicity in some of the park's forests, 60 - 100 years. 1/ Litter declines to a constant level after a stand is about 100 years old, indicating that in mature stands fine fuels decompose about as fast as they accumulate. Table 232.22 shows predicted rates of ground-fire spread through fuels in forest stands of various ages. Results are expressed in meters per minute. Weather conditions used for this simulation are the conditions most conducive to fire spread from weather conditions at Polebridge. After an initial period of high fire hazard, predicted ground-fire spread increases with stand age.

- 232.3 Intermediate-sized fuels (dead and down material from 0.6 cm. to 7.6 cm., 0.25 to 3. in., in diameter) accumulate rapidly during the first stages of plant succession after fire, then level off. They usually build up slowly as the stand approaches maturity, but little drastic variation is seen.
- 232.4 It is the accumulation of large fuels, greater than 7.6 cm (3 in.) in diameter, which shows the greatest variation through time. Figure 232.4 shows these fuels calibrated from 0 to 80 mT/ha (1.64 lb/sq ft).

1/ Periodicity of 51 years has been observed in lodgepole - subalpine fir stands by Singer (1975b:viii). He suggests a natural fire rotation of 123 years for his entire study area (1975b:13).

Figure 232.4

Fuel Loadings of Large Fuels according to Stand Age.
Included are Dead and Down Woody Material greater than 7.6 cm
(3 in) in Diameter *

* from preliminary fuel report by Collin Bevins (1975 Jun 1).

Trees killed by fire account for the very heavy loadings during the first 20 - 40 years after fire, but this burned matter deteriorates and the large fuels fall off rapidly as young forest grows in. After about 50 years, large fuels again begin to accumulate. The increase accelerates around 90 years after fire, and shows no sign of levelling off as stands become mature.

- 232.5 Although large fuels do not contribute significantly to fire spread, they are largely responsible for the time that a fire smolders on a site and therefore its total heat output. Table 232.5 shows the predicted intensity of ground fire in forest stands of various ages. In the heavy fuels characteristic of a recently burned stand, an intense fire may be expected. While new forest grows in, these initial large fuels decline and expected heat output from a fire is less. But large fuels accumulate as the forest ages, increasing the potential heat output from a fire (Columns 3-4). The dry weather conditions under which large fuels can burn are rare, but when such fires occur the resulting intense heat can alter soil wettability on the site and change the pattern of plant succession which follows. Under conditions of periodic lightning fire, large fuels rarely accumulate to extreme levels, except where they are clumped together in pockets of unstable soil, windfall or avalanche. But fire suppression is increasing the distribution of older stands and likewise the accumulation of large fuels. Heavy loadings of these fuels occur more and more frequently, and the land is thereby subject to a wider distribution of intense fires than has ever been known under the natural regime.

Table 232.5 Heat output from Fire

Maximum heat output from a ground fire is shown in Kilocalories per square meter per second, for forest stands of four ages, 25 years to 200 years. Fuel and weather conditions used in this simulation are the same as those for Table 232.22, and may be found in Appendix E. Fire spread predictions are according to three-strata model by Bevins 1976, which uses equations from Rothermel (1972).

		Maximum Ground fire heat output (in kilocalories/m ² /sec.) in fuels typical of four stand ages			
		1 25 years	2 50 years	3 100 years	4 200 years
Rank of Burning Index	1st to 5th highest	162.2	28.0	39.1	131.6
	10th highest	148.5	25.5	35.6	119.3
	20th highest	19.0	18.2	19.0	21.4

232.6 The fuel buildup problem has long been recognized in logging and slash disposal operations, and has also been recorded for several wildland areas, including Grand Teton, Yellowstone, Yosemite, Sequoia and Kings Canyon National Parks, the Selway-Bitterroot Wilderness and the Teton Wilderness. 1/ Fire suppression efforts have interfered with fire's recycling effects in Glacier and have altered vegetative cover and fuels from their natural distributions.

1/ Grand Teton National Park 1974 Nov 7: 1; Yellowstone National Park 1975: 2; Murphy 1967; Aldrich & Mutch 1972: 30; Reese et al 1975: 9-10.

Chapter 2. DESCRIPTION OF THE ENVIRONMENT

Section 4. DESCRIPTION OF VEGETATION

241. History of Vegetation

242. High Elevation Vegetation

243. East Side Forests

244. Low Elevations, West Side

244.1 McDonald Drainage - Very Moist Sites

244.2 Middle Fork Areas - Moderate Moisture

244.3 North Fork Area - Moderate to Dry Conditions

245. Vegetation and the Fire Environment

241. HISTORY OF VEGETATION

241.1 Glacier's present vegetation mosaic has developed since the last ice retreat, during the past 10,000 years. As a result, soil development (primary succession) is still the single most important determinant of plant communities at the higher elevations. 1/ At low elevations, however, forest cover has been present for thousands of years. As the ice receded from these lower slopes, lodgepole pine invaded, accompanied by lesser quantities of other pine species, spruce, fir, and Douglas-fir. About 5,000 years ago, the climate apparently became warmer and drier, leading to an increase in ponderosa pine and Douglas-fir. Pollen records from two west-side lakes show, in the last 2,000 - 3,000 years, increased quantities of fir, spruce, western redcedar and western hemlock. 2/ Forest fires have probably always had some role in shaping these forests.

241.2 Early descriptions of Glacier's landscape emphasize the complex patchwork of vegetation on mountain slopes, composed of many stages of forest growth after fire. 3/ The vegetation map of Glacier, which was completed in the 1930s, records in great detail the forest mosaic which existed then. 4/ A map drawn today, which used the same scheme, would have many differences due to recent fires and the progression of each stand's recovery after fire, but the impression of overwhelming variation would be the same. Glacier's vegetative cover is a dynamic network affected by many environmental forces, including fire.

1/ Kessell 1976: 71.

2/ Hansen 1948.

3/ Ayres 1900.

4/ National Park Service 1936.

The diversity of communities maintained by these forces generates stability of the entire network. 1/

1/ Vogl 1970: 71-72.

242. HIGH ELEVATION VEGETATION

- 242.1 Although about two-thirds of Glacier's land area is forested, it is the extravagant display of the high country, row after row of high peaks exhibiting bare rock, alpine tundra and snowfields, which catches the eye. Glacier's alpine landscape varies from rock outcrops, which support very sparse vegetation, lichens and small herbs, to talus meadows, shrubfields, and dense Krummholz forests. Within the high-elevation plant communities, isolated stands of subalpine larch may be found. This species is generally restricted to alpine communities in the North Cascades and Inland Empire region. 1/
- 242.2 The Heavens Peak Fire of 1936 spread through Swiftcurrent Pass (elevation 2190 m., 7185 ft) during a period of drought and high wind. Fires do occur in the high country, but they are infrequent - perhaps at a natural frequency of 300 - 600 years. 2/ Because climate and soil conditions make vegetative change very slow in alpine areas, meadows and shrub patches created by fire persist longer there than on lower forest sites. 3/
- 242.3 Conditions of lower elevation and greater sheltering may be found near many small lakes within the park's deep, glaciated cirques. Here, the Krummholz patches typical of alpine areas become larger and may give way to almost continuous Krummholz forest with scattered patches of meadow and rock outcrop. As conditions become

1/ Arno 1970.

2/ Kessell 1976: 71.

3/ Martinka 1972 1: 11.

less severe, species composition of the forest does not change, but the forest's appearance becomes quite different. Upright stands of subalpine fir, spruce and whitebark pine are found where sufficient shelter and moisture are available. Forested stands are threaded by wide talus slides, which cut from rock ridge tops down to lake edges and creek bottoms.

243. EAST SIDE FORESTS

- 243.1 Whitebark pine and subalpine fir comprise the east side subalpine forest; at lower elevations, Douglas-fir, spruce and subalpine fir are characteristic of mature forest, but much of the area is covered by successional lodgepole pine. Forests on the east side alternate with prairies, moist meadows, shrub communities, aspen groves, rock outcrops and limber pine savannah.
- 243.2 Lightning ignitions are much less frequent on the east side of Glacier than on the west, but they have burned large areas because of strong winds and dry fuel conditions. Ayres' description in 1910 of the east side conifer forests, aspen groves and grasslands reveal that man-caused fire played an important role in the landscape that now prevails. Camper and hunter fires burned large areas in the late 1800s, but fires, both natural and man-caused, probably also invaded from the grasslands outside the park and burned into aspen and conifer forests on the lower slopes of the east side. 1/
- 243.3 Vegetation grows more slowly on the east side than on the west, due to the severe climate and high elevation, but decomposition is slow too. The time scale for fuel buildup may be longer than for west-side forests, but accumulations of continuous fuels pose the same problem of potential fire spread.
- 243.4 Although aspen in some forests seems dependent upon fire for vigor and regeneration, 2/ this may not be true for aspen in areas adjacent to Glacier's eastern boundary. 3/ Fire's role in maintaining grasslands on the east side is largely unknown, but is currently being investigated. 4/

1/ Habeck 1970a: 4.

3/ Lynch 1955: 340.

2/ Loope & Gruell 1973: 440. 4/ Dwyer 1975 Jun (pers. com.)

244. WEST SIDE FORESTS

The low areas on Glacier's west side appear at first to be homogeneous forest broken by occasional grasslands, but this forest actually changes with variations in soil, climate, topography and the disturbances of flood and fire.

244.1 MCDONALD DRAINAGE - VERY MOIST SITES

- 244.11 An extension of the Pacific Coastal climate into northwestern Montana 1/ makes Glacier the eastern limit of the range for several tree species, including western red cedar, western hemlock, grand fir, western white pine and Pacific yew, and numerous herb and shrub species. These species are common only in the McDonald Valley, but occasionally occur in the Camas drainage near Rogers Lake. 2/
- 244.12 Near the outlet of Avalanche Creek in a very moist and sheltered valley, grows a cedar and hemlock community with trees over 500 years old. 3/ Individual trees in this bottomland community show evidence of fire, but a crown fire has probably not occurred here in the last 500 years. In similar cedar groves, in the Selway-Bitterroot Wilderness, Habeck found that isolated trees occasionally become ignited, but that the resulting fires showed little propensity to spread elsewhere. 4/ Just upstream from the creek outlet, at a slightly higher elevation in the same drainage, the forest burned approximately 175 years ago, 5/ and due to moisture and soil conditions, has succeeded to dense, almost pure hemlock with occasional cedar, larch and western white pine.

1/ Habeck 1970b: 24.

2/ Kessell 1976: 69.

3/ Habeck 1970a: 53.

4/ Habeck 1973: 106.

5/ Kessell 1975 Nov(pers. com.)

244.13 Although fires are not foreign to this moist environment, they do not occur as frequently here as they do in other west-side communities. Forest development uninterrupted for hundreds of years has produced a community-type rare in the park. Plant productivity is very high, and consequently large fuels accumulate. As much as 100 metric tons per hectare (2.5 pounds/sq ft) may be found in localized pockets of these stands. 1/ Conditions favorable to fire spread are very rare on these sites, but such heavy fuels would make a fire here very intense.

244.2 MIDDLE FORK AREAS - MODERATE MOISTURE

244.21 Most of the west-side forests, from the McDonald drainage south along the Middle Fork Flathead River, are drier than the Avalanche Creek area. The forest which covers this portion of Glacier varies with elevation, sheltering and moisture conditions and, of course, time since the last fire. Mature stands on open slopes are composed mainly of subalpine fir and Douglas-fir. Spruce occurs in draws and ravines. Most forest stands have varying concentrations of larch and western white pine, remnants from the last fire; younger stands have lodgepole pine as well. In most areas which have burned in the last 75 years, lodgepole is the most abundant species, though an understory of Douglas-fir, spruce or cedar may grow beneath.

244.22 Fires occur every 25 - 100 years on dry sites, but perhaps only every 250 years in most communities. 2/ Almost all of the Apgar Mountains, where lightning fires are most frequent, and 31% of Glacier's west side south of Camas Creek, 3/ have burned at least once since 1910,

1/ Kessell 1974b: 24-26.

2/ Kessell 1976: 71.

3/ Martinka 1974b: 4.

despite a policy of total and immediate fire suppression. Most of the low-elevation area between Lake McDonald and the Middle Fork of the Flathead River burned in an intense fire in 1929; its vegetation is now predominantly lodgepole pine with an understory of Douglas-fir and spruce or cedar. On higher slopes, the 1929 fire gave way to patchy burns. Mature forest remains near the mountaintops, at elevations around 1828 m. (6000 ft.).

- 244.23 Accumulation of the small fuels, which contribute most to fire spread, is probably greater for open, dry slopes on the west side than for any other areas in the park. 1/ Fire-maintained communities here are the rule rather than the exception. Some areas of the Apgar Mountains and Middle Fork have burned more than once during this century. In these lodgepole pine communities, where lightning storms are frequent, one fire may "breed" the next. Large amounts of dead fuel are produced when an intense fire sweeps rapidly through a young forest, killing most of the trees but not consuming them. Resulting fuel loadings make these stands immediately susceptible to another fire.2/ If the fire recurs before the seedling population is old enough to bear cones, seedlings may be consumed and little viable seed source will remain. 3/ Invasion by wind-carried seeds, such as larch, is possible; but on a large reburn, forest recovery may be slow. On occasional sites where the fire was very intense, shrub succession may be retarded because of soil alteration and erosion. 4/ Frequent fire may be one factor which has contributed to the slow forest recovery on the south slopes of the Belton Hills, which last burned in 1929. 5/

1/ Kessell 1974b: 24-26.

5/ Habeck 1970a: 40.

2/ Wellner 1970: 54; Aldrich and Mutch 1972: 23.

3/ Heinselman 1973: 347.

4/ Agee 1974: 29.

244.3 NORTH FORK AREA - MODERATE TO DRY CONDITIONS

244.31 Due to the reduced moisture extending over the crest of the Whitefish Range and to the porous soils and frequent flooding of the ancient North Fork of the Flathead River plain, the area of Glacier north of the Camas drainage supports vegetation in some ways quite different from that of the other west-side drainages. 1/ Large grasslands alternate with the bottomland forests. Portions of the grasslands contain islands of big sagebrush. Lodgepole pine and aspen groves surround the grasslands, some of the lodgepole forming open savannahs. Ponderosa pine dominates park-like savannahs and occurs in other forest situations, mixed with Douglas-fir and lodgepole pine. Forested bottomlands are covered by extensive spruce and cottonwood development. Aspen grovelands are found adjacent to meadows, prairie intrusions and some of the ponderosa pine savannahs.

244.32 Many portions of the North Fork area have been subjected to repeated fires. Singer's study of wildfire and ungulates indicates that under a natural regime, fire visited the Douglas-fir stands near Polebridge an average of every 36 years and slightly more often in savannah situations (29 years). 2/ Grasslands and lodgepole pine savannahs probably were burned by ground fires at 10 - 15 years intervals. In contrast the spruce stands in the moist draws are 250-370 years old and usually function as firebreaks rather than as fuels. 3/

1/ Habeck 1970a: 9.

2/ Singer 1975b: 15.

3/ Singer 1975b: 15.

- 244.33 Because fire has been a frequent influence on some of the North Fork communities, the effects of its virtual absence after 65 years are noticeable. This big sagebrush distribution seems to be increasing in the absence of fire. 1/ Although the boundaries of the North Fork grasslands seem almost stable at present, a very slow invasion by conifers may be occurring under the total suppression policy. 2/ Fire stimulates the successful reproduction of aspen stands in the North Fork, and these are declining where fire has been eliminated. 3/
- 244.34 The ponderosa pine communities in Glacier's North Fork are unique. They mark the northeast edge of the range of this species in the region. In Glacier, ponderosa are subject to a fire regime, which may be less regular than in most of their range. 4/ Fires occur every few years on some sites, every 60 years on others.
- Mature ponderosa pine have thick, fire-resistant bark and high crowns which ground fires usually do not reach. Ground fire enhances ponderosa reproduction in slightly sheltered openings. When fire is excluded from these stands, a dense understory of other species (Douglas-fir and spruce) grows tall and soon reaches the ponderosa crowns. After an extended period of fire suppression, a ground fire may reach the ponderosa crowns by way of these younger trees and burn the entire stand. The resulting open, exposed conditions are not conducive to ponderosa reproduction, and the stand may be permanently changed to

1/ Singer 1975b: 18.

2/ Koterba & Habeck 1971: 1634-1635.

3/ Singer 1975b: 17.

4/ Lunan 1972: 2.

Figure 244.34 Fire Management in the Ponderosa Pine Savannas. Sketches by Carl Whittaker, July 1974.

Fire serves to clear out the ground cover in this mature ponderosa pine stand, and doesn't reach the tree crowns. Bark of the big tree is fire resistant, and the grasses and forbs will return to the site soon, as illustrated below.

When periodic fires have been eliminated, the understory trees grow until a "bridge" of fuel reaches to the crowns of the ponderosas. The whole stand of ponderosa may be wiped out by a fire.

Some years later, with the ponderosa seed source removed, lodgepole pine forms the new forest. This cover is less favorable for certain species of wildlife.

spruce and Douglas-fir. 1/ There has been a minimum of young ponderosa produced in the last 180 years, 2/ and some of Glacier's ponderosa stands now have fuel "bridges" which constitute a hazard to their perpetuation. 3/ Drawings by Carl Whittaker in 1974 illustrate the potential results of fire in the ponderosa after fuel distribution has been altered by long-term fire suppression (Figure 244.34).

1/ Kessell 1975 Jan 2: 3.

2/ Lunan 1972: 55.

3/ Lunan 1972: 53-55.

245. VEGETATION AND THE FIRE ENVIRONMENT

- 245.1 Species which have coexisted with fire for millennia are able not only to survive forest fires, but also to use fire in many aspects of growth and reproduction. Mature western larch, ponderosa pine and Douglas-fir have very thick bark, which enables them to survive fires,^{1/} and provide a seed source to repopulate the burned area. ^{2/} Larch's light seeds are blown into burns, ^{3/} as are those of many herb species.^{4/} Fire may scorch and kill the needles on the deciduous larch, but their branches are able to resprout the next year. ^{5/}
- 245.2 Although much of the living vegetation above the ground may be killed by a fire, roots just below the surface are usually damaged very little. It is these plants which cover a burned area almost immediately after fire. Mountain maple and the berry-producing shrubs show rapid growth and great productivity in the first few years. ^{6/} The year after intense fires on Huckleberry Mountain and the Glacier Wall, prolific resprouting of mountain maple, serviceberry and Ceanothus species, with stem leaders as long as 76 cm. (30 in.), was observed. ^{7/} In addition to this rapid growth, some shrub and hardwood species respond to fire by producing stem leaders higher in nutrients for wildlife than those produced in older stands. ^{8/} Fire stimulates reproduction by suckering from roots of aspen trees. Singer has documented this process in Glacier's North Fork. ^{9/}

^{1/} Brown & Davis 1973: 52.
^{2/} Brown & Davis 1973: 34.
^{3/} Brown & Davis 1973: 36.
^{4/} Ahlgren & Ahlgren 1960: 508-509.

^{5/} Vogl 1970: 72.
^{6/} Brown & Davis 1973: 38; Isdahl & Kapler 1973 Apr 12: 9; Wright & Heinselman 1973: 324.
^{7/} Martinka 1969b: 4.
^{8/} Leege & Hickey 1971.
^{9/} Singer 1975b: 17.

245.3 Until a burned forest area is about 10 years "old," then, shrubs are the predominant cover. But tree seedlings are growing at the same time. Lodgepole pine cones are opened by the heat of fire. Nine years after fire near Camas Creek, 18,000 lodgepole seedlings are present per hectare (7,284/acre). 1/ Because fires remove the deep litter of the forest floor and expose mineral soil, trees with shallow tap-roots -- Douglas-fir 2/, paper birch 3/, ponderosa pine and lodgepole pine 4/ - - are able to grow. When fire kills the overstory as well as consuming ground litter, light is available which is required for the rapid growth of many species: western larch, lodgepole, Douglas-fir, 5/, paper birch 6/, and white pine 7/. The trees grow above the shrubs and, in 20 or 30 years, provide forest cover. This young forest shades seedlings of other species, perhaps western redcedar, spruce or subalpine fir, which will comprise the forest 200 or 300 years after the fire. The predominance today of lodgepole pine and western larch throughout the park testifies to the fact that fires are an extremely important determinant of Glacier's vegetation, especially on low elevation and dry sites. Kessell has estimated that 95% of Glacier's forests below 1524 meters elevation (5,000 feet) have burned in the past 400 years. 8/

1/ Bevins 1976 June 15 (prelim. data).

2/ Brown & Davis 1973: 34.

3/ Ahlgren & Ahlgren 1960: 515.

4/ Brown & Davis 1973: 33.

5/ Brown & Davis 1973: 34.

6/ Ahlgren & Ahlgren 1960: 515.

7/ Ahlgren & Ahlgren 1960: 514.

8/ Kessell 1976: 71.

- 245.4 Regrowth often varies from the pattern described above. Some sites on the lower slopes of the Appar Mountains, for instance, produced immediately after the 1929 fire a young forest of cedar, without the usual initial cover of lodgepole pine. The sheltered slopes along Avalanche Creek have re-stocked in the 150 years following fire with a dense, almost pure hemlock forest. Vegetation on the site of the 1967 Glacier Wall Fire (Figure 242.4) shows re-stocking of approximately 26,000 trees per hectare (10,522/acre), about 30% of which are "ever-green" species: Douglas-fir, spruce, western larch, western white pine and western redcedar. Lodgepole pine, the species which usually pioneers in burned areas, does not occur. 1/
- 245.5 Because ground fires under the forest canopy have been more easily controlled than crown fires, detailed information is not available in the park on vegetative succession after ground fires. Herbs in savannahs and grasslands are generally stimulated by fire, and the entire site returns to a vegetational composition similar to pre-fire cover within 20 - 40 years after burning. 2/
- 245.6 Living trees which have been scarred by fire or struck by lightning, and even those near a lightning-struck tree, are more susceptible than their neighbors to attacks by insects and diseases. 3/ Canopy fires tend to create lodgepole stands in which most trees are the same age. Although isolated lodgepole pines often survive to become 150 years old or older, most of the trees in these dense, homogeneous stands decline in vigor as little as 80 years after they originated in fire. 4/

1/ Bevins prelim. data 1976 June 9.

2/ Kessell 1976.

3/ Ahlgren & Ahlgren 1960: 503; Taylor, A. 1973: 465-466.

4/ McCambridge & Trostle 1972: 1; Kessell 1975 Feb 8: 28,34.

During the time of settlement in Glacier's North Fork, 1900 to 1930, Singer estimates that the portion of his study area burned per unit time was more than double that during the 300 years prior to settlement. 1/ Ayres describes several large fires on Glacier's east side, which were caused by hunters and other visitors during the late 1800s. 2/

The Act of May 11, 1910, established Glacier as a National Park, in order to provide for the benefit and enjoyment of the people, and also to preserve unimpaired for future generations the natural qualities for which it was established. 3/

Glacier National Park, once an integral part of a wilderness a continent wide, was defined as an independent land unit with purposes separate and different from those of surrounding areas. Glacier is delineated by a 300-kilometer (186 mile) boundary which consists in part of natural discontinuities -- rivers, and streams, but also of mapped lines which are marked on the land only by fences and survey markers.

1/ Singer 1975b: 13-14.

2/ Habeck 1970a: 19-20.

3/ Glacier National Park 1973 Jul 23.

Table 245.4 Re-stocking of trees on
1967 Glacier Wall Fire, from
preliminary report, Collin D. Bevins, 9 June 1976.

		1 Stems/ Hectare	2 Percent of Total	3 Average Height (cm.)
Species	Willow species <u>Salix</u> species	8,360	32.0	86.0
	W. paper birch <u>Betula papyrifera</u>	7,480	28.6	88.0
	Mountain maple <u>Acer glabrum</u>	3,360	12.9	88.0
	Douglas-fir <u>Pseudotsuga</u> <u>menziesii</u>	2,760	10.6	39.0
	Spruce species <u>Picea</u> species	2,360	9.0	32.0
	Western larch <u>Larix occidentalis</u>	1,360	5.2	77.0
	Western white pine <u>Pinus monticola</u>	280	1.1	40.0
	Quaking aspen <u>Populus tremuloides</u>	80	0.3	70.0
	Western red cedar <u>Thuja plicata</u>	80	0.3	40.0
	Total stems/hectare	26,120	100.0	

As a result of this decline, these stands sometimes become susceptible to windthrow and mountain pine beetle attack. The creation of an even-aged stand by fire, followed by accumulation of dead fuels due to wind or insect damage on a few sites, followed by another fire there, suggest a self-perpetuating process. 1/ Indeed, these events, as well as the longer "fire rotation" found under other conditions in the park, all contribute to perpetuating the natural diversity of vegetation.

1/ Wright & Heinzelman 1973: 324.

Chapter 2. DESCRIPTION OF THE ENVIRONMENT

Section 5. DESCRIPTION OF FAUNA

- 250. INTRODUCTION TO WILDLIFE
- 251. PRIMARY CONSUMERS AND OMNIVORES
- 252. PREDATOR SPECIES
- 253. OTHER FAUNA
- 254. SUMMARY: WILDLIFE AND FIRE

250. INTRODUCTION TO WILDLIFE

Wildlife abundance and variety depend on the quality and spatial distribution of suitable habitat. Some species of mammals, such as moose and beaver, depend on recently burned areas for their food supply. Predators depending for food upon these consumer species may be expected to be favored by fire incidence. Many consumer species favor some level of succession after fire for food or breeding habitat. A few species do not seem to use burns at all. A diverse environment, a mosaic of topographic types and stand ages following fire, maintains the intricate food web found in Glacier. 1/

251. PRIMARY CONSUMERS AND OMNIVORES

- 251.1 Glacier's largest ungulate, moose, prefer young aspen and willow stands to those on old burn sites. They seem better able to use areas opened by crown fires than other ungulates, despite deep snow levels and exposure to weather and predators. In the North Fork bottomlands, aspen are not regenerating without fire. 2/ Moose seem to have declined in some areas of the North Fork since the 1940s, perhaps in part because of habitat decline. 3/
- 251.2 Beaver require deciduous stands close to lakes and streams for food and shelter. Because these stands are, in some areas, maintained by fire, beaver often frequent recent burns. A study in Minnesota showed that beaver felled all the useable aspen and birch 70 - 100 years after fire and then moved onto a more recent burn. 4/

1/ Singer 1975b: ix.
2/ Singer 1975b: 28,45,17,42.
3/ Singer 1975a: 8.
4/ Heinzelman 1973: 371.

In Glacier's North Fork, where deciduous stands are maintained by both avalanche and fire, the decline of aspen due to removal of fire will affect the beaver population to some extent.

- 251.3 Some ungulates use burned areas for specific food plants during a particular season. During the spring and fall, and during winters of little snow accumulation, elk in the North Fork graze on grassland and in lodgepole pine savannah, habitats favored, although probably not maintained by fire. During the winter, elk feed on shrubs in areas opened by fire but use adjacent forests for shelter from cold and wind, and for protection from predators. 1/

The elk population of an area seems to reach peak numbers within 25 years after a major fire, when partial reforestation of burns by conifers is beginning. 2/ The south slopes of the Belton Hills, which burned in the Halfmoon Fire of 1929, but left some patches of conifers intact, are well known for their wintering elk.

- 251.4 During the winter months, mule deer feed in the shrubfields of early post-fire succession, even in the large, open Flathead burn of 1967. Whitetail deer inhabit forested areas and occasionally use the shrubfields, which follow a large fire. 3/ It is more difficult for whitetails than for elk to travel in the deep snow which accumulates in areas opened by fire; in the North Fork, whitetail deer avoid recent burns during the winter. 4/

- 251.5 Woodland caribou are native to Glacier. There is no evidence that they are present now,^{5/} but reintroduction has been recommended. 6/

1/ Singer 1975b: 21-22; Martinka 1974b: 10. 4/ Singer 1975b: 25.

2/ Martinka 1975b: 9. 5/ Singer 1975a: 8.

3/ Martinka 1974b: 11. 6/ Martinka 1975 Sep 18: 2.

These ungulates are forest inhabitants, feeding mostly on tree lichens in the closed-canopy forest. The North Fork River area, where caribou lived before their disappearance from the park, has historically been a patchwork of forest stands of widely varying ages, from a 1944 burn to spruce stands several hundred years old. This fire-maintained pattern was acceptable to caribou prior to the introduction of fire control. 1/ Before reintroduction of caribou is initiated, however, a thorough study of habitat requirements and the effects of various fire alternatives will be necessary.

- 251.6 Both grizzly and black bears may be found in Glacier. Grizzlies, numbering approximately 200 in the park, 2/ are a threatened species in the United States south of Canada. 3/ They are able to use a variety of food sources, moving into whatever area has the best food supply during that season. Burned areas are frequented in late summer and early fall because of the profuse berry crop usually available there. 4/ Twenty-eight different grizzlies were seen on the 1929 burn near Huckleberry Lookout in the fall of 1973, 5/ more than 10% of the park's estimated grizzly population on less than 1% of the park's land area.
- 251.7 Whereas grizzly bears seem to prefer the open habitat available in alpine areas, avalanche paths or recent burns, 6/ black bears inhabit forested areas. They, too, take advantage of the good berry crops on burns, but they usually remain near the forest edge. 7/ Perpetuation

1/ Singer 1975 Apr 7.

2/ Martinka 1974a: 5.

3/ Public Law 93-205, Section 4. (Endangered Species Act, 1973).

4/ Martinka 1972: 7; Martinka 1972 Mar 1: 11; Wright & Heinselman 1973: 324.

5/ Martinka 1973 Oct 25: Table 5.

6/ Martinka 1972 Mar 1: 12.

7/ Martinka 1974a: 10.

- of early successional shrubfields is important to grizzlies during at least one season each year; black bears use a patchwork landscape where maturing forest alternates with occasional shrubfield and meadow.
- 251.8 Glacier's bird population uses every stratum of the landscape for food and shelter. Juncos may be found nesting in the turf along a trail; twenty meters higher, a mature ponderosa pine or a dead larch burned by many fires may harbor a nest of Yellow-bellied sapsuckers or even an American kestrel.1/ The increased berry yield after fire favors birds as well as bears.2/ An early spring fire could destroy nests,3/ but fires create nest sites for several species.4/ Mountain bluebirds nest in a 1910 burn in Glacier. Pileated woodpeckers nest in a 1929 burn.5/ Ruffed grouse may be best suited to a mosaic where aspen stands are interspersed with older forest.6/
252. PREDATOR SPECIES
- 252.1 Some predator birds feed on insects which invade forest stands. Northern three-toed and Black-backed three-toed woodpeckers exploit the mountain pine beetle outbreaks in recent burns;7/ warblers thrive when spruce budworm epidemics invade an older even-aged spruce or fir stand.8/ Stand age diversity provides nest sites and food sources for a variety of bird species.
- 252.2 Larger predator species also depend on available prey. Rocky Mountain timber wolves, an endangered species in the United States outside of

1/ McClelland and Frissell 1975: 416

2/ Wright & Heinselman 1973: 324.

3/ Ahlgren & Ahlgren 1960.

4/ McClelland & Frissell 1975: 416.

5/ McClelland 1975: 26.

6/ Heinselman 1973: 373.

7/ Heinselman 1973: 373.

8/ Heinselman 1973: 373.

Alaska,1/ travel in Glacier but are rare and careful to avoid human use areas. 2/ The other large predators, including mountain lions and coyotes, are more closely tied to Glacier's prey populations. Predators rely for food in winter on deer, elk and moose, smaller mammals (including beaver)3/, mountain sheep and mountain goats. If woodland caribou are reintroduced, these too will be a prey species.4/ During winters when snow is deep and crusted, predators have an advantage in open areas. The predators which pursue elk, mule deer and moose in open burns are often able to outrun their prey on crusted snow. 5/

A winter with little snow, on the other hand, seems to favor the prey species. Two mountain lions were killed near populated areas in the open winter and dry spring of 1973 and one was found dead; all three were emaciated.

- 252.3 Habitat changes continuously and prey populations fluctuate. Predators may respond by shifting use from a declining prey population to one more plentiful. 6/ But all these species are related in a delicate network. Forces, which alter any one population, predator or prey, will probably affect the others.

253. OTHER FAUNA: Fish, insects, microfauna

- 253.1 Some fires burn almost all of the soils humus cover and can accelerate the natural process of erosion. 7/ Increased runoff into streams and rivers may temporarily disturb the fish population, but long-term alteration of fish habitat due to sedimentation because of fire is rare. 8/

1/ Public Law 93-205, Sec. 4.
(Endangered Species Act, 1973)

2/ Singer 1975a: 10.

3/ Singer 1975a: 10.

4/ Martinka 1975 Sep 18: 2.

5/ Singer 1975b: 29.

6/ Carbyn 1974: 160.

7/ Ahlgren & Ahlgren 1960: 497;
Wright & Heinselman 1973: 322.

8/ Aldrich & Mutch 1972: 53.

Little is known about the effects of smaller, less intense fires. Daytime warming of streams due to cover removal, light sedimentation and runoff of nitrogen compounds released from burned vegetation, all may rejuvenate a stream's vegetation and microfauna.1/ Protection from fire may be causing reduction of streamflow and decline in riparian vegetation in some areas of California.2/

- 253.2 Some insects and parasites invade an area soon after fire;3/ others are able to use fire-created stands only a century or more after their origin. If insects have killed most of the trees in a stand, a fire may tap the nutrient resources tied up in dead wood, stimulate germination of shrubs and new trees and remove the "epidemic" insect population from the local area.4/ Aside from studies on insect outbreaks, little is known about the dynamics of insect populations in the fire environment.
- 253.3 Massive decrease of soil microfauna may occur after a fire, but the effects usually occur only in the top layer of soil, and recovery is rapid.5/ Although a fire may kill some rodents and temporarily remove their habitat,6/ the number of species of small mammals has been observed to reach its maximum when a burn is about 25 years old.7/

1/ Duff 1972 May 31: 6.

2/ Agee 1974: 19-20.

3/ Taylor, A. 1973.

4/ Heinzelman 1970: 32.

5/ Agee 1974: 66.

6/ Ahlgren & Ahlgren 1960: 306.

7/ Agee 1974: 17.

254. The relation of fire to Glacier's fauna has been sketched for only 19 of some 270 bird and mammal species, and for no specific insects, fish species or micro-organisms. Although a great deal is unknown about the subtle relationships which govern this natural system, it is a general principle of wildlife ecology that diversity of stand ages and the edges between stands encourages the greatest diversity and vigor in wildlife populations.^{1/} As these features decrease with the increasing success of fire suppression, fewer mammals and birds can be supported in the plant community.

^{1/} Allen 1954: 72; Dasmann 1964:74.

Chapter 2. DESCRIPTION OF THE ENVIRONMENT

Section 6. HUMAN USE AND ADMINISTRATION

- 260. Introduction
- 261. History of Human Use
- 262. Present Use Within the Park
 - 262.1 Visitation
 - 262.2 Special Uses of the Park
 - 262.3 Human Use and Fire
- 263. Glacier's Neighbors and the Region

The land now called Glacier National Park has changed little in the last several thousand years, but people have visited the land and settled here. Since 1897, when the Lewis and Clark Forest Reserve was formed which included all of the present area of Glacier National Park, agencies of the U. S. Government have been charged with "managing" this resource. 1/ The conflict between preservation and use is a perennial problem in park management 2/ and it increases as understanding of the environment and volume of use continue to grow.

1/ Bowers (no date) Received 1975:75.

2/ Buchholtz 1969.

261. HISTORY OF HUMAN USE

- 261.1 There is no doubt that Indians were the first humans to the region.

No tribe actually inhabited the park, but several are thought to have traveled the trails and passes in the park. French traders and trappers working for the Hudson's Bay Fur Company probably visited the park during the early 1800s, but the hostility of the Blackfeet prevented them from using the area extensively.

- 261.2 Between 1850 and 1900, organized parties began to enter Glacier's mountains and explore them. Railroad surveys, boundary survey parties, the U.S. Army and various others pushed farther and farther into the area, finding new routes across the mountains.

In 1890, copper ore was found at the head of Quartz drainage, and there was a rush of prospectors. When it was found that minerals did not exist in sufficient quantity for profit, mining died out. A few weather-beaten log cabins and prospect holes scattered in the mountains are all that remain. After the miners' excitement had disappeared, the region was visited only by big game hunters and occasional sightseers until it was made a national park in 1910. The Great Northern Railway completed their rail line through Marias Pass in 1891, and in 1911-1912, they built hotels and chalets to accommodate the park visitors.

- 261.3 Although settlement in and near Glacier was sparse, human effects on the land and fire patterns were marked. Fire was the principal force available for clearing land. In pioneer days the smoke from "settler fires" was often regarded as a sign of progress. Continuous areas of heavy fuels created by early logging contributed to large, intense fires during the late 1800s, throughout the Northwest. 1/

1/ Brown & Davis 1973: 16, 20.

262. PRESENT USE WITHIN THE PARK

262.1 Visitation

262.11 Although most of Glacier's natural landscape is little changed from the wilderness of centuries ago, innumerable intrusions now permit extensive use of the area by visitors: 518 kilometers (322 mi.) of roads and 1100 km. (684 mi.) of hiking trails lace the park and make every major drainage accessible. Backcountry visitors may stay overnight in 68 backcountry campgrounds or in Granite Park and Sperry Chalets, which were built in the early 1900s by the Great Northern Railroad to accommodate touring parties in that era. Some 24,000 overnight stays were recorded for Glacier's backcountry campgrounds in 1975, and 3600 stays in the two chalets. Day use of the trails is even higher than overnight use. Many places can be visited by easy walks. The total number of visitors entering on Glacier's roads surpassed 1½ million in 1975.

262.12 Visitor concentrations are most apparent at Many Glacier, along the Going-to-the-Sun Road, at Lake McDonald and at Two Medicine Lakes. The Going-to-the-Sun Road, which traverses the park from Lake McDonald to Logan Pass (elevation 2031 m., 6,664 feet) and follows along St. Mary Lake, is the main attraction for most visitors. It provides a cross-section of the park features for the enjoyment of day-use visitors and a threshold for wilderness use, both for short walks and extended trips. In 1975, peak travel surpassed 400 cars per hour. Developments accommodating visitors within the park are concentrated at Many Glacier, Lake McDonald, Rising Sun and Apgar. Smaller developments are present in other areas of the park, including Goat Haunt, Logan Pass and Two

- 262.22 The Many Glacier and Lake McDonald Hotels, the St. Mary Ranger Station, and Granite Park and Sperry Chalets have been nominated to the National Register of Historic Places, to provide protection and to plan for visitor enjoyment of their cultural and historic values. 1/ These sites have an historic claim to preservation. In addition to these five structures, there are some forty structures owned by the National Park Service which are more than 50 years old and require the same protection from alteration or destruction, at least until their historical significance has been determined. 2/ Another fifty buildings will require this same protection within the decade. Most of these buildings are located near developed areas and roads; they are not particularly difficult to protect from forest fire. The backcountry chalets and patrol cabins, however, are remote and cannot be easily protected with mechanical equipment. These require special attention in a fire management plan.
- 262.23 Some 320 hectares (791 acres) of land within Glacier's boundaries are privately owned. Although much of this property is in areas which are already developed, some is quite remote. These private inholdings are to be protected to the best of fire suppression capabilities. Natural fire zones will not include privately owned land in the park.
- 262.24 The National Park Service staff in Glacier during the summer of 1975 numbered 265 including 196 seasonal employees; this excludes the people employed by commercial visitor services. The task of protecting

1/ Glacier National Park 1973 Mar 23:27.

2/ 80 Stat. 915, 16 U.S.C. 470. (Historic Preservation Act of 1966).

Medicine. Parts of the North Fork drainage have semi-private camp-grounds, picnic areas and boating facilities.

- 262.13 Glacier's visitation declines during the winter months when heavy snow blankets the entire park. During the winter, ski touring and snow shoeing enable visitors to see many areas, even though only 19 km. (12 mi.) of park roads are kept open. Approximately 3000 skiers and snowshoers used the park in winter of 1974-1975, and 132 overnight stays were recorded. Bands of elk and deer seek the lower elevations during the winter 1/ and are often more visible to visitors than during the summer months.

262.2 Special Uses of the Park

- 262.21 The unique character of Glacier National Park as a land in many ways unaltered by human influences has led to the proposal that most of its area be designated wilderness under the protection of the Wilderness Act of 1964, 2/ and to its being named a world biosphere reserve in 1975. 3/ These land designations aim to perpetuate valuable pristine areas for study and enjoyment by present and future generations. The sense of personal perspective and serenity available to visitors in an environment not dominated by man is emphasized in wilderness areas.4/ One of the key objectives in the Biosphere Reserve program is the perpetuation of genetic strains. An undisturbed area is a scientific resource of unknown proportions. Restoration of the occasional but powerful force of fire restores an important dynamic process which influenced this land before man's intrusion.

1/ Martinka 1974b:6; Glacier National Park 1975 Aug 15:4.

2/ Public Law 88-577.

3/ Purkerson 1975: 14.

4/ Aldrich and Mutch 1972: 68.(Wilderness Act)

and managing Glacier's land and visitors has changed a great deal since 1910, when a Superintendent and one Clerk administered Glacier National Park, which was visited by some 4,000 persons. 1/ Facilities for park management operations are located at St. Mary, Many Glacier, Two Medicine, Walton, Goat Haunt, near West Glacier, Apgar, Polebridge, Kintla, Bowman, Cut Bank, Belly River, Lubec, Logging Creek and a five-acre administrative site outside park boundaries at East Glacier. Several other structures are located in Glacier's roadless areas, including power and telephone lines, radio repeaters, snow-survey devices, and fire lookouts.

262.3 Human Use and Fire

- 262.31 All park activity in fire control and management has the saving of human life as the primary objective, and is conducted to prevent unacceptable loss of damage to property. In order to meet these objectives, structural fires have the highest dispatch priority.2/ Like most of the park's historic buildings, the visitor facilities, administrative facilities and privately owned lands are almost all located in developed areas and near roads. They are not difficult to reach quickly in case of fire, and heavy mechanized equipment (pumps and tankers) may be used without further encroaching on the natural landscape. In locations where this is not the case, protection is provided to the best of the park's ability.

1/ Glacier National Park 1911:9; Bowers (no date) Received 1975: 83-85; Robinson 1960:56.

2/ Glacier National Park 1974 Jun 10: 233.100.

262.32 The need for natural fire has been discussed in newspaper articles and meetings with local organizations since 1974. 1/ Slide programs and interpretive talks discussing natural fire, and short hikes with visitors, began in Glacier in 1975. These programs originated with the research staff of Gradient Modeling. They continued in 1976 as part of the regular naturalist program, along with preparation of informative brochures relating to fires and fire management. Travelers on the Going-to-the-Sun Road pass two large areas burned quite recently - on the slopes of the Going-to-the-Sun Mountain (burned in 1969) and the Garden Wall (burned in 1967). A display along the road indicates where fires in 1967 and 1936 originally burned and points out the succession which has followed fire. Along Lake McDonald, the visitor passes through forest now nearly 50 years old, which has grown since fires during the late 1920s.

1/ Hungry Horse News 1974 Nov 29.

263. GLACIER's NEIGHBORS AND THE REGION

263.1 Populations of adjacent counties, essentially rural and encompassing about 28,000 sq. km. (10,810 square miles), total 57,000 people.

Although the immediate area is sparsely settled, there is considerable use of Glacier by the nearby, relatively small population centers of Kalispell, Great Falls, Missoula, and Helena, in Montana, and Coeur d'Alene, Idaho. The nearest metropolitan areas are Spokane in eastern Washington, the complex cities on Puget Sound in western Washington, and Salt Lake City, a considerable distance to the south in Utah. Most of Glacier's visitors are transcontinental travelers or visitors from Canada.

263.2 Lands adjacent to Glacier on the south and west are national forest lands within the Flathead National Forest. A small portion of the Lewis and Clark National Forest adjoins the park east of the Continental Divide. Abutting the park on the east is the 3600 sq. km. (889,200 acre) Blackfeet Indian Reservation.

Along the International boundary, Glacier forms the United States section of the Waterton-Glacier International Peace Park, which was established in 1932 by Presidential proclamation and by the Canadian Parliament. West of the Continental Divide is Canadian Forest land along the boundary.

263.3 Within 150 km. (93.2 mi.) of Glacier are 80,000 square kilometers (19.76 million acres) of national forest lands. About 10% of these lands are established as wilderness in the National Wilderness Preservation System and 3% are administratively designated by the Forest

Service as primitive lands. The rest of this forest is being managed mainly for timber production, with allowance for extensive recreational and hunting use, some mining, and oil and gas exploration. Forestry is the primary industry in the area. Tourism is very important, especially in the immediate vicinity of the park. There is also considerable agriculture, ranching and mining.

- 263.4 Much of Glacier's boundary is politically determined, consisting of survey lines across the east side and the International Boundary line on the north. The west-side portions of the boundary are natural features (rivers and streams), but even these are far from complete as ecological barriers. Birds, large predators and ungulates do not observe these markers, 1/ nor do weather changes and climate patterns, nor do forest fires, even though rivers may be useful fire breaks. Cooperative agreements and fire management plans aim to assist neighboring lands in fire control and to prevent fire trespass from the park onto another agency's land. Management, planning and development, particularly along the International Boundary, must be closely coordinated with neighboring agencies and owners. 2/

1/ Singer 1975 Jul 1; Singer 1975 Apr.

2/ Glacier National Park (no date): 4. (draft Statement for Management)

Chapter 2. DESCRIPTION OF THE ENVIRONMENT

Section 7. Fire Suppression Effects

- 271. Direct Effects of Fire Suppression Activities
- 272. Altering the Natural Landscape
- 273. Summary of Fire Management Problem

271. DIRECT EFFECTS OF SUPPRESSION ACTIVITIES

271.1 Fires are a part of the way of living things in Glacier. Fire suppression activities are completely foreign to the natural system. Fire is removed, and suppression activities interfere mechanically with the land. Particularly in the fragile alpine environment, fire suppression activities have obvious and long-term effects. 1/ Fire suppression is important in areas where human safety is endangered and where property values take precedence over wilderness perpetuation. Fire suppression is a major concern in summer staffing and training in the park. During fire suppression trees are cut, helispots cut and cleared, retardant dropped and heavy equipment introduced. Firelines are constructed by removing all fuels down to mineral soil and are often oriented uphill, contributing to rapid soil erosion. Careful planning and line construction can minimize the detrimental effects of fire suppression. 2/ Fire management planning and decisions can prevent these effects in some areas.

271.2 During a fire, trails in the area are closed to visitors for their own safety, particularly in the presence of suppression activities which include helicopter use and retardant drops. Depending on the complexity of the suppression effort, visitors may find extensive aircraft supply operations intruding on their experience of wild-land solitude several drainages away from the fire itself. Aerial surveillance, to monitor fires not being suppressed, would be minor compared with the magnitude of air traffic typically involved in large fires. During the Curley Fire of 1974, six helicopters were

1 Smith and Henderson 1970: 88.

2/ Agee 1974: 19-20.

used during one day's operations, in addition to a small patrol plane and occasional passages by a retardant bomber. Resulting noise and, to a lesser degree, visual pollution pervaded landscapes many miles away.

- 271.3 Some effects of fire suppression efforts remain long after the landscape begins to recover. Fire lines are sometimes used as trails and old fire camps as occasional campgrounds. The most obvious visual intrusion from fire suppression in Glacier is the network of bulldozer line which was built on the side of Huckleberry Mountain during the 1967 Flathead Fire. Nine years after the fire, shrubs, lodgepole pine and western larch are growing throughout the burn, but these lines still stand out clearly against the rest of the hillside. Because of the damage effected by dozer lines, bulldozers are not normally used to control fires in Glacier National Park.

272. ALTERING THE NATURAL LANDSCAPE

- 272.1 Glacier, like other northern Rocky Mountain forests, has a history of large wildfires over which no control can be effective. 1/ Although control policy has been in effect since 1910, fire control efforts have been far from completely successful. During times of severe drought, some fires have burned large areas. The fact remains, however, that most fires have been extinguished while very small. These fires might have burned small areas, reducing fuels and creating barriers to the spread of future burns, and contributing to a mosaic of vegetation available for use by many animals.
- 272.2 The natural mosaic in which mature forest alternates with disturbed areas is interesting to the viewer and has a beauty all its own. Savannas and grasslands maintained by fire, and recently burned sites covered with flowering herbs, shrubs and seedling trees, exist in sharp contrast to the surrounding forest, providing an element of diversity as important to aesthetics as it is to wildlife. 2/ On a recently burned area, the visitor finds dramatic contrast between towering snags and burgeoning ground vegetation. In the years following the 1967 Glacier Wall Fire, "...fireweed and wild hollyhock bloomed profusely in many sections of the fire area The blackened trees within the flowering burn added a contrasting, but in no way detracting, facet to the scene. Without fire, the bloom would not have appeared." 3/ This display occurred adjacent to the heavily traveled the Going-to-the-Sun Road, where it was visible to most park visitors.

1/ Wellner 1970: 47-47.

2/ Iltis et al. 1970.

3/ McClelland 1975:29.

272.3 Even though fire suppression has not prevented large burns in Glacier's lower west-side forests, they are slowly changing because fire has, to a degree, been eliminated. Late successional species are very slowly becoming more common than they would be if lightning fires were not suppressed,1/ a sign that natural vegetation distribution is being altered and plant species diversity is being decreased. 2/ Because fine fuels do not fluctuate appreciably with stand age, the spread rate of a potential ground fire probably does not change greatly with stand age. A fire's potential impact on the burned area, due to heavy loads of large fuels, however, probably does increase with time.

Some fire-dependent plant species, such as ponderosa pine and aspen, are threatened 3/ by the attempt to eliminate fire. Habitat for many animal populations is being decreased. 4/ The occasional burned areas which constitute part of the beauty of a natural landscape and may act as firebreaks in a large fire are becoming fewer, increasing the risk of conflagration during drought years. Unnatural homogeneity in some vegetation types of the Selway-Bitterroot Wilderness has been attributed to fire suppression. 5/

273.

1/ Habeck 1970b: 34.

2/ Kessell 1975d: 72.

3/ Kessell 1976: 72; Lunan 1972: 2; Singer 1975b: 17.

4/ Martinka 1972 Mar 1: 11; Martinka 1975 Sep 18.

5/ Aldrich and Mutch 1972: 30.

273. SUMMARY

In his report to the U. S. Geological Survey in 1900, H. B. Ayres noted that fire was one of the most important determinants of Glacier's plant communities. 1/ Many researchers since that time have confirmed this idea and have urged park managers to allow some natural fires in the park. 2/ Removing this occasional, but powerful, force removes part of the area's natural character, violating the original purposes for which the park was established, detracting from its wilderness qualities and jeopardizing a scientific resource of unknown proportions.

1/ Habeck 1970a: 18-22

2/ Habeck 1970a: 2; Kessell 1975 Jan 2: 4; Koterba & Habeck, 1971: 16-34; Lunan 1972: 56; Martinka 1969a: 31; Martinka 1975 Sep 18: 2; Singer 1974 Apr 7:1.

CHAPTER 3. Alternative Fire Management Plans

Alternative 1. Continued Total Suppression of All Fires

(No action Alternative)

- 311. DESCRIPTION OF ALTERNATIVE
- 312. IMPACTS OF CONTINUED SUPPRESSION OF ALL FIRES
 - 312.1 Effects on Vegetation
 - 312.2 Effects on Wildlife
 - 312.3 Effects on Soil, Water and Fish Populations
 - 312.4 Effects on Air Quality
 - 312.5 Effects on Visitor Experience, Park Planning and Economics
- 313. ADVERSE EFFECTS AND MITIGATING MEASURES
- 314. SHORT-TERM EFFECTS IN RELATION TO LONG-TERM EFFECTS
- 315. IRREVERSIBLE AND IRRETRIEVABLE EFFECTS
 - 315.1 Irreversible
 - 315.2 Irretrievable

311. DESCRIPTION OF ALTERNATIVE: Continued total suppression of all fires

311.1 Glacier National Park will continue to extinguish all forest fires from all causes as rapidly as possible. Manning of fire lookouts and employment of an Aerial Observer (fire spotter) will be continued in order to provide for rapid discovery of fires. Training of personnel will encompass only skills for fire suppression. Public information programs will concentrate on the short-term effects of fire and the need for fire prevention. Suppression techniques on going fires will be limited to those causing the least erosion and permanent alteration of the environment.

311.2 Dead material on the forest floor, a part of the natural system, should not be removed but instead should be altered by natural means -- decomposition, flood and avalanche. However, in cases where the fire hazard to a developed area from forest fuels is judged to outweigh environmental and economic costs, fuels may be removed mechanically.

312. IMPACTS OF CONTINUED SUPPRESSION OF ALL FIRES

312.1 Effects on Vegetation

312.11 Vegetative change, continuous and unavoidable in a living system, will be one way -- toward late successional or "climax" species. 1/. The process of forest aging will be preserved, but the rejuvenation of the forest landscape, normally accomplished by fire, will be avoided. Where fire suppression is successful, several changes from wilderness conditions will be taking place. Shade - tolerant species (tree species such as cedar, hemlock, grand fir, subalpine fir and spruce; shrubs and herbs such as mountain-lover and pyrola) will be favored. 2/

1/ Wellner 1970: 56.

2/ Agee 1974: 14.

Figure 312.11 Plant Species Diversity after Crown Fire*
West Slope Forests 900 - 1400 m above Mean Sea Level (3000 - 4500 ft.)

Diversity is indicated in relation to stand age as number of species found on a sample plot. Herb and shrub vigor is greatest during the first 25 years after fire. As dense forest grows in, herbs and shrubs decrease. A slight increase in diversity occurs as the dense forest matures, 100-150 years after fire. After this age, diversity declines.

Species which are favored by high temperatures or an open seedbed for germination and seedling growth, including lodgepole pine, larch, Douglas-fir, fireweed, and Ceanothus species, will be reduced. Most shrubfields which have resulted from fire will succeed to conifer forest, due to competition for light, nutrients or water, or due to the inhibitory effects of chemicals in the accumulating litter. 1/ As landscapes are covered by more continuous mature forest, the variety of herbs and shrubs will decrease. 2/ (Figure 312.11).

- 312.12 Aspen stands in the North Fork are not reproducing and will not be perpetuated without fire. 3/ Some prairie country in the same area will be invaded by sagebrush. 4/ Grasslands in the North Fork seem at this time to be in equilibrium with surrounding lodgepole pine, 5/ but in some cases they will be lost without fire. 6/ A ponderosa pine stand near Camas Creek was destroyed in the 1967 Flathead Fire and lodgepole succession on the site indicates that ponderosa will not return in that area. 7/ Other ponderosa pine stands in the park probably will not be perpetuated under a policy of total fire suppression. 8/
- 312.13 The subtle process of forest maturation may eventually make stands more ripe for other vegetation changes, such as blowdown, 9/ infestation by insects (spruce budworm and mountain pine beetle), 10/ and decline from dwarf mistletoe. 11/ As successful fire suppression shifts stand age distribution in the park toward a greater area covered by mature stands, these visible effects on the forests are likely to increase. 12/

1/ Kessell 1975b: 15.
2/ Agee 1974: 15.
3/ Kessell 1975 Feb 8:15.
4/ Singer 1975b: 17.
5/ Singer 1975b: 18.
6/ Singer 1975b: 16.

7/ Kessell 1975 Jan 2:3.
8/ Lunan 1972: 53-55.
9/ Wright & Heinzelman 1973: 323.
10/ Heinzelman 1973: 370.
11/ Wright & Heinzelman 1973: 324.
12/ Heinzelman 1970: 32.

312.14 "Despite modern technology, no reasonable hope exists for isolating accumulated forest fuels from ignition sources. Lightning and man have combined to perpetuate the fire cycles observed in the past." 1/

Even if it were possible to eliminate lightning from an area, forest fire ignition would occur from other sources. Because of the steady increase in park visitation and back-country use in Glacier, the potential for man-caused fires is increasing.

The effects of fires in the future, under this management alternative of total suppression, will differ from the effects of fires under the natural regime insofar as the fuels have been altered by fire suppression.

In a fire spreading rapidly through a continuous living crown and dead fuels, fewer unburned patches will remain than in smaller fires. 2/ The trend toward uniform cover will be self-perpetuating. Accumulation of large fuels on localized sites and on north-facing slopes will increase the potential fire intensity on these sites. The disturbance to the environment caused by fire suppression activities, as described in Section 270, will continue at its current level or increase.

1/ Beaufait 1971: 1.

2/ Aldrich & Mutch 1972: 12; Rowe & Scotter 1973: 453.

312.15 Although it seems very unlikely to us now, fire suppression techniques may become effective enough at some time in the technological future to eliminate large fires even in times of severe drought. Since sources of ignition are not likely to be eliminated,^{1/} this will involved mechanical removal or chemical reduction of fuels on a large scale.

At present, mechanical methods of altering fuels are extremely expensive, even on a small scale, and side effects of some methods are unknown. ^{2/} The practice removes materials and hence nutrients from the area. If these methods should develop to a state where they are economical for large scale applications in remote areas, they would reduce fire hazard, but most likely would also create an artificial looking landscape.

If fire should be successfully eliminated for a long time, fire-dependent species will decrease, most shrubfields on moderate slopes will succeed to forests. It is unlikely that mechanical or chemical fuel alteration on a large scale will ever be compatible with the National Park Service objective of perpetuating the natural scene.

^{1/} Aldrich & Mutch 1972: 1, 54; Beaufait 1971: 7, 18; Komarek 1967: 15, 33; Smith & Henderson 1970: 89; Wright & Heinselman 1973: 324-325.

^{2/} Agee 1974: 16.

312.2 Effects on Wildlife

312.21 Few wild animals are killed in forest fires; 1/ this will not occur at all where fire suppression is successful. But animals will still be affected by fire suppression because their habitat will be changed. For moose and mule deer, recently burned areas produce preferred browse.2/ Beaver in Glacier may require recently burned areas, as they do in Minnesota. 3/ These species will tend to decline with the elimination of fire. Although elk exploit a variety of habitats even in winter,4/ they favor successional sites. Nine of eleven elk winter ranges in the Middle Fork have burned since 1910. 5/ Martinka estimates that the best elk habitat occurs around 25 years after fire, in areas where successional shrubfields are interspersed with conifer stands.6/ Three of the food species of whitetail deer -- larch, lodgepole pine and aspen -- will decrease with fewer or no fires.7/ In the absence of fire, brush species will grow out of reach of browsing ungulates and form dense thickets which are inaccessible.8/ Large fires, which will occur in the park during drought years despite suppression efforts, will not leave many community edges and unburned patches useful to most wildlife. Blacktail deer living in mature forest in Oregon appear more susceptible to parasites than those browsing on recently burned sites. 9/ Black bears prefer forest to open areas for cover, but they feed on berry-producing shrubs on burned sites.10/ This food source, especially

1/ Agee 1974: 59.
2/ Singer 1975b: 42.
3/ Heinzelman 1973: 371.
4/ Singer 1975b: 6.
5/ Martinka 1974: 6.

6/ Martinka 1974: 9.
7/ Martinka 1970: 2.
8/ Martinka 1974: 10.
9/ Heinzelman 1973: 373.
10/ Martinka 1974a: 10.

during late summer and fall, will be less available. Where grasslands are dependent on fire, another of the important food sources of black bears will decline.

- 312.22 Because many warbler species thrive on spruce budworm infestations in living trees, they will benefit from a no-fire environment in some ways. 1/ Woodland caribou and pine marten rarely use recently burned sites. 2/ They will be unaffected or favored by preservation of the maturing forest canopy and gradual elimination of recently burned areas.
- 312.23 Grizzly bears take advantage of a variety of habitats. As recent burns succeed to forest, grizzlies will not find the extensive berry patches which they use every fall. Some bird species which nest in burned snags and feed on insects in burns will decline. Predators will be affected as their prey is affected. A decline in elk, deer and moose may reduce mountain lions and coyotes and eliminate the already rare Rocky Mountain timber wolf. 3/ In addition to responding to any decline in their prey species, predators will lose some of the open areas where they have an advantage in hunting because of crusted snow and an increased range of visibility.
- 312.24 In lodgepole pine forests in Yellowstone National Park, twelve species of small mammals occurred on a 25-year-old burn, and only five were found on a site 111 years "old." On 405 hectares (1,000 acres) of a 13-year-old burn, 235 pairs of birds were nesting; only 49 pair nested in similar stands 111 and 300 + years old. 4/ It is

1/ Heinselman 1973: 373.

2/ Agee 1974: 60; Hayes 1970: 111.

3/ Martinka 1975 Sep 18: 2.

4/ Taylor, D. 1973: 1394-1395.

an axiom of wildlife ecology that the greatest variety of plant communities and plant species allows the greatest diversity of wildlife. 1/ Under a policy of total fire suppression, diversity in all forms of living things will decrease. 2/

312.3 Effects on soil, water and fish populations

- 312.31 Vegetation development uses soil nutrients to form wood and deposits a reservoir of nutrient-rich litter and other dead materials on the forest floor. Because decomposition of these materials is very slow, the soil reservoir of chemicals and minerals, particularly nitrogen, 3/ may be slowly depleted, and subsequent vegetational development may be retarded. 4/ Changes in watershed and stream characteristics will be subtle, related to the gradual succession of recently burned openings in the canopy to mature forest. Stream side (riparian) vegetation will maintain stable soil banks and cool, relatively stable water temperatures. 5/ However, the gradual increase in forest cover will transpire more water, slowly reducing streamflow and riparian vegetation. 6/ Fish habitat may be reduced over an extended period of time. 7/
- 312.32 Depending on the topography at the fire and the equipment used, fire suppression activities can cause erosion. Because most fireline in Glacier has been constructed by hand, little effect has been noticeable from a distance. But bulldozers and even explosives are being used in other areas. If the hazard of unacceptable fire spread should warrant use of these suppression methods in Glacier, the resulting soil erosion would be severe. 8/

1/ Agee 1974: 17.

2/ Taylor, D. 1973; Kessell 1975 Jan 2.

3/ Behan 1970: 14.

4/ Agee 1974: 19; Kessell 1975b: 13

5/ Duff 1972 May 31: 3.

6/ Houston 1973: 1116; Agee 1974: 19.

7/ Duff 1972 May 31: 3.

8/ Smith & Henderson 1970: 88

312.33 Chemical retardants used on fires serve as unnatural stimulants to vegetation, but their long-term effects are not yet known. 1/

Retardant dropped in a stream has been known to kill hundreds of local fish, but the fish movement returned to normal within days. 2/

312.34 Under extremely dry, windy conditions, some fires escape all controls. Their effects will be unnatural in proportion to the alteration of stand composition and fuel loadings, due to fire suppression. After only 40 to 70 years of fire suppression in Glacier, it is difficult to sort out natural from unnatural fuel loadings on specific sites. After another century of suppression, however, fuel loadings which were rare prior to this century will be present in many forest stands. Heavy fuels will combine with very dry weather and soil to generate occasional large continuous fires with high intensity on some sites.

In pockets where very intense burning takes place, the affected soil will be susceptible to rapid erosion. Decreased moisture will be available to plants, because of soil alteration and exposure to solar heating. 3/ Due to these conditions, a community of shrubs may become established, at the exclusion of other species, for many years.

Streambeds may be altered by sedimentation. Reduction in streamside vegetation will raise water temperatures and reduce the fish population for a time.

312.4 Effects on Air Quality

As long as fire suppression is successful, the air will be clear of smoke from fires within the park. It has been suggested that particles in forest fire smoke are able to "scavenge" some toxic chemicals produced by industrial pollution from the atmosphere, 4/ but this has not been

1/ Yellowstone National Park 1975:9 3/ Agee 1974: 62-63.

2/ Agee 1974: 17-18

4/ Agee 1974: 64.

investigated. It is possible that removing natural particulates from the atmosphere would have unforeseen effects. However, smoke particulates are rarely in short supply. Prescribed burning on national forest lands frequently reduces visibility in the park.

Fires will escape suppression efforts only under weather conditions which make for fast-spreading fires, incomplete combustion and heavy smoke concentration. As fuels slowly become more continuous throughout a mature forest, the possibility increases that a large fire will occur, releasing an intense concentration of visible particulates. Use of retardant to slow down a fire only increases smoke emissions. 1/ It is known that naturally produced particulates in heavy concentrations combine with industrial pollutants to form substances harmful to the lungs. 2/

312.5 Effects on Visitor Experience, Park Planning and Economics

312.51 While fire suppression is successful, the forest will appear to be preserved intact. Recently burned landscapes will be absent. A uniform high, dense forest canopy will continue to develop uninterrupted on most of the park's lower slopes. Although fire is not by any means the only source of variety in Glacier, it is the principal agent responsible for alerting vegetative cover over large areas.

The numbers and visibility of large animals will decrease. Removing fire, an essential force in the natural system, will lessen the park's integrity as a true wilderness and eliminate the opportunity for ecologists to describe many yet-unknown features of this ecosystem.

1/ Sandberg et al. 1975: 281.

2/ Spirtas & Levin 1970: 1.

- If park visitors are to have the opportunity to view a natural, functioning park ecosystem, the opportunity to view the violent forces of change, such as a forest fire, must not be excluded. 1/
- 312.52 The extent of intrusion from fire suppression will depend upon the fire size and the means used to suppress it; intense use of mechanized equipment, including bulldozers, will leave scars on the land, which will last for centuries. 2/ Extensive aircraft use will disturb more than the fire area; noise and visual disturbance pervades areas many miles away, and is unavoidable if aircraft are used.
- 312.53 The risk of fire's destroying valuable historical features and visitor or administrative facilities, or of a fire from Glacier invading land outside the park or destroying private property, will be low during years of low fire danger, but costs will accrue even for fires which burn a small area and show low potential for spread. In the long run large fires will be at least as likely to occur as under other management plans, and their likelihood will increase as the period of suppression grows longer.
- 312.54 Presuppression costs for fuel management and intense patrol will increase as the hazard of fire in dense, heavy fuels increases. A severe drought year will pose risks of trespass of fires from Glacier on installations inside the park, private property and lands adjacent to the park boundaries. It will be necessary to close down large areas of the park's backcountry and road access to visitor use. Costs of fire trespass will add to costs of fire suppression in the park. Smoke concentration may cause visitor stays to be shortened and the local economy may suffer loss.

1/ McClelland 1975: 30.

2/ McClelland 1975: 28.

313 ADVERSE EFFECTS AND MITIGATING MEASURES

- 313.1 Without fire, forest succession will continue. Depletion of the soil's supply of some nutrients and the predominance of old-age stands will make the forests continually more susceptible to insects, parasites and windthrow. The forest canopy is partially opened by wind and disease. Increased light is sometimes made available for new growth, but the other rejuvenating effects of fire do not occur. Nutrients are not released for new growth, and the seedbed is not cleared of deep litter to enable pioneer species to become established. Some species that require fire or its effects to reproduce may be lost altogether. No mitigating measures are proposed.
- 313.2 Forage quality, quantity, vigor and availability will decline for moose, elk, deer and beaver. Predators which depend in large part on these species will decline. Animals which show selective use of recent burns, such as grizzly and black bears, may also be affected. Feeding yards and other artificial food sources could be provided for ungulates, but this practice is unacceptable in a national park.
- 313.3 Fuel buildup will continue with an increased potential for a serious conflagration, larger and more intense on some sites than under natural fuel conditions. Complete fire suppression is probably unrealistic. Techniques of altering fuels will be developed to protect human developments. These will approximate only some of the effects of fire, and will leave an artificial appearance on the landscape.
- 313.4 Fire lines, even if hand constructed, may accelerate erosion. In a major conflagration, all modern methods of fire control may be employed,

including aircraft, chemical retardant, large numbers of ground forces and possibly other mechanized equipment.

Line construction will be planned to effect the least possible permanent damage. Use of mechanized equipment to build line will be avoided wherever possible. Restoration of firelines will be unable to remove altogether the scars from suppression activity. Noise and visual disturbance from aircraft is unavoidable.

- 313.5 Slow-burning fires during moist fire seasons will continue to be suppressed, even in delicate alpine areas, incurring high costs and causing disruption in the natural environment.

Efforts will be made to find more efficient and environmentally acceptable fire control methods.

- 313.6 Suppressing all fires may produce a low-contrast environment. Large areas will exhibit uniform mature forests; when an area burns, the resulting vegetation will also tend to be quite uniform over a large area.

No mitigating measures are proposed.

314. SHORT-TERM EFFECTS IN RELATION TO LONG-TERM EFFECTS

314.1 Fire history indicates that uncontrolled fires will occur in time.

The short-term protection of Glacier's forests may lead to fuel distributions which will result in a larger fire than would normally occur. Clean air, safety for human lives and property, and protection of land adjacent to the park during moderate fire seasons will only be postponing a confrontation with the forest fuel problem. As the probability of a large fire increases, so does the risk that the park or portions of it will be closed due to fire hazard or going fires during part of the summer. The attendant risks of economic losses in the area likewise increase.

314.2 Although in the short run the green forest cover of the park will be preserved, every year of total fire suppression will result in additional degradation of scientific and aesthetic values. Ecosystem composition will progressively depart from normal patterns; mature forests and some wildlife populations will decline. The number of species of plants, birds, mammals and insects will decline with time. The extent of these damages depends on the extent to which fires can actually be suppressed.

314.3 Total fire suppression is expected by many park visitors. However, as the public becomes more aware of the role of fire in natural areas, total suppression may become less acceptable.

314.4 Supplemental appropriations are usually required to control a large fire. Growing public awareness of the natural role of fire and tightening of finances throughout the Department of the Interior and National Park Service may make this fire management alternative impossible to carry out.

315. IRREVERSIBLE AND IRRETRIEVABLE EFFECTS

315.1 Irreversible

Species that require early successional stages will be reduced. With the reduction of communities and vegetative mosaics, certain animal species will decline. Fire lines and other long-lasting marks of fire suppression will continue to intrude on the landscape and alter vegetative succession and watershed characteristics. Total fire suppression requires commitment of funds, personnel and equipment that would be better used elsewhere in some cases.

315.2 Irretrievable

Without fire, the natural vegetative mosaic will be lost. Natural communities which depend on fire will slowly be replaced. The earliest to disappear will be pine savannahs, some aspen and some meadows. If fire suppression is successful for another century or two, lodgepole pine, white pine, and larch will disappear from many stands. The wilderness quality of the park will be diminished as man succeeds in controlling one of the forces most important to the natural ecosystem. The ability to measure long-term changes in the ecosystem and the forces which enable it to remain stable under natural perturbation by fire will be lost.

In the event of a large, uncontrollable fire, historic resources, and private property will all be subject to destruction. On some sites, the potential for normal vegetative succession may be lost due to soil erosion or alteration. The hazards of such occurrences will exist under any management technique which deals with a force as powerful and potentially destructive as fire. Continued suppression eliminates this risk in years of moderate fire danger, but increases it in years of drought.

Chapter 3. ALTERNATIVE FIRE MANAGEMENT PLANS

Section 2. ALLOWING ALL FIRES TO BURN
(WITH LIMITS TO PROTECT HUMAN SAFETY)

321. Description of Alternative

322. Sources of Forest Fires in Glacier

323. Impacts of Allowing All Fires to Burn

321. DESCRIPTION OF ALTERNATIVE: ALLOWING ALL FIRES TO BURN, WITH LIMITS
TO PROTECT HUMAN SAFETY

All forest fires in Glacier National Park, which do not endanger human life or threaten private property or neighboring land, will be allowed to burn. Fire control plans and staff will be maintained to prevent unacceptable danger to human life and damage to park facilities or private property. Trespass of fires from the park on neighboring lands is likely. Because the land itself seems to have always adjusted to a capricious fire regime, natural features which are threatened by fires will not be protected.

322. SOURCES OF FOREST FIRES IN GLACIER

322.1 Both lightning-caused and man-caused fires are a part of the Glacier National Park environment. Evidence of lightning fires in conifer forests of western and northern North America dates back to the forest development which followed the Pleistocene. 1/ Man-caused fires prior to 1900 burned over much of Glacier's east slope grassland. 2/ According to records kept since 1910, lightning ignitions have accounted for 62% of the forest fires from the park's establishment through 1968.

322.2 Not all forest fires which affected Glacier started with in the park. Fires carried by prevailing winds have invaded from the miles of forest south and west of the park, and may also have swept in from the half-continent of grassland on the park's eastern boundary.

1/ Habeck 1970b: 30.

2/ Habeck 1970b: 22

323. IMPACTS OF ALLOWING ALL FIRES TO BURN

- 323.1 Restoring fire by allowing selected natural ignitions to burn would not completely restore the fire frequency that existed before white settlement. Some man-caused fires, under this plan, will be allowed to add to the effects of natural fires. This alternative has the advantage of burning a total area probably closer to that burned under a natural regime. In addition, it will avoid the impacts of fire suppression (building fireline, clearing helispots, and using aircraft). However, it has several drawbacks.
- 323.2 More total area will be burned under this alternative than without the admission of man-caused fires, but its distribution will be determined by a pattern of human use, not by any natural pattern. 1/ The total burned area will exceed that which is natural in areas heavily used by visitors and along the railroad right-of-way. Unnaturally frequent reburns in these areas will on some sites cause accelerated soil erosion, increased sedimentation in streams and retarded plant succession. 2/
- 323.3 Because of their distribution, hazards to human life and property from man-caused fires are greater than from natural fires. A disproportionate amount of recently burned area will be near visitor travel routes and facilities, giving the public a distorted image of the frequency of fire. Trespass on neighboring lands by fires originating in Glacier will be costly, not only on a financial basis, but also in terms of cooperation with neighboring agencies and other public relations.

1/ Heinselman 1970: 39

2/ Wellner 1970: 57

323.4 Due to above disadvantages and to other factors, the National Park Service does not allow man-caused fires to play a role in fulfilling resource management objectives at this time. 1/ Because both fire and weather records are incomplete, scientists and resource managers are not able to simulate the distribution of natural fires. Without this information, man-caused fires cannot be evaluated in relation to the natural distribution and frequency of fires. If such technology becomes available, National Park Service policies may be revised and a detailed investigation of the effects of man-caused fires conducted.

1/ National Park Service 1975: 12

Chapter 3. ALTERNATIVE FIRE MANAGEMENT PLAN

Alternative 3. Allowing Selected Lightning-Caused Fires to Burn

331. DESCRIPTION OF ALTERNATIVE

331.1 General Plan Description

331.2 Fire Management Zones

331.3 Future Development of Fire Management Plan

332. IMPACTS OF ALLOWING SELECTED LIGHTNING-CAUSED FIRES TO BURN

332.1 Effects on Vegetation

332.2 Effects on Wildlife

332.3 Effects on Soils, Water, and Microclimate

332.4 Effects on Air Quality

332.5 Effects on Visitor Experience, Park Planning and Economics

333. ADVERSE EFFECTS AND MITIGATING MEASURES

334. SHORT-TERM EFFECTS IN RELATION TO LONG-TERM EFFECTS

335. IRREVERSIBLE AND IRRETRIEVABLE EFFECTS

335.1 Irreversible

335.2 Irretrievable

331. DESCRIPTION OF ALTERNATIVE: ALLOWING SELECTED LIGHTNING-CAUSED FIRES TO BURN

331.1 General Plan Description

- 331.11 Lightning-caused fires which do not endanger human life, visitor and administrative facilities, private property or land adjacent to Glacier National Park, will be allowed to burn in pre-designated zones and under specified weather conditions. All man-caused fires* will be suppressed as soon as possible. Fire lookouts will be manned and an aerial observer (fire spotter) will be employed so that all fires may be reported to and evaluated by managers as soon as possible.
- 331.12 The likelihood of fire occurrence and the potential for fire spread vary throughout the park and with daily and seasonal changes in weather. In many areas, fires are not likely to spread beyond natural fire-breaks (lakes, mountain ranges, talus slopes, etc.). In other areas, the proximity of visitor or administrative facilities and private property require stringent limits on the use of natural fire.
- 331.13 The fire management plan will "zone" the park into sections according to probable fire behavior characteristics and the hazard of spread to private and park facilities and to adjacent lands. Each zone will have a "prescription," which will describe the action to be taken in the event of ignition in that zone. The prescription for a zone will

* "Man-caused fires" will in this assessment refer only to those fires which are ignited by man accidentally or for purposes which are not approved management objectives. "Prescribed fires," which are ignited in order to fulfill documented, approved management objectives, are assessed in Section 340.

be defined not only according to fixed conditions, such as location and predominant fuels, but also according to variables, such as the time of year, potential for fire spread, and the regional fire situation. (This assessment will refer to "natural-fire zones," in which at the time of fire discovery the prescription is for no suppression or for limited suppression action, and "total-suppression zones," in which at the time of fire discovery the prescription is for suppression of all fires.) For zones near park boundaries and developed areas, the prescription will, for the present at least, require suppression. As fire management techniques develop, and as information and experience are gained from implementing fire management in natural-fire areas, the zones will be revised, and natural-fire zones will probably be expanded.

- 331.14 The final decision to allow a lightning-caused fire to burn will be made by park managers after evaluating local conditions, manpower, and equipment available, and the region-wide fire situation. While natural fires are burning, park radio bulletins and memoranda will inform employees, and press releases will inform the public, of the current situation. All natural fires will be monitored by lookouts and aerial observers. Fuels and spread rates will be measured by assigned personnel. Fire managers will maintain close surveillance over going fires.
- 331.15 Public information efforts, interpretive programs and orientation for park employees will emphasize that fire is a force essential to the perpetuation of Glacier's natural landscape. The goal of interpretation in the parks is to contribute to understanding and thereby appreciation of the natural environment. "The beauty of nature can be compared

to a lovely painting: both can be compared to some degree by the untutored, but true appreciation requires some knowledge of them. 1/ This is especially true in the presentation of lightning-caused fire, because prevention has been the only message to the public concerning fire for many years. Prevention of accidental fires will continue to be emphasized, but in addition, public interpretation efforts will show that lightning-caused fire is a force essential to the perpetuation of Glacier's natural landscape.

331.2 Fire Management Zones

331.21 The zones in which lightning-caused fires are allowed to burn will include only those areas in which, because of natural fire breaks (lakes, talus slopes, rocky ridges, etc.), a fire probably will not spread into total-suppression zones. This will include much of Glacier's area above timberline and also the forested slopes in the upper parts of several drainages. In the fragile alpine environment, where soil formation from parent rock determines vegetative cover, the removal of all vegetation and humus for fireline construction sets back vegetative succession severely. Where natural fire zones include continuous forest on the slopes of the park's upper valleys, boundaries will be selected so that spread across boundaries, into a zone where natural fire is not allowed, can be prevented.

331.22 Fire danger indices, 2/ special forecasts from the U.S. Weather Service, 3/ and the gradient model application for fuel and fire

1/ Goldman 1966.

2/ Deeming *et al* 1972.

3/ Burnham & Paterson 1975: 5-6

spread predictions (Section 331.3), will provide indications of fire spread and potential control problems. These indicators will inform the decisions of managers, but the managers themselves will prescribe the course of action to be followed, that is: no suppression, partial suppression or prevention action, or total suppression. Using information from fire monitoring personnel and reviewing weather conditions and forecasts, the fire management team may change their course of action in case of unforeseen developments.

331.23 Fires which are allowed to burn and the entire fire area will be monitored carefully. Visitor use in the area will be controlled to protect human safety. With the exception of backcountry patrol cabins, there are no structures which require protection from natural fires in the initial fire management zones. Prescriptions for management zones will provide for prevention or suppression in order to protect these historic park facilities.

331.24 Fire behavior is often erratic because of rapid weather changes. As is the case with the alternative of park-wide total suppression (Section 310.), some fires will trespass across boundaries. Fires which "escape" tend to do so during times of high wind and drought. The prescriptions for natural-fire zones will specify conditions under which unacceptable risk of "escape" from the zone makes immediate suppression advisable. In addition to this pre-planned option for suppression, managers will judge weather conditions through the duration of each fire which is allowed to burn, and will take suppression action to prevent spread across zone boundaries.

331.3 Future Development of Fire Management Plan

331.31 The areas in which natural fires are most frequent and the effects of eliminating them are most obvious are not in zones where fires are easily controlled or natural fire breaks are frequent. Zones which allow selected fires to burn in alpine and subalpine environments answer only a part of the fire management problem in Glacier. More refined tools for management are being developed. When they are tested and applied, and as information and experience are gained from natural-fire zones, Glacier's fire management plan will be altered and expanded.

- 331.32 One tool which is available in Glacier is the Gradient Modeling fire spread and vegetation succession model. 1/ using site descriptions already derived from aerial photos and maps, managers can access fuel and vegetation descriptions. Computer programs use these site and fuel descriptions, and weather conditions described by the user, to calculate likely ground fire spread and intensity, and the probability of crown fire occurrence. Predictions of vegetation's succession after fires of varying intensities are also available. These predictions will assist managers in evaluating zones and in future planning. Because weather is extremely variable even over a short time span, this fire behavior model requires careful interpretation by managers for fires which will last for several days or weeks.
- 331.33 When smoke dispersal and weather conditions are studied in conjunction with results of the fire model and other information, the fire manage-

1/ The gradient vegetation and fire model are described briefly in Kessell (1975a) and in detail in Kessell (1976). The model uses the fire spread model which was developed at the U.S.F.S. Northern Forest Fire Laboratory by Rothermel (1972).

ment team will be better able to decide upon the course of action to be taken for each fire. Some zones which now require total suppression of all fires may be altered so that, perhaps in wet summers or during the fall, or under given conditions of partial suppression, fires may be allowed to burn.

- 331.34 Natural fire, of course, was the habit of the land before humans arrived in the area. In Glacier, an ecosystem governed by natural forces which is to be preserved for future generations, the restoration of natural fire is seen as a fulfillment of the mission of the National Park Service. The natural mosaic of the landscape will be perpetuated and diversity of plant species will be preserved, contributing to vigor and diversity in wildlife populations. Adverse effects, such as reduction of visibility due to wood smoke and risks to irreplaceable manmade features, will be minimized by decisions of the fire management team. Any decisions for suppression will result in the same impacts on the environment described for Alternative 1, Total Suppression (311. through 315.).
- In its initial stages, this alternative will result in an increasing number of small (less than 0.1 hectare, $\frac{1}{4}$ acre) burned areas, and an occasional larger "burn" in remote areas of the park.
- Fire managers and ecologists will continually evaluate and develop the plan, with the objective of restoring natural fires to the park without increasing risks to human safety and valuable property.

332. IMPACTS OF ALLOWING SELECTED LIGHTNING-CAUSED FIRES TO BURN

332.1 Effects on Vegetation

332.11 Occurrence of lightning fires at their natural frequencies in different areas of the park will support the natural ecosystems, more stable in the long run because of their diversity than any which could be maintained by eliminating fire altogether.1/ The park will appear much as it is now, but the number and area of recent burns will increase. Sites covered by early successional species will alternate with maturing and near-climax forests. In a national park, where only non-consumptive uses are permitted, concern about "waste" of a timber resource does not apply.2/ The aim is not to preserve or restore any abstract condition, but rather "to permit all natural processes to operate."3/

332.12 When natural fires occur in communities where the effects of eliminating fire have become noticeable, they will in most cases restore the dynamics of that environment to conditions as they were previous to fire suppression. Lodgepole pine4/ and big sagebrush,5/ which are now slowly invading grasslands in the North Fork, will be reduced; grasses will again be favored. Aspen in the same area will begin to sprout more vigorously,6/ and savannah communities will be maintained.7/ If vertical fuel distribution has been altered by fire suppression, as is the case in some of Glacier's ponderosa pine stands, the pre-fire community may not be restored after natural fire occurs, (Para. 244.34).

1/ Agee 1974: 47; Vogl 1970:71-72

2/ Houston 1971

3/ Kilgore 1972: 366

4/ Koterba & Habeck 1971: 1634

5/ Singer 1975b: 18

6/ Singer 1976b: 17

7/ Singer 1975b: 16; Lunan 1972:56

332.13 Natural fires will create discontinuities in fuels. In the long run, this will contribute to decreasing the hazard of large fires and very intense localized burns. In some cases, particularly in subapline areas, a recent burn will constitute a barrier to the spread of another fire.^{1/} On a day-to-day basis during the fire season, however, increasing fire perimeters on natural fires will increase the potential for rapid spread and spotting. Where a fire is very intense or where it burns in heavy fuels because of previous suppression, a natural fire may be followed by slow vegetative recovery (Para. 246.34, 312.14, 312.33). This may also occur on sites where succession after the last fire has not yet generated seed-producing forest cover.

332.14 A natural fire which crosses zone boundaries into an area where fires are not allowed will be subject to suppression. Alterations in soil and vegetation due to the building of fireline and the use of retardants will be the same as for Alternative 1 (Para. 312.32). Succession after the fire will depend upon the fire's behavior and fuel loadings for the site (Para. 312.33), as well as the effects of suppression activities. The long-term effects throughout a zone where no natural fires are allowed will, of course, be the same as for Alternative 1: less variation in stand ages and continued accumulation of forest fuels.

^{1/} Aldrich & Mutch 1972: 36

332.2 Effects on Wildlife

332.21 Most large mammals and rodents avoid forest fires without harm; smaller rodents and snakes find protection by burrowing into the ground.1/ Red-tailed hawks and kestrels have been observed hovering near fires in the Southeast to capture migrating rodents, and scavengers consume any animals killed by fire.2/ But the most important effect on primary consumers (grazers and most rodents) by fire is habitat change. Permitting natural fires to burn increases the variation in the stand ages and habitats available to animals. The proportion of stands less than 50 years old, those which harbor the greatest variety in large mammals, will increase. Wildlife habitat in Glacier will approach the distribution and quality which existed before settlement began. Productivity and nutrient content (protein) will be very high on recently burned sites.4/ This increase in forage vigor, and a greater frequency of these recently burned stands, will favor moose, elk, deer and beaver.5/ Black bears will use berry crops on fire-created shrubfields and graze near the forest edge in fire-cleared meadows.6/ Blue grouse will have access to their breeding-grounds of immature thickets.7/ Ruffed grouse will benefit from a mosaic where fire-stimulated aspen alternate with forest.8/ Birds will find

1/ Stoddard 1963: 169

2/ Stoddard 1963: 167-169

3/ Taylor, D. 1973: 1395

4/ Legee & Hickey 1971

5/ Singer 1975b: 28; Heinselman 1973: 371
Martinka 1974b: 10

6/ Martinka 1974a: 10

7/ Hayes 1970: 112

8/ Heinselman 1973: 373

on recent burns abundance of insects for food. 1/ Because spring fires are infrequent in Glacier, disturbance by fire to nesting birds will be rare. Many bird species will nest in the snags, which remain after fire. Although populations of small mammals will be reduced immediately after a fire, their numbers will increase rapidly as soon as the ashes have been settled by rain. Voles will tend to decrease, but mice and snow-shoe hares will increase. 2/

- 332.23 Large fires have not been frequent in Glacier, but they account for most of the area that has been burned. Where the entire canopy is removed by a fire and an area of homogeneous vegetation is produced, mule deer will browse in the winter, 3/ and grizzlies will abound in the fall. 4/ If a great deal of forage is available to wildlife on a large burn, browsing will usually not be intense enough to prune shrubs and keep them within reach, 5/ but in some cases ungulates will maintain a shrubfield in a burned area for several years. This process, where wildlife use retards vegetational succession, is now taking place on the Belton Hills. 6/

- 332.24 If woodland caribou are re-introduced into the park, as has been proposed, the potential impact of natural fires on their habitat will require scrutiny. The vegetation mosaic natural to the North Fork, which was greatly influenced by fire prior to about 1930, can provide the old-age forest stands and arboreal lichens which caribou require. 7/

1/ Agee 1974: 31.

2/ Hayes 1970: 112; Heinselman 1973: 372

3/ Martinka 1975b: 11.

4/ Martinka 1973 Oct 25.

5/ Agee 1974: 30, 61

6/ Habeck 1970b: 40.

7/ Singer 1975b: 43.

- 332.25 Where wolves in the North Fork prey upon beaver,^{1/} they will benefit from beavers' increase after fire. Mountain lions and coyotes showed spectacular increases following fires in British Columbia.^{2/} In addition to finding greater numbers of prey under the natural fire regime, predators will sometimes be favored by the deep crusted snow, which accumulates on winter range in fire-created shrubfields during the winter.^{3/}
- 332.3 Effects on Soils, Hydrology and Microclimate
- 332.31 A fire's effects on soil and water depend on fire intensity, the amount of fuel removed, seed source and dispersal, and rainfall after the fire.^{4/} Natural fires in Glacier's many kinds of environments will exhibit highly varied effects on soils and subsequent vegetational recovery. Vegetation on stream sides, which does not accumulate heavy fuels, will recover rapidly from fire.^{5/} Vegetation on dry south slopes, on the other hand, may take much longer to recover and will provide browse to ungulate species for many years.
- 332.32 Calcium, phosphorus, potassium and other minerals valuable to plant productivity will be in soluble form after fire.^{6/} and will be displaced downhill in subsequent rains, unless rapid vegetational recovery on-site utilizes them quickly.^{7/} Most of the nitrogen present in litter on the forest floor will be volatilized during fires;^{8/} however, a decrease in soil acidity^{9/} will cause bacteria to thrive and increase the overall availability of nitrogen to

^{1/} Singer 1975 Apr: 8

^{2/} Hayes 1970: 111

^{3/} Singer 1975b: 30

^{4/} Vogl 1970: 69; Heinselman 1973: 347; Aldrich & Mutch 1972: 53

^{5/} Duff 1972 May 31: 3

^{6/} Isaac 1963: 10. Behan (1970: 12) states that there are 16 different minerals necessary to plant growth and reproduction

^{7/} Agee 1974: 64

^{8/} Aldrich & Mutch 1972: 18; Behan 1970: 17; Isaac 1963: 10.

^{9/} Agee 1974: 66

plants.1/ When shrubs such as Ceanothus species and alder invade, micro-organisms in their root systems will also increase the soil's richness in nitrogen compounds.

- 332.33 Soil temperatures will increase on burned sites. Many factors will contribute to this effect: removal of insulating litter,2/ increased sunlight due to removal of vegetation,3/ the dark color of ash and exposed soil,4/ and even the insulating properties of heavy snow accumulation during the winter.5/ Wind speed will increase on burns where the forest canopy has been removed, slightly accelerating soil loss, but also providing transportation for seed recruitment.
- 332.34 Streamflow in burned areas will increase because plant transpiration6/ has been reduced. Water temperatures may on a few sites rise to levels intolerable to fish populations. Runoff immediately after a fire may contain ash compounds lethal to fish,7/ but streams will flush themselves rapidly of these substances and fish populations will return.* If streamside vegetation is destroyed, eroded soil will fill in fish resting pools8/ with nutrient rich sediment which will, in the long run, replenish nutrients in the aquatic environment.9/ Fish have coexisted with natural fire for centuries. When habitat is altered to become

* Runoff of toxic chemicals from a burned clearout in Oregon had disappeared in 12 days (Duff 1972 May 31: 4).

1/ Behan 1970: 12

2/ Kessell 1975b: 10

3/ Heinzelman 1973: 323

4/ Kessell 1975b: 10; Ahlgren & Ahlgren 1960: 506

5/ Rowe and Scotter 1973: 455-456

6/ Ahlgren & Ahlgren 1960: 509; Hayes 1970: 112

7/ Duff 1972 May 31: 5

8/ Hayes 1970: 112

9/ Duff 1972 May 31: 6

temporarily intolerable to a given species, this may be part of a cycle which perpetuates long-term diversity and stability. 1/

332.4 Effects on Air Quality

332.41 Smoke from forest fires will be the effect most obvious to visitors not actually observing the fire and to residents of the surrounding area.2/ Natural fires will burn under all weather conditions, for periods as long as two or three months. They will at times produce smoke concentrations which will be carried into the valleys and perhaps trapped there for a time by temperature inversions.3/ Smoke will usually disperse rapidly through the atmosphere, away from heavily populated areas, due to prevailing winds. But occasionally visibility will be severely reduced in the park.4/

332.42 The hydrocarbons and other chemicals produced by forest fires are not considered significant hazards to health.5/ The carbon dioxide which fires will release is the same amount which would be released by slow decay of the same vegetation, so it will not contribute to a significant long-term change in the carbon dioxide concentration of the atmosphere.6/

The particulates in wood smoke will ultimately contribute to raindrop formation and be removed from the atmosphere.7/ During periods when particulate concentration is very high, the risk will increase that smoke

1/ Aldrich & Mutch 1972: 50

6/ Murphy 1972: 105

2/ Brown & Davis 1973: 559; Schaefer 1973: 287

3/ Beaufait 1971: 12, 15

7/ Ward & Lamb 1970: 135;
Beaufait 1971: 15-16

4/ Beaufait 1971: 9

5/ Beaufait 1971: 9; Murphy 1972: 105

particulates will combine with toxic pollutants from local industry to create harmful substances. Particulate concentrations higher than 400 mcg/m^3 is the level identified as dangerous by Beaufait, 1/ but the highest level of particulate concentration recorded since 1966 was 92 mcg/m^3 observed during the third quarter of 1971. 2/

332.5 Effects on Visitor Experience, Park Planning and Economics

332.51 The heavy forest cover on the park's lower slopes and the open sub-alpine forest will continue to predominate, but greater variety in vegetation at every stage of succession following fire will be visible. Fields of wildflowers such as fireweed and wild hollyhock will thrive during the first few years after fire, floral displays otherwise unusual on lower slopes in the park. Standing snags, at first black but later weathered to stark white, will stand as signs of the tremendous forces in nature. Shrub-fields will exhibit patchworks of color and abundant berry crops in the fall, and easily-viewed wildlife habitat in the winter. These sites will have as much beauty in their naturalness as any other area.

332.52 During initial phases of natural fire management, burned areas will probably be in remote areas. Recent burns which are visible will at first not be understood by many visitors; because of years of fire suppression, the use of any fires in a national park will seem wrong. Interpreters will use this opportunity to illustrate the essential role played in the natural environment by occasional forces of rapid change,

1/ Beaufait 1971: 9.

2/ U. S. Environmental Protection Agency 1976 June 6.

not only fire, but also windthrow, avalanche, and flood. Fire will not be acceptable to all of the public until it is explained.^{1/} But it is likely that, as occurred in the southeastern states with prescribed fire, the ability of the public to understand has been underestimated.^{2/}

- 332.53 Wilderness values in natural-fire zones will not longer be degraded by the marks of fire suppression and disrupted by suppression activities. Future research will add to understanding the dynamics of long-term stability in Glacier's ecosystems and the changes which are affecting the park from outside -- both man's alterations of his planet and long-term natural changes on the earth.
- 332.54 Areas of the park will occasionally be closed to visitor use because of fires. The presence of smoke from fires may at times cause visitors to shorten their stays in the park.^{3/} Occasional losses to the local economy may occur, but this effect will be negligible during most fire seasons. Implementation of natural fire management and continual updating of fire management plans will require orientation of the park's personnel and training for fire crews in fire behavior and other data collection.
- 332.6 Summary and Costs
- Although fuel reductions effected by many years of natural fire will reduce the probability of large fires during drought years, the natural distribution of fire is so variable that this effect will not be measurable. During years of moderate moisture, the

^{1/} McClelland 1968: 74

^{2/} Butts 1968: 11

^{3/} Miller 1971

exorbitant costs of suppressing fires (\$1500 per acre, \$3700 per hectare in Glacier) will be avoided in natural-fire zones, although monitoring crews and air surveillance will incur some expense. If managers decide to suppress natural fires because of drought or other conditions, suppression efforts will incur the same costs and impacts on the land as under any other management plan (Section 310). Occasionally, a fire may spread from a natural-fire zone into a suppression zone. Suppression in these cases will be difficult and costly. The public reaction to fire "escape" will affect further implementation of natural fire management in Glacier and may impede similar plans in other natural areas.

333. ADVERSE EFFECTS AND MITIGATING MEASURES

- 333.1 Some visitors and area residents will object to any use of fire in Glacier, and to reduced visibility caused by smoke. The total area covered by climax vegetation will decline. Fish populations may temporarily be reduced in some parts of streams near localized sites where large fuels were burned.

Interpretive programs will explain the place of natural fire in Glacier. Greater understanding of the importance of all stages of plant succession will contribute to greater appreciation of their beauty. Increased variety in plant cover, increased numbers and visibility of large mammals (moose, elk, beaver, and associated predators) and birds will mitigate this impact.

- 333.2 While large fires are burning, smoke will temporarily block distant views. During evening and early morning stable air periods, it will settle in the valleys and cause some visitor reaction. Visitors with respiratory problems may be adversely affected. Average length of visitor stay will occasionally be shortened.

The number of natural fires allowed may be limited during high visitor use or during temperature inversions, in order to reduce smoke and visual impact.

- 333.3 Fires may cross from natural-fire zones into suppression zones. With current fuel levels, it is doubtful that a well-organized suppression effort could stop a fire that had gained momentum.

Fire management zones will be designed so that natural boundaries contribute as much as possible to fire containment. Fuels may be reduced mechanically or by prescribed fire to form buffer areas around management zones. Fires will be monitored to determine if the fire will spread across zone boundaries. If so, or if human life will be endangered, control efforts at the fire, along zone boundaries and near critical areas will be undertaken.

- 333.4 Frequent burning on localized sites in large burns can cause accelerated erosion and slow vegetative succession.

Severe erosion and slow vegetative recovery may be natural events. The management plan for an area may be altered to eliminate fires for a time.

- 333.5 On each fire and in each zone where suppression is the decision, all adverse impacts of Alternative 1 will still be present (Sec. 313).

Prescribed fire and mechanical modification of fuels will be considered for areas where it is not safe to allow natural fires to burn. Any mechanical modification will require a specific environmental assessment. Each prescribed fire (Section 340) will be documented with specific objectives and thorough planning for ignition, containment and backup in case of emergency. Research on the ecological role of fire will continue so that the fire management plan may be improved and expanded. The overall impact of this alternative, when compared to total suppression over the entire park, will be less.

333.6 Where the need for fire has already been identified as critical, such as in the ponderosa pine savannah, natural fires may remove the current vegetation because of unnatural fuel distribution.

Prescribed fire (Section 340) may be used to break up fuel blocks and restore fire to critical areas immediately; the natural fire frequency will then be able to maintain them as it did previous to man's intrusion.

333.7 A fire in a natural fire zone, unlike most suppressed fires, is not always controlled in a matter of days. Some management fires will require personnel and equipment for monitoring and 24-hour surveillance for a duration of weeks or months. In cases where manpower is taxed for monitoring natural fires, preparation for other fires may suffer. Control will be required in some cases to prevent fires from spreading across boundaries or to protect life and property. When this occurs, further costs will accrue.

Overall wildfire suppression costs will decrease, in the long run. Suppression costs, however, are usually met by a funding procedure separate from park operating expenses. Separate funding procedures have not been established for natural fire management, so costs of fire monitoring will be met out of routine operating funds.

The savings in suppression will not actually mitigate the costs of monitoring natural fires.

333.8 In addition to financial costs, consideration must be given to the priorities on the park resource manager's time.^{1/} The integrity

^{1/} Comments by C. M. Fauley 1976.

of Glacier National Park is threatened by numerous influences such as Cabin Creek coal mining north of the international border; adjacent U.S.F.S./B.L.M. and state oil and gas leasing; fluorides from an aluminum plant; domestic livestock trespass; antiquated sanitation systems; increased visitation in fragile backcountry areas and in critical wildlife habitat; and increasing winter use. Management fires may drain the park's management resources in regard to these other resource concerns.

No mitigating measures are planned.

334. SHORT-TERM EFFECTS IN RELATION TO LONG-TERM EFFECTS

- 334.1 There will be temporary reduction of visibility by smoke, but this will be followed by greater variety in the landscape and increased species diversity. Greater biotic complexity on a site will last until the forest canopy closes and will then decline, a natural cycle. The overall vegetative pattern created by natural fire will be a mosaic, including habitat for organisms that require both open and dense habitat. In the long run, climax stands and watersheds will show increased vitality because of periodic renewal by fire.
- 334.2 Succession on some sites may be dramatically altered after fire, because of unexpected intensity or subsequent severe weather. As natural phenomena, these occasional, rapid alterations belong in the fire environment. They will be available for observation and study. Wilderness and scientific resources will be preserved. The long-term objective of restoring fire to its natural place as a significant factor in the park ecosystem will be achieved. The organic purposes of Glacier National Park to perpetuate the natural environment for the inspiration and enjoyment of present and future generations will be fulfilled.
- 334.3 Any time a fire is allowed to burn, there is increased risk that, at some time before the fall rains and snows extinguish it, it will burn or spot in a zone where fires are not allowed. This risk will become less as more is learned from monitoring of natural fires and as prescription fires are implemented to reduce risks. The long-term hazard of large fires in unnatural fuels will be slightly reduced with each natural fire, but these effects belong to very long

cycles, in terms of human perspective. They will be measurable, if at all, only after another century or two.

- 334.4 Initial investments for research, planning and training will result in eventual reduced costs of fire suppression and less disturbance of the natural environment from fire suppression activity.

335. IRREVERSIBLE AND IRRETRIEVABLE EFFECTS

335.1 Irreversible

Short-term intrusions by fire-blackened sites and the even more temporary effects of smoke pollution will require commitment to a thorough, continual public education and public relations program. Commitment to a natural fire management program will be accompanied by the continual risk that a large fire burning in a zone or one which escapes across zone boundaries will force temporary loss of the use of natural fire in Glacier and in other natural areas.

335.2 Irretrievable

Under any fire management plan in any natural environment, valuable private property, neighboring lands and historical sites such as old patrol cabins, ranger stations and chalets, will be susceptible to damage or loss from fire. The risks under this management plan are slightly increased in natural-fire zones during years of high fire danger, but will, with time, become less than those of Alternative 1.

Chapter 3. ALTERNATIVE FIRE MANAGEMENT PLANS

Alternative 4. Introducing Fire by Artificial Ignition to Selected Areas (Prescribed Fires)

- 341. Description of Alternative
- 342. Impacts of Prescribed fires
 - 342.1 Effects on Vegetation
 - 342.2 Effects on Wildlife
 - 342.3 Effects on Soil and Water
 - 342.4 Effects on Air Quality
 - 342.5 Effects on Visitor Experience, Park Planning and Economics
- 343. Adverse Effects and Mitigating Measures
- 344. Short-Term Effects in Relation to Long-Term Effects
- 345. Irreversible and Irretrievable Effects

341. DESCRIPTION OF ALTERNATIVE: Introducing Fires by Artificial Ignition to Selected Areas (Prescribed Fires)*
- 341.1 In certain areas and at certain times, intentional fires will be introduced into selected areas. Weather conditions will be selected and fuels modified, if necessary, so that the fire can be confined to a pre-determined area but will burn with sufficient intensity to accomplish specified management goals. If prescribed fire is used in Glacier, it will be in conjunction with either Alternative 1 (total suppression of all fires) or Alternative 3 (allowing selected fires to burn). The prescribed fire alternative alone provides no plans for natural and man-caused fires.
- 341.2 When prescribing the use of fire in Glacier, managers will evaluate weather, topography, fuels, safety and smoke dispersal potential, and will develop a strategy for confining the fire to the desired area. This plan will often include constructing fire line, but already-existing fuel breaks, such as roads, trails, streams and other natural vegetative discontinuities will be exploited to minimize disturbance of the environment.

*The meaning of "prescribed fire" as used throughout this section is taken from the Society of American Foresters definition (1971): Skillful application of fire to natural fuels under conditions of weather, fuel moisture, soil moisture, etc., that will allow confinement of the fire to a predetermined area, and at the same time will produce the intensity of heat and rate of spread required to accomplish certain planned benefits to one or more objectives of silviculture, wildlife management, grazing, hazard reduction, etc. A broader definition frequently used (U.S.D.I. 1974 Nov 1:590.1.3B) may include fires set by either artificial or natural causes. To avoid ambiguity, the latter use will be avoided here.

341.2 Prescribed fire may be used to reduce hazardous fuel loads in areas where natural fires are not allowed (along boundaries of fire management zones or near developed areas) and in areas where the natural fire regime can be restored without undue risk after unnatural fuel loadings have been reduced. In order to safely return stands such as ponderosa pine savannahs to a near-natural state, prescriptions may combine mechanical removal or redistribution of fuels with fire.

341.3 Many of the impacts of a successful prescription fire will be similar to those from natural fires. However, there are important technical differences. When land managers decide to introduce fire on a site, they determine the fire's boundaries, size and intensity. They choose whether or not to begin burning, depending on predicted weather and smoke dispersal conditions. They are able to estimate quite closely the costs of implementation. Prescribed fire gives the managers much greater control than natural or accidental man-caused fires. There are important philosophical differences between lightning fires in a land molded by natural forces and the planned introduction of fire under controlled conditions. Even if it were economically and technologically possible, an attempt to simulate the distribution and effects of natural fires by using prescription fire would not be appropriate in a natural area. Natural fire management and prescribed fire can complement one another, but natural fire cannot be replaced by prescribed fire.

341.4 Prescription fires are no longer an innovative technique in the management of natural areas. Everglades National Park first began field work on the effects of natural fires in 1951, and initiated a

prescribed fire research program in 1958. 1/ Sequoia-Kings Canyon National Parks first prescribed fires in 1969. 2/ In Grand Teton National Park, the Teton Wilderness Area and the Alberta Rockies, all areas with climate and vegetation to some degree similar to Glacier's, prescribed fire is being used to reduce fuels and restore natural fire. 3/ Other national parks where prescribed and natural fire are currently being used include Yosemite, Lava Beds and Crater Lake. 4/

342. IMPACTS OF PRESCRIBED FIRES

342.1 Effects on Vegetation

- 342.11 The benefits of natural fire will occur. Fuels will be altered, usually reduced, germination of many tree and shrub species will be stimulated and seedbeds will be prepared for species which require light and warm soil, cleared of litter. Less risk of "escape" will occur than with fires under other management alternatives, because the location and time of ignition are chosen, and control will be thoroughly preplanned. The effects which follow fire will depend on weather and fuel conditions during the burn and the available seed, all of which can be managed and planned to some extent. Succession will also depend on some post-fire conditions, such as rainfall and later seed production on the site. 5/

1/ Robertson 1953; Robertson et al. 1966. Described by Butts (1968): 34.

2/ Kilgore 1972: 346.

3/ Grand Teton National Park 1974 Nov 7; Reese et al 1975; Agee 1974.

4/ Bevins (pers. com.)

5/ Vogl 1970: 69.

- 342.12 Prescribed fires will not usually be used when burning conditions would cause the greatest fuel reduction because the hazards of spread are also very high. Fall burning, burning with backfires, and the repetition of fire on a site are techniques by which the effects of intense natural fires will be simulated where necessary. 1/ Because fuel distributions can be manipulated prior to a burn, prescription fire may be the only method by which some stands of ponderosa pine, where fuels are distributed unnaturally because of fire suppression, can be perpetuated in Glacier.
- 342.13 The use of prescribed fire requires detailed study and careful planning.

In any situation where a man is interjecting management upon the landscape, it is important that the necessary study be undertaken to make sure that his management does what is intended, as well as assuring himself that what he does will not also provide unwanted effects. 2/

The ponderosa pine savannahs are the only areas in Glacier for which prescribed fire has been specifically recommended 3/, but further use may be planned in the future. Where careful study indicates that prescribed fire will provide the most benefits with the least cost to park users, area residents and the environment, this alternative will be considered.

Fires may be used to reduce the risk of natural fires crossing zone boundaries, or to return fuels on a site to levels so that natural fires may be allowed there. Where forest fuel loadings are judged hazardous to areas of intense visitor or administrative use, or to

1/ Agee 1974: 26.

2/ Lunan 1972: 2-3.

3/ Kessell 1975 Jan 2: 5; Lunan 1972: 55-56.

park structures, prescription fires may be introduced to provide for long-term safety. In grasslands and savannah communities near the park's boundaries, prescription fires may substitute for natural fires because of the danger of trespass from park fires onto neighboring lands.

342.2 Effects on Wildlife

Prescribed fire has been used in many areas to create or maintain habitat for large mammals (Talon Creek, Bitterroot Mountains in Montana, and Table Mountain in eastern Washington).* Prescriptions will usually produce small areas surrounded by mature forest, compared with the occasional large burns produced by some wildfires. The diverse food and cover available on recently burned sites and along stand boundaries will allow maximum diversity in plants and all kinds of animals. 1/

342.3 Effects on Soil and Water

Although the effects of fire are always variable, managers will control the burning conditions and intensity of prescribed fires. As a result, unwanted soil erosion from prescribed fires will be rare. Some humus and vegetation will usually remain, so that nutrients will become available for vigorous plant development after the fire. Little impact from prescribed fires will be noticed on streams. 2/

342.4 Effects on Air Quality

Like other impacts from prescribed fires, the amount of smoke and its dispersal will be subject to control.

Fires can be scheduled at times when atmospheric conditions will vent smoke to high altitudes and when subsequent weather conditions will cleanse the atmosphere within a reasonable period. 3/

*Leege 1968: 240-241. Talon Creek work is being conducted by Rod Norum; Table Mtn. prescriptions by Dale Ward (Bevins, pers. com.).

1/ Isaac 1963: 12; Taylor, D. 1973.

2/ Agee 1974: 35-36.

3/ Beaufait 1971: 19.

Burning under dry fuel conditions will produce much less particulate matter than with green fuels. 1/ Hot fires and backfires will produce the smallest and least visible particulates from heavy fuels. 2/ Information concerning atmospheric burning conditions will be acquired from forecasts for prescribed burning and spot (site-specific) forecasts which are provided by the National Weather Service. 3/ Unstable atmospheric conditions and high-elevation winds blowing away from populated areas will disperse smoke rapidly; subsequent rains will cleanse the atmosphere and return particles to the earth.

342.5 Effects on Visitor Experience, Park Planning and Economics

342.51 Plant communities now threatened by fire suppression will be perpetuated for the enjoyment of visitors. Visitors will view greater variety in the landscape and come to an understanding of the dramatic renewing power of fire. Fire control personnel and researchers will be able to observe and work with fire behavior, and measure succession and other effects in a planned situation.

Economic and aesthetic effects from area closure and from slow smoke dispersal will be of short duration. Prescription fires will be used to protect valuable areas of human use. The risks of "escape" incurred by introducing fire will be weighed against the value of resources which will be endangered if fire is not used.

342.52 When managers prescribe fire locations and perimeters, they are controlling a natural system; they become "gardeners" in the sense that fire distribution and size are planned, rather than occurring at near-random times

1/ Komarek 1970: 156.

2/ Schaefer 1973: 286, Ward & Lamb 1970: 131.

3/ Burnham & Paterson 1975: 5-6.

and places. 1/ The effects of substituting a man-caused ignition for a possible natural one will include firelines, planned boundaries and intrusion of equipment and personnel during the burn. Costs for prescribed fires will be incurred from planning, training of personnel, site preparation and use of equipment.

Prescribed fires are at this time impractical in areas remote from roads. Because of the philosophical impacts of restoring "a certain abstract condition" rather than permitting natural processes to operate,2/ and because of the expense of prescribing fire, this fire management alternative cannot substitute for natural fires. It is instead an alternative to total suppression with mechanical fuel manipulation where the risks are too great to permit natural fires. 3/

1/ Murie 1974 Jul 18: 5.

2/ Kilgore 1972: 366.

3/ Agee 1974: 25.

343. ADVERSE EFFECTS AND MITIGATING MEASURES

343.1 Recently burned landscapes may not be appreciated by visitors until more extensive ecological education has been accomplished throughout parks and schools.

Specified objectives of restoring valuable ecosystems or reducing hazards of uncontrollable fire will be accomplished. In addition, the effects of fire and the succession which follows fire can be observed by visitors and measured by ecologists, contributing to public understanding of fire's role and the refinement of the fire management plan.

343.2 Smoke from prescribed fires will in some cases temporarily reduce visibility.

This problem will be mitigated by doing prescribed burning under unstable atmospheric conditions when smoke will not accumulate. There will usually be lower particulate concentrations and less impact on visitors and area residents from prescribed fires than from any other fire management practices. Some fire can be scheduled in the "off season" when smoke impact will affect fewer visitors but management objectives can still be accomplished.

343.3 Prescribed burning substitutes the plans and technology of park management for what was, before European man's presence, an event of sporadic natural occurrence. The concept of wilderness as it applies to Glacier will be affected by this philosophical difference. The effects of human intrusion on wilderness values will be mitigated by the long-term perpetuation of the area which would be threatened

by not introducing fire, and by restoration of the natural fire regime in some areas.

- 343.4 Fire lines and retardants, where they are used to control a prescribed burn, will directly alter vegetation from the natural pattern of succession. Fire lines will tend to accelerate soil erosion and form strips of delayed plant succession.

By using natural or existing fire breaks, such as roads and geologic features, the impact from fire lines will be minimized.

- 343.5 The possibility that a prescribed fire will "escape" will always be present. Damage to developments or biotic communities that were not intended to be burned is a greater possibility for this fire management method than for use of lightning fires in natural-fire zones, because fires will be prescribed only in areas where the risks from natural fires are unacceptable.

Suppression will be applied, visitors will be alerted and evacuated if necessary, and protection strategies will be implemented for facilities or park boundaries which are threatened.

- 343.6 Costs will accrue for planning and training, preparing a site for prescribed fire and carrying it out. These costs will not equal the usual costs of fire suppression because aircraft will not be used extensively and access will be relatively easy. But fiscal operations in the National Park Service do not permit savings from fire suppression to be applied to other fire management activities. Prescribed fire will be used only where protection of environmental or man-made resources warrants the expenditure.

344. SHORT-TERM EFFECTS IN RELATION TO LONG-TERM EFFECTS

- 344.1 Expenditures and any degradation of wilderness values from the planned, direct application of fire will be exchanged for perpetuation of plant communities, protection of valuable structures and neighboring lands, and preservation of irreplaceable historic resources. Use of prescribed fire may in some areas enable managers to restore the natural fire regime.
- 344.2 The risk that a prescription burn will burn more than is intended will be traded for reduction of the long-term risks posed by systematic fire suppression.

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345. IRREVERSIBLE AND IRRETRIEVABLE EFFECTS

345.1 Irreversible

If a fire should escape control, alterations in the surrounding area will occur. Valuable installations may be damaged or destroyed and irreplaceable historic sites may be lost.

345.2 Irretrievable

The ideological intrusion of planning what would be a natural event and altering fuel arrays prior to burning will be unavoidable.

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APPENDIX A
Measurement Conversion Factors

UNIT	CONSTANT	UNIT	1/CONSTANT
Centimeters	* 2.5400	= inches	0.3937
Meters	* 3.2808	= feet	0.3048
Meters	* 0.049709	= chains	20.117081
Kilometers	* 0.62139	= miles	1.60930
Hectares	* 2.4710	= acres	0.4047
Sq. km.	* 0.3861	= sq. mi.	2.5900
Meters/min.	* 2.982552	= chains/hr.	0.335283
Metric tons/ha.	* 0.0205	= pounds/sq.ft.	48.78
Metric tons/ha.	* 0.446094	= tons/acre	2.241680
Kg.Cals/m/min.	* 1.209482	= BTU/ft./min.	0.826800

TEMPERATURE CONVERSION

(FAHRENHEIT - 32) * 0.5556 = CELSIUS

CELSIUS/0.5556 + 32 = FAHRENHEIT

APPENDIX B
Fire Size Classes

CLASS	SIZE RANGE (HECTARES)	(ACRES)
A	0. - 0.10117	0.00 - 0.25
B	0.10117 - 4.04690	0.25 - 10.
C	4.04690 - 40.46900	10. - 100.
D	40.46900 - 121.40700	100. - 300.
E	121.40700 - 404.69000	300. - 1000.
F	404.69000 - 2023.45000	1000. - 5000.
G	2023.45000 and greater	5000. and greater

APPENDIX C
Common and Scientific Names

PLANT SPECIES

COMMON NAME	SCIENTIFIC NAME
Alder, green	<u>Alnus sinuata</u>
Alder, mountain	<u>Alnus incana</u>
Aspen, quaking	<u>Populus tremuloides</u>
Birch, bog	<u>Betula glandulosa</u> var. <u>glandulosa</u>
Birch, water	<u>Betula occidentalis</u> var. <u>inopina</u>
	var. <u>occidentalis</u>
Birch, western paper	<u>Betula papyrifera</u> var. <u>commutata</u>
	Var. <u>subcordata</u>
Cedar, western red	<u>Thuja plicata</u>
Cottonwood	<u>Populus trichocarpa</u>
Deerbrush	<u>Ceanothus velutinus</u> var. <u>velutinus</u>
Douglas-fir	<u>Pseudotsuga menziesii</u> Var. <u>glauca</u>
Fir, grand	<u>Abies grandis</u>
Fir, subalpine	<u>Abies lasiocarpa</u>
Fireweed (Willow-weed)	<u>Epilobium</u> spp.
Hemlock, western	<u>Tsuga heterophylla</u>
Hollyhock	<u>Lilium rivularis</u>
Larch, alpine	<u>Larix laricina</u>
Larch, western	<u>Larix occidentalis</u>
Maple, mountain	<u>Acer glabrum</u> var. <u>douglasii</u>
	var. <u>glabrum</u>
Mountain-lover	<u>Pachistima myrsinites</u>
Pine, limber	<u>Pinus flexilis</u>
Pine, lodgepole	<u>Pinus contorta</u> var. <u>latifolia</u>
Pine, ponderosa	<u>Pinus ponderosa</u>
Pine, western white	<u>Pinus monticola</u>
Pine, whitebark	<u>Pinus albicaulis</u>
Pyrola	<u>Pyrola</u> spp.
Sagebrush, big	<u>Artemisia tridentata</u>
Serviceberry, western	<u>Amelanchier alnifolia</u>
Spruce, Engelmann	<u>Picea engelmannii</u>
Spruce, white	<u>Picea glauca</u>
Yew, western	<u>Taxus brevifolia</u>

Plant nomenclature taken from Kessell, S.R. 1974a. Checklist of vascular plants of Glacier National Park. Glacier National Park Natural History Association, West Glacier. 63 pp.

MAMMAL SPECIES

COMMON NAME	SCIENTIFIC NAME
Bear, black	<u>Ursus americanus</u>
Bear, grizzly	<u>Ursus arctos</u>
Beaver	<u>Castor canadensis</u>
Caribou, woodland	<u>Rangifer caribou</u>
Coyote	<u>Canis latrans</u>
Deer, black-tailed	<u>Odocoileus hemionus</u> subspecies
Deer, mule	<u>Odocoileus hemionus</u> subspecies
Deer, white-tailed	<u>Odocoileus virginianus</u>
Elk, American	<u>Cervus canadensis</u>
Goat, mountain	<u>Oreamnos americanus</u>
Hare, snowshoe	<u>Lepus americanus</u>
Lion, mountain	<u>Felis concolor</u>
Marten, pine	<u>Martes americana</u>
Moose,	<u>Alces alces</u>
Sheep, bighorn	<u>Ovis canadensis</u>
Wolf, Rocky Mountain timber	<u>Canis lupus irremotus</u>

BIRD SPECIES

COMMON NAME	SCIENTIFIC NAME
Bluebird, Mountain	<u>Sialia currucoides</u>
Grouse, Blue	<u>Dendragapus obscurus</u>
Grouse, Ruffed	<u>Bonasa umbellus</u>
Hawk, Red-tailed	<u>Buteo jamaicensis</u>
Junco	<u>Junco</u>
Kestrel, American	<u>Falco sparverius</u>
Sapsucker, Yellow-bellied	<u>Sphyrapicus varius</u>
Warbler family	<u>Parulidae</u>
Woodpecker, Northern black-backed	
Northern	<u>Picoides arcticus</u>
Woodpecker, /three-toed	<u>Picoides tridactylus</u>

Bird and mammal taken from Shea, David S. 1971 a and b.
 Glacier National Park Birds and Mammals Field Checklists.
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APPENDIX D

Glossary of Selected Terms

AGE OF STAND - Years since the last fire which burned most of the forest canopy.

CLIMATE - Weather at a given place or area over a period of time, expressed in averages, totals, extremes and frequencies.

Brown & Davis 1973:112.

CLIMAX VEGETATION - The final or stable community in a developmental series, self-perpetuating and in equilibrium with the physical habitat.

Odum 1971: 265.

CROWN FIRE - A fire that advances from top to top of trees more or less independently of the ground or surface fire.

U.S. Forest Service 1956.

DIVERSITY - Variety; multiformity (World Publ. Co., 1957). Sometimes measured in biological systems by the number of species present ("richness"). Other indicators of diversity, measures of "dominance" and "evenability," take into account the distribution and quantity of each species present (Odum 1971: 148-152).

DROUGHT - A period of moisture deficiency, extensive in area and time.

Deeming et al. 1972: 15.

DUFF - The partially decomposed organic material of the forest floor beneath the litter of freshly fallen twigs, needles, and leaves.

Deeming et al. 1972: 15.

ECOSYSTEM - A physico-chemical environment (abiotic) and a biotic assemblage of plants, animals, and microbes, which function together.

Kormondy 1969: 1.

EMISSIONS - Gases and particles which are discharged by the combustion of forest fuels in fire, including carbon dioxide, various hydrocarbons (terpenes, olefins and aldehydes), water and particulates. Only carbon dioxide, water and particulates exist in forest fire smoke above background amounts.

Beaufait 1971: 9.

FIRE DAY - A day on which at least one forest fire is discovered.

FIRE SEASON - The period of the year during which fires are likely to occur, spread and do sufficient damage to warrant organized fire control.

Brown & Davis 1971: 112, from U.S.F.S. 1956.

FIRE WEATHER - Weather conditions which influence fire starts, behavior or control.
Brown & Davis 1973: 112.

FIRE YEAR - A year during which at least one forest fire is discovered.

FIRE YEAR (IMPORTANT) - A year in which at least 6% of a study area burned (Heinselman 1973: 344). Associated with periodic drought, and tending to occur in cycles. "Though there seems to be some cyclic trend to the recurrence of severe droughts, they are due to large-scale fluctuations... which are not yet well understood" (Brown & Davis 1973: 115).

FUEL (FOREST) - The materials which are burned in a forest fire: duff, litter, grass, dead branchwood, snags, logs, stumps, weeds, brush, foliage, and, to a limited degree, green trees.
Brown & Davis 1973: 8.

FUEL BUILDUP - The accumulation of forest fuels which occurs as a stand ages. Buildup in the different types of fuels does not usually occur as a steady rate of increase, but instead follows the cycle of vegetation production and succession.

FUEL LOADINGS - Amount of forest fuel present on a particular site at a given time.

GROUND FIRE - This term has been used to refer only to fire in the duff layer beneath the litter on the forest floor (Brown & Davis 1973: 9). In this paper, however, it is used in opposition to crown fire, and therefore refers to a fire spreading through any or all of three layers: litter, woody dead and down, or standing shrubs (three-strata spread model by Collin Bevins, 1976, Gradient Modeling, Inc.).

RELATIVE HUMIDITY - Ratio between amount of water vapor a unit of air contains at a given temperature and the amount of water vapor required for saturation at that temperature and pressure.

Brown & Davis 1973: 121.

INVERSION - Wherever temperature increases with altitude.

Brown & Davis 1973: 124.

LITTER - The top layer of the forest floor, composed of loose debris, including dead sticks, branches, twigs, and recently fallen leaves or needles; little altered in structure by decomposition.

Deeming et al. 1977: 16.

LOCALIZED - Limited to a particular area; clumped on a site rather than randomly distributed.

MANAGEMENT FIRE - Fires of natural origin and also prescribed fires, which contribute to the attainment of the park's management objectives through execution of pre-determined prescriptions defined in a portion of an approved Resource Management Plan.

National Park Service 1975: 1.

MAN-CAUSED FIRES - Refers in this paper to forest fires ignited accidentally (from campfires, for instance, or railroad brakes) and by arsonists; does not include fires ignited intentionally by fire management personnel to fulfill approved, documented management objectives (prescribed fires).

MATURITY - Stand age after which change is too slow to be predictable with models now available. Maturity is reached in Glacier's east-side forests around 200 years after fire, on the west side around 150 years. Larch may, for instance, decrease from 5% to 1% in the 300 years after maturity, but the rate of change is too slow to be measurable.

MOSAIC (VEGETATIVE) - The pattern of vegetative cover which occurs over a large area and is composed of several community types because of such influences as elevation, topography, micro-climate, avalanche, flood, soil conditions and fire.

NATURAL-FIRE ZONE - An area, bounded for the most part by natural fuel discontinuities, in which, under weather conditions specified in a fire management plan, lightning-caused fires may be allowed to burn naturally.

PARTICULATES - Microscopic bits of matter ranging in size from 500 microns down to .0002 of a micron. (There are 10,000 microns in a centimeter, about 25,000 in an inch.) Particulates can be suspended in the atmosphere from a few seconds to several months. They are usually composed of carbon or mineral ash (Beaufait 1971: 9). Some properties of particulates themselves, and their ability to carry or react with other substances, makes them potentially harmful to human health (Spirtas & Levin 1970: 1).

PERIODICITY (FREQUENCY) OF FIRE - The average time lapse between natural fires in an area. Fire rotation is usually a summary of fire's effects over a large, diverse area. Periodicity assumes a relatively uniform area, and refers to the habit of fire in that specific community.

POLLUTION - Any unwanted change in a chemical, physical, biological or aesthetic component of an ecosystem, caused specifically by man's addition of a substance or condition (e.g., extraneous noise) to the ecosystem
McClelland 1968: 60.

PRESCRIBED FIRE - The skillful application of fire to natural fuels under conditions of weather, fuel moisture, soil moisture, etc., that will allow confinement of the fire to a predetermined area, and at the same time will produce the intensity of heat and rate of spread required to accomplish certain planned benefits to one or more objectives of silviculture. Objective is to apply fire scientifically to realize maximum net benefits at minimum damage and acceptable cost.

Society of American Foresters 1971.

ROTATION OF NATURAL FIRES - The average number of years required in nature to burn over and reproduce an area equal to the total area under consideration.

Heinselman 1973: 358.

SNAG - An isolated dead tree, killed by fire, insects, disease, lightning, or other factors, which remains standing within the living forest.

McClelland 1975: 414.

STABILITY - The ability to resist change. Even though fire may revert vegetation to earlier stages, and thereby appear to reduce stability, the successional communities initiated by fire actually generate stability because they result in diversity of species, life-forms and the overall distribution of vegetative communities.

Vogl 1970: 71-72.

SUCCESION AFTER FIRE - Selective regeneration of species which follows fire.

Heinselman 1970: 35.

TIMELAG - The time necessary for a fuel particle to lose approximately 63% of the difference between its initial moisture content and its equilibrium moisture content.

Deeming et al. 1972: 18.

TOTAL - SUPPRESSION ZONE - An area in which policy dictates that all natural and man-caused fires will be suppressed under all weather conditions.

UNGULATES - The group of mammals which have hoofs. (Includes, in Glacier, white-tailed and mule deer, American elk, moose, bighorn sheep and mountain goats.)

World Publ. Co. 1957.

WILDERNESS - Undeveloped Federal land retaining its primeval character and influence which "... generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable..." The visitor must accept wilderness largely on its own terms. Modern conveniences are not provided for the comfort of the visitor; and the risks of wilderness travel, of possible dangers from accidents, wildlife, and natural phenomena must be accepted as part of the wilderness experience.

National Park Service 1975 Jul.

APPENDIX E
Forest Fuel and Weather Values for Simulation

I. Forest Fuel Accumulation Values (metric tons/hectare)

FUEL TYPE	YEARS SINCE LAST FIRE			
	25	50	100	200
Litter	5.7	4.8	6.6	4.6
Grasses	0.6	0.8	0.9	1.3
1 Hour	0.8	1.0	1.0	1.8
10 Hour	1.6	1.6	1.4	5.0
100 Hour	9.0	6.0	3.5	6.0
>100 Hour	64.0	11.0	22.0	77.0
Shrub foliage	0.3	0.6	0.7	0.2
Shrub stems	1.4	2.2	3.6	1.0

II. Peabridge Weather for Selected Days of high Burning Index

Rate of Days	FUEL MOISTURE (PERCENT)			(MPH) WINDSPEED	(PERCENT) CURED
	1-HOUR	10-HOUR	100-HOUR		
1-5	2.2	2.2	5.5	13	100
10th	3.0	3.2	6.4	10	100
20th	5.5	3.8	7.8	8	95