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# Fire Ecology of Western Montana Forest Habitat Types

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## RESEARCH SUMMARY

This report summarizes available information on fire as an ecological factor for forest habitat types in western Montana. The forest habitat types are assigned to Fire Groups based primarily on fire's role in forest succession. For each Fire Group, information is presented on (1) the relationships of major tree species to fire, (2) fire effects on undergrowth, (3) forest fuels, (4) the natural role of fire, (5) fire and forest succession, and (6) fire management considerations.

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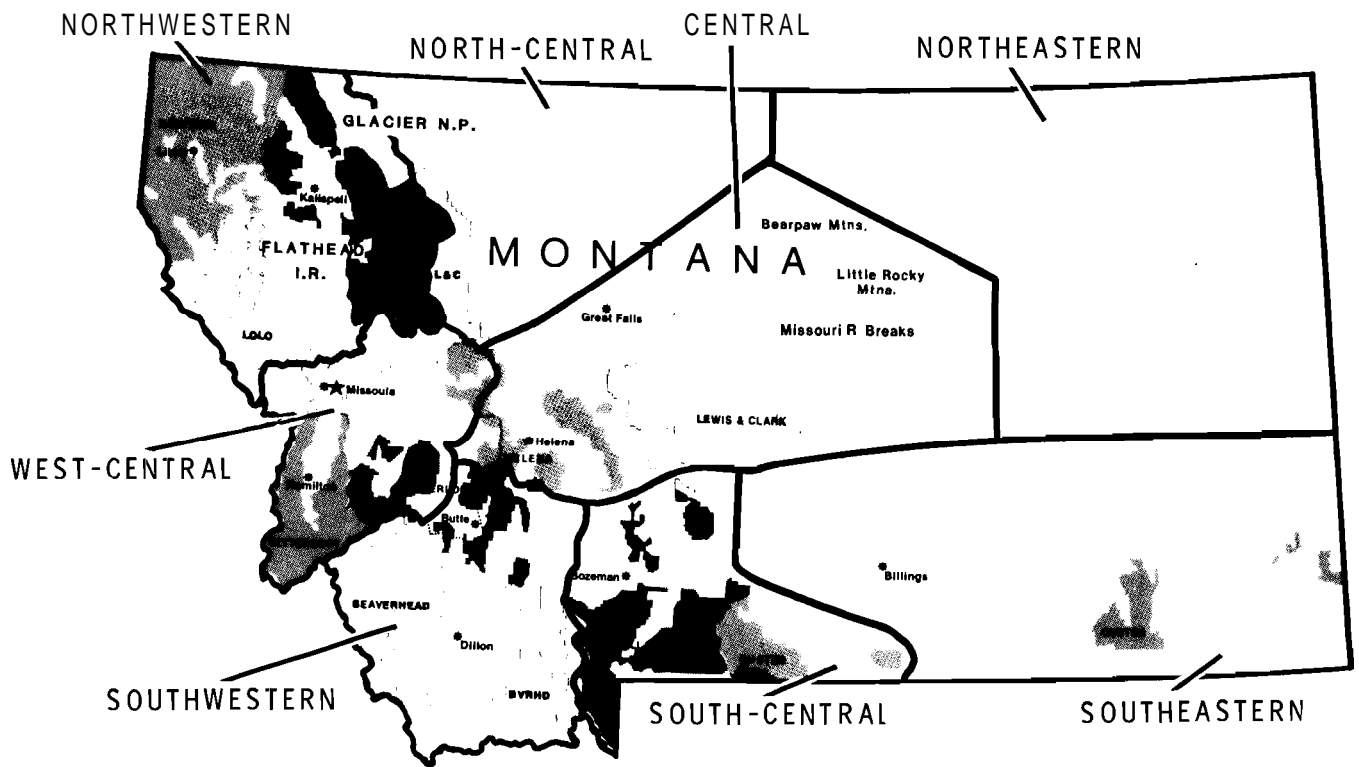


Figure 1—Forest regions of Montana (source: Arno 1979).

# Fire Ecology of Western Montana Forest Habitat Types

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## INTRODUCTION

This report summarizes available fire ecology and management information that applies to forest habitat types west of the Continental Divide in Montana—specifically, on the Bitterroot, Flathead, Kootenai, and Lolo National Forests; the western portions of the Deerlodge and Helena National Forests and Glacier National Park; the Flathead Indian Reservation; and on adjoining State and private timberlands. The primary purpose of this report is to help forest managers understand the role of fire in western Montana forests, especially the role of fire in forest tree succession.

Habitat types are assigned to 10 "Fire Groups" based on the response of the tree species to fire and the roles these tree species take during successional stages. The exception is Fire Group Zero, which is a description of miscellaneous vegetation types. Because Fire Groups One and Three only occur east of the Continental Divide in Montana, they are not discussed in this report (see Fischer and Clayton 1983).

The Fire Groups defined in this report include a number of borderline cases. Differences in fire behavior and in successional patterns often depend on small local changes in fuel, temperature, moisture, sunlight, topography, and seed availability. Thus, it would be possible for stands that key to the same habitat type to fall into different Fire Groups. Assignment of habitat types to more than one Fire Group is kept to a minimum in this report. A certain reliance is placed on the judgment of the land manager in evaluating the local conditions of any particular site. The groups defined in this report are intended as a general guide, not a definitive treatment.

## Format

This report is patterned after "Fire Ecology of Montana Forest Habitat Types East of the Continental Divide" (Fischer and Clayton 1983) and essentially updates and expands the scope of a previous report, "Fire Ecology of the Lolo National Forest" (Davis and others 1980), which is no longer available.

The major topics presented in this report are:

**Relationship of Major Tree Species to Fire**—This section contains a discussion of each principal tree species in western Montana forests with regard to its resistance or susceptibility to fire and its role as a successional component of forest communities. Particular attention is given

to special adaptations to fire, such as corky bark, serotinous cones, or seeds that require mineral soil for germination.

**Undergrowth Response to Fire**—This is a brief summary of the effect of fire on the response of important understory grass, forb, and shrub species. Particular attention is given to fire-adaptive traits or survival strategies that determine whether fire generally increases or decreases species cover in the immediate postfire period.

**Wildlife Response to Fire**—This section contains brief summaries of the general effects of fire on common western Montana mammals, reptiles, amphibians, and birds. Fire response of wildlife is largely inferred from expected changes in habitat as a result of fire.

**Fire Use Considerations**—This briefly summarizes cautions that apply to the use of fire for resource management purposes. Emphasis is on effective use of fire, site protection, minimizing damage to residual stand, and wildlife habitat protection.

**Habitat Types and Phase, ADP Codes, and Forest Region**—The Fire Groups are defined with reference to "Forest Habitat Types of Montana" (Pfister and others 1977). A complete list of the habitat types west of the Continental Divide in Montana is included as appendix A.

Habitat types are designated in the standard format of "series/type-phase," in which "series" designates the potential climax dominant tree, "type" designates a definitive undergrowth species, and "phase" provides a further subdivision where needed. The "ADP codes" are the automatic data processing codes for National Forest System use in the Forest Service Northern Region.

The forest region designation refers to those described for Montana by Arno (1979) as illustrated in figure 1.

**Vegetation**—We describe the characteristic overstory and understory vegetation for each Group. Climax and seral species are identified. A complete distribution of tree species showing their successional status is included as appendix B.

**Forest Fuels**—For each Fire Group, we discuss the kind and amount of dead, woody material likely to be found on the forest floor. The discussion is based on fuel inventory data (Brown 1974) from two sources. The prime source is a photo series for appraising natural fuels in wild stands on Montana National Forests (Fischer 1981a, 1981b, 1981c). The other source is a summary of downed woody fuel on National Forests in the Northern Rockies (Brown

and See 1981). Summary fuel information pertaining to all Fire Groups is presented in a separate section preceding the Fire Group discussions.

It is important to remember that these discussions are about dead, woody material on the forest floor. Live fuel and standing dead fuel are treated casually, if at all, because fuel data on this material were not collected as part of the inventories mentioned above.

Cover type names used in this section were suggested by the Society of American Foresters (Eyre 1980).

**Role of Fire**—Information on the important trees and forest fuel characteristics is integrated with the results of fire history studies to describe the historical (presettlement period, generally prior to 1900) role of fire in shaping the vegetative composition of a particular Fire Group. This section is mainly a literature review covering succession and fire within the appropriate habitat types.

For this report, three levels of fire severity are recognized: low or cool, moderate, and high or severe. A **low-severity** or cool fire is one that has minimal impact on the site. It burns in surface fuels consuming only the litter, herbaceous fuels, and foliage and small twigs on woody undergrowth. Little heat travels downward through the duff. A moderate fire burns in surface fuels but may also involve a tree understory. It consumes litter, upper duff, understory plants, and foliage on understory trees. Individuals and groups of overstory trees may torch out if fuel ladders exist. A high-severity or severe fire is one that burns through the overstory and consumes large woody surface fuels or removes the entire duff layer over much of the area. Heat from the fire impacts the upper soil layer and often consumes the incorporated soil organic matter.

**Forest Succession**—The generalized succession diagram and associated text represents a simplified, synthetic overview of fire's role in succession for each Fire Group.

The diagram for each Fire Group represents a visual summary of the effects that fires of varying severity can have on the habitat types that make up the group. Secondary succession begins with the shrub/herb stage, but the diagram can be used from any stage of stand development. Numerous facts that may influence the vegetation on the landscape have been neglected to emphasize the potential influences of fire and fire suppression.

Successional pathway flow charts represent a synthesis of confirmed knowledge and unconfirmed speculation that forms a complex series of hypotheses concerning the many possible influences fire may have on the vegetation of the Fire Groups. The flow charts follow the method suggested by Kessell and Fischer (1981).

How trees respond to fire often depends on their size. Tree size classes used in our flow charts are defined by the Society of American Foresters (1958). Saplings are trees 2 to 4 inches in diameter at breast height (d.b.h.). Small poles are trees 4 to 8 inches d.b.h. Large poles are trees 8 to 12 inches d.b.h.

The conifer species names are symbolized to simplify the diagrams and flow charts. The symbols are defined as follows:

*Abies grandis*, grand fir (ABGR)

*Abies lasiocarpa*, subalpine fir (ABLA)

*Juniperus scopulorum*, Rocky Mountain juniper (JUSC)

*Larix lyallii*, subalpine larch (LALY)

*Larix occidentalis*, western larch (LAOC)

*Picea engelmannii*, Engelmann spruce (PICEA)

*Pinus albicaulis*, whitebark pine (PIAL)

*Pinus contorta*, lodgepole pine (PICO)

*Pinus monticola*, western white pine (PIMO)

*Pinus ponderosa*, ponderosa pine (PIPO)

*Pseudotsuga menziesii*, Douglas-fir (PSME)

*Thuja plicata*, western redcedar (THPL)

*Tsuga heterophylla*, western hemlock (TSHE)

*Tsuga mertensiana*, mountain hemlock (TSME)

**Fire Management Considerations**—This section suggests how the preceding information can be used to develop fire management plans that support land and resource management objectives. The discussion is intended to be suggestive, not dogmatic. Each manager is in a much better position than are the authors to relate the information in this report to a particular management situation.

## The Fire Groups

The forest habitat types of Montana have been assembled into 12 Fire Groups (table 1) that are defined as follows:

**Fire Group Zero:** A miscellaneous, heterogeneous collection of special habitats. In western Montana forests these sites exist as scree, forested rock, wet meadow, mountain grassland, aspen grove, and alder glade.

**Fire Group One:** Dry limber pine habitat types. These occur almost exclusively east of the Continental Divide in Montana.

**Fire Group Two:** Warm, dry ponderosa pine habitat types. This group consists of both open ponderosa pine stands with a predominantly grass undergrowth and dense mixed-aged stands of ponderosa pine. These sites may exist as fire-maintained grasslands and do not support Douglas-fir, except as "accidental" individuals.

**Fire Group Three:** Warm, moist ponderosa pine habitat types. These sites occur exclusively east of the Continental Divide in Montana. These sites are often occupied by stagnant, overgrown thickets of ponderosa pine saplings.

**Fire Group Four:** Warm, dry Douglas-fir habitat types. Under "natural" conditions, these sites support fire-maintained ponderosa pine stands. In the absence of fire, Douglas-fir regenerates beneath the pine and eventually dominates the overstory.

**Fire Group Five:** Cool, dry Douglas-fir habitat types. Douglas-fir is often the only conifer present on these sites. In the absence of fire, a dense Douglas-fir sapling understory may develop.

**Fire Group Six:** Moist Douglas-fir habitat types. Douglas-fir often dominates all stages of succession on these sites, even when subjected to periodic fire.

**Fire Group Seven:** Cool habitat types usually dominated by lodgepole pine. This group includes stands in which fire maintains lodgepole pine as a dominant seral species as well as those stands in which lodgepole is a persistent dominant.

Table 1—Summary of Montana forest habitat type Fire Groups (see appendix C for formal listing of habitat type Fire Groups)

Habitat type <sup>1</sup>	Forest region <sup>2</sup>	Habitat type <sup>1</sup>	Forest region <sup>2</sup>	Habitat type <sup>1</sup>	Forest region <sup>2</sup>
<b>FIRE GROUP ONE</b>		<b>FIRE GROUP SIX</b>		<b>FIRE GROUP NINE</b>	
PIFL/AGSP	NC,C,SW,SC	PSMEIPHMA-PHMA	NW,WC,C,SW,SC	PICEA/EQAR	NW,NC,C,SW,SC
PIFLIFEID-FEID	NC,C,SW,SC	PSME/VICA*	C	PICENCLUN-VACA	NW
PIFLIFEID-FESC	NC,C	PSMEIVAGL-VAGL	NW,WC,C,SW,SC	PICENCLUN-CLUN	NW
PIFL/JUCO	NC,C,SW,SC	PSMEIVAGL-ARUV	NW,WC,C	PICEA/GATR	WC,C,SW,SC
<b>FIRE GROUP TWO</b>		PSMEIVAGL-XETE	NW,WC,C	ABLNOPHO	NW
PIPO/AND	SE	PSMEILIBO-SYAL	NW,WC,C	ABLNCLUN-CLUN	NW,WC,NC
PIPOIAGSP+	NW,WC,C,SE	PSME/LIBO-ARUV*	C	ABLNCLUN-ARNU	NW,WC,NC
PIPOIFEID-FEID	WC,C,SE	PSME/LIBO-CARU+	NW,WC,C,SW	ABLA/CLUN-VACA	NW,WC
PIPOIFEID-FESC+	NE,WC,C	PSMEILIBO-VAGL	WC,C	ABLNCLUN-XETE	NW,WC,NC
PIPOIPUTR-AGSP	WC,C	PSMEISYAL-CARU	NW,WC,C,SW,SC	ABLNCLUN-MEFE	NW,WC,NC
PIPOIPUTR-FEID	NW,WC,C	PSMEISYAL-SYAL	NW,WC,NC,C,SW,SC	ABLINGATR	WC,NC,C,SC
PIPOISYAL-SYAL	NW,WC,C,SE	PSMEIAMAL*	C	ABLNCACA-CACA	WC,C,SW,SC
PIPO/SYOC*	C	PSMEICARU-ARUV	NW,WC,C	ABWCACA-GATR	WC,C,SW
PIPOIARUV'	C	PSMEICARU-CARU	NW,WC,NC,C,SW,SC	ABWLIBO*	C
PIPO/JUHO*	C	PSMENACA	NW,WC	ABLA/LIBO-LIBO	NW,WC,NC,C,SW,SC
PIPO/JUSC**	C	PSME/JUCO	NC,C,SW	ABLNLIBO-XETE	NW,WC
<b>FIRE GROUP THREE</b>		<b>FIRE GROUP SEVEN</b>		ABLNMEFE	NW,WC,NC,SW,SC
PIPO/SYAL-BERE	C,SE	PSME/JUCO	NC,C,SW	TSME/MEFE	NW,WC
PIPOIBERE'	C	PSMENACA	NW,WC,NC,C	ABLNALSI	WC,NC,SW,SC
PIPOIAMAL'	C	PSMEICOCA-LIBO'	C	<b>FIRE GROUP TEN</b>	
PIPOIPRVI-PRVI	SE	PSMEICOCA-VAMY'	C	PICEA/SEST-PICEA	C
PIPOIPRVI-SHCA	SE	PICEA/VACA	NW,NC	PICENJUCO'	C
<b>FIRE GROUP FOUR</b>		PICEA/LIBO	WC,C,SC,SW	PICENRIMO'	SW,SC
PSME/AGSP	NW,WC,C,SW,SC	ABLANACA	NW,WC,C,SW	ABLA-PIALNASC	WC,NC,C,SW,SC
PSME/FESC	NW,WC,C	ABLNCACA-VACA	NW,WC,C,SW	ABLA/LUHI-VASC	NW,WC,NC,SW
PSMEIPHMA-CARU	NW,WC	ABLA/LIBO-VASC	NW,WC,NC,C,SC,SW	ABLA/LUHI-MEFE	NW,WC,C
PSMEISYAL-AGSP	NW,WC,C	ABLNXETE-VASC	NW,WC,NC,SW	ABLNJUCO'	C
PSMEISYOC-CHVI'	C	ABLANAGL	WC,C,SC,SW	TSMEILUHI-VASC	NW
PSMEISYOC-SHCA'	C	ABLANASC-CARU	C,SC,SW	TSMEILUHI-MEFE	NW
PSMEICARU-AGSP	NW,WC	ABLANASC-VASC	NW,WC,C,SC,SW	PIAL-ABLA h.t.'s	NW,WC,NC,C,SW,SC
PSME/CARU-PIPO	NW,WC,C	ABLNCAGE-CAGE	NC,SW	LALY-ABLA h.t.'s	NW,WC,SW
PSME/SPBE	NW,WC,C,NC	PICO/PUTR	SC	PIAL h.t.'s	WC,C,SW,SC
PSMEIARUV+	C,SC	PICO/VACA	WC,NC,C,SW	<b>FIRE GROUP ELEVEN</b>	
PSMEIBERE-ARUV'	C	PICOILIBO+	NW,WC,C,SC,SW	ABGR/XETE	NW,WC
PSME/BERE-BERE*	C	PICO/VASC	NW,WC,C,SC,SW	ABGRICLUN-CLUN	NW,WC
PSMEIJUSC**	C	PICO/CARU	C,SC,SW	ABGRICLUN-ARNU	NW,WC
PSMEIMUCU**	C	PICO/JUCO	C	ABGRICLUN-XETE	NW
<b>FIRE GROUP FIVE</b>		<b>FIRE GROUP EIGHT</b>		ABGR/LIBO-LIBO	NW,WC
PSME/FEID	NW,WC,SW,SC	PICEA/LIBO*	C	ABGRILIBO-XETE	NW
PSMEICARU-AGSP	C	PICENPHMA	SC	THPLICLUN-CLUN	NW,WC
PSME/CAGE	WC,C,SC,SW	PICENSMST	WC,C,SW,SC	THPUCLUN-ARNU	NW,WC
PSME/ARCO	C,SW	ABLNXETE-VAGL	NW,WC,NC,SW	THPUCLUN-MEFE	NW,WC
PSME/SYOR	SW	TSME/XETE	NW	THPUOPHO	NW
PICENSEST-PSME	NC,C,SW	ABLNVASC-THOC	C,SW	TSHEICLUN-CLLIN	NW
		ABWCARU	NC,C,SW,SC	TSHEICLUN-ARNU	NW
		ABLNCLPS	NC,C,SW,SC		
		ABLA/ARCO	NC,C,SW		
		ABLNCAGE-PSME	C,SW,SC		

<sup>1</sup>Habitat types are as described by Pfister and others (1977) except those designated as follows:

<sup>\*</sup>habitat types of Bearpaw and Little Rocky Mountains (Roberts 1980)

<sup>\*\*</sup>habitat types of Missouri River Breaks (Roberts and Sibbersen 1979)

+common to both Pfister and others (1977) and Roberts (1980).

<sup>2</sup>Forest regions are as described by Arno (1979).

**Fire Group Eight:** Dry, lower subalpine habitat types. This is a collection of habitat types in the spruce and subalpine fir series that usually support mixed stands of Douglas-fir and lodgepole pine.

**Fire Group Nine:** Moist, lower subalpine habitat types. Fires are infrequent but severe in these types, and the effects of fire are long lasting. Spruce is usually a major component of seral stands.

**Fire Group Ten:** Cold, moist upper subalpine and timberline habitat types. This is a collection of high-elevation habitats in which fires are infrequent. Fires are often small in areal extent because of normally sparse fuels. Severe fires have long-term effects. Subalpine fir, spruce, whitebark pine, and subalpine larch are the predominant conifers.

**Fire Group Eleven:** Moist grand fir, western redcedar, and western hemlock habitat types. These are generally moist habitats in which fires are infrequent but often severe. In Montana they occur exclusively west of the Continental Divide.

Because Fire Groups One and Three do not occur in western Montana, they will not be discussed in this report. A detailed listing of the Fire Groups by habitat type is provided in appendix C.

## Nomenclature

Common names of trees and undergrowth plants are used throughout the text of the report. Scientific plant names that correspond to the common names used in the text are listed in appendix D. Common and scientific names follow the "Checklist of United States Trees (Native and Naturalized)" by Little (1979) and the "National Handbook of Plant Names" (USDA-SCS 1981).

Exceptions may occur in habitat type names, which follow the sources listed in table 1.

## RELATIONSHIPS OF MAJOR TREE SPECIES TO FIRE

Wildfire plays a major role in forest succession throughout the Northern Rocky Mountains, including forests in western Montana. Lodgepole pine, for example, owes its present widespread occurrence to past fire. Without fire, Douglas-fir would dominate areas where ponderosa pine now occurs but is not climax. Similarly, periodic fire allows western larch and western white pine to persist on many sites where they are not climax. Fire also favors Engelmann spruce at the expense of subalpine fir (Wellner 1970).

Table 2 summarizes the relative fire resistance of the principal conifers in western Montana forests. Minore (1979) provides a more complete review of comparative autecological characteristics of Northwestern tree species.

### Ponderosa Pine (*Pinus ponderosa*)

Ponderosa pine has many fire-resistant characteristics. Seedlings and saplings are often able to withstand fire. Seedlings and saplings can maintain themselves on sites with fire intervals as short as 6 years if fire severity is low. Development of insulative bark and the tendency for meristems to be shielded by enclosing needles and thick bud scales contribute to the temperature resistance of pole-sized and larger trees.

Propagation of fire into the crown of pole-sized and larger trees growing in relatively open stands (dry sites) is unusual. First, the tendency of ponderosa pine to self-prune lower branches keeps the foliage separated from

Table 2—Relative fire resistance of the principal conifers occurring west of the Continental Divide in Montana (source: Flint 1925)

Species	Thickness of bark of old trees	Root habit	Resin in old bark	Tolerance		Relative inflammability of foliage	Lichen growth	Degree of fire resistance
				Branch habit	Stand habit			
Western larch	Very thick	Deep	Very little	High and very open	Open	Low	Medium heavy	Most resistant
Ponderosa pine	Very thick	Deep	Abundant	Moderately high and open	Open	Medium	Medium to light	Very resistant
Douglas-fir	Very thick	Deep	Moderate	Moderately low and dense	Moderate to dense	High	Heavy medium	Very resistant
Grand fir	Thick	Shallow	Very little	Low and dense	Dense	High	Heavy	Medium
Lodgepole pine	Very thin	Deep	Abundant	Moderately high and open	Open	Medium	Light	Medium
Western white pine	Medium	Medium	Abundant	High and dense	Dense	Medium	Heavy	Medium
Western redcedar	Thin	Shallow	Very little	Moderately low and dense	Dense	High	Heavy	Medium
Engelmann spruce	Thin	Shallow	Moderate	Low and dense	Dense	Medium	Heavy	Low
Mountain hemlock	Medium	Medium	Very little	Low dense	Dense	High	Medium to heavy	Low
Western hemlock	Medium	Shallow	Very little	Low dense	Dense	High	Heavy	Low
Subalpine fir	Very thin	Shallow	Moderate	Very low and dense	Moderate to dense	High	Medium to heavy	Very low



burning surface fuels. Second, the open, loosely arranged foliage does not lend itself to combustion or the propagation of flames. Third, the thick bark is relatively unburnable and does not easily carry fire up the bole or support residual burning. Resin accumulations, however, can make the bark more flammable.

On moist ponderosa pine sites, Douglas-fir or grand fir often form dense understories, which may act as fuel ladders that can carry surface fires to the overstory. Consequently, crown fires are more frequent on moist sites than they are on dry sites. Understory ponderosa pine may also be more susceptible to fire damage because crowded conditions can result in slower diameter growth. Such trees do not develop their protective layer of insulative bark as early as do faster growing trees. They remain vulnerable to cambium damage from ground fires longer than their counterparts in open stands. The thick, overcrowded foliage of young stands or thickets also negates the fire-resisting characteristic of open, discontinuous crown foliage commonly found in this species.

Ponderosa pine seedling establishment is favored when fire removes the forest floor litter and grass and exposes mineral soil. Fire resistance of the open, parklike stands is enhanced by generally light fuel quantities. Heavy accumulations of litter at the base of trunks increase the intensity and duration of fire, often resulting in a fire scar or "cat face." Flammable resin deposits around wounds can make an individual tree susceptible to fire damage and can enlarge existing fire scars.

Because ponderosa pine is among the most fire-resistant trees growing in Montana, it has a competitive advantage over most other species when mixed stands burn.

### **Rocky Mountain Juniper (*Juniperus scopulorum*)**

Young juniper trees are easily killed by fire primarily because of their small size, thin bark, and compact crown. Fire has long been recognized as a means to control this species because juniper does not resprout. Often young trees are killed just by scorching the crown and stem.

As juniper ages, the bark thickens and the crown develops a bushy, open form. A hot fire can kill or severely damage such a tree, but the same tree may survive a cool fire. Low, spreading branches can provide a route for fire to enter the crown, thereby increasing the potential for damage. Often large junipers have survived a number of fires (four to six).

The different effects of fire on young and old juniper trees are largely a function of the site. The species commonly occupies dry environments that support limited undergrowth. When surface fuels are sparse, fire damage is minimal.

### **Douglas-fir (*Pseudotsuga menziesii*)**

Mature Douglas-fir is a relatively fire-resistant tree. Saplings, however, are vulnerable to surface fires because of their thin, photosynthetically active bark, resin blisters, closely spaced flammable needles, and thin twigs and bud

scales. The moderately low and dense branching habit of saplings enables surface fires to be carried into the crown layer. Older trees develop a relatively unburnable, thick layer of insulative corky bark that provides protection against cool to moderately severe fires. Fire-resistant bark takes about 40 years to develop on moist (favorable) sites. This protection is often offset by a tendency to have branches the length of the bole. The development in the lower trunk of "gum cracks," which streak the bark with resin, can provide a mechanism for serious fire injury.

Douglas-fir often occurs in open stands, but it also grows in dense stands with continuous fuels underneath. Dense sapling thickets can form an almost continuous layer of flammable foliage about 10 to 26 ft (3 to 8 m) above ground that will support wind-driven crown fires. Even small thickets of saplings provide a route by which surface fires can reach the crowns of mature trees.

As with ponderosa pine, heavy fuel accumulations at the base of the tree increase the probability of fire injury. Also, resin deposits often contribute to the enlargement of old fire scars during subsequent fires.

### **Engelmann Spruce (*Picea engelmannii*)**

Engelmann spruce, including hybrids with white spruce (*Picea glauca*) (Habeck and Weaver 1969), is easily killed by fire. The dead, dry, flammable lower limbs, low-growing canopy, thin bark, and lichen growth in the branches contribute to the species' vulnerability. The shallow root system is readily subject to injury from fire burning through the duff. Large old spruce may occasionally survive one or more light fires, but deep accumulations of resinous needle litter around their bases usually make them particularly susceptible to fire damage. Survivors are often subjected to successful attack by wood-destroying fungi that easily enter through fire scars. The high susceptibility of spruce to fire damage is mitigated in part by the generally cool and moist sites where it grows.

Spruce is not an aggressive pioneer. It is a moderate seeder, but seed viability is rated good and the vitality persistent (Alexander and Sheppard 1984). Seedlings can survive on a wide variety of seedbeds. Initial establishment and early growth of seedlings may be slow, but is usually good when encouraged by shade and abundant moisture. Spruce seedlings will occur as members of a fire-initiated stand with lodgepole pine. Spruce's shade tolerance allows it to establish and grow beneath a lodgepole pine canopy. On sites where it is the indicated climax species, spruce will eventually dominate the stand, but it takes a long period without any fire before this can occur.

Restocking will occur more quickly if some spruce trees survive within the burn than if regeneration is dependent on seed from trees at the fire edge. Pockets of spruce regeneration often become established around such surviving seed trees up to a distance of 300 ft (90 m), the effective seeding distance for spruce. Successful regeneration diminishes 100 to 150 years after establishment due to insufficient sunlight at ground level and to accumulating duff. At this point, the more tolerant subalpine fir begins to dominate in the understory.

## Western Larch (*Larix occidentalis*)

Western larch is the most fire-resistant conifer in the Northern Rocky Mountains. It possesses an insulating bark that can, in mature trees, range from 3 to 6 inches (7 to 15 cm) thick. The fire resistance of western larch is enhanced by its tendency to self-prune lower branches and its tolerance of defoliation. Western larch is a deciduous conifer and replaces its needles annually. Defoliation by fire is less traumatic for larch than for conifers that normally replace their needles at 2- or 3-year intervals.

Western larch can become established rapidly on mineral soil exposed by fire. Its lightweight seeds can be blown from considerable distances to potential germination sites. A highly intolerant species, western larch requires full or near-full sun for best development. Lodgepole pine and larch are both potential seral dominants on many sites. Western larch is a better competitor where there is higher soil moisture.

Western larch is long lived. Old fire-scarred tree stumps in the Seeley Lake area of western Montana indicate ages in excess of 900 years at the time of cutting. Such longevity helps maintain larch as a stand component and potential seed source for many years.

## Lodgepole Pine (*Pinus contorta*)

Individual mature lodgepole pine trees are moderately resistant to surface fires. Lodgepole's thin bark makes it susceptible to death from cambium heating. However, lodgepole pine is alone in its ability to perpetuate itself on a site despite fire. Indeed, on most sites where lodgepole grows, fire is necessary for the species' continued dominance.

Lodgepole pine's key fire survival attribute is cone serotiny. Although there are exceptions, most lodgepole stands in western Montana are composed of trees containing both serotinous and nonserotinous or open cones. The ratio of serotinous to nonserotinous cones seems to be related to the fire frequency for the site: the higher the fire frequency the greater the proportion of serotinous cones and vice versa (Perry and Lotan 1979).

A temperature of 113 °F (45 °C) is usually required to melt the resin that binds the scales of a serotinous cone. Heat from a fire is about the only way such temperatures will occur in the crown of a standing lodgepole pine. Large quantities of highly viable seed are therefore available to regenerate a site following a stand-destroying fire.

Aside from serotinous cones, other silvical characteristics (Fowells 1965) that contribute to lodgepole pine's success in dominating a recently burned site are:

1. Early seed production. Cones bearing viable seed are produced by trees as young as 5 years in open stands and by trees 15 to 20 years old in more heavily stocked stands. This feature not only allows relatively young stands to regenerate a site following fire, but also the seed from open cones on recently regenerated lodgepole can fill in voids left by the original postfire seeding from serotinous cones.
2. Prolific seed production. Good cone crops occur at 1- to 3-year intervals with light crops intervening.
3. High seed viability. Viable seed has been found in 80-year-old serotinous cones.

4. High survival and rapid growth. High seedling survival and rapid early growth are characteristic of lodgepole, especially on mineral soil seedbeds exposed to full sunlight.

Lodgepole pine's success in revegetating a site following fire often results in dense, overstocked stands. Such stands are susceptible to stagnation, snow breakage, windthrow, dwarf mistletoe (*Arceuthobium americanum*) infestation, and mountain pine beetle (*Dendroctonus ponderosae*) attack. The combined effect of these factors is extreme buildup of dead woody fuel on the forest floor. Thus, the stage is set for another stand-destroying wildfire.

## Whitebark Pine (*Pinus albicaulis*)

Whitebark pine is a semitolerant or midtolerant species (Arno and Hoff in press) that has been observed as a pioneer inhabiting recently burned sites. It occurs as the potential climax species on alpine timberline and exceptionally dry sites but is a seral species in upper subalpine forests (Arno 1986). Whitebark pine is moderately fire resistant. It has a relatively thin bark and is susceptible to fire injury from hot surface fires that heat the tree's cambium. The characteristically dry, exposed site and open stand structure tend to reduce whitebark pine's vulnerability to fire. The fact that whitebark pine often reaches ages of 500 years or more reflects the reduced fire threat.

Near its lower elevational limit, whitebark pine may occur in small groups with lodgepole pine, subalpine fir, and Engelmann spruce. However, the general impression of whitebark pine communities is that of open stands where the undergrowth is predominantly continuous low shrubs, forbs, and grasses. Occasionally larger shrubs and stunted trees are present.

Fires that burn in the undergrowth are usually of low-to-moderate severity. But the low, ground-hugging crowns of associated conifers can provide a fuel ladder, and downfall in the vicinity of mature trees locally increases crown fire potential. Hence, severe fires are possible.

Severe wildfires starting in lower elevations can spread throughout the upper elevation forests to timberline. Although the open nature of a whitebark pine forest acts as a firebreak, many trees can be killed under these conditions. The most common fires are lightning fires that do not spread far. However, during extended dry periods of high fire danger, these usually benign fires may spread downhill into dense lower elevation forests.

Whitebark pine has a large, wingless seed that does not disperse by wind. Regeneration on burned sites is usually the result of seed germination from bird and rodent seed caches, especially those of Clark's nutcracker (*Nucifraga columbiana*) (Hutchins and Lanner 1982).

## Subalpine Fir (*Abies lasiocarpa*)

Subalpine fir is rated as the least fire-resistant Northern Rocky Mountain conifer because of its thin bark, resin blisters, low and dense branching habit, and moderate-to-high stand density in mature forests. As a result, fire most often acts as a stand-replacement agent when it burns through a subalpine fir forest. Even relatively cool

ground fires can cook the cambium or spread into the ground-hugging branches and from there up into the crown.

Subalpine fir may begin producing cones when only 20 years old, but maximum seed production is by dominant trees 150 to 200 years old. Subalpine fir has the ability to germinate and survive on a fairly wide range of seedbeds.

Subalpine fir can occur in a fire-initiated stand with Douglas-fir, lodgepole pine, and other seral species because it germinates successfully on a fire-prepared seedbed. But subalpine fir usually remains a slower growing, minor component dominated by less tolerant species.

Subalpine fir can better exist under low light conditions than most associated species. But Engelmann spruce will often grow faster than subalpine fir where light intensity exceeds 50 percent of full sunlight. Subalpine fir is shade tolerant and is the indicated climax species on many sites containing lodgepole pine. Where a seed source exists, the fir will invade and grow in the understory of lodgepole stands. Given a long enough fire-free period, subalpine fir will overtop lodgepole pine on sites where it is the indicated climax.

### **Mountain Hemlock (*Tsuga mertensiana*)**

Mountain hemlock is vulnerable to fire damage. It is only slightly more fire resistant than subalpine fir. Its thin bark affords some protection, but low-hanging branches, highly flammable needles, and a tendency to grow in dense groups make it susceptible to fire injury. Trees that survive fires often suffer subsequent mortality from fungus-infected fire wounds.

Mountain hemlock grows in pure stands or in mixtures with a variety of species. In Montana, subalpine fir, Engelmann spruce, and whitebark pine are common associates. Mountain hemlock sites are typically moist with average annual precipitation over 50 inches (127 cm), making fire occurrence low. When these forests do dry, however, fires often burn severely.

Mountain hemlock is a tolerant tree, surpassing subalpine fir in this respect. It is considered a coclimax species with subalpine fir where they occur together. Mountain hemlock seedlings and saplings survive prolonged suppression and respond well to release.

The ability of mountain hemlock to act as a pioneer species apparently varies with locality. In northern California and southern Oregon, nearly pure, even-aged stands on old burn sites have been reported. In central Oregon, British Columbia, and Alaska, it has invaded small openings, meadows, glacial moraines, and heather communities. It is an invader of burned sites in the high-elevation forests of the Northern Rocky Mountains.

### **Western White Pine (*Pinus monticola*)**

Western white pine is moderately resistant to fire. Its resistance is favored by medium thick bark, moderately flammable foliage, self-pruning of lower limbs, and especially, its tall stature. But, older trees retain abundant resin in their bark and often have lichen-covered branches. These factors, plus the often dense stand structure, reduce western white pine's fire resistance.

Young trees are especially vulnerable because of their compact stand structure and the lack of thickened bark. Western white pine is a fire species that depends on severe fires to recycle stands and create an early successional habitat. Its common occurrence in nearly pure, even-aged stands is further evidence of colonization after fire. Soil temperature and adequate moisture appear to control germination, but light seems to have little importance because seeds can germinate in shade. Mineral surfaces provide a better seedbed than duff surfaces, but white pine seed is able to lie over in duff for 2 or 3 years then germinate upon the removal of the litter layer.

The early growth of western white pine seedlings is not rapid, but it is the fastest growing sapling and pole-sized tree in the Northern Rockies. The first 30 to 40 years are critical to the development of the stand because during this time dominance and stand composition are established. Mortality and pruning subsequently determine the fire resistance of the stand and of individual trees.

Western white pine is moderately shade tolerant and will continue to reproduce under a partial canopy of associated seral species (Douglas-fir, western larch, lodgepole pine, and perhaps grand fir). This ability and its longevity (400 to 500 years) permit it to remain as a stand component for several centuries following major disturbance.

### **Grand Fir (*Abies grandis*)**

An individual, mature grand fir can resist low to moderately severe fires primarily because of its moderately thick bark. However, its low and dense branching habit, highly flammable foliage, heavy lichen growth, relatively shallow root system, and dense stand habit make it susceptible to fire injury and death.

Fire resistance is strongly influenced by site. Grand fir succumbs to ground fire when the duff burns deeply enough to injure the root system. On relatively dry mountain slopes where grand fir grows, the deeper root system, lighter fuel loadings, and more open stand structure make it less vulnerable. However, decay frequently enters through fire wounds.

Grand fir tolerates partial shading and is a successful invader of small openings and shrubfields. It can continue to establish in developing stands until the canopy closes.

Grand fir has rather low reproductive success. It has the lowest percentage germination of any of the associates of white pine. Damping off fungus and other biotic agents take a heavy toll of seedlings during wet seasons, and insolation and drought cause mortality during the dry summer months. Not until their third year are the seedlings well established. Young trees on dry sites or upland slopes develop tap roots, making them more resistant to drought and fire than shallow-rooted trees on more moist sites.

In partial shade, grand fir can form a considerable part of the dominant reproduction, but in full sun it is subordinate to faster growing intolerant species. Heavy competition restricts it to a role as an understory component. Suppressed trees will show some response to release, but such individuals do not attain optimal growth or stature and often develop bole rot before attaining commercial size. Grand fir does best when it retains a dominant position from the time of its initial establishment.

## Western Hemlock (*Tsuga heterophylla*)

Western hemlock is easily killed by fire because of its thin bark, shallow roots, highly flammable foliage, and low-branching habit. It tends to form dense stands and its branches are often lichen-covered, which serve to increase its susceptibility to fire damage. Postburn mortality of individuals is common due to fungal infection of fire wounds.

The range of western hemlock in Montana is restricted to the northwest portion, where relatively warm, mesic conditions prevail. Except during especially long dry periods in summer, fire seldom burns these sites.

Hemlock becomes a prolific seeder at an early age. It can be an aggressive pioneer because of its quick growth in full overhead light and its ability to survive under a wide variety of seedbed conditions. The light, winged seeds can be carried a considerable distance by wind.

Hemlock is a highly tolerant climax species. It survives long periods of suppression and will respond well to release. It is often found as a codominant with western redcedar on climax or near-climax stands.

## Western Redcedar (*Thuja plicata*)

Western redcedar has only low to moderate fire resistance. Its thin bark, shallow root system, and low, dense branching habit make it susceptible to fire damage. Despite this apparent low resistance, the species often survives because of its large size and tenacity if any portion of the bole isn't killed.

Western redcedar is found in the mesic to hydric environments of western Montana—a region with a modified maritime climate. These moist sites provide redcedar's best protection from fire. Riparian stringers of western redcedar may act as firebreaks. The generally moist duff found beneath redcedar does not readily burn.

Redcedar is not an aggressive pioneer species because the succulent seedling is susceptible to high soil temperatures and is slow in root development. Seedling survival on burned or unburned mineral soil is best under partial shade. Small seed size and rapid drying of organic material account for the poor germination on duff. In its favor, redcedar is a prodigious seed producer, a characteristic that enables it to enter pioneer communities at an early stage.

Western redcedar will reproduce vegetatively in old-growth stands with a high soil moisture. Adventitious roots may develop from low hanging branches, live fallen trunks, or even live branches that fall on a wet soil surface.

Western redcedar is highly shade tolerant. It can germinate, grow, and even reach maturity under low-light conditions. However, its growth is retarded by dense shade, and it responds well when competition is removed.

Western redcedar is often the indicated climax species where it occurs. It can also serve as a late-seral or coclimax tree on western hemlock sites.

## Subalpine Larch (*Larix lyallii*)

Subalpine larch is a thin-barked species easily damaged by fire. However, it is moderately fire-resistant primarily

because of its stand habit. It grows only on the highest elevations inhabiting extremely rocky and generally moist and cold sites. Alpine larch can grow in pure groves, in small groups, or as isolated individuals. In the lower portion of its elevational distribution, it occurs with subalpine fir, Engelmann spruce, and whitebark pine.

In the timberline zone, fire is a cause of tree mortality but is less frequent and widespread than in contiguous forests below. Severe fires may enter the subalpine larch stands from lower forests. However, they do not always adversely affect subalpine larch stands. For example, northern Idaho's severe Sundance Fire of 1967 swept the ridges of Roman Nose Mountain burning most of the whitebark pine and killing much of the spruce and fir in the cirques, but causing only minor damage to isolated stands of subalpine larch (Arno 1970). Sparse vegetation and rocky slopes curtail the intensity of fire in these areas.

When subalpine larch grows in association with a vigorous stand of subalpine fir, Engelmann spruce, and whitebark pine, it is an intolerant seral species that dies out when overtopped by other conifers. Arno (1970) stated that fire allowed subalpine larch to remain a major forest component with these species in some areas.

## UNDERGROWTH RESPONSE TO FIRE

Many of the common shrubs and herbaceous plants that grow on the forest floor of Montana forests can renew themselves from surviving plant parts following fire. Other plants are quite susceptible to fire kill and often must re-establish or colonize from off-site seed sources in unburned areas within or immediately adjacent to the burned area.

Current understanding of the process of plant succession following fire in western Montana forests and its management implications are succinctly summarized by Stickney (1982):

...the severity of the disturbance treatment directly affects the representation of the survivor component in the postfire vegetation. Since survivors derive from plants already established at the time of disturbance, it is possible, by pretreatment inventory, to determine the potential composition for the survivor component. For this reason it also follows that forest stands with little undergrowth vegetation could be expected to have a sparse or limited survivor component following disturbance. In addition, if the colonizer component is composed mostly of shade-tolerant climax-like species the rate of survivor recovery can be expected to be slow. Nearly all of our native forest shrub species are capable of surviving burning, and they can therefore be expected to function as survivors. A majority of the predisturbance forest herb species also demonstrated the ability to survive fire, particularly those species with underground stems (rhizome) or rootcrowns (caudex). As a generalization, the more severe the fire treatment to vegetation, the less the survivor component. In the drier, more open forest types this usually results in a reduction of amount, but not major changes in composition. However, in the moister forest types, where the undergrowth

is made up of more mesic shade-tolerant species, marked changes in postfire composition can occur as increasing severity reduces survivor representation.

The severity of disturbance treatment (particularly fire) influences the potential for colonizer presence in two ways: (1) the degree of severity creates the character of the ground surface on which colonizer seedlings germinate, and (2) it activates onsite stored seed. Generalizing, the more severe the disturbance treatment the more favorable the site becomes for colonizers. As the extent of exposed mineral soil increases, the ground surface becomes more favorable as a site for germination and establishment of colonizer plants. Increases in treatment severity also favor germination of ground-stored seeds by increasing their exposure to light or heat.

Predicting the occurrence of colonizers in post-disturbance vegetation is much less certain than

predicting for survivors, but knowledge of the previous succession history can provide the potential composition of residual colonizers. Locally this information is often available from an adjacent or nearby clearcut. Least predictable is the offsite colonizer component, for its occurrence is dependent on the timing of the disturbance to the availability and dispersal of offsite airborne seed. Even in this case reference to local clearcuts can provide some idea of the composition for the most common offsite colonizer species likely to occur

Table 3 is a brief summary of plant response to fire for some species that occur in western Montana forests. The fire response information is generalized. Remember, plant response to fire depends on many factors including soil and duff moisture, phenological stage of the plant, and the severity of the fire, especially in terms of the amount of heat that travels downward through the duff and upper layer of soil.

Table 3—Summary of **postfire** survival strategy and fire response for some shrubs and herbaceous plants occurring in forests west of the Continental Divide in Montana (sources: Arno and Simmerman 1982; Bradley 1984; Crane and others 1983; Daubenmire and Daubenmire 1968; Hironaka and others 1983; Kramer 1984; Lotan and others 1981; Lyon and Stickney 1976; McLean 1969; Miller 1977; Morgan and Neuenschwander 1985; Mueggler 1965; Nimir and Payne 1978; Noste 1985; Rowe 1983; Stickney 1981; Tiedemann and Klock 1976; Volland and Dell 1981; Wright 1980, 1978, 1972; Wright and Bailey 1982, 1980; Wright and others 1979)

Species	Fire Group(s)	Postfire survival strategy	Comments on fire response
<b>SHRUBS:</b>			
<i>Alnus sinuata</i> Sitka alder	6,8,9,10,11	Sprouts from surviving root crown.	Usually increases on site following fire. Early seed production (after 5 years) aids in this increase.
Amelanchier alnifolia Western serviceberry	ubiquitous'	Sprouts from surviving root crown, frequently producing multiple stems.	Pioneer species; usually survives even severe fires especially if soil is moist at time of fire. Coverage usually increases following fire.
Arctostaphylos <i>uva-ursi</i> Kinnikinnick	ubiquitous	May sprout from a root crown; <b>regeneration</b> from stolons more common. May have somewhat fire-resistant seeds.	Susceptible to fire-kill. Will survive some low severity fires when duff is moist and therefore not consumed by fire. May invade burned area from unburned patches.
<i>Artemisia tridentata</i> Big sagebrush	1,2,4,5	Wind-dispersed seed. Subspecies vaseyana stores seed in the soil that <b>germinates</b> as a result of fire-induced heating.	Susceptible to <b>fire-kill</b> . Recovery is hastened when a good seed crop exists before burning.
<i>Berberis repens</i> Creeping Oregon grape	ubiquitous	Sprouts from surviving rhizomes that grow 0.5 to 2 inches (1.5 to 5 cm) below soil surface.	Moderately resistant to fire-kill. Usually survives all but severe fires that remove duff and cause extended heating of upper soil.
Ceanothus <i>velutinus</i> Snowbrush ceanothus	2,4,5,6,7,8,9,11	Soil-stored seed germinates following heat treatment. It can also sprout from root crowns following a cool fire.	Usually increases following fire, often dramatically.
<i>Cornus canadensis</i> Bunchberry dogwood	5,6,7,9,11	Sprouts from surviving rhizomes that grow 2 to 5 inches (5 to 13 cm) below soil surface.	Moderately resistant to fire-kill. Will survive all but severe fires that remove duff and cause extended heating of upper soil.
<i>Cornus stolonifera</i> Redosier dogwood	6,9,11	Sprouts from surviving rhizomes or stolons (runners).	Susceptible to fire-kill. Will survive all but severe fires that remove duff and cause extended heating of upper soil.
<i>Holodiscus discolor</i> Oceanspray	4,6,9,11	Regenerates from soil-stored seed or sprouts from surviving root crown.	Moderately resistant to fire-kill. Is often enhanced by fire.
<i>Juniperus communis</i> Common juniper	1,4,5,6,7,8,10	Bird-dispersed seed.	Susceptible to fire-kill. Seed requires long germination period.

(con.)

Table 3 (Con.)

Species	Fire Group(s)	Postfire survival strategy	Comments on fire response
<i>Juniperus horizontalis</i> Creeping juniper	1,2,5	Similar to <i>J. communis</i> .	See <i>J. communis</i> .
<i>Linnaea borealis</i> American twinflower	6,7,8,9,11	Sprouts from surviving root crown located just below soil surface. Fibrous roots and runners at soil surface.	Susceptible to fire-kill. May survive some cool fires where duff is moist and not consumed. Can invade burned area from unburned patches.
<i>Lonicera utahensis</i> Utah honeysuckle	4,5,6,7,8,9,10,11	Sprouts from surviving root crown.	Often a reduction in cover and frequency following fire.
<i>Menziesia ferruginea</i> Rusty menziesia	6,9,10,11	Sprouts from surviving root crown.	Susceptible to fire-kill. Moderate to severe fires reduce survival and slow redevelopment.
<i>Oplopanax horridum</i> Devil's club	9,11	May sprout from root crown.	Susceptible to fire-kill
<i>Pachystima myrsinites</i> Mountain lover	6,8,9,10,11	Sprouts from surviving root crown and from buds along taproot.	Moderately resistant to fire-kill. Usually survives low to moderate severity fires that do not consume the duff and heat soil excessively. Usually increases.
<i>Philadelphus lewisii</i> Lewis mockorange	0,1,2,4,5,11	Sprouts from root crown	Fire resistant; a vigorous resprouter
<i>Physocarpus malvaceus</i> Mountain ninebark	0,1,2,4,5,6,8,9,11	Sprouts from surviving root crown or horizontal rhizomes.	Fire resistant. Resprouts well although spreading may be somewhat delayed.
<i>Potentilla fruticosa</i> Shrubby cinquefoil	0,1,2,4,5,8,9,10	Sprouts from surviving root crown	Susceptible to fire-kill, but may survive low to moderate fires.
<i>Prunus virginiana</i> Chokecherry	0,1,2,4,5,6,7,9	Sprouts from surviving root crown; occasionally from rhizomes.	Usually increases coverage following fire.
<i>Purshia tridentata</i> Antelope bitterbrush	1,2,4,5,6,7	A weak sprouter. Animal-dispersed seed and seed caches present on area prior to fire.	Susceptible to fire-kill, especially in summer and fall. Decumbent growth form sprouts vigorously, columnar form does not. Spring burns enhance sprouting, fall burns are best for regeneration by seed.
<i>Ribes lacustre</i> Prickly currant	1,4,7,8,9	Sprouts from surviving root crown that is located beneath soil surface.	Resistant to fire-kill. Usually increases even after severe fire. Seedlings may establish after low or moderate fires.
<i>Rubus parviflorus</i> Thimbleberry	6,7,8,9,11	Sprouts from surviving rhizomes; seedlings from soil-stored and possible bird-dispersed seed.	Spreads vigorously from rhizomes; rapid recovery after fire.
<i>Salix scouleriana</i> Scouler willow	6,7,8,9,10,11	Sprouts from root crown/caudex. Has numerous wind-borne seeds.	Resprouts vigorously after fire and seeds germinate readily on moist burned sites.
<i>Shepherdia canadensis</i> Russet buffaloberry	1,4,5,7,8,9,10,11	Sprouts from surviving root crown and from buds along taproot.	Moderately resistant to fire-kill. Will usually survive cool to moderately severe fires that fail to consume duff and heat soil extensively.
<i>Sorbus scopulina</i> Greene mountainash	6,7,8,9,10,11	Sprouts from deep-seated rhizomes.	Resprouts vigorously after fire.
<i>Spiraea betulifolia</i> White spirea	3,4,5,6,7,8 ubiquitous	Sprouts from surviving root crown and from rhizomes that grow 2 to 5 inches (5 to 13 cm) below surface.	Resistant to fire-kill. Will usually survive even a severe fire. Generally increases coverage following fire.
<i>Symphoricarpos albus</i> Common snowberry	2,3,4,6,7,8,9 ubiquitous	Sprouts vigorously from surviving rhizomes that are located between 2 and 5 inches (5 to 13 cm) below soil surface.	Resistant to fire-kill. Will usually survive even severe fires. Greatly enhanced by cool to moderately severe fires.
<i>Taxus brevifolia</i> Pacific yew	9,11	Bird-dispersed seed	Easily killed by fire because of thin bark.
<i>Vaccinium globulare</i> Blue huckleberry	0,6,7,8,9,10,11	Shallow and deep rhizomes	Moderately resistant to fire-kill. Will usually survive cool to moderately severe fires.
<i>Vaccinium scoparium</i> Grouse whortleberry	6,7,8,9,10,11	Sprouts from surviving rhizomes that grow in duff layer or at surface of soil.	Moderately resistant to fire-kill. Will usually survive cool to moderately severe fires that fail to consume the lower layer of duff.

(con.)

Table 3 (Con.)

Species	Fire Group(s)	Postfire survival strategy	Comments on fire response
FORBS:			
Adenocaulon bicolor American trailplant	6,7,9,11	Sprouts from rhizomes near mineral soil surface.	Moderately susceptible to fire-kill. May survive moderately severe fires that fail to consume lower duff.
Apocynum androsaernifolium Spreading dogbane	2,4,5,6,7,	Sprouts from surviving rhizomes.	Generally maintains prefire frequency following fire.
Aralia <i>nudicaulis</i> Wild sarsaparilla	6,9,11	Sprouts from surviving rhizomes.	Generally resistant to fire-kill.
Arnica cordifolia Heartleaf arnica	ubiquitous	Sprouts from surviving rhizomes that creep laterally from 0.4 to 0.8 inches (1 to 2 cm) below soil surface. Wind-dispersed seed.	Susceptible to fire-kill. Shoots produce small crowns within the duff that are easily killed by all but cool fires that occur when duff is moist. May rapidly invade burned area via wind-borne seed.
Arnica <i>latifolia</i> Broadleaf or mountain arnica	4,5,6,7,8,9,10,11	Sprouts from surviving rhizomes that creep laterally in the soil.	Susceptible to fire-kill. Will usually survive cool to moderately severe fires. May exhibit rapid initial regrowth accompanied by heavy flowering and seeding establishment.
Aster conspicuus Conspicuous aster	1,2,4,6,7,8,9,10,11	Sprouts from surviving rhizomes that mostly grow from 0.5 to 2 inches (1.5 to 5 cm) below soil surface.	Moderately resistant to fire-kill. Will usually survive cool to moderately severe fires that do not result in excessive soil heating. May rapidly increase following fire.
Astragalus <i>miser</i> Timber milkvetch	0,1,2,4,5,7,8,9,10,11	Sprouts from buds along surviving taproot that may be 2 to 8 inches (5 to 20 cm) below root crown.	Resistant to fire-kill. Can regenerate from taproot even when entire plant crown is destroyed. Can send up shoots and set seed the first year. May increase dramatically following fire. Note: Milkvetch is poisonous to sheep and cattle.
Balsamorhiza sagittata Arrowleaf balsamroot	0,1,2,4,5,6,8,10	Regrowth from surviving thick caudex.	Resistant to fire-kill. Will survive even the most severe fire.
Chimaphila urnbellata Prince's pine	6,7,8,9,10,11	Rhizomes in duff near mineral soil surface.	May survive moderate fires that do not thoroughly heat duff.
Clintonia <i>uniflora</i> Queencup beadlily	6,8,9,11	Sprouts from surviving rhizomes.	Usually decreases following fire. Postfire environment evidently not conducive to rapid recovery.
Fragaria virginiana Virginia strawberry	ubiquitous	Sprouts from surviving stolons (runners) at or just below soil surface.	Susceptible to fire-kill. Will often survive cool fires that do not consume duff because of high duff moisture content.
<i>Galium</i> triflorum Sweetscented bedstraw	6,7,8,9,11	Sprouts from surviving rhizomes; barbed, animal-borne seeds.	Susceptible to fire-kill. Usually a sharp decrease following severe fire. Can increase following spring and fall fires.
Osmorhiza chilensis Mountain sweetroot	ubiquitous	Short shallow roots; barbed, animal-dispersed seeds.	Moderately fire resistant; temporary increase after fire.
Pyrola secunda Sidebells shineleaf	1,5,6,8,9,10,11	Sprouts from surviving rhizomes that grow mostly in the duff or at soil surface.	Susceptible to fire-kill. Coverage frequently reduced following fire. May survive cool fires when duff moisture is high.
Smilacina racemosa False Solomon's seal	ubiquitous	Sprouts from surviving stout creeping rhizomes.	Moderately resistant to fire-kill. May be killed by severe fires that remove duff and heat soil excessively. Usually maintains prefire frequency.
Smilacina stellata Starry false Solomon's seal	ubiquitous	Sprouts from surviving creeping rhizomes,	Moderately resistant to fire-kill. May be killed by fires that remove duff and heat upper soil. Frequency often reduced following fire.
Thalictrum occidentale Western meadowrue	0,1,4,5,6,7,8,9,11	Sprouts from surviving rhizomes.	Susceptible to fire-kill. Frequency usually reduced following fire. May survive cool fires that do not consume duff.

(con.)

Table 3 (Con.)

Species	Fire Group(s)	Postfire survival strategy	Comments on fire response
Xerophyllum <i>tenax</i> Common beargrass	0,6,7,8,9,10, 11	Sprouts from a surviving stout shallow rhizome.	Susceptible to fire-kill. Will survive cool fires that do not consume lower duff. Resprouts will flower vigorously after a fire until new overstory canopy develops.
Zygadenus elegans Mountain deathcamas	0,1,2,4,5,6,7, 8,9,10	Sprouts from surviving tunicated bulb.	Resistant to fire-kill.
GRASSES:			
Agropyron spicatum Bluebunch wheatgrass	1,2,4,5	Seed germination and some sprouts from surviving rhizomes.	Usually not seriously damaged by fire. Response depends on severity of fire and physiological state of plant. Damage will be greatest following dry year.
Calamagrostis rubescens Pinegrass	0,2,4,5,6,7,8, 9,10,11	Sprouts from surviving rhizomes that grow within the top 2 inches (5 cm) of soil.	Moderately resistant to fire-kill. Will usually survive cool to moderately severe fires that do not completely consume duff. Burned areas are often successfully invaded by pinegrass.
<i>Carex</i> geyeri Elk sedge	ubiquitous	Sprouts from surviving rhizomes.	Invades burned areas and forms dense stands. Often increases following fire.
<i>Carex</i> rossii Ross sedge	ubiquitous	Seed stored in duff or soil that germinates when heat treated. Sprouts from surviving rhizomes.	Increased coverage usually results following most fires severe enough to heat but not completely consume duff. Often increases.
Festuca <i>idahoensis</i> Idaho fescue	1,2,4,5,6,7,8, 9	Seed germination and survival of residual plant.	Susceptible to fire-kill. Response will vary with severity of fire and physiological state of plant. Can be seriously harmed by hot summer and fall fires. Only slightly damaged during spring or fall when soil moisture is high.
Festuca scabrella Rough fescue	1,2,4,5,6,7,8, 9,10	Seed germination and residual plant survival.	Usually harmed by spring burning.
Koeleria cristata Junegrass	1,2,4,5,6,7,8	Seed germination and residual plant survival.	Susceptible to fire-kill. Response will vary according to fire severity and physiological state of plant.
<i>Luzula</i> hitchcockii Woodrush	7,9,10	Sprouts from surviving rhizomes.	Often a slight increase following fire.

"Ubiquitous" denotes species whose distribution includes 10 or more Fire Groups and many or most habitat types within those Fire Groups



## WILDLIFE RESPONSE TO FIRE

The effects of fire on wildlife are primarily secondary effects. Fire creates, destroys, enhances, or degrades favorable wildlife habitat (food supply, cover, shelter, physical environment), thereby causing changes in the subsequent occurrence and abundance of animal species on a burned area (fig. 2). Table 4 lists the probable effects of fire on some mammals, reptiles, and amphibians in western Montana forests. The indicated fire effects are either inferred from habitat requirements or from studies conducted on specific wildfire or prescribed fire areas. Keep in mind that a major problem in attempting any generalization about the effects of fire on wildlife is the variation in fires: intensity, duration, frequency, location, shape, extent, season, fuels, sites, soils, and prescribed fires as compared to wildfires (Lyon and others 1978).

The response of bird species to fire has been hypothesized by Kramp and others (1983) using a classification suggested by Walter (1977).

Four fire response categories are recognized in this classification: fire-intolerant, fire-impervious, fire-adapted, and fire-dependent. These classes are described as follows (Kramp and others 1983):

Fire-intolerant species decrease in abundance after fire and are present only in areas characterized by very low fire frequency and severity. Characteristic western Montana species include the hermit thrush, red-breasted nuthatch, and brown creeper, which are closely associated with closed canopy forests. These birds prefer a dense

nesting and foraging cover but do not use fire-opened habitat.

Fire-impervious bird species are unaffected by fire; they neither increase nor decrease because of fire. Bird species whose niche incorporates successional and climax community types may be expected to show the highest flexibility in response to fire.

Fire-adapted species are associated with habitat that is characterized by recurring fires of various severity. These species, however, are not dependent on fire-influenced habitat. Fire-adapted species may also occupy areas with the same frequency-severity ratio as fire intolerant species. Fire-adapted birds include those that use both dense canopy areas and openings; a predator such as the sharp-shinned hawk is an example. Such birds benefit by increased hunting success in recent burns, but generally depend on unburned habitat for nesting sites.

Fire-dependent species are associated with fire-dependent and fire-adapted plant communities. When fire frequency decreases, these plant communities shift to fire-neutral or fire-intolerant types, and fire-dependent species are unable to persist. The blue grouse might be a western Montana example. The bird depends on medium to large fire-created forest openings with shrub-grass-forb vegetation for breeding adjacent to dense foliage conifers for roosting and hooting.

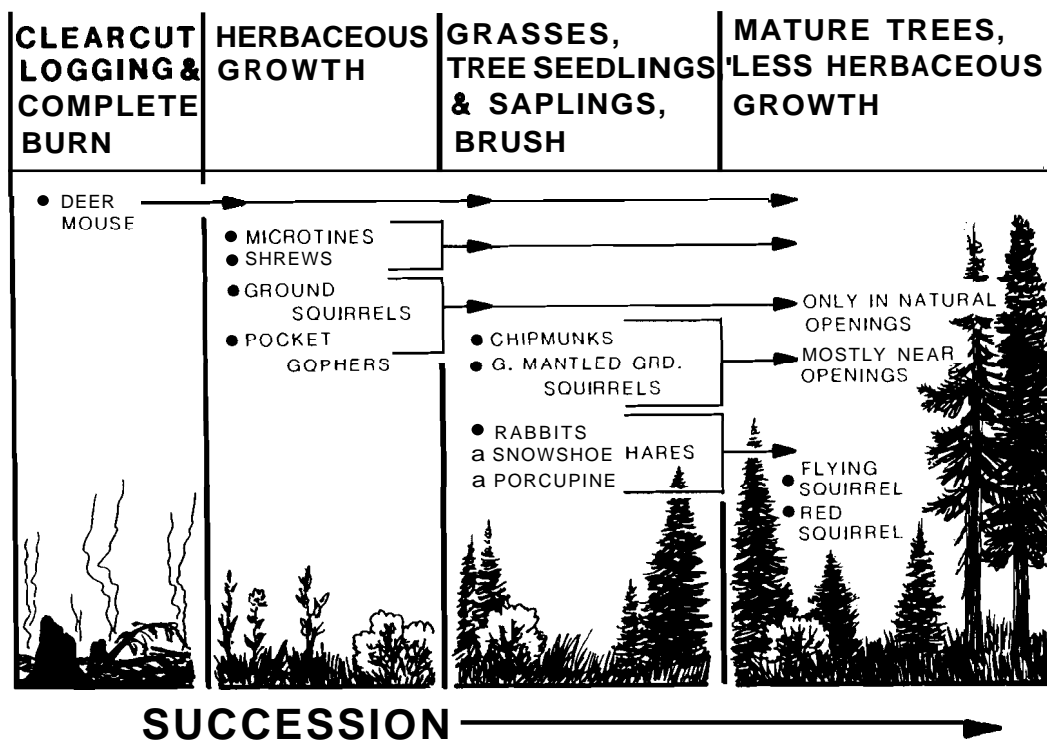


Figure 2—Small mammals found in the successional stages after clearcut logging and burning (from Ream and Gruell 1980).

Table 4—Probable effects of fire on some western Montana mammals, reptiles, and amphibians (major sources: Allen 1983; Bendell 1974; Bernard and Brown 1977; Black and Tabor 1977; Halvorson 1981, 1982; Hobbs and Spowart 1984; Kelsall and others 1977; Lyon and others 1978; Maser and others 1981; Ream 1981; Ream and Gruell 1980; Thomas 1979; USDA Forest Service 1978; Verner and Bass 1980; Wright and Bailey 1982). Classification, scientific names, and common names according to USDA Forest Service (1978).

Species	Fire Groups	Habitat considerations	Fire effects
<b>INSECTIVORA</b> (insect eaters)			
Masked shrew <i>Sorex cinereus</i>	4,5,6,7,11	Prefers moist situations in forest or open. Requires a mat of ground vegetation for cover; stumps, logs, and slash piles for nest sites.	May be temporarily eliminated from severe burns where duff and ground cover are absent. Some direct mortality of nestlings possible.
Vagrant shrew <i>S. vagrans</i>	2,4,5,6,7,8,9,10,11	Prefers streamsides, marshes, and bogs, but also occurs in moist soil; mat of ground vegetation or debris for cover. Stumps, rotten logs for feeding and nesting.	May be temporarily eliminated from severe burns where duff, ground cover, and debris are absent. Some direct mortality of nestlings possible.
<b>CHIROPTERA</b> (bats)			
Little brown myotis <i>Myotis lucifugus</i>	2,7,8,9,10	Common in forest and at the forest edge. Requires snags and tree holes for roosting and for maternity colony sites.	Severe fires may destroy roosting and breeding sites. Relatively impervious to cool and moderate fires.
Long-eared myotis <i>M. evotis</i>	2,4,5,6,7,8,9,10	Occurs in coniferous woodland as well as in spruce-fir zone. Uses snags and tree holes for roosting and for breeding colonies.	Severe fires may destroy roosting and breeding sites; otherwise relatively impervious to fire.
Small-footed myotis <i>M. subulatus</i>	2,7,8,9,10	Most common in ponderosa pine zone. May use hollow trees and snags for roosting and breeding.	Severe fires may destroy roosting and breeding sites but with little impact on populations.
Long-legged myotis <i>M. volans</i>	2,4,5	Prefers open coniferous forests. May use tree cavities for roosting and breeding.	Severe fires may destroy roosting and breeding sites but with little impact on populations.
Silver-haired bat <i>Lasionycteris noctivagrans</i>	2,4,5	Feeds in openings and adjacent to mature forest. Roosts in tree <b>foilage</b> ; uses hollow trees and snags for breeding.	Severe fires may destroy some roosting and breeding sites. Relatively impervious to fire.
Big brown bat <i>Eptesicus fuscus</i>	2,4,5	Common over grassy meadows surrounded by ponderosa pine. Roosts and breeds in hollow trees and snags.	Severe fires may reduce breeding and roosting sites. Relatively impervious to fire.
Western big-eared bat <i>Plecotus mwnsendii</i>	2,7,8,9,10	May be found in forests up through spruce-fir zone. Not a tree user.	Relatively impervious to fire.
Hoary bat <i>Lasiurus cinereus</i>	2,4,5	Prefers wooded areas and trees with dense <b>foilage</b> for roosting and breeding.	Severe fires can destroy roosting and breeding sites. Cool fires have little effect on populations.
<b>LAGOMORPHA</b> (pikas, hares, and rabbits)			
Pika <i>Ochotona princeps</i>	2,4,5,6,7,8,9,10,11	Prefers high-altitude talus slopes adjacent to forest openings containing grasses and forbs.	Relatively impervious to fire. Severe fires may create favorable forest openings with abundant grass-forb food supply.
Mountain cottontail <i>Sylvilagus nuttalli</i>	2	Prefers dense shrubby undergrowth and pole-sized trees for cover. Uses downed logs for cover and nest sites.	Temporarily eliminated from severe burns but reoccupy as shrub cover increases. Will continue to use less than severe burns.
Snowshoe hare <i>Lepus americanus</i>	4,5,6,7,8,9,10,11	Prefers dense shrubs in forest openings or under pole-sized trees for food and cover. Uses downed logs for cover and nest sites.	Temporarily eliminated from severe burns. Populations may increase dramatically as shrubs <b>resprout</b> and dominate the area. Will continue to use less than severe burns.
<b>RODENTIA</b> (gnawing mammals)			
Least chipmunk <i>Eutamias minimus</i>	7,8,9,10	Present in high mountain coniferous forests. Requires open areas with stumps, downed logs, and shrubs or other high vegetation for cover.	Temporarily decreases following severe fire that reduces cover. Return first season after fire and usually abundant by third <b>postfire</b> year.

(con.)

Table 4 (Con.)

Species	Fire Groups	Habitat considerations	Fire effects
<b>Redtail</b> chipmunk <i>E. ruficaudus</i>	<b>2,4,5,6,7,8,9,10,11</b>	Most common in forest openings or edges with abundant shrub undergrowth.	May be temporarily reduced or eliminated on severe burns lacking cover. Use of moderate burns may continue at reduced level, especially if cover and fresh seed is abundant. Populations may exceed <b>pre</b> -burn levels by second or third <b>postfire</b> year.
Yellowpine chipmunk <i>E. amoenus</i>	<b>2,4,5,6,7,8,9,10,11</b>	Prefers shrub, seedling, and sapling stages of forest succession. Usually abundant in open ponderosa pine forests and edges. Needs shelter of downed logs, debris, or shrubs. Often burrows under downed logs and stumps.	Recent burns with stumps and shrubs are favored habitat, especially as seed and fruit producing annuals become available.
Yellow-bellied marmot <i>Marmota flaviventris</i>	<b>2,4,5,6,7,8,9,10,11</b>	Prefers rocky outcrops or talus slopes; forest openings up through spruce-fir zone. Uses downed logs for cover; burrows under tree roots. Feeds on green grass and forbs.	Relatively impervious to fire. Benefits from fire-created openings dominated by grass and forbs.
Hoary marmot <i>M. caligata</i>	<b>6,7,8,9,10</b>	Found in alpine and subalpine habitats; on talus slopes near grassy alpine meadows.	Relatively impervious to fire. Benefits from fire-created grassy openings.
Uinta ground squirrel <i>Spermophilus armatus</i>	<b>4,5,6,7,8,9,10</b>	Prefers moist habitats with lush vegetation and soft soil; subalpine meadows; forest edges.	May increase dramatically on areas where fire has killed overstory. May be favored by increased light and temperature as well as increase in herbaceous growth.
<b>Columbian</b> ground squirrel <i>S. columbianus</i>	<b>2,4,5,6,7,11</b>	Prefers subalpine meadows, forest edges, open woodlands, pine flats, and alpine tundra. Uses downed logs for cover. Burrows on rocky, partly forested gentle slopes.	May increase on areas where canopy has been opened by fire, especially if grass, forbs, and seed are abundant.
Golden-mantled squirrel <i>S. lateralis</i>	<b>2,4,5,6,7,8,9,10,11</b>	Widespread from ponderosa pine forest to alpine meadows. Most abundant in open <b>forests</b> lacking a dense undergrowth or understory. Needs downed logs, stumps, or rocks for cover. Burrows for shelter.	Generally increases on recently burned areas due to increased abundance of forbs, providing adequate escape cover exists.
Red squirrel <i>Tamiasciurus hudsonicus</i>	<b>2,4,5,6,7,8,9,10,11</b>	Found in late successional forests. Nests in tree cavities and branches. Feeds on conifer seeds, nuts, bird eggs, fungi. Uses downed logs for cover.	Essentially eliminated following <b>stand</b> -replacing fires. Cavities in fire-killed trees may be used for dens but only if surrounded by live trees.
Northern flying squirrel <i>Glaucomys sabrinus</i>	<b>2,4,5,6,7,8,9,10,11</b>	Prefers a mature forest. Requires snags and trees with nest cavities. Also requires an abundance of downed logs. Feeds on conifer seed, serviceberries, and mushrooms.	Same as for red squirrel except may forage for fungi in recent burns.
Northern pocket gopher <i>Thomomys talpoides</i>	<b>2,4,5,6,7,8,9,10,11</b>	Prefers disturbed areas of secondary vegetative growth; also pine forests, alpine parks, and meadows. Occurs mostly in deep sandy soils but also in clay and gravelly soils. Requires an herbaceous food source, especially annual forbs.	Population densities usually increase on areas burned by fires that open canopy and disturb the soil resulting in undergrowth of early successional forbs and grasses.
Beaver <i>Castor canadensis</i>	All	Requires streams or lakes bordered by stands of aspen, alder, birch, poplars, or willow for food and building materials.	Populations usually increase following fires that initiate a successional sequence that includes aspen as an intermediate stage.
Western harvest mouse <i>Reithrodontomys megalotis</i>	All	Generally restricted to grass-forb stages on all habitat types. Usually nests on ground but sometimes in woodpecker holes.	Generally favored by fires that result in establishment of seed-producing annual plants.

(con.)

Table 4 (Con.)

Species	Fire Groups	Habitat considerations	Fire effects
Deer mouse <i>Peromyscus maniculatus</i>	All	Ubiquitous. Occurs in most successional stages of most habitat types. Nests in burrows, trees, and stumps. Uses downed logs for nesting sites and cover.	Populations reduce immediately following fire but significantly increase as soon as rain settles the ash. Most abundant small mammal on severely burned areas.
White-footed mouse <i>P. leucopus</i>	2,3,4	Found in riparian woodlands, pine, and aspen; brushy areas; in grasslands below woodlands. Burrows in sandy soils but may nest in old bird or squirrel nests, or under stumps and logs.	Response to fire similar to that of deer mouse. Preferred habitat less likely to experience severe fire.
Bushytail woodrat <i>Neotoma cinerea</i>	2,4,5,6,7,8,9,10,11	Prefers rocky situations. Dens in rock crevices; sometimes in hollow logs. Gathers conifer seed, berries, fungi, twigs, shoots, and green vegetation.	Relatively impervious to fires that occur in high-elevation rocky habitat. Usually not abundant on recent burns.
Southern red-backed mouse (boreal red-backed vole) <i>Clethrionomys gapperi</i>	2,4,5,6,7,8,9,10,11	Prefers <b>mesic</b> areas within coniferous forests that contain abundance of large debris on forest floor and undergrowth of shrubs and herbs. Feeds on conifer seed, bark, fungi, and green vegetation. A coniferous overhead tree canopy is preferred.	Usually eliminated from severely burned areas within 1 year after fire. If overstory trees are present and survive, favorable habitat may return in 7 or more years after the fire.
Mountain phenacomys (heather vole) <i>Phenacomys intermedius</i>	2,4,5,6,7,8,9,10,11	Found in both dry and moist habitats; in grassy areas and in shrub patches in conifer forests. Burrows under stumps or downed logs. Feeds on seeds, bark, green vegetation, lichens, and berries.	Probably eliminated from severe burns. Reinvades with the establishment of suitable cover.
Meadow vole <i>Microtus pennsylvanicus</i>	2,4,5,6,7,8,9,10,11	Requires a mat of ground cover for runways, palatable herbs, conifer seed, and moisture. Uses downed logs for cover and nest sites. Usually found near streamside.	Usually eliminated from severe burns where surface organic layer is absent. The wet nature of preferred habitat tends to resist fire.
Longtail vole <i>M. longicaudus</i>	2,4,5,6,7,8,9,10	Widespread in wet mountain meadows and forest edge, often near streams. Requires a grass-sedge-forb food source. Less restricted to runways and dense grass than other <i>Microtus</i> .	Use increases with removal of tree canopy especially on moist north slopes
Muskrat <i>Ondatra zibethicus</i>	Wide range	Occupies cattail marshes; banks of ponds, lakes, or slow-moving streams. Requires a source of succulent grasses or sedges, or other aquatic vegetation.	Periodic fire retains marshes in a subclimax state and removes unfavorable vegetation that crowds out useful plants.
Western jumping mouse <i>Zapus princeps</i>	2,4,5,6,7,8,9,10,11	Requires a well-developed extensive herbaceous layer along edge of rivers, streams, lakes, or other wet areas and moist soil. Uses downed logs for cover and nest sites. Eats seed, grass, and forbs.	Generally eliminated from severe burns that lack the required vegetative cover.
Porcupine <i>Erethizon dorsatum</i>	4,5,6,7,8,9,10,11	Prefers medium and old-age conifer stands of less than 70 percent crown closure and containing shrubs and herbs. Uses hollow logs and tree cavities for dens.	Use of severely burned areas curtailed especially if overstory is killed. May continue to use light and moderate burns.
<b>CARNIVORA (flesh-eaters)</b>			
Coyote <i>Canis latrans</i>	All	Widespread occurrence in most habitats and most successional stages. Uses hollow logs or stumps for dens. Preys on mice.	Increased use of burned areas that support abundant small mammal populations.
Gray wolf <i>C. lupus</i>	4,5,6,7,8,9,10	Highly adaptable but probably restricted to wilderness forests. Preys on other mammals.	Probable increased use of burned areas that support an abundant population of prey species.

(con.)

Table 4 (Con )

Species	Fire Groups	Habitat considerations	Fire effects
Red fox <i>Vulpes fulva</i>	2,4,5,6,7,8, 9,10,11	Prefers open areas in or near forest. Uses hollow stumps and logs for dens. Food includes berries, insects, birds, rodents, squirrels, rabbits, and other small mammals.	Benefits from fires that create favorable habitat for small mammal prey species, especially those that enhance snowshoe hare populations.
Black bear <i>Ursus americanus</i>	4,5,6,7,8,9, 10	Prefers mature forests mixed with shrub-fields and meadows. Omniverous—eats what is available. Requires windfalls, excavated holes, or uprooted or hollow trees for den sites.	Benefits from abundant regeneration of berry-producing shrubs following fire.
Grizzly bear <i>U. horribilis</i>	2,4,5,6,7,8, 9,10,11	Uses all available habitat but prefers early successional stages for feeding and mature forest for cover. Occurrence is increasingly restricted to wilderness-type lands.	Seral forest communities maintained by fire are important for preferred berry-producing plants.
Raccoon <i>Procyon lotor</i>	Widespread	Very adaptable to environmental change; in riparian situations; along marshes, streams, and lakes. Uses hollow trees and downed logs for dens. Omniverous.	Relatively impervious to fire because of mobility and wide ecological amplitude.
Marten <i>Martes americana</i>	2,3,5,6,7,8, 9,10,11	A forest dweller; requires relatively dense climax or near-climax situation. Uses tree or snag cavities and hollow stumps for nest sites. Food includes tree squirrels, chipmunks, mice, berries, and insects.	Eliminated from severely burned stands. Benefits from vegetative mosaics resulting from periodic small fires because of increased food supply. Burns containing adequate cover may be used for feeding during summer and fall.
Fisher <i>M. pennanti</i>	2,4,5,6,7,8, 9,10,11	Prefers forest of large trees with many windfalls and downed logs. Nests in tree holes, hollow logs, and snags. Eats squirrels, porcupines, woodrats, mice, rabbits, insects, and berries.	Preferred habitat is adversely affected by severe fire. Benefits from increase in prey species on burns adjacent to favorable habitat. Adapts better to early successional stages than marten.
Ermine (shorttail weasel) <i>Mustela erminea</i>	2,4,5,6,7,8, 9,10,11	Prefers mature dense forest for breeding and resting; meadows or other forest openings for hunting. Dens often located in hollow logs and snags. Voles are an important prey; also mice, shrews, and chipmunks.	Adversely affected by severe fire that removes ground debris or kills overstory trees. Benefits from increased biomass of prey species that usually results on fire-created grass-forb successional stages.
Longtail weasel <i>M. frenata</i>	Wide range	Ubiquitous—common in most habitats. Prefers open areas and young pole stands. Den sites include logs, stumps, and snags. A major predator of voles and mice; also gophers, chipmunks, birds, insects, and vegetation.	Benefits from increased biomass of prey species that usually result on recently burned areas.
Mink <i>M. vison</i>	Wide range	May occur in any habitat containing fish-supporting marshes, lakes, and streams. Hollow logs and tree stumps along streams may be used for den sites.	Relatively impervious to most fires. May be adversely affected where fire removes streamside cover and debris.
Wolverine <i>Gulo luscus</i>	4,5,6,7,8,9, 10,11	Prefers moderate to dense forests containing large trees. Uses logs and snags as den sites. Prey includes marmots, gophers, squirrels, birds, insects; also eats fruit.	Adversely affected by fire that destroys preferred habitat but benefits from increased biomass of prey species on nearby burns.
Badger <i>Taxidea taxus</i>	Wide range	Grass-forb stages of conifer forest succession are a preferred habitat. Likes deep, friable soil for burrow excavation and rodent capturing.	Benefits from fires that result in grass-forb successional stages because of the abundant rodent populations that are often present.

(con.)

Table 4 (Con.)

Species	Fire Groups	Habitat considerations	Fire effects
Striped skunk <i>Mephitis mephitis</i>	Wide range	Prefers early successional stages of forest, but may be found in all stages and cover types. Uses hollow logs, stumps, and snags for den sites. Food includes large insects and small rodents.	Relatively impervious to fire. Benefits from increased biomass of prey species that usually occur on severe burns.
River otter <i>Lutra canadensis</i>	Wide range	Occurs along streams, marshes, and lakes. Dens in bank. Aquatic.	Essentially impervious to fire.
Mountain lion (cougar, puma) <i>Felis concolor</i>	2,4,5,6,7,8,9,10,11	Found throughout all habitat types and successional stages. Highly mobile. Hunts deer, hares, rodents, and porcupines.	Often flourish on recently burned areas due to increased prey availability.
Lynx <i>Lynx canadensis</i>	4,5,6,7,8,9,10	Primarily in dense coniferous forests at higher elevations. May den in hollow logs. Snowshoe hare is an important prey species.	Benefits from fire-initiated shrub stages of succession that support large populations of snowshoe hare.
Bobcat <i>L. rufus</i>	Widespread	Found in most habitats and successional stages; shrub-sapling stages are especially desirable. May establish den under large logs or in hollow logs. Preys on rodents, reptiles, and invertebrates.	Relatively impervious to fire. Benefits from any fire-induced increase in availability of prey species.
<b>ARTIODACTYLA (even-toed hoofed mammals)</b>			
Elk <i>Cervus canadensis</i>	4,5,6,7,8,9,10,11	Prefers <b>semiopen</b> forest but with areas of dense cover for shelter. Requires food supply of grass, forbs, and shrubs, especially Scouler willow, maple, serviceberry, <b>redstem</b> , and bitter cherry.	Severe burns usually experience a decline in first year use; then an increase as preferred browse species become available. Moderate fires in forest may remove ground debris and other obstructions to movement.
Mule deer <i>Odocoileus hemionus</i>	Wide range	Occupies a wide range of habitats including open montane and subalpine coniferous forest; forest edges, woodlands, and shrubfields. Shrub-seedling-sapling stage of succession preferred. Needs trees and shrubs for cover on winter range. Preferred food includes tender new growth of palatable shrubs—ceanothus, cherry, mountain-mahogany, bitterbrush; many forbs and some grasses.	Fire may improve winter nutrition in grassland and mountain shrub communities by increasing the amount of green grasses. Often a decline in use during first post-burn year and then an increase in subsequent years.
Whitetail deer <i>O. virginianus</i>	Widespread	Prefers dense forest; rough, open shrublands; thickets along streams and woodlands. Diet includes shrubs, twigs, fungi, grasses, and forbs.	Fire-initiated early successional stages supporting new growth of grasses, forbs, and shrubs provide a preferred food source.
Moose <i>Alces alces</i>	All	Prefers subclimax forests with lakes and swamps. <b>Ideal</b> habitat includes a mosaic of numerous age classes and distribution of aspen and associated trees and shrubs within the wintering range.	Fires that result in abundant aspen and willow regeneration create a preferred habitat. Optimal successional stage occurs from 11 to 30 years following a severe fire.
Mountain goat <i>Oreamnos americanus</i>	4,5,6,7,8,9,10,11	Frequents alpine and high subalpine zones; on steep slopes. Feeds on grasses, sedges, and shrubs.	Relatively impervious to fire; usually above fire-prone forest areas. Fire that sweeps up through subalpine and alpine forests may create favorable goat range.
Bighorn sheep (mountain sheep) <i>Ovis canadensis</i>	4,5,6,7,8,9,10	Preferred habitat characterized by rugged rocky mountain slopes with sparse trees and adjacent to alpine meadows. Feeds on alpine shrubs and forbs in summer; shrubs and perennial grasses in winter.	Canopy removal by fire yields increased productivity of undergrowth and makes available more open habitat. Fire may retard successional advance of alpine grasslands and improve productivity and palatability of important forage species. Fire can improve nutrition in mountain shrublands by increasing availability of green grass.

(con.)

Table 4 (Con.)

Species	Fire Groups	Habitat considerations	Fire effects
Woodland caribou Rangifer caribou	7,8,9,10,11	Lightly stocked seral or mature spruce-fir forests interspersed with lakes, bogs, and fens provide prime habitat. Lichens are important winter food; shrubs and forbs used during the summer.	Severe stand-replacing fires result in displacement or elimination of caribou use and replacement by moose.
CAUDATA (salamanders)			
Tiger salamander Ambystoma <i>tigrinum</i>	2,4,5,6,7,8, 9,10,11	Found in and near pools, ponds, lakes, and streams. Adults sometimes burrow in decayed logs in damp forest situations.	Impervious to fire except for minor direct mortality in severe fire situations.
Rough-skinned newt Taricha granulosa	11	Inhabits grassland, woodland, and forest in cold permanent streams. Some hide under slabs of bark, logs, or rotten wood in riparian zones.	Generally impervious to fire. Some direct mortality possible in severe fire situations.
Coeur d'Alene salamander (Van Dyke's salamander) Plethodon vandykei	7,8,9,10	Inhabits humid Douglas-fir and dwarf maple forests, in rock and dirt talus and gravel.	Moisture conditions in preferred habitat generally preclude severe fire effects. Habitat destruction by mechanical means has made this species rare.
SALIENTIA (frogs and toads)			
Tailed frog Ascaphus <i>truei</i>	2,4,5,6,7,8, 9	Inhabits cold streams in humid forests of Douglas-fir, spruce, pine, and maple. Comes to shore only on cold rainy days.	Impervious to fire.
Spotted frog Rana pretiosa	2,4,5,6,7,8, 9	Highly aquatic.	Impervious to fire.
Leopard frog R. <i>pipiens</i>	Wide range	Stays around water. In summer it inhabits swamps, grassy woodland, or short-grass meadows.	Generally impervious to fire. Some direct mortality possible from fast-spreading surface fire.
Pacific tree frog Hyla <i>regilla</i>	2,4,5,6,7,8, 9,10,11	Varied habitats. May inhabit damp recesses among rocks and logs in damp woodland or forest. Uses downed logs for hiding and thermal.	Damp habitat minimizes fire effects. Surface fire under severe drying conditions could degrade habitat.
Boreal toad (western toad) Bufo <i>boreas</i>	2,4,5,6,7,8, 9,10,11	Found in or near water. Burrows in loose soil.	Relatively impervious to fire.
CHELONIA (turtles)			
Snapping turtle Chelydra serpentina		Highly aquatic.	Impervious to fire.
Painted turtle Chrysemys picta		Highly aquatic. Basks near the water on mudbanks, rocks, and logs.	Impervious to fire.
SQUAMATA (snakes and lizards)			
Western skink Eumeces skiltonianus	2,4,5,6,7,11	Found in woodland and forest with dense vegetation. Inhabits rocky streamsides, dry grassy hillsides, forest openings, and meadows. Hides under logs and bark. Diet includes moths, beetles, crickets, grasshoppers, and spiders.	Severe surface fires will reduce cover and food supply.
Northern alligator lizard Gerrhonotus <i>coeruleus</i>	2,4,5,6,7,11	Inhabits woodland and forests. Occurs under bark, inside rotten logs, and under rocks and debris. Searches under surface objects for insects and small animals.	Surface fires can destroy habitat and result in some direct mortality.
Rubber boa (Rocky Mountain boa) Charina <i>bottae</i>	2,4,5,6,7,8, 9,10,11	Found near streams and meadows in all forest types; prefers pole to mature stands. Uses rotting logs and bark of fallen and standing dead trees for hiding. Feeds on <b>rodents</b> , insects, and lizards on forest floor.	Severe surface fire can remove cover and temporarily reduce abundance of prey species.

(con.)

Table 4 (Con.)

Species	Fire Groups	Habitat considerations	Fire effects
Racer (Western yellow-bellied racer) <i>Coluber constrictor</i>	2	Inhabits open woodlands, wooded ravines, and thickets. Diet includes lizards, frogs, small rodents, snakes, and insects.	Surface fire may adversely affect food supply.
Gopher snake (bullsnake) <i>Pituophis melanoleucus</i>	2,4,5,6,7	Highly adaptable species; occupies a variety of habitats. Mainly hunts on surface for small mammals.	Relatively impervious to fire because of wide ecological amplitude.
Common garter snake (red-sided garter snake; valley garter snake) <i>Thamnophis sirtalis</i>	2,4,5,6,7,8, 9	Widely distributed in many different habitats that include a water source. Diet largely aquatic but includes small mammals.	Impervious to fire.
Western rattlesnake (prairie rattlesnake) <i>Crotalus viridis</i>	Widespread	Highly variable habitats, including open woodlands to mountain forests. Often found in rock outcrops. Hunts on surface for rodents.	Relatively impervious to fire except for possible direct mortality in severe surface fire situations.

Hypothesized fire tolerance for some western Montana  
bird species is classified in table 5.

Table 5—Hypothesized fire tolerance for some western Montana birds (adopted from Kramp and others 1983)

Fire intolerant	Fire impervious	Fire adapted	Fire dependent
Ash-throated flycatcher ( <i>Myiarchus cinerascens</i> )	American crow ( <i>Corvus brachyrhynchos</i> )	American kestrel ( <i>Falco sparverius</i> )	Blue grouse ( <i>Dendragapus obscurus</i> )
Black-capped chickadee ( <i>Parus atricapillus</i> )	American robin ( <i>Turdus migratorius</i> )	American robin ( <i>Turdus migratorius</i> )	House wren ( <i>Troglodytes aedon</i> )
Brewer's sparrow ( <i>Spizella breweri</i> )	Black-billed magpie ( <i>Pica pica</i> )	Black-headed grosbeak ( <i>Pheucticus melanocephalus</i> )	Mourning dove ( <i>Zenaida macroura</i> )
Brown creeper ( <i>Certhia americana</i> )	Blue jay ( <i>Cyanocitta cristata</i> )	Blue-winged teal ( <i>Anas discors</i> )	Sandhill crane ( <i>Grus canadensis</i> )
Burrowing owl ( <i>Athene cunicularia</i> )	Blue-winged teal ( <i>Anas discors</i> )	Brewer's sparrow ( <i>Spizella breweri</i> )	Wild turkey ( <i>Meleagris gallopavo</i> )
Cassin's finch ( <i>Carpodacus cassinii</i> )	Brown-headed cowbird ( <i>Molothrus ater</i> )	Canada goose ( <i>Branta canadensis</i> )	
Chipping sparrow ( <i>Spizella passerina</i> )	Brown thrasher ( <i>Toxostoma rufum</i> )	Clark's nutcracker ( <i>Nucifraga columbiana</i> )	
Golden-crowned kinglet ( <i>Regulus satrapa</i> )	Canada goose ( <i>Branta canadensis</i> )	Cliff swallow ( <i>Hirundo pyrrhonota</i> )	
Great horned owl ( <i>Bubo virginianus</i> )	Cedar waxwing ( <i>Bombycilla cedrorum</i> )	Common nighthawk ( <i>Chordeiles minor</i> )	
Hammond's flycatcher ( <i>Empidonax hammondi</i> )	Clark's nutcracker ( <i>Nucifraga columbiana</i> )	Common poorwill ( <i>Phalaenoptilus nuttallii</i> )	
Hermit thrush ( <i>Catharus guttatus</i> )	Cliff swallow ( <i>Hirundo pyrrhonota</i> )	Cooper's hawk ( <i>Accipiter cooperii</i> )	
Mountain chickadee ( <i>Parus gambeli</i> )	Common raven ( <i>Corvus corax</i> )	Downy woodpecker ( <i>Picoides pubescens</i> )	
Northern goshawk ( <i>Accipiter gentilis</i> )	Common snipe ( <i>Gallinago gallinago</i> )	Fox sparrow ( <i>Passerella iliaca</i> )	
Pine siskin ( <i>Carduelis pinus</i> )	Eastern kingbird ( <i>Tyrannus tyrannus</i> )	Gadwall ( <i>Anas strepera</i> )	
Purple finch ( <i>Carpodacus purpureus</i> )	European starling ( <i>Sturnus vulgaris</i> )	Green-tailed towhee ( <i>Pipilo chlorura</i> )	
Pygmy nuthatch ( <i>Sitta pygmaea</i> )	Gadwall ( <i>Anas strepera</i> )	Hairy woodpecker ( <i>Picoides villosus</i> )	
Red-breasted nuthatch ( <i>Sitta canadensis</i> )	Great blue heron ( <i>Ardea herodias</i> )	House wren ( <i>Troglodytes aedon</i> )	

(con.)



Table 5 (Con.)

Fire intolerant	Fire impervious	Fire adapted	Fire dependent
Red crossbill ( <i>Loxia curvirostra</i> )	Horned lark ( <i>Eremophila alpestris</i> )	Killdeer ( <i>Charadrius vociferus</i> )	
Ruby-crowned kinglet ( <i>Regulus calendula</i> )	MacGillivray's warbler ( <i>Oporornis tolmiei</i> )	Lark sparrow ( <i>Chondestes grammacus</i> )	
Rufous-sided towhee ( <i>Pipilo erythrophthalmus</i> )	Mallard ( <i>Anas platyrhynchos</i> )	Luzuli bunting ( <i>Passerina amoena</i> )	
Sharp-shinned hawk ( <i>Accipiter striatus</i> )	Mourning dove ( <i>Zenaidura macroura</i> )	Mallard ( <i>Anas platyrhynchos</i> )	
Solitary vireo ( <i>Vireo solitarius</i> )	Northern flicker ( <i>Colaptes auratus</i> )	Mountain bluebird ( <i>Sialia currucoides</i> )	
Western flycatcher ( <i>Empidonax difficilis</i> )	Northern pintail ( <i>Anas acuta</i> )	Northern flicker ( <i>Colaptes auratus</i> )	
Western tanager ( <i>Piranga ludoviciana</i> )	Red-winged blackbird ( <i>Agelaius phoeniceus</i> )	Northern pintail ( <i>Anas acuta</i> )	
White-crowned sparrow ( <i>Zonotrichia leucophrys</i> )	Snowy egret ( <i>Egretta thula</i> )	Purple martin ( <i>Progne subis</i> )	
White-throated sparrow ( <i>Zonotrichia albicollis</i> )	Song sparrow ( <i>Melospiza melodia</i> )	Red-naped sapsucker ( <i>Sphyrapicus nuchalis</i> )	
Yellow-rumped warbler ( <i>Dendroica coronata</i> )	Steller's jay ( <i>Cyanocitta stelleri</i> )	Rufous-sided towhee ( <i>Pipilo erythrophthalmus</i> )	
Yellow warbler ( <i>Dendroica petechia</i> )	Townsend's solitaire ( <i>Myadestes townsendi</i> )	Snowy egret ( <i>Egretta thula</i> )	
	Turkey vulture ( <i>Cathartes aura</i> )	Three-toed woodpecker ( <i>Picoides tridactylus</i> )	
		Tree swallow ( <i>Tachycineta bicolor</i> )	
		Vaux's swift ( <i>Chaetura vauxi</i> )	
		Vesper sparrow ( <i>Pooecetes gramineus</i> )	
		Violet-green swallow ( <i>Tachycineta thalassina</i> )	
		Western bluebird ( <i>Sialia mexicana</i> )	
		Western kingbird ( <i>Tyrannus verticalis</i> )	
		Western meadowlark ( <i>Sturnella neglecta</i> )	
		Western screech owl ( <i>Otus kennicottii</i> )	
		Western wood-pewee ( <i>Contopus sordidulus</i> )	
		Wild turkey ( <i>Meleagris gallopavo</i> )	
		Williamson's sapsucker ( <i>Sphyrapicus thyroideus</i> )	
		Winter wren ( <i>Troglodytes troglodytes</i> )	

<sup>1</sup>Scientific and common names follow the American Ornithologists' Union (A.O.U.) 1983 Check-list as contained in the National Geographic Society. **Field Guide to the Birds of North America**, 1983. 464 p.

## SUMMARY ON DOWNED, DEAD FUEL

Downed dead woody fuel consists of dead twigs, branches, stems, and boles of trees that have fallen and lie on or near the ground (Brown and See 1981). Table 6 is a summary of such fuel for western Montana forests based on 6 years of Forest Service forestwide inventories on the Bitterroot, Flathead, Kootenai, and Lolo National Forests. These inventories were conducted for timber management planning, often in anticipation of timber harvest, so many stands were "high risk" stands with higher than normal

fuel accumulations. Fuel loads and duff depths are presented in table 6 for seven different habitat type groups defined by Brown and See (1981) based on similarity of loading and correspondence to the habitat type Fire Groups.

The values in table 6 are group averages. Habitat type averages are shown in figure 3, which also shows how habitat type loadings compare. Brown and See (1981) provide additional summaries of fuel loads that should be useful aids for fire management.

Table 6—Average downed woody loadings and duff depths for western Montana forests by habitat type, loading groups, and equivalent Fire Groups (source: Brown and See 1981)

Habitat type loading groups <sup>1</sup>	Equivalent habitat type Fire Groups	Downed woody				Duff depth inches
		1/4-1 inch	1-3 inches	Over 3 inches	Total woody	
		----- Tons/acre -----				
2	2,3,4,5	0.8	1.5	10.9	13.2	0.9
3	6	.9	1.5	9.1	11.5	1.0
4	7,8	.9	1.5	15.6	18.4	1.1
5	9	.9	1.8	22.0	24.7	1.5
6	10	.8	1.4	15.6	17.8	1.3
7	11	1.3	2.2	21.5	25.0	1.8

- <sup>1</sup>2 = Dry site Douglas-fir and moist site ponderosa pine.
- <sup>1</sup>3 = Moist site Douglas-fir.
- <sup>1</sup>4 = Cool sites dominated by lodgepole pine; dry, lower elevation subalpine fir.
- <sup>1</sup>5 = Moist site, lower elevation subalpine fir.
- <sup>1</sup>6 = Cold, moist site upper elevation subalpine fir.
- <sup>1</sup>7 = Warm, moist sites; mostly cedar-hemlock.

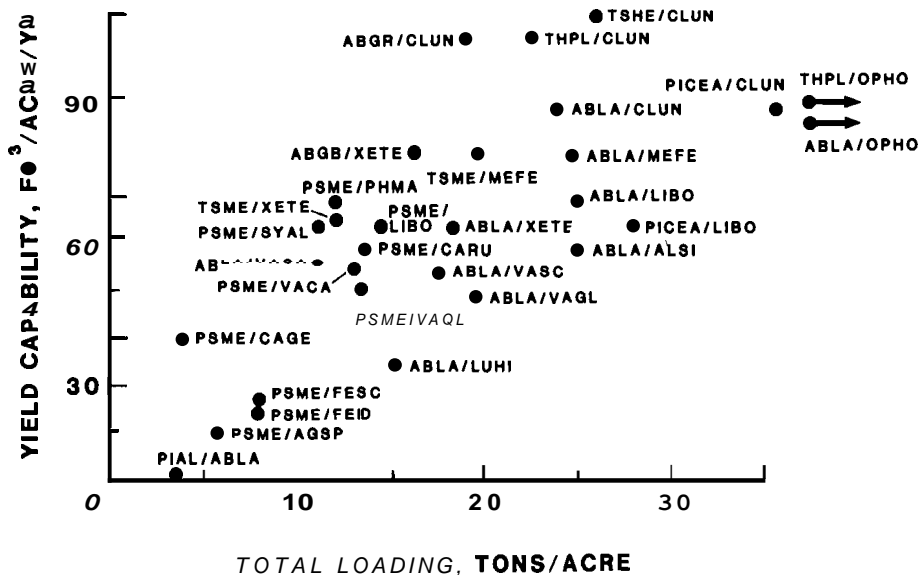


Figure 3—Ordination of habitat types by yield capability and total downed woody fuel loading for western Montana and northern Idaho National Forests. Yield capabilities are from Pfister and others (1977). Plotted habitat types are represented by at least five stands or 35 sample points (source: Brown and See 1981). See table 1 for Fire Group assignment of habitat types.

## FIRE USE CONSIDERATIONS

Fire management applications of fire ecology information are presented at the end of each Fire Group discussion. The use of fire to accomplish certain resource management objectives is suggested in these fire management presentations. The following fire use considerations apply generally to all Fire Groups.

### Heat Effects and Insect Attack

Care must be taken when burning in forest stands to prevent or minimize scorching the crowns of residual overstory trees. Heavy fuel accumulations or slash concentrated near the base of overstory trees may require scattering or other treatment to avoid lethal cambium heating. Excessive crown scorch, cambium damage, or both can result in loss of vigor and increased susceptibility to bark beetle attack or tree mortality. For example, the relationships between crown defoliation and mortality caused by the western pine beetle in ponderosa pine have been generalized as follows (Stevens and Hall 1960):

Percentage defoliation	Percentage of trees killed by beetles
0-25	0-15
25-50	13-14
50-75	19-42
75-100	45-87

The season in which a fire occurs is an important factor influencing tree mortality and the occurrence, duration, and severity of a potential beetle attack on fire-weakened trees. The result of crown scorching is usually more severe during the active growth period early in the summer than later when growth has slowed, terminal buds have formed, and a food reserve is being accumulated (Wagener 1955, 1961). Likewise, crown scorching that occurs in early spring, before or immediately after bud burst, often results in minimum damage to the tree.

Prescribed burning of understory vegetation and dead surface fuels can be carried out without serious threat of subsequent damage by bark beetles provided the overstory trees are not severely scorched (Fischer 1980). If accidental scorching does occur and bark beetle activity is detected, prompt removal of the severely scorched trees will reduce the probability of subsequent damage to healthy green trees. If scorching occurs outside the active growth period, scorched trees may recover and regain lost vigor. This may take 3 years, but signs of recovery should be visible during the first growing season that follows scorching.

### Frequency of Burning

The effects of repeated burning on a given site are not well defined for western Montana forests. Consequently, it seems prudent to gear the frequency of prescribed fire on a site to the wildfire frequencies that existed prior to organized fire suppression (see Arno 1980). Consequences of too frequent fire might include loss of seed source, loss of nutrients, and a decline in the fertility of the site.

## Large Woody Debris

An important fire use consideration is the need to retain a certain amount of woody material for maintenance of forest site quality. Current understanding of the relationships between organic matter and ectomycorrhizae in Northern Rocky Mountain forest soils is based on work by Harvey, Jurgensen, and Larsen in western Montana (Harvey 1982). They found ectomycorrhizal development was stimulated by the presence of decayed wood in the soil. Decayed wood also has a moisture and nutrient regime often favorable to continued seedling growth. These potential benefits are especially important on moderately dry sites.

Scattered large logs left on a site also retard soil movement and provide shade for young seedlings. The more tolerant tree species such as subalpine fir or Engelmann spruce will not successfully regenerate without at least partial shade. Harvey and others (1981) suggest that about 11 to 17 tons per acre (2.5 to 3.8 kg/m<sup>2</sup>) of fresh residues larger than 6 inches (15 cm) in diameter should be left on the site following logging and burning. In addition, only as much mineral soil should be bared as is necessary to obtain desired stocking. These authors further suggest that amounts of organic matter in excess of the above requirements can be considered undesirable especially on dry sites. Excess buildup of fuels can set the stage for high-intensity wildfires that result in an extreme reduction of the soil's organic reserves. Numerical relationships for predicting duff and woody fuel consumption by prescribed fire in the Northern Rocky Mountains are provided by Brown and others (1985).

A final reason for leaving moderate amounts of large diameter woody debris scattered on the site following logging and burning is to supply food and cover for wildlife. Many small mammals that reside in western Montana forests rely on forest floor debris for cover and nesting sites. Rotten logs are often important foraging sites for both mammals and birds. Logs, for example, are important feeding sites for pileated woodpeckers.

Woodpeckers and other cavity-nesting birds (and mammals) also require snags, preferably scattered patches of snags, for nesting sites (McClelland and Frissell 1975; McClelland and others 1979).

The need to retain moderate amounts of scattered large-diameter woody debris should not preclude slash disposal. Unabated logging slash represents a significant fire hazard on most sites, usually greatly in excess of the pretreatment situation. This increased hazard will exist for at least 3 to 5 years, even with a maximum compaction effect from winter snows.

Unabated logging slash as well as large accumulations of deadfall in untreated stands can affect elk behavior and movement. Elk use may be diminished when slash inside a treatment unit exceeds 1.5 ft (0.5 m) in depth and dead and down material outside the opening exceeds 1.5 ft (0.5 m) (Boss and others 1983).

### Heat Effects on Soil

Properly applied, prescribed fire has a low risk of causing long-term adverse effects on the fertility of the most common western Montana soils. However, the effect on

naturally infertile soils is unclear and should be monitored. The intense heat and ashes resulting from burning dozer-piled slash can affect regeneration success on the area occupied by the piles. Therefore, size of piles should be kept small, and burning should be deferred to periods of relatively high fuel and soil moisture (Holdorf 1982).

## Prescribed Fire Planning

From a fire management perspective, a successful prescribed fire is one that is executed safely, burns under control, accomplishes the prescribed treatment, and attains the land and resource management objectives for the area involved. Successful prescribed burning requires planning. Such planning should be based on the following factors (Fischer 1978):

1. Physical and biological characteristics of the site to be treated.
2. Land and resource management objectives for the site to be treated.
3. Known relationships between preburn environmental factors, expected fire behavior, and probable fire effects.
4. The existing art and science of applying fire to a site.
5. Previous experience from similar treatments on similar sites.

## FIRE GROUP ZERO: MISCELLANEOUS SPECIAL HABITATS

Group Zero is a miscellaneous collection of habitats that do not fit into the Montana habitat type classifications.

### Scree

Scree refers to slopes covered with loose rock fragments, usually lying near the maximum possible angle of repose so that any disturbance causes minor rock slides down the face of the slope. Scree slopes may be treeless or they may support scattered trees with sparse undergrowth. Usually scree communities are regarded as special environments where the vegetation is in an uneasy equilibrium with the unstable substrate.

The discontinuous fuel often makes scree slopes unburnable. Individual trees or islands of vegetation may ignite, but fire spread is limited. A severe wind-driven fire could pass over the intervening open spaces and destroy a scree community, but this rarely happens. Due to the harsh environment, these sites do not revegetate well, and revegetation following a fire can take a long time.

### Forested Rock

Forested rock is usually a steep canyon wall or mountainside composed of rock outcrops, cliffs, and occasional clumps of trees clinging to ledges and crevices. Species growing here include ponderosa pine, Douglas-fir, juniper, and alder. Forested rock is especially prominent along the canyons of major rivers and in rugged upper subalpine areas near timberline. These sites bear a certain similarity to scree sites, but the substrate is solid and climax species frequently become established.

Surface fires do not burn well because of the vertical and horizontal discontinuity of ground fuels. The probab-

ity of crown fires depends on the density and arrangement of trees on the rock face. In some cases the islands of vegetation are so widely scattered as to be almost immune to wildfire. In other cases, particularly low-elevation Douglas-fir forested rock communities, a continuity of foliage from the base to the top of a cliff can occur. Each tree forms a ladder into the lower branches of the next higher tree upslope. In such cases crown fires can occur over ground that would not support a less severe surface fire.

Revegetation of rocky sites proceeds at a rate characteristic of the site and depends on the severity of the fire, the age and depth of the soil on ledges and in pockets of rock, erosion if any, and the availability of seeds.

### Wet Meadow

A meadow is an opening in the forest that is characterized by herbaceous vegetation and abundant water. Subirrigation is common during at least some part of the growing season. Mountain meadows are frequently too wet to burn during the fire season. In midsummer, wet meadows often act as natural firebreaks, but during the late summer and early fall they may carry grass fires. In some situations, especially when meadows are dominated by grass, they may burn early in the spring following snowmelt and prior to greenup.

Streamside meadows may gradually become drier in the course of succession from a hydric to a mesic condition. The buildup of organic material and trapped sediments from the flowing water, combined with a possible deepening of the streambed and lowering of the water table, can leave former meadows in an intermediate condition between wet meadow and grassland. In some such sites the meadow becomes bordered by fire-maintained grassland. Fire suppression has allowed conifers to invade meadows where they would not normally be found.

### Mountain Grassland

A mountain grassland (or grassy bald) is a grass-covered opening within an otherwise continuous coniferous forest. Mountain grasslands may act as firebreaks and can be maintained as grassland by light fires, but usually their fire ecology is less obvious. Despain (1973) found boundaries between grassland and forest in the Bighorn Mountains of Wyoming, which he attributed to topography and soils. Daubenmire (1943) suggested that soil factors might cause permanent mountain grasslands. It is also possible that these are natural grasslands that have little potential for forest development. Caution is indicated in management of stands adjacent to mountain grasslands until conditions responsible for their perpetuation are determined.

### Aspen Grove

Groves of quaking aspen or quaking aspen and black cottonwood can occur as local climax vegetation on streamside sites or as fire-maintained stands in areas that would otherwise be dominated by conifers. In the fire-maintained areas, the absence of fire can result in the gradual elimination of aspen due to lack of successful regeneration by suckering.

## Alder Glade

An alder glade is an opening in the forest occupied by alder. Such sites usually appear on local areas that are too wet for associated conifers. Because they are wet, alder glades burn infrequently, but they can burn intensely and then resprout from surviving underground stems. Burning tends to make the stand more dense because each burned plant puts up several new shoots during recovery. Alder, like aspen, can exist as a fire-maintained stand in areas where conifer invasion is possible.

## Fire Management Considerations

Group Zero sites will not burn readily under normal summertime weather conditions. Fire managers can take advantage of this fact when developing preattack plans and when delineating fire management areas, units, or zones. These sites can also serve as anchor points for fuelbreaks and firebreaks.

Meadows and aspen groves can be important wildlife habitats. Prescribed fire is a suitable tool for maintaining desired forage conditions on these sites.

## FIRE GROUP TWO: WARM, DRY PONDEROSA PINE HABITAT TYPES

ADP code	Habitat type-phase (Pfister and others 1977)	Montana forest region (Arno 1979)
130	<i>Pinus ponderosa</i> / <i>Agropyron spicatum</i> h.t. (PIPOIAGSP), ponderosa pinelbluebunch wheatgrass	Northwestern and west central
141	<i>Pinus ponderosa</i> / <i>Festuca idahoensis</i> h.t.- <i>Festuca idahoensis</i> phase (PIPOIFEID-FEID), ponderosa pine/Idaho fescue-Idaho fescue phase	West central
142	<i>Pinus ponderosa</i> / <i>Festuca idahoensis</i> h.t.- <i>Festuca scabrella</i> phase (PIPOIFEID-FESC), ponderosa pine/Idaho fescue-rough fescue phase	West central
161	<i>Pinus ponderosa</i> / <i>Purshia tridentata</i> h.t.- <i>Agropyron spicatum</i> phase (PIPO/PUTR-AGSP), ponderosa pinelantelope bitterbrush/bluebunch wheatgrass phase	West central
162	<i>Pinus ponderosa</i> / <i>Purshia tridentata</i> h.t.- <i>Festuca idahoensis</i> phase (PIPOIPUTR-FEID), ponderosa pinelantelope bitterbrush-Idaho fescue phase	Northwestern and west central
171	<i>Pinus ponderosa</i> / <i>Symphoricarpos albus</i> h.t.- <i>Symphoricarpos albus</i> phase (PIPO/SYAL-SYAL), ponderosa pine/common snowberry-common snowberry phase	Northwestern and west central

## Vegetation

Fire Group Two consists of ponderosa pine stands with predominantly grass undergrowth. These sites may exist as fire-maintained grassland and will support Rocky Mountain juniper and Douglas-fir as accidental individuals. Rocky Mountain juniper may be a minor climax species on some sites. Sites are typically hot, dry, south-facing and west-facing slopes at low elevations, forming the lower timberline in the area. Slopes are often steep with poorly developed soils. Moisture stress is a critical factor for plant growth during summer months. Stocking limitations often result in low productivity, although some sites regenerate readily.

In the undergrowth, common snowberry, antelope bitterbrush, and chokecherry are important shrubs. On rocky outcrops near Darby, MT (Bitterroot National Forest), curleaf mountain-mahogany (curleaf cercocarpus) is common. Herbaceous species include Idaho and rough fescue and white stoneseed.

## Forest Fuels

Fuel loads tend to be light when compared to other Fire Groups. Often, the most abundant surface fuel is cured grass. This is especially true for mature, open-grown stands of ponderosa pine. Downed woody fuels in such stands usually consist of widely scattered, large trees (deadfalls) and concentrations of needles, twigs, branchwood, bark flakes, and cones near the base of individual trees. Fuel loads in such stands may be less than 1 ton per acre (0.2 kg/m<sup>2</sup>).

Fuel loads in dense pole and small sawtimber stands may be much higher than in the older open-type stands. Figure 4 and table 7 show a range of loadings that can exist in these young stands.

## Role of Fire

The natural role of fire in warm, dry ponderosa pine stands is threefold:

1. To maintain grasslands. Grassland areas capable of supporting juniper and ponderosa pine may remain treeless through frequent burning.

2. To maintain open ponderosa pine stands. The open condition is perpetuated by periodic fires that either reduce the number of seedlings, remove dense understories of sapling or pole-sized trees, or thin overstory trees.

3. To encourage ponderosa pine regeneration. Fire exposes mineral soil, reduces seedling-damaging cutworm populations, reduces competing vegetation, and increases nutrient availability. Depending on the subsequent seed crop, weather, and continuity of the seedbed, regeneration may appear as dense stands, separated thickets, or scattered individuals. Periodic fires can create uneven-aged stands comprising various even-aged groups. Severe fires will result in a predominantly even-aged stand.

Historically, natural fire frequencies in forests adjacent to grasslands were fairly high, according to numerous studies conducted in the ponderosa pine forest types throughout the Western States. These studies show fire to have been a frequent event, at intervals from 5 to 25



Figure 4—A range of Group Two fuel loads: Stand 24 is a 137-year-old ponderosa pine stand on a ponderosa pine/Idaho fescue h.t.-Idaho fescue phase; Stand 72 is an 8-year-old ponderosa pine stand on a ponderosa pine/common snowberry h.t.-common snowberry phase. See table 7 for fuel load by size class, total fuel load, and duff depth.

Table 7—Fuel loadings by size class for stands shown in figure 4

Stand number	Age <sup>1</sup>	Habitat type-phase	Size class (inches)						Total
			0-1/4	1/4-1	1-3	3-6	6-10	10-20	
	Years		----- Tons/acre -----						
24	137	PIPO/FEID-FEID	0.10	0.60	0.40	0.10	0	0	1.10
72	80	PIPO/SYAL-SYAL	.14	2.20	4.40	5.34	2.30	2.10	16.48

<sup>1</sup>Age is of overstory dominants

years in most locations. On the Bitterroot National Forest, Arno (1976) and Arno and Peterson (1983) reported a range of 2 to 20 years and mean fire-free intervals of 6 to 12 years for fires somewhere in small stands of 50 to 100 acres (20 to 40 ha). Fire history investigators caution that these figures are conservative estimates of past mean fire-free intervals. Intervening light ground fires could have effects on stand development without leaving scars on trees.

Wright (1978) suggests a fire interval of 50 years or more for the PIPO/PUTR h.t. He bases this hypothesis on observation and current knowledge of the susceptibility of bitterbrush to fire (Nord 1965; Weaver 1967; Wright 1978). Other investigators suggest that ponderosa pine communities with shrub understories experienced fire frequencies of considerably less than 50 years (Gruell and others 1982; Weaver 1957, 1959, 1961).

The effects of fire suppression during the 20th century on some sites have been confounded by the rocky, dry nature, low site productivity, and the influence of grazing.

In more productive sites, the absence of fire has resulted in overstocking and increased fuels. Natural regeneration is often quite slow, and in many cases fire suppression has caused little fuel buildup. In fact, on gravelly south slopes, fuels are light and variable both vertically and horizontally in spite of 50 years or more without fire. Occasionally, thickets of moderate to heavy fuels do occur, but the surrounding sparse fuels and open stand structure tend to reduce the hazard. Such areas may not be available to burn during years of low to moderate fire danger simply because of lack of fuel. However, during severe fire danger, wind-driven fires may spread through the sparse dry fuels.

## Forest Succession

A generalized concept of natural forest succession for Fire Group Two sites and how fire affects this succession is shown in figure 5 (subsequent numbers in this section refer to fig. 5).

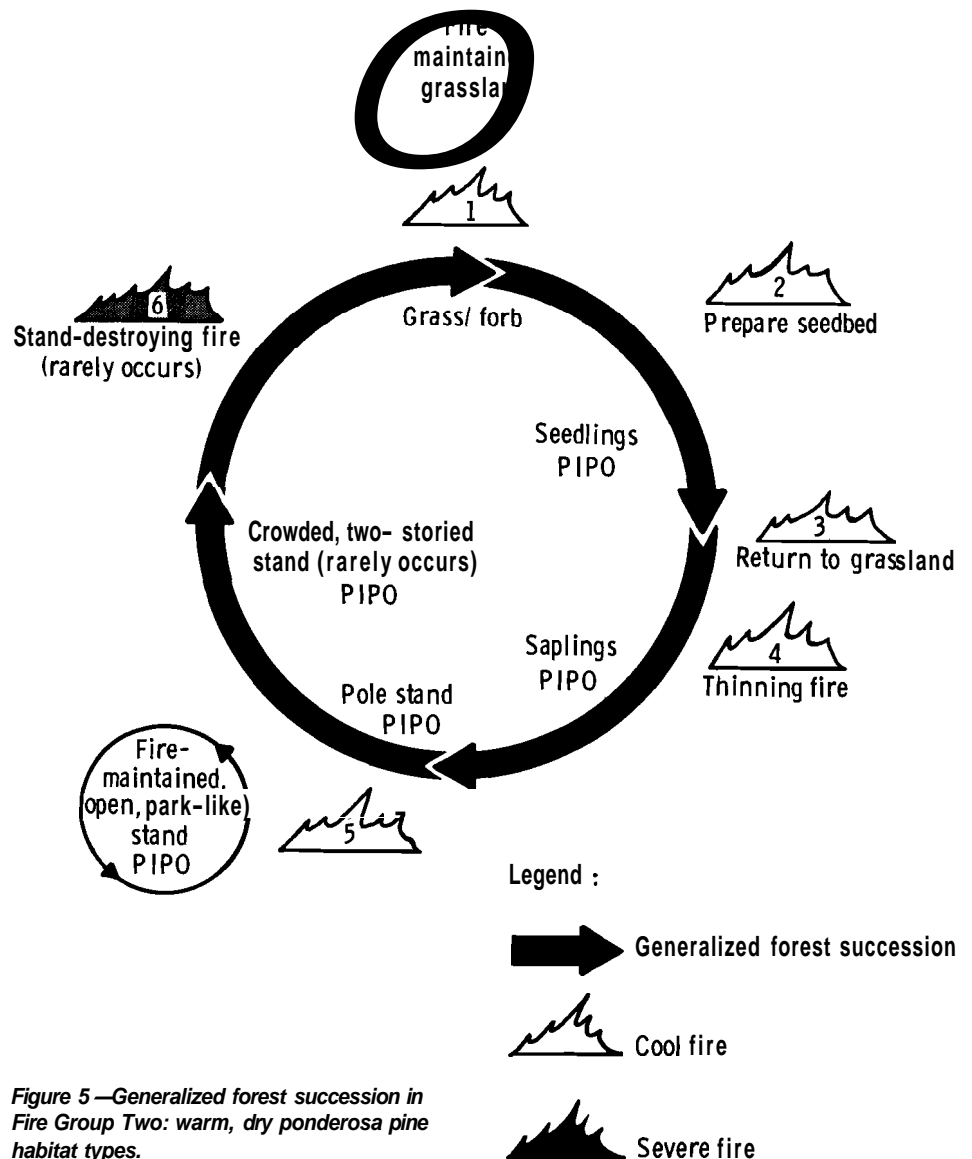


Figure 5—Generalized forest succession in Fire Group Two: warm, dry ponderosa pine habitat types.

Frequent fires tend to maintain the grassland community by killing pine seedlings (No. 1). Grasses dominate the undergrowth, but other herbs and small shrubs may be present. Ponderosa pine seedlings may become established gradually over a long fire-free period resulting in an all-aged, all-sized stand, or as a single age class following a seedbed-preparing fire (No. 2). In the absence of further burning, the seedlings develop into saplings. Fires during this period may have the effect of killing the young trees (No. 3) or thinning them (No. 4).

With sufficient time the remaining saplings mature to pole-sized trees. Subsequent light ground fires tend to produce an open stand of mature trees (No. 5). In the absence of fire, the stand may (in theory) become overstocked and accumulate enough fuel to support a severe stand-destroying fire (No. 6).

Successional pathways that reflect the interaction of fire, the absence of fire, and silvics on forest stand development are hypothesized in figure 6.

## Fire Management Considerations

Fire management considerations for Fire Group Two are wildfire hazard reduction, forage production, site preparation and stocking control, and recreation site development and maintenance.

**Wildfire Hazard Reduction**—Prescribed fire can be used to reduce dense patches of small trees and accumulated dead grass, needles, and woody debris in stands of pole-sized and larger trees, thereby lessening the chance of tree-killing wildfires. Similarly, slash hazard can be reduced by broadcast burning after cutting. Where heavy fuel loads exist prior to the initial entry with prescribed fire, it is often best to plan several burns in successive years rather than to risk the cambium kill and crown scorch often associated with a hot fire. Heavy fuel loads can also be reduced through firewood removals and, during safe periods, piling and burning. Once fuels have been reduced to an acceptable level, periodic light burning can be used to maintain stands in a low-hazard condition.

**Forage Production**—Within the PIPO/AGSP h.t., PIPO/FEID h.t., and PIPO/SYAL h.t. light surface fires will rejuvenate shrubs through sprouting and cause a temporary increase in grass and forb production. Grazing may have to be deferred for 1 or 2 years before burning on open, heavily grazed sites where percentage of cover by plants is low and litter is sparse. Where it will carry, fire can be used to rejuvenate the undergrowth, especially within the PIPO/PUTR h.t., by killing decadent bitterbrush and thereby regenerating the site from onsite sprouting or from offsite seed cached in the burn by rodents. As a general rule, luxuriant growth of shrubs will not result from fire use on Group Two sites.

**Site Preparation and Stocking Control**—Fire can create a mineral soil seedbed where this is necessary for successful ponderosa pine regeneration. Once a new stand is established and an adequate number of trees 10 to 12 ft (3 to 3.7 m) or taller are in the overstory, fire can be used to thin the new stand (Wright 1978). Subsequent use of fire at intervals of 5 to 10 or 15 years will remove unnecessary reproduction and accumulated dead woody fuel,

thereby increasing stand vigor, reducing fire hazard, and increasing grass, forb, and shrub production (Wright 1978).

**Recreation Site Development and Maintenance**—Prescribed fire or partial cutting and prescribed fire can be used to create parklike openings underneath mature stands of ponderosa pine in which campgrounds and picnic areas can be installed. Periodic use of fire in spring or fall can maintain such openings and reduce fire hazard in and around campgrounds.

## FIRE GROUP FOUR: WARM, DRY DOUGLAS-FIR HABITAT TYPES

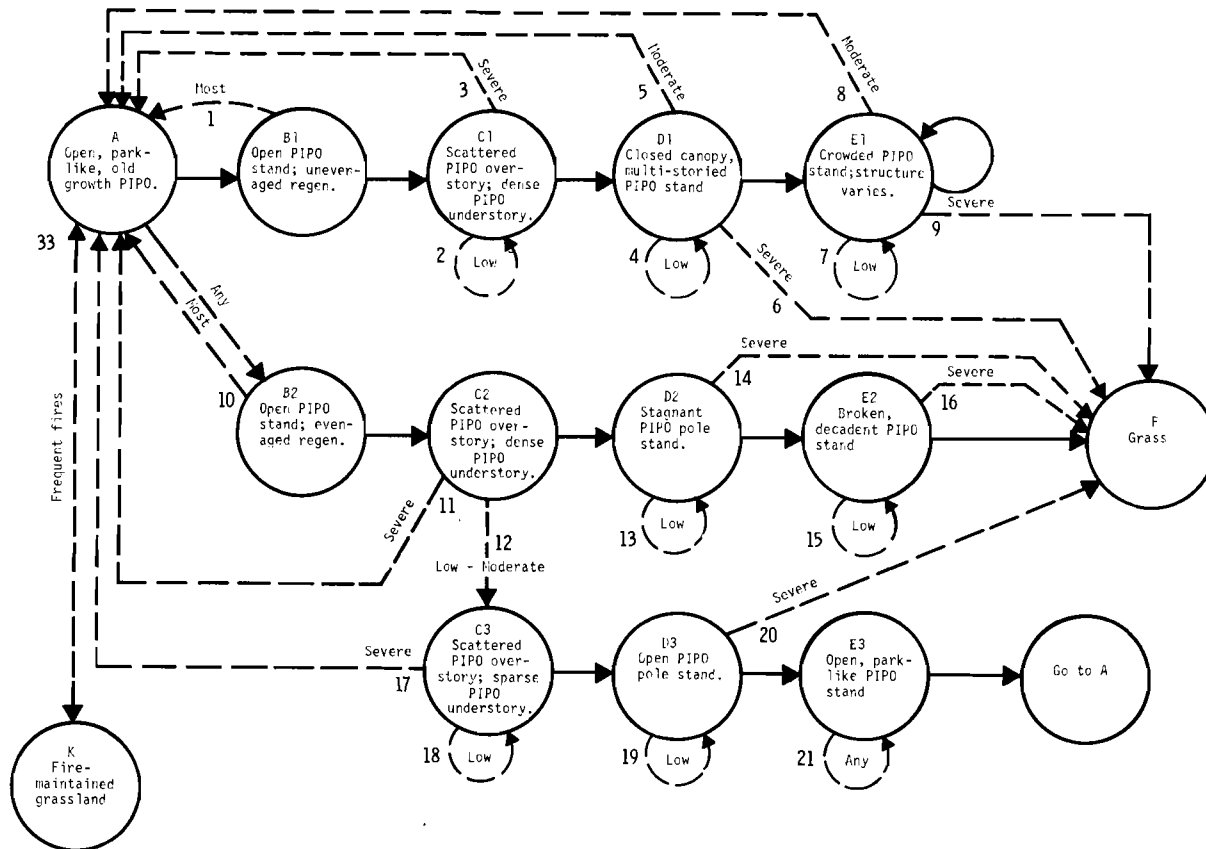
ADP code	Habitat type-phase (Pfister and others 1977)	Montana forest region (Arno 1979)
210	<i>Pseudotsuga menziesii</i> <i>Agropyron spicatum</i> h.t. (PSME/AGSP), Douglas-fir/bluebunch wheatgrass	Northwestern and west central
230	<i>Pseudotsuga menziesii</i> / <i>Festuca scabrella</i> h.t. (PSME/FESC), Douglas-fir/lough fescue	Northwestern and west central
262	<i>Pseudotsuga menziesii</i> <i>Physocarpus malvaceus</i> h.t.- <i>Calamagrostis rubescens</i> phase (PSMEIPHMA-CARU), Douglas-fir/ninebark-pinegrass phase	Northwestern and west central
311	<i>Pseudotsuga menziesii</i> <i>Symphoricarpos albus</i> h.t.- <i>Agropyron spicatum</i> phase (PSME/SYAL-AGSP), Douglas-fir/snowberry-bluebunch wheatgrass phase	Northwestern and west central
321	<i>Pseudotsuga menziesii</i> <i>Calamagrostis rubescens</i> h.t.- <i>Agropyron spicatum</i> phase (PSME/CARU-AGSP), Douglas-fir/pinegrass-bluebunch wheatgrass phase	Northwestern and west central
324	<i>Pseudotsuga menziesii</i> / <i>Calamagrostis rubescens</i> h.t.- <i>Pinus ponderosa</i> phase (PSME/CARU-PIPO), Douglas-fir/pinegrass-ponderosa pine phase	Northwestern and west central
340	<i>Pseudotsuga menziesii</i> / <i>Spiraea betulifolia</i> h.t. (PSME/SPBE), Douglas-fir/white spirea	Northwestern and west central

## Vegetation

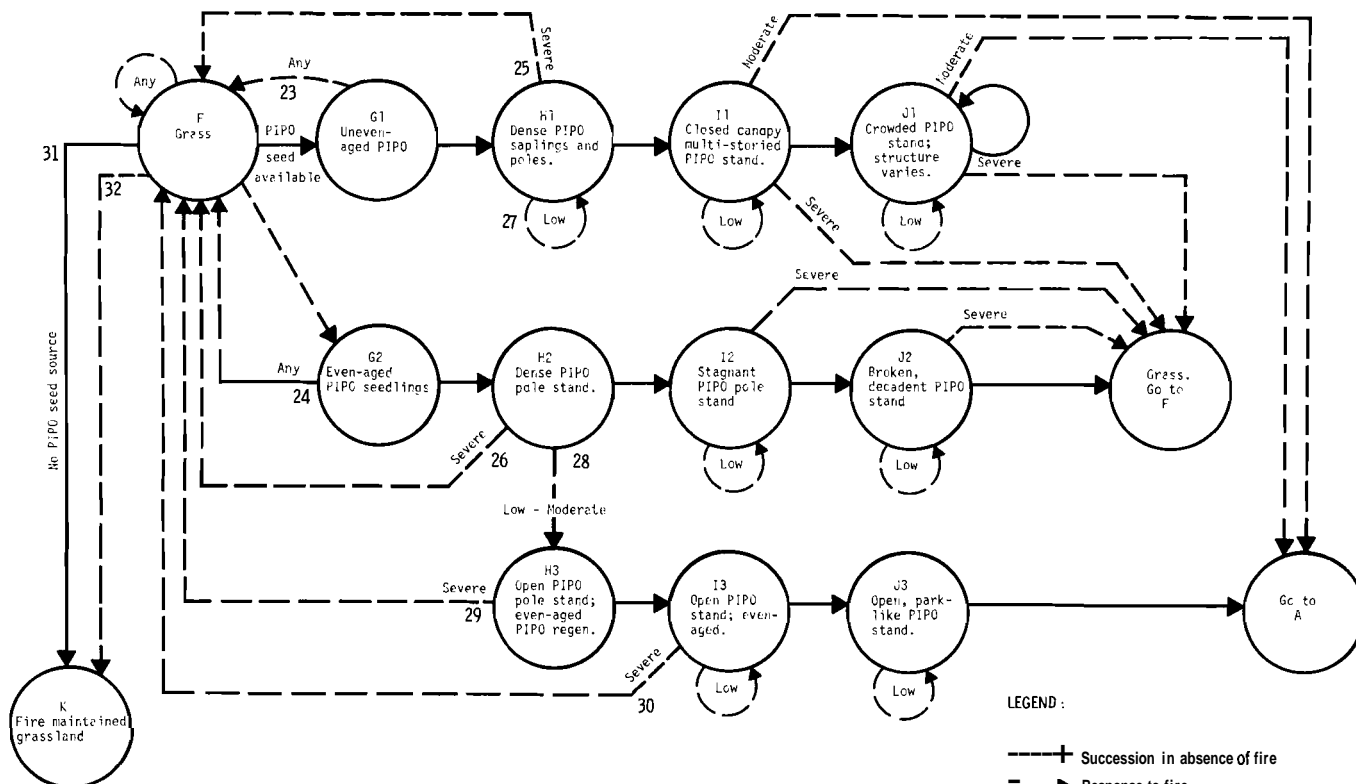
Group Four consists of Douglas-fir habitat types where ponderosa pine usually occurs as a major seral or climax associate especially at lower elevations. Group Four stands may exist as fire-maintained ponderosa pine stands that develop Douglas-fir regeneration beneath the pine in the



1. SUCCESSION FROM THE OPEN, PARKLIKE, OLD GROWTH PONDEROSA PINE STATE



2. SUCCESSION FROM THE GRASS STATE



LEGEND :

- + Succession in absence of fire
- - -> Response to fire
- Low Cool or light surface fire
- Mod. Fire of intermediate (moderate) severity
- Severe Hot, stand-destroying fire
- 1, 2, etc 1/ Reference number. (see text)

Figure 6—Hypothetical fire-related successional pathways for Fire Group Two habitat types. (1) Succession from the open, parklike, old-growth ponderosa pine state and (2) succession from the grass state.

absence of disturbance. Douglas-fir is usually present in seral stands, but ponderosa pine often dominates. Sites are too droughty for most other conifer species.

Rocky Mountain juniper may be a minor climax species within the PSME/AGSP h.t. Stands tend to be open, but dense stands or thickets can occur in the absence of fire or where good seed years and favorable moisture conditions have followed fire. The understory is usually sparse because of lack of moisture. Major herbs include bluebunch wheatgrass, rough and Idaho fescue, pinegrass, arrowleaf balsamroot, white stoneseed, junegrass, and spreading dogbane. The most common shrubs are common snowberry, kinnikinnick, white spirea, chokecherry, western serviceberry, and mountain ninebark.

## Forest Fuels

Fuel loads are heavier on the average than those found in Fire Group Two ponderosa pine stands but lighter than those in most other groups. The average fuel load for the stands that were sampled was about 11 tons per acre (2.5 kg/m<sup>2</sup>). As a general rule, fuel loads tend to increase with the stand age as a result of accumulated downfall from insect and disease damage, blowdown, and natural thinning. This is especially true in dense, young stands where heavy mortality from natural thinning (suppression mortality) can cause rapid fuel accumulation.

The different types of fuel situations likely to be encountered are shown in figure 7 and listed in table 8. All of these ponderosa pine stands are growing within a PSME/PHMA-CARU h.t.

Stand 73 (fig. 7) is a ponderosa pine stand that represents the average fuel load for the group. Most of the downed, dead fuel is the result of accumulated downfall of material larger than 3 inches (7.6 cm) in diameter (table 8).

The relationship between stand condition and fuel load is suggested by stands 76 and 75 (fig. 7). Both stands are 60-year-old ponderosa pine stands within a PSME/PHMA-CARU h.t. These stands are growing within 0.5 mile (0.8 km) of each other in the same drainage. Downfall from natural thinning is responsible for the considerable difference in fuel loads (table 8).

Sometimes the combined effect of moderate amounts of periodic deadfall and moderate amounts of natural downfall from natural thinning will result in a heavy fuel load. This is shown in stand 74 (fig. 7).

Live fuels can be a significant factor in some Group Four stands. Dense thickets of Douglas-fir regeneration may become established during fire-free periods. Overstories become susceptible to stand-destroying crown fire when such situations are allowed to develop.

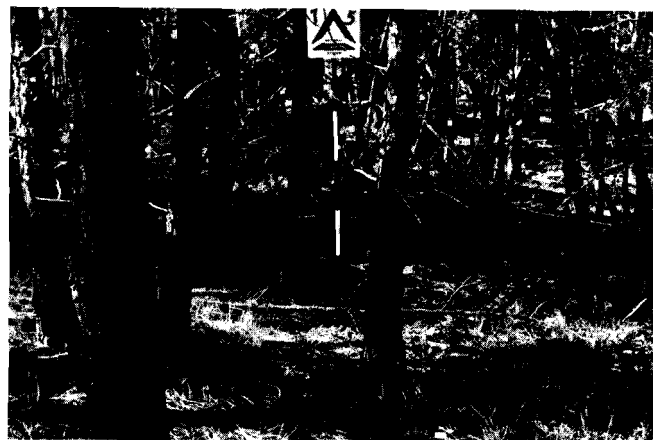


Figure 7—Examples of Group Four fuel loads on the Douglas-fir/mountain ninebark h.t.-pinegrass phase. Stand age, total fuel load, and fuel load by size class are given in table 8.

Table 8—Fuel loadings by size class for stands shown in figure 7

Stand number	Habitat type-phase	Age <sup>1</sup>	Duff depth	Size class (inches)							Total
				0-1/4	1/4-1	1-3	3-6	6-10	10-20	20+	
		Years	Inches	----- Tons/acre -----							
76	PSMEIPHMA-CARU	60		0.1	0.9	0.8	0.6	0.1	0	0	2.5
75	PSME/PHMA-CARU	65		.5	1.4	4.6	3.1	.5	.7	0	10.8
73	PSME/PHMA-CARU	175		.5	1.0	1.1	1.8	5.6	1.5	0	11.5
74	PSME/PHMA-CARU	175		.9	1.7	3.6	4.0	4.5	1.8	3.7	20.2

<sup>1</sup>Age is of overstory dominants.

## Role of Fire

In the Douglas-fir climax series habitat types, naturally occurring fire will maintain grasslands, open stands of Douglas-fir or seral ponderosa pine, and prepare seedbeds (see Group Two). But there are additional effects (Davis and others 1980):

1. Frequent fires in seral stands maintained a ponderosa pine "fire climax" condition by killing fire-susceptible Douglas-fir seedlings. In this role, fire frequency largely determined the stand composition.

2. Following a prolonged fire-free period, Douglas-fir regeneration became established beneath the canopy. A ground or surface fire that reached a thicket of saplings and small poles could ascend into the overstory, killing or injuring adjacent mature trees through the vegetative "fuel ladder." Fuel ladders increased the potential destructiveness of a fire by providing access to the canopy. During periods of high fire danger, this often resulted in a stand-destroying crown fire.

Historic fire frequency probably was not different from that of Group Two—usually 5 to 25 years between fires. Successful suppression of surface fires in open, fire-

maintained stands over the last several decades has increased the potential for a fire to become severe.

## Forest Succession

The theoretical climax forest is an all-aged or multi-storied Douglas-fir forest, as shown in figure 8 (subsequent numbers in this section refer to fig. 8). Such a forest is unlikely to be achieved because of the prolonged fire-free period necessary for its development. Most old-growth forests will be open stands with varying understories depending on the stand's fire history. A grass/forb community with shrubs and conifer seedlings becomes established following a severe stand-destroying fire (No. 1). Frequent fire during this stage can result in a fire-maintained grassland (No. 2). A light burn during the herb/shrub stage may result in a seedbed favorable to conifer seedlings, but this may be unimportant where seedling establishment is not hindered by ground cover.

In the absence of fire, the herb/shrub stage gives way to conifer seedlings. Except on those high-elevation sites above its cold limits, ponderosa pine will dominate initially if it dominated the prefire stand. Douglas-fir seedlings will

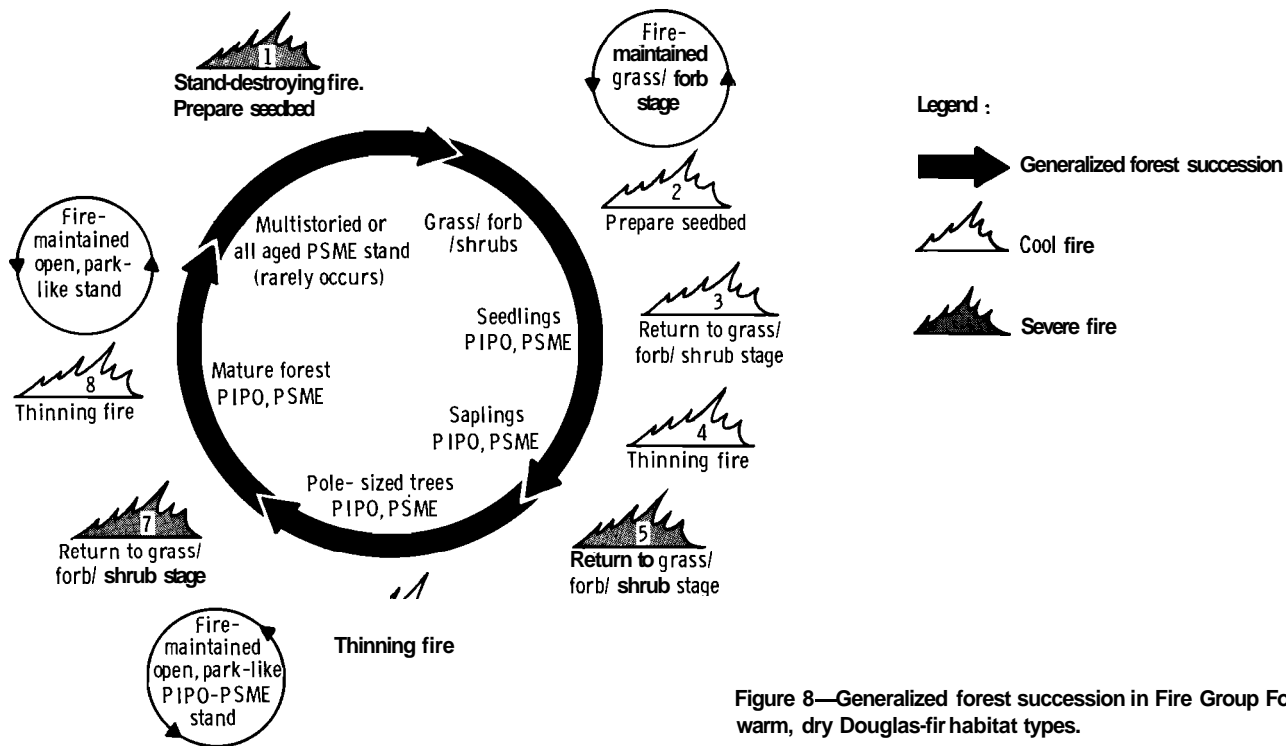


Figure 8—Generalized forest succession in Fire Group Four: warm, dry Douglas-fir habitat types.

also be present. Variation in seed crops is a factor in regeneration. A poor seed year often retards regeneration. A fire at this stage reverts the site to an herbshrub state (No. 3).

In the absence of fire, ponderosa pine and Douglas-fir saplings develop. Species composition and density of stems depends on site conditions, length of the regeneration period, and how long fire has been absent. Not much ponderosa pine, for example, will be present if fire is absent for a prolonged period. A severe fire returns the site to the herbshrub stage (No. 5). A light to moderate severity fire tends to thin out Douglas-fir saplings and badly suppressed ponderosa pine saplings (No. 4). A cool fire at this stage will also remove any recent seedlings.

The pole-sized tree stage can be represented by (1) a rather open stand of Douglas-fir and ponderosa pine poles with a scattered seedling and sapling understory, (2) a predominantly ponderosa pine or Douglas-fir pole stand with varying understory, or (3) a scattered pole stand with grass/forb/shrub understory. A light to moderately severe fire at this stage may thin the stand, removing understory vegetation and susceptible Douglas-fir stems (No. 6). Frequent fire maintains an open, parklike stand of ponderosa pine on most sites. A severe fire reverts the site to the herbshrub state (No. 7).

A mature forest of ponderosa pine, Douglas-fir, or a combination of the two, will eventually develop. Periodic fire at this stage maintains the stand in an open, parklike condition (No. 8). Douglas-fir and some ponderosa pine regeneration may form in the understory of such stands during fire-free intervals. If fire is excluded for an unusually long period, the theoretical climax situation could develop.

Hypothetical succession following fire and the absence of fire in this group is presented in figure 9. The elevation and geographic location of the site is a major determinant of species composition. Ponderosa pine will play a major role in plant succession on most Group Four sites.

The successional sequences of community types and accompanying information provided by Arno and others (1985) can be used to aid predictions of successional development of seral communities (and treatment response) within the PSME/PHMA-CARU h.t.'s in relation to various fire and harvest treatments.

## Fire Management Considerations

For Group Four, fire management considerations include wildfire hazard reduction, silviculture, range and wildlife habitat management, and recreation and esthetics.

**Wildfire Hazard Reduction**—In the prolonged absence of fire and fuel management, hazardous fuel situations often develop. The combination of dense Douglas-fir (or ponderosa pine) understories, accumulated deadfall, decadent shrubs, and other accumulated litter and debris can produce fires severe enough to scorch the crowns and kill the cambium of overstory trees. Guidelines provided by Brown and others (1985) can be used to write fire pre-

scriptions for safely reducing this hazard. Prescribed fire can also be used to reduce the hazard associated with logging slash resulting from clearcuts and partial cuts. Most fire prescriptions can be written so as to accomplish silvicultural, range, and wildlife objectives as well as hazard reduction.

**Silviculture**—Where timber management is an objective, fire can be used to dispose of slash, prepare seedbeds, control species composition, and reduce the probability of stand-destroying wildfires. Ponderosa pine is often a favored timber species. It may, for example, be deemed desirable to maintain ponderosa pine dominance in stands where Douglas-fir is plagued with severe mistletoe, chronic budworm, or root rot damage. Fire can be used to remove unwanted Douglas-fir regeneration once the ponderosa pine reaches about 5 inches (about 13 cm) in diameter. Wright (1978) recommends there be an adequate number of trees 10 to 12 ft (3 to 2.7 m) tall before regular prescribed burning begins, although light surface fires will leave trees 6 to 8 ft (1.8 to 2.4 m) tall unharmed. Larger Douglas-fir trees will also survive most light surface fires, so there need be no concern about completely eliminating Douglas-fir from the stand. However, where butt rot is common on overstory Douglas-fir, increased mortality should be expected.

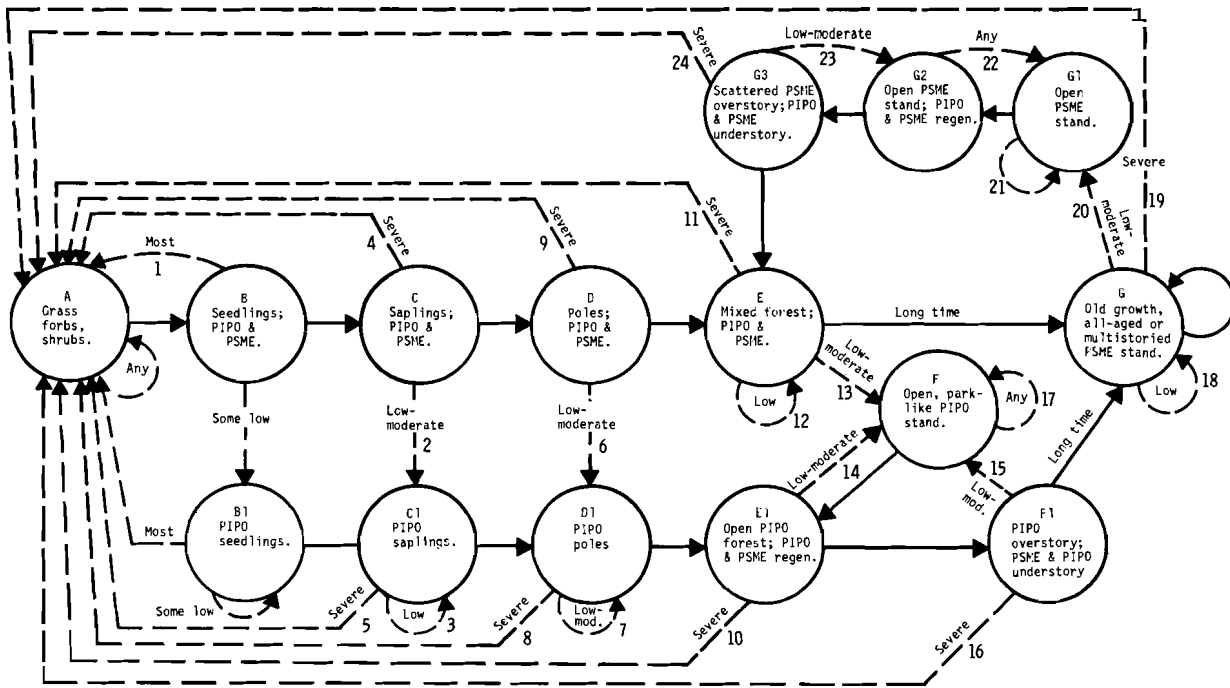
**Range and Wildlife Habitat Management**—Big game winter and spring range can be rejuvenated with properly applied prescribed fire, especially in the spring. Such fires can reduce encroachment by Douglas-fir, remove accumulated dead plant materials, recycle nutrients, regenerate mature and decadent shrubs, and increase distribution and production of nutrient-rich grasses, forbs, and legumes. Prescribed fires can be used to increase the nutritional value of critical wintering and fawning habitat, and thereby reduce neonatal fawn losses of mule deer (Schneegas and Bumstead 1977). Williams and others (1980) found that deer and cattle preferred forage within a burned PSME/AGSP h.t. over unburned controls.

**Recreation and Esthetics**—Prescribed fire can be used to greatly reduce fire hazard on areas immediately adjoining campgrounds. Such treatment also improves viewing and travel from the campground to the surrounding forest.

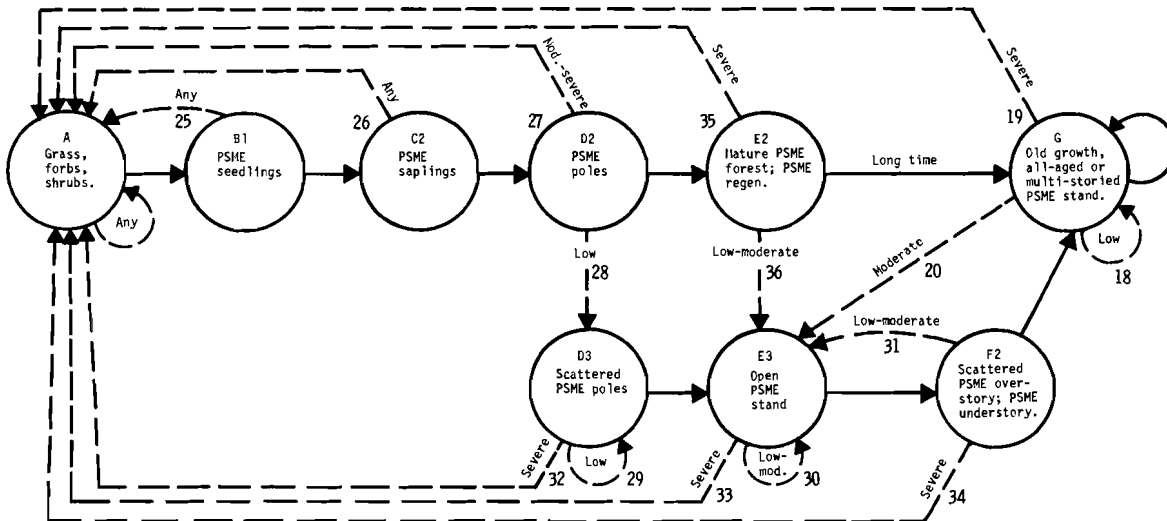
## FIRE GROUP FIVE: COOL, DRY DOUGLAS-FIR HABITAT TYPES

ADP code	Habitat type-phase (Pfister and others 1977)	Montana forest region (Arno 1979)
220	<i>Pseudotsuga menziesii/Festuca idahoensis</i> h.t. (PSME/FEID), Douglas-fir/Idaho fescue	Northwestern and west central
330	<i>Pseudotsuga menziesii/Carex geyeri</i> h.t. (PSME/CAGE), Douglas-fir/leek sedge	Northwestern and west central

1. SITES WITHIN COLD LIMITS OF PONDEROSA PINE



2. SITES ABOVE THE COLD LIMITS OF PONDEROSA PINE



LEGEND :

- Succession in absence of fire
- - - → Response to fire
- Low Cool or light surface fire
- Mod. Fire of intermediate (moderate) severity
- Severe Hot, stand-destroying fire
- 1, 2, etc. Reference number, (see text)

Figure 9—Hypothetical fire-related successional pathways for Fire Group Four habitat types. (1) Sites within the cold limits of ponderosa pine and (2) sites above the cold limits of ponderosa pine.

## Vegetation

Fire Group Five habitat types support Douglas-fir stands even under the influence of periodic fire. Douglas-fir is the indicated climax species on these sites. It dominates most seral communities and often is the only conifer present. Sites are apparently too dry for lodgepole pine and too cold for ponderosa pine. Rocky Mountain juniper, white-bark pine, and lodgepole pine may occur as accidental individuals, minor seral species, or minor climax species.

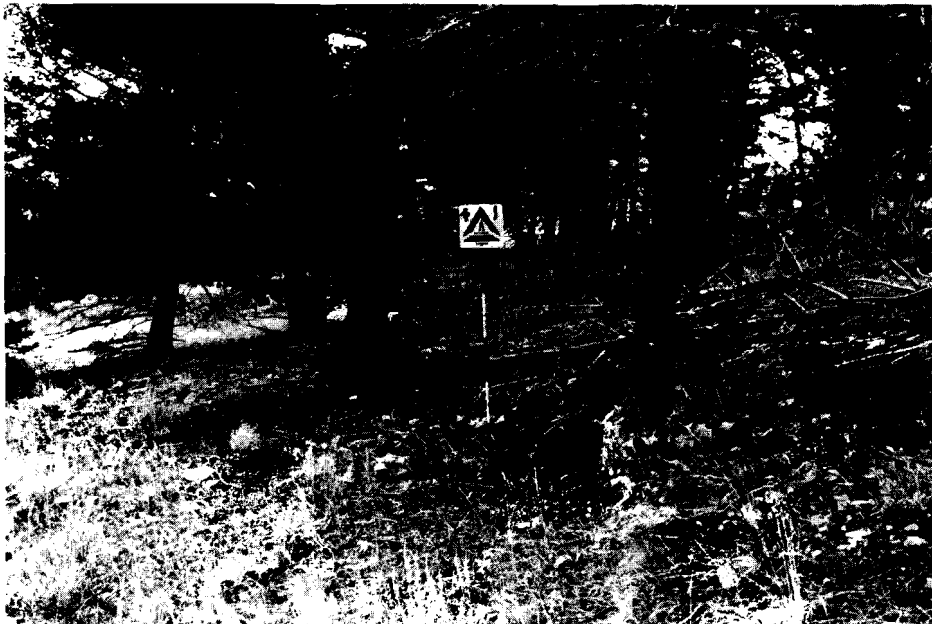
Regeneration is often difficult. On north-facing and northeast-facing slopes, however, heavily overstocked stagnant stands often develop. Undergrowth may be sparse. Common undergrowth forbs include heartleaf arnica, false Solomon's seal, mountain sweetroot, and western meadow-rue. Common grasses include bluebunch wheatgrass, elk sedge, and Idaho fescue.

Shrubs include big sagebrush, common juniper, wax currant, and white spirea.

## Forest Fuels

Downed, dead fuel loads average about 10 tons per acre (about 2 kg/m<sup>2</sup>). Downed woody fuel loadings calculated by Brown and See (1981) are shown in table 6 and in figure 3.

While downed, dead woody fuel loadings are greater than in Fire Groups One, Two, Three, and Four, live fuels are less concern. Both undergrowth and regeneration are usually sparse. This factor plus the usual open nature of the stands result in a low probability of crown fire. Individual trees will often have branches close to the ground (fig. 10). If sufficient fuels are available on the ground, torching can occur.



*Figure 10—A Fire Group Five stand on a Douglas-fir/Idaho fescue h.t. This 100-year-old Douglas-fir stand has a downed dead fuel load of 6.6 tons per acre (1.5 kg/m<sup>2</sup>). Material less than 3 inches (7.6 cm) in diameter accounts for 2.8 tons per acre (0.62 kg/m<sup>2</sup>), and material more than 3 inches (7.6 cm) accounts for the remaining 3.8 tons per acre (0.85 kg/m<sup>2</sup>). Duff depth is 0.9 inch (2.3 cm).*

## Role of Fire

Under natural conditions, fire occurred less frequently within Group Five habitat types than it did within ponderosa pine habitat types (Groups Two and Three) or within the warmer Douglas-fir habitat types (Group Four). The relatively light fuel loads, sparse undergrowth, and generally open nature of the stands would appear to favor long fire-free intervals. However, Arno and Gruell (1983, 1986) estimate a mean fire interval of 35 to 45 years in pre-settlement stands in southwestern Montana.

Fire's role in seedbed preparation is confounded by the difficulty of regeneration to progress beyond the seedling stage on these droughty sites because of undergrowth and overstory competition. Where dense regeneration does occur, fire probably played a role as a thinning agent in sapling and pole-sized stands. Ground fire probably maintained many mature stands in an open, parklike condition. Many presettlement stands were actually maintained as seral grasslands with scattered trees inhabiting rocky microsites. The prolonged absence of fire has allowed these groves to become forest stands (Arno and Gruell 1983, 1986).

## Forest Succession

The generalized forest succession discussed here and illustrated in figure 10 assumes sites are above the cold limits of ponderosa pine.

Frequent fire could maintain sites as grassland, as shown in figure 11, No. 1 (subsequent numbers in this section refer to fig. 11). A fire in the herb/shrub stage will prepare a seedbed (No. 2) for Douglas-fir seedlings. Seedling establishment is usually slow and probably requires

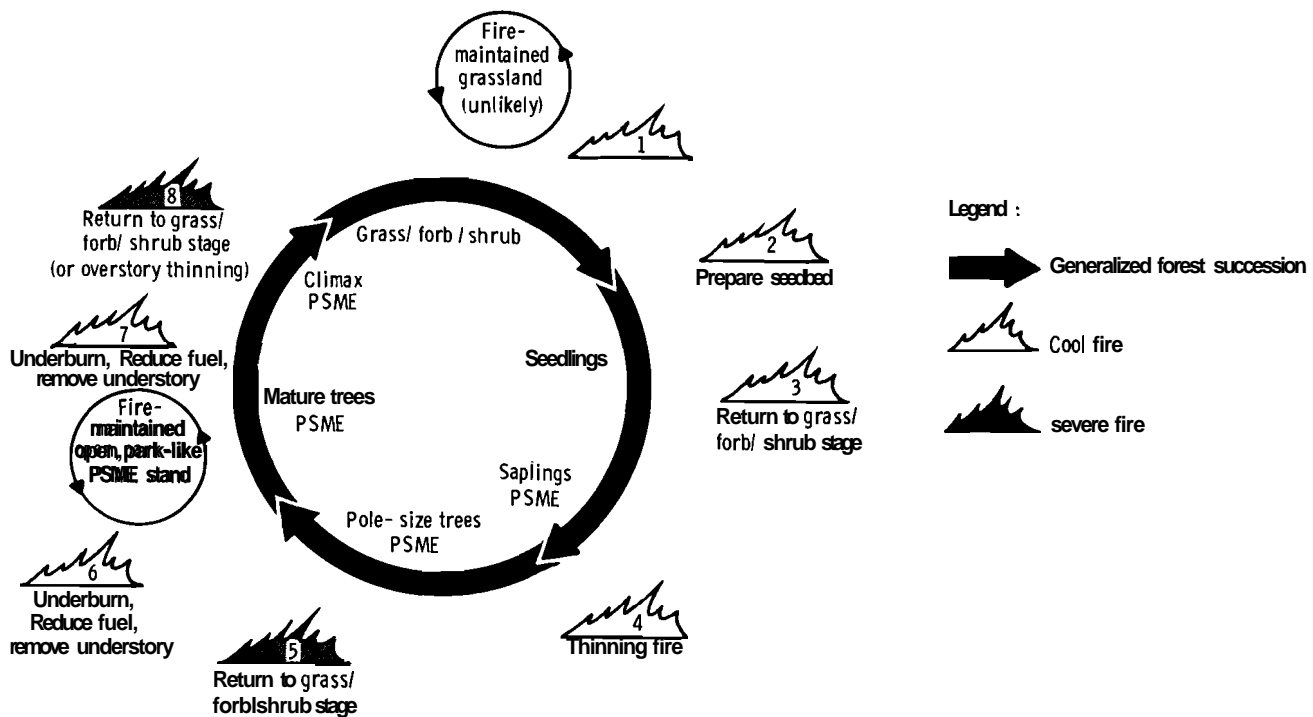


Figure 11—Generalized forest succession in Fire Group Five: cool, dry Douglas-fir habitat types.

favorable combination of adequate seedbed, adequate moisture, and abundant seed. When favorable conditions for seedling establishment do occur, an even-aged stand usually develops. Any fire in either the seedling stage or the sapling stage reverts the site to a treeless condition (No. 3).

A light surface fire in a pole-sized stand usually thins out the more susceptible stems (No. 4). A severe fire in pole-sized stands (No. 5) is likely to kill all trees and again revert the site to the herb/shrub stage. A less-than-severe fire in a mature stand (No. 6) may act as an underburn and thin the stand, thereby creating an open stand condition. Subsequent light burns could maintain this open condition and result in a parklike Douglas-fir stand. If a stand escapes fire and nears the climax situation, it will likely have a Douglas-fir understory, sparse undergrowth, and moderate amounts of dead fuel on the forest floor. A light fire would remove the undergrowth and reduce dead woody fuel (No. 7). A severe fire in a climax or near climax stand would either destroy the stand and revert the site to the herb/shrub stage or thin the overstory and leave an open parklike stand (No. 8).

Hypothetical succession following fire and the absence of fire on most Group Five habitat types is presented in figure 12. This presentation does not pertain to those sites on which ponderosa pine is a major seral component

(PSMEICARU-AGSP h.t.). Succession on such sites is better represented by figure 8 (Fire Group Four).

## Fire Management Considerations

Hazard reduction, site preparation, and forage production are the fire management considerations for Group Five.

**Hazard Reduction and Site Preparation**—Fire can be used following timber harvest to prepare seedbed and to reduce wildfire hazard from the harvest-related slash. Care must be taken to control fire intensity when burning in partial-cut stands. The hazard reduction objective in such situations should be to remove the fine fuels only. Attempts to burn the larger slash could result in fire damage to the residual trees.

**Forage Production**—Periodic light surface fires in open canopy stands of mature trees can maintain parklike conditions and undergrowth species favorable to big game and livestock. The use of fire for forage production may be difficult on some sites because of the commonly sparse undergrowth. Usually, livestock grazing must be deferred for at least 1 year prior to burning to assure enough fuel to carry a fire.

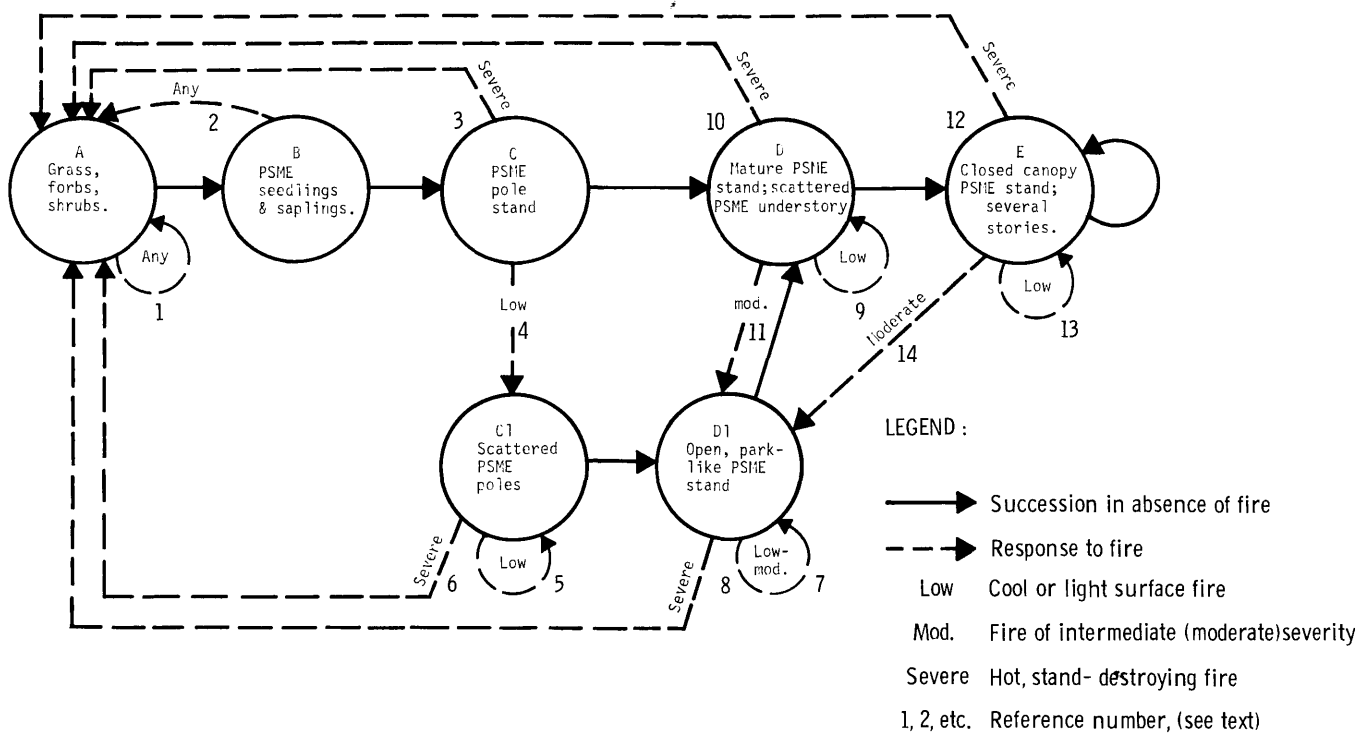


Figure 12—Hypothetical fire-related successional pathways for Fire Group Five habitat types.

## FIRE GROUP SIX: MOIST DOUGLAS-FIR HABITAT TYPES

ADP code	Habitat type-phase (Pfister and others 1977)	Montana forest region (Arno 1979)			
250	<i>Pseudotsuga menziesii/Vaccinium caespitosum</i> h.t. (PSME/VACA), Douglas-fir/dwarf huckleberry	Northwestern and west central	283	<i>Pseudotsuga menziesii/Vaccinium globulare</i> h.t.- <i>Xerophyllum tenax</i> phase (PSME/VAGL-XETE), Douglas-fir/blue huckleberry-common beargrass phase	Northwestern and west central
261	<i>Pseudotsuga menziesii/Physocarpus malvaceus</i> h.t.- <i>Physocarpus malvaceus</i> phase (PSME/PHMA-PHMA), Douglas-fir/ninebark-ninebark phase	Northwestern and west central	291	<i>Pseudotsuga menziesii/Linnaea borealis</i> h.t.- <i>Symphoricarpos albus</i> phase (PSME/LIBO-SYAL), Douglas-fir/twinflower-snowberry phase	Northwestern and west central
281	<i>Pseudotsuga menziesii/Vaccinium globulare</i> h.t.- <i>Vaccinium globulare</i> phase (PSME/VAGL-VAGL), Douglas-fir/blue huckleberry-blue huckleberry phase	Northwestern and west central	292	<i>Pseudotsuga menziesii/Linnaea borealis</i> h.t.- <i>Calamagrostis rubescens</i> phase (PSME/LIBO-CARU), Douglas-fir/twinflower-pinegrass phase	Northwestern and west central
282	<i>Pseudotsuga menziesii/Vaccinium globulare</i> h.t.- <i>Arctostaphylos uva-ursi</i> phase (PSME/VAGL-ARUV), Douglas-fir/blue huckleberry-kinnikinnick phase	Northwestern and west central	293	<i>Pseudotsuga menziesii/Linnaea borealis</i> h.t.- <i>Vaccinium globulare</i> phase (PSME/LIBO-VAGL), Douglas-fir/twinflower-blue huckleberry phase	Northwestern and west central
			312	<i>Pseudotsuga menziesii/Symphoricarpos albus</i> h.t.- <i>Calamagrostis rubescens</i> phase (PSME/SYAL-CARU), Douglas-fir/snowberry-pinegrass phase	Northwestern and west central
			313	<i>Pseudotsuga menziesii/Symphoricarpos albus</i> h.t.- <i>Symphoricarpos albus</i> phase (PSME/SYAL-SYAL), Douglas-fir/snowberry-snowberry phase	Northwestern and west central



- |     |   |                                  |
|-----|---|----------------------------------|
| 322 | <i>Pseudotsuga menziesii</i><br><i>Calamagrostis rubescens</i> h.t.-<br><i>Arctostaphylos uva-ursi</i> phase<br>(PSMEICARU-ARUV),<br>Douglas-fir/pinegrass-<br>kinnikinnick phase | Northwestern and<br>west central |
| 323 | <i>Pseudotsuga menziesii</i><br><i>Calamagrostis rubescens</i> h.t.-<br><i>Calamagrostis rubescens</i> phase<br>(PSMEICARU-CARU),<br>Douglas-fir/pinegrass-pinegrass<br>phase     | Northwestern and<br>west central |

## Vegetation

Fire Group Six habitat types occur throughout western Montana usually at elevations of about 3,000 to 6,500 ft (about 914 to 1,981 m). Douglas-fir is both the indicated climax species and a vigorous member of seral communities. It is not uncommon for Douglas-fir to dominate all stages of succession on these sites. Ponderosa pine, western larch, and lodgepole pine are seral components whose abundance varies considerably by phase.

Whitebark pine is usually well represented at upper elevations within the PSMEICARU-CARU h.t. Subalpine fir and spruce are essentially absent. At low elevations, Group Six sites can be found on all aspects. On cooler sites, ponderosa pine becomes less important and larch and lodgepole increase in importance.

Shrubs and moist site forbs dominate the undergrowth, along with pinegrass and elk sedge. Common shrubs include mountain ninebark, common snowberry, white spirea, oceanspray, dampwoods blueberry, dwarf huckleberry, grouse whortleberry, kinnikinnick, American twinflower, and common juniper. Forbs include mountain sweetroot, wartberry fairybells, common beargrass, starry false Solomon's seal, western meadowrue, heartleaf arnica, and mountain arnica.

## Forest Fuels

Downed, dead fuel loads average about 12 tons per acre (less than 3 kg/m<sup>2</sup>), according to Brown and See (1981) (table 6), but can be much heavier. Inventories of photo plots (Fischer 1981a, 1981b) showed a range of from 1 to 74 tons per acre (0.2 to 16.6 kg/m<sup>2</sup>). Fuel conditions will vary according to stand density, species composition, age, and stand history. The tendency toward overstocking and the development of dense understories result in high-hazard fuel conditions in many stands. Natural thinning, snow breakage, blowdown, and insect and disease mortality operate at a high level in many stands. Relatively deep duff often develops and may contain a lot of rotten logs. Fires often smolder undetected until burning conditions become favorable for fire spread.

The most hazardous conditions occur in well-stocked stands with dense Douglas-fir understories (fig. 13). These stands are characterized by relatively large amounts of downed twigs and small stems and branchwood less than 3 inches in diameter (table 9) beneath partially fallen and standing dead saplings and small pole-sized stems.



A



B



C



D

**Figure 13—Examples of high hazard fuel conditions in Fire Group Six stands in Montana. Stands 27A and 86 are Douglas-fir forests near Lincoln and Lolo, respectively. Stands 85 and 6 are lodgepole pine stands with Douglas-fir understories near Lolo. Habitat types, stand age, and fuel loadings are given in table 9.**

Table 9—Fuel loadings by size class for Fire Group Six stands shown in figures 13, 14, and 15

Stand number	Habitat type-phase	Age <sup>1</sup>	Duff depth	Size class (inches)							Total
				0-1/4	1/4-1	1-3	3-6	6-10	10-20	20+	
		Years	Inches	----- Tons/acre -----							
27A	PSMENAGL-XETE	90	1.9	0.2	0.8	1.2	1.9	5.2	1.7	0	11.0
85	PSMENAGL-XETE	70	2.2	.5	1.9	4.3	.2	1.6	4.2	0	12.7
86	PSMEIPHMA-PHMA	65	2.4	.8	1.8	3.7	.4	7.5	2.0	0	16.2
6	PSMENAGL-XETE	80	2.1	1.2	3.1	3.1	.3	7.3	13.3	0	28.3
68	PSME/CARU-ARUV	50	1.8	.5	.7	.2	0	0	0	0	1.4
80	PSMEILIBO-VAGL	280	1.5	.3	.8	.7	.8	1.1	0	0	3.7
26A	PSME/VAGL-XETE	170	.7	.2	.4	.7	1.9	.8	0	0	4.0
14A	PSMEIPHMA-PHMA	70	2.0	.9	1.8	1.2	.3	.3	0	0	4.5
78	PSMEILIBO-VAGL	320	1.9	.2	1.1	1.7	3.3	.7	31.0	0	38.0
48A	PSME/VACA	130	2.2	.2	1.0	1.2	4.2	14.9	10.2	0	31.7
95	PSMEILIBO-CARU	145	2.2	.5	1.8	5.0	10.3	25.6	9.7	0	52.9
28	PSMENAGL-XETE	110	2.7	.3	1.5	4.3	12.2	17.0	2.0	36.6	73.9

<sup>1</sup>Age is of overstory dominants.

The absence of dense understories results in reduced fire hazard, even in well-stocked stands (fig. 14 and table 9). However, the density of overstory trees and the presence of dead branches near ground level create a crown fire potential under severe burning conditions. Downed dead

fuel tends to accumulate over time in these stands, the result of individual tree mortality and subsequent downfall (fig. 15). Gradual accumulation of downed dead fuel greater than 3 inches in diameter (table 9) increases the damage potential of surface fires.

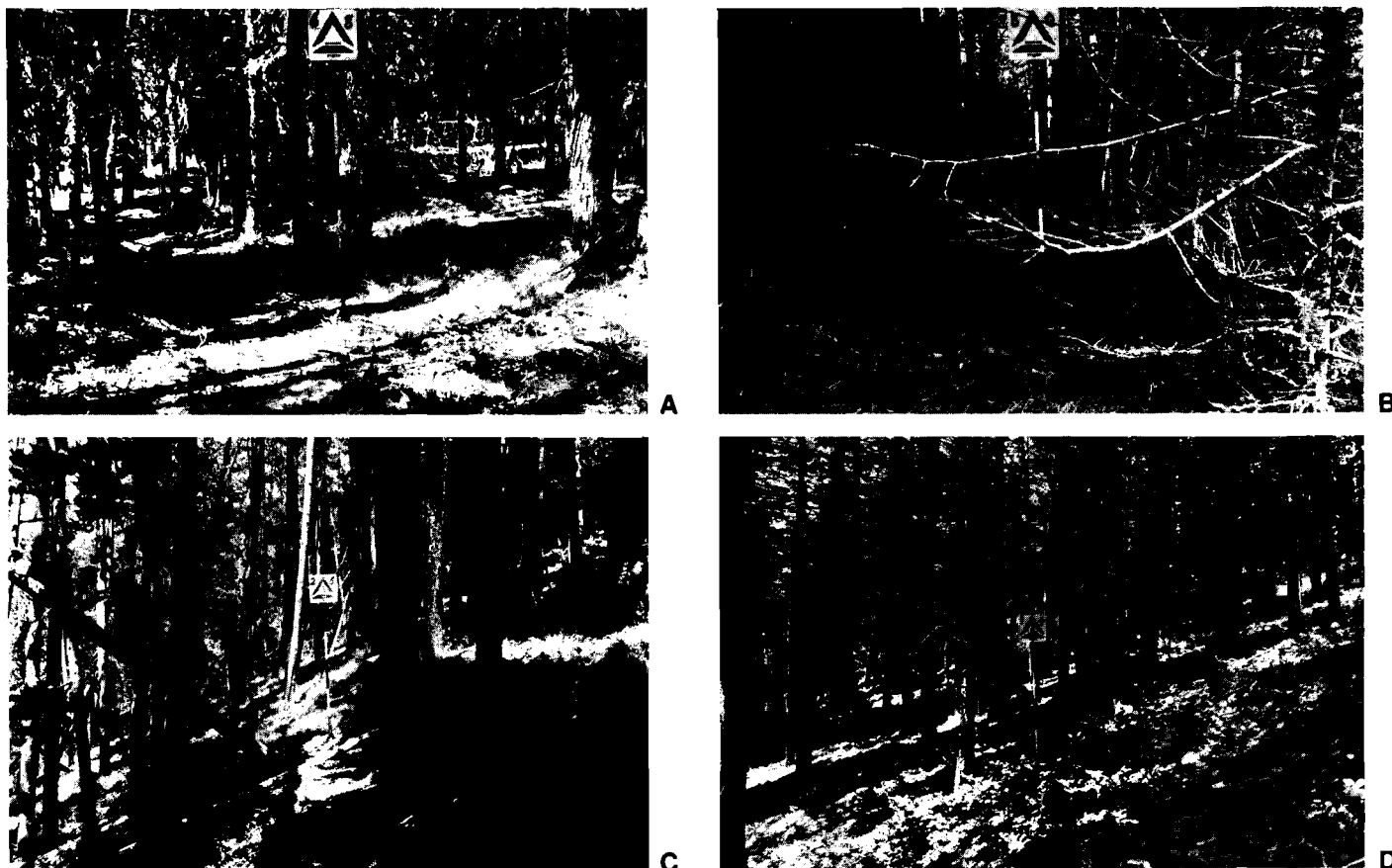
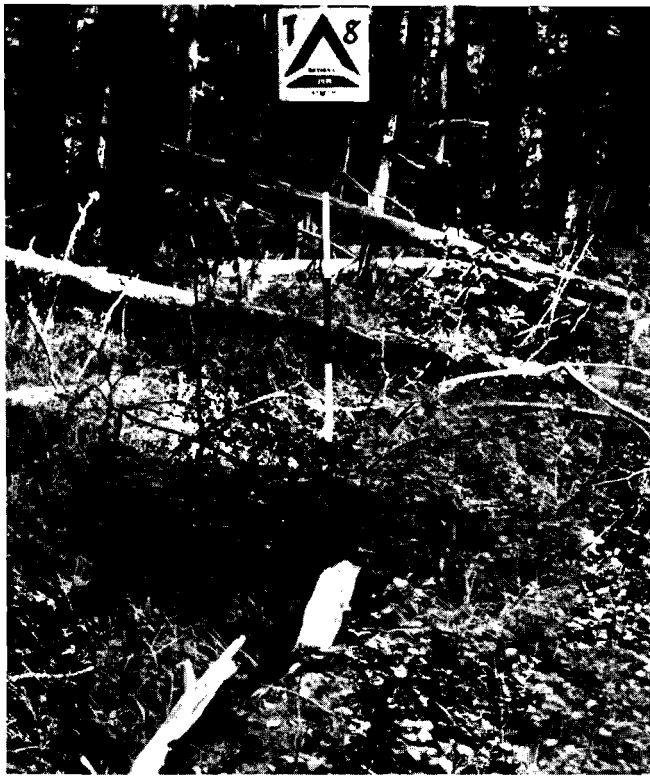


Figure 14—Examples of Fire Group Six stands with light fuel loadings in Montana. Stands 68 and 80 are western larch—Douglas-fir and ponderosa pine—western larch—Douglas-fir stands, respectively, near Missoula. Stand 26A is a lodgepole pine stand near Lincoln. Stand 14A is a Douglas-fir forest near Troy. Habitat types, stand age, and fuel loadings are given in table 9.



A



B



C



D

Figure 15—Examples of Fire Group Six stands with heavy fuel loadings in Montana. Stand 78 is a ponderosa pine—western larch—Douglas-fir stand near Missoula. Stand 48A is a lodgepole pine stand near Philipsburg. Stand 95 is a Douglas-fir stand near Bonita, and stand 28 is a western larch—Douglas-fir forest near Clinton. Habitat types, stand age, and fuel loadings are given in table 9.

## Role of Fire

Fire history studies conducted within the PSMEICARU h.t. in southwestern Montana indicate a mean fire interval of 42 years for presettlement stands (Arno and Gruell 1983). A tentative mean fire-free interval of 15.8 years was reported by Habeck (Crane and others 1983) within a PSMEIPHMA-PHMA h.t. near Missoula, MT.

Fire was an important agent in controlling density and species composition. Low to moderate severity fires converted dense stands of pole-sized or larger trees to a more open condition, and subsequent light burning maintained stands in a parklike state. Frequent low or moderate fires favored larch and ponderosa pine over Douglas-fir in stands where these species occurred. Severe fires probably occurred on dense, fuel-heavy sites and resulted in stand replacement. Stand-replacement fires favored lodgepole pine on sites where this species was present.

Fire's role as a seedbed-preparing agent is less important in this group than in those previously discussed. Douglas-fir can establish on a variety of seedbeds and is not dependent on mineral soil conditions for successful regeneration.

Fire has a demonstrable effect on wildlife habitat through its effects on food plants. The combination of opening up stands by killing overstory trees, reducing competition by removing understories, and rejuvenating sprouting plants through top kill, can significantly increase the availability of palatable browse and forage.

Fire's role as a stand replacement agent becomes more pronounced when the natural fire-free interval is increased through fire suppression, unless corresponding fuel reduction occurs.

## Forest Succession

The theoretical climax condition on Group Six sites is a multistoried Douglas-fir stand, although a fire-maintained open forest condition was the normal situation during the presettlement period, as shown in figure 16 (subsequent numbers in this section refer to fig. 16). Following a severe, stand-destroying fire (No. 1), grass, forbs, and shrubs dominate the site. Subsequent fires in this stage perpetuate herbs and shrubs (No. 2). Seedlings of Douglas-fir, lodgepole pine, and larch may become established if the fire-free interval is of adequate length. A fire in the seedling stage (No. 3) most likely returns the site to herbs and shrubs, although some ponderosa pine seedlings may survive some cool fires.

Low or moderate fires in the sapling stage (No. 4) thin the stand, if ponderosa pine and western larch are dominant, or eliminate Douglas-fir and lodgepole pine where these species are major components.

Many pole-sized Douglas-fir, western larch, and ponderosa pine will survive low or moderate fires (No. 6), which may serve to increase seral species as well as thin the stand. Severe fires kill trees of all species (No. 5). If serotinous trees are present, a new stand of nearly pure lodgepole pine initiates from their seeds.

Low to moderate fires (No. 7) in mature mixed conifer stands thin them, while severe fires revert these sites to the shrub/herb stage.

Climax Douglas-fir stands are rare because of the presence of seral species whose longevity is greater than the usual fire-free interval. Climax stands are more likely to occur on sites where Douglas-fir is the seral dominant as well as the climax species, notably on sites within PSMEI

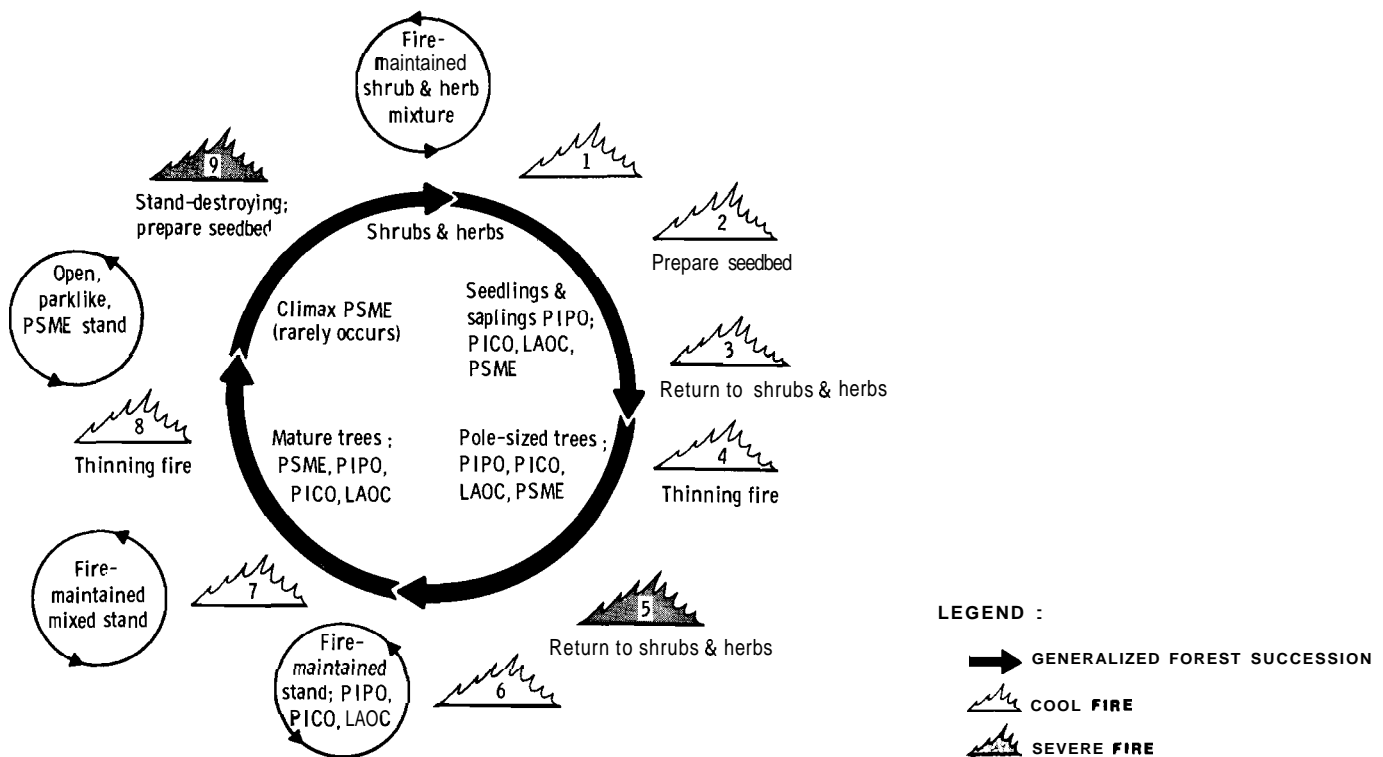


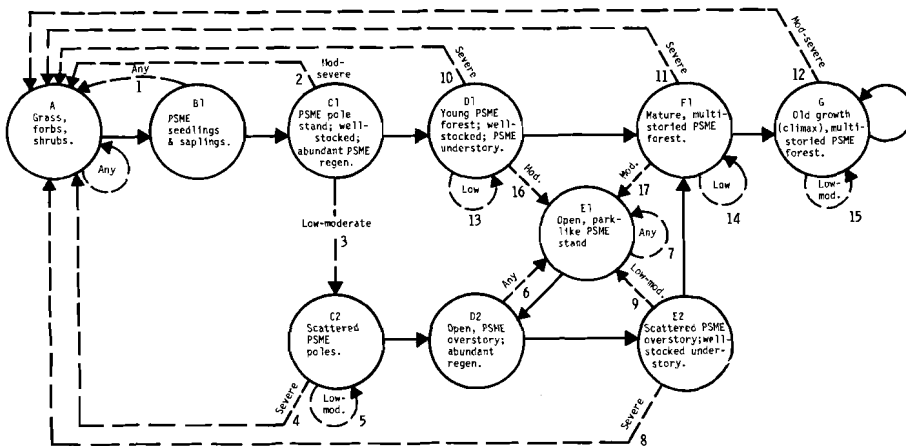
Figure 16—Generalized forest succession in Fire Group Six: moist, Douglas-fir habitat types.

PHMA-PHMA and PSME/CARU-CARU habitat types. Frequent low to moderate fires in the climax conditions on these sites will create a more open, parklike stand of Douglas-fir (No. 8), whereas a severe fire returns the stand to the shrub/herb stage (No. 9).

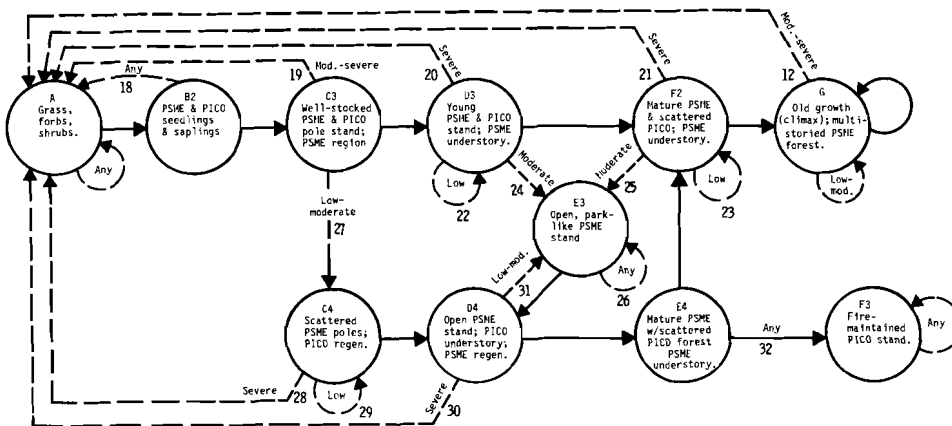
Group Six sites support stands whose seral development falls within one of three basic patterns: (1) where ponderosa pine and western larch are seral dominants, (2) where Douglas-fir is the only important conifer present throughout succession, and (3) where lodgepole pine and Douglas-fir together dominate the successional process. Hypothe-

sized successional pathways for stands where ponderosa pine and western larch share dominance with Douglas-fir are similar to those illustrated in figure 9 (Fire Group Four). Ponderosa pine and larch respond similarly to fire, although ponderosa pine exhibits a greater fire resistance through the small-pole stage, and larch survives moderate to severe fires better at larger diameter classes. Hypothesized successional pathways for Douglas-fir stands and mixed stands of lodgepole pine and Douglas-fir are illustrated in figure 17.

1. SITES SUPPORTING ESSENTIALLY PURE STANDS OF DOUGLAS-FIR



2. SITES SUPPORTING MIXED STANDS OF DOUGLAS-FIR AND LODGEPOLE PINE



LEGEND:

- Succession in absence of fire
- - - → Response to fire
- Low Cool or light surface fire
- Mod. Fire of intermediate (moderate) severity
- Severe Hot, stand-destroying fire
- 1, 2, etc. Reference number, (see text)

Figure 17—Hypothetical fire-related successional pathways for Fire Group Six habitat types. (1) Sites supporting essentially pure stands of Douglas-fir, and (2) sites supporting mixed stands of Douglas-fir and lodgepole pine.

The successional sequences of community types provided by Arno and others (1985) can be used as an aid in predicting successional development of seral communities within the PSME/PHMA and PSMENAGL-XETE h.t. in relation to fire and harvest treatments.

## Fire Management Considerations

Opportunities for using prescribed fire to accomplish management objectives are probably greater on Group Six sites than in any other. Often, a single fire can accomplish a variety of management objectives.

**Wildfire Hazard Reduction**—On sites where ponderosa pine and western larch are dominant seral components and where overstory Douglas-fir trees are large, fire can be used to reduce the risk of damage from wildfire by reducing the accumulated woody debris on the forest floor or the slash resulting from logging activities. Similarly, crown fire potential can be reduced by using fire to remove dense understories or patches of shrub and tree regeneration. Guidelines provided by Brown and others (1985) should be used to write fire prescriptions for safely reducing wildfire hazard in these stands.

Fire can be used to reduce hazard in thinning slash if ponderosa pine and western larch leave trees are 5 inches (13 cm) in diameter or larger and lower branches are high enough above the forest floor so fire will not be carried to the crown. In heavily thinned stands, slash may have to be burned when it is green to minimize damage to residual stand.

Where shaded fuelbreaks have been created, periodic prescribed fire can be used to maintain these areas in a fuel-free condition.

**Silviculture**—Fire can be used to favor ponderosa pine and western larch at the expense of Douglas-fir where this is silviculturally desirable. A relatively light surface fire can be used to remove Douglas-fir understories, thereby reducing the competition for moisture and nutrients. Where such fires burn hot enough to create openings in the stand, or to bare mineral soil in existing openings, ponderosa pine and western larch regeneration may become established.

On logged areas, fire can prepare sites that are immediately favorable for establishment of ponderosa pine and western larch regeneration by providing a mineral soil seedbed. Prescribed fire guidelines (Brown and others 1985) provide a basis for writing fire prescriptions that allow the manager to remove only as much duff as is necessary to obtain desired stocking. Such fires should also reduce grass and shrub competition for the new seedlings. Where large amounts of pinegrass and elk sedge are present in the understory, care should be taken to prescribe a fire hot enough to kill the root crowns. A light fire will often encourage the pinegrass and elk sedge to the detriment of tree seedlings.

**Range and Wildlife Habitat Management**—Fire can be used to stimulate the production of wildlife food on some sites. Light- and medium-intensity surface fires will result in increased density and nutrient content of dampwoods blueberry (blue huckleberry) and other sprouting shrubs where present. This in turn should result in increased berry production for grouse, bear, and other wildlife, as well as for humans. Highly palatable new shoot growth on dampwoods blueberry (blue huckleberry) and other sprouting shrubs will provide increased browse for deer, elk, and other wildlife. Grass and forb production may also be increased and their nutrient content temporarily enhanced. Hot surface fires will favor reproduction of conifers and shrubs such as snowbrush ceanothus.

Fires in logging slash will often result in a tremendous increase in the abundance of palatable shrub species as well as grasses and forbs that were present in the preburn stand along with conifer seedlings. A similar situation will usually follow stand replacement wildfires.

**Fire Use Considerations**—When planning fire use, fire managers should use the results and recommendations reported by DeByle (1981), Miller (1977), Stark (1977), Stark and Steele (1977), Norum (1977), Beaufait and others (1977), and Steele and Beaufait (1969). Research results suggest that high-intensity fires be avoided on steep, dry south slopes.

## FIRE GROUP SEVEN: COOL HABITAT TYPES USUALLY DOMINATED BY LODGEPOLE PINE

ADP code	Habitat type-phase (Pfister and others 1977)	Montana forest region (Arno 1979)
250	<i>Pseudotsuga menziesii/Vaccinium caespitosum</i> h.t. (PSMEIVACA), Douglas-fir/dwarf huckleberry	Northwestern and west central
450	<i>Picea/Vaccinium caespitosum</i> h.t. (PICEA/VACA), spruce/dwarf huckleberry	Northwestern and west central
470	<i>Picea/Linnaea borealis</i> h.t. (PICEA/LIBO), spruce/twinflower	West central
640	<i>Abies lasiocarpa/Vaccinium caespitosum</i> h.t. (ABLAIVACA), subalpine fir/dwarf huckleberry	Northwestern and west central
654	<i>Abies lasiocarpa/Calamagrostis canadensis</i> h.t.- <i>Vaccinium caespitosum</i> phase (ABLAIVACA), subalpine fir/bluejoint-dwarf huckleberry phase	Northwestern and west central
663	<i>Abies lasiocarpa/Linnaea borealis</i> h.t.- <i>Vaccinium scoparium</i> phase (ABLA/LIBO-VASC), subalpine fir/twinflower-grouse whortleberry phase	Northwestern and west central
692	<i>Abies lasiocarpa/Xerophyllum tenax</i> h.t.- <i>Vaccinium scoparium</i> phase (ABLAIXETE-VASC), subalpine fir/beargrass-grouse whortleberry phase	Northwestern and west central
720	<i>Abies lasiocarpa/Vaccinium globulare</i> h.t. (ABLAIVAGL), subalpine fir/blue huckleberry	West central
732	<i>Abies lasiocarpa/Vaccinium scoparium</i> h.t.- <i>Vaccinium scoparium</i> phase (ABLAIVASC-VASC), subalpine fir/grouse whortleberry-grouse whortleberry phase	Northwestern and west central

920	<i>Pinus contorta/Vaccinium caespitosum</i> h.t. (PICOIVACA), lodgepole pineldwarf huckleberry	West central
930	<i>Pinus contorta/Linnaea borealis</i> c.t. (PICOILIBO), lodgepole pine/twinflower	Northwestern and west central
940	<i>Pinus contorta/Vaccinium scoparium</i> c.t. (PICOIVASC), lodgepole pinelgrouse whortleberry	Northwestern and west central

### Vegetation

Fire Group Seven contains two groups of habitat types. The first group consists of lodgepole pine climax series habitat types (and community types) that support essentially pure stands of lodgepole pine, which constitutes the persistent dominant species on these sites. The other group consists of those Douglas-fir, spruce, and subalpine fir habitat types that are usually found supporting lodgepole pine-dominated stands. Wildfires evidently recycle the stands before the lodgepole pine dies out.

Subalpine fir, spruce, Douglas-fir, and whitebark pine occur in varying amounts with lodgepole pine on most sites.

Undergrowth often consists of dense mats or layers of grasses or shrubs. The most common graminoid species are pinegrass, bluejoint, and elk sedge. Common shrubs include grouse whortleberry, dampwoods blueberry (blue huckleberry), dwarf huckleberry, American twinflower, kinnikinnick, white spirea, bunchberry dogwood, common snowberry, and creeping Oregon grape. Heartleaf arnica, broadleaf arnica, and western meadowrue are among the more common forbs.

### Forest Fuels

The average downed woody loading is about 18 tons per acre (about 4 kg/m<sup>2</sup>) (table 6). Inventories of photo plots (Fischer 1981b) showed a range of about 3 to 35 tons per acre (about 0.7 to 7.8 kg/m<sup>2</sup>) (fig. 18 and table 10), but maximum loads may greatly exceed this range. Mathews (1980) reports extreme fuel loads in excess of 150 tons per acre (34 kg/m<sup>2</sup>) in west-central Montana (fig. 19).

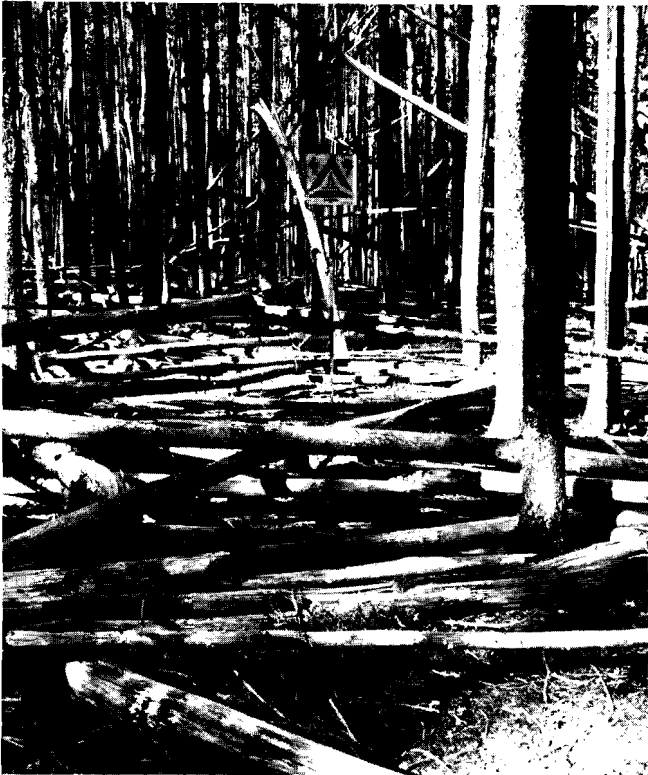
Fuel loads are characterized by relatively large amounts of material 3 inches (7.6 cm) or more in diameter. At least half the total weight is usually contributed by large material. As a general rule, the proportion of the total fuel load made up of material 3 inches (7.6 cm) or more in diameter increases as the total load increases.



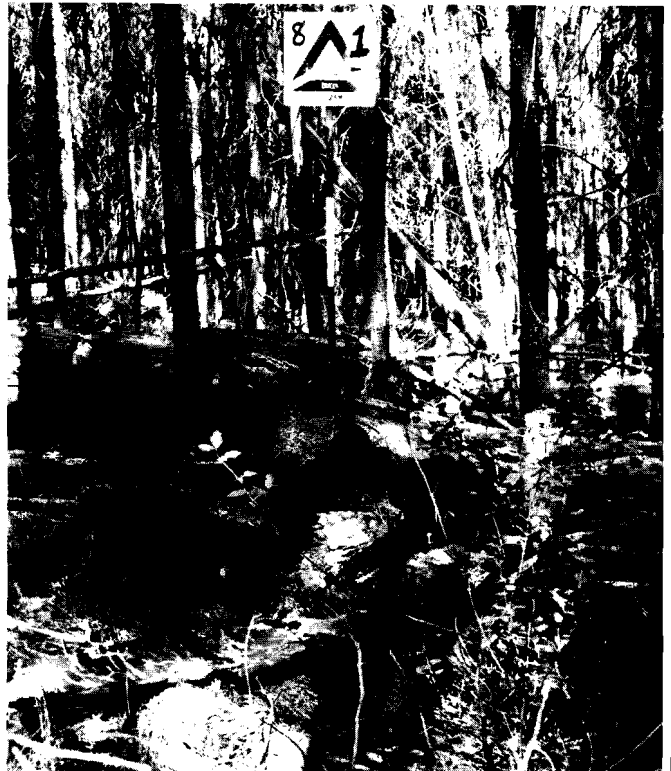
A



B



C



D

*Figure 18—A range of stand conditions and fuel loadings in Group Seven lodgepole pine stands in western Montana. Stands 1 and 81 are near Lolo. Stand 24A is near Lincoln, and stand 49A is near Hamilton. Habitat types, stand age, and fuel loadings are presented in table 10.*



Table 10—Fuel loadings by size class for stands shown in figure 18

Stand number	Habitat type-phase	Age <sup>1</sup>	Duff depth	Size class (inches)							Total
				0-1/4	1/4-1	1-3	3-6	6-10	10-20	20+	
1	ABLA/VACA	80	1.4	0.6	0.9	3.8	1.4	0.4	0	0	7.1
24A	ABLNKETE-VASC	160	.8	.3	1.0	2.5	7.7	1.3	0	0	12.8
49A	ABLN/VACA	165	2.3	.3	1.4	8.1	11.8	1.0	0	0	22.6
8L	PICEA/LIBO	50	1.6	.3	.8	2.4	2.8	6.3	22.1	0	34.7

<sup>1</sup>Age of overstory dominants

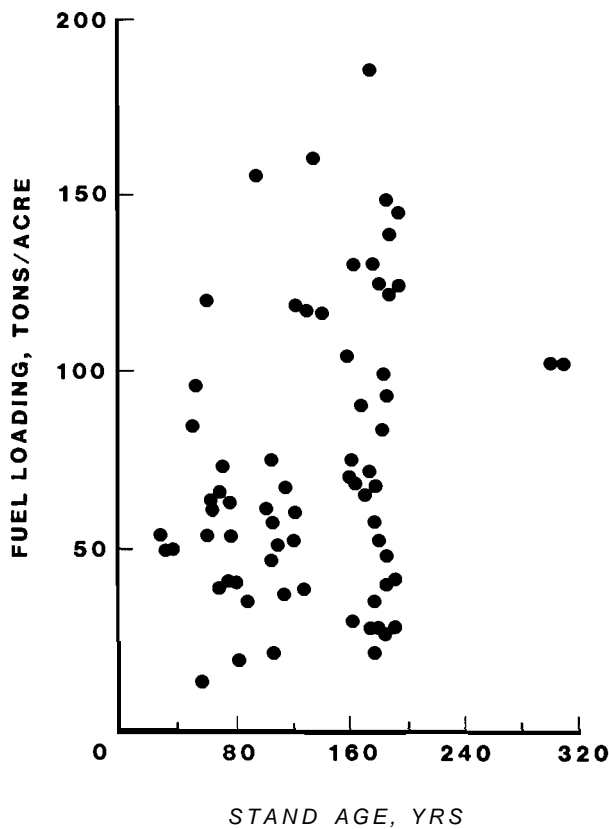


Figure 19—Fuel loading versus stand age for 71 lodgepole pine stands in the East Fork of the Bitterroot River drainage near Sula, MT (Mathews 1980).

Live fuels can be a problem but not to the extent they are in some other Fire Groups. The primary live fuel consideration is related to the occurrence of dense patches or entire stands of young lodgepole with intermingled crowns and lower branches extending down to the surface fuels. When ignited under favorable burning conditions, such stands are usually destroyed in a few minutes.

Many mature stands are characterized by densely stocked, clean-boled trees with large amounts of deadfall on the forest floor (fig. 18 and table 10). An immediate source of deadfall in a young lodgepole stand is the snags

created by the previous fire. Lyon (1984) found that after 2 years with little windthrow, lodgepole pine snags on the Sleeping Child Burn (Bitterroot National Forest) fell at an annual rate of 13.4 percent (fig. 20). Overall, an average of 497 snags per acre was reduced to an average of 75 snags per acre after 15 years (table 11). After 21 years, nearly 93 percent of all snags had fallen (fig. 20).

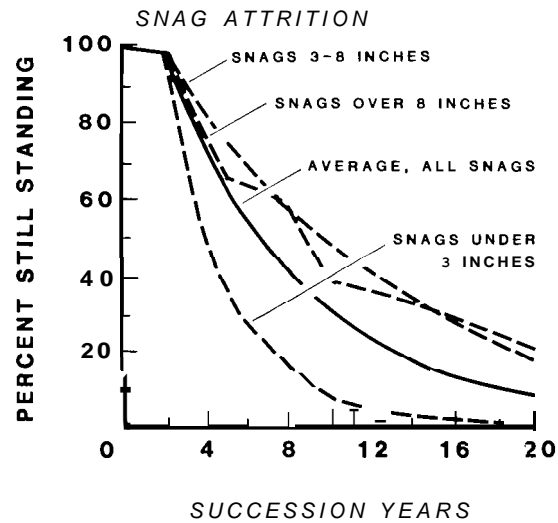


Figure 20—Percentage of lodgepole pine snags still standing, by year and diameter class, Sleeping Child Burn, Bitterroot National Forest, MT, 1962 to 1982 (Lyon 1984).

Table 11—Average number of snags per acre by size class and year of count, Sleeping Child Burn, Bitterroot National Forest, MT (Lyon 1977) (totals may not agree because of rounding)

Size class	Year					
	1962	1963	1966	1969	1971	1976
<i>Inches</i>						
Under 3	266	265	96	41	28	4
3 to 8	159	156	124	103	85	50
8 to 12	64	62	40	36	24	19
Over 12	7	7	7	6	4	3
<b>Total</b>	<b>497</b>	<b>390</b>	<b>268</b>	<b>186</b>	<b>141</b>	<b>75</b>

Aside from fire-created snags, sources of deadfall are thinning, snow breakage and windthrow of live trees, dwarf mistletoe mortality, and mountain pine beetle attack and subsequent mortality. Mountain pine beetle attack is often the mechanism that causes the lodgepole stand to break up. Cumulative mortality during a mountain pine beetle epidemic (duration of about 11 years) frequently amounts to 85 percent or more of the large, 8-inch (20-cm) diameter trees in a lodgepole pine stand (Cole and Amman 1980).

Brown (1975) has characterized fuel cycles and fire hazard in lodgepole pine stands, as shown in figure 21. Curve A of that figure corresponds to what Muraro (1971) describes as typical fire hazard in lodgepole pine where young stands, especially dense ones, are most hazardous. Least hazardous are moderately dense to open advanced, immature and mature stands. Hazard increases as stands become overmature and ground fuels build up from down-fall and establishment of shade-tolerant species. Curve C depicts conditions not uncommonly found. Ground fuel quantities and fire potential remain relatively low throughout the life of the stand until it undergoes decadence. Individual stands can vary anywhere between curves A and C during younger growth periods and develop higher fire potential at later periods of growth (curve B).

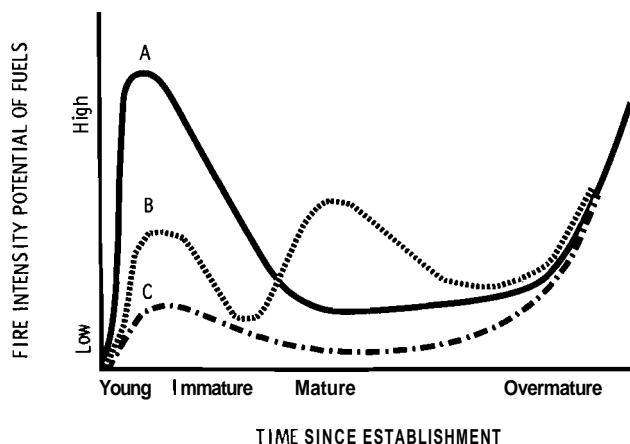


Figure 21—Fuel cycles and fire intensity potential in lodgepole pine (Brown 1975).

## Role of Fire

On sites below about 7,500 ft (2,286 m) the role of fire in seral lodgepole forests is almost exclusively as an agent that perpetuates or renews, lodgepole pine. Without periodic disturbance, the shade-tolerant species replace lodgepole because it does not regenerate well on duff or under shaded conditions. Fire interrupts the course of succession and increases the proportion of lodgepole with each burn. Within 50 to 100 years following a severe fire in a lodgepole-dominated stand, a reestablished lodgepole pine forest will exist even though shrubs and herbaceous cover may become dominant immediately following the burn.

Large-scale stand-replacing fires play a major role in the ecology of lodgepole pine stands. The natural periodicity of severe fires in seral lodgepole stands probably ranges from

less than 100 years to about 500 years (Hendrickson 1970). Recurring cool fires may thin the stand or otherwise rejuvenate it without doing serious damage. However, in stands greater than 60 to 80 years old, fuels build up to a hazardous level due to natural thinning, mountain pine beetle outbreaks, dwarf mistletoe infestations, and fire-killed timber (snags) from previous fires. Eventually a chance ignition sets off a major conflagration. Such a fire may cover thousands of acres. Vast tracts of lodgepole can develop in this way as the serotinous cones open and shower the burn with seeds. The Sleeping Child Burn on the Bitterroot National Forest in western Montana is an extreme example in modern times (Lyon 1984).

The almost exclusive dominance of lodgepole pine within the lodgepole pine community types is attributed in large part to fire. Pfister and others (1977) suggest the following reasons for the absence of other species on lodgepole pine climax series sites:

1. Historic, repeated wildfires over large areas may eliminate seed sources of potential shade-tolerant competitors.
2. Light ground fires may remove invading shade-tolerant competitors from the understory.
3. Dense stands may prevent regeneration of all conifers for up to 200 years in the absence of disturbance or stand deterioration.
4. Sites may be unfavorable for the establishment of other conifers. (In Montana, the best example of this situation is within the PICO/PUTR h.t.)

Above 7,500 ft (2,286 m) the role of fire in lodgepole forests appears to differ from the classic pattern. At these altitudes the fire season is relatively short, productivity is low, and mountain pine beetle activity is inhibited by low temperatures and the short growing season. Romme (1980, 1982) has estimated a mean fire interval of 300 to 400 years for stand-destroying fires in subalpine forests of Yellowstone National Park. The spread of fire is often limited. Small, lightning-caused fires burn out patches of forest several acres in area and then die out. The result may be a mosaic of age classes, not the uniform single-aged forests prevalent on many lower elevation sites (Day 1972).

Brown's (1975) discussion of fire cycles and community dynamics in lodgepole pine forests is an important source of information on the role of fire in lodgepole pine forests (fig. 22). Brown also discusses the differential effects of fires of varying severity on lodgepole pine forests. He emphasizes the critical role of fuel and duff moisture in determining fire severity and, consequently, fire effects.

The roles of fire and mountain pine beetle are inextricable in most lodgepole pine forests. The following description of this interrelationship is from Amman's (1977) "Role of the Mountain Pine Beetle in Lodgepole Pine Ecosystems."

The role of the beetle differs in conjunction with the two basic ecological roles of lodgepole pine, where lodgepole pine is seral and where it is persistent or climax. The beetles' continued role in the seral stands will depend upon the presence of fire.

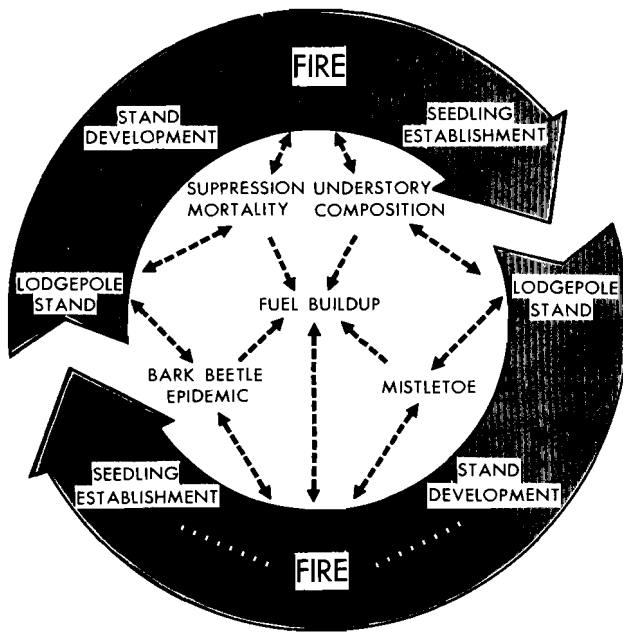


Figure 22—Lodgepole pine fire cycle showing inter-relationships among influences (Brown 1975).

### Role of Mountain Pine Beetle Where Lodgepole Pine Is Seral

Absence of fire: Lodgepole pine stands depleted by the beetle and not subjected to fire are eventually succeeded by the more shade-tolerant species consisting primarily of Douglas-fir at the lower elevations and subalpine fir and Engelmann spruce at the higher elevations throughout most of the Rocky Mountains. Starting with a stand generated by fire, lodgepole pine grows at a rapid rate and occupies the dominant position in the stand. Fir and spruce seedlings also established in the stand grow more slowly than lodgepole pine.

With each infestation, the beetle kills most of the large, dominant lodgepole pines. After the infestation, both residual lodgepole pine and the shade-tolerant species increase their growth. When the lodgepole pines are of adequate size and phloem thickness, another beetle infestation occurs. This cycle is repeated at 20- to 40-year intervals depending upon growth of the trees, until lodgepole pine is eliminated from the stand.

The role played by the mountain pine beetle in stands where lodgepole pine is seral is to periodically remove the large, dominant pines. This provides growing space for subalpine fir and Douglas-fir, thus hastening succession by these species. The continued presence of the beetle in these mixed-species stands is as dependent upon fire as that of lodgepole pine. Without it, both are eliminated.

Presence of fire: Where lodgepole pine is seral, forests are perpetuated through the effects of periodic fires (Tackle 1965). Fires tend to eliminate competitive tree species such as Douglas-fir,

the true firs, and spruces. Following fire, lodgepole pine usually seeds in abundantly. Serotinous cones attached to the limbs of the tree open because of the intense heat of the fire and release their seed (Clements 1910; Lotan 1975).

Large accumulations of dead material caused by periodic beetle infestations result in very hot fires when they do occur (Brown 1975). Hot fires of this nature eliminate Douglas-fir, which otherwise is more resistant to fire damage than lodgepole pine. The dominant shade-tolerant species are eliminated, resulting in a return to a pure lodgepole pine forest. On the other hand, light surface fires would not be adequate to kill large, thick-barked Douglas-fir and return lodgepole pine to a dominant position in the stand.

Following regeneration of lodgepole pine after fire, the mountain pine beetle-lodgepole interactions would be similar to those described in the absence of fire. A fire may interrupt the sere at any time, reverting the stand back to pure lodgepole pine. However, once succession is complete, lodgepole pine seed will no longer be available to seed the burned areas except along edges where the spruce-fir climax joins persistent or climax lodgepole pine.

### Role of Mountain Pine Beetle Where Lodgepole Pine Is Persistent or Climax

Lodgepole pine is persistent over large acreages, and because of the number of shade-tolerant individuals of other species found in such persistent stands, the successional status is unclear (Pfister and Daubenmire 1975). In any case, lodgepole pine persists long enough for a number of beetle infestations to occur. In such cases and those of a more limited nature when lodgepole pine is climax because of special climatic or soil conditions, the forest consists of trees of different sizes and ages ranging from seedlings to a few over-mature individuals. In these forests, the beetle infests and kills most of the lodgepole pines as they reach larger sizes. Openings created in the stand as a result of the larger trees being killed, are seeded by lodgepole pine. The cycle is then repeated as other lodgepole pines reach sizes and phloem thicknesses conducive to increases in beetle populations.

The result is two- or three-story stands consisting of trees of different ages and sizes. A mosaic of small clumps of different ages and sizes may occur. The overall effect is likely to be more chronic infestations by the beetle because of the more constant source of food. Beetle infestations in such forests may result in death of fewer trees per hectare during each infestation than would occur in even-aged stands developed after fires and in those where lodgepole pine is seral.

Fires in persistent and climax lodgepole pine forests should not be as hot as those where large epidemics of beetles have occurred. Smaller, more continuous deposits of fuel are available on the

forest floor. The lighter beetle infestations, and thus lighter accumulations of fuel, would result in fires that would eliminate some of the trees but probably would not cause total regeneration of the stand. This would be beneficial to the beetle because a more continuous supply of food would be maintained. Where large accumulations of fuel occur after large beetle epidemics, fire would completely eliminate the beetle's food supply from vast acreages for many years while the entire stand of trees grow from seedlings to sizes conducive to beetle infestation.

The mountain pine beetle's evolutionary strategies have been successful. It has exploited a niche that no other bark beetle has been able to exploit, that of harvesting lodgepole pine trees as they reach or slightly before they reach maturity. Such trees are at their peak as food for the beetle. Harvesting at this time in the age of the stand maintains the vigor of the stand, and keeps the stand at maximum productivity. (End of Amman 1977 excerpts.)

## Forest Succession

The theoretical climax forest will vary according to habitat type as shown in figure 23 (subsequent numbers in this section refer to fig. 23). Except for stands within the lodgepole pine community types and the PICO/PUTR h.t., however, the climax situation is rarely achieved. Fire almost always interrupts succession before a near-climax condition develops.

Following a stand-destroying fire, a short-lived herb/shrub stage dominates. This stage is short-lived because

the lodgepole pine seedlings quickly become established and overtop the undergrowth. However, a fire in the herb/shrub stage (No. 1) will extend its period of dominance. Recurring fire at frequent intervals could conceivably maintain the site in herbs and shrubs. A fire during the seedling/sapling stage also returns the site to herbs and shrubs (No. 2). The likelihood of a fire at this stage is not great on most sites.

The effect of a fire during the pole stage depends on fire severity. A cool fire (No. 3) thins the stand while a severe fire (No. 4) destroys it. Because pole-sized lodgepole pine usually contain serotinous cone crops, periodic fire at this stage can result in a fire-maintained lodgepole pine stand. The effect of fire in a mature lodgepole forest is essentially the same as in the pole forest. A cool fire thins the stand and a severe fire recycles the stand (Nos. 5 and 6). The probability of a severe stand-destroying fire greatly increases as a previously unburned mature stand starts to break up and an understory of climax species develops. It is usually at this stage rather than the climax stage that fire destroys the stand (No. 7).

Hypothetical successional pathways for Fire Group Seven forests are illustrated in figure 24. Starting with an herb/shrub state (state A, fig. 24) two major paths exist depending on whether the site is classified as belonging to either a lodgepole pine community type or a lodgepole pine habitat type, or whether the site is a potential Douglas-fir, spruce, or subalpine fir climax.

The successional sequences of community types provided by Arno and others (1985) can be used as an aid for predicting successional development of seral communities within the ABLAIXETE-VASC h.t. in relation to various types of fire and harvest treatments.

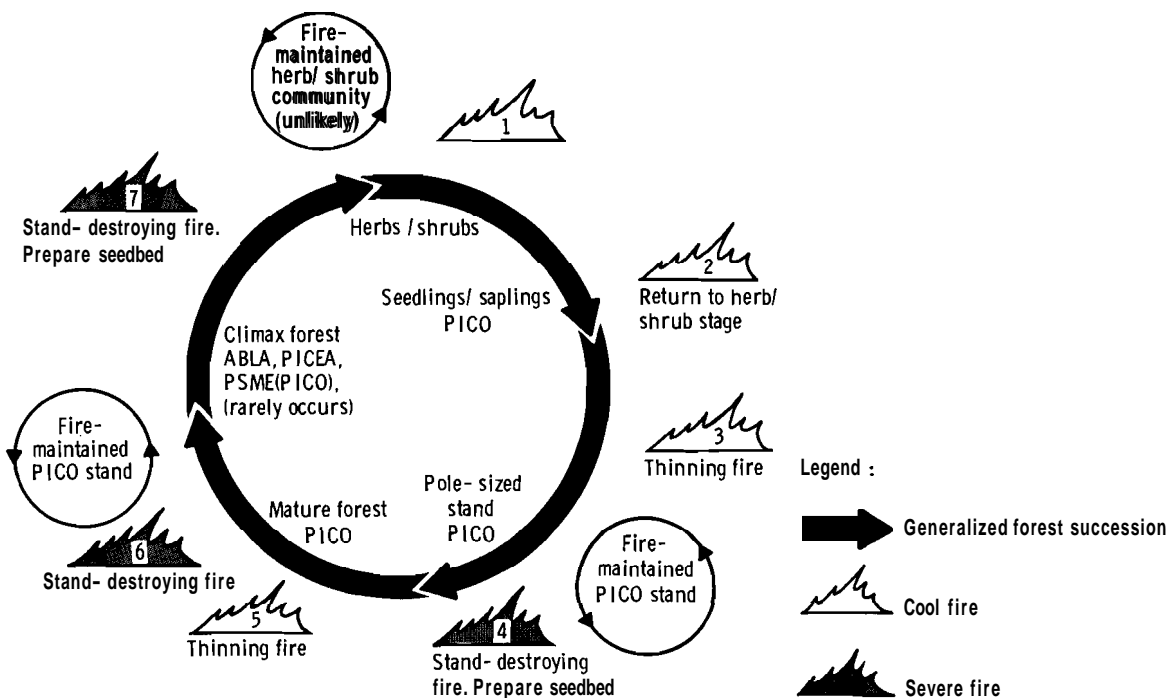
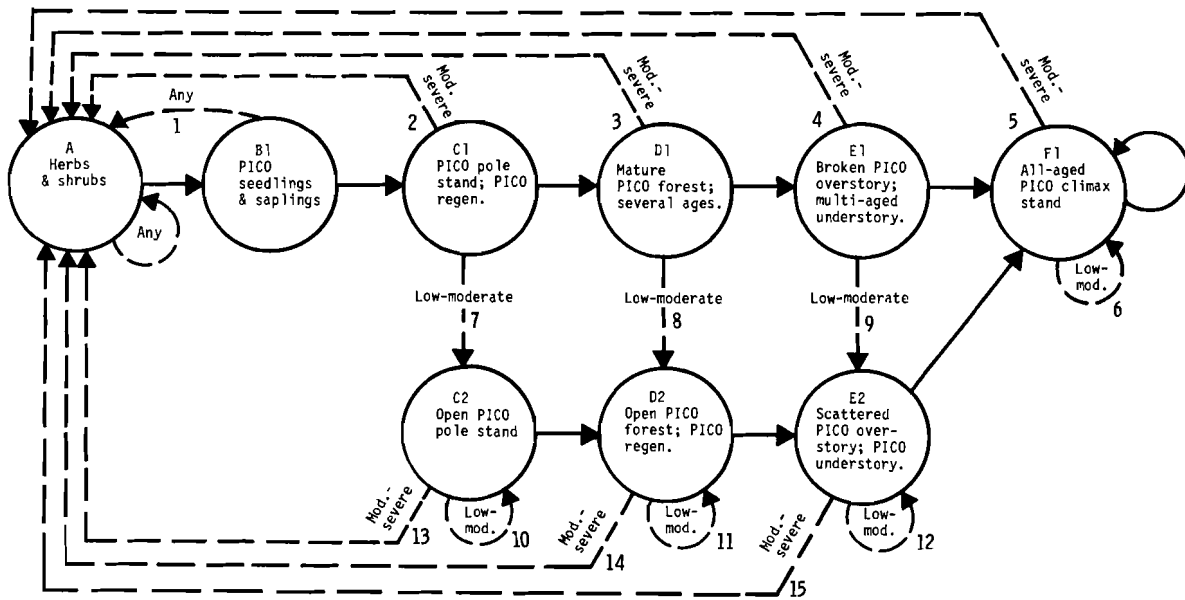
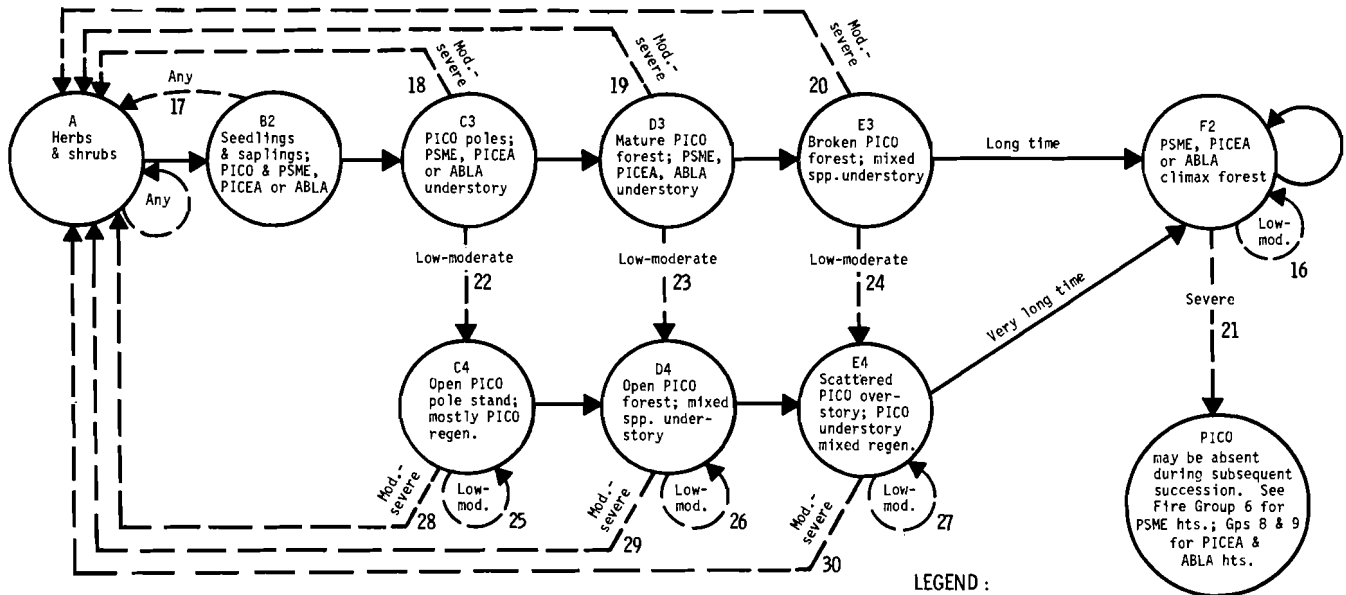


Figure 23—Generalized forest succession in Fire Group Seven: cool habitat types usually dominated by lodgepole pine.

1. LODGEPOLE PINE HABITAT TYPES



2. DOUGLAS-FIR, SPRUCE, AND SUBALPINE FIR HABITAT TYPES



LEGEND :

- > Succession in absence of fire
- - - -> Response to fire
- Low Cool or light surface fire
- Mod. Fire of intermediate (moderate) severity
- Severe Hot, stand-destroying fire
- 1, 2, etc. Reference number, (see text)

Figure 24—Hypothetical fire-related successional pathways for Fire Group Seven habitat types: (1) Lodgepole pine habitat types and (2) Douglas-fir, spruce, and subalpine fir habitat types.

## Fire Management Considerations

Perhaps the primary fire management consideration in this group is protection from unwanted fire during extended periods of drought and during severe fire weather conditions. Fires at such times often crown and become holocausts if the lodgepole stand is ready physiognomically to burn (Despain and Sellers 1977).

Opportunities for fire use are limited in natural stands because of the low fire resistance of lodgepole pine, spruce, and subalpine fir. The other side of this problem is that during "safe" fire weather, it is often difficult to sustain a fire. But low- to medium-severity surface fires do occur. Thus, there may be opportunities to use prescribed fires to accomplish specific management objectives.

Prescribed fire has been suggested as a management tool for controlling dwarf mistletoe. According to Alexander and Hawksworth (1975), prescribed burning, in relation to mistletoe control, can serve two purposes: (1) eliminate infected residual trees in logged-over areas and (2) destroy heavily infected stands on unproductive sites so that they can be replaced by young healthy stands.

The primary use of prescribed fire in lodgepole pine has been and undoubtedly will continue to be for hazard reduction and site preparation in conjunction with tree harvesting and subsequent regeneration. Broadcast burning and pile and windrow burning have been the most often used methods of accomplishing these tasks. Successful broadcast slash burning usually yields increased forage production for big game. Slash disposal of any kind aids big game movement through these stands.

Lotan and Perry (1983) have summarized the various considerations that determine the appropriate use of fire for site preparation and regeneration of lodgepole pine forests (fig. 25). Silviculturists and fire managers should consult Lotan and Perry (1983) before developing fire prescriptions to regenerate lodgepole pine.

As indicated earlier, the primary concern in the fire management of many commercial lodgepole pine forests is the prevention of stand-destroying fires. Timber harvest for a variety of products, and subsequent slash disposal, are the primary means to this end. Harvest schedules should be developed and implemented to create age-class mosaics of lodgepole pine. This minimizes the areal extent of stand-destroying fires. Silvicultural practices designed to harvest trees susceptible to mountain pine beetle before the trees are attacked (Cole and Amman 1980) can greatly reduce the threat of severe fires in second-growth stands of lodgepole pine. The use of lodgepole pine for firewood, poles, posts, wood chips, and sawlogs may provide opportunities for fuel management-related harvesting.

In some wilderness areas, periodic crown fires play a

vital role in natural development of lodgepole pine ecosystems, and their use should be considered when consistent with the need to protect human life, property, and resource values outside wilderness. Fellin (1980) presents a case for fire use in lodgepole pine stands:

In many areas where natural fires have been suppressed, forest residues resulting from mountain pine beetle epidemics accumulate until hot fires occur. According to D. Cole (1978), "such fires are normally more destructive than ones that would have otherwise occurred if fires had not been suppressed, and they tend to perpetuate future extremes in the mountain pine beetle lodgepole pinelfire interactions." Several opinions have been expressed that the bark beetle epidemics now rampant in the Rockies and Intermountain West may be a product of fire exclusion (Schwennesen 1979). In Glacier National Park, the mountain pine beetle epidemic took such a strong hold because fire suppression programs were so successful and trees that ordinarily might have been burned are now mature and ripe for the beetles (Kuglin 1980).

D. Cole (1978) suggests that a deliberate program of fire management and prescribed fire can be instituted to moderate the mountain pine beetle-lodgepole pine-fire interaction cycle. His premise is that both wildfire and prescribed fire management plans can be developed to use fire to "create a mosaic of regenerated stands within extensive areas of timber that have developed." D. Cole (1978) believes that prescribed fires can create these ecosystem mosaics more effectively than wildfires. With the recent change from fire control to fire management, managed wildfires will be, in fact, prescribed fires.

Guidelines have been developed by McGregor and Cole (1985) to assist forest managers in integrating pest management techniques for the mountain pine beetle with other resource considerations in the process of planning and executing balanced resource management of lodgepole pine forests. The guidelines present visual and classification criteria and methods for recognizing and summarizing occurrence and susceptibility status of lodgepole pine stands according to habitat types and successional roles and important resource considerations associated with them. McGregor and Cole (1985) review appropriate silvicultural systems and practices, including use of fire, for commercial and noncommercial forest land designations including parks, wilderness, and other reserved areas.

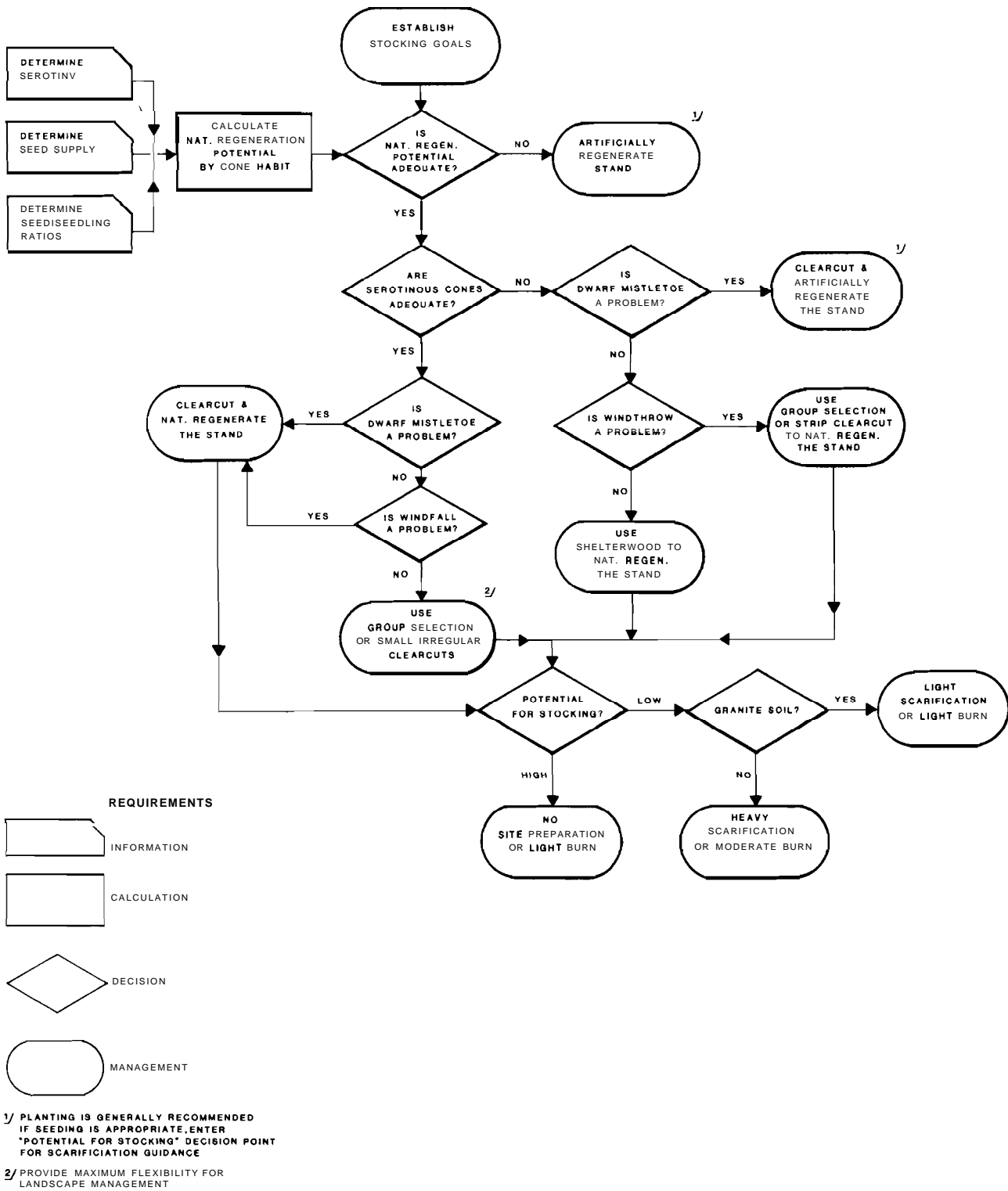


Figure 25—The decision chain for lodgepole pine regeneration (Lotan and Perry 1983).

## FIRE GROUP EIGHT: DRY, LOWER SUBALPINE HABITAT TYPES

ADP code	Habitat type-phase (Pfister and others 1977)	Montana forest region (Arno 1979)
480	<i>Picea/Smilacina stellata</i> h.t. (PICEAISMST), spruce/starry false Solomon's seal	West central
691	<i>Abies lasiocarpa/Xerophyllum tenax</i> h.t.- <i>Vaccinium globulare</i> phase (ABLAIXETE-VAGL), subalpine firbeargrass-blue huckleberry phase	Northwestern and west central
710	<i>Tsuga mertensiana/Xerophyllum tenax</i> h.t. (TSME/XETE), mountain hemlockbeargrass	Northwestern and west central

### Vegetation

Fire Group Eight consists of dry lower subalpine habitat types where spruce, subalpine fir, or mountain hemlock are the indicated climax species. West of the Continental Divide in Montana, Fire Group Eight is represented by three habitat types: ABLAIXETE-VAGL and TSMEI XETE and a minor amount of PICEAISMST. East of the Divide, Group Eight has much greater representation (Fischer and Clayton 1983).

Douglas-fir and lodgepole pine are dominant seral species, with lesser amounts of spruce, and occasional larch or western white pine. The prevalence of Douglas-fir and lodgepole pine may be due, in part, to periodic wildfire that sets back the invasion of subalpine fir and spruce.

Stands usually contain luxuriant undergrowth. Common grasslike species are pinegrass and elk sedge. Shrub layers are dominated by one or more of the following species: mountain lover, American twinflower, common snowberry, dampwoods blueberry (blue huckleberry), and grouse whortleberry.

Among the more prevalent forbs are heartleaf arnica, broadleaf arnica, western meadowrue, pyrola, and false Solomon's seal. Solomon's seal and beargrass are also conspicuous on some sites.

### Forest Fuels

Downed dead woody fuel loadings average about 18 tons per acre (about 4 kg/m<sup>2</sup>) according to Brown and See (1981) (table 6). Maximum loads may greatly exceed this value. Fuel loadings of 1 ton per acre to about 80 tons per acre (about 0.2 to 18 kg/m<sup>2</sup>) were measured during photo plot fuel inventory in western Montana (Fischer 1981b). With few exceptions, 20 tons per acre (4.5 kg/m<sup>2</sup>) represented the low end of the range of loadings encountered during photo plot inventory. The range of stand and fuel conditions is shown in figure 26.

Stands are characterized by relatively large amounts of downed woody fuel of all size classes, but especially large

amounts of material greater than 3 inches (7.6 cm) in diameter (fig. 26 and table 12).

As is the case within many subalpine fir habitat types, live fuels can contribute significantly to overall fire hazard during dry conditions. Dense understories develop in many stands and provide fuel ladders to the overstory tree crowns (fig. 27), although some stands are devoid of such understories (fig. 26).

Relatively deep duff layers may form (table 12). When the duff is dry, fire in the duff can cause considerable mortality by heating the shallow roots of subalpine fir and Engelmann spruce.

### Role of Fire

Fire history data for lower subalpine habitat types in the Northern Rocky Mountains have been summarized by Arno (1980). He reported that almost 60 percent of the mature (greater than 100 years) western Montana ABLA/XETE stands sampled showed obvious evidence of ground fire after establishment.

The occurrence of periodic low- to moderate-severity fire favors Douglas-fir and lodgepole pine. Such fires set back invasion by the more tolerant subalpine fir and spruce, which in the absence of fire form dense understories and eventually take over the site. Fires of moderate severity probably help Douglas-fir maintain a position of dominance or codominance with lodgepole in many stands. The more fire-resistant Douglas-fir has a better chance of surviving such fires and is able to successfully regenerate in fire-created openings where mineral soil has been exposed. Severe, stand-destroying fire will generally favor lodgepole pine on many of these sites. Some large, thick-barked Douglas-fir trees will often survive fires severe enough to kill all the lodgepole pine trees, thereby assuring the presence of Douglas-fir in the new stand.

Before organized fire, suppression fire intervals probably fell between those reported for Fire Group Seven lodgepole pine stands (about 50 years) and those identified for the more moist lower subalpine types of Fire Group Nine (90 to 130 years).

### Forest Succession

Generalized forest succession in the dry lower subalpine habitat types of Fire Group Eight is similar to the moist lower subalpine habitat types of Group Nine. The major difference between the two is that the drier Group Eight stands experience more frequent, generally less severe fires than Group Nine stands.

Because of the similarity of fire-related forest succession in the two groups, generalized forest succession is jointly discussed under Fire Group Nine. Similarly, successional pathways for Fire Group Eight are presented with those of Fire Group Nine.

The successional sequences of community types provided by Arno and others (1985) can be used as an aid in predicting successional development of seral communities within the ABLAIXETE-VAGL h.t. in relation to fire and harvest treatments.



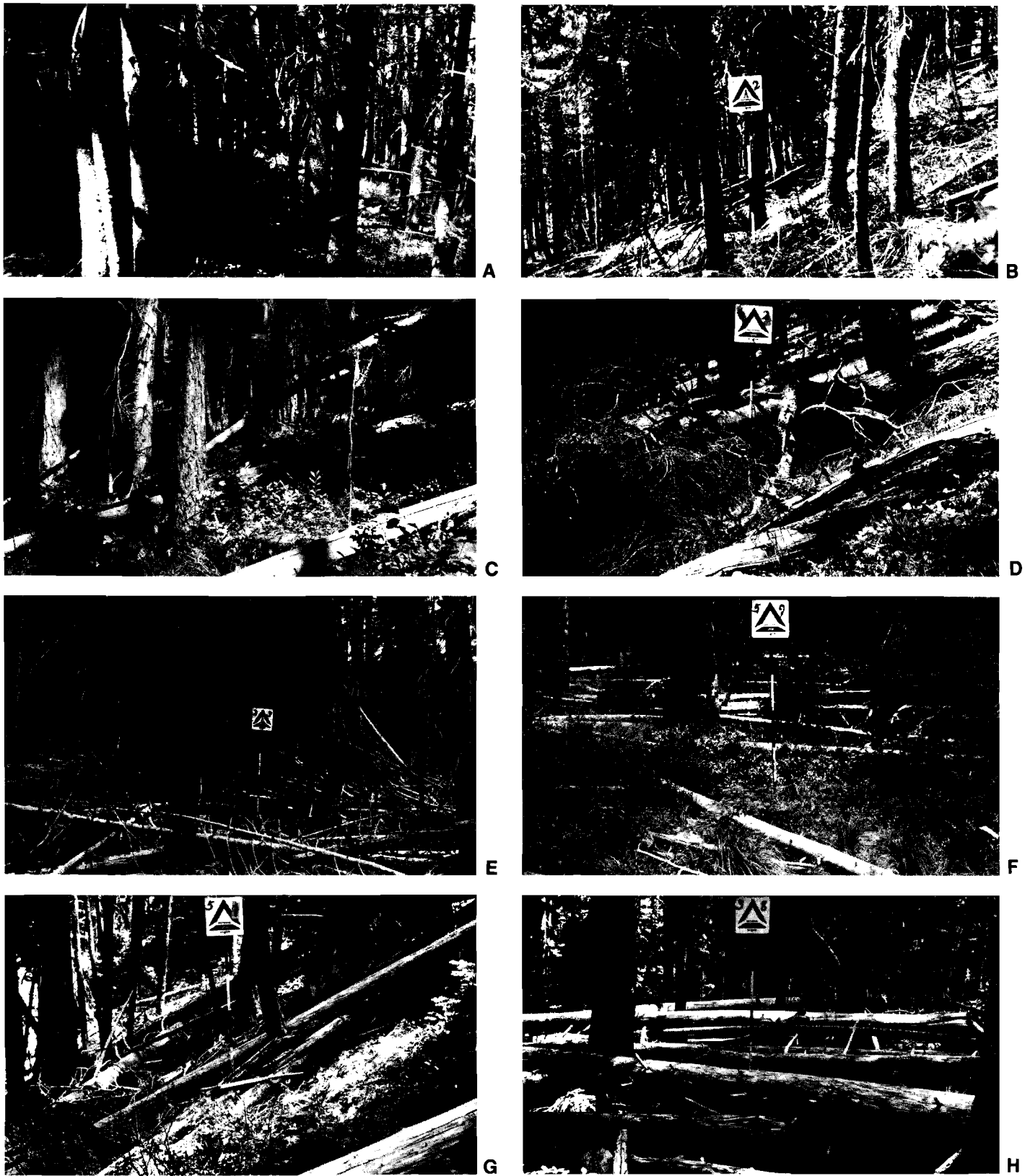


Figure 26—Examples of Fire Group Eight stand and fuel conditions in western Montana. All of these ABLA/XETE-VAGL h.t.'s support Engelmann spruce-subalpine fir stands except stands 61 and 42, which are lodgepole pine and interior Douglas-fir respectively. Stand age and fuel loadings are given in table 12.

Table 12 —Fuel loadings by size class for stands shown in figures 26 and 27

Stand number	Habitat type-phase	Age <sup>1</sup>	Duff depth	Size class (inches)							Total
				0-1/4	1/4-1	1-3	3-6	6-10	10-20	20+	
		Years	Inches	----- Tons/acre -----							
45	ABLNxEtE-VAGL	90	1.3	0.3	0.6	0.3	0.1	0	0	0	1.3
2A	ABLNxEtE-VAGL	80	2.2	.6	1.5	2.9	2.3	2.0	0	0	9.3
61	ABLNxEtE-VAGL	140	2.8	.5	1.7	1.3	5.2	11.5	4.1	0	24.8
42	ABLNxEtE-VAGL	335	1.1	.4	1.9	2.5	1.6	2.9	5.4	11.9	26.6
23A	ABLNxEtE-VAGL	150	3.1	.6	1.9	3.2	11.7	16.3	0	0	33.7
59	ABLNxEtE-VAGL	120	1.3	.4	1.4	2.1	9.4	24.7	2.8	0	40.8
51	ABLNxEtE-VAGL	210	3.2	.5	2.7	4.1	5.8	18.6	14.7	2.9	49.3
20A	ABLNxEtE-VAGL	165	3.4	.5	1.4	3.8	16.7	22.0	6.6	0	51.0
38	ABWxEtE-VAGL	200	2.9	.2	1.4	5.0	11.8	47.1	11.8	0	77.3

<sup>1</sup>Age of overstory dominants.

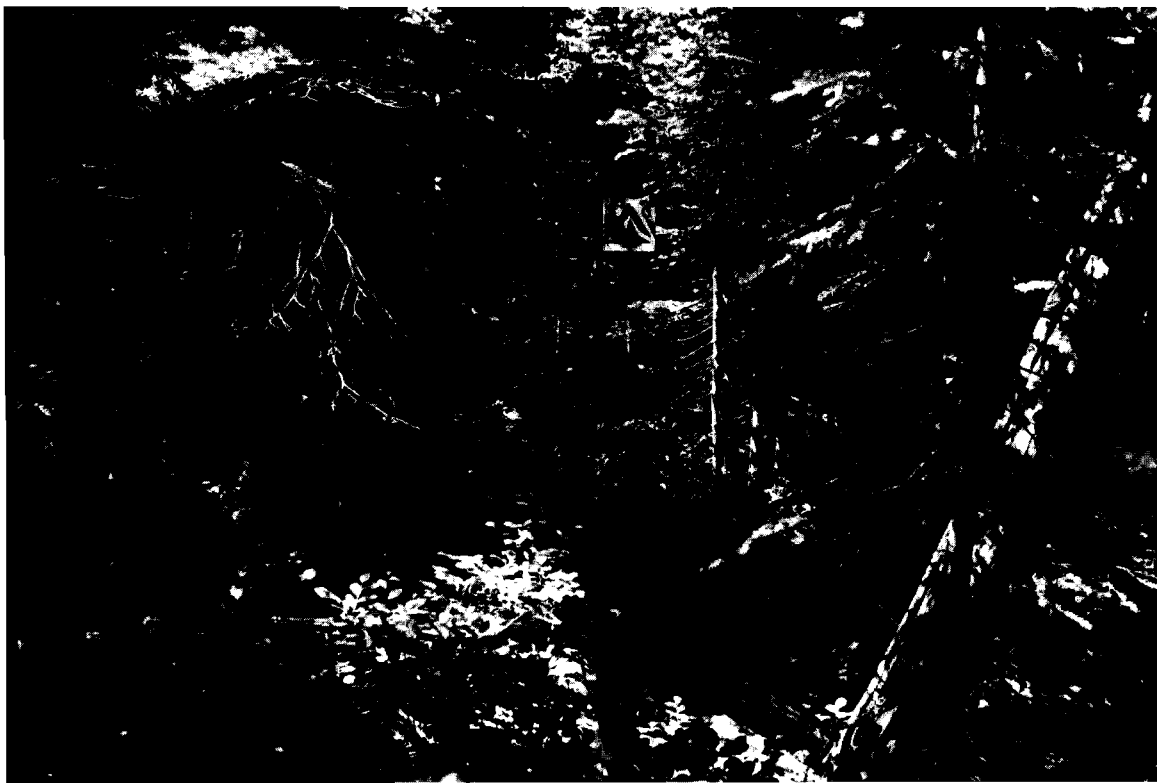


Figure 27 —An example of a Fire Group Eight Engelmann spruce-subalpine fir stand with a high crowning potential caused by a dense understory. Stand age and fuel loadings are given in table 12.

## Fire Management Considerations

Fire protection is usually an important fire management consideration during severe burning conditions especially where timber production is a management objective. When conditions are less than severe, fires may be of low to moderate severity and result in only moderate damage or no damage to overstory trees, despite the relatively low resistance of many of the species present.

Fire can be used to dispose of logging slash on harvest areas, but broadcast burning for site preparation is often hampered by high duff moisture and scarcity of acceptable burning days during traditional fall prescribed burning periods.

Where timber production is not a management objective, opportunities may exist for the use of prescribed fires to accomplish fire management (Fischer 1984). Such fires can create vegetative mosaics that in turn provide a diversity of wildlife habitats, diverse scenery, and enhanced recreational opportunities. Vegetative mosaics can also reduce the probability of widespread wildfire damage to watershed values.

## FIRE GROUP NINE: MOIST, LOWER SUBALPINE HABITAT TYPES

ADP code	Habitat type-phase	Montana forest region
	(Pfister and others 1977)	(Arno 1979)
410	<i>Picea/Equisetum arvense</i> h.t. (PICEA/EQAR), spruce/common horsetail	Northwestern
420	<i>Picea/Clintonia uniflora</i> h.t.- <i>Vaccinium caespitosum</i> phase (PICEA/CLUN-VACA), spruce/queencup beadlily-dwarf huckleberry phase	Northwestern
422	<i>Picea/Clintonia uniflora</i> h.t.- <i>Clintonia uniflora</i> phase (PICEA/CLUN-CLUN), spruce/queencup beadlily-queencup beadlily phase	Northwestern
440	<i>Picea/Galium triflorum</i> h.t. (PICEA/GATR), spruce/sweetscented bedstraw	West central
610	<i>Abies lasiocarpa/Oplopanax horridum</i> h.t. (ABLA/OPHO), subalpine fir/devil's club	Northwestern
621	<i>Abies lasiocarpa/Clintonia uniflora</i> h.t.- <i>Clintonia uniflora</i> phase (ABLA/CLUN-CLUN), subalpine fir/queencup beadlily-queencup beadlily phase	Northwestern and west central
622	<i>Abies lasiocarpa/Clintonia uniflora</i> h.t.- <i>Aralia nudicaulis</i> phase (ABLA/CLUN-ARNU), subalpine fir/queencup beadlily-wild sarsaparilla phase	Northwestern and west central

623	<i>Abies lasiocarpa/Clintonia uniflora</i> h.t.- <i>Vaccinium caespitosum</i> phase (ABLA/CLUN-VACA), subalpine fir/queencup beadlily-dwarf huckleberry phase	Northwestern and west central
624	<i>Abies lasiocarpa/Clintonia uniflora</i> h.t.- <i>Xerophyllum tenax</i> phase (ABLA/CLUN-XETE), subalpine fir/queencup beadlily-beargrass phase	Northwestern and west central
625	<i>Abies lasiocarpa/Clintonia uniflora</i> h.t.- <i>Menziesia ferruginea</i> phase (ABLA/CLUN-MEFE), subalpine fir/queencup beadlily-menziesia phase	Northwestern and west central
630	<i>Abies lasiocarpa/Galium triflorum</i> h.t. (ABLA/GATR), subalpine fir/sweetscented bedstraw	West central
651	<i>Abies lasiocarpa/Calamagrostis canadensis</i> h.t.- <i>Calamagrostis canadensis</i> phase (ABLA/CACA-CACA), subalpine fir/bluejoint-bluejoint phase	West central
653	<i>Abies lasiocarpa/Calamagrostis canadensis</i> h.t.- <i>Galium triflorum</i> , phase (ABLA/CACA-GATR), subalpine fir/bluejoint-sweetscented bedstraw phase	West central
661	<i>Abies lasiocarpa/Linnaea borealis</i> h.t.- <i>Linnaea borealis</i> phase (ABLA/LIBO-LIBO), subalpine fir/twinflower-twinflower phase	Northwestern and west central
662	<i>Abies lasiocarpa/Linnaea borealis</i> h.t.- <i>Xerophyllum tenax</i> phase (ABLA/LIBO-XETE), subalpine fir/American twinflower-common beargrass phase	Northwestern and west central
670	<i>Abies lasiocarpa/Menziesia ferruginea</i> h.t. (ABLA/MEFE), subalpine fir/menziesia	Northwestern and west central
680	<i>Tsuga mertensiana/Menziesia ferruginea</i> h.t. (TSME/MEFE), mountain hemlock/menziesia	Northwestern and west central
740	<i>Abies lasiocarpa/Alnus sinuata</i> (ABLA/ALSI), subalpine fir/Sitka alder	West central

## Vegetation

Fire Group Nine is a collection of moist and wet lower subalpine habitat types in the spruce and subalpine fir climax series. Soils are moist or wet (supersaturated with water) much of the year. Elevations range from about 2,900 to 7,500 ft (892 to 2,308 m).

Engelmann spruce is usually a major component of seral stands along with lodgepole pine and Douglas-fir. Older stands are usually dominated by subalpine fir and spruce although Douglas-fir and lodgepole may be well represented in the overstory. Notable exceptions to this general pattern of species composition occur within the ABLAI CACA h.t., which is too wet for Douglas-fir, and within the PICEAIEQAR h.t., where spruce is usually the only successful conifer. However, two broadleaf species, paper birch and black cottonwood, may be abundant in seral stands within the PICEAIEQAR h.t. Whitebark pine occurs either accidentally or on some sites as a minor seral component.

Abundant undergrowth occurs on these moist sites. The more common grass and forb species include red baneberry, wild sarsaparilla, broadleaf arnica, bluejoint, pinegrass, queencup beadlily, field horsetail, sweetscented bedstraw, Richardson's geranium, sidebells shineleaf, arrowleaf groundsel, twisted stalk, darkwoods violet, common beargrass, and many other wet-site forbs.

Among the shrubs that occur within more than one habitat type or phase are Sitka alder, redosier dogwood, twinflower, Utah honeysuckle, rusty menziesia, thimbleberry, dampwoods blueberry (blue huckleberry), dwarf

huckleberry, and grouse whortleberry. Less widespread but abundant on particular habitats are kinnikinnick, bunchberry dogwood, western wintergreen, manyleaf swampl laurel, prickly currant, russet buffaloberry, common snowberry, and devil's club.

## Forest Fuels

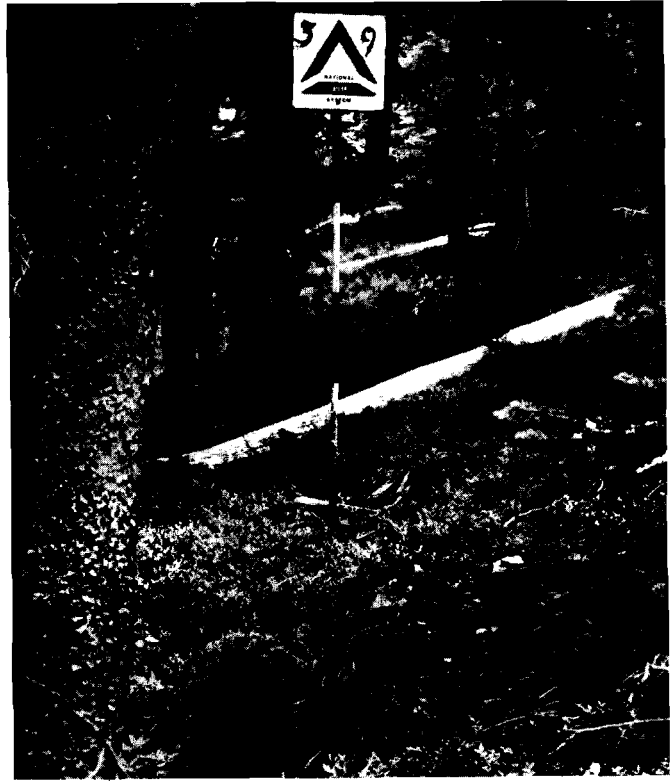
Fire Group Nine fuels are similar to those found in Fire Group Eight. Downed dead woody material on the forest floor averages about 25 tons per acre (about 5.6 kg/m<sup>2</sup>) (table 6) but may be much higher.

A large percentage of the downed woody fuel is material greater than 3 inches (6.7 cm) in diameter (figs. 28 and 29, and table 13). The combination of deep duff and large amounts of dead rotten fuel can result in severe surface fire during unusually dry moisture conditions. Where dense understories exist (fig. 30), such fires can easily spread to the tree crowns and destroy the stand. Even if a severe surface fire does not crown, there is a good chance the overstory trees will be killed by cambium heating.

Under normal moisture conditions for these sites, a lush undergrowth of shrubs and herbs usually serves as an effective barrier to rapid fire spread (fig. 31).



A

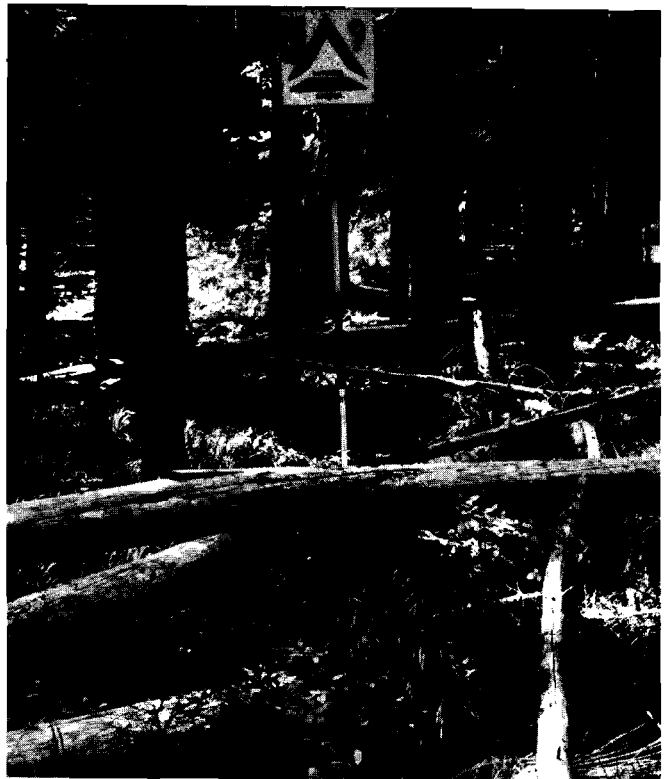


B

**Figure 28**—Examples of characteristic light to moderate fuel loadings for Fire Group Nine stands. All of these ABWMEFE h.t.'s support Engelmann spruce-subalpine fir stands except stand 33, which is larch—Douglas-fir. Stand age and fuel loadings are given in table 13.



C



D



E

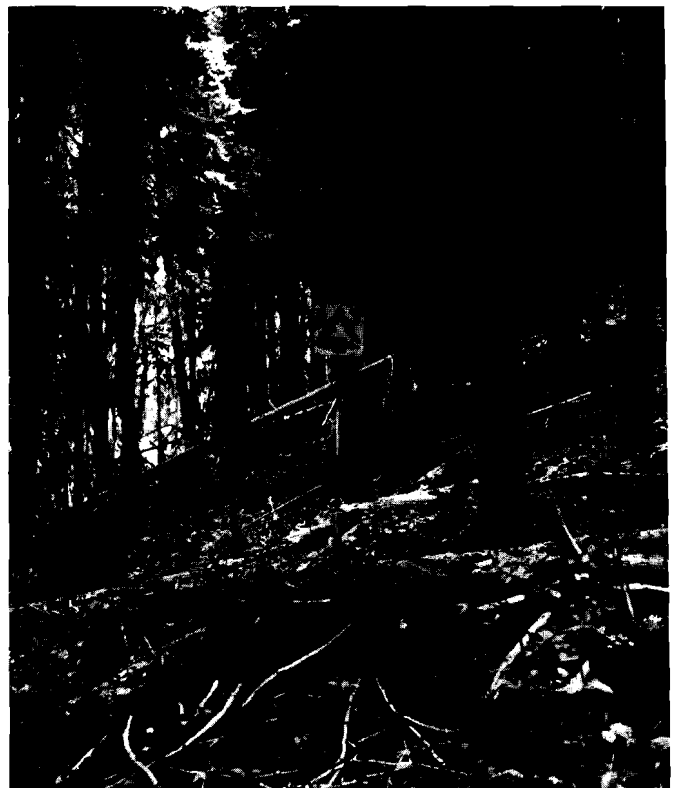


F

Figure 28— (Con.)



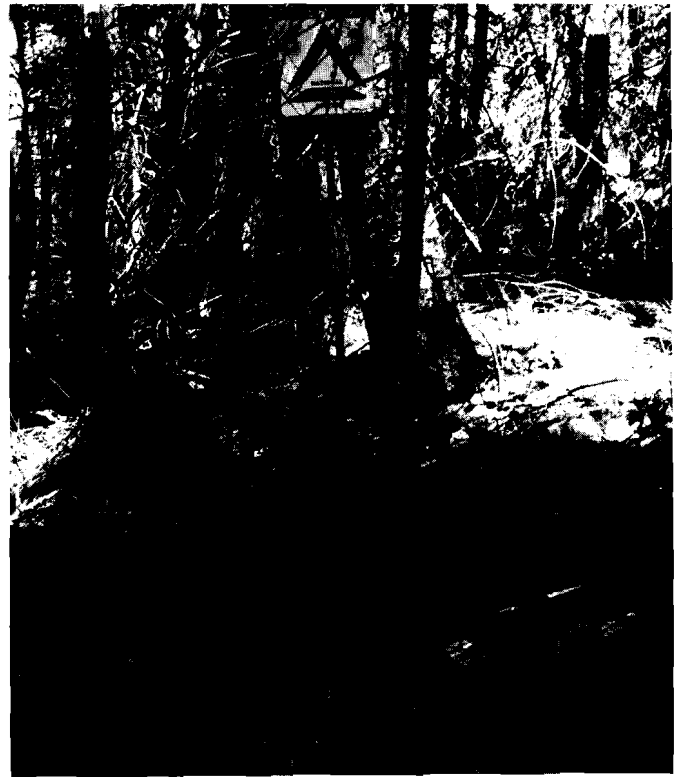
A



B



C



D

*Figure 29—Examples of characteristic heavy fuel loadings for Fire Group Nine stands. Stands 20 and 3 are on ABWCLUN-MEFE h.t.'s. Stands 93, 47, and 10 are ABWMEFE. And stand 62 is a ABWGATR. Stand age and fuel loadings are given in table 13.*



E



F

Figure 29— (Con.)

Table 13—Fuel loadings by size class for stands shown in figures 28, 29, 30, and 31

Stand number	Habitat type-phase	Age <sup>1</sup>	Duff depth	Size class (inches)							Total
				0-1/4	1/4-1	1-3	3-6	6-10	10-20	20+	
		Years	Inches	Tons/acre							
40	ABLNMEFE	70	2.5	0.2	1.8	1.6	1.4	1.5	0	0	6.5
39	ABLNMEFE	130	1.2	.1	.4	1.4	3.3	3.0	0	0	7.2
35	ABWMEFE	110	.9	.2	1.0	3.3	4.5	0	0	0	9.0
82	ABLA/LIBO-LIBO	55	1.5	.3	.3	1.5	1.7	7.3	1.6	0	12.7
21A	ABLNMEFE	175	2.5	.2	.9	1.9	9.7	7.5	0	0	20.2
54	ABLNMEFE	295	2.5	.7	2.7	4.1	6.8	6.0	1.5	0	21.8
41	ABLNMEFE	105	1.4	.2	1.1	2.9	8.3	7.3	2.1	0	21.9
36	ABLNMEFE	190	2.6	.4	2.0	2.9	8.1	8.9	0	0	22.3
22A	ABWMEFE	185	1.9	.5	1.8	2.0	5.9	9.4	2.9	0	22.5
19	ABLNMEFE	120	1.2	.3	.9	2.9	7.7	14.6	1.6	0	28.0
57	ABLNCLUN-MEFE	150	4.0	.2	1.1	.6	1.7	11.1	17.8	0	32.5
96	ABLNMEFE	250	2.8	.7	1.6	1.8	4.4	17.2	7.8	0	33.5
33	ABLNMEFE	134	2.5	.5	2.9	12.9	13.0	2.2	5.4	0	36.9
20	ABLNCLUN-MEFE	110	3.4	.7	1.6	3.5	4.6	6.0	23.5	0	39.9
93	ABLNMEFE	180	2.3	.7	1.5	2.3	3.8	14.3	22.7	0	45.3
47	ABLNMEFE	350	2.6	.8	2.6	6.8	4.6	4.3	27.6	0	46.7
62	ABLA/GATR	65	4.1	.7	1.6	1.3	1.3	3.2	6.7	35.8	50.6
10	ABLNMEFE	90	2.7	1.1	3.2	2.2	12.5	28.8	11.7	0	59.5
52	ABLNMEFE	175	2.9	.5	2.8	2.6	4.5	16.3	32.8	3.3	62.8
3	ABLNCLUN-MEFE	140	4.5	.4	.9	.5	2.7	7.7	57.1	3.3	72.6

<sup>1</sup>Age is of overstory dominants.



A



B



C



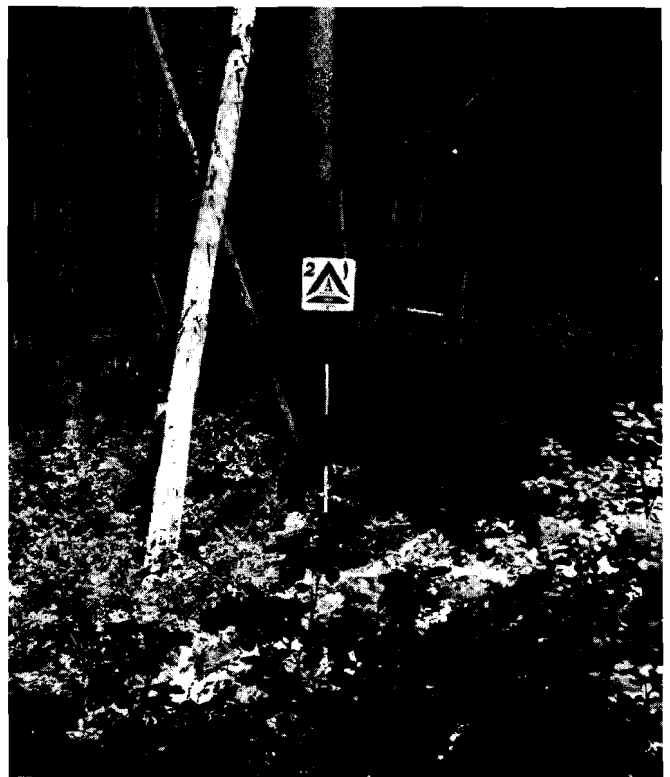
D

Figure 30—Examples of high crown fire potential caused by dense under-  
stories on Group Nine habitats. Stand 82 is an Engelmann spruce-subalpine fir  
stand on an ABLA/LIBO h.t. Stand 41 is an ABWMEFE h.t. supporting a  
lodgepole pine forest. Stands 36 and 52 are Engelmann spruce-subalpine fir  
stands on an ABWMEFE h.t. Stand age and fuel loadings are given in  
table 13.

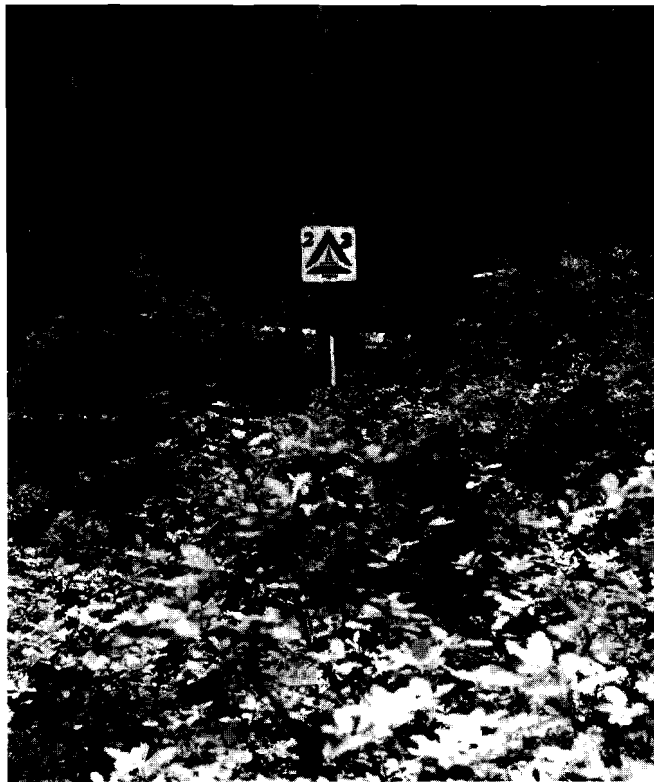




A



B



C



D

Figure 31—Examples of lush undergrowth that under normal moisture conditions retards fire spread in Fire Group Nine habitat types. Stand 57 is an Engelmann spruce-subalpine fir stand on an ABLA/CLUN-MEFE h.t. All others are ABLA/MEFE. Stand age and fuel loadings are given in table 13.

## Role of Fire

Fire history information for moist, lower subalpine habitat types is limited. Mean fire-free intervals are probably longer than those of the drier upland sites in Fire Group Eight.

Sneck (1977) studied the fire history within the ABLAI CLUN h.t. at Coram Experimental Forest in northwestern Montana. She found that mean fire-free intervals ranged with topography: intervals of greater than 117 years in valleys, 121 years on mountain slopes, and 146 years on lower alpine slopes. The average of these intervals is 128 years. Fires at Coram were reported to be small, moderately severe surface fires that occasionally crowned, especially near the ridgetops. These fires thinned stands and prepared a mineral seedbed for conifer regeneration. Small, moderate-severity fires were typical at Coram, which is mesic and discontinuous of fuels. Infrequent, widespread, severe fires have been documented for the somewhat drier surrounding habitats (Sneck 1977; Arno 1980).

Freedman (1983) studied fire history within the ABLAI CLUN h.t. and PICEA/CLUN h.t. in the Goat Creek area of the upper Swan Valley near Condon, MT. Collectively, these moist forest types had adjusted fire-free intervals (Arno and Peterson 1983) of about 30 years before 1905, with extremes between 10 and 100 years (Freedman and Habeck 1985). Freedman's study sites contained abundant ponderosa pine, which may account for the rather high fire frequencies.

The impact of fire on Group Nine sites west of the Divide in Montana is indicated by stand condition and species composition. The general absence of spruce, subalpine fir, or mountain hemlock climax condition is evidence of disturbance by past fires. The dominance of lodgepole pine, Douglas-fir, larch, or spruce on many sites suggests these stands developed on a fire-created mineral soil seedbed. Frequent moderate to severe fires may be restricted in their occurrence because many mature stands have an overstory that includes fire-sensitive spruce and lodgepole.

The frequency of light surface fires is difficult to surmise. The moist nature of these sites would limit the opportunity for such fires to a brief period during the summer. It seems reasonable to assume that lightning did in fact start such fires and that a certain amount of fuel reduction was accomplished. Left undisturbed, these fires probably flared up occasionally and created openings that favored establishment of seral species.

## Forest Succession

The general pattern of succession for Fire Groups Eight and Nine forests is quite similar. Both groups share many of the same seral and climax tree species, and so have much the same fire response. The two groups are primarily distinguished by the frequency and severity of fire. The following discussion of generalized fire-related forest succession applies to both groups.

In theory, the drier habitat types (Fire Group Eight) should have more frequent fires, particularly those of low to moderate severity. These fires would maintain stands in

a seral condition. Because of their moist conditions, habitat types in Fire Group Nine should have lower fire frequency. The relatively high loadings of both live and dead fuels, combined with periodic summer drought, increase the chance for severe, stand-replacing burns when fires do occur.

The potential climax forest would be composed of pure stands of subalpine fir, spruce, or mountain hemlock. The climax situation on any of these sites requires a long time to develop and, consequently, is rarely found. The near-climax condition is more common. It is often characterized by a dense understory of subalpine fir, spruce, and mountain hemlock, while Douglas-fir, lodgepole pine, and often spruce form the overstory. In northwestern Montana, larch or white pine may be the dominant overstory species.

A stand-destroying fire in the climax or near-climax stage results in an herb/shrub stage (fig. 32, No. 1), followed by a seedlings/sapling stage (subsequent numbers in this section refer to fig. 32). Seedlings and saplings may be Douglas-fir, lodgepole pine, larch, white pine, or spruce. Species composition varies with site conditions. Douglas-fir or lodgepole pine frequently dominate. Whitebark pine seedlings may occur as accidentals, and some subalpine fir may be present in the initial stand.

Any fire in the seedlings/sapling stage reverts the stand to the shrub/herb condition (No. 2). Moderate fires in pole-sized stands (No. 3) will favor the more fire-resistant Douglas-fir, larch, or possibly western white pine over lodgepole pine, spruce, mountain hemlock, or subalpine fir. A severe fire (No. 4) destroys the stand. Where serotinous lodgepole pine is present, seedlings of this species form a pure or nearly pure stand.

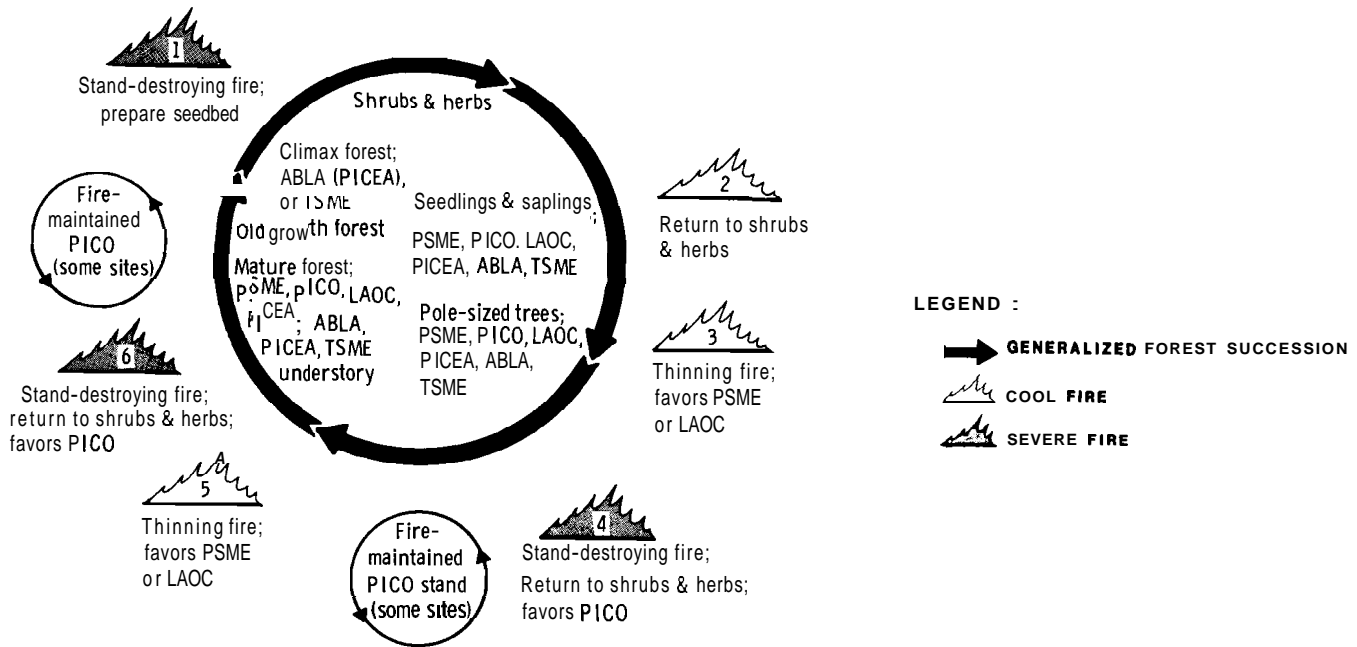
In the continued absence of fire, a mature stand develops. Lodgepole pine, Douglas-fir, larch, or white pine dominate the overstory, beneath which is a dense understory of subalpine fir, spruce, and mountain hemlock. A cool fire (No. 5) removes this understory and some of the lodgepole pine, thereby favoring the reproduction of Douglas-fir, larch, or white pine.

A moderate or severe fire could remove much of the Douglas-fir, leaving the site to be regenerated by either serotinous lodgepole pine or remnant larch. Some severe fires remove even the fire-resistant larch. In this case, or where there are severe fires in near-climax stands, the site returns to a treeless condition (No. 6). If fire does not occur for a long time, the near-climax stand may develop to the climax state, although a fire-free interval of this length is unlikely.

In each stage of stand development discussed, Fire Group Nine sites have less chance of burning than those in Group Eight because of their generally more mesic conditions.

Two potential successional pathways are hypothesized for Fire Groups Eight and Nine (fig. 33). They are distinguished primarily by their inclusion of either lodgepole pine or western larch with Douglas-fir as the major seral species. The complete separation of larch and lodgepole is somewhat artificial. It is possible for both to occur on the same site, although one species is usually more common.

Fire history information for subalpine habitat types is limited, particularly for moist Fire Group Nine sites.



**Figure 32**—Generalized forest succession in Fire Group Eight: dry, lower subalpine habitat types. And in Fire Group Nine: moist, lower subalpine habitat types.

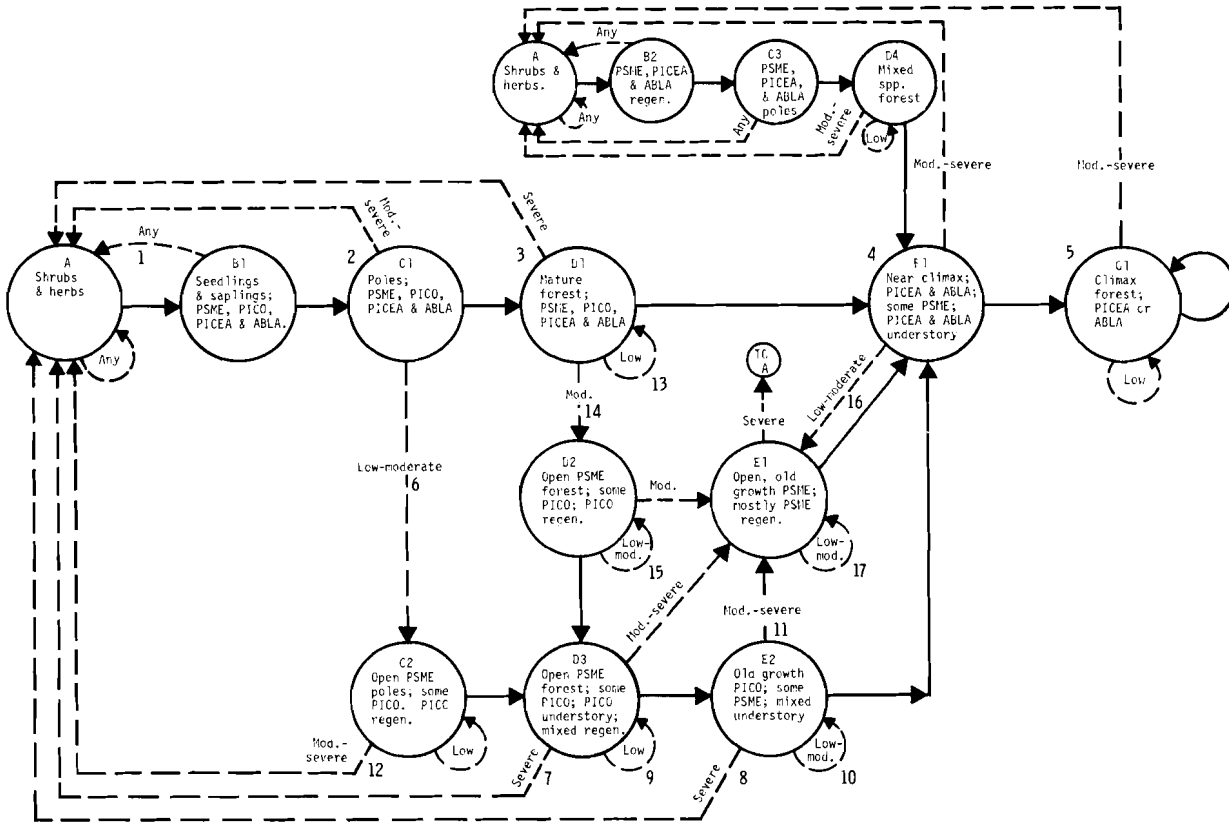
Available evidence indicates that fires on such sites are infrequent and are mostly low severity or stand-replacing. Moderate-severity fires are apparently less frequent although they do occur (Sneck 1977). Pathways illustrating successional events (fig. 33) following low or severe fires should be considered more applicable to Fire Group Nine than to Fire Group Eight.

Many stands belonging to the PICEA/EQAR h.t. do not follow the successional pathways shown for other Fire Groups Eight and Nine habitat types (fig. 33). On these sites, spruce is the only conifer in seral and climax conditions. Such stands may tolerate some low-severity fire, but

in most cases, any fire will return them to the shrub/herb stage. Some sites will have substantial amounts of aspen or black cottonwood in seral stands. Without periodic fire these intolerant trees are replaced by the tolerant longer lived spruce. With fire, aspen may be dominant because of its ability to regenerate from root suckers.

The successional sequences of community types and accompanying information provided by Arno and others (1985) can be used as an aid for predicting successional development of seral communities (and treatment response) within the ABLA/MEFE h.t. in relation to various types of fire and harvest treatments.

1. DOUGLAS- FIR AND LODGEPOLE PINE ARE SERAL DOMINANTS



2. LARCH, WHITE PINE, AND DOUGLAS- FIR ARE SERAL DOMINANTS

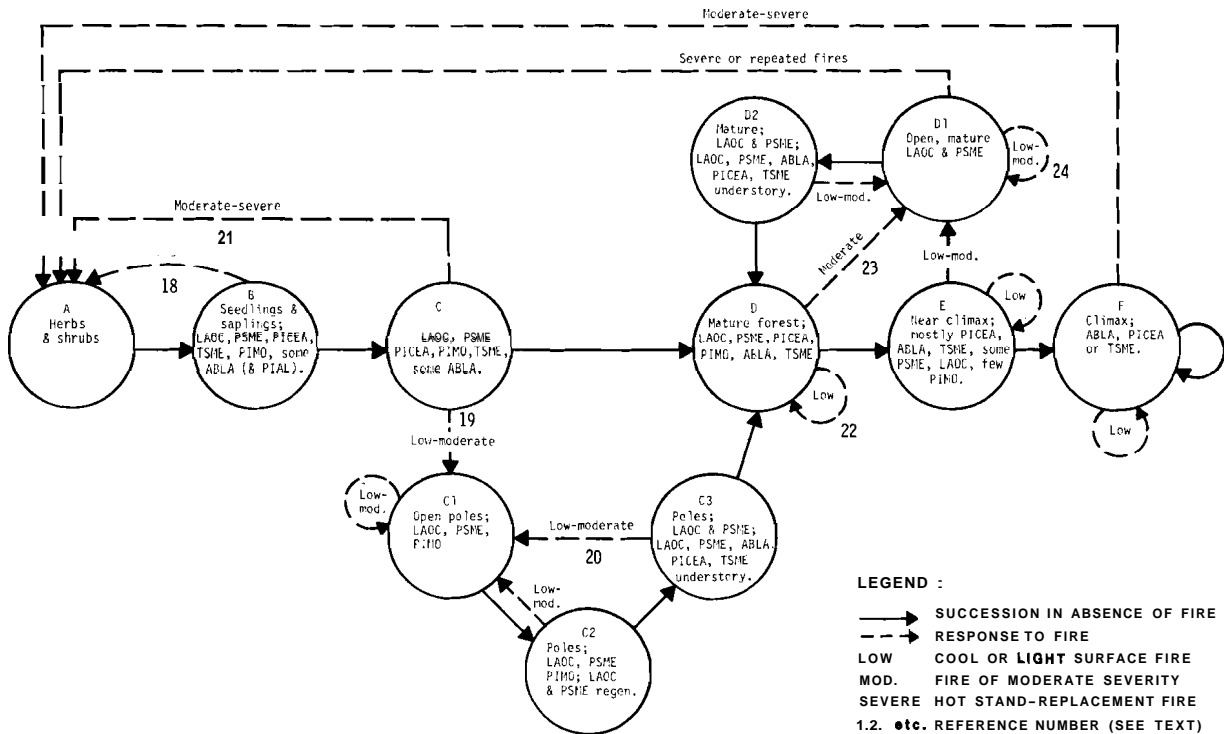


Figure 33—Hypothetical fire-related successional pathways for Fire Group Eight and Nine habitat types: (1) Douglas-fir and lodgepole pine are seral dominants and (2) larch, white pine, and Douglas-fir are seral dominants.

## Fire Management Considerations

Fire protection is usually necessary in undisturbed stands during severe burning conditions. This is especially true for areas where timber production is a management objective. When burning conditions are less than severe, fires may be of low to moderate severity and result in only moderate damage or no damage to overstory trees (other than subalpine fir), despite the relatively low fire resistance of many of the species present. If slash is present, unacceptable tree mortality can result even during moderate burning conditions.

Broadcast burning is an effective method for reducing slash hazards and for preparing seedbeds in clearcuts and in larch/Douglas-fir shelterwoods. Timing of a burn is important. These sites are so cool and moist that times when effective broadcast burns can be achieved are limited. The moisture content of the duff must be low enough to allow the fire to bare mineral soil over much of the area. Often, such favorable moisture conditions occur only during the late summer. When prescribed fires are conducted under high duff moisture conditions, failure to adequately bare mineral soil often results in establishment of a shrubfield, especially on north slopes. Shearer and Schmidt (1982) describe how a shrubfield that resulted from an unsuccessful burn was successfully prescribe burned and reforested 14 years later.

Burning slash in large windrows or piles can create enough heat to alter the physical structure of the soil, which in turn may result in a reduction in density and growth rate of conifer regeneration. Such a condition may persist for 15 years or more (Vogel and Ryder 1969). Consequently, windrows should be narrow and piles should be small when these methods are used.

Additional guidelines for fire use for slash disposal and site preparation and silviculture are provided by Roe and others (1970). This reference should be consulted before planning fire use on these sites.

Slash disposal plans should consider the need for some residues to remain on the site for nutrient cycling and as a source of shade for successful seedling development.

The often complex structure of subalpine forests reflects their fire history. These forests are what they are partly because of past patchy or uneven burns and partly because of their climate and soils. As a general rule, their natural development has not been affected by past fire suppression (Habeck and Mutch 1973). Management objectives are oriented toward nonconsumptive use such as watershed and big game sanctuary. Many are roadless; many are within designated wildernesses. Consequently, the appropriate fire management policy may be one that allows some fires to burn according to a predetermined fire management prescription (Fischer 1984).

## FIRE GROUP TEN: COLD, MOIST UPPER SUBALPINE AND TIMBERLINE HABITAT TYPES

ADP code	Habitat type-phase (Pfister and others 1977)	Montana forest region (Arno 1979)
	Upper Subalpine	
820	<i>Abies lasiocarpa</i> - <i>Pinus albicaulis</i> / <i>Vaccinium scoparium</i> h.t. (ABLA-PIAL/VASC), subalpine fir-whitebark pine/grouse whortleberry	West central
831	<i>Abies lasiocarpa</i> / <i>Luzula hitchcockii</i> h.t.- <i>Vaccinium scoparium</i> phase (ABLAILUHI-VASC), subalpine fir/smooth woodrush-grouse whortleberry phase	Northwestern and west central
832	<i>Abies lasiocarpa</i> / <i>Luzula hitchcockii</i> h.t.- <i>Menziesia ferruginea</i> phase (ABLAILUHI-MEFE), subalpine fir/smooth woodrush-menziesia phase	Northwestern and west central
841	<i>Tsuga mertensiana</i> / <i>Luzula hitchcockii</i> h.t.- <i>Vaccinium scoparium</i> phase (TSME/LUHI-VASC), mountain hemlock/smooth woodrush-grouse whortleberry phase	Northwestern
842	<i>Tsuga mertensiana</i> / <i>Luzula hitchcockii</i> h.t.- <i>Menziesia ferruginea</i> phase (TSMEILUHI-MEFE), mountain hemlock/smooth woodrush-menziesia phase	Northwestern
	Timberline	
850	<i>Pinus albicaulis</i> - <i>Abies lasiocarpa</i> h.t.'s (PIAL-ABLA h.t.'s), whitebark pine-subalpine fir	Northwestern and west central
860	<i>Larix lyallii</i> - <i>Abies lasiocarpa</i> h.t.'s (LALY-ABLA h.t.'s), subalpine larch-subalpine fir	Northwestern and west central
870	<i>Pinus albicaulis</i> h.t.'s (PIAL h.t.'s), whitebark pine	West central

## Vegetation

Fire Group Ten consists of high-elevation forests near and at the timberline. All the stands lie above the climatic limits of Douglas-fir, and many stands are above the cold limits of lodgepole pine. Subalpine fir or mountain hemlock are the indicated climax in all of the upper subalpine habitat types in western Montana. Whitebark pine and Engelmann spruce are long-lived seral species. Lodgepole pine occurs on some upper subalpine sites.

Timberline habitat types support stands composed of subalpine larch, whitebark pine, Engelmann spruce, and subalpine fir. Trees characteristically grow in groups with open areas in between. Competition due to differences in tolerance is not as pronounced at timberline as it is in lower forests. Habitat types at these high elevations are named for their dominant tree component rather than an indicated climax species.

Undergrowth in the upper subalpine habitat types is usually composed of only a few important species, and in timberline habitat types undergrowth occurs in mosaics. Shrubs that may occur on Group Ten sites include menziesia, red heath, yellow mountain heather, white flower rhododendron, mountain gooseberry, grouse whortleberry, and common juniper.

Common forbs are broadleaf arnica, ballhead sandwort, beargrass, and slender hawkweed. Grass and grasslike vegetation include Ross sedge, Idaho fescue, Parry rush, and smooth woodrush.

## Forest Fuels

Fire Group Ten sites are characterized by relatively sparse fine fuels and moderate to heavy loadings of widely scattered large-diameter fuels. Brown and See (1981) report an average downed woody loading of about 18 tons per acre (about 4 kg/m<sup>2</sup>) for stands in western Montana (table 6).

Fuel inventory data for subalpine and timberline forests are scarce. Data collected on several Selway-Bitterroot Wilderness sites are shown in table 14.

The fuel loadings shown in table 14 are averages for all sampled stands. They differ, therefore, from the individual stand data presented for the other Fire Groups. Keep in mind that the standard deviations of table 14 values are often as great as the values themselves. Nonetheless, trends are apparent. The drier ABLAILUHI-VASC h.t.

yields, on the average, about a third the amount of down and dead woody material as the moist ABLA/LUHI-MEFE h.t. Also notice the additional amount of fuel produced by the duff within these habitat types. Inspection of the original data sheets shows that much of the down woody material 3 inches (8 cm) and larger is rotten.

The downed and dead woody fuel loadings often take the form of scattered large-diameter downfall resulting from wind and snow breakage, windthrow, and mortality caused by insects or disease. Such heavy fuels do not necessarily reflect a serious fire hazard. The mitigating effects of the normally cool, moist site, the short fire season, and the usually sparse and often discontinuous nature of fine surface fuels must be considered when evaluating overall fire potential. Examples of Group Ten fuel and stand conditions are shown in figure 34.

## Role of Fire

Fire is secondary to site factors (climate and soil) as an influence on forest development on these sites. The cold, moist, rocky, snowbound, unproductive, and otherwise fire-resistant environment that characterizes many of the sites not only makes fires infrequent but severely limits their areal extent. Lightning does ignite fires, but the paucity of continuous fine surface fuels coupled with the rain that commonly accompanies thunderstorms usually limits fire spread and severity. Historical fire frequencies ranging from 35 to 300 years have been reported for individual sites (Romme 1980). Such figures are difficult to interpret because a fire may involve only one or two trees in a stand. For this reason the concept of fire frequency does not apply well in upper subalpine and timberline sites.

In more continuous forests of this group, the most pronounced fire effect is to produce stand-replacing fires at long intervals, perhaps 200 years or more. Stand-destroying fires are most likely to occur during extended drought conditions when severe wind-driven crown fires develop in the forests below and burn into the upper subalpine and timberline forests. Vegetation recovery following such fires is usually slow because of the extremely short growing season and cold climate. Arno (1984) reported reinvasion of whitebark pine on timberline sites 50 to 200 years after fire in the Bitterroot Mountains. Based on his observations in many upper subalpine habitat types, Arno (1986) suggests that fire has been important in perpetuating an abundance of whitebark pine.

Table 14—Average fuel loadings for several Group Ten stands in western Montana

Stand number	Habitat type-phase	Duff depth	Size class (inches)							Total
			0-1/4	1/4-1	1-3	3-6	6-10	10-20	20+	
		<i>Inches</i>	<i>Tons/acre</i>							
80	ABLNUHI-VASC	7.2	0.2	0.7	0.2	0.7	3.3	2.8	0	7.0
48	ABLNUHI-MEFE	33.5	.2	.6	1.4	1.9	7.0	11.1	3.6	25.8
25	LALY-ABLA	11.2	.1	.3	.1	.4	2.0	4.8	3.3	11.0



A



B



C



D



E

Figure 34—Examples of fuel and stand conditions in some Fire Group Ten habitats. (A) A PIAL-ABLA h.t. with scattered downed woody fuel and flammable thicket of fir. Snags shown will eventually add to surface fuel loads. (B) A PIAL h.t. with sparse surface fuels and clusters of whitebark pine. (C) An ABLA/LUHI h.t. showing lush surface vegetation and low-hanging branches. (D) An ABWLUHI-MEFE h.t. with heavy dead woody fuels intermingled with dense live fuels. (E) A typical LALY-ABLA h.t.

# Forest Succession

Secondary succession begins with a mixture of herbs and shrubs (fig. 35). It is likely that herbaceous plants will dominate for an extended period. Fire may initiate secondary succession, but it is unlikely that it has a role in maintaining it. Physical disruption of the stand by snow and wind, rock slides, and talus slippage is more important on moist sites and north slopes than is fire in maintaining early stages of succession.

It takes a long time before conifers dominate some sites, perhaps 100 years. It may take another 100 years before a mature forest exists. It is unlikely that fuel or stand conditions will support a fire of any consequence during this period. Surface fires do occur, especially in whitebark pine stands on south slopes and ridges. Such fires act as underburns, reducing fuels and killing some overstory trees. Severe fires may occur over small areas, but their effect will usually be limited to the creation of vegetative mosaics. Eventually the mature forest will begin to break up under the impact of wind and snow breakage, windthrow, mortality caused by insects and disease, and senescence. Stand-destroying fires, especially those that invade from lower elevation forests, become a possibility during extended drought.

Without disturbance, the mature trees will progress into a climax stand. This advance successional stage requires decades, possibly two or three centuries. Low- to moderate-severity fires rarely have a significant impact on a mature stand because of the open structure and lack of continuous fine woody fuels. However, severe fires that enter the crowns and kill the cambium of trees return the site to the early successional stages (fig. 35).

A simple succession pathway postulated for Fire Group Ten is shown in figure 36.

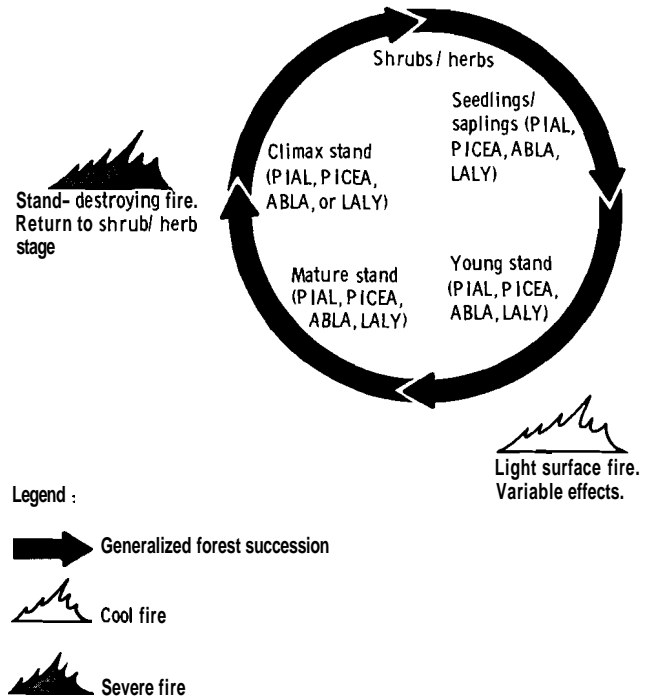
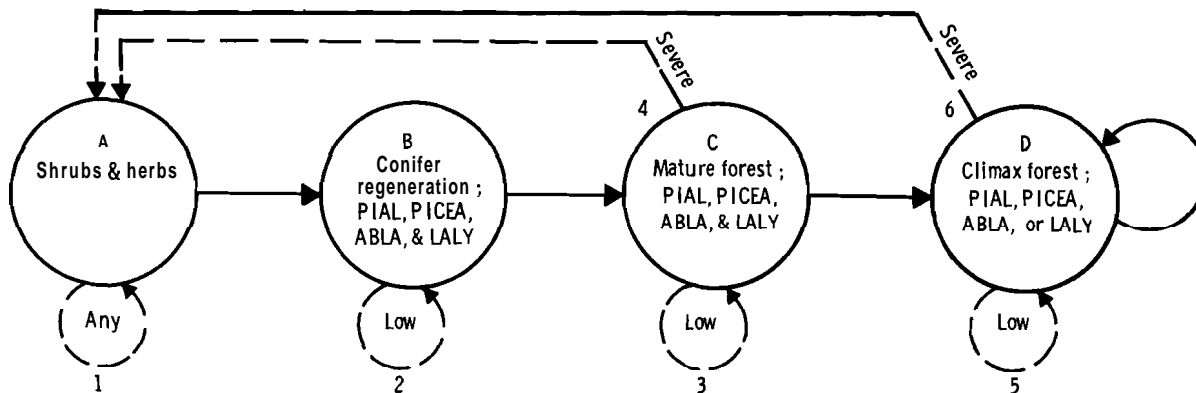


Figure 35—Generalized forest succession in Fire Group Ten: cold, moist upper subalpine and timberline habitat types. Low-severity lightning fires may occur at any stage with little effect on succession.



LEGEND:

- Solid arrow: Succession in absence of fire
- Dashed arrow: Response to fire
- Low: Cool or light surface fire
- Mod.: Fire of intermediate (moderate) severity
- Severe: Hot, stand-destroying fire
- 1, 2, etc.: Reference number, (see text)

Figure 36—Hypothetical fire-related successional pathways for Fire Group Ten habitat types.



## Fire Management Considerations

Timber production is rarely an important management objective for forests in this group. Most areas are managed as watersheds, natural areas, and sanctuaries for wildlife. For example, whitebark pine forests are important food producers for jays, bears, squirrels, deer, and elk (Forcella and Weaver 1980). Most are roadless, and many are in designated wildernesses. Fire is an infrequent visitor, and when it does occur, damage in terms of management objectives is generally slight. But these sites are often fragile and can easily be damaged by modern, mechanized firefighting equipment.

The status of whitebark pine communities should be of particular concern to managers of upper subalpine forests. In some areas the welfare of the grizzly bear, a threatened species, appears to be partially dependent on the availability of whitebark pine cone crops in large caches made by red squirrels (Arno 1986). On many upper subalpine sites whitebark pine is being replaced successionally by more shade-tolerant species. Arno (1986) attributes this situation to fire suppression coupled with damage from mountain pine beetle and white pine blister rust (*Cronartium ribicola*). Due to the wilderness location of many whitebark pine stands, fire may be the major practical means of regenerating this species. Consequently, the primary fire management consideration for many upper subalpine and timberline forests should be the aggressive development of prescriptions that allow fire to more nearly play its natural role.

## FIRE GROUP ELEVEN: WARM, MOIST GRAND FIR, WESTERN REDCEDAR, AND WESTERN HEMLOCK HABITAT TYPES

ADP code	Habitat type-phase (Pfister and others 1977)	Montana forest region (Arno 1979)
510	<i>Abies grandis/Xerophyllum tenax</i> h.t. (ABGR/XETE), grand firbeargrass	Northwestern and west central
521	<i>Abies grandis/Clintonia uniflora</i> h.t.- <i>Clintonia uniflora</i> phase (ABGRICLUN-CLUN), grand firqueencup beadlily-queencup beadlily phase	Northwestern and west central
522	<i>Abies grandis/Clintonia uniflora</i> h.t.- <i>Aralia nudicaulis</i> phase (ABGRICLUN-ARNU), grand firqueencup beadlily-wild sarsaparilla phase	Northwestern and west central
523	<i>Abies grandis/Clintonia uniflora</i> h.t.- <i>Xerophyllum tenax</i> phase (ABGRICLUN-XETE), grand firqueencup beadlily-beargrass phase	Northwestern

591	<i>Abies grandis/Linnaea borealis</i> h.t.- <i>Linnaea borealis</i> phase (ABGRILIBO-LIBO), grand firfirtwinflower-twinflower phase	Northwestern and west central
592	<i>Abies grandis/Linnaea borealis</i> h.t.- <i>Xerophyllum tenax</i> phase (ABGRILIBO-XETE), grand firfirtwinflower-beargrass phase	Northwestern
531	<i>Thuja plicata/Clintonia uniflora</i> h.t.- <i>Clintonia uniflora</i> phase (THPL/CLUN-CLUN), western redcedarqueencup beadlily-queencup beadlily phase	Northwestern and west central
532	<i>Thuja plicata/Clintonia uniflora</i> h.t.- <i>Aralia nudicaulis</i> phase (THPLICLUN-ARNU), western redcedarqueencup beadlily-wild sarsaparilla phase	Northwestern and west central
533	<i>Thuja plicata/Clintonia uniflora</i> h.t.- <i>Menziesia ferruginea</i> phase (THPL/CLUN-MEFE), western redcedarqueencup beadlily-menziesia phase	Northwestern and west central
550	<i>Thuja plicata/Oplopanax horridum</i> h.t. (THPL/OPHO), western redcedar/devil's club	Northwestern
571	<i>Tsuga heterophylla/Clintonia uniflora</i> h.t.- <i>Clintonia uniflora</i> phase (TSHEICLUN-CLUN), western hemlockqueencup beadlily-queencup beadlily phase	Northwestern
572	<i>Tsuga heterophylla/Clintonia uniflora</i> h.t.- <i>Aralia nudicaulis</i> phase (TSHEICLUN-ARNU), western hemlockqueencup beadlily-wild sarsaparilla phase	Northwestern

## Vegetation

Fire Group Eleven is composed of moist, warm habitat types often occurring on valley bottoms, benches, ravines, and protected exposures in west-central Montana and more commonly on upland sites in northwestern Montana. This group occurs only west of the Continental Divide in Montana and reflects the influence of the inland maritime climate in west-central and northwestern portions of the State.

Up to 10 species of conifers may occur during the successional process: ponderosa pine, Douglas-fir, Engelmann spruce, lodgepole pine, subalpine fir, grand fir, western redcedar, western white pine, western larch, or western hemlock. The potential establishment of any of these species depends on site conditions, fire frequency, and the availability of viable seed. Western hemlock, western redcedar, and grand fir are climax species within the group.

Undergrowth is characterized by a rich variety of moist site herbs and shrubs. Important shrubs include western serviceberry, common snowberry, thimbleberry, white spirea, bunchberry dogwood, dampwoods blueberry (blue huckleberry), mountain lover, Rocky Mountain maple, and menziesia. Pacific yew and devil's club are locally common. Widespread moist site forbs are darkwoods violet, queen-cup beadlily, common beargrass, sidebells shineleaf, broad-leaf arnica, starry false Solomon's seal, wild sarsaparilla, American trailplant, American twinflower, western rattlesnake plantain, lady fern, wartberry fairybells, and three-leaf foamflower. Columbia bromegrass, pinegrass, and elk sedge are the predominant graminoid species.

## Forest Fuels

Fuel loadings average 25 tons per acre (5.6 kg/m<sup>2</sup>), which exceeds that of any other Fire Group in western Montana. Much of the downed woody fuel results from

accumulated deadfall and occasional natural thinning. Because of the often heavy grand fir and cedar component, a relatively heavy load of twigs and small branchwood is usually included in the fuel load. Compared to the other Fire Groups, Group Eleven fuel loadings average higher in all size classes (table 6). The large material, which may account for 75 percent of the fuel load, is often rotten.

Despite the heavy fuel loadings that characterize these stands, fire hazard is normally low to moderate under normal weather conditions. The potential for serious conflagrations is usually mitigated by the high humidity of these moist sites. Young stands and older open-canopy stands often support a lush undergrowth, while closed-canopy stands allow little sunlight to reach the cool, moist forest floor. Characteristic stand and fuel conditions are shown in figures 37, 38, and 39 for grand fir sites, western redcedar sites, and western hemlock sites, respectively. Fuel loadings are presented in table 15.

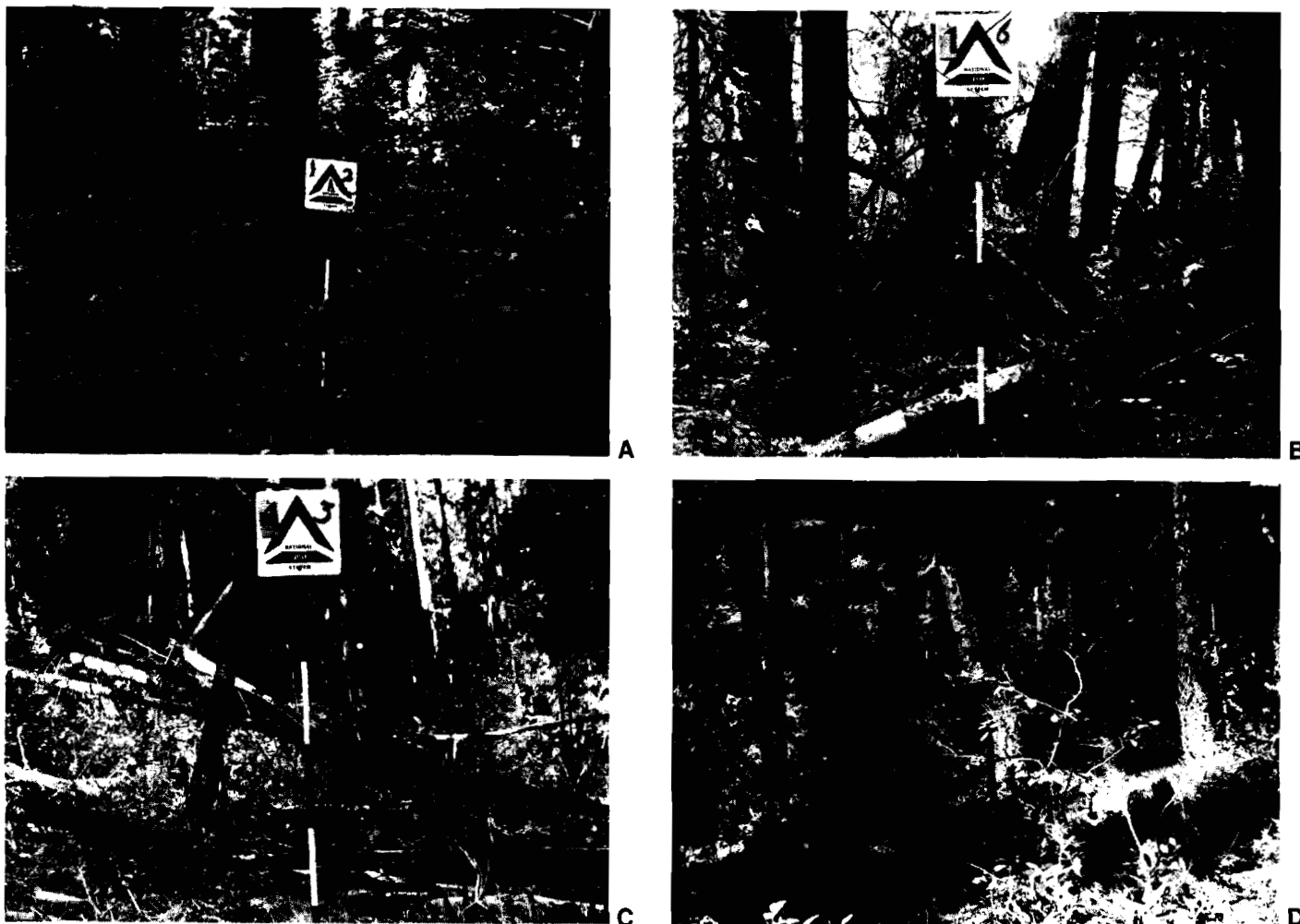


Figure 37—Characteristic stand and fuel conditions for Fire Group Eleven grand fir habitat types. Stand 63 is an ABGR/XETE h.t., others are ABGR/CLUN-CLUN. Stand age and fuel loadings are given in table 15.



E



F

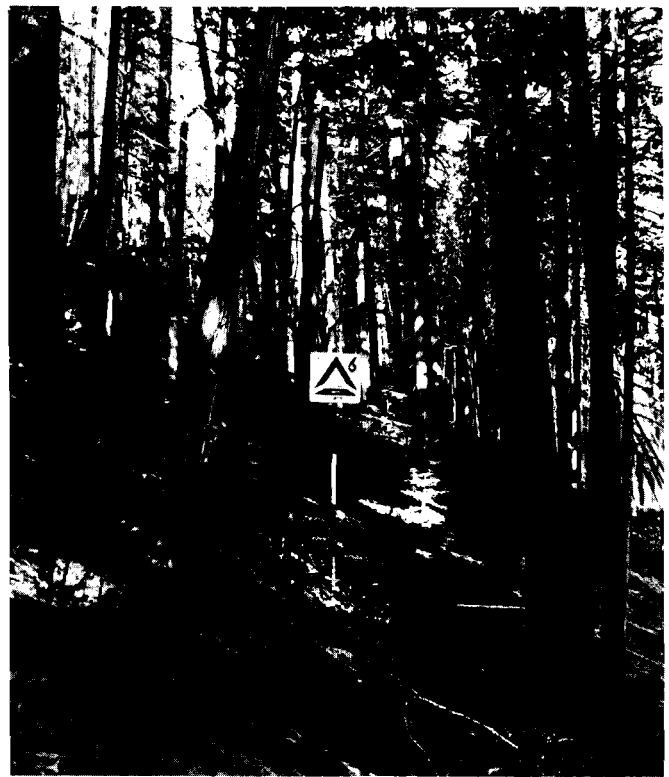


G

Figure 37—(Con.)



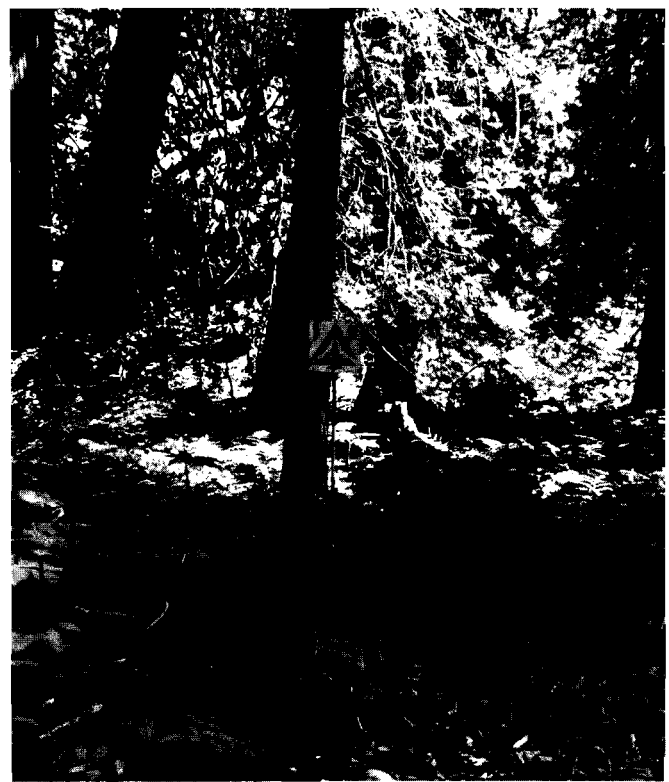
A



B



C



D

Figure 38—Characteristic stand and fuel conditions for Fire Group Eleven western redcedar habitat types. Stand 17A is a THPUCLUN-ARNU h.t. Stands 6A and 7A are THPUCLUN-CLUN h.t.'s. And stand 15A is an old growth cedar stand on a THPUOPHO h.t. Stand age and fuel loadings are given in table 15.



A



B



C



D



E

Figure 39—Characteristic stand and fuel conditions for Fire Group Eleven western hemlock habitat types. All of these stands are on TSHE/CLUN-CLUN h.t.'s. Stand age and fuel loadings are given in table 15.

Table 15—Fuel loadings by size class for stands shown in figures 37, 38, and 39

Stand number	Habitat type-phase	Age <sup>1</sup>	Duff depth	Size class (inches)							Total
				0-1/4	1/4-1	1-3	3-6	6-10	10-20	20+	
		<i>Years</i>	<i>Inches</i>	<i>Tons/acre</i>							
9A	TSHEICLUN-CLUN	170	2.8	0.4	1.1	0.5	1.8	4.6	0.5	0	8.9
4A	TSHEICLUN-CLUN	120	2.0	.6	1.2	1.3	4.0	2.8	1.0	0	10.9
17A	THPLICLUN-ARNU	100	3.1	.2	1.1	2.3	2.1	2.9	2.9	0	11.5
12A	ABGRICLUN-CLUN	115	2.7	.3	1.1	.4	1.1	6.4	3.5	0	12.8
3A	TSHEICLUN-CLUN	190	2.9	.4	1.1	1.5	1.8	4.1	4.4	0	13.3
16	ABGRICLUN-CLUN	120	2.6	.9	1.7	2.1	3.3	6.1	2.2	0	16.3
6A	THPLICLUN-CLUN	200	3.1	.4	1.7	1.1	2.2	2.8	4.2	4.6	17.0
7A	THPLICLUN-CLUN	210	3.5	.4	1.7	3.2	1.7	7.9	4.6	0	19.5
13	ABGRICLUN-CLUN	100	1.8	.3	1.5	3.5	9.3	5.0	2.6	0	22.2
63	ABGRIXETE	125	1.9	.4	1.9	.7	3.6	8.3	7.4	0	22.3
65	ABGRICLUN-CLUN	120	2.6	.5	1.9	3.6	7.2	10.8	0	0	24.0
8A	TSHEICLUN-CLUN	210	3.0	.7	2.1	3.1	5.4	3.9	7.8	4.1	27.1
16A	TSHEICLUN-CLUN	85	5.3	.6	2.2	2.5	9.3	21.1	3.2	0	29.9
25	ABGRICLUN-CLUN	115	4.0	1.1	2.2	5.5	.6	6.3	17.1	2.6	35.4
66	ABGRICLUN-CLUN	280	4.0	.6	1.6	1.2	3.5	4.4	26.7	0	38.0
15A	THPLIOPHO	400+	2.8	.2	1.1	1.0	.4	1.3	3.2	50.4	57.6

## Role of Fire

The inland maritime climate that prevails in northwestern Montana exerts a strong influence on forest development and the role of fire in these forests.

The relatively warm, moist conditions sustain the growth of diverse and highly productive stands. These same factors keep the fire frequency generally low. Hydric and mesic sites may actually serve as firebreaks to ground fires. A fire may burn into the edge of a stand, possibly scarring some trees, but it will usually die out when it reaches the moist duff layer.

Moist weather conditions predominate, but the region is occasionally subject to severe summer drought. Heavy fuel loadings exist in most stands because of overall high plant productivity. This, combined with droughty conditions, sets the stage for severe, widespread fires. Stands are replaced and sites revert to pioneer species.

Fire severities vary greatly from the minor ground fire of moist sites to the stand replacement fire. Within this range of variation, some generalities can be made. In Group Eleven habitat types, fire can:

1. Provide mineral seedbed suitable for both seral and potential climax species.
2. Produce a mosaic of various seral communities across the landscape.

3. Affect within-stand tree diversity because of differential species response to the fire regime.

When considering the role of fire in Group Eleven, remember that there is a vast site and moisture difference between dry grand fir (ABGRIXETE) habitat types and the wet cedar and hemlock (THPLIOPHO) habitat types.

Fire frequencies for cedar-hemlock stands in northern Idaho have been estimated by Arno and Davis (1980). They reported fire-free intervals from 50 to greater than 200 years. Within the ABGR/CLUN h.t. in the Swan Valley, Antos and Habeck (1981) estimated a mean fire-free interval of 100 to 200 years between stand-replacing fires. Perhaps the 30-year interval reported within the ABGR/CLUN h.t. in the Swan Valley (Freedman and Habeck 1985) represents the extreme for these forests.

Postfire succession is governed by more than the nature of the fire itself. Fires of the same severity in the cedar-hemlock zone may result in different seral communities. The initial floral component, seeds stored on site, and the accidents of natural seeding and seedling establishment, may structure the community following the fire more than the characteristics of the fire itself. While this is generally true for all Fire Groups, it is more pronounced in Fire Group Eleven.

# Forest Succession

The theoretical climax condition is a reproducing stand of grand fir, western hemlock, or western redcedar, as shown in figure 40 (subsequent numbers in this section refer to fig. 40).

Following a stand-replacing fire, succession begins with a shrubherb field. Duration of this stage depends on the availability of tree seed and the occurrence of multiple burns (No. 1). Many sites in northern Idaho initially burned in 1910 and subsequently reburned in the 1920's and 1930's remain as shrubherb fields today.

If seed is available and multiple burns do not occur, seedlings of both climax and seral trees will establish on a burned site (No. 2). Most fires in the seedlingsapling stage will revert the stand to a treeless condition (No. 3).

Moisture is not generally limiting in stands included in Fire Group Eleven. These sites are highly productive, and pole and mature stands are usually dense. Although this condition leads to a high fuel loading, severe fires are infrequent because of the high moisture status.

Low to moderate fires (No. 4) in pole-sized or mature

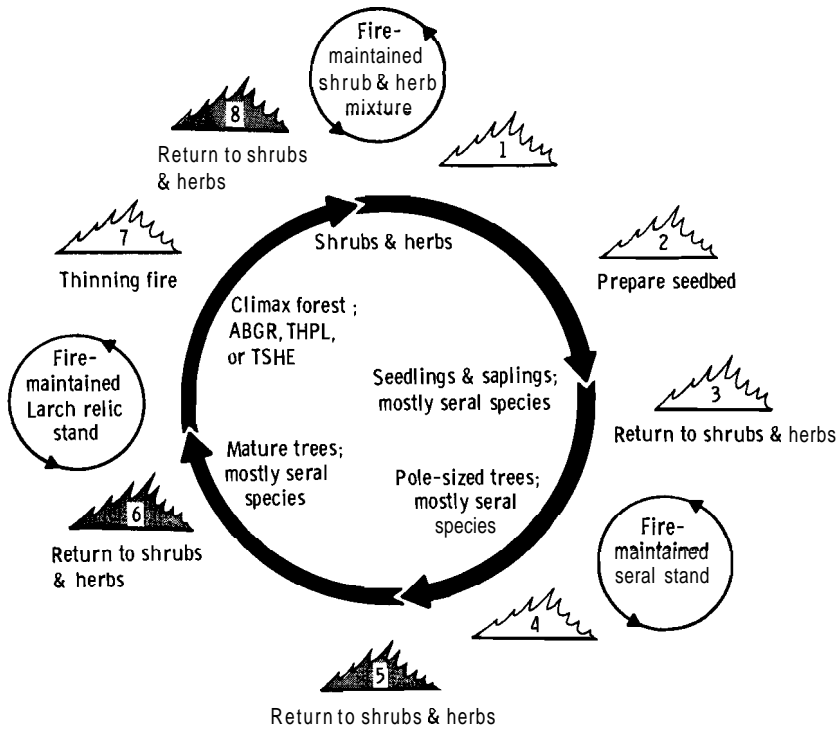
stands favor intolerant seral species over climax western redcedar, grand fir, or western hemlock, which are less fire resistant.

When severe fires do occur in these stands (No. 5) they are generally returned to a shrubherb field. This may be a short-lived condition if serotinous lodgepole pine was present in the preburn stand. In this case, seedlings of lodgepole pine would soon initiate a new stand.

Mature larch may survive severe fires in mature or near-climax stands (No. 6). These trees would then provide seed for a postburn stand. A "larch relict" stand may be the result of frequent low to moderate fires in mature stands.

True climax status, where grand fir or western hemlock or western redcedar or a combination are the only trees on site, is rarely achieved. Seral species are long-lived, and fire occurs frequently enough that stands seldom develop beyond the near-climax stage.

Climax stands may withstand low thinning fires (No. 7), but moderate or severe fires (No. 8) return the site to a shrubherb stage.



**LEGEND :**

- GENERALIZED FOREST SUCCESSION
- COOL FIRE
- SEVERE FIRE

Figure 40—Generalized forest succession in Fire Group Eleven: moist, warm grand fir, western redcedar, and western hemlock habitat types.

Habeck (1963, 1968, 1970) has studied the composition and successional development of Glacier National Park cedar-hemlock forests. Figure 41 depicts his generalized scheme of fire's impact on succession in these forests. Figure 42 presents generalized successional pathways that are hypothesized to be significant in Swan Valley, Flathead National Forest, grand fir forests following stand-replacing fires (Antos and Habeck 1981; Antos and Shearer 1980).

In the hypothetical successional pathway presented in figure 43, two general sequences are illustrated: (1) the circumstance in which lodgepole pine has the major role in early stand development, and (2) where larch becomes the dominant seral species.

There are three relatively dry grand fir habitat types in western Montana: ABGRIXETE h.t., ABGR/LIBO-XETE h.t., and ABGR/LIBO-LIBO h.t. Stands within these types undergo a postdisturbance successional sequence that fits the general pattern illustrated in the multiple pathway diagram (fig. 43). However, their fire ecology differs enough to warrant individual discussion. Compared with other habitat types in this Fire Group, they (1) have a greater fire frequency, (2) experience more underburning

and fewer stand replacing fires, and (3) tend to be dominated by seral species, with grand fir playing a minor role in early successional stands.

The relatively dry conditions permit a higher frequency of low- or moderate-severity fires that in turn favor ponderosa pine, lodgepole pine, larch, and Douglas-fir over the less resistant grand fir. Arno and Petersen (1983) estimated a mean fire interval of 30 years for grove-sized stands within the ABGR/LIBO-LIBO h.t. sites in the Bitterroot Valley of western Montana. This can be compared with the considerably longer estimates for more mesic types (discussed under "Role of Fire" for Group Eleven habitat types).

The ABGRIXETE h.t. is the driest of all the grand fir habitat types represented in Montana. Lodgepole pine or larch or both are the important successional species in this type, with lodgepole pine dominating. The likelihood of stand-replacing fires within the ABGRIXETE h.t. during presettlement times was less than that of other Group Eleven habitat types because of their lower productivity and more frequent underburning. The portions of multiple pathway sequence 1 (fig. 43) that illustrate succession after low or moderate fires are better models of postfire

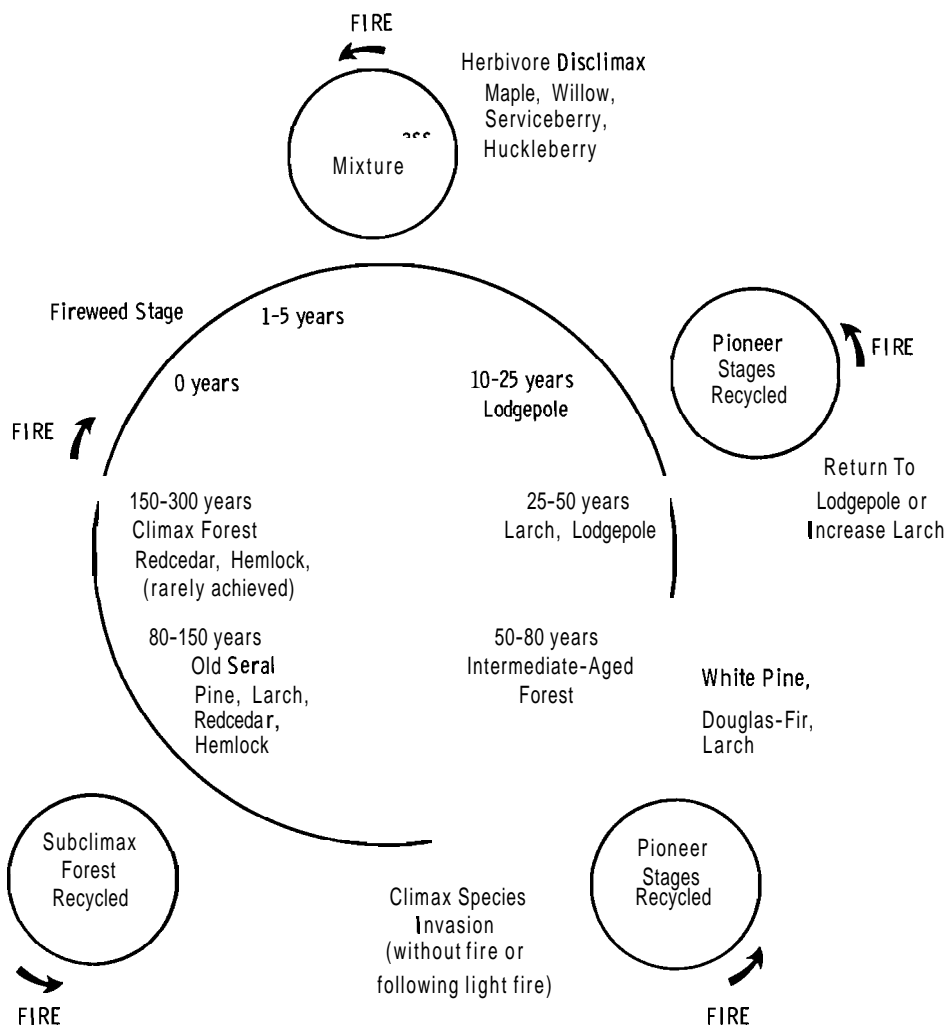
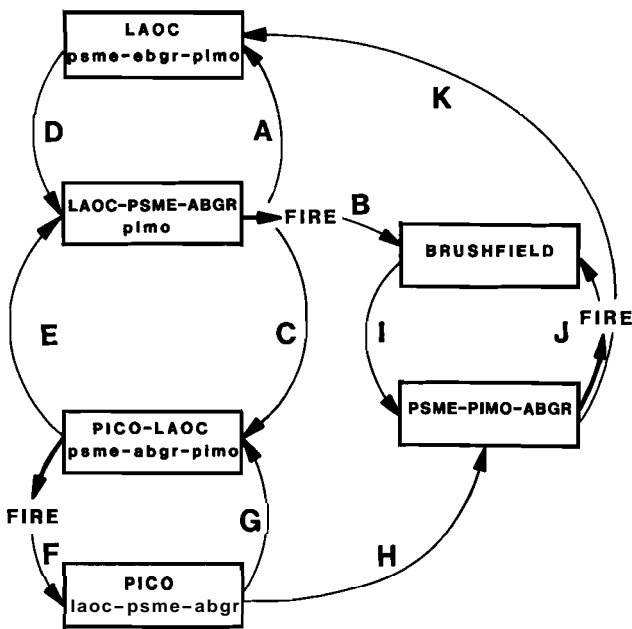


Figure 41—The effect of fire on successional development in upland cedar-hemlock forests near Lake McDonald, Glacier National Park, MT (after Habeck 1970).





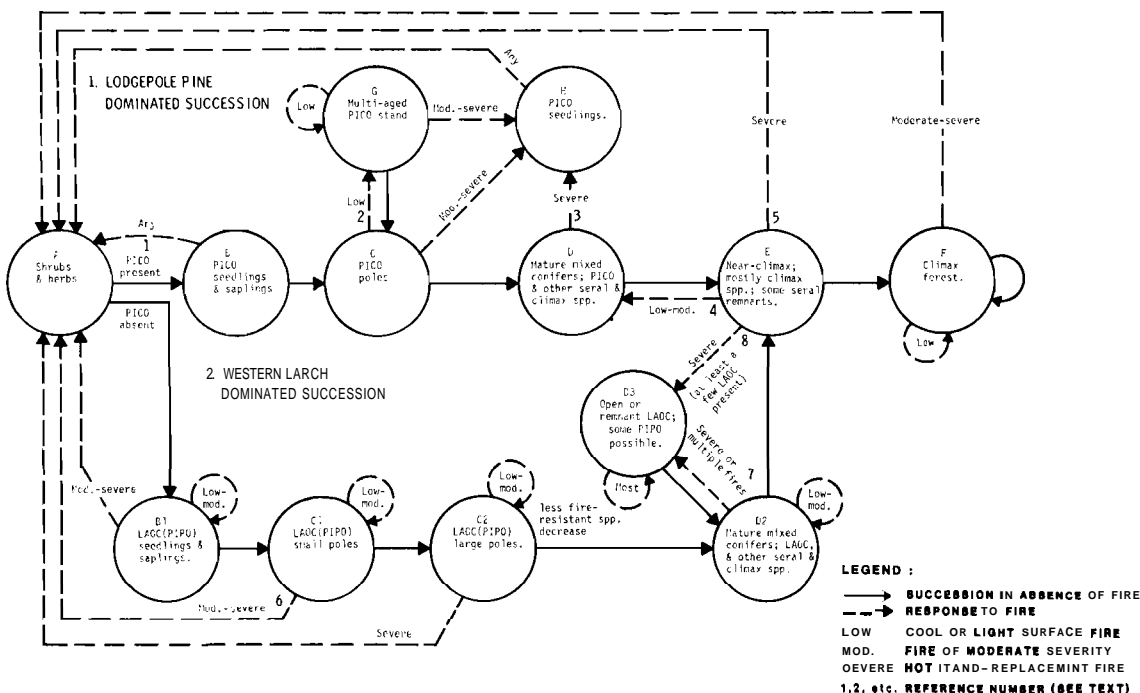
**Figure 42**—Patterns of community dynamics within the Swan Valley, Flathead National Forest, MT. (A) Lodgepole pine seed source absent. (B) Larch and lodgepole establishment fail. (C) Lodgepole seed source present. (D) Douglas-fir and grand fir increase with time. (E) Lodgepole dies out of the stand. (F) Burned stand young enough that larch does not survive fire so lodgepole increases. (G) Lodgepole discussion. (H) Lodgepole dies out and no larch in stand. (I) Slow brushfield invasion. (J) No larch seed source present. (K) Larch seed source present. (After Antos and Habeck 1981.)

tree response for stands within the drier ABGR/XETE h.t. than those for severe fires.

In presettlement times western larch was also an important seral species on sites within the ABGR/LIBO-XETE h.t. and ABGR/LIBO-LIBO h.t. In some of these stands, especially those within the ABGR/LIBO-LIBO h.t., larch shared the role of seral dominant with ponderosa pine. These two trees occurred together in varying proportions. Stand composition ranged from larch dominated, to mostly ponderosa pine. On all stands, the tolerant understory consisted of Douglas-fir and grand fir. Succession with ponderosa pine is similar to that for larch. Successional pathway 2 (fig. 43) models the process.

### Fire Management Considerations

Fire Group Eleven habitat types are often highly productive timber-growing sites. Where timber management is the objective, and even-aged silviculture is applied to favor seral species such as ponderosa pine or overstory Douglas-fir and western larch, broadcast fire can be used to reduce slash hazard and prepare seedbed after harvest operations. Broadcast burning is inappropriate when partial cutting leaves heat-susceptible grand fir, western white pine, and associated species in the overstory. Recommended silvicultural procedures, including the use of fire, to obtain natural regeneration within the ABGR/CLUN h.t. in the Swan Valley are summarized in table 16 (Antos and Shearer 1980). On most sites within the THPLICLUN h.t., according to Antos and Shearer (1980), the procedure (table 16) recommended for mature forest on north or east slopes with larch can be used. They also recommend a shelterwood cut with broadcast burning or scarification and piling and burning for south slope seepage sites within the THPLICLUN h.t.



**Figure 43**—Hypothetical fire-related successional pathways for Fire Group Eleven habitat types.

**Table 16**—Recommended silvicultural procedures to obtain natural regeneration on the *Abies grandis/Clintonia uniflora* habitat type in the Swan Valley (after Antos and Shearer 1980).

Forest to be cut	Recommended procedure	Result
Mature forest on north or east slopes with larch	<b>Clearcut</b> or seed-tree <sup>1</sup> cut leaving larch and Douglas-fir seed trees; site preparation by broadcast burning or scarification	Larch-dominated stand with some Douglas-fir and small amounts of other species mostly below the canopy
Mature forest on north slope with no larch	Seed-tree or shelterwood <sup>1</sup> cut leaving Douglas-fir and mixture of other species, including white pine, grand fir, and spruce (leave spruce only if old ones are vigorous on site); site preparation by piling and burning (broadcast burning if thin-barked trees are considered)	Mixed forest of Douglas-fir with some grand fir and white pine (spruce)
Mature forest on south or west slope or any other site where seedling establishment might be difficult; larch present	<b>Shelterwood</b> <sup>1</sup> leaving mostly larch and Douglas-fir; site preparation by broadcast burning or piling and burning	Larch-dominated stand with varying amounts of Douglas-fir depending in part on seed source ratios in shelterwood
Mature forest on south slope or any other site where establishment might be difficult; larch absent	Shelterwood cut leaving mostly Douglas-fir; site preparation by broadcast burning or by piling and burning	Douglas-fir stand with some grand fir
Forest with groups of healthy advanced regeneration of Douglas-fir, usually in groups from light burns on dry sites	Combination of group selection and shelterwood cut; site preparation by piling and burning; broadcast burning might be possible in parts of area	Stand with two or more age class groups of Douglas-fir with some larch and grand fir

<sup>1</sup>Remove seed trees and shelterwood trees as soon as adequate regeneration is well established.

The use of fire for site preparation will usually result in increased spring and summer browse for big game in addition to successful regeneration of seral tree species. Frequent burns will maintain shrubfields on south slopes for game winter range.

Moisture conditions are usually high enough to prevent serious heat damage by low-severity wildfire, especially in old stands. Low-severity or smoldering surface fires may cause some heat damage to grand fir, white pine, western hemlock, western redcedar, subalpine fir, and spruce. Surface fires often scar the base of these species, creating favorable entry points for decay organisms. During drought, the large, often rotten forest floor fuels can dry out. Fires that start under low fuel moisture conditions can be severe and can result in death for almost the entire stand. Summertime fuel moisture conditions in young stands are not nearly as high as in older more dense stands. Consequently, the effects of fire are often more severe than they are in older stands.

Group Eleven sites are often found between streams and forest roads in western Montana. Consequently, roadside fuel reduction activities often are concentrated in these habitats. Such programs should take into account the need for retaining some large woody material both for maintenance of site quality and for woodpecker food supply. Also, snags and snag patches should be retained for their value as nest trees for cavity-nesting birds.

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# APPENDIX A: HABITAT TYPES OCCURRING WEST OF THE CONTINENTAL DIVIDE IN MONTANA

Abbreviations and scientific names are from Pfister and others' (1977) publication, "Forest Habitat Types of Montana." The "ADP codes" are the automatic data processing codes for National Forest System use.

				Habitat types and phases	
ADP code	Abbreviation	Scientific name	Common name		
100		<b>PINUS PONDEROSA CLIMAX SERIES</b>			
130	PIPO/AGSP h.t.	<i>Pinus ponderosa</i> /Agropyron spicatum h.t.	ponderosa pinelbluebunch wheatgrass		
140	PIPO/FEID h.t.	<i>Pinus ponderosa</i> /Festuca idahoensis h.t.	ponderosa pinelldaho fescue		
141	-FEID phase	-Festuca idahoensis phase	-Idaho fescue phase		
142	-FESC phase	-Festuca scabrella phase	-rough fescue phase		
160	PIPO/PUTR h.t.	<i>Pinus ponderosa</i> /Purshia tridentata h.t.	ponderosa pinelantelope bitterbrush		
161	-AGSP phase	-Agropyron spicatum phase	-bluebunch wheatgrass phase		
162	-FEID phase	-Festuca idahoensis phase	-Idaho fescue phase		
170	PIPO/SYAL h.t.	<i>Pinus ponderosa</i> /Symphoricarpos albus h.t.	ponderosa pinelcommon snowberry		
171	-SYAL phase	-Symphoricarpos albus phase	-common snowberry phase		
200		<b>PSEUDOTSUGA MENZIESII SERIES</b>			
210	PSME/AGSP h.t.	<i>Pseudotsuga menziesii</i> /Agropyron spicatum h.t.	Douglas-firbluebunch wheatgrass		
220	PSME/FEID h.t.	<i>Pseudotsuga menziesii</i> /Festuca idahoensis h.t.	Douglas-firldaho fescue		
230	PSME/FESC h.t.	<i>Pseudotsuga menziesii</i> /Festuca scabrella h.t.	Douglas-firrough fescue		
250	PSME/VACA h.t.	<i>Pseudotsuga menziesii</i> /Vaccinium caespitosum h.t.	Douglas-firdwarf huckleberry		
260	PSME/PHMA h.t.	<i>Pseudotsuga menziesii</i> /Physocarpus malvaceus h.t.	Douglas-firmountain ninebark		
261	-PHMA phase	-Physocarpus malvaceus phase	-mountain ninebark phase		
262	-CARU phase	-Calamagrostis rubescens phase	-pinegrass phase		
280	PSMENAGL h.t.	<i>Pseudotsuga menziesii</i> /Vaccinium globulare h.t.	Douglas-firblue huckleberry		
281	-VAGL phase	-Vaccinium globulare phase	-blue huckleberry phase		
282	-ARUV phase	-Arctostaphylos uva-ursi phase	-kinnikinnick phase		
283	-XETE phase	-Xerophyllum tenax phase	-beargrass phase		
290	PSME/LIBO h.t.	<i>Pseudotsuga menziesii</i> /Linnaea borealis h.t.	Douglas-firtwinflower		
291	-SYAL phase	-Symphoricarpos albus phase	-common snowberry phase		
292	-CARU phase	-Calamagrostis rubescens phase	-pinegrass phase		
293	-VAGL phase	-Vaccinium globulare phase	-blue huckleberry phase		
310	PSME/SYAL h.t.	<i>Pseudotsuga menziesii</i> /Symphoricarpos albus h.t.	Douglas-fircommon snowberry		
311	-AFSP phase	-Agropyron spicatum phase	-bluebunch wheatgrass phase		
312	-CARU phase	-Calamagrostis rubescens phase	-pinegrass phase		
313	-SYAL phase	-Symphoricarpos albus phase	-common snowberry phase		
320	PSME/CARU h.t.	<i>Pseudotsuga menziesii</i> /Calamagrostis rubescens h.t.	Douglas-firpinegrass		
321	-AGSP phase	-Agropyron spicatum phase	-bluebunch wheatgrass phase		
322	-ARUV phase	-Arctostaphylos uva-ursi phase	-kinnikinnick phase		
323	-CARU phase	-Calamagrostis rubescens phase	-pinegrass phase		
324	-PIPO phase	-Pinus ponderosa phase	-ponderosa pine phase		
330	PSME/CAGE h.t.	<i>Pseudotsuga menziesii</i> /Carex geyeri h.t.	Douglas-firlelk sedge		
340	PSME/SPBE h.t.	<i>Pseudotsuga menziesii</i> /Spiraea betulifolia h.t.	Douglas-firwhite spirea		
400		<b>PICEA CLIMAX SERIES</b>			
410	PICENEQAR h.t.	<i>Picea/Equisetum arvense</i> h.t.	sprucelcommon horsetail		
440	PICENGATR h.t.	<i>Picea/Galium triflorum</i> h.t.	sprucelsweetscented bedstraw		
450	PICEA/VACA h.t.	<i>Picea/Vaccinium caespitosum</i> h.t.	spruceldwarf huckleberry		
470	PICENLIBO h.t.	<i>Picea/Linnaea borealis</i> h.t.	spruceltwinflower		
480	PICEA/SMST h.t.	<i>Picea/Smilacina stellata</i> h.t.	sprucelstarry false Solomon's seal		
500		<b>ABIES GRANDIS CLIMAX SERIES</b>			
510	ABGR/XETE h.t.	<i>Abies grandis</i> /Xerophyllum tenax h.t.	grand fir/common beargrass		
520	ABGR/CLUN h.t.	<i>Abies grandis</i> /Clintonia uniflora h.t.	grand firqueencup beadlily		
521	-CLUN phase	-Clintonia uniflora phase	-queencup beadlily phase		
522	-ARNU phase	-Aralia nudicaulis phase	-wild sarsaparilla phase		
523	-XETE phase	-Xerophyllum tenax phase	-beargrass phase		

(con.)

## APPENDIX A (Con.)

		Habitat types and phases	
ADP code	Abbreviation	Scientific name	Common name
501		<b>THUJA PLICATA CLIMAX SERIES</b>	
530	THPL/CLUN h.t.	<i>Thuja plicata</i> / <i>Clintonia uniflora</i> h.t.	western redcedar/queencup beadlily
531	-CLUN phase	- <i>Clintonia uniflora</i> phase	-queencup beadlily phase
532	-ARNU phase	- <i>Aralia nudicaulis</i> phase	-wild sarsaparilla phase
533	-MEFE phase	- <i>Menziesia ferruginea</i> phase	-menziesia phase
550	THPL/OPHO h.t.	<i>Thuja plicata</i> / <i>Oplopanax horridum</i> h.t.	western redcedar/devil's club
590	ABGR/LIBO h.t.	<i>Abies grandis</i> / <i>Linnaea borealis</i> h.t.	grand firtwinflower
591	-LIBO phase	- <i>Linnaea borealis</i> phase	-twinflower phase
592	-XETE phase	- <i>Xerophyllum tenax</i> phase	-beargrass phase
502		<b>TSUGA HETEROPHYLLA CLIMAX SERIES</b>	
570	TSHE/CLUN h.t.	<i>Tsuga heterophylla</i> / <i>Clintonia uniflora</i>	western hemlock/queencup beadlily
571	-CLUN phase	- <i>Clintonia uniflora</i> phase	-queencup beadlily phase
572	-ARNU phase	- <i>Aralia nudicaulis</i> phase	-wild sarsaparilla phase
600		<b>ABIES LASIOCARPA CLIMAX SERIES</b>	
700		Lower subalpine h.t.'s	
610	ABLA/OPHO h.t.	<i>Abies lasiocarpa</i> / <i>Oplopanax horridum</i> h.t.	subalpine fir/devil's club
620	ABLA/CLUN h.t.	<i>Abies lasiocarpa</i> / <i>Clintonia uniflora</i> h.t.	subalpine fir/queencup beadlily
621	-CLUN phase	- <i>Clintonia uniflora</i> phase	-queencup beadlily phase
622	-ARNU phase	- <i>Aralia nudicaulis</i> phase	-wild sarsaparilla phase
623	-VACA phase	- <i>Vaccinium caespitosum</i> phase	-dwarf huckleberry phase
624	-XETE phase	- <i>Xerophyllum tenax</i> phase	-beargrass phase
625	-MEFE phase	- <i>Menziesia ferruginea</i> phase	-menziesia phase
630	ABLNGATR h.t.	<i>Abies lasiocarpa</i> / <i>Galium triflorum</i> h.t.	subalpine firlsweetscented bedstraw
640	ABLNVACA h.t.	<i>Abies lasiocarpa</i> / <i>Vaccinium caespitosum</i> h.t.	subalpine fir/dwarf huckleberry
650	ABLA/CACA h.t.	<i>Abies lasiocarpa</i> / <i>Calamagrostis canadensis</i> h.t.	subalpine fir/bluejoint
651	-CACA phase	- <i>Calamagrostis canadensis</i> phase	-bluejoint phase
653	-GATR phase	- <i>Galium triflorum</i> phase	-sweetscented bedstraw phase
654	-VACA phase	- <i>Vaccinium caespitosum</i> phase	-dwarf huckleberry phase
660	ABLA/LIBO h.t.	<i>Abies lasiocarpa</i> / <i>Linnaea borealis</i> h.t.	subalpine firtwinflower
661	-LIBO phase	- <i>Linnaea borealis</i> phase	-twinflower phase
662	-XETE phase	- <i>Xerophyllum tenax</i> phase	-beargrass phase
663	-VASC phase	- <i>Vaccinium scoparium</i> phase	-grouse whortleberry phase
670	ABLMEFE h.t.	<i>Abies lasiocarpa</i> / <i>Menziesia ferruginea</i> h.t.	subalpine firlmenziesia
680	TSME/MEFE h.t.	<i>Tsuga mertensiana</i> / <i>Menziesia ferruginea</i> h.t.	mountain hemlock/menziesia
690	ABLXETE h.t.	<i>Abies lasiocarpa</i> / <i>Xerophyllum tenax</i> h.t.	subalpine fir/beargrass
691	-VAGL phase	- <i>Vaccinium globulare</i> phase	-blue huckleberry phase
692	-VASC phase	- <i>Vaccinium scoparium</i> phase	-grouse whortleberry phase
710	TSME/XETE h.t.	<i>Tsuga mertensiana</i> / <i>Xerophyllum tenax</i> h.t.	mountain hemlock/beargrass
720	ABLANAGL h.t.	<i>Abies lasiocarpa</i> / <i>Vaccinium globulare</i> h.t.	subalpine fir/blue huckleberry
730	ABLANASC h.t.	<i>Abies lasiocarpa</i> / <i>Vaccinium scoparium</i> h.t.	subalpine fir/grouse whortleberry
731	-VASC h.t.	- <i>Vaccinium scoparium</i> phase	-grouse whortleberry phase
800		Upper subalpine h.t.'s	
820	ABLA-PIAL/VASC h.t.	<i>Abies lasiocarpa</i> - <i>Pinus albicaulis</i> / <i>Vaccinium scoparium</i> h.t.	subalpine fir-whitebark pine/grouse whortleberry
830	ABLA/LUHI h.t.	<i>Abies lasiocarpa</i> / <i>Luzula hitchcockii</i> h.t.	subalpine fir/smooth woodrush
831	-VASC phase	- <i>Vaccinium scoparium</i> phase	-grouse whortleberry phase
832	-MEFE phase	- <i>Menziesia ferruginea</i> phase	-menziesia phase
840	TSME/LUHI h.t.	<i>Tsuga mertensiana</i> / <i>Luzula hitchcockii</i> h.t.	mountain hemlock/smooth woodrush
841	-VASC phase	- <i>Vaccinium scoparium</i> phase	-grouse whortleberry phase
842	-MEFE phase	- <i>Menziesia ferruginea</i> phase	-menziesia phase
890		Timberline h.t.'s	
850	PIAL-ABLA h.t.'s	<i>Pinus albicaulis</i> - <i>Abies lasiocarpa</i> h.t.'s	whitebark pine-subalpine fir
860	LALY-ABLA h.t.'s	<i>Larix lyallii</i> - <i>Abies lasiocarpa</i> h.t.'s	subalpine larch-subalpine fir
870	PIAL h.t.'s	<i>Pinus albicaulis</i> h.t.'s	whitebark pine

## APPENDIX B: DYNAMIC STATUS OF TREE SPECIES

Distribution of tree species in western Montana habitat types showing their dynamic status as interpreted from sample stand data (after Pfister and others 1977).

Fire Group	Habitat type-phase	Tree species														
		JUSC	PIPO	PSME	PICO	LAOC	PICEA	ABGR	PIMO	THPL	TSHE	ABLA	TSME	PIAL	LALY	BEPA
2	PIPO/AGSP	(F)	C	a	-	-	-	-	-	-	-	-	-	-	-	-
	PIPOIFEID-FEID	a	C	a	-	-	-	-	-	-	-	-	-	-	-	-
	PIPOIFEID-FESC	a	C	a	-	-	-	-	-	-	-	-	-	-	-	-
	PIPOIFEID-AGSP	a	C	a	-	-	-	-	-	-	-	-	-	-	-	-
	PIPOIPUTR-FEID	(c)	C	a	-	-	-	-	-	-	-	-	-	-	-	-
	PIPOISYAL-SYAL	a	C	a	-	-	-	-	-	-	-	-	-	-	-	-
4	PSME/AGSP	(c)	C	C	-	-	-	-	-	-	-	-	-	-	-	-
	PSME/FESC	a	C	C	-	-	-	-	-	-	-	-	-	-	-	-
	PSMEIPHMA-CARU	-	S	C	a	a	-	-	-	-	-	-	-	-	-	-
	PSMEISYAL-AGSP	-	S	C	-	-	-	-	-	-	-	-	-	-	-	-
	PSMEICARU-AGSP	-	S	C	-	-	-	-	-	-	-	-	-	-	-	-
	PSME/CARU-PIPO	-	S	C	-	-	-	-	-	-	-	-	-	-	-	-
	PSME/SPBE	-	(S)	C	a	a	-	-	-	-	-	-	-	-	-	-
5	PSME/FEID	a	a	C	-	-	-	-	-	-	-	-	-	-	-	-
	PSME/CAGE	-	(s)	C	a	a	-	-	-	-	-	-	-	-	-	-
6	PSMEIVACA	-	(S)	C	S	(S)	a	-	-	-	-	a	-	-	-	-
	PSME/PHMA-PHMA	-	(s)	C	(s)	(s)	-	a	-	-	-	-	-	-	-	-
	PSMEIVAGL-VAGL	-	(s)	C	S	(s)	a	-	-	-	-	a	-	a	-	-
	PSME/VAGL-ARUV	-	S	C	(s)	(s)	-	a	-	-	-	-	-	-	-	-
	PSME/VAGL-XETE	-	(s)	C	S	(S)	-	a	-	-	-	a	-	a	-	-
	PSMEILIBO-SYAL	-	(s)	C	(s)	(S)	-	-	-	-	-	-	-	-	-	-
	PSMEILIBO-CARU	-	(s)	C	(S)	(S)	-	-	-	-	-	a	-	-	-	-
	PSMEILIBO-VAGL	-	(s)	C	S	(s)	a	a	-	-	-	a	-	-	-	-
	PSMEISYAL-CARU	-	(s)	C	(s)	a	a	-	-	-	-	-	-	-	-	-
	PSMEISYAL-SYAL	-	(s)	C	(s)	-	-	-	-	-	-	-	-	a	-	-
	PSMEICARU-ARUV	-	S	C	s	s	-	-	-	-	-	-	-	-	-	-
PSMEICARU-CARU	-	a	C	(S)	(s)	-	-	-	-	-	a	-	a	-	-	
7	PSMEIVACA	-	(S)	C	S	(S)	a	-	-	-	-	a	-	-	-	-
	PICENVACA	-	(s)	S	S	S	C	-	-	-	-	a	-	-	-	-
	PICENLIBO	-	a	S	S	-	C	-	-	-	-	a	-	a	-	-
	ABLNVACA	-	-	(s)	S	a	(c)	-	-	-	-	c	-	a	-	-
	ABLNCACA-VACA	-	-	a	S	-	s	-	-	-	-	C	-	-	a	-
	ABLNLIBO-VASC	-	-	s	S	a	s	-	-	-	-	-	-	a	-	-
	ABWXETE-VASC	-	-	(s)	S	-	s	-	-	-	-	C	a	(s)	-	-
	ABLANAGL	-	-	S	S	-	(s)	-	-	-	-	C	-	-	s	-
	ABLANASC-VASC	-	-	a	S	-	(s)	-	-	-	-	-	C	-	-	s
	PICO/LIBO															
PICO/VASC																
8	PICEA/SMST	-	(s)	S	S	-	C	-	-	-	-	a	-	a	-	-
	ABLAIXETE-VAGL	-	(s)	S	S	(s)	s	a	(s)	-	-	C	a	(s)	-	-
	TSME/MEFE	-	-	(s)	s	s	s	-	(s)	-	-	C	C	(s)	-	-

(con.)

# APPENDIX B (Con.)

Fire Group	Habitat type-phase	Tree species														
		JUSC	PIPO	PSME	PICO	LAOC	PICEA	ABGR	PIMO	THPL	TSHE	ABLA	TSME	PIAL	LALY	BEPA
9	PICENEQAR	-	-	a	a	-	C	-	-	-	-	a	-	-	-	(s)
	PICEAICLUN-VACA	-	(s)	S	S	S	C	-	a	-	-	a	-	-	-	-
	PICEAICLUN-CLUN	-	(s)	S	(S)	S	C	-	a	-	-	a	-	-	-	(S)
	PICENGATR	-	(s)	S	S	-	C	-	-	-	-	a	-	-	a	-
	ABLA/OPHO	-	-	s	-	s	S	-	s	-	a	C	-	-	-	-
	ABLAICLUN-CLUN	-	(s)	S	(S)	S	S	(s)	(s)	a	a	C	-	-	-	a
	ABLNCLUN-ARNU	-	a	s	(s)	S	S	(s)	(s)	-	a	C	-	-	-	(S)
	ABLA/CLUN-VACA	-	(s)	S	S	s	s	a	a	-	-	C	-	-	a	-
	ABLAICLUN-XETE	-	-	S	S	S	S	a	(s)	-	a	C	(c)	a	-	-
	ABLNCLUN-MEFE	-	-	S	s	s	S	(C)	(s)	a	a	C	(c)	a	-	-
	ABLINGATR	-	-	a	S	S	(s)	S	-	-	-	-	C	-	-	-
	ABLNCACA-CACA	-	-	-	-	S	-	S	-	-	-	-	C	-	(s)	-
	ABLAICACA-GATR	-	-	-	-	s	-	S	-	-	-	-	C	-	-	-
	ABLA/LIBO-LIBO	-	(s)	S	S	(S)	S	a	-	-	C	-	-	-	a	-
	ABLAILIBO-XETE	-	a	S	S	S	s	a	(s)	-	-	-	C	-	-	-
	ABLA/MEFE	-	-	(S)	S	(s)	S	a	a	-	-	C	a	(s)	-	-
	TSME/MEFE	-	-	(s)	s	s	s	-	(s)	-	-	C	C	(s)	-	-
ABLA/ALSI	-	-	(S)	S	-	S	-	-	-	-	C	-	(s)	-	-	
10	ABLA-PIALIVASC	-	-	-	(S)	-	S	-	-	-	-	C	-	S	-	
	ABLAILUHI-VASC	-	-	-	(s)	-	S	-	-	-	-	C	a	S	-	
	ABLAILUHI-MEFE	-	-	-	a	-	S	-	-	-	-	C	-	s	(C)	
	TSMEILUHI-VASC	-	-	-	(s)	-	s	-	-	-	-	C	C	s	-	
	TSMEILUHI-MEFE	-	-	-	a	-	s	-	-	-	-	(C)	C	a	-	
	PIAL-ABLA h.t.'s	-	-	-	-	-	(C)	-	-	-	-	(C)	-	(C)	-	
	LALY-ABLA h.t.'s	-	-	-	-	-	(c)	-	-	-	-	(C)	-	(C)	(C)	
PIAL h.t.'s	-	-	a	-	-	a	-	-	-	-	a	-	C	-		
11	ABGR/XETE	-	s	S	S	S	a	C	a	a	-	a	-	-	-	
	ABGRICLUN-CLUN	-	(s)	S	(s)	(s)	(S)	C	(s)	a	-	(C)	-	-	-	
	ABGRICLUN-ARNU	-	a	S	a	S	S	C	(s)	a	a	a	-	-	s	
	ABGRICLUN-XETE	-	a	S	s	S	(S)	C	s	a	a	c	-	-	a	
	ABGR/LIBO-LIBO	-	(s)	S	s	S	a	C	-	-	-	a	-	-	a	
	ABGRILIBO-XETE	-	(s)	S	s	s	a	C	-	-	-	-	-	-	-	
	THPLICLUN-CLUN	-	a	S	(s)	S	S	(c)	(s)	C	a	(c)	-	-	(s)	
	THPUCLUN-ARNU	-	-	S	a	S	(S)	(c)	(s)	C	(c)	(s)	-	-	(s)	
	THPLICLUN-MEFE	-	-	S	S	S	S	a	(s)	C	-	c	-	-	-	
THPL/OPHO	-	-	s	-	a	s	(s)	a	(C)	(C)	(c)	-	-	(s)		
TSHEICLUN-ARNU	-	a	(s)	a	S	(S)	(c)	-	c	C	(c)	-	-	(s)		
0	SCREE	-	(C)	C	a	-	(c)	-	-	-	(c)	-	(c)	-	-	

C = major climax; S = major seral; a = accidental; c = minor climax; s = minor seral; ( ) = in certain areas of the type

## APPENDIX C: HABITAT TYPE FIRE GROUPS FOR MONTANA FORESTS

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### Fire Group 0 - Miscellaneous special habitats:

Scree;  
Forested rock;  
Meadow; Grassy bald; Alder glade; Aspen grove

### Fire Group 1 - Dry limber pine habitat types:

*Pinus flexilis/Agropyron spicatum* (PIFLIAGSP; limber pinelbluebunch wheatgrass)  
*Pinus flexilis/Festuca idahoensis* h.t.-*Festuca idahoensis* phase (PIFLIFEID-FEID; limber pinelldaho fescue-rough fescue phase)  
*Pinus flexilis/Festuca idahoensis* h.t.-*Festuca scabrella* phase (PIFUFEID-FESC; limber pinelldaho fescue-rough fescue phase)  
*Pinus flexilis/Juniperus communis* h.t. (PIFLIJUCO; limber pinelcommon juniper)

### Fire Group 2 - Warm, dry ponderosa pine habitat types:

*Pinus ponderosa/Andropogon* spp. h.t. (PIPOIAND; ponderosa pinelbluestem)  
*Pinus ponderosa/Agropyron spicatum* h.t. (PIPOIAGSP; ponderosa pinelbluebunch wheatgrass)  
*Pinus ponderosa/Festuca idahoensis-Festuca idahoensis* phase (PIPOIFEID-FEID; ponderosa pinelldaho fescue-Idaho fescue phase)  
*Pinus ponderosa/Festuca idahoensis* h.t.-*Festuca scabrella* phase (PIPOIFEID-FESC; ponderosa pinelldaho fescue-rough fescue phase)  
*Pinus ponderosa/Purshia tridentata* h.t.-*Agropyron spicatum* phase (PIPOIPUTR-AGSP; ponderosa pinelantelope bitterbrush-bluebunch wheatgrass phase)  
*Pinus ponderosa/Purshia tridentata* h.t.-*Festuca idahoensis* phase (PIPOIPUTR-FEID; ponderosa pinelantelope bitterbrush-Idaho fescue phase)  
*Pinus ponderosa/Symphoricarpos albus* h.t.-*Symphoricarpos albus* phase (PIPOISYAL-SYAL; ponderosa pinelcommon snowberry-common snowberry phase)  
*Pinus ponderosa/Symphoricarpos occidentalis* h.t. (PIPOISYOC; ponderosa pinelwestern snowberry)  
*Pinus ponderosa/Arctostaphylos uva-ursi* h.t. (PIPOIARUV; ponderosa pinelkinnikinnick)  
*Pinus ponderosa/Juniperus horizontalis* h.t. (PIPOIJUHO; ponderosa pinelcreeping juniper)  
*Pinus ponderosa/Juniperus scopulorum* h.t. (PIPOIJUSC; ponderosa pinelRocky Mountain juniper)

### Fire Group 3 - Warm, moist ponderosa pine habitat types:

*Pinus ponderosa/Symphoricarpos albus* h.t.-*Berberis repens* phase (PIPOISYAL-BERE; ponderosa pinelcommon snowberry-hollygrape phase)  
*Pinus ponderosa/Berberis repens* h.t. (PIPOIBERE; ponderosa pinelhollygrape)  
*Pinus ponderosa/Amelanchier alnifolia* h.t. (PIPOIAMAL; ponderosa pinelwestern serviceberry)  
*Pinus ponderosa/Prunus virginiana* h.t.-*Prunus virginiana* phase (PIPOIPRVI-PRVI; ponderosa pinelchokecherry-chokecherry phase)  
*Pinus ponderosa/Prunus virginiana* h.t.-*Shepherdia canadensis* phase (PIPOIPRVI-SHCA; ponderosa pinelchokecherry-russet buffaloberry phase)

### Fire Group 4 - Warm, dry Douglas-fir habitat types:

*Pseudotsuga menziesii/Agropyron spicatum* h.t. (PSMEIAGSP; Douglas-firbluebunch wheatgrass)  
*Pseudotsuga menziesii/Festuca scabrella* h.t. (PSME/FESC; Douglas-firrough fescue)  
*Pseudotsuga menziesii/Physocarpus malvaceus* h.t.-*Calamagrostis rubescens* phase (PSME/PHMA-CARU; Douglas-firmountain ninebark-pinegrass phase)  
*Pseudotsuga menziesii/Symphoricarpos albus* h.t.-*Agropyron spicatum* phase (PSMEISYAL-AGSP; Douglas-fircommon snowberry-bluebunch wheatgrass phase)  
*Pseudotsuga menziesii/Symphoricarpos occidentalis* h.t.-*Chrysopsis villosa* phase (PSMEISYOC-CHVI; Douglas-firwestern snowberry-hairy goldenaster phase)  
*Pseudotsuga menziesii/Symphoricarpos occidentalis* h.t.-*Shepherdia canadensis* phase (PSMEISYOC-SHCA; Douglas-firwestern snowberry-russet buffaloberry phase)  
*Pseudotsuga menziesii/Calamagrostis rubescens* h.t.-*Agropyron spicatum* phase (PSMEICARU-AGSP; Douglas-fir/pinegrass-bluebunch wheatgrass phase)  
*Pseudotsuga menziesii/Calamagrostis rubescens* h.t.-*Pinus ponderosa* phase (PSMEICARU-PIPO; Douglas-fir/pinegrass-ponderosa pine phase)  
*Pseudotsuga menziesii/Spiraea betulifolia* h.t. (PSMEISPBE; Douglas-firwhite spirea)  
*Pseudotsuga menziesii/Arctostaphylos uva-ursi* h.t. (PSMEIARUV; Douglas-firkinnikinnick)  
*Pseudotsuga menziesii/Berberis repens* h.t.-*Arctostaphylos uva-ursi* phase (PSMEIBERE-ARUV; Douglas-firhollygrape-kinnikinnick phase)  
*Pseudotsuga menziesii/Berberis repens* h.t.-*Berberis repens* phase (PSME/BERE-BERE; Douglas-firhollygrape-hollygrape phase)  
*Pseudotsuga menziesii/Juniperus scopularum* h.t. (PSMEIJUSC; Douglas-fir/Rocky Mountain juniper)  
*Pseudotsuga menziesii/Muhlenbergia cuspidata* h.t. (PSMEIMUCU; Douglas-fir/plains muhly)

(con.)

## APPENDIX C (Con.)

### Fire Group 5 - Cool, dry Douglas-fir habitat types:

- Pseudotsuga menziesii/Calamagrostis rubescens* h.t.-*Agropyron spicatum* phase (PSMEICARU-AGSP; Douglas-fir/pinegrass-bluebunch wheatgrass phase)
- Pseudotsuga menziesii/Festuca idahoensis* h.t. (PSMEIFEID; Douglas-fir/Idaho fescue)
- Pseudotsuga menziesii/Carex geyeri* h.t. (PSMEICAGE; Douglas-fir/elk sedge)
- Pseudotsuga menziesii/Arnica cordifolia* h.t. (PSMEIARCO; Douglas-fir/heartleaf arnica)
- Pseudotsuga menziesii/Symphoricarpos oreophilus* h.t. (PSMEISYOR; Douglas-fir/mountain snowberry)
- Picea/Senecio streptanthifolius* h.t.-*Pseudotsuga menziesii* phase (PICENSEST-PSME; spruce/cleftleaf groundsel-Douglas-fir phase)

### Fire Group 6 - Moist Douglas-fir habitat types:

- Pseudotsuga menziesii/Physocarpus malvaceus* h.t.-*Physocarpus malvaceus* phase (PSMEIPHMA-PHMA; Douglas-fir/mountain ninebark-mountain ninebark phase)
- Pseudotsuga menziesii/Viola canadensis* h.t. (PSMENICA; Douglas-fir/Canada violet)
- Pseudotsuga menziesii/Vaccinium globulare* h.t.-*Vaccinium globulare* phase (PSMENAGL-VAGL; Douglas-fir/blue huckleberry-blue huckleberry phase)
- Pseudotsuga menziesii/Vaccinium globulare* h.t.-*Arctostaphylos uva-ursi* phase (PSMENAGL-ARUV; Douglas-fir/blue huckleberry-kinnikinnick phase)
- Pseudotsuga menziesii/Vaccinium globulare* h.t.-*Xerophyllum tenax* phase (PSMENAGL-XETE; Douglas-fir/blue huckleberry-beargrass phase)
- Pseudotsuga menziesii/Linnaea borealis* h.t.-*Symphoricarpos albus* phase (PSMEILIBO-ARUV; Douglas-fir/twinflower-common snowberry phase)
- Pseudotsuga menziesii/Linnaea borealis* h.t.-*Arctostaphylos uva-ursi* phase (PSMEILIBO-ARUV; Douglas-fir/twinflower-kinnikinnick phase)
- Pseudotsuga menziesii/Linnaea borealis* h.t.-*Vaccinium globulare* phase (PSMEILIBO-VAGL; Douglas-fir/twinflower-blue huckleberry phase)
- Pseudotsuga menziesii/Symphoricarpos albus* h.t.-*Calamagrostis rubescens* phase (PSMEISYAL-CARU; Douglas-fir/common snowberry-pinegrass phase)
- Pseudotsuga menziesii/Symphoricarpos albus* h.t.-*Symphoricarpos albus* phase (PSMEISYAL-SYAL; Douglas-fir/common snowberry-common snowberry phase)
- Pseudotsuga menziesii/Amelanchier alnifolia* h.t. (PSMEIAMAL; Douglas-fir/western serviceberry)
- Pseudotsuga menziesii/Calamagrostis rubescens* h.t.-*Arctostaphylos uva-ursi* phase (PSMEICARU-ARUV; Douglas-fir/pinegrass-kinnikinnick phase)
- Pseudotsuga menziesii/Calamagrostis rubescens* h.t.-*Calamagrostis rubescens* phase (PSMEICARU-CARU; Douglas-fir/pinegrass-pinegrass phase)
- Pseudotsuga menziesii/Vaccinium caespitosum* h.t. (PSMEIVACA; Douglas-fir/dwarf huckleberry)
- Pseudotsuga menziesii/Juniperus communis* h.t. (PSMEIJUCO; Douglas-fir/common juniper)

### Fire Group 7 - Cool habitat types usually dominated by lodgepole pine:

- Pseudotsuga menziesii/Juniperus communis* h.t. (PSMEIJUCO; Douglas-fir/common juniper)
- Pseudotsuga menziesii/Vaccinium caespitosum* h.t. (PSMENACA; Douglas-fir/dwarf huckleberry)
- Pseudotsuga menziesii/Cornus canadensis* h.t.-*Linnaea borealis* phase (PSMEICOCA-LIBO; Douglas-fir/bunchberry dogwood-twinflower phase)
- Pseudotsuga menziesii/Cornus canadensis* h.t.-*Vaccinium myrtillus* phase (PSMEICOCA-VAMY; Douglas-fir/bunchberry dogwood-whortleberry phase)
- Picea/Vaccinium caespitosum* h.t. (PICEANACA; spruce/dwarf huckleberry)
- Picea/Linnaea borealis* h.t. (PICENLIBO; spruce/twinflower)
- Abies lasiocarpa/Vaccinium caespitosum* h.t. (ABLANACA; subalpine fir/dwarf huckleberry)
- Abies lasiocarpa/Calamagrostis canadensis* h.t.-*Vaccinium caespitosum* phase (ABLAICACA-VACA; subalpine fir/bluejoint-dwarf huckleberry phase)
- Abies lasiocarpa/Linnaea borealis* h.t.-*Vaccinium scoparium* phase (ABLNLIBO-VASC; subalpine fir/twinflower-grouse whortleberry phase)
- Abies lasiocarpa/Xerophyllum tenax* h.t.-*Vaccinium scoparium* phase (ABLNXETE-VASC; subalpine fir/beargrass-grouse whortleberry phase)
- Abies lasiocarpa/Vaccinium globulare* h.t. (ABLNVAGL; subalpine fir/blue huckleberry)
- Abies lasiocarpa/Vaccinium scoparium* h.t.-*Calamagrostis rubescens* phase (ABLANASC-CARU; subalpine fir/grouse whortleberry-pinegrass phase)
- Abies lasiocarpa/Vaccinium scoparium* h.t.-*Vaccinium scoparium* phase (ABLANASC-VASC; subalpine fir/grouse whortleberry-grouse whortleberry phase)
- Abies lasiocarpa/Carex geyeri* h.t.-*Carex geyeri* phase (ABLAICAGE-CAGE; subalpine fir/elk sedge-elk sedge phase)
- Pinus contorta/Purshia tridentata* h.t. (PICOIPUTR; lodgepole pine/antelope bitterbrush)
- Pinus contorta/Vaccinium caespitosum* h.t. (PICO/LIBO; lodgepole pine/twinflower)
- Pinus contorta/Vaccinium scoparium* h.t. (PICONASC; lodgepole pine/grouse whortleberry)
- Pinus contorta/Calamagrostis rubescens* h.t. (PICOICARU; lodgepole pine/pinegrass)
- Pinus contorta/Juniperus communis* h.t. (PICONUCO; lodgepole pine/common juniper)

(con.)



## APPENDIX C (Con.)

### Fire Group 8 - Dry, lower subalpine habitat types:

- Picea/Linnaea borealis* h.t. (PICEAILIBO; spruceltwinflower)  
*Picea/Physocarpus malvaceus* h.t. (PICEAIPHMA; sprucelmountain ninebark)  
*Picea/Smilacina stellata* h.t. (PICEAISMST; sprucelstarry false Solomon's seal)  
*Abies lasiocarpa/Xerophyllum tenax* h.t.-*Vaccinium globulare* phase (ABWXETE-VAGL; subalpine fir/beargrass-blue huckleberry phase)  
*Tsuga mertensiana/Xerophyllum tenax* h.t. (TSMEIXETE; mountain hemlock/beargrass)  
*Abies lasiocarpa/Vaccinium scoparium* h.t.-*Thalictrum occidentale* phase (ABLANASC-THOC; subalpine fir/grouse whortleberry-western meadowrue phase)  
*Abies lasiocarpa/Clematis pseudoalpina* h.t. (ABLAICLPS; subalpine fir/virgin's bower)  
*Abies lasiocarpa/Arnica cordifolia* h.t. (ABLAIARCO; subalpine fir/heartleaf arnica)  
*Abies lasiocarpa/Carex geyeri* h.t.-*Pseudotsuga menziesii* phase (ABLAICAGE-PSME; subalpine fir/elm sedge-Douglas-fir phase)  
*Picea/Clintonia uniflora* h.t.-*Clintonia uniflora* phase (PICEAICLUN-CLUN; sprucelqueencup beadlily-queencup beadlily phase)  
*Picea/Galium triflorum* h.t. (PICEAIGATR; sprucelsweetscented bedstraw)  
*Abies lasiocarpa/Oplopanox horridum* h.t. (ABWOPHO; subalpine fir/devil's club)  
*Abies lasiocarpa/Clintonia uniflora* h.t.-*Clintonia uniflora* phase (ABLAICLUN-CLUN; subalpine fir/queencup beadlily-queencup beadlily phase)  
*Abies lasiocarpa/Clintonia uniflora* h.t.-*Aralia nudicaulis* phase (ABLAICLUN-ARNU; subalpine fir/queencup beadlily-wild sarsaparilla phase)  
*Abies lasiocarpa/Clintonia uniflora* h.t.-*Vaccinium caespitosum* phase (ABLAICLUN-VACA; subalpine fir/queencup beadlily-dwarf huckleberry phase)  
*Abies lasiocarpa/Clintonia uniflora* h.t.-*Xerophyllum tenax* phase (ABLAICLUN-XETE; subalpine fir/queencup beadlily-beargrass phase)  
*Abies lasiocarpa/Clintonia uniflora* h.t.-*Menziesia ferruginea* phase (ABLAICLUN-MEFE; subalpine fir/queencup beadlily-menziesia phase)  
*Abies lasiocarpa/Galium triflorum* h.t. (ABLAIGATR; subalpine fir/sweetscented bedstraw)  
*Abies lasiocarpa/Calamagrostis canadensis* h.t.-*Calamagrostis canadensis* phase (ABLAICACA-CACA; subalpine fir/bluejoint-bluejoint phase)  
*Abies lasiocarpa/Calamagrostis canadensis* h.t.-*Galium triflorum* phase (ABWCACA-GATR; subalpine fir/bluejoint-sweetscented bedstraw phase)  
*Abies lasiocarpa/Linnaea borealis* h.t. (ABLAILIBO; subalpine fir/twinflower)  
*Abies lasiocarpa/Linnaea borealis* h.t.-*Linnaea borealis* phase (ABLAILIBO-LIBO; subalpine fir/twinflower-twinflower phase)  
*Abies lasiocarpa/Linnaea borealis* h.t.-*Xerophyllum tenax* phase (ABLAILIBO-XETE; subalpine fir/twinflower-beargrass phase)  
*Abies lasiocarpa/Menziesia ferruginea* h.t. (ABLA/MEFE; subalpine fir/menziesia phase)  
*Tsuga mertensiana/Menziesia ferruginea* h.t. (TSMEIMEFE; mountain hemlock/menziesia)  
*Abies lasiocarpa/Alnus sinuata* h.t. (ABLAIALSI; subalpine fir/sitka alder)

### Fire Group 10 - Cold, moist upper subalpine and timberline habitat types:

- Picea/Senecio streptanthifolius* h.t.-*Picea* phase (PICEAISEST-PICEA; spruce/cleftleaf groundsel-spruce phase)  
*Picea/Juniperus communis* h.t. (PICEAJUCO; spruce/common juniper)  
*Abies lasiocarpa/Ribes montigenum* h.t. (ABLAIRIMO; subalpine fir/mountain gooseberry)  
*Abies lasiocarpa/Pinus albicaulis/Vaccinium scoparium* h.t. (ABLA-PIALNASC; subalpine fir-whitebark pine/grouse whortleberry)  
*Abies lasiocarpa/Luzula hitchcockii* h.t.-*Vaccinium scoparium* phase (ABLAILUHI-VASC; subalpine fir/smooth woodrush-grouse whortleberry phase)  
*Abies lasiocarpa/Luzula hitchcockii* h.t.-*Menziesia ferruginea* phase (ABLAILUHI-MEFE; subalpine fir/smooth woodrush-menziesia phase)  
*Abies lasiocarpa/Juniperus communis* h.t. (ABLAJUCO; subalpine fir/common juniper)  
*Tsuga mertensiana/Luzula hitchcockii* h.t.-*Vaccinium scoparium* phase (TSMEILUHI-VASC; mountain hemlock/smooth woodrush-grouse whortleberry phase)  
*Tsuga mertensiana/Luzula hitchcockii* h.t.-*Menziesia ferruginea* phase (TSMEILUHI-MEFE; mountain hemlock/smooth woodrush-menziesia phase)  
*Pinus albicaulis-Abies lasiocarpa* h.t.'s (PIAL-ABLA h.t.'s; whitebark pine-subalpine fir)  
*Larix lyallii-Abies lasiocarpa* h.t.'s (LALY-ABLA h.t.'s; subalpine larch-subalpine fir)  
*Pinus albicaulis* h.t.'s (PIAL h.t.'s; whitebark pine)

(con.)

## APPENDIX C (Con.)

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Fire Group 11 - Warm, moist grand fir, western hemlock, and western redcedar habitat types:

*Abies grandis/Xerophyllum tenax* h.t. (ABGRIXETE; grand fir/beargrass)

*Abies grandis/Clintonia uniflora* h.t.-*Clintonia uniflora* phase (ABGRICLUN-CLUN; grand fir/queencup beadlily-queencup beadlily phase)

*Abies grandis/Clintonia uniflora* h.t.-*Aralia nudicaulis* phase (ABGRICLUN-ARNU; grand fir/queencup beadlily-wild sarsaparilla phase)

*Abies grandis/Clintonia uniflora* h.t.-*Xerophyllum tenax* phase (ABGRICLUN-XETE; grand fir/queencup beadlily-beargrass phase)

*Abies grandis/Linnaea borealis* h.t.-*Linnaea borealis* phase (ABGRILIBO-LIBO; grand fir/twinflower-twinflower phase)

*Abies grandis/Linnaea borealis* h.t.-*Xerophyllum tenax* phase (ABGRILIBO-XETE; grand fir/twinflower-beargrass phase)

*Thuja plicata/Clintonia uniflora* h.t.-*Clintonia uniflora* phase (THPUCLUN-CLUN; western redcedar/queencup beadlily-queencup beadlily phase)

*Thuja plicata/Clintonia uniflora* h.t.-*Aralia nudicaulis* phase (THPLICLUN-ARNU; western redcedar/queencup beadlily-wild sarsaparilla phase)

*Thuja plicata/Clintonia uniflora* h.t.-*Menziesia ferruginea* phase (THPLICLUN-MEFE; western redcedar/queencup beadlily-menziesia phase)

*Thuja plicata/Oplopanax horridum* h.t. (THPLIOPHO; western redcedar/devil's club)

*Tsuga heterophylla/Clintonia uniflora* h.t.-*Clintonia uniflora* phase (TSHE/CLUN-CLUN; western hemlock/queencup beadlily-queencup beadlily phase)

*Tsuga heterophylla/Clintonia uniflora* h.t.-*Aralia nudicaulis* phase (TSHEICLUN-ARNU; western hemlock/queencup beadlily-wild sarsaparilla phase)

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## APPENDIX D: SCIENTIFIC NAMES OF PLANTS IN TEXT

Common name	Scientific name	Common name	Scientific name
Alder	<i>Alnus</i> spp.	Pacific yew	<i>Taxus brevifolia</i>
American trailplant	<i>Andenocaulon bicolor</i>	Paper birch	<i>Betula papyrifera</i>
American twinflower	<i>Linnaea borealis</i>	Parry rush	<i>Juncus parryi</i>
Antelope bitterbrush	<i>Purshia tridentata</i>	Pinegrass	<i>Calamagrostis rubescens</i>
Arrowleaf balsamroot	<i>Balsamorhiza sagittata</i>	Plains muhly	<i>Muhlenbergia cuspidata</i>
Arrowleaf groundsel	<i>Senecio triangularis</i>	Ponderosa pine	<i>Pinus ponderosa</i>
<b>Ballhead sandwort</b>	<b><i>Arenaria congesta</i></b>	Prickly currant	<i>Ribes lacustre</i>
Big sagebrush	<i>Artemisia tridentata</i>	Prince's pine	<i>Chimaphila umbellata</i>
Black cottonwood	<i>Populus trichocarpa</i>	Pyrola	<i>Pyrola</i>
Bluejunch wheatgrass	<i>Agropyron spicatum</i>	Quaking aspen	<i>Populus tremuloides</i>
Bluejoint	<i>Calamagrostis canadensis</i>	<b>Queencup beadlily</b>	<i>Clintonia uniflora</i>
<b>Bluestem</b>	<i>Andropogon</i>	<b>Redosier dogwood</b>	<i>Cornus stolonifera</i>
Bracken fern	<i>Pteridium aquilinum</i>	Richardson's geranium	<i>Geranium richardsonii</i>
Broadleaf arnica	<i>Arnica latifolia</i>	Rocky Mountain juniper	<i>Juniperus scopulorum</i>
Bunchberry dogwood	<i>Cornus canadensis</i>	Rocky Mountain maple	<i>Acer glabrum</i>
Canada violet	<i>Viola canadensis</i>	Ross sedge	<i>Carex rossii</i>
Chokecherry	<i>Prunus virginiana</i>	Rough fescue	<i>Festuca scabrella</i>
Cleftleaf groundsel	<i>Senecio streptanthifolius</i>	Russet buffaloberry	<i>Shepherdia canadensis</i>
Columbia bromegrass	<i>Bromus vulgaris</i>	Rusty menziesia	<i>Menziesia ferruginea</i>
Common snowberry	<i>Symphoricarpos albus</i>	Scouler willow	<i>Salix scouleriana</i>
Common beargrass	<i>Xerophyllum tenax</i>	Shrubby cinquefoil	<i>Potentilla fruticosa</i>
Common juniper	<i>Juniperus communis</i>	Sidebells shineleaf	<i>Pyrola secunda</i>
Conspicuous aster	<i>Aster conspicuus</i>	Sitka alder	<i>Alnus sinuata</i>
Creeping juniper	<i>Juniperus horizontalis</i>	Slender hawkweed	<i>Hieracium gracile</i>
Creeping Oregon grape	<i>Berberis repens</i>	Smooth <b>woodrush</b>	<i>Luzula hitchcockii</i>
<b>Curlleaf mountain mahogany</b> or <b>curlleaf cercocarpus</b>	<i>Cercocarpus ledifolius</i>	Solomon's seal	<i>Polygonatus pubescens</i>
Dampwoods blueberry	<i>Vaccinium globulare</i>	Snowbrush ceanothus	<i>Ceanothus velutinus</i>
Darkwoods violet	<i>Viola orbiculata</i>	Spreading dogbane	<i>Apocynum androsaemifolium</i>
Devil's club	<i>Oplopanax horridum</i>	Spruce	<i>Picea</i>
Douglas-fir	<i>Pseudotsuga menziesii</i>	Starry false Solomon's seal	<i>Smilacina stellata</i>
Dwarf huckleberry	<i>Vaccinium caespitosum</i>	Subalpine fir	<i>Abies lasiocarpa</i>
Dwarf mistletoe	<i>Arceuthobium</i>	Subalpine larch	<i>Larix lyallii</i>
Elk sedge	<i>Carex geyeri</i>	Sweetscented <b>bedstraw</b>	<b><i>Galium triflorum</i></b>
Engelmann spruce	<i>Picea engelmannii</i>	Sweetleaf arnica	<i>Arnica</i>
False Solomon's seal	<i>Smilacina racemosa</i>	Thimbleberry	<i>Rubus parviflorus</i>
Field horsetail	<i>Equisetum arvense</i>	Threelobed foamflower	<i>Tiarella trifoliata</i>
Grand fir	<i>Abies grandis</i>	Timber milkvetch	<i>Astragalus miser</i>
Greene mountainash	<i>Sorbus scopulina</i>	Twisted stalk	<i>Streptopus amplexifolius</i>
Grouse whortleberry	<i>Vaccinium scoparium</i>	Utah honeysuckle	<i>Lonicera utahensis</i>
Hairy goldenaster	<i>Chrysopsis villosa</i>	Virginia strawberry	<i>Fragaria virginiana</i>
Heartleaf arnica	<i>Arnica cordifolia</i>	Virgin's bower	<i>Clematis pseudoalpina</i>
Hollygrape	<i>Berberis</i>	Wartberry fairybells	<i>Disporum trachycarpum</i>
Idaho fescue	<i>Festuca idahoensis</i>	Wax currant	<i>Ribes cereum</i>
<b>Junegrass</b>	<i>Koeleria cristata</i>	Western hemlock	<i>Tsuga heterophylla</i>
Kinnikinnick	<i>Arctostaphylos uva-ursi</i>	Western larch	<i>Larix occidentalis</i>
Lady fern	<i>Athyrium felix-femina</i>	Western meadowrue	<i>Thalictrum occidentale</i>
Lewis mockorange	<i>Philadelphus lewisii</i>	Western rattlesnake plantain	<b><i>Goodyera oblongifolia</i></b>
Limber pine	<i>Pinus flexilis</i>	Western <b>redcedar</b>	<i>Thuja plicata</i>
Lodgepole pine	<i>Pinus contorta</i>	Western <b>serviceberry</b>	<i>Amelanchier alnifolia</i>
<b>Manyleaf swampl Laurel</b>	<i>Kalmia polifolia</i>	Western snowberry	<i>Symphoricarpos occidentalis</i>
Mountain arnica	<i>Arnica latifolia</i>	Western white pine	<i>Pinus monticola</i>
Mountain deathcamas	<i>Zygadenus elegans</i>	Western wintergreen	<b><i>Gaultheria humifusa</i></b>
Mountain gooseberry	<i>Ribes montigenum</i>	White stoneseed	<i>Lithospermum ruderale</i>
Mountain heath	<i>Phyllodoce empetriformis</i>	White spirea	<i>Spiraea betulifolia</i>
Mountain hemlock	<i>Tsuga mertensiana</i>	White spruce	<i>Picea glauca</i>
Mountain lover	<i>Pachystima myrsinites</i>	Whitebark pine	<i>Pinus albicaulis</i>
Mountain <b>ninebark</b>	<i>Physocarpus malvaceus</i>	Whiteflower rhododendron	<i>Rhododendron albiflorum</i>
Mountain snowberry	<i>Symphoricarpos oreophilus</i>	Whortleberry	<i>Vaccinium myrtillus</i>
Mountain sweetroot	<i>Osmorhiza chilensis</i>	Wild sarsaparilla	<i>Aralia nudicaulis</i>
Oceanspray	<i>Holodiscus</i>	<b>Woodrush</b>	<i>Luzula hitchcockii</i>
		Yellow mountain heather	<i>Phyllodoce glandulifolia</i>

Scientific and common names are taken from Checklist of United States Trees (Native and Naturalized) (Little 1979) and National Handbook of Plant Names (USDA SCS 1981).



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Fischer, William C.; Bradley, Anne F. Fire ecology of western Montana forest habitat types. General Technical Report INT-223. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station; 1987. 95 p.

Provides information on fire as an ecological factor for forest habitat types in western Montana. Identifies Fire Groups of habitat types based on fire's role in forest succession. Describes forest fuels and suggests considerations for fire management.

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KEYWORDS: fire ecology, forest ecology, forest fire, fire management, habitat types, forest fuels

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