FIRE ECOLOGY OF LOLO NATIONAL FOREST HABITAT TYPES

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FOREWORD

Fire management actions will support resource management objectives when land managers have a knowledge of fire relationships and the skill to use this knowledge during the planning process. The result of this "front-end" analysis will be the development of presuppression, suppression, and fire use criteria and actions that actively further management direction. This paper provides fire ecology knowledge that managers need for appropriate resource decisions.

This fire ecology paper by Davis, Clayton, and Fischer will significantly assist Lolo National Forest personnel to establish the following fire-related management guidance:

1. Develop fire information data base.

    a. Determine fire history.
    b. Determine man's impacts on the biological system.
    c. Determine fire ecology relationships.
    d. Determine fuel situation by such specifics as cover type and habitat type.

2. Process and interpret data base (fire behavior potential and management implications).

3. Integrate fire information with habitat type groups.

4. Formulate land management alternatives.

5. Formulate fire management strategies for land management alternatives.

6. Simulate fire and economic consequences of each fire management strategy.

7. Select a management alternative and its fire management strategy.

8. Prepare operational fire management plans (for example, fire use plan, pre-attack plan, fuel management plan, fire management area plan, wilderness fire management plan).

The habitat type groups used in this publication are helpful descriptors that can be used to connect fire/ecosystem relationships to the planning process and to implement fire management prescriptions. The habitat type groups are recognizable parts of ecosystems that are ecologically distinct in terms of topographic features, soils, vegetation, fuels, and fire behavior potential. The groups can be classified and mapped; thus, they can serve as a ready index for many kinds of information.

Not only does the ecosystem stratification account for the important intraunit attributes, but it also portrays interactions among units. The patterning of habitat type groups in space (each with inherent biological, physical, and climatic features) guides a logical process in formulating management decisions.

We are indebted to Davis, Clayton, and Fischer for providing relevant information to land managers in a format that is especially helpful for program and project planning.

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RESEARCH SUMMARY

This report summarizes available information on fire as an ecological factor for forest habitat types occurring on the Lolo National Forest.

The Lolo National Forest habitat types are grouped into 10 Fire Groups based primarily on fire's role in forest succession.

For each Fire Group, information is presented on (1) the relationship of major tree species to fire, (2) forest fuels, (3) the natural role of fire, (4) fire and plant succession, and (5) relative fire management considerations.

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INTRODUCTION

PURPOSE

This report is a summary of available fire ecology and management information that applies to habitat types of the Lolo National Forest. Primary attention is given to the tree component. The undergrowth is treated by plant form, except in a few cases where certain species are discussed.

Habitat types are arranged into 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 collection of miscellaneous vegetation types.

The reader should be cautioned that (as in all cases where an attempt has been made to impose order on the heterogeneity of nature) the Fire Groups defined in this report include a number of borderline cases. Differences in fire behavior and in successional patterns often depend on very 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. 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.

The information contained in this report is geared to the composition of habitat types on the Lolo National Forest. Many of these habitats occur throughout western Montana; therefore, the information may be extrapolated with care.

FORMAT

Habitat Types — Phase and Ecoclass Code

The Fire Groups are defined with reference to *Forest Habitat Types of Montana* (Pfister and others 1977) and the "ecoclass" silvicultural grouping of On and Losensky (1977). The habitat types occurring in the Lolo National Forest are listed in 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 ecoclass codes take the form "XX - # - ###" (appendix B). The first letter, representing the dominant plant lifeform, is always a "C," which stands for "conifer." The second letter is an abbreviated symbol representing the dominant potential climax species, such as "S" for subalpine fir. The single-digit number represents the silvicultural group (1 through 8), and the last three digits are data processing codes associated with Pfister's habitat types.

Relationship of Major Tree Species to Fire

This section of each chapter is devoted to a discussion of the characteristics of each important tree species in the Fire Group 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.

Forest Fuels

In this section, 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 different sources. The prime source is a photo series for appraising natural fuels in wild stands on the Lolo National Forest and vicinity. The other source is timber inventory (Stage I) fuel data from western Montana national forests.

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 are those suggested by the Society of American Foresters (1954).

Role of Fire

Information on the important trees and forest fuel is integrated with available fire history studies to describe the role of fire in shaping the vegetative composition of a particular Fire Group. This section is mainly a literature review covering succession and fire in the appropriate habitat types.

Fire intensity is described as light, moderate, and severe. Light fires are low intensity surface fires which burn through surface fuels and remove a portion of the litter and duff. Moderate fires are surface fires of higher intensity which burn through shrubs and other understory vegetation. Such fires are capable of torching overstory trees. The greatest intensity and potential for damage is experienced with severe fires, which often kill the overstory and recycle the vegetation to the secondary successional stages. More concise descriptions of fire intensity are not possible because the literature provides little basis for more precision.

Succession Diagram

The succession diagram and associated text represent a simplified, synthetic overview of fire's role in succession for all habitats of each Fire Group. For clarity, no literature references are given in this section since it is intended to serve as a graphic and uncomplicated presentation of the material covered earlier in the chapter.

The accompanying diagram represents a visual summary of the effects that fires of varying intensity can have on the habitat types. Secondary succession begins with the lowest seral form, but the diagram can be used from any stage of stand development. In habitat types with aggressive seral conifers, the shrub/herb stage is short lived. Numerous facts which may influence the vegetation on the landscape have been neglected in order to emphasize the potential influences of fire and fire suppression.

The conifer species are symbolized in order to simplify the diagrams. The symbols are defined as follows:

Pinus ponderosa, ponderosa pine (PIPO)
Pseudotsuga menziesii, Douglas-fir (PSME)
Pinus contorta, lodgepole pine (PICO)
Larix occidentalis, western larch (LACO)
Picea engelmannii, Engelmann spruce (PICEA)
Abies lasiocarpa, subalpine fir (ABLA)
Tsuga mertensiana, mountain hemlock (TSME)

Larix lyallii, alpine larch (LALY)
Pinus albicaulis, whitebark pine (PIAL)
Abies grandis, grand fir (ABGR)
Thuja plicata, western redcedar (THPL)
Tsuga heterophylla, western hemlock (TSHE)

Fire Management Considerations

The purpose of this section is to suggest 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 individual manager is in a much better position than are the authors to relate the information presented in this report to a particular management situation.

THE FIRE GROUPS

The forest habitat types of Montana (Pfister and others 1977) have been assembled into 12 Fire Groups which are defined as follows:

Fire Group Zero: A heterogeneous collection of special habitats. On the Lolo National Forest these sites exist as scree, forested rock, meadow, grassy bald, and alder glade.

Fire Group One: Dry limber pine habitat types. These occur most often east of the Continental Divide in Montana. This group is not represented on the Lolo National Forest.

Fire Group Two: Warm, dry ponderosa pine habitat types. This group consists of open ponderosa pine stands with a predominantly grass undergrowth. 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 in eastern Montana. Fire Group Three is not represented on the Lolo.

Fire Group Four: Warm, dry Douglas-fir habitat types. These are areas that exist in nature as fire-maintained ponderosa pine stands that develop Douglas-fir regeneration beneath the pine in the absence of disturbance.

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

Fire Group Six: Moist Douglas-fir habitat types. Group Six habitat types will support substantial amounts of Douglas-fir 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 as well as those in which it is a persistent dominant species.

Fire Group Eight: Dry, lower subalpine habitat types. This is primarily an eastern Montana group although it is represented on the Lolo.

Fire Group Nine: Moist, lower subalpine habitat types. Group Nine is a collection of lower subalpine habitats in which fires are infrequent, but severe, with long-lasting effects.

Fire Group Ten: Cold, moist upper subalpine and timberline habitat types. Group Ten is a collection of high-elevation habitats in which fires are infrequent. Small area fires are common because of the fuel situation. Severe fires have long-term effects.

Fire Group Eleven: Warm, moist grand fir, western redcedar, and western hemlock habitat types. These are moist habitats in which fires are infrequent and often severe.

Habitat types representing ten of the twelve Fire Groups defined above occur on the Lolo National Forest. Fire Groups One and Three habitats are absent. Fire Group Five and Eight habitats occupy only a small acreage. Consequently, Fire Groups One and Three are not discussed in this report and Fire Groups Five and Eight are discussed together with Groups Six and Nine, respectively.

FIRE GROUP ZERO

MISCELLANEOUS SPECIAL HABITATS

The following special habitats account for 9 percent of the land area on the Lolo National Forest.

Scree

Scree (talus or rock debris) describes slopes covered with loose rock fragments (Fairbridge 1968). Often scree slopes are treeless, but those with finer rock can support open forest cover with sparse undergrowth. Species composition is extremely variable with ponderosa pine, Douglas-fir, western larch, spruce, alpine larch, and subalpine fir all occasionally associated with scree (Pfister and others 1977).

The lack of fuel makes scree slopes almost unburnable. Individual trees or clumps of vegetation can ignite, but fire spread is limited by discontinuous vegetation. Windswept crown fires could carry fire through this habitat, but, in actuality, scree slopes rarely burn.

Because of the lack of soil development, low site production, and low site moisture, revegetation of burned scree slopes would be slow.

Forested Rock

Forested rock is a rock face or rock outcrop that supports some conifer (and possibly hardwood) trees with sparse undergrowth. Vegetation may grow in clumps or be scattered over the rock formation. Species growing here include ponderosa pine, Douglas-fir, juniper, and alder.

Surface fire poses little threat to the plant cover because the rock component limits fire spread and may even act as a fire break. Intense fires in adjoining, contiguous forest may burn across the forested rock as spot fires or windswept crown fires.

Revegetation is slow on forested rock because of the lack of soil development, low site productivity, and low site moisture.

Meadow

Meadow vegetation in this context is herbaceous matter growing on sites that are subirrigated part or all of the growing season (On and Losensky 1977). Consequently, meadows are difficult to burn. In fact, their succulent vegetation may act as firebreaks to moderately intense fires; however, if these habitats dry out late in the growing season, they become more flammable.

Fire may reduce meadow vegetation to ground level, but species that are capable of resprouting will be little damaged. Naturally occurring fire has had a role in maintaining meadows. Fire suppression has allowed conifers to invade many of these habitats.

Grassy Bald

Grass covered openings within continuous forest comprises only 0.4 percent of the Lolo National Forest.

If the balds are green, they can act as firebreaks. If the grass is cured, then windswept fire can quickly burn across the opening into heavier fuels within the forest. In this manner, the readily ignitable, fine herbaceous fuels hamper fire suppression by augmenting fire spread.

This habitat is relatively unharmed by fire because the herbaceous vegetation resprouts readily. In fact, grassy balds would probably benefit from the nutrient increase from ash and removal of decadent foliage. Fire may also be a factor that keeps conifer regeneration from invading the openings.

Alder Glade

An alder glade is an opening in the forest vegetated by *Alnus*. The site is characteristically a mesic location (north slope, wet meadow, ravine, seepage) that is too wet for associated conifers.

Alder is moderately fire resistant because of its nonflammable bark and nonresinous leaves. Resistance is further enhanced when *Alnus* grows in thickets because the duff is cool and moist and undergrowth is sparse. In addition, its occurrence on mesic sites reduces vulnerability to fire.

Alder glades probably burn infrequently, but intensely. Fire promotes dense stands of *Alnus* because it stimulates resprouting. As with aspen, alder stands may be maintained by fire.

Fire Management Considerations

Fire managers can take advantage of the presence of Group Zero habitats when developing preattack plans and when delineating fire management areas. These areas can also serve as anchor points for fuel breaks or firebreaks.

FIRE GROUP TWO

WARM, DRY PONDEROSA PINE HABITAT TYPES

Habitat type - phase (Pfister and others 1977)	Ecoclass code (On and Losensky 1977)
Pinus ponderosa/Agropyron spicatum h.t. (PIPO/AGSP), ponderosa pine/bluebunch wheatgrass.	CP-1-130
Pinus ponderosa/Festuca idahoensis h.t.-*Festuca idahoensis* phase (PIPO/FEID-FEID), ponderosa pine/ Idaho fescue-Idaho fescue phase.	CP-1-141
Pinus ponderosa/Festuca idahoensis h.t.-*Festuca scabrella* phase (PIPO/FEID-FESC), ponderosa pine/ Idaho fescue-rough fescue phase.	CP-1-142
Pinus ponderosa/Purshia tridentata h.t.-*Agropyron spicatum* phase (PIPO/PUTR-AGSP), ponderosa pine/ bitterbrush-bluebunch wheatgrass phase.	CP-1-161
Pinus ponderosa/Purshia tridentata h.t.-*Festuca idahoensis* phase (PIPO/PUTR-FEID), ponderosa pine/ bitterbrush-Idaho fescue phase.	CP-1-162
Pinus ponderosa/Symphoricarpos albus h.t.-*Symphoricarpos albus* phase (PIPO/SYAL-SYAL), ponderosa pine/snowberry-snowberry phase.	CP-1-171

This group consists of open-grown ponderosa pine stands with predominantly grass undergrowth. These are habitats which may exist as fire-maintained grassland and which will support juniper and Douglas-fir as "accidental" individuals. In some habitat types, juniper may be a minor climax species. Sites are typically hot, dry, south- and west-facing slopes at low elevations, forming the lower timberline in the area. Slopes are often steep with poorly developed soils. During summer months, moisture stress is a critical factor for plant growth. Group Two habitat types cover only 0.1 percent of the Lolo National Forest.

Relationship of Major Tree Species to Fire

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 juniper since it 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 habit. An intense fire can kill or severely damage such a tree, but the same tree can survive a lesser surface fire. Low, spreading branches may provide a route for fire to enter the crown thereby increasing the potential for damage. Often large junipers can survive 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, subhumid environments which support limited undergrowth. When surface fuels are sparse, fire damage is minimal.

In the Lolo National Forest, juniper and ponderosa pine are the only successfully reproducing conifers in the *Pinus ponderosa* climax series. Juniper occurs as an accidental or minor climax individual.

Pinus ponderosa

Ponderosa pine has many fire-resistant characteristics. Seedlings are able to withstand high temperatures, whether from a light surface fire or from the severe thermal stress inherent in becoming established on hot, dry exposures. Early development of insulative bark and the tendency for meristems to be shielded by enclosing needles and thick bud scales contribute to this temperature resistance.

Propagation of fire into the crown is unusual because of four factors. First, 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. Second, the tendency of ponderosa pine to self-prune lower branches keeps the foliage separated from burning surface fuels. Third, the open, loosely arranged foliage does not lend itself to combustion or the propagation of flames. Fourth, the foliage has a high moisture content.

Seedling establishment is favored when fire removes the litter and exposes mineral soil. Fire resistance of the Group Two open, parklike stands is enhanced by variable 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 make the tree susceptible to fire damage and usually cause an enlargement of the scar.

Forest Fuels

Fuel loads in Group Two stands tend to be rather light when compared to stands in other fire groups. Often, the most abundant surface fuel is nonwoody, dead, or curing 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/acre (0.2 kg/m^2).

Fuel loads in dense pole and small sawtimber stands may be much higher than in the older open-type stands. Figure 1 shows a range of loadings that can exist in these young stands. Stand 24 (fig. 1A) shows a 137-year-old interior ponderosa pine stand on a *Pinus ponderosa/Festuca idahoensis* h.t.-*Festuca idahoensis* phase (PIPO/FEID-FEID), ponderosa pine/Idaho fescue-Idaho fescue phase with a fuel load of 1.1 tons/acre (0.3 kg/m^2). The fuels in this stand are primarily pine needles. Stand 72 (fig. 1B) is an 80-year-old interior ponderosa pine stand on a *Pinus ponderosa/Symphoricarpos albus* h.t.-*Symphoricarpos albus* phase (PIPO/SYAL-SYAL), ponderosa pine/snowberry-snowberry phase. Total fuel load is 16.5 tons/acre (3.7 kg/m^2), most of which is the result of natural thinning caused by competition for light and moisture. A comparison of fuel loadings by size class for these two stands is given in table 1.

Figure 1.--A range of Group Two fuel loads: A. Stand 24 is a 137-year-old ponderosa pine stand on a *Pinus ponderosa/Festuca idahoensis* h.t.-*Festuca idahoensis* phase; B. Stand 72 is an 80-year-old ponderosa pine stand on a *Pinus ponderosa/Symphoricarpos albus* h.t.-*Symphoricarpos albus* phase. See table 1 for fuel load by size class and total fuel load.

Table 1.--*Fuel loading by size class for two Fire Group Two stands (fig. 1)*

Stand number	Age	Size class (inches)						Total
		0-1/4	1/4-1	1-3	3-6	6-10	10-20	
	Years	*Tons/acre*						
24	137	0.01	0.60	0.40	0.10	0	0	1.10
72	80	0.14	2.20	4.40	5.34	2.30	2.10	16.48

Role of Fire

The PIPO habitat types are too dry to support the more mesic tree species except as accidental individuals. Consequently, fire's role is limited to three functions:

1. Maintaining grasslands. Grassland areas capable of supporting ponderosa pine may remain treeless through frequent burning.
2. Maintaining open pine stands. The open condition is perpetuated by periodic fires which reduce the number of seedlings and thin stands. Fire burning in the heavier accumulation of needle litter beneath mature trees eliminates regeneration. Also, litter and dense undergrowth covering mineral soil prevents seedling establishment.

3. Preparing a seedbed by exposing mineral soil, reducing competing vegetation, and increasing nutrient availability. Depending on the 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 comprised of various even-aged groups. Severe fires will result in a predominantly even-aged stand.

Natural fire frequencies in forests adjacent to grasslands are fairly high, according to numerous fire history studies conducted in the ponderosa pine forest types throughout the western States. These studies have shown fire to be a frequent event, occurring at intervals of from 5 to 25 years in most locations. In Group Two habitat types of the Bitterroot National Forest, Arno (1976) reported a range of 2 to 20 years and a mean fire-free interval of 10 years for fires occurring somewhere in sizeable stands (100 to 200 acres [40 to 81 hectares]). Fire history investigators caution that these figures are conservative estimates of the mean fire-free intervals. Intervening light ground fires could have effects on stand development without leaving scars on trees.

The effects of fire suppression during the 20th century on some Lolo National Forest Group Two 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 on Group Two sites in the Lolo National Forest is quite slow, and, in many cases, fire suppression has caused very little fuel buildup. In fact, on gravely south slopes, fuels are light and variable both vertically and horizontally in spite of 50 or more years without fire. Occasionally, thickets of moderate to heavy fuels do occur, but the surrounding sparse fuels and openstand structure reduce the hazard. Such areas may not be available to burn during some years simply because of a lack of fuel.

Generally, the herbaceous and shrub growth recover well after fire. Wildlife forage can be improved by burning through the elimination of old unpalatable vegetation and their replacement by nutrient-enriched regrowth. In the case of the *Pinus ponderosa/ Purshia tridentata* h.t. (PIPO/PUTR), ponderosa pine/bitterbrush, fire reduced or eliminated *Purshia tridentata* temporarily, but the plant quickly reestablished itself. With repeated burns, the undergrowth can go to grasses.

Succession Diagram

Figure 2 is a generalized succession diagram for Fire Group Two habitats. Repeated, frequent fires will maintain a predominantly herbaceous community by killing tree seedlings and favoring plants capable of root stock regeneration (fig. 2, No. 1). Grasses dominate the undergrowth, but other herbs and small shrubs may be present especially in *Pinus ponderosa/Symphoricarpos albus* h.t.'s (PIPO/SYAL), ponderosa pine/snowberry. Ponderosa seedlings may become established during an extended fire-free period or episodically following a seedbed preparing burn (fig. 2, No. 2). On dry sites, seedbed preparation may be less significant because litter cover is sparse and mineral soil is already exposed. If undisturbed, the seedlings will develop into saplings then pole-sized trees; however, a light-to-moderate fire during the seedling/sapling stage will return the site to a grass-dominated community (fig. 2, No. 3) or thin the regeneration (fig. 2, No. 4) by killing the younger and smaller pines. Local fuel situations are very important to survival of seedlings and saplings.

Over time, the pole-sized trees mature. Periodic fires during this time create an open, parklike stand (fig. 2, No. 5). Light ground fires keep the stand from becoming overcrowded because the accumulated litter and undergrowth burn hotly enough to kill most of the regeneration. Severe fires are not likely to occur in stands of pole-sized or mature trees.

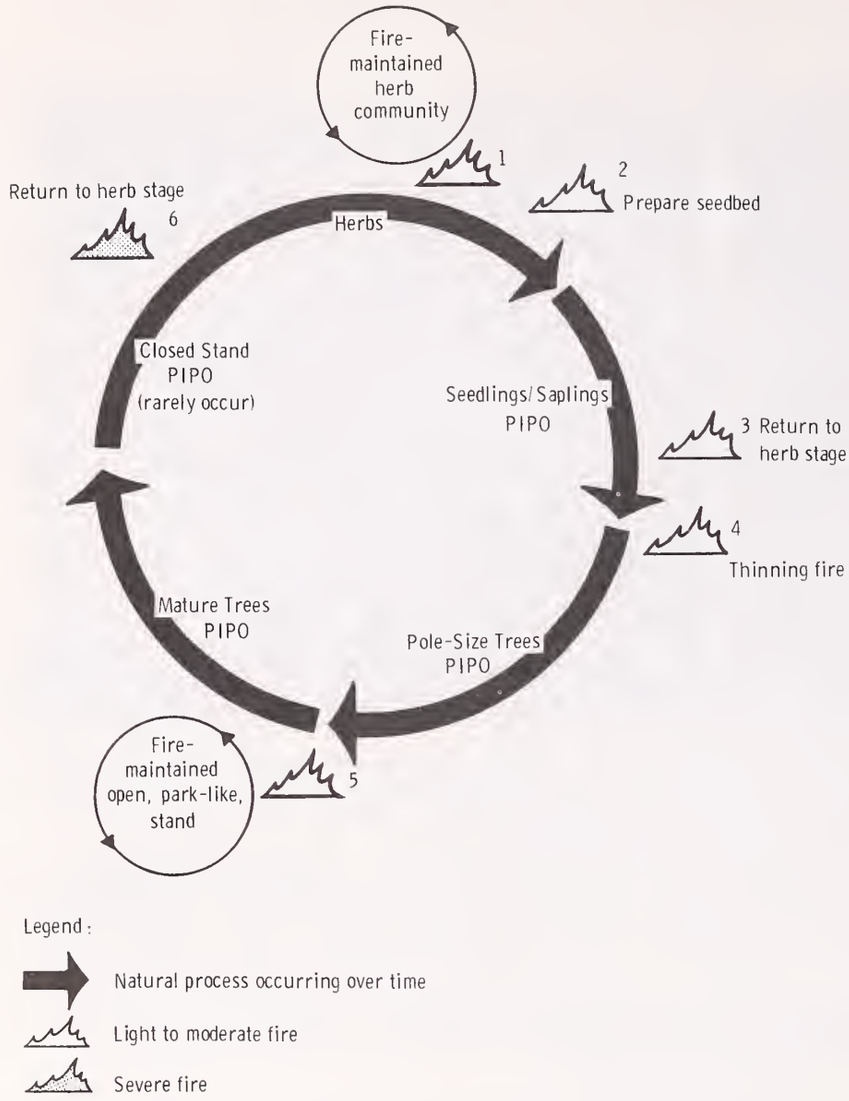


Figure 2.--Forest succession in Fire Group Two: Ponderosa pine climax series habitat types.

Long periods of successful fire suppression could, in theory, produce overstocking of these sites due to the maturation of unthinned saplings; however, other site factors are so limiting that this condition is rarely observed in the Lolo National Forest. The formation of overstocked stands and their elimination by stand-destroying fires (fig. 2, No. 6) is probably not a common, natural event in these habitat types.

Fire Management Considerations

Fire management activities should be geared to resource management objectives and stand conditions. This is especially important when using fire (Fischer 1978). Fire management activities in Group Two stands are most often designed to reduce wildfire hazard, regenerate trees, and improve forage production.

Wildfire Hazard Reduction

Prescribed fire can be used to reduce 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. In order to maintain a low level of flammability in Group Two stands, fire must be applied periodically whenever sufficient fuel accumulates to carry fire. Where heavy fuels 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 (see fire use considerations below).

Silviculture

Because seedling establishment is often difficult and growth is slow, fire should be excluded from areas while desirable ponderosa pine regeneration is present. If regeneration is absent, but desired, prescribed fire can be used to prepare seedbeds. Prescribed fire is particularly useful for removing the duff layer on *Pinus ponderosa/Symphoricarpos albus* h.t.'s (PIPO/SYAL), ponderosa pine/snowberry.

Range and Wildlife Habitat Management

Forage production for livestock and big game can be enhanced by proper application of fire on Group Two habitat types. On *Pinus ponderosa/Agropyron spicatum* h.t.'s (PIPO/AGSP), ponderosa pine/bluebunch wheatgrass and *Pinus ponderosa/Festuca idahoensis* h.t.'s (PIPO/FEID), ponderosa pine/Idaho fescue, grasses can be rejuvenated by removing dead grass and releasing stored nutrients. Fire will often result in an increased production of nutrient-rich forbs on these habitat types. On *Pinus ponderosa/Symphoricarpos albus* h.t.'s (PIPO/SYAL), ponderosa pine/snowberry, light surface fires will rejuvenate shrubs through fire-simulated sprouting and cause a temporary increase in grass and forb production. Fire may be difficult to apply on *Pinus ponderosa/Purshia tridentata* h.t.'s (PIPO/PUTR), ponderosa pine/bitterbrush where percent cover by plants is low and litter is sparse. Where it will carry, fire can be used to rejuvenate the undergrowth by killing decadent bitterbrush and thereby allowing new plants to invade the site. As a general rule, luxuriant growth of shrubs will not result from fire use on Group Two habitat types.

Fire Use Considerations

Care must be taken when burning in forest stands to prevent or minimize scorching the crowns of desired overstory trees. If heavy fuel accumulations or slash occur near the base of overstory trees lethal cambium heating must also be avoided.

Excessive crown scorch, cambium damage, or both can result in tree mortality, loss of vigor, and increased susceptibility to bark beetle attack.

For example, the relationship between crown defoliation and mortality caused by the western pine beetle (*Dendroctonus brevicomis*) in ponderosa pine has been generalized as follows (Stevens and Hall 1960):

Percent defoliation	Percent 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 the occurrence, duration, and severity of beetle attack--should one occur--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 by the fire. 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.

Another consideration concerns 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 1976).

Another very important consideration concerns 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 Mountains forest soils is based on recent work in western Montana (Harvey, Jurgensen, and Larsen 1976, 1979b; Harvey, Larsen, and Jurgensen 1976; Jurgensen, Larsen, and Harvey 1977; and Larsen, Jurgensen, and Harvey 1978).

Harvey, Larsen, and Jurgensen (1979a) offer the following general guidelines for wood management:

Within the northern Rocky Mountains, the high productivity and rapid decay rates of warm-moist forests make them less sensitive to depletion than sites with low-to-moderate productivity. However, in specific instances, managing for certain types of old growth forest may retain aspects of decayed wood conservation, even on productive sites (Franklin and others 1979). Conversely, dry- or cold-site management should emphasize conservation of large woody materials within fuel limits that do not create unacceptable wildfire risk. Such woody materials should, where possible, be left in contact with the soil to create optimum conditions for decay.

Where early access to mineral soil seedbeds is critical to reforestation, post-harvest slash treatments should be directed toward creating a mosaic of fuel dispersal. It would be advantageous to have both large woody residues and bare mineral surface scattered across the site; so seeds can germinate rapidly and seedlings have access to the nutrients, moisture, and ectomycorrhizal activity provided by decaying wood and humus. Size of both slash piles and windrows for prescribed burning should be dictated by minimum standards that will achieve adequate small fuel reduction. Soil disturbance should be minimal and not create continuous expanses of mineral surface.

Management of wood on intermediate sites is less clear. Until more data are available, they should be treated as though they are at least moderately sensitive to reduction of soil wood.

Harvey, Jurgensen, and Larsen's preliminary estimates indicate that about 10 to 15 tons of 4-inch (10-cm) diameter or larger woody material should remain on the site following logging and burning. In addition, only as much mineral soil should be bared as is necessary to obtain desired stocking. The 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.

Scattered large logs left on a site also retard soil movement and provide shade for young seedlings. Some species will not successfully regenerate without such shade.

A third reason for leaving a moderate amount of woody material of large diameter scattered over the forest floor is to assure a food source for woodpeckers, especially the pileated woodpecker (*Dryocopus pileatus*). Woodpeckers and other cavity-nesting birds also require snags, preferably scattered patches of snags, for nesting sites (McClelland and Frissell 1975; McClelland and others 1979). Fuel management programs should consider such needs.

FIRE GROUP FOUR

WARM, DRY DOUGLAS-FIR HABITAT TYPES USUALLY FIRE-MAINTAINED PONDEROSA PINE STANDS

Habitat type - phase (Pfister and others 1977)	Ecoclass code (On and Losensky 1977)
Pseudotsuga menziesii/Agropyron spicatum h.t. (PSME/AGSP), Douglas-fir/bluebunch wheatgrass.	CD-1-210
Pseudotsuga menziesii/Festuca scabrella h.t. (PSME/FESC), Douglas-fir/rough fescue.	CD-1-230
Pseudotsuga menziesii/Physocarpus malvaceus h.t.-*Calamagrostis rubescens* phase (PSME/PHMA-CARU), Douglas-fir/ninebark-pinegrass.	CD-2-262
Pseudotsuga menziesii/Symphoricarpos albus h.t.-*Agropyron spicatum* phase (PSME/SYAL-AGSP), Douglas-fir/snowberry-bluebunch wheatgrass phase.	CD-1-311
Pseudotsuga menziesii/Calamagrostis rubescens h.t.-*Agropyron spicatum* phase (PSME/CARU-AGSP), Douglas-fir/pinegrass-bluebunch wheatgrass phase.	CD-1-321
Pseudotsuga menziesii/Calamagrostis rubescens h.t.-*Pinus ponderosa* phase (PSME/CARU-PIPO), Douglas-fir/pinegrass-ponderosa pine phase.	CD-2-324
Pseudotsuga menziesii/Spiraea betulifolia h.t. (PSME/SPBE), Douglas-fir/white spiraea.	CD-2-340

Group Four consists of Douglas-fir habitat types that exist in nature as fire-maintained ponderosa pine stands and develop Douglas-fir regeneration beneath the pine in the absence of disturbance. Douglas-fir may be present in seral stands, but pine will dominate. These habitat types are too droughty for other conifer species except those occurring as accidental individuals (appendix C). These stands are generally quite open, but dense stands or thickets can occur where fire has been excluded or where good seed years have followed fire. The understory is usually sparse because of lack of moisture and consists of herbs (mainly grasses) and occasional patches of ninebark and serviceberry. Group Four habitat types cover 10 percent of the Lolo National Forest.

Relationship of Major Tree Species to Fire

Juniperus scopulorum

Juniper has the same relation to fire in Group Four as it does in Group Two. The species occurs only in two habitat types as an accidental or minor climax tree (appendix C).

Pinus ponderosa

The major effect that fire has on ponderosa pine in this group is the elimination of competing species, particularly Douglas-fir. In this group of habitat types, ponderosa's fire-resistant characteristics give it a competitive advantage over Douglas-fir.

Pseudotsuga menziesii

Mature Douglas-fir is a fire-resistant tree; however, saplings are vulnerable to surface fires because of their thin bark, resin blisters, closely spaced inflammable needles, and thin 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 bark that provides protection against low-to-medium intensity fires. The development of "gum cracks" in the lower trunk that streak the bark with resin, can provide a mechanism for serious fire injury. Douglas-fir does occur in open-grown stands, but more often it grows in denser stands with continuous fuels underneath. As with ponderosa pine, heavy fuel accumulations at the base of the tree increase the probability of fire injury. Also, resin deposits usually enlarge old scars.

Douglas-fir regeneration is favored by fire, which reduces vegetation cover and exposes mineral soil so shallow taproots of seedlings can take hold. Also, the increased sunlight enhances rapid growth. On dry sites, too much exposure can retard conifer vegetation.

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 Group Four stands that were sampled was about 11 tons/acre (2.5 kg/m^2), with a range of from 2 to 30 tons/acre (0.5 to 6.7 kg/m^2). As a very general rule, fuel loads tend to increase with stand age as a result of accumulated downfall from insect and disease damage, blowdown, and natural thinning. Stands of the same age may have widely different fuel loads, however. This is especially true in dense, young stands where heavy mortality from natural thinning can cause rapid fuel accumulation.

The different types of Group Four fuel situations likely to be encountered are shown in figure 3 and listed in table 2. All of these ponderosa pine stands are growing on a *Pseudotsuga menziesii/Physocarpos malvaceus* h.t.-*Calamagrotes rubescens* phase (PSME/PHMA-CARU), Douglas-fir/ninebark-pinegrass.

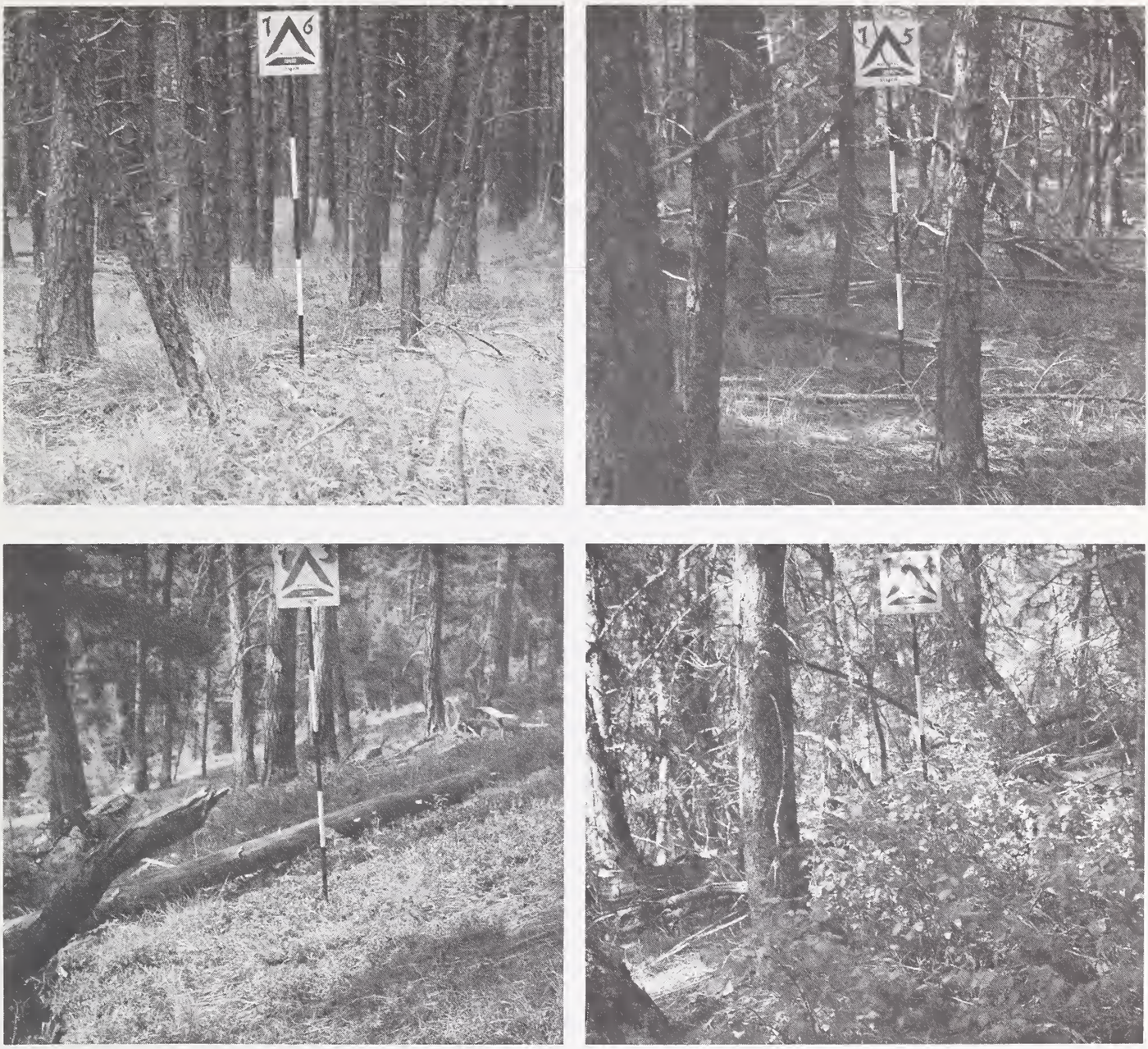


Figure 3.--Examples of Group Four fuel loads on a *Pseudotsuga menziesii/Physocarpus malvaceus* h.t.-*Calamagrostis rubescens* phase. Stand age, total fuel load, and fuel load by size class are given in table 2.

Table 2.--*Fuel loading by size class for four Fire Group Four stands (fig. 2)*

Stand number	Age	Size class (inches) 0-1/4	1/4-1	1-3	3-6	6-10	10-20	20+	Total
	Years	*Tons/acre*							
76	60	0.14	0.90	0.80	0.64	0.13	0	0	2.61
75	65	0.47	1.40	4.60	3.05	0.50	0.70	0	10.72
73	172	0.45	1.00	1.10	1.76	5.64	1.47	0	11.42
74	173	0.89	1.70	3.60	3.96	4.50	1.83	3.70	20.18

Stand 73 (fig 3) is a ponderosa pine stand that represents the average fuel load for Group Four stands. It has a load of 11.4 tons/acre (2.6 kg/m^2), most of which is the result of accumulated downfall of material larger than 3 inches (7.6 cm) in diameter (table 2).

The relationship between stand condition and fuel load is shown by stands 76 and 75 (fig 3). Both stands are 60-year-old ponderosa pine stands on a *Pseudotsuga menziesii/Physyocarpus malvaceus* h.t.-*Calamagrostis rubescens* phase. These stands are growing within one-half mile (0.8 km) of each other in the same drainage. Downfall from natural thinning has made the difference between a fuel load of 2.6 tons/acre (0.6 kg/m^2) in stand 76 and 10.7 tons/acre (2.4 kg/m^2) in stand 75 (table 2).

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 situation is shown in stand 74 (fig. 3), a 173-year-old ponderosa pine stand with a 60-year-old Douglas-fir understory. The fuel load in this stand is 20.2 tons/acre (4.5 kg/m^2).

Role of Fire

Fire in the Douglas-fir climax series habitat types of Group Four maintains grasslands, opens up stands, and prepares seedbeds (see Group Two), but there are additional effects:

1. Frequent fires in seral pine stands can prevent the establishment of Douglas-fir creating a "fire climax." In this role, fire frequency largely determines the stand composition.
2. Following a prolonged fire-free period Douglas-fir regeneration becomes established beneath the canopy. A ground or surface fire that reaches a thicket of saplings and small poles can ascend into the overstory, killing or injuring adjacent mature trees through the vegetative "fuel ladder." Fuel ladders increase the potential destructiveness of a fire by providing access to the canopy. During periods of high fire danger, this can result in a stand-destroying crown fire.

Historic fire frequency in Group Four habitat types probably is not very different from that of Group Two, that is, about 10 years beyween fires. Successful suppression of surface fires in open, fire-maintained ponderosa pine stands over the last few decades has altered the sites toward a severely overstocked and highly flammable condition that has increased the fire potential.

Succession Diagram

The accompanying diagram (fig. 4) represents the effects of fire in Group Four. Frequent burning will maintain a shrub and herb community in which individual conifers may be present (fig 4, No. 1). The exclusion of fire will permit the establishment initially of ponderosa pine and then of Douglas-fir. Conifer seedlings also may become established following a burn (fig. 4, No. 2), but this effect of fire can be of minor importance where seedling establishment is not hindered by ground cover. A light-to-moderate intensity fire during the seedling/sapling stage will recycle the vegetation to the shrub/herb stage (fig. 4, No. 3) or thin the conifers (fig. 4, No. 4) by killing the smaller and younger trees.

A stand of pole-size trees becomes established with time. A severe fire at this stage returns the stand to an earlier phase of development (fig. 4, No. 5). The likelihood of a severe fire increases with suppression mortality and fuel ladders. Naturally occurring, moderate intensity fires favor the establishment of young ponderosa pines rather than a pine/Douglas-fir mixture (fig. 4, No. 6). This is due to the greater fire tolerance of young pine and its superior ability to occupy burned sites. Subsequent fires will maintain an open, parklike ponderosa stand by thinning the understory and favoring ponderosa.

In the absence of fire, the mixed seedlings develop into a stand of mature trees, in which Douglas-fir will tend to replace the ponderosa pine if given sufficient time. Ground fires through the mixed stand will not harm mature specimens of either species, but will tend to keep the stand open and discourage regeneration (fig. 4, No. 7). Periodic fires will tend to favor a pine understory.

Without fire, Douglas-fir regeneration quickly appears beneath the overstory and in time creates a fuel ladder situation that often precedes stand-destroying fires in these types. High intensity fires in mature stands (fig. 4, No. 8) or climax Douglas-fir stands (fig. 4, No. 9) will revert the site to the earliest vegetation stage. A climax Douglas-fir forest is not likely to be achieved in this group because of the prolonged fire-free period necessary for its development.

Fire Management Considerations

Fire management considerations and opportunities for Group Four stands involve hazard reduction, seedbed preparation, control of species composition, safeguarding recreation sites, improving wildlife habitat, and enhancing esthetic values.

Wildfire Hazard Reduction

In the absence of fire, hazardous fuel situations often develop in Group Four stands. Ablaze, the combination of dense Douglas-fir (or ponderosa pine) understories, accumulated deadfall, decadent shrubs, and other accumulated litter and debris can produce fires intense enough to scorch the crowns and kill the cambium of overstory trees. Although they were developed in western larch--Douglas-fir forests (fire Groups Five and Six), Norum's (1977) guidelines can be used to write fire prescriptions 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 in Group Four stands. Most fire prescriptions can be writen so as to accomplish silvicultural, range, and wildlife objectives as well as hazard reduction.

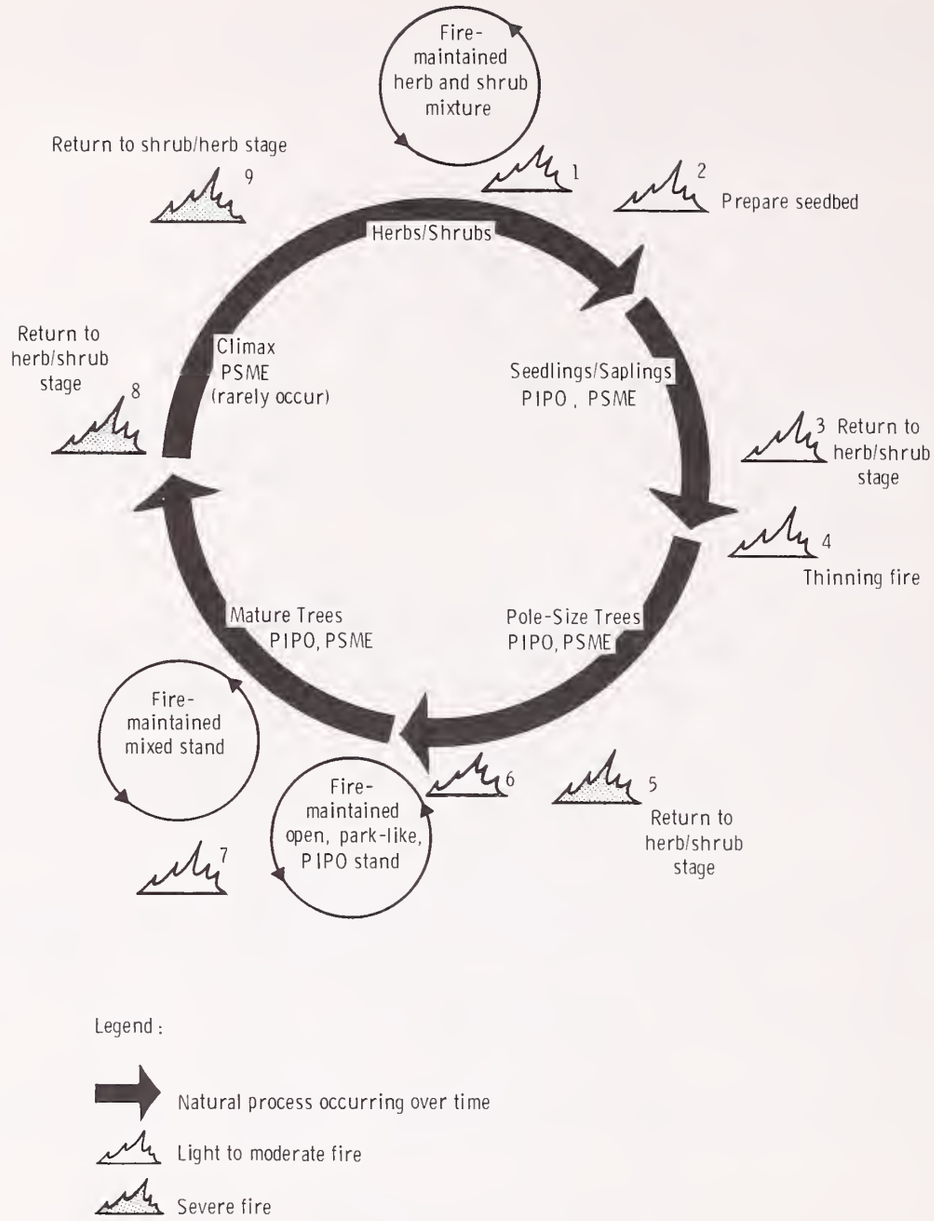


Figure 4.--Forest succession in Fire Group Four: fire-maintained ponderosa pine stands in Douglas-fir climax series habitat types.

More than one fire entry may be necessary to reduce hazard to an acceptable level in some stands. An example might be stands with a dense Douglas-fir understory that has been severely damaged by spruce budworm defoliation. Once an acceptable level of hazard has been accomplished, it can be maintained by periodic burning.

Prescribed fire can also be used to maintain shaded fuel breaks in a fuel-free condition.

Silviculture

Where timber management is the objective, fire can be used to dispose of slash, prepare seedbeds, control species composition, and to reduce the probability of stand-destroying wildfires. Ponderosa pine is often a favored timber species on Group Four habitat types. If this is the case, 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 that there be an adequate number of trees 10 to 12 ft (3-3.7 m) tall before regular prescribed burning begins, although low intensity fires will leave trees 6 to 8 ft (1.8-2.4 m) tall unharmed. Larger Douglas-fir trees will also survive most low intensity surface fires; so there need be no concern about completely eliminating Douglas-fir from the stand. Where butt rot is common on overstory Douglas-fir, however, 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 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 fire 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).

Recreation and Esthetics

Prescribed fire can be used to fireproof the areas immediately adjoining campgrounds. Such treatment not only reduces fire hazard, but also improves viewing and travel from the campground to the surrounding forest.

A similar use of fire is for fireproofing and improving esthetic values along travel routes. An example from the Lolo National Forest would be the use of fire along the Lolo Trail, not only to reduce wildfire hazard, but, more importantly, to preserve the historical scene of an open forest with large ponderosa pine trees.

Fire Use Considerations

The considerations regarding fire use identified in the discussion of fire management considerations for Fire Group Two habitat types also apply here.

FIRE GROUP FIVE

COOL, DRY DOUGLAS-FIR HABITAT TYPES

Habitat type - phase (Pfister and others 1977)	Ecoclass code (On and Losensky 1977)
Pseudotsuga menziesii/Festuca idahoensis h.t. (PSME/FEID), Douglas-fir/Idaho fescue.	CD-1-220
Pseudotsuga menziesii/Carex geyeri h.t. (PSME/CAGE), Douglas-fir/elk sedge.	CD-3-330

FIRE GROUP SIX

MOIST, DOUGLAS-FIR HABITAT TYPES

Habitat type - phase (Pfister and others 1977)	Ecoclass code (On and Losensky 1977)
Pseudotsuga menziesii/Vaccinium caespitosum h.t. (PSME/VACA), Douglas-fir/dwarf huckleberry.	CD-2-250
Pseudotsuga menziesii/Physocarpus malvaceus h.t.- *Physocarpus malvaceus* phase (PSME/PHMA-PHMA), Douglas-fir/ninebark-ninebark phase.	CD-2-261
Pseudotsuga menziesii/Vaccinium globulare h.t.- *Vaccinium globulare* phase (PSME/VAGL-VAGL), Douglas-fir/blue huckleberry-blue huckleberry phase.	CD-3-281
Pseudotsuga menziesii/Vaccinium globulare h.t.- *Arctostaphylos uva-ursi* phase (PSME/VAGL-ARUV), Douglas-fir/blue huckleberry-kinnikinnick phase.	CD-2-282
Pseudotsuga menziesii/Vaccinium globulare h.t.- *Xerophyllum tenax* phase (PSMA/VAGL-XETE), Douglas-fir/blue huckleberry-beargrass phase.	CD-2-283
Pseudotsuga menziesii/Linnaea borealis h.t.- *Symphoricarpos albus* phase (PSME/LIBO-SYAL), Douglas-fir/twinflower-snowberry phase.	CD-5-291
Pseudotsuga menziesii/Linnaea borealis h.t.- *Calamagrostis rubescens* phase (PSME/LIBO-CARU), Douglas-fir/twinflower-pinegrass phase.	CD-5-292
Psuedotsuga menziesii/Linnaea borealis h.t.- *Vaccinium globulare* phase (PSME/LIBO-VAGL), Douglas-fir/twinflower-blue huckleberry phase.	CD-5-293
Pseudotsuga menziesii/Symphoricarpos albus h.t.- *Calamagrostis rubescens* phase (PSME/SYAL-CARU), Douglas-fir/snowberry-pinegrass phase.	CD-2-312
Pseudotsuga menziesii/Symphoricarpos albus h.t.- *Symphoricarpos albus* phase (PSME/SYAL-SYAL), Douglas-fir/snowberry-snowberry phase.	CD-2-313
Pseudotsuga menziesii/calamagrostes rubescens h.t.- *Arctostaphylos uva-ursi* phase (PSME/CARU-ARUV), Douglas-fir/pinegrass-kinnikinnick phase.	CD-2-322
Pseudotsuga menziesii/Calamagrostis rubescens h.t.- *Calamagrostis rubescens* phase (PSME/CARU-CARU), Douglas-fir/pinegrass-pinegrass phase.	CD-3-323

Group Five and Six habitat types are those that will support substantial amounts of Douglas-fir even under the influence of periodic natural burning. Douglas-fir is the indicated climax species as well as a vigorous member of most seral communities. Ponderosa pine, western larch, and lodgepole pine are seral components whose abundance varies considerably by phase, that is, accidental to major seral (appendix C) (Pfister and others 1977). For Group Six habitat types having seral communities dominated by lodgepole pine, the reader should also refer to Fire Group Seven. The undergrowth consists of herbs and low shrubs.

At low elevations, Group Five and Six sites can be found on all aspects. As elevation increases (and on cooler or moister sites), ponderosa pine becomes less important and larch and lodgepole pine increase. Group Five and Six habitat types together cover 29 percent of the Lolo National Forest.

Relationship of Major Tree Species to Fire

Pinus ponderosa

Fire's role as a seedbed-preparing agent is important to the success of ponderosa pine in Group Six. The higher productivity of these sites, as compared with Groups Two and Four, creates more duff and more aggressive undergrowth competition. It is doubtful that ponderosa would be able to regenerate successfully in these habitat types without periodic ground fires to remove duff and thin the understory and undergrowth. Ponderosa may form pure or nearly pure stands depending on fire history and available seed source. Ponderosa pine is essentially absent on Group Five habitat types on the Lolo National Forest.

Ponderosa pine is more vulnerable to crown damage in Group Six because the surrounding mixture of uneven-aged conifers creates a fuel ladder that can carry fire into the top of the pine. The density of some stands promotes wind-driven crown fires.

Pseudotsuga menziesii

Douglas-fir is much more aggressive in these groups than in Group Four because of increased seedling survival in the cool, moist ground-level microhabitat. Douglas-fir is the climax species and is favored by protection from fire. Absence of fire results in a dense understory of fir saplings that compete with one another for light and with mature overstory trees for moisture. Nearly pure stands of fir can result from fire exclusion. Douglas-fir is often the only tree found on Group Five habitat types on the Lolo National Forest.

Dense sapling thickets can form an almost continuous layer of flammable foliage about 10 to 26 ft (3 to 8 m) above the 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.

Larix occidentalis

Western larch is similar to ponderosa pine in that it possesses a thick, fire-resistant bark and has a tendency to self-prune its lower branches. Light-to-moderate ground fires, therefore, have little effect on mature larch. Even young seedlings will often survive high temperatures for short durations.

Since larch is a shade-intolerant species, a disturbance such as fire is essential for removing competing vegetation and creating a mineral soil seedbed. The light, winged seeds of western larch are readily dispensed across newly burned areas.

Larch's deciduous nature makes it unusually resistant to crown scorch injury. Since larch grows a new crop of needles annually, defoliation is not as great a hardship for it as for conifers that retain their needles for 3 or more years.

In Group Six stands, larch shares with ponderosa pine the role of a pioneer invader, but it usually appears as a minor seral element associated with pine. In the more mesic habitat types, larch replaces ponderosa pine to some extent.

Larch and lodgepole pine frequently occupy the same role as seral species. Since larch lives longer and grows taller, it eventually surpasses the lodgepole component.

Pinus contorta

Lodgepole pine is well known for its role as a fire-follower. Although moderately resistant to fire injury, many lodgepole pines bear serotinous cones that will not open to release their seeds until after heat treatment. Following a stand-destroying fire, this reseeding capacity gives lodgepole pine a substantial advantage over other tree species in getting established on the site. Rapid growth and the ability to set seed while still in the sapling stage help it to maintain dominance.

In Group Six, lodgepole pine is generally confined to the role of a minor seral component because it is readily "shaded-out" by maturing Douglas-fir and larch. Typically, lodgepole appears within 30 years after a fire and is shaded-out roughly a century later (50 to 200 years).

Lodgepole regeneration frequently takes the form of closely spaced "doghair" thickets. Such thickets are very susceptible to fire damage because of the density of saplings, flammable foliage, thin resinous bark, and down and dead fuels. Lodgepole can become a fire climax stand under these conditions, because regeneration naturally favors another lodgepole thicket.

Forest Fuels

Fuel loads measured in Fire Group Five and Six stands ranged from about 1 ton/acre to over 75 tons/acre (0.2 to 16.8 kg/m^2). Within this range three rather distinct levels of loading can be recognized. For the purpose of this discussion, these levels have been identified as light, medium, and heavy.

Light Fuel Loads

An average load of about 3 tons/acre (0.7 kg/m^2) and a range of from 1 to 6 tons/acre (0.2 to 4.5 kg/m^2) characterizes the light loadings in Fire Group Five and Six stands. Fuels in these stands consist almost entirely of scattered twigs and branchwood less than 3 inches (7.6 cm) in diameter. Larger materials rarely account for more than 1 ton/acre (0.2 kg/m^2). Figure 5 shows such situations on the Lolo National Forest.

Figure 5.--Examples of light fuel loads in Group Five and Six stands. Stand 43 is a Douglas-fir stand on a *Pseudotsuga menziesii/Vaccinium globulare* h.t.-*Xerophyllum tenax* phase (PSME/VAGL-XETE), Douglas-fir/blue huckleberry-beargrass phase. Stand 71 is a western larch/Douglas-fir stand on a *Pseudotsuga menziesii/Physocarpos malvaceus* h.t.-*Psycocarpos malvaceus* phase (PSME/PHMA-PHMA), Douglas-fir/ninebark-ninebark phase. Total load of down woody fuel, load by size class, and stand age are shown in table 3.

Medium Fuel Loads

Medium fuel loads range from 6 to 20 tons/acre (1.4 to 4.5 kg/m^2) with 12 tons/acre (2.7 kg/m^2) being average. Materials larger than 3 inches (7.6 cm) in diameter usually account for more than half the total load. Scattered deadfalls that accumulate over the life of the stand are the most abundant fuels except where heavy downfall from natural thinning is a factor. Figure 6 shows four examples of medium fuel loads in Group Five and Six stands.

Heavy Fuel Loads

Heavy loads in Group Five and Six stands average about 39 tons/acre (8.7 kg/m^2), but range from about 20 tons/acre to over 75 tons/acre (4.5 kg/m^2 to 16.8 kg/m^2). Examples of heavy fuel loads are shown in figure 7.

Figure 6.--Examples of medium fuel loads for Group Five and Six stands. Stand 49 is a Douglas-fir stand on a *Pseudotsuga menziesii/Calamagrostis malvaceus* h.t.-*Calamagrostis rubescens* phase (PSME/CARU-CARU), Douglas-fir/pinegrass-pinegrass phase. Stand 77 is a ponderosa pine/western larch/Douglas-fir stand on a *Pseudotsuga menziesii/Calamagrostis rubescens* h.t.-*Artostaphylos uva-ursi* phase (PSME/CARU-ARUV), Douglas-fir/pinegrass-kinnikinnick phase. Stand 85 is a lodgepole pine stand on a *Pseudotsuga menziesii/Vaccinium globulare* h.t.-*Xerophyllum tenax* phase (PSME/VAGL-XETE), Douglas-fir/blue huckleberry-beargrass phase. Stand 86 is a Douglas-fir stand on a *Pseudotsuga menziesii/Physocarpus malvaceus* h.t.-*Pysocarpus malvaseus* phase (PSME/PHMA-PHMA), Douglas-fir/ninebark-ninebark phase. Total fuel loads, loading by size class, and stand age are given in table 3.

Figure 7.--Examples of heavy fuel loads in Group Five and Six stands. Stand 6 is a lodgepole pine stand, stand 48 is a Douglas-fir stand, and stand 28 is a western larch/Douglas-fir stand. All are on a *Pseudotsuga menziesii/Vaccinium globulare* h.t.-*Xerophyllum tenax* phase (PSME/VAGL-XETE), Douglas-fir/blue huckleberry-beargrass phase. Total fuel load, loading by size class, and stand age are shown in table 3.

Table 3.--*Fuel loading by size class for nine Fire Group Five and Six stands (fig. 5 to 7)*

Stand number	Age	Size class (inches) 0-1/4	1/4-1	1-3	3-6	6-10	10-20	20+	Total
	Years	*Tons/acre*							
43	85	0.44	1.20	0.80	0.50	0	0	0	1.38
71	75	0.48	1.90	2.10	0.83	0	0	0	5.31
49	295	0.36	0.90	1.20	0.55	1.00	3.71	0	7.22
77	190	0.08	0.50	0.80	0.12	2.04	8.77	0	12.31
85	70	0.45	1.90	4.30	0.20	1.61	4.22	0	12.68
86	65	0.77	1.80	3.70	0.39	7.52	1.99	0	16.17
6	80	0.32	0.80	0.70	0.84	1.11	0	0	28.23
48	190	0.22	1.10	1.90	3.30	14.55	17.42	3.52	42.01
28	100	0.27	1.50	4.30	12.23	17.01	2.01	36.63	73.95

Role of Fire

Fire appears to be important in Groups Five and Six as a seedbed-preparing and stand-thinning agent. Fire favors the pioneer species ponderosa pine, lodgepole pine, and western larch in Group Six. In stands that have escaped regular ground fires for several decades, flames can climb through the Douglas-fir understory into the overstory, developing into a crown fire or torching the canopy.

Fire has a demonstrable effect on wildlife habitat in these Groups through its effects on food plants. An important species in some habitat types is *Vaccinium globulare* (blue huckleberry). Light burning in the early spring stimulates huckleberry to produce more shoots. Late summer or fall burning, however, reduces the number of huckleberry plants since it tends to be more intense. Because of heavy use by grouse, bear, deer, and elk, spring burning is preferred in areas designated for wildlife habitat.

The historical frequency of fire in a group of stands similar to those found in Groups Five and Six was given by Arno (1976). The mean interval of fire occurring somewhere in sizeable stands (100 to 200 acres; 40 to 81 hectares) was about 28 years with a range of 5 to 67 years during the two centuries from 1700 to 1900.

Succession Diagram

A comparison of figure 3 with figure 8 shows that succession in Groups Five and Six habitat types is very similar to that of Group Four. Ponderosa pine is followed by lodgepole pine and western larch as seral species.

Secondary succession in Groups Five and Six begins with a mixture of shrubs and herbs. Conifer seedlings may be a minor component of this stage. Frequent fires will maintain a predominant shrub and herb community by killing conifer regeneration (fig. 8, No. 1). Tree seedlings may become established in the seedbed created by fire (fig. 8, No. 2) or germinate on the site during a prolonged period without disturbance. Conifers appearing in this stage will depend on the seed source, but, generally, there will be at least two species represented especially in Group Six. Because Douglas-fir is more aggressive in these habitat types than in Group Four, it is often found in young stands.

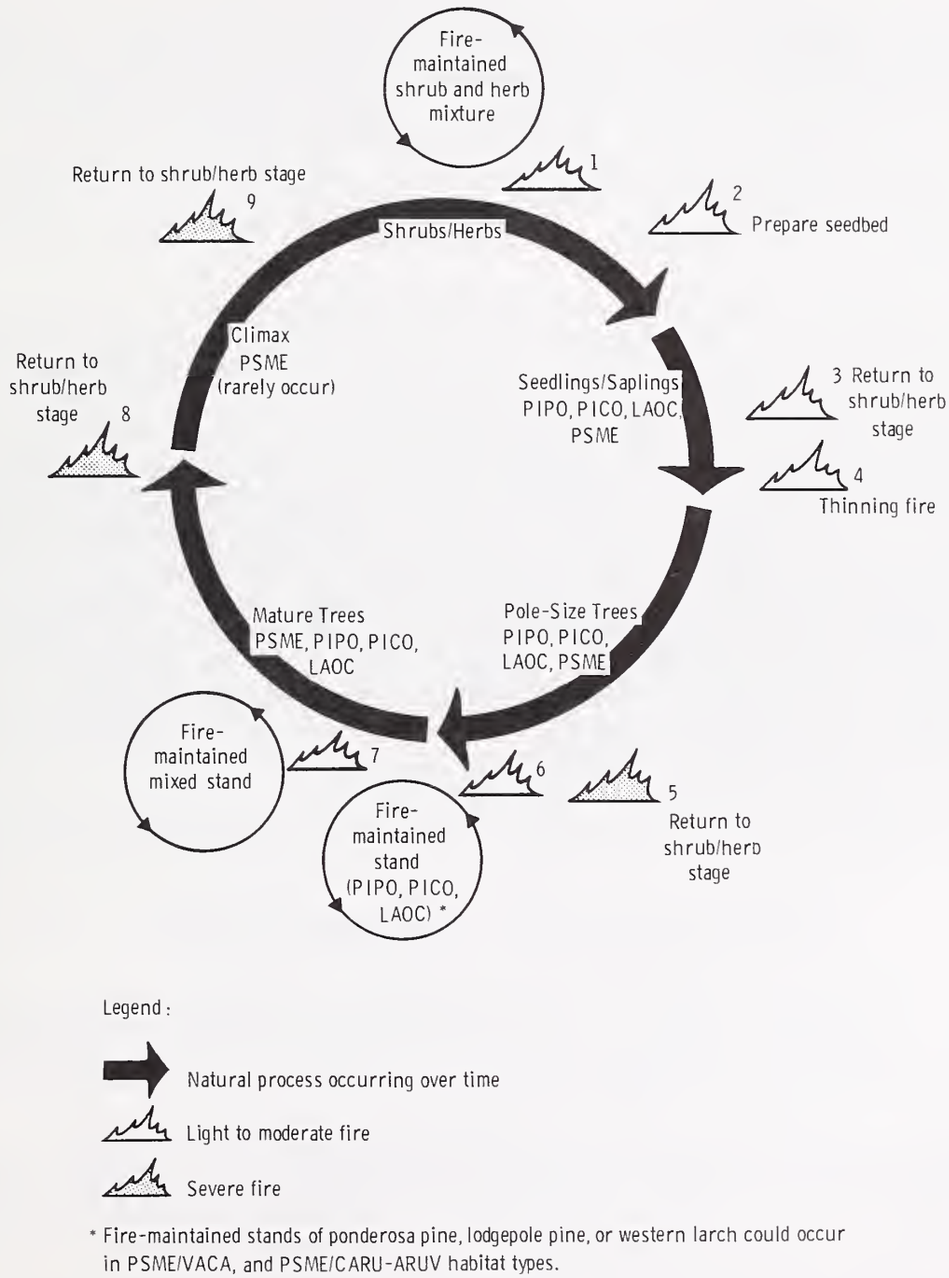


Figure 8.--Forest succession in Fire Groups Five and Six: Douglas-fir climax series habitat types dominated by Douglas-fir.

A fire occurring during the seedling/sapling stage will have the same effect it would have had in previous groups. The vegetation will be returned to a shrub/herb community (fig. 8, No. 3) or the regeneration will be thinned (fig. 8, No. 4). More continuous ground fuels occurring in these habitats increase the probability of more complete burns.

When the trees are pole size, a severe fire could destroy the stand (fig. 8, No. 5). Site productivity is moderate-to-high in Group Five and Six habitats, and dense stands do develop. Fuel ladders and suppression mortality increase the potential destructiveness of fire during this successional stage.

Ground and surface fires of lower intensity maintain open seral stands. In some of the habitat types [*Pseudotsuga menziesii/Vaccinium caespitosum* h.t. (PSME/VACA), Douglas-fir/dwarf huckleberry and *Psuedotsuga menziesii/Calamagrostis rubescens* h.t.-*Arctostaphylos uva-ursi* phase (PSME/CARU-ARUV), Douglas-fir/pinegrass-kinnikinnick phase], ponderosa, lodgepole, and/or larch may be dominant (fig. 8, No. 6). In the other habitats where Douglas-fir is more aggressive, the fir will usually dominate a mixture of the seral trees (fig. 8, No. 7). The species composition largely depends upon the seed source and the influence of past fires.

Long periods without fire can result in the establishment of a dense Douglas-fir understory that can act as a fuel ladder to the overstory. A severe, stand-destroying fire in a closed mature stand will recycle the site to a shrub/herb stage (fig. 8, No. 8).

A climax forest composed only of Douglas-fir is not likely to occur in the Group Six habitat types where ponderosa, lodgepole, and larch are prominant components, primarily because the interval between fires is shorter than the life span of seral trees. However, in Group Five and some Group Six stands, notably on *Pseudotsuga menziesii/Physocarpus malvaceus* h.t.-*Physocarpus malvaceus* phase (PSME/PHMA-PHMA), Douglas-fir/ninebark-ninebark phase and *Pseudotsuga menziesii/Calamagrostis rubescens* h.t.-*Calamagrostis rubescens* phase (PSME/CARU-CARU), Douglas-fir/pinegrass-pinegrass phase often achieve near-climax status because Douglas-fir is the only important tree even in early succession. Intervening fires are generally light-to-moderate and do not disrupt succession. A stand-destroying fire in a climax stand would return the vegetation to a shrub/herb-dominated community (fig. 8, No. 9).

Huckleberry can be stimulated by light burning that leaves most of the duff, or it can be temporarily reduced by a moderate fire that burns down to mineral soil.

Fire Management Considerations

Opportunities for using prescribed fire (planned ignition) to accomplish management objectives are probably greater in Group Five and Six habitat types than in any others. Often, a single fire prescription can be written to accomplish a variety of management objectives with the same fire.

Fire management opportunities fall within four general categories: wildfire hazard reduction, silviculture, range and wildlife habitat management, and recreation and esthetics.

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 probability of surface fires of high intensity by reducing the accumulated woody debris on the forest floor or the slash resulting from logging activities. Similarily, crown fire potential can be reduced by using fire to remove dense understories or patches of shrub and tree regeneration. Norum's (1977) guidelines should be used to write fire prescriptions for safely reducing wildfire hazard in Group Five and Six stands.

Fire might also be useful for reducing hazard in thinning slash if ponderosa pine and western larch leave trees are about 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. Several entries with fire might be necessary to safely reduce hazard to acceptable limits in heavily thinned stands.

Where shaded fuel breaks have been installed, 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. Norum's (1977) prescribed fire guidelines 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 (*Calamagrostis rubescens*) and elk sedge (*Carex geyeri*) 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 in some Group Five and Six habitat types. Light and medium intensity surface fires will result in increased density and nutrient content of blue huckleberry (*Vaccinium globulare*) 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 *Vaccinium* 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 conifer reproduction and shrubs such as snowbrush ceanothus (*Ceanothus velutinus*).

In slash areas, fire will often result in a tremendous increase in the abundance of palatable shrub species that were present in the preburn stand along with conifer seedlings. A similar situation will usually follow stand replacement wildfires. Grass and forb production will be increased tremendously in both these situations.

Fire Use Considerations

The considerations regarding fire use identified in the discussion of fire management considerations for Fire Group Two also apply here.

When planning fire use in Group Five and Six habitat types, fire managers should use the results and recommendations reported by DeByle (1976), Miller (1977, 1978), Stark (1977), Stark and Steele (1977), Norum (1976, 1977), Beaufait and others (1977), Packer and Williams (1976), Shearer (1975), Packer (1973), and Steele and Beaufait (1969). All of the studies reported in these publications were conducted in Group Five and Six habitat types on or near the Lolo National Forest. Fire managers should pay particular attention to the differences in fire response between northerly and southerly exposures, especially as they relate to vegetation development and erosion potential. 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

Habitat type - phase (Pfister and others 1977)	Ecoclass code (On and Losensky 1977)
Picea/Linnaea borealis h.t. (PICEA/LIBO), spruce/twinflower.	CE-5-470
Abies lasiocarpa/Vaccinium caespitosum h.t. (ABLA/VACA), subalpine fir/dwarf huckleberry.	CS-4-640
Abies lasiocarpa/Calamagrostis canadensis h.t.- *Vaccinium caespitosum* phase (ABLA/CACA-VACA), subalpine fir/bluejoint-dwarf huckleberry phase.	CS-7-654
Abies lasiocarpa/Linnaea borealis h.t.- *Vaccinium scoparium* phase (ABLA/LIBO-VASC), subalpine fir/twinflower-grouse whortleberry phase.	CS-4-663
Abies lasiocarpa/Xerophyllum tenax h.t.- *Vaccinium scoparium* phase (ABLA/XETE-VASC), subalpine fir/beargrass-grouse whortleberry phase.	CS-4-692
Abies lasiocarpa/Vaccinium globulare h.t. (ABLA/VAGL), subalpine fir/blue huckleberry.	CS-4-720

Group Seven is composed of habitats which, regardless of theoretical climax species, are usually dominated by lodgepole pine because of the fire regimen (Pfister and others 1977, appendixes B and C-1). The group is intended to include sites where lodgepole is a "dominate seral," as well as those where it is a "persistent" dominant. In *Picea/Linnaea borealis* (PICEA/LIBO), spruce/twinflower and *Abies lasiocarpa/Vaccinium globulare* (ABLA/VAGL), subalpine fir/blue huckleberry habitat types, Douglas-fir can be a major seral species (appendix C). Only 0.5 percent of the Lolo National Forest is covered by these habitat types.

Relationship of Major Tree Species to Fire

Pinus contorta

Two effects of fire on lodgepole pine stands are markedly important in Group Seven. First, light-to-moderate intensity ground fire thins the understory and prepares a mineral bed for the seeds released from serotinous cones. In some cases, the frequency of fire prevents the successful establishment of more shade-tolerant species, such as Douglas-fir, spruce, and subalpine fir.

Second, lodgepole forests of this group seem to invite stand-destroying wildfires. Mountain pine beetle epidemics can create enormous amounts of downfall and standing snags. Down and dead wood provide abundant fuel for an intense fire. Wind-driven crown fires cause stand replacement over large areas. Abundant seed supplies after such fires, provided by lodgepole's serotinous cones, virtually assure that recovery will be dominated by lodgepole. Often the result is very densely stocked, even-aged stands.

Thus, fire insures perpetuation of the lodgepole pine forest, maintaining a "fire climax" community.

The conditions under which lodgepole pine forests develop may vary considerably and the precise mechanisms may differ from one site to another, but the net effect is similar. Aside from serotinous cones, other silvical characteristics that contribute to establishment success are seed viability, germination energy, rapid growth, seedling survival in a wide array of microsites, and prolific seed production, that is, having good crops at 1- to 3-year intervals. These features enable lodgepole to gain early dominance.

In some forested regions, not including the Lolo National Forest, self-regenerating stands of lodgepole pine occur in habitats unsuitable for other conifers. These situations usually represent special conditions of edaphic features and/or topographic features (such as frost pockets, nightly accumulations of cold air, and subalpine climate). These areas do not frequently burn because widely spaced trees, low fuel levels, low, scattered undergrowth, and gentle slopes create situations unfavorable for fire spread. Cones are nonserotinous and so do not require a heat treatment for seed dispersal.

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, high foliage flammability, and moderate-to-high stand density in mature forests. As a result, fire most often acts as an agent of replacement when it burns through a subalpine fir stand. Even light ground fires have the potential of cooking the cambium or of spreading into the ground-hugging branches up into the crown.

Subalpine fir can occur in the initial stand with lodgepole pine because it germinates successfully on a fire-prepared seedbed; however the fir is a minor component, and is slower growing, and therefore, is not as conspicuous as the pine. If forest succession is undisturbed, the fir will eventually take over the site because it germinates and grows in shade. Subalpine fir can occur in the initial stand or invade during a later successional stage.

Picea engelmannii

Although slightly less susceptible to fire damage than subalpine fir, Engelmann spruce does succumb easily to 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. Older trees that have deep accumulations of litter around their bases are particularly susceptible. The season of high fire risk is comparatively short, however, in the generally cool and moist habitats where spruce grows.

Even though spruce is considered a late succession species, seedlings have been observed as members of the fire-initiated stand with lodgepole. With time and without disturbance, spruce slowly dominates the stand as conditions become unsuitable for pine. This may be a temporary phase on sites where subalpine fir is the true potential climax dominant.

Forest Fuels

Available fuel data show a range of fuel loading from 3.5 tons/acre to 35 tons/acre (0.8 kg/m^2 to 7.8 kg/m^2). Average fuel load is about 20 tons/acre (4.5 kg/m^2). In young stands, fuels are often the result of natural thinning or downfall of dead overstory trees from the previous stand. In older stands, accumulated downfall of insect-killed trees is often the primary source of fuel. Figure 9 shows examples of light and moderate fuel loads in young stands.

Heavy fuel loads can and do occur in stands of this group, although such situations were not reflected in either of the data bases available. This is probably due to the small acreage of old stands in Fire Group Seven habitat types on the Lolo National Forest.

Table 4.--*Fuel loadings by size class for four Fire Group Seven stands (fig. 9)*

Stand number	Age	Size class (inches)							Total
		0-1/4	1/4-1	1-3	3-6	6-10	10-20	20+	
	Years	*Tons/acre*							
1	80	0.55	0.90	3.80	1.42	0.40	0	0	7.07
35A	125	0.32	1.20	5.10	4.27	1.09	0	0	11.98
49A	165	0.32	1.40	8.10	11.82	1.02	0	0	22.66
81	50	0.26	0.80	2.40	2.82	6.31	22.14	0	34.73

Figure 9.--A range of fuel loads in Group Seven stands. Stand 1 is a lodgepole pine stand on an *Abies lasiocarpa/Vaccinium caespitosum* h.t. (ABLA/VACA), subalpine fir/bluejoint. Stand 35A is a lodgepole pine stand on an *Abies lasiocarpa/Vaccinium globulare* h.t. (ABLA/VAGL), subalpine fir/blue huckleberry. Stand 49A is a lodgepole pine stand on an *Abies lasiocarpa/Vaccinium caespitosum* h.t. (ABLA/VACA), subalpine fir/bluejoint. Stand 81 is a lodgepole pine stand on a *Picea/Linnaea borealis* h.t. (PICEA/LIBO), spruce/twinflower. Table 4 shows total load, loading by size class and stand age.

Role of Fire

The role of fire in seral lodgepole forests is almost exclusively as an agent that perpetuates or renews lodgepole pine. Without periodic disturbance, the more tolerant species can replace lodgepole because it does not regenerate successfully on duff in shaded conditions. Periodic fires interrupt the natural course of succession and increase the proportion of lodgepole with each burn. Burns of moderate intensity disrupt the succession without destroying the stand. The pine's ability to set seed while still in the sapling stage gives it an added advantage over competing species. Within 50 to 100 years after fire in a lodgepole-dominated stand, a reestablished pine cover will exist even though shrubs and herbaceous cover may have become temporarily dominant immediately after the burn. The regeneration of spruce, fir, and other conifers largely depends on the availability of a seed source.

It is in Group Seven that stand-destroying fires assume a dominant role in the overall successional pattern. Brown (1975) discussed the fuel accumulation concept for lodgepole pine forests and illustrated the fire potential trends over time. Lodgepole forests are particularly susceptible to such fires when the stand is overstocked and when suppression mortality and downfall contribute to the fuel situation. Other factors such as dwarf mistletoe infestations, mountain pine beetle outbreaks, and effects of preceding fires often create tremendous fuel accumulations that contribute to violent, widespread burns.

Old-growth spruce/fir stands represent an advanced stage of the fire-initiated lodgepole pine forest. They are not self-perpetuating climax communities. Spruce does not regenerate well under a dense, closed canopy and, in the absence of fire, spruce/fir will progress toward a fir/spruce community. In Group Seven, this would hold for all habitat types except *Picea/Linnaea borealis* h.t. (PICEA/LIBO), spruce/twinflower, in which spruce is the climax tree.

Natural fire frequency in lodgepole stands varies from a few years to 200 years, generally insufficient time for lodgepole to be replaced by climax species. In some areas, the successional status of lodgepole is in doubt because of the scarcity of other conifers within vast tracts of lodgepole forests. In these areas, pine is apparently a fire-maintained disclimax, but it could be an actual climax. Fire would have to be excluded for centuries before the issue could be settled with certainty.

Studies of fire history have shown that fire is a regular feature of lodgepole pine disclimax forests. In Group Seven habitat types occurring in the Bitterroot National Forest, Arno (1976) found that the mean fire-free interval was 21 years with a range of from 3 to 67 years. These figures represent fire occurring somewhere in a sizeable stand (100 to 200 acres [40 to 81 hectares]) and not the frequency of fire reoccurring on a specific site. Gabriel (1976) reported an average of 40 years and Tande (1977) 27 years. Studies from other areas in the Rocky Mountains vary, but are essentially in agreement with these figures. Severe and multiple burns have usually favored lodgepole above all other associated conifers.

Succession Diagram

Figure 10 shows the successional patterns of Fire Group Seven. As in previous groups, the shrub and herb community is perpetuated by repeated, frequent fires (fig. 10, No. 1); however, fire simultaneously prepares a seedbed for lodgepole seedlings (fig. 10, No. 2), or lodgepole seedlings can appear during the shrub/herb stage.

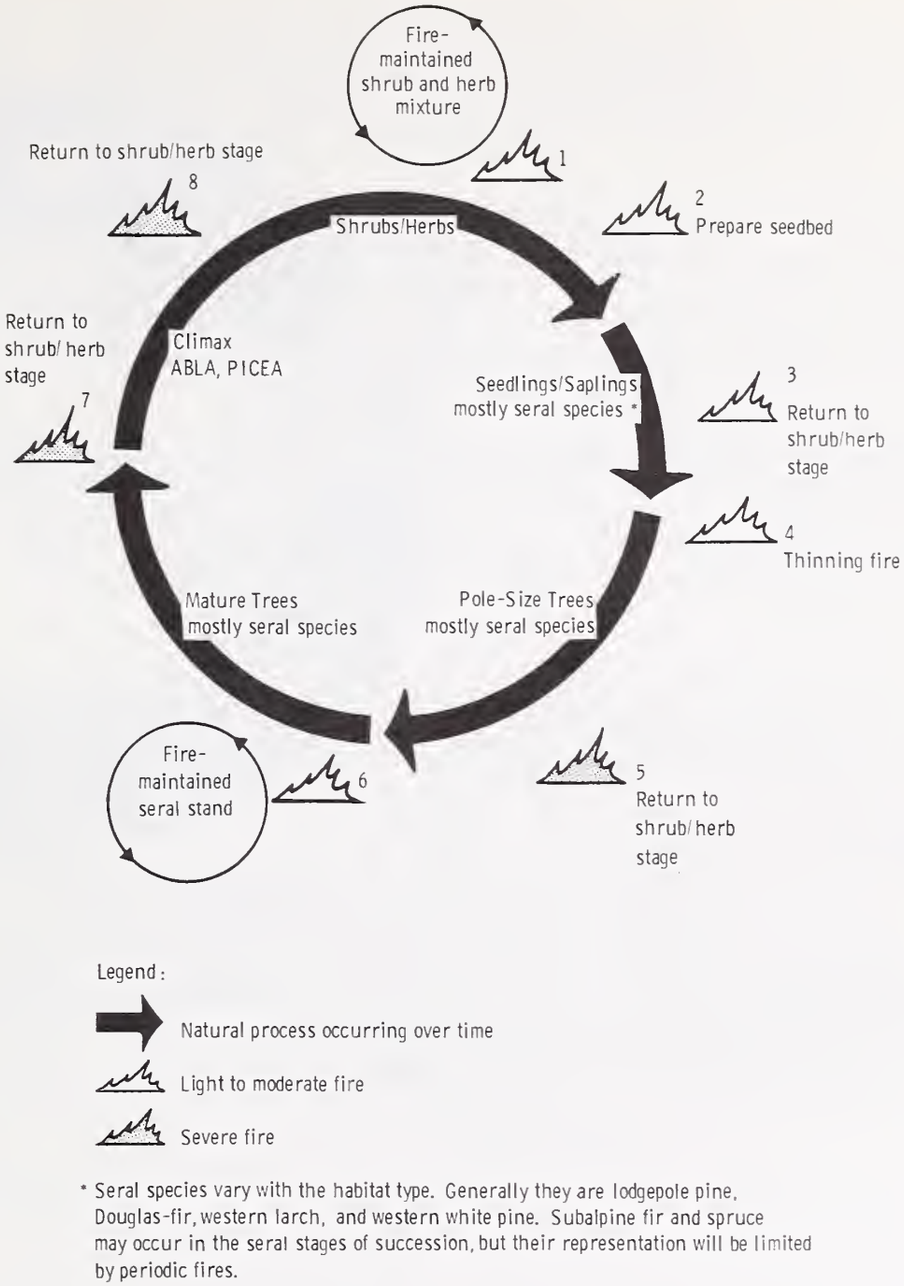


Figure 10.--Forest succession in Fire Group Seven: fire-maintained lodgepole pine stands in spruce and subalpine fir climax series habitat types.

Seedlings and saplings are thin-barked and, consequently, not fire resistant. A fire will kill small trees and return the site to the shrub/herb dominated mixture (fig. 10, No. 3) or thin the regeneration by removing only a portion of the trees (fig. 10, No. 4).

Tree regeneration is mostly lodgepole because of its prolific seeding and rapid early growth. With the passage of time, the young trees develop into a stand of pole-size trees. A severe fire during this stage (fig. 10, No. 5) would recycle the vegetation to the original community. Suppression mortality and downfall would increase the likelihood of a fire burning intensely.

Reoccurring light-to-moderate fires will do less damage to maturing lodgepole than to younger stages of invading Douglas-fir, spruce, and subalpine fir (fig. 10, No. 6). Even though some pines will die, the net effect is to increase the relative proportion of lodgepole on the site. A byproduct is the creation of varying amounts of standing dead timber that falls and would support a more severe fire at a later date.

A severe fire in a mature lodgepole forest can kill almost every tree over extensive acreages. The Sleeping Child burn (1961) is an example. However, even in the case of a fire that completely destroys the stand (fig. 10, No. 7), the survival of an abundant seed supply is assured by the serotinous cones that are present high in the canopy.

After 100 to 200 years without major disturbance, a lodgepole forest begins to break up with old age. At this time, substantial amounts of more shade-tolerant trees begin to appear, provided there is a seed source within a reasonable distance. Eventually, a subalpine fir or spruce climax stand can develop. In practice, this is not usual since lodgepole stands become increasingly flammable with age and even more so as the fir and spruce understory becomes established.

On occasion, a subalpine fir or spruce climax forest will eventually exclude lodgepole, burn, and recycle the site to the earliest vegetation stage (fig. 10, No. 8). Stahelin (1943) and Brown (1975) described the successional patterns of lodgepole pine stands and the forest composition from lodgepole to old growth spruce and fir. Their successional diagrams are shown in figures 11 and 12, respectively.

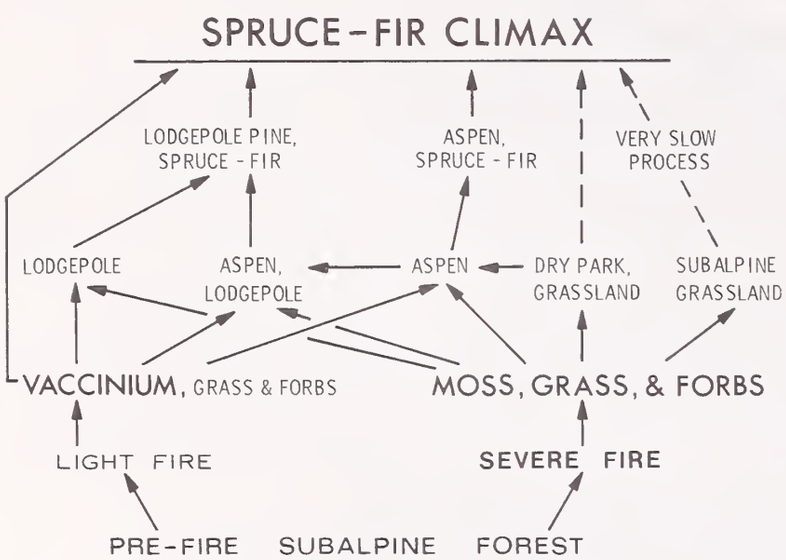


Figure 11.--Major trends of secondary succession on subalpine forests after light and severe fires (adapted from Stahelin 1943).

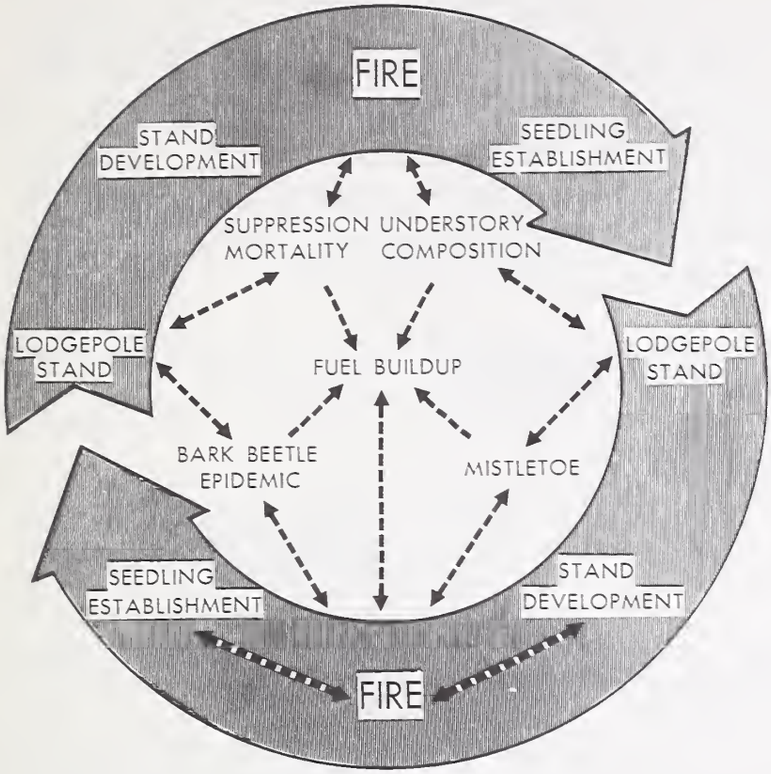


Figure 12.--Lodgepole pine fire cycle showing interrelationships among influences (adapted from Brown 1975).

Fire Management Considerations

Perhaps the primary fire management consideration in Group Seven habitat types 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 that result in complete stand mortality 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 in Group Seven stands. Low-to-medium intensity surface fires do occur in Group Seven stands, however. Thus, there may be opportunities to use prescribed fires (either planned or chance ignition) to accomplish specific management objectives.

Prescribed fire has been suggested as a management tool for controlling dwarf mistletoe (*Arceuthobium* spp.). 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 Group Seven habitat types has been and undoubtedly will continue to be for hazard reduction and site preparation in conjunction with tree harvesting. Broadcast burning and windrowing and burning have been the most often used methods of accomplishing these tasks. Successful broadcast slash burning in Group Seven stands will usually yield increased forage production for big game. Slash disposal of any kind will aid big game movement through these stands. The cautions regarding removal of too much woody material discussed in fire management considerations for Group Two habitats also apply here.

As mentioned above, a major concern in the management of lodgepole pine in the general forest zone is the regulation of sweeping crown fires. A key element in this regulation is the establishment and maintenance of an age-class mosaic. This can be accomplished through harvest practices and fire use. In wilderness, however, 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.

Managers should use the information contained in the two-volume proceedings of the symposium: "Management of lodgepole pine ecosystems" (Baumgartner 1973) as a guide for fire management actions in Group Seven habitat types.

FIRE GROUP EIGHT

DRY LOWER SUBALPINE HABITAT TYPES

Habitat type - phase (Pfister and others 1977)	Ecoclass code (On and Losensky 1977)
Abies lasiocarpa/Xerophyllum tenax h.t.- *Vaccinium globulare* phase (ABLA/XETE-VAGL), subalpine fir/beargrass-blue huckleberry phase.	CS-4-691
Tsuga mertensiana/Xerophyllum tenax h.t.- (TSME/XETE), mountain hemlock/beargrass.	CS-4-710

FIRE GROUP NINE

MOIST, LOWER SUBALPINE HABITAT TYPES

Habitat type - phase (Pfister and others 1977)	Ecoclass code (On and Losensky 1977)
Picea/Galium triflorum h.t. (PICEA/GATR), spruce/sweetscented bedstraw.	CS-7-440
Abies lasiocarpa/Oplopanax horridum h.t. (ABLA/OPHO), subalpine fir/devil's club.	CS-7-610
Abies lasiocarpa/Clintonia uniflora h.t.- *Clintonia uniflora* phase (ABLA/CLUN-CLUN), subalpine fir/queencup beadlily-queencup beadlily phase.	CS-6-621
Abies lasiocarpa/Clintonia uniflora h.t.- *Aralia nudicaulis* phase (ABLA/CLUN-ARNU), subalpine fir/queencup beadlily-wild sarsaparilla phase.	CS-6-622
Abies lasiocarpa/Clintonia uniflora h.t.- *Vaccinium caespitosum* phase (ABLA/CLUN-VACA), subalpine fir/queencup beadlily-dwarf huckleberry phase.	CS-6-623

Habitat type - phase	Ecoclass code
Abies lasiocarpa/Clintonia uniflora h.t.- *Xerophyllum tenax* phase (ABLA/CLUN-XETE), subalpine fir/queencup beadlily-beargrass phase.	CS-6-624
Abies lasiocarpa/Clintonia uniflora h.t.- *Menziesia ferruginea* phase (ABLA/CLUN-MEFE), subalpine fir/queencup beadlily-menziesia phase.	CS-6-625
Abies lasiocarpa/Galium triflorum h.t. (ABLA/GATR), subalpine fir/sweetscented bedstraw.	CS-7-630
Abies lasiocarpa/Calamagrostis canadensis h.t.- *Calamagrostis canadensis* phase (ABLA/CACA-CACA), subalpine fir/bluejoint-bluejoint phase.	CS-7-651
Abies lasiocarpa/Calamagrostis canadensis h.t.- *Galium triflorum* phase (ABLA/CACA-GATR), subalpine fir/bluejoint-sweetscented bedstraw phase.	CS-7-653
Abies lasiocarpa/Linnaea borealis h.t.- *Linnaea borealis* phase (ABLA/LIBO-LIBO), subalpine fir/twinflower-twinflower phase.	CS-6-661
Abies lasiocarpa/Linnaea borealis h.t.- *Xerophyllum tenax* phase (ABLA/LIBO-XETE), subalpine fir/twinflower-beargrass phase.	CS-6-662
Abies lasiocarpa/Menziesia ferruginea h.t. (ABLA/MEFE), subalpine fir/menziesia.	CS-6-670
Tsuga mertensiana/Menziesia ferruginea h.t. (TSME/MEFE), mountain hemlock/menziesia.	CS-6-680

Fire Groups Eight and Nine are a collection of habitat types in the spruce and subalpine fir series. Although they encompass a wide variety of conditions, they generally have the same relationship to fire. Fire frequency is low, but fires that do occur are often severe and their effects may be long lasting. These habitat types rarely progress to mature climax stands because of the fire regimen. Group Eight and Nine habitat types cover 32 percent of the Lolo National Forest.

Groups Eight and Nine describe a generalized pattern of fire ecology in subalpine habitats. The specific successional patterns will vary considerably even within a habitat type depending on the composition of the stand and the fire behavior. The roles of associated species vary with the habitat type (appendix C) and specific site conditions.

Relationship of Major Tree Species to Fire

Pinus contorta

Lodgepole pine's role in Groups Eight and Nine is that of an intolerant species whose very existence is dependent upon periodic fires. It is a major component of seral stands in the lower subalpine habitat types. Being an intolerant species, it is unable to regenerate successfully in conditions associated with later forest succession. Its greatest expression is in the fire-initiated stand.

In Groups Eight and Nine, lodgepole differs from its role in Group Seven by not being the dominating seral species. It usually occurs in mixed stands with Douglas-fir, western larch, and western white pine.

Larix occidentalis

Western larch is the most fire-resistant conifer in the northern Rocky Mountains. It is, however, more vulnerable to damage in these habitats because it grows in dense stands in association with low-canopy conifers and tall shrubs that can carry fire into the crowns. It is a subclimax species maintained by fire. It cannot successfully regenerate in the shaded conditions of the later successional stages and will lose dominance to more tolerant species if overtopped.

Larch is a major seral component of Group Eight and Nine stands in northwestern Montana (Pfister and others 1977). Locally, it may occur in nearly pure stands.

Pinus monticola

Western white pine is moderately resistant to fire damage. Resistance is favored by the medium thick bark, moderate flammability of the foliage, the tall stature, especially, and the self-pruning. Abundant resin in old bark, heavy lichen growth, and dense stand habit lessen white pine's resistance, however. Young stands of white pine are vulnerable to crown fires because of their more compact structure.

Western white pine is a fire species that owes its very existence to replacement burns that recycle stands and create early successional habitat. Its characteristic occurrence in nearly pure, even-aged stands is further evidence of stand-replacing fires.

Western white pine is a major component of some stands in northwestern Montana, but it usually grows in association with Douglas-fir, western larch, and lodgepole pine. Because it is an intolerant tree, it is always a subclimax species leading to fir, spruce, cedar, and hemlock forests.

Soil temperature and adequate moisture appear to control germination, but light seems to have little importance since 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 the western white pine seedling is not very 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 composition are established. Mortality and pruning subsequently determine the fire resistance of the stand and of individual trees.

Pseudotsuga menziesii

Douglas-fir's fire resistant qualities were discussed in Groups Four, Five, and Six. In Groups Eight and Nine, it is a major, fire-promoted component of seral stands in the lower subalpine habitat types. Douglas-fir is more susceptible to fire damage in these groups because it grows in dense stands. Conifer regeneration and tall shrubs provide a fuel ladder for fire to enter the canopy. While the thick bark offers older trees limited protection from surface fires, fires that reach the crowns destroy trees of all ages.

Douglas-fir is more shade tolerant than western larch and the pines. Its ability to endure shade enables it to regenerate after the fire-initiated stand has been established. When shade conditions become too limiting for Douglas-fir, it is replaced by subalpine fir, Engelmann spruce, and hemlock.

Picea engelmannii

In Group Eight and Nine habitats, Engelmann spruce functions primarily as a persistent seral component of the stand. Fire recycles spruce stands, which usually revert to lodgepole pine, Douglas-fir, and western larch mixtures. Spruce can appear in early successional stages if suitable microsites occur for available seed.

Spruce is not an aggressive pioneer. It is a moderate seeder, but seeds are viable over extended periods. Initial establishment and early growth of seedlings are slow, but usually good when encouraged by shade and abundant moisture. 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 feet (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 accumulating duff. At this point, the more tolerant true firs, western redcedar, and western hemlock begin to successfully regenerate.

Abies lasiocarpa

Subalpine fir has the same relationship to fire in these groups as it does in Group Seven. Its low fire resistance makes it readily vulnerable to death or severe injury from burning. Thus, fire acts as a recycling agent that reduces the fir component and often replaces it with early seral species.

Subalpine fir is the major climax dominant in these groups. Where fires are infrequent, as in the cold, wet habitat types, fir has time to attain dominancy. In the drier and lower elevation habitat types, however, fir is usually subordinate to more aggressive early serals, such as Douglas-fir, lodgepole pine, western larch, western white pine, and sometimes ponderosa pine. Here, fire is more frequent and seral species are more competitive.

Subalpine fir may begin producing cones when only 20 years old, but maximum seed production is by dominant trees 150 to 200 years old. The tree's performance as a seral is enhanced by its ability to germinate and survive on a fairly wide range of seedbeds. Fir has the advantage of a large seed that can quickly produce a vigorous root system.

In a closed canopy situation, establishment and early survival of fir are favored by relatively deep shade. It can exist under low light conditions better than most associated species, but cannot compete successfully with spruce where light intensity exceeds more than 50 percent of full sunlight.

Forest Fuels

Fuel loads in Group Eight and Nine habitat types will range from about 1 ton/acre to more than 80 tons/acre (0.2 to 17.9 kg/m^2). The average load would be about 30 tons/acre (6.7 kg/m^2), which is greater than the average load of any other group. This average does not reflect a central tendency. A load of 10 tons/acre (2.2 kg/m^2), for example, seems to occur just as frequently as a load of 60 tons/acre (13.5 kg/m^2).

The range of fuel loads in Groups Eight and Nine is similar to that of Group Six. An important difference does exist, however. Group Eight and Nine stands have a greater percentage of their fuel load made up of large diameter downfalls. Table 5 and figure 13 show a sequence of increasing fuel loads in this group. Notice that the amount of material less than 3 inches (7.6 cm) in diameter does not change very much from stand to stand. It is the amount of large material that determines the load. This large material is usually distributed fairly evenly throughout the stand, but it may be concentrated as shown in stands 10 and 3 (fig. 13).

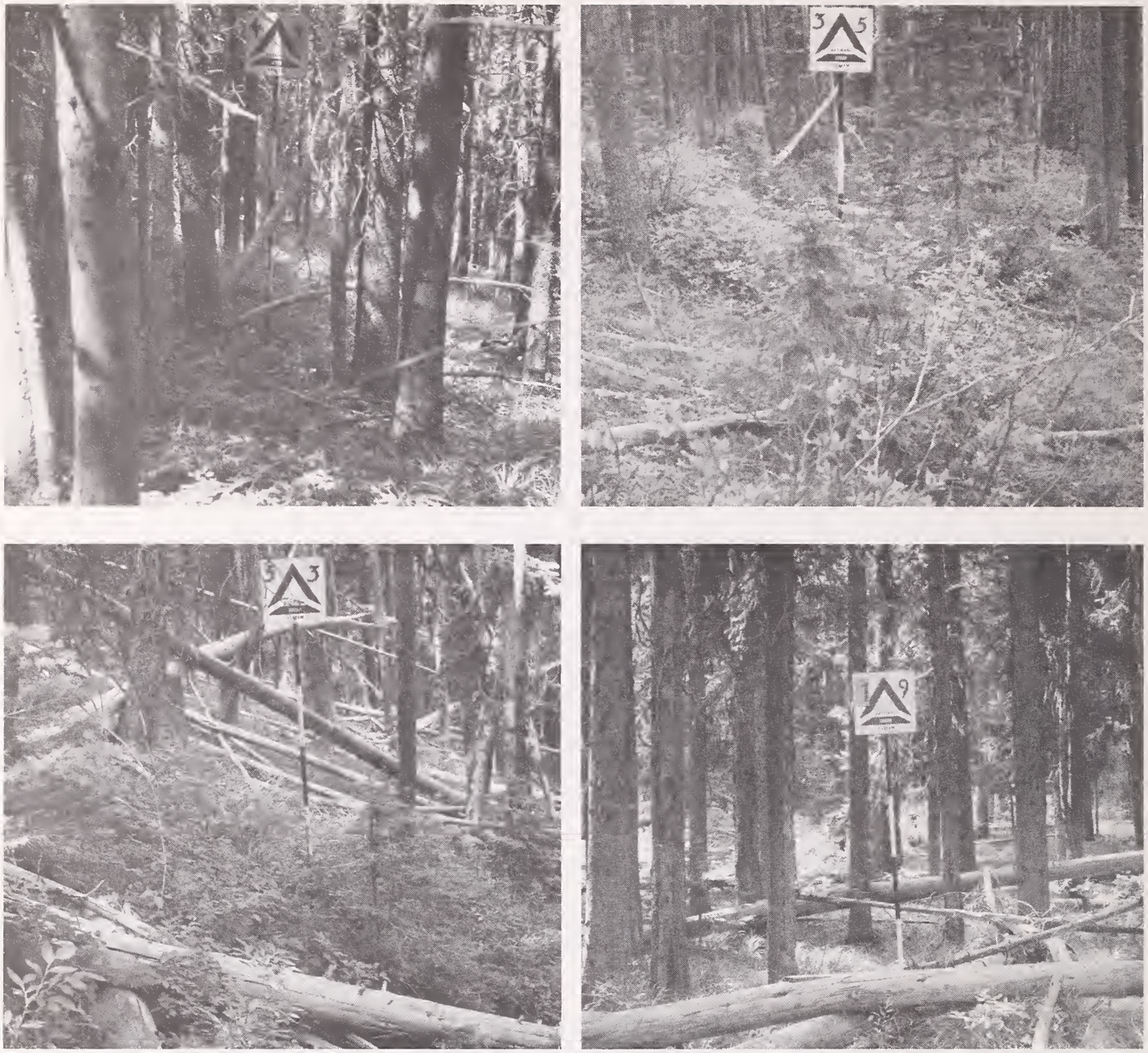


Figure 13.--Examples of typical Group Eight and Nine loads. Stand 53 is a western larch/Douglas-fir stand, all others are Engelmann spruce/subalpine fir. Habitat types are *Abies lasiocarpa/Xerophyllum tenax* h.t.-*Vaccinium globulare* phase (ABLA/XETE-VAGL), subalpine fir/beargrass-blue huckleberry phase for stands 45, 59, 22, and 38; *Abies lasiocarpa/Menziesia ferruginea* h.t. (ABLA/MEFE), subalpine fir/menziesia for stands 35, 53, 19, and 10; and *Abies lasiocarpa/Clintonia uniflora* h.t.-*Menziesia ferruginea* phase (ABLA/CLUN-MEFE), subalpine fir/queencup beadlily-menziesia phase for stand 35. Total load and loading by size class and stand age are shown in table 5.

Fig. 13.--con.

Table 5.--*Fuel loadings by size class for 11 Group Eight and Nine stands*

Stand number	Age	Size class (inches)							Total
		0-1/4	1/4-1	1-3	3-6	6-10	10-20	20+	
	Years	*Tons/acre*							
45	86	0.30	0.60	0.30	0.07	0	0	0	1.27
35	110	0.21	1.00	3.30	4.50	0	0	0	9.01
53	125	0.32	1.40	4.50	7.96	6.30	0	0	20.48
19	120	0.29	0.90	2.90	7.69	14.56	1.60	0	27.94
59	120	0.42	1.40	2.10	9.42	24.66	2.80	0	40.80
22	74	0.56	1.70	2.40	4.07	25.58	13.61	0	47.92
10	90	1.08	3.20	2.20	12.50	28.80	11.67	0	59.45
3	140	0.35	0.90	0.50	2.74	7.70	57.12	3.34	72.65
38	200	0.17	1.40	5.00	11.76	47.06	11.84	0	77.23
42	335	0.39	0.90	2.50	1.57	2.87	5.35	11.90	26.48
46	357	0.67	2.30	6.00	2.59	7.81	18.94	0	38.31

Frequently, the fuel load may be a result of a few very large diameter deadfalls. This situation is shown in stands 42 and 46 (fig. 14). Compare these stands to stands 19 and 59 (fig. 13 and table 5) for examples of comparable loadings with different size class distributions.

Figure 14.--Examples of heavy fuel loads that result from the presence of a few larger diameter deadfalls. Stand 42 is a Douglas-fir stand on an *Abies lasiocarpa/Menziesia ferruginea* h.t.-*Vaccinium globulare* phase (ABLA/MEFE-VAGL), subalpine fir/menziesia-blue huckleberry phase, and stand 46 is an Engelmann spruce/subalpine fir stand on an *Abies lasiocarpa/Menziesia ferruginea* h.t. (ABLA/MEFE: subalpine fir/menziesia. Total load and loading by size class and stand age are shown in table 5.

Role of Fire

Fire is less frequent in these subalpine habitat types than in previously discussed groups. Fire intensity can vary between light surface fires and stand-replacing burns. By opening the canopy and preparing a mineral seedbed, fire encourages shade-intolerant species.

Douglas-fir and lodgepole pine are the major components of seral stands. Locally, western larch and western white pine may be prominent in seral forests. Spruce and subalpine fir may be present in the fire-initiated stand, but they usually do not become prominent until later successional stages.

The mesic climate, dense stand habit, and long interval between fires in the subalpine forests lead to replacement burns. Apparently, fire is more frequent and less intense in the dry habitat types such as *Abies lasiocarpa/Xerophyllum tenax* h.t. (ABLA/XETE), subalpine fir/beargrass and less frequent, but more intense, in wet ones like *Abies lasiocarpa/Menziesia ferruginea* h.t. (ABLA/MEFE), subalpine fir/menziesia, *Abies lasiocarpa/Galium triflorum* h.t. (ABLA/GATR), subalpine fir/sweetscented bedstraw, *Abies lasiocarpa/Clintonia uniflora* h.t. (ABLA/CLUN), subalpine fir/queencup beadlily, and *Tsuga mertensiana/Menziesia ferruginea* h.t. (TSME/MEFE), mountain hemlock/menziesia (Arno 1976; Pfister and others 1977).

Fire maintains Group Eight and Nine forests in a seral status. If these forests had not been continuously disturbed by past fires, the climax spruce and fir would dominate most areas.

In the subalpine fir habitat types, revegetation of a burn will be determined by the composition of the preburn forest, the degree of fire damage, the amount of available seed, and the seedling survival. Fire favors intolerant trees, and repeated burns often promote one species.

Arno (1976) reported an average fire frequency of 24 years for habitat types belonging to Fire Groups Eight and Nine in his study in the Bitterroot Valley. In a more mesic forest type in Coram Experimental Forest, Sneck (1977) reported an average frequency of 140 years for these habitat types. Fire frequencies in Lolo National Forest stands probably fall within these extremes.

The effect of past fire suppression efforts has been to limit the spread of recent fires in these habitats. Over time, this will lead to abnormal fuel loadings and create a greater hazard than now exists.

Succession Diagram

Secondary succession in this group begins with a mixture of shrubs and herbs and possibly some conifer seedlings (fig. 15). Either shrubs or herbs may predominate, but neither is likely to be completely absent. Recurrent fires will maintain this community (fig. 15, No. 1).

Conifer seedlings become established over time without disturbance. Or, they germinate after a seedbed preparing burn (fig. 15, No. 2). The regeneration primarily consists of shade-intolerant trees, but the tolerant species may form a significant portion of the fire-initiated stand.

Young trees among plants in the undergrowth are less fire tolerant than surrounding plants. Therefore, a fire occurring soon after regeneration will return the vegetation to a shrub/herb mixture (fig. 15, No. 3) or thin the young trees (fig. 15, No. 4).

As the stand ages, trees are killed through suppression mortality and shade-tolerant species regenerate beneath the canopy. Downfall, standing snags, and fuel ladders increase the probability of an intense burn. A severe fire during the pole-size stage would recycle the site to the original secondary successional stage (fig. 15, No. 5).

Fire in a mature seral stand can have two results. Light-to-moderate intensity burns will control the succession of more tolerant trees and perpetuate a predominantly seral forest (fig. 15, No. 6). The tolerant species will probably never by eliminated from the seral stage, but their representation will be limited by periodic fires. A severe, stand-destroying fire will return the forest to the secondary successional stage of shrubs and herbs (fig. 15, No. 7). A new seral stand will be initiated from available seed.

Without periodic disturbance, the mature seral stand will progress into a forest of climax species. This requires decades, perhaps centuries, of uninterrupted succession since many intolerant species can live from 300 to 400 years. A climax forest can develop if the forest goes many years without burning. In theory this could happen, but it is unusual for habitat types in the lower subalpine group to escape burning for that long. A severe fire in the climax forest recycles the site to the early successional stage (fig. 15, No. 8).

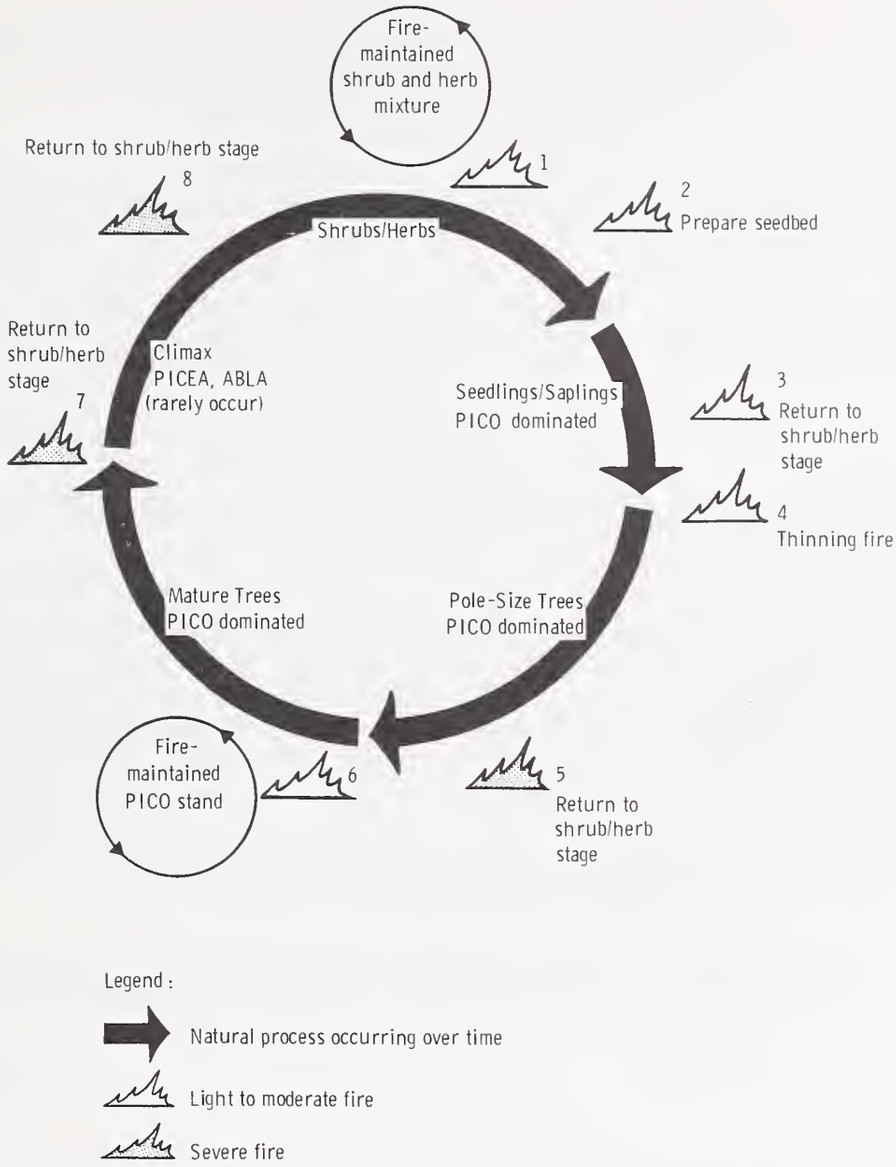


Figure 15.--Forest succession in Fire Groups Eight and Nine: lower subalpine habitat types.

Fire Management Considerations

There is a great potential for fire management programs designed to take advantage of fire's natural role in Group Eight and Nine habitat types. Fire may be compatible with management objectives for many of these areas, hence, opportunities for reducing fire suppression costs often occur.

Fire protection is usually necessary during severe burning conditions, especially for areas where timber production is a management objective. At other times, fires may be of low-to-moderate intensity and result in only moderate damage or no damage to overstory trees, despite the relatively low fire resistance of many of the species present. The preceding statement refers to undisturbed natural stands. If slash is present, unacceptable tree mortality can result under quite easy burning conditions.

Broadcast burning is an effective method for reducing slash hazard and for preparing seedbeds in clearcuts, but not in partial cuts. Timing of a burn is important. Group Eight and Nine habitats 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.

Burning slash in large windrows or piles often creates enough heat in the soil to inhibit plant growth for a long period of time. Consequently, windrows should be narrow and piles should be small when these methods are used.

Additional guidelines for fire use and silviculture in Group Eight and Nine stands are provided by Roe and others (1970). This reference should be consulted before planning fire use in these habitats.

Slash disposal plans should consider the need for some residues to remain on the site as discussed in the fire management considerations for Group Two habitats. Large logs left on the site also provide needed 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 fires and partly because of their climate and soils. Their natural development has not, as a general rule, been affected by past fire suppression policies (Habeck and Mutch 1973). Management objectives for these habitat types are often oriented toward nonconsumptive use. These types usually have high watershed and big game sanctuary values. Many of the areas that contain these habitat types are roadless and are destined to remain so. Many are in designated wilderness areas. Consequently, the appropriate fire management policy is usually one that allows fire to play its natural role especially during the prefire and postfire seasons. Often this policy must be constrained because of air quality considerations and because of the occasional threat of long distance spotting or wind-driven crown fires.

FIRE GROUP TEN

COLD, MOIST UPPER SUBALPINE AND TIMBERLINE HABITAT TYPES

Habitat types - phase (Pfister and others 1977)	Ecoclass code (On and Losensky 1977)
Upper Subalpine	
Abies lasiocarpa/Luzula hitchcockii h.t.- *Vaccinium scoparium* phase (ABLA/LUHI-VASC), subalpine fir/smooth woodrush-grouse whhortleberry phase.	CS-6-831
Abies lasiocarpa/Luzula hitchcockii h.t.- *Menziesia ferruginea* phase (ABLA/LUHI-MEFE), subalpine fir/smooth woodrush-menziesia phase.	CS-6-832
Tsuga mertensiana/Luzula hitchcockii h.t.- *Vaccinium scoparium* phase (TSME/LUHI-VASC), mountain hemlock/smooth woodrush-grouse whortleberry phase.	CM-7-841
Tsuga mertensiana/Luzula hitchcockii h.t.- *Menziesia ferruginea* phase (TSME/LUHI-MEFE), mountain hemlock/smooth woodrush-menziesia phase.	CM-7-842

Timberline

Pinus albicaulis-Abies lasiocarpa h.t.'s
(PIAL-ABLA h.t.'s), whitebark pine-subalpine fir. CA-8-850

Larix lyallii-Abies lasiocarpa h.t.'s
(LALY-ABLA h.t.'s), alpine larch-subalpine fir. CA-8-860

Pinus albicaulis h.t.'s (PIAL h.t.'s), whitebark pine. CA-8-870

Fire Group Ten is a collection of upper subalpine and timberline habitat types of the subalpine fir series. They cover 6 percent of the Lolo National Forest. Fuels are predominantly herb and shrub species and scattered downfall. Low-intensity lightning fires that have limited spread because of the lack of available fuels are characteristic of these habitats. Infrequent stand-destroying fires that enter from continuous forests of lower elevations have the greatest ecological effect. Recovery is slow because of the cold climate and short growing season.

Relationship of Major Tree Species to Fire

Picea engelmannii

Thin bark and low-growing canopy make spruce vulnerable to fire damage and to death. Fuels consist primarily of the undergrowth and scattered downfall, however, which limit fire spread and intensity. In addition, infrequent fires and the short burning season in these cold habitat types reduce the potential of fire damage.

Spruce is not an aggressive pioneer, but in the wetter Group Ten habitats, it is a persistent seral species. It is longer lived than *Abies* and functions as an important stand component. On dry sites, it is only a minor seral stand member. In the timberline habitats, it is more vigorous than *Abies* and can occur as a member of the climax stand.

Initial establishment and growth of seedlings are slow because of the cold climate in the higher elevations; so spruce may be slow to recover after fire.

Abies lasiocarpa

Subalpine fir has little resistance to fire and is readily killed. The vulnerability of subalpine fir to fire is counteracted in the timberline habitat types by the trees growing in small groups separated by rocks and open areas. Low ground fuel loadings on these sites limit fire spread and intensity.

In the *Abies lasiocarpa/Luzula hitchcockii* h.t. (ABLA/LUHI), subalpine fir/smooth woodrush, fir is the indicated climax. Its growth is quite slow, however, and 200 years may pass before it reaches dominant stand height (60 to 70 feet; 18 to 21 m). Fir trees seldom live more than 250 years because of wind and snow breakage or decay. Contributions of subalpine fir to the heavy fuel loadings increase the susceptibility of the longer-lived seral species, spruce, and whitebark pine to fire damage.

At timberline, fir is notably stunted having a shrublike structure or a shrubby skirt. It is slow to recover after fire.

Tsuga mertensiana

Mountain hemlock is another vulnerable species only slightly more fire resistant than subalpine fir. Its moderately thick bark affords some protection; but low-hanging branches, highly flammable needles, and a tendency to grow in dense groups make it vulnerable to fire damage. Fire injury makes it susceptible to rot.

Mountain hemlock is a climax species with marginal occurrence in the Lolo National Forest. Where moisture is ample (above 50 inches/yr; 127 cm/yr), it occupies a variety of slopes and exposures. In the subalpine fir series, mountain hemlock and subalpine fir are the only two trees capable of perpetuating themselves as climax dominants. Climax communities codominated by hemlock and fir are found in northwestern Montana.

Mountain hemlock grows in pure stands or in a mixture with a wide variety of associated species. The mountain hemlock habitat types are typically moist and fire occurrence is low. When these forests become dry enough to burn, however, they often burn very severely.

The ability for mountain hemlock to be a pioneer species apparently varies with locality. In northern California and southern Oregon, it has been reported to produce nearly pure, even-aged stands on old burn sites. In central Oregon, British Columbia, and Alaska it has invaded small openings, meadows, glacial moraines, and heather communities. It is an invader of burn sites in the montane taiga of the northern Rocky Mountains. Its absence, however, on recently disturbed areas in southeastern British Columbia suggests that it may not be a pioneer species everywhere.

Pinus albicaulis

Whitebark pine is an intolerant seral species that has been observed as a pioneer inhabiting burn sites. It is moderately fire resistant, but its dry, exposed habitat and open structure tend to reduce its vulnerability to fire. Whitebark pine may occur as small groups of trees especially near its lower elevational limit where it appears with subalpine fir and Engelmann spruce. The general impression of whitebark pine habitat types, however, is that of open stands where the undergrowth is predominantly continuous low shrubs, forbs, and grasses. Occasionally larger shrubs and stunted trees occur.

Fires burn with low-to-moderate intensity in the undergrowth. The low, ground-hugging crowns of associated conifers, however, provide a fuel ladder and the downfall in the vicinity of mature trees locally increases fire intensity and flame residence time. Many of the larger individual pines in the Lolo National Forest were killed by mountain pine beetle between 1909 and 1940 (Arno 1970). This has increased the potential severity of fires in stands of whitebark pine. Despite the massive amounts of downfall, few severe fires have occurred, probably because of unfavorable burning conditions.

Intense wildfires starting in lower elevations can burn 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 nor do much damage.

Larix lyallii

Alpine larch is a thin-barked species easily damaged by fire. It is moderately fire-resistant, however, primarily because of its stand habit. It grows only on the highest elevations inhabiting rock faces, talus slopes, shallow soils, and moist, marshy sites. Alpine larch can grow in pure groves, in small groups, or as isolated individuals. At the lowest limits of its distribution, it may occur 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 alpine larch stands from lower forests; however, they do not always adversely affect alpine larch stands. The severe Sundance Fire of 1967 swept the ridges of Roman Nose Mountain (Selkirk Mountains, Idaho) burning most of the whitebark pine and killing much of the spruce and fir in the cirques, but caused only minor damage to isolated stands of alpine larch. Sparse vegetation and rocky slopes curtail the intensity of fire in these areas.

When alpine larch grows with 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 alpine larch to remain a major forest component with these species on Salmon Mountain, Idaho.

Forest Fuels

Fuel information for Group Ten habitat types of the Lolo National Forest is lacking. Data do exist, however, from the nearby Selway-Bitterroot Wilderness Area. Table 6 shows some of the Selway-Bitterroot data for two upper subalpine habitat types and one timberline habitat type that occur on the Lolo.

Table 6.--*Average fuel loadings for Group Ten stands*

Habitat type	Number of plots	Size class (inches)							Total woody	Duff
		0-1/4	1/4-1	1-3	3-6	6-10	10-20	20+		
		Tons/acre								
ABLA/LUHI-VASC	80	0.16	0.69	0.24	0.66	3.26	2.78	0	7.79	7.23
ABLA/LUHI-MEFE	48	0.21	0.56	1.37	1.94	6.98	11.07	3.60	25.73	33.48
LALY-ABLA	25	0.10	0.26	0.13	0.37	1.97	4.84	3.28	10.95	11.23

The fuel loadings shown in table 6 are averages for all sampled stands rather than individual stand data presented for the other fire groups. Keep in mind that the standard deviation of table 6 values is often as great as the values themselves. Nonetheless, differences can be noticed. The drier *Abies lasiocarpa/Luzula hitchcockii* h.t.-*Vaccinium scoparium* phase (ABLA/LUHI-VASC), subalpine fir/smooth woodrush-grouse whortleberry phase habitats average about one-third the amount of down and dead woody material as the moist *Abies lasiocarpa/Luzula hitchcockii* h.t.-*Menziesia ferruginea* phase (ABLA/LUHI-MEFE), subalpine fir/smooth woodrush-menziesia phase types. Also notice the additional amount of fuel produced by the duff in 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.

Role of Fire

Large fires are infrequent in Fire Group Ten. Lightning strikes often ignite fires, but spread is limited by low fuel quantities and the wet weather that commonly accompanies thunderstorms.

The upper subalpine seral stand components are lodgepole pine, whitebark pine, and spruce. This subalpine habitat category is above the elevational limits of Douglas-fir, western larch, and western white pine; so spruce, fir, and mountain hemlock have a larger role in revegetating burned areas. Despite heavy fuel accumulations resulting from wind and snow damage, mountain pine beetle, and decay, severe fires are infrequent because of unfavorable burning conditions. Stand-destroying fires occur at intervals of 200 years or more. Lesser fires occur more frequently, but rarely do more than temporarily reduce the undergrowth and kill a few trees over a small area.

Timberline zone fires are not generally intense because of low fuel quantities, discontinuous fuels, and open-structured forest. Severe fires approaching timberline from contiguous forests below, however, occasionally destroy stands of alpine larch, whitebark pine, Engelmann spruce, and subalpine fir. Small area fires usually do not have the intensity or the spread potential to inflict much damage. Vegetation recovery is slow in the timberline zone because of the extremely short growing season and cold climate. Revegetation may take several decades and, in some cases, the effect of intense fires may be evident for centuries.

Vegetation growth and fuel accruement are slow in the higher elevations. Fire suppression policies have had little consequence on fire frequency or fuel loadings in these areas.

Succession Diagram

In Group Ten, secondary succession begins with a mixture of herbs and shrubs probably including some conifer seedlings (fig. 16). It is likely that herbaceous plants will dominate. Recurrent fire can maintain a predominantly herb/shrub community (fig. 16, No. 1).

Conifer seedlings can become established over time, but it is more likely that seedlings will germinate after a fire that reduces competition from the undergrowth species and prepares a mineral seedbed (fig. 16, No. 2). The seedling/sapling stage is composed of one or more of the major tree species since intolerant seral species, other than lodgepole, do not grow in the high elevations.

Small trees are less fire tolerant than the undergrowth species. A fire that occurs soon after regeneration will return the vegetation to a herb/shrub mixture (fig. 16, No. 3) or thin the regeneration (fig. 16, No. 4).

Pole-size trees are susceptible to fire damage because of their thin bark and low stature. A fire at this stage would kill the overstory and favor herb and shrub species (fig. 16, No. 5). It would be uncommon, however, for one fire to regenerate a Group Ten stand a second to appear when the trees are pole size. Fire frequencies are not usually so high, nor are sufficient fuels available so soon after stand replacement.

As the stand ages, trees are killed through suppression, snow/wind damage, insects, or diseases. Fire can have two effects in the mature stand. Light-to-moderate burns will thin the trees (fig. 16, No. 6) and prepare a seedbed for conifer regeneration to grow beneath the protection of the overstory. A severe fire, that probably would enter from lower elevations and more continuous fuels, will kill the overstory component and recycle the site to the herb/shrub stage (fig. 16, No. 7).

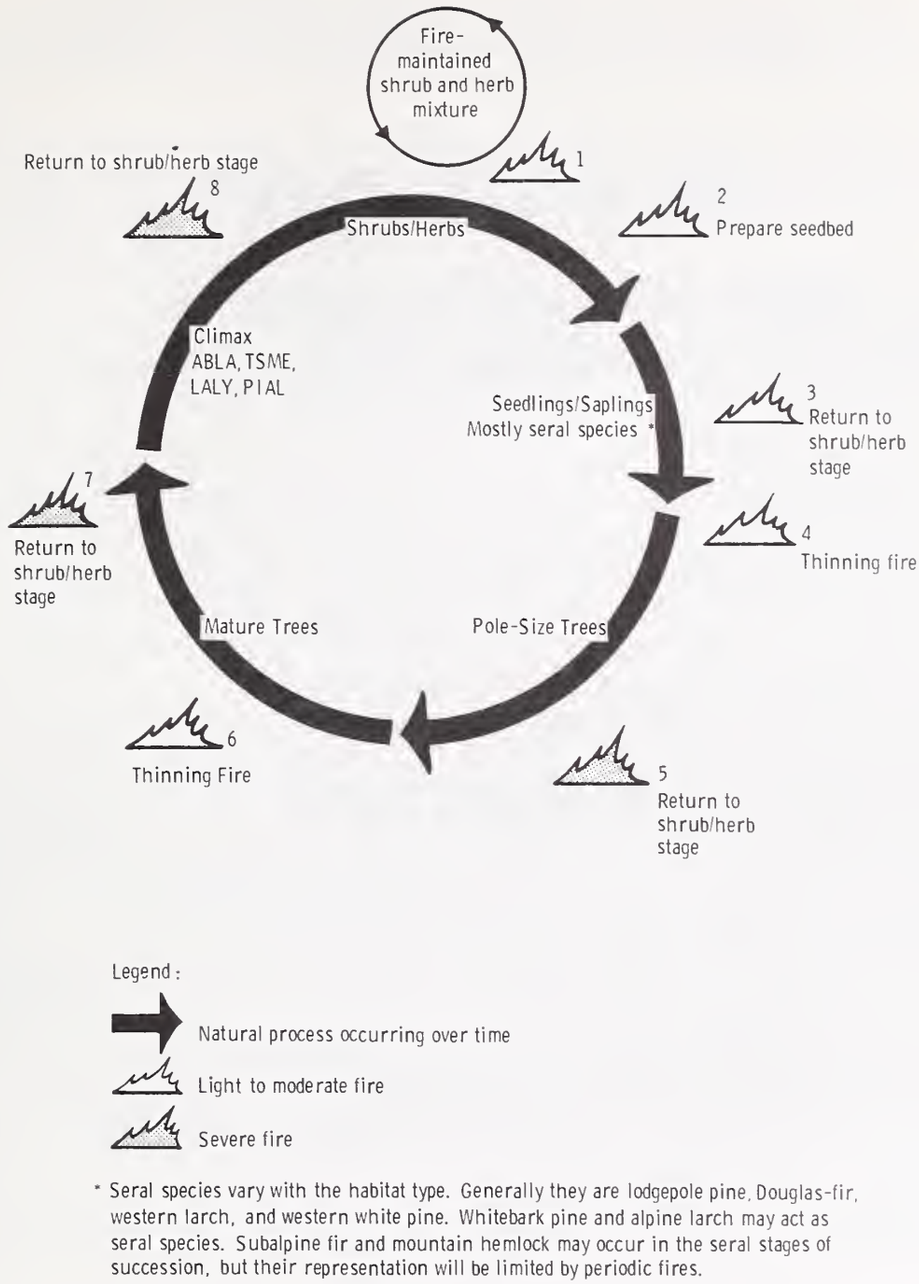


Figure 16.--Forest succession in Fire Group Ten: upper subalpine and timberline habitat types.

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 fires rarely have a significant impact on a mature stand because of the open structure and lack of woody fuels; however, severe fires that enter the crowns and kill the cambium of trees return the site to the early successional stages (fig. 16, No. 8).

Fire Management Considerations

Timber production is rarely an important management objective in Group Ten habitat types. Most of these areas are managed as watersheds and game sanctuaries. Most are roadless and many are in wilderness areas. Fire is an infrequent visitor and, when it does occur, damage, in terms of management objectives, is generally slight. These sites are often fragile and can easily be damaged by modern, mechanized fire-fighting equipment.

The primary fire management consideration for Group Ten habitats should be the development of fire management 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

Habitat type - phase (Pfister and others 1977)	Ecoclass code (On and Losensky 1977)
Abies grandis/Xerophyllum tenax h.t. (ABGR/XETE), grand fir/beargrass.	CG-3-510
Abies grandis/Clintonia uniflora h.t.-*Clintonia uniflora* phase (ABGR/CLUN-CLUN), grand fir/queencup beadlily-queencup beadlily phase.	CG-5-521
Abies grandis/Clintonia uniflora h.t.-*Xerophyllum tenax* phase (ABGR/CLUN-XETE), grand fir/queencup beadlily-beargrass phase.	CG-5-523
Thuja plicata/Clintonia uniflora h.t.-*Clintonia uniflora* (THPL/CLUN-CLUN), western redcedar/queencup beadlily-queencup beadlily phase.	CC-5-531
Thuja plicata/Clintonia uniflora h.t.-*Aralia nudicaulis* phase (THPL/CLUN-ARNU), western redcedar/queencup beadlily-wild sarsaparilla phase.	CC-5-532
Thuja plicata/Clintonia uniflora h.t.-*Menziesia ferruginea* phase (THPL/CLUN-MEFE), western redcedar/queencup beadlily-menziesia phase.	CC-5-533
Thuja plicata/Oplopanax horridum h.t. (THPL/OPHO), western redcedar/devil's club.	CC-7-550
Tsuga heterophylla/Clintonia uniflora h.t.-*Aralia nudicaulis* phase (TSHE/CLUN-ARNU), western hemlock/queencup beadlily-wild sarsaparilla phase.	CH-4-572

This group is a collection of warm moist habitat types, occurring on moist valley bottoms, benches, ravines, and protected exposures. In these moist habitats, fires are infrequent and often severe. Group Eleven habitat types make up 13 percent of the Lolo National Forest. The grand fir (*Abies grandis*) habitats are the driest in this group.

Relationship of Major Tree Species to Fire

Abies grandis

An individual, mature grand fir is moderately fire resistant primarily because of its moderately thick bark; however, its low and dense branching habit, highly flammable foliage, heavy lichen growth, shallow root system, and dense stand habit make it susceptible to fire injury, and death.

Fire resistance is strongly influenced by habitat. 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, thinner duff fuels, and more open stand structure make fir less vulnerable. Decay often enters through fire wounds.

Grand fir is a shade-tolerant species in all associations in which it grows. When it grows with *Thuja* and *Tsuga*, it occurs as a subordinate to these more tolerant species. Douglas-fir is a major component of seral stands in grand fir habitats. Western larch, lodgepole pine, spruce, subalpine fir, ponderosa pine, and western white pine are seral dominants or components of mixed stands that out-compete grand fir during the initial stages of succession.

Grand fir is not an aggressive pioneer. Seedling mortality is high because of biotic agents in the wet seasons and because of drought and insolation in late summer. Initial survival and growth are favored by moderate shade. In partial shade, fir can form a considerable part of the dominant reproduction, but, in full sun conditions, it is subordinate to faster growing intolerant species. Early growth is determined more by the amount of competition than site quality.

Tsuga heterophylla

Western hemlock is vulnerable to fire because of its relatively thin bark, exposed roots, lichen growth, highly flammable foliage, low branching habit, and dense stand habit; however, its cool, mesic habitat offers protection against all but the most severe wildfires. Fungi enter through fire scars and compound fire-caused damage.

Associated seral species in the western hemlock habitat types are Douglas-fir, western larch, spruce, lodgepole pine, and western white pine. Grand fir, subalpine fir, and western redcedar are either minor seral or minor climax components.

Thuja can maintain itself indefinitely as a minor climax species in the *Tsuga* series because of its shade tolerance, longevity, and vegetative reproduction ability.

Hemlock is 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 seed can be carried a considerable distance, but usually falls within a few hundred feet of the parent tree. Germination under forest conditions is excellent on a wide variety of seedbeds, including stumps and logs, as long as adequate moisture is available.

Thuja plicata

Western redcedar is only moderately resistant to fire because of its thin bark, shallow root system, and moderately low and dense branching habit. Resistance is enhanced by the mesic environment which can act as a firebreak to low-and-moderate intensity fires.

Seral stands are dominated by Douglas-fir, western larch, and spruce. Minor seral components are lodgepole pine, western white pine, grand fir, and subalpine fir. The true firs may also assume roles as minor climax components. Hemlock appears as a subordinate species to *Tsuga* or as a coclimax.

Cedar 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. Rapid drying of the duff and the small size of the seed account for the poor germination on duff; however, cedar is a prodigious seed producer, a characteristic that enables it to enter pioneer communities at an early stage.

Western redcedar is a shade-tolerant species. It commonly grows in association with *Tsuga*. Dense stands of cedar and associates exclude most subordinate vegetation; however, a wide variety of undergrowth species may appear when stands are at all open.

Associated Conifers

Douglas-fir, western larch, lodgepole pine, ponderosa pine, western white pine, subalpine fir, and spruce are all associates in Group Eleven habitat types. They have been discussed in detail and so will not be covered in this chapter. In grand fir, western redcedar, and western hemlock habitat types these trees occur as minor or major seral species or as minor climax components (appendix C). The pioneer and seral species in this group are fire dependent.

Forest Fuels

Light fuel loadings are rare in Group Eleven stands on the Lolo National Forest. The range of loadings likely to be found is from 15 tons/acre to over 40 tons/acre (3.4 kg/m^2 to 9.0 kg/m^2). The average fuel load is about 25 tons/acre (5.6 kg/m^2). Most of the fuel results from accumulated deadfall and occasional natural thinning. Because of the heavy grand fir and cedar component of Group Eleven stands, a relatively heavy load of twigs and small branchwood is included in the fuel load. The large material, which accounts for about 75 percent of the fuel load, is often rotten.

Figure 17 shows examples of different levels of fuel loading. Reference to table 7 shows that the amount of small dead fuels is fairly constant while the amount of 10- to 20-inch fuels actually determines the load.

Figure 17.--Examples of fuel loadings in Group Eleven stands. All are grand fir/western larch/Douglas-fir stands on an *Abies grandis/Clintonia uniflora* h.t.-*Clintonia uniflora* phase (ABGR/CLUN-CLUN), grand fir/queencup beadlily-queencup beadlily phase. Total load, loading by size class, and stand age are given in table 7.

Table 7.--*Fuel loadings by size class for five Group Eleven stands*

Stand number	Age	Size class (inches) 0-1/4	1/4-1	1-3	3-6	6-10	10-20	20+	Total
	Years	*Tons/acre*							
16	120	0.89	1.70	2.10	3.28	6.07	2.20	0	16.24
15	85	0.62	1.30	3.30	3.60	3.18	8.53	0	20.53
65	118	0.45	1.90	3.60	7.18	10.79	0	0	27.42
25	114	1.14	2.20	5.50	0.64	6.33	17.13	2.58	35.52
66	280	0.62	1.60	1.20	3.49	4.40	26.72	0	38.03

Role of Fire

Fire is less frequent in these habitat types than in other fire groups because of the mesic to hydric environments. In dense stands, scarcely any undergrowth is present, and duff and heavier fuels are cool and usually moist. These conditions do not encourage fire intensity nor fire spread.

There are two distinct effects and behavior of fire in Group Eleven. First, the mesic site may act as a firebreak to ground fires. A fire may burn into the edges of a stand, possibly scarring some trees, but it will usually die out when it reaches the moist duff layer.

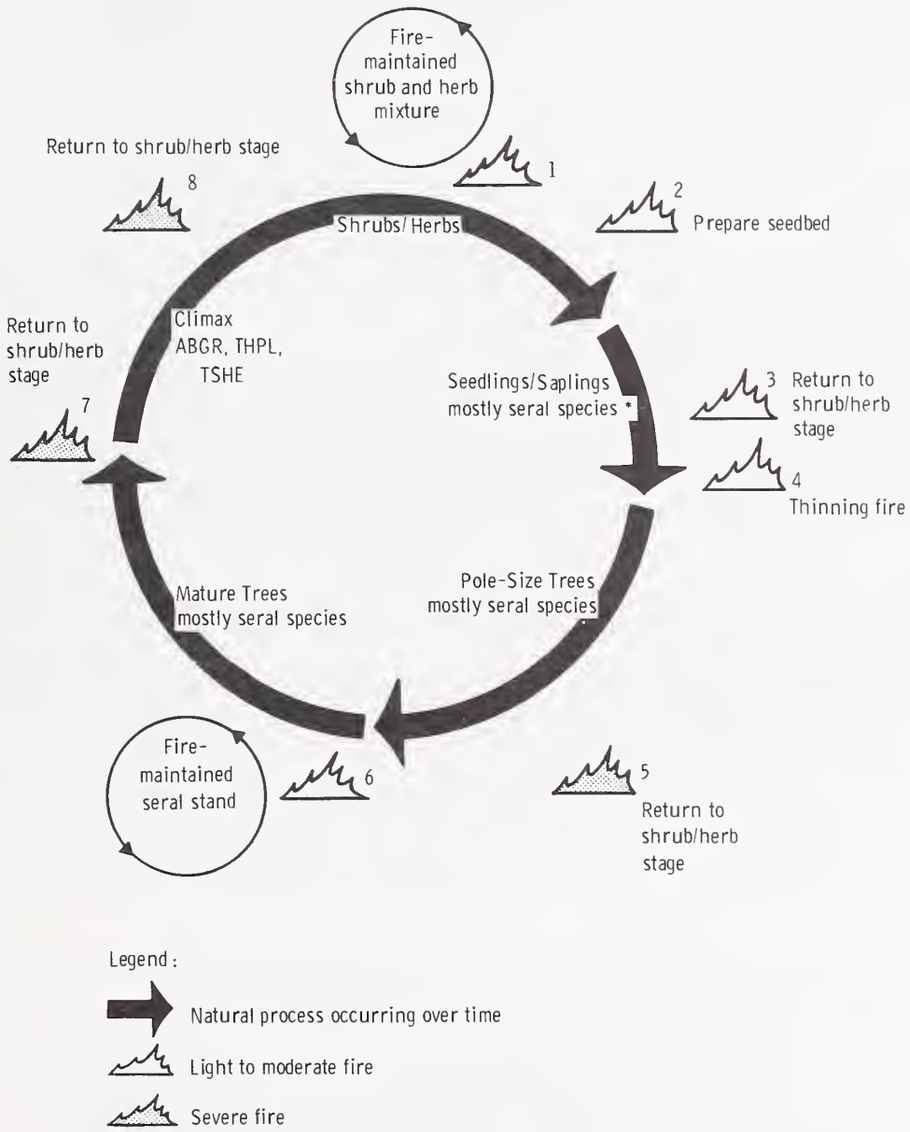
Secondly, plant productivity in Group Eleven is high; so heavy fuels accumulate. These moist habitat types do not frequently burn, but, when they do, the heavy fuels make fires intense. A stand-replacing burn results; so the site reverts to pioneer plants.

Climax and seral species invade a fresh burn simultaneously when both seed sources are available. The seral trees quickly out-compete the climax species and reduce them to the role of a slow-growing understory. Douglas-fir is a common seral tree; but when fires follow one another within a few decades, lodgepole pine, western larch, and white pine stands increase. Frequent fires could maintain grand fir, western hemlock, and western redcedar habitat types as seral forests.

Fire history investigations have shown that severe, stand-replacing fires occurred anywhere from 150 to more than 500 years. Moderate-to-light ground fires occur anywhere from 50 to 100 years. Often fires that died out in the moist grand fir, western redcedar, and western hemlock habitat types devastated the surrounding forests.

Succession Diagram

In group Eleven, secondary succession begins with a mixture of shrubs and herbs and possibly some conifer seedlings (fig. 18). Frequent fires occurring at this stage maintain the undergrowth community (fig. 18, No. 1). With time, conifer seedlings become established. Seedling establishment will also take place following a seedbed preparing burn (fig. 18, No. 2). The regeneration usually is composed of intolerant trees, but *Abies, Thuja,* and *Tsuga* may form a significant portion of the fire-initiated stand.



* Seral species vary with the habitat type. Generally they are ponderosa pine, lodgepole pine, Douglas-fir, western larch, western white pine, subalpine fir, and spruce. Grand fir, western redcedar, and western hemlock may occur in seral stages, but their representation will be limited by periodic fires.

Figure 18.--Forest succession in Fire Group Eleven: grand fir, western redcedar, and western hemlock habitat types.

A light-to-moderate fire occurring during the early seral stages would kill the young conifers and return the site to a shrub and herb community (fig. 18, No. 3). If the burn were incomplete, the fire would act as a thinning agent (fig. 18, No. 4).

Group Eleven sites are highly productive. Dense vegetation in stands of pole-sized trees promote severe fires (fig. 18, No. 5); however, these are moist sites, and stand-destroying fires are not common during this stage.

Fire in the mature seral stand can have two results. First, light-to-moderate fires would maintain fire-resistant, intolerant species at the expense of less resistant trees (fig. 18, No. 6). Grand fir, western redcedar, and western hemlock may not be completely eliminated, but their representation will be limited. Second, a severe, stand-destroying fire will return the forest to the early secondary stages of a shrub- and herb-dominated mixture (fig. 18, No. 7). A new conifer stand will develop from available seed. The frequency of fires may promote one seral tree species, such as western larch or western white pine, and thereby create a nearly pure stand.

Short intervals between fires in the mesic habitats of Group Eleven are not usual, so the seral stand will progress to the climax forest over time. A forest of climax species takes centuries of uninterrupted succession in order to develop. It may be 300 to 400 years before the intolerant trees become subordinate to the climax component.

A severe fire in the climax stand (fig. 18, No. 8) will cause the site to revert to a shrub and herb mixture that probably will include some conifer seedlings.

The successional development and fire disturbance for cedar-hemlock and grand fir forests have been illustrated by Habeck (1970) and Antos (personal communication). Their diagrams are shown in figures 19 and 20, respectively.

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 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 and associated species in the overstory. 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.

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

Group Eleven habitats 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.

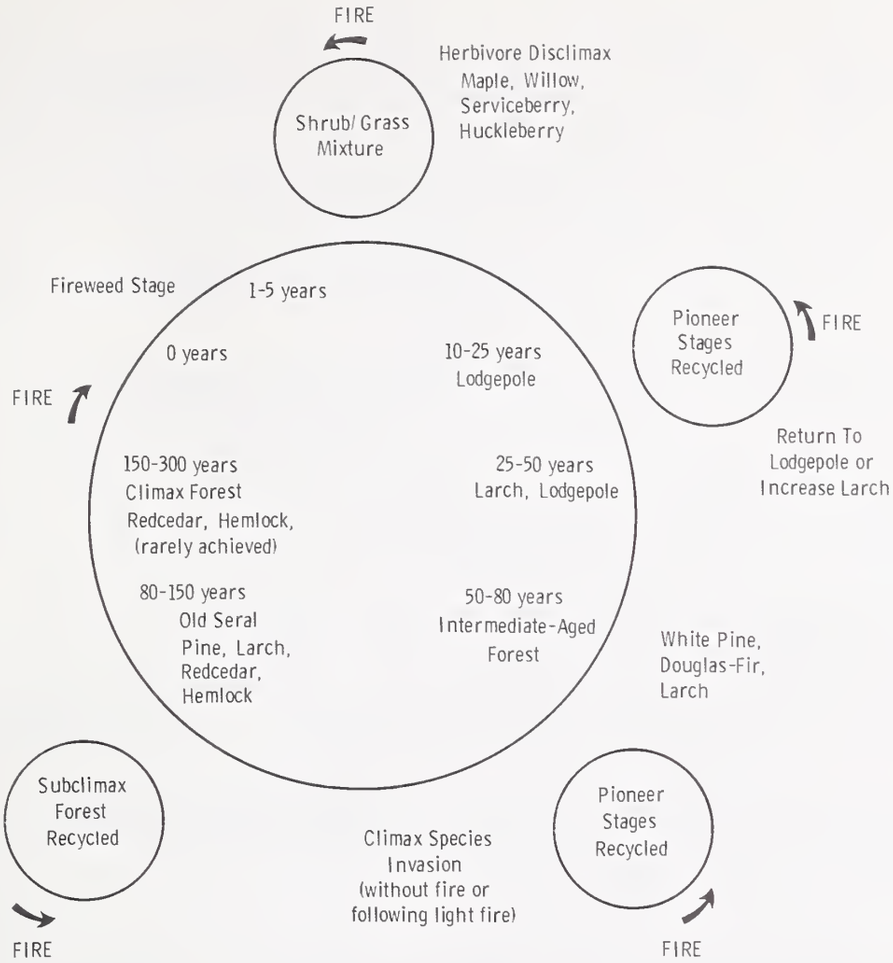
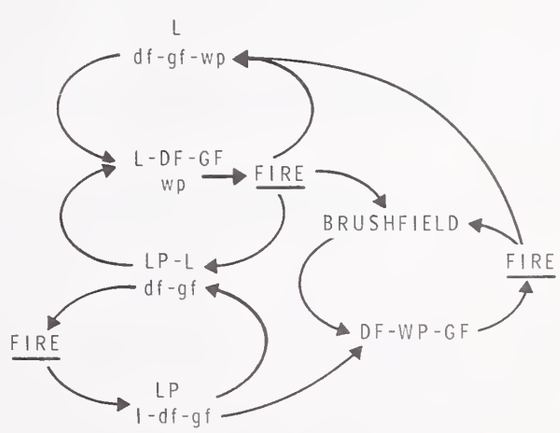


Figure 19.--Successional development scheme and fire disturbance recycles in the upland cedar-hemlock forests on the Lake McDonald area, Glacier National Park (after Habeck 1970).



L = Western Larch
DF = Douglas-Fir
GF = Grand Fir
WP = Western White Pine
LP = Lodgepole Pine

Capital letters indicate major species and lower-case letters indicate minor species.

Figure 20.--Generalized successional patterns following fire on grand fir sites within Swan Valley, Montana (Antos 1977).

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APPENDIX A

APPENDIX A

Forest Habitat Types Occurring in the Lolo National Forest

ADP code[1]	Abbreviation	Habitat types and phases: Scientific names	Common names
100		*PINUS PONDEROSA* CLIMAX SERIES	
130	PIPO/AGSP	*Pinus ponderosa/Agropyron spicatum* h.t.	ponderosa pine/bluebunch wheatgrass
140	PIPO/FEID h.t.	*Pinus ponderosa/Festuca idahoensis* h.t.	ponderosa pine/Idaho fescue
141	FEID phase	*Festuca idahoensis* phase	Idaho fescue phase
142	FESC phase	*Festuca scabrella* phase	rough fescue phase
160	PIPO/PUTR h.t.	*Pinus ponderosa/Purshia tridentata* h.t.	ponderosa pine/bitterbrush
161	AGSP phase	*Agropyron spicatum* phase	bluebunch wheatgrass phase
162	Feid phase	*Festuca idahoensis* phase	Idaho fescue phase
170	PIPO/SYAL h.t.	*Pinus ponderosa/Symphoricarpos albus* h.t.	ponderosa pine/snowberry
171	SYAL phase	*Symphoricarpos albus* phase	snowberry phase
200		*PSEUDOTSUGA MENZIESII* CLIMAX SERIES	
210	PSME/AGSP h.t.	*Pseudotsuga menziesii/Agropron spicatum* h.t.	Douglas-fir/bluebunch wheatgrass
220	PSME/FEID h.t.	*Pseudotsuga menziesii/Festuca idahoensis* h.t.	Douglas-fir/Idaho fescue
230	PSME/FESC h.t.	*Pseudotsuga menziesii/Festuca scabrella* h.t.	Douglas-fir/rough fescue
250	PSME/VACA h.t.	*Pseudotsuga menziesii/Vaccinium caespitosum* h.t.	Douglas-fir/dwarf huckleberry
260	PSME/PHMA h.t.	*Pseudotsuga menziesii/Physocarpos malvaceus* h.t.	Douglas-fir/ninebark
261	PHMA phase	*Physocarpos malvaceus* phase	ninebark phase
262	CARU phase	*Calamagrostis rubescens* phase	pinegrass phase
280	PSME/VAGL h.t.	*Pseudotsuga menziesii/Vaccinium globulare* h.t.	Douglas-fir/blue 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.	*Pseudotsuga menziesii/Linnaea borealis* h.t.	Douglas-fir/twinflower
291	SYAL phase	*Symphoricarpos albus* phase	snowberry phase
292	CARU phase	*Calamagrostis rubescens* phase	pinegrass phase
293	VAGL phase	*Vaccinium globulare* phase	blue huckleberry phase
310	PSME/SYAL h.t.	*Pseudotsuga menziesii/Symphoricarpos albus* h.t.	Douglas-fir/snowberry
311	AGSP phase	*Agropyron spicatum* phase	bluebunch wheatgrass phase
312	CARU phase	*Calamagrostis rubescens* phase	pinegrass phase
313	SYAL phase	*Symphoricarpos albus* phase	snowberry phase
320	PSME/CARU h.t.	*Pseudotsuga menziesii/Calamagrostis rubescens* h.t.	Douglas-fir/pinegrass
321	AGSP phase	*Agropyron spicatum* phase	bluebunch wheatgrass phase
322	ARVU phase	*Arctostaphylos uva-ursi* phase	kinikinnick phase
323	CARU phase	*Calamagrostis rubescens* phase	pinegrass phase
324	PIPO phase	*Pinus ponderosa* phase	ponderosa pine phase
330	PSME/CAGE h.t.	*Pseudotsuga menziesii/Carex geyeri* h.t.	Douglas-fir/elk sedge
340	PSME/SPBE h.t.	*Pseudotsuga menziesii/Spiraea betulifolia* h.t.	Douglas-fir/white spiraea

(continued)

ADP code[1]	Abbreviation	Habitat types and phases: Scientific names	Common names
400		*PICEA* CLIMAX SERIES	
440	PICEA/GATR h.t.	*Picea/Galium triflorum* h.t.	spruce/sweetscented bedstraw
470	PICEA/LIBO h.t.	*Picea/Linnaea borealis* h.t.	spruce/twinflower
500		*ABIES GRANDIS* CLIMAX SERIES	
510	ABGR/XETE h.t.	*Abies grandis/Xerophyllum tenax* h.t.	grand fir/beargrass
520	ABGR/CLUN h.t.	*Abies grandis/Clintonia uniflora* h.t.	grand fir/queencup beadlily
521	CLUN phase	*Clintonia uniflora* phase	queencup beadlily phase
523	XETE phase	*Xerophyllum tenax* phase	beargrass phase
501		*THUJA PLICATA* CLIMAX SERIES	
530	THPL/CLUN h.t.	*Thuja plicata/Clintonia uniflora* h.t.	western redcedar/queencup beadlily
531	CLUN phase	*Clintonia uniflora* phase	queencup beadlily phase
532	ARNU phase	*Aralia nudicaulis* phase	wild sarsaparilla phase
533	MEFE phase	*Menziesia ferruginea* phase	menziesia phase
550	THPL/OPHO h.t.	*Thuja plicata/Oplopanax horridum* h.t.	western redcedar/devil's club
502		*TSUGA HETEROPHYLLA* CLIMAX SERIES	
570	TSHE/CLUN h.t.	*Tsuga heterophylla/Clintonia uniflora* h.t.	western hemlock/queencup beadlily
572	ARNU phase	*Aralia nudicaulis* phase	wild sarsaparilla phase
600		*ABIES LASIOCARPA* CLIMAX SERIES	
700		lower subalpine h.t.'s	
610	ABLA/OPHO h.t.	*Abies lasiocarpa/Oplopanax horridum* h.t.	subalpine fir/devil's club
620	ABLA/CLUN h.t.	*Abies lasiocarpa/Clintonia uniflora* h.t.	subalpine fir/queencup beadlily
621	CLUN phase	*Clintonia uniflora* phase	queencup beadlily phase
622	ARNU phase	*Aralia nudicaulis* phase	wild sarsaparilla phase
623	VACA phase	*Vaccinium caespitosum* phase	dwarf huckleberry phase
624	XETE phase	*Xerophyllum tenax* phase	beargrass phase
625	MEFE phase	*Menziesia ferruginea* phase	menziesia phase
630	ABLA/GATR h.t.	*Abies lasiocarpa/Galium triflorum* h.t.	subalpine fir/sweetscented bedstraw
640	ABLA/VACA h.t.	*Abies lasiocarpa/Vaccinium caespitosum* h.t.	subalpine fir/dwarf huckleberry
650	ABLA/CACA h.t.	*Abies lasiocarpa/Calamagrostis canadensis* h.t.	subalpine fir/bluejoint
651	CACA phase	*Calamagrostis canadensis* phase	bluejoint phase
653	GATR phase	*Galium triflorum* phase	sweetscented bedstraw phase
654	VACA phase	*Vaccinium caespitosum* phase	dwarf huckleberry phase
660	ABLA/LIBO h.t.	*Abies lasiocarpa/Linnaea borealis* h.t.	subalpine fir/twinflower
661	LIBO	*Linnaea borealis* phase	twinflower phase
662	XETE phase	*Xerophyllum tenax* phase	beargrass phase
663	VASC phase	*Vaccinium scoparium* phase	grouse whortleberry phase
670	ABLA/MEFE h.t.	*Abies lasiocarpa/Menziesia ferruginea* h.t.	subalpine fir/menziesia

(continued)

ADP code[1]	Abbreviation	Habitat types and phases: Scientific names	Habitat types and phases: Common names
680	TSME/MEFE h.t.	*Tsuga mertensiana/Menziesia ferruginea* h.t.	mountain hemlock/menziesia
690	ABLA/XETE h.t.	*Abies lasiocarpa/Xerophyllum tenax* h.t.	subalpine fir/beargrass
691	VAGL phase	*Vaccinium globulare* phase	blue huckleberry phase
692	VASC phase	*Vaccinium scoparium* phase	grouse whortleberry phase
710	TSME/XETE h.t.	*Tsuga mertensiana/Xerophyllum tenax* h.t.	mountain hemlock/beargrass
720	ABLA/VAGL h.t.	*Abies lasiocarpa/Vaccinium globulare* h.t.	subalpine fir/blue huckleberry
800		Upper subalpine h.t.'s	
830	ABLA/LUHI	*Abies lasiocarpa/Luzula hitchcockii* h.t.	subalpine fir/smooth woodrush
831	VASC phase	*Vaccinium scoparium* phase	grouse whortleberry phase
832	MEFE phase	*Menziesia ferruginea* phase	menziesia phase
840	TSME/LUHI h.t.	*Tsuga mertensiana/Luzula hitchockii* h.t.	mountain hemlock/smooth woodrush
841	VASC phase	*Vaccinium scoparium* phase	grouse whortleberry phase
842	MEFE phase	*Menziesia ferruginea* phase	menziesia phase
890		Timberline h.t.'s	
850	PIAL-ABLA h.t.'s	*Pinus albicaulis-Abies lasiocarpa* h.t.'s	whitebark pine-subalpine fir
860	LALY-ABLA h.t.'s	*Larix lyallii-Abies lasiocarpa* h.t.'s	alpine larch-subalpine fir
870	PIAL h.t.'s	*Pinus albicaulis* h.t.'s	whitebark pine

[1]Automatic data processing codes for National Forest System use.

APPENDIX B

APPENDIX B

Ecoclass Code for Lolo National Forest Habitat Types

(On and Losensky 1977)

The Ecoclass System was developed to provide a hierarchial approach to vegetation for all levels of land planning. The following example illustrates the meaning of the code.

CP-1-162

Formation	Association	Subgroup	Habitat type - phase
C(conifer)	P(ponderosa pine)	1(warm, dry)	162 (PIPO/PUTR-FEID)

The ecoclass code symbols used in the ecoclass code are defined:

Formation

C-Coniferous forest areas, stands dominated by conifers even though hardwoods may be present; climax coniferous forest.

Association

A-Alpine, open forest parks of subalpine fir, whitebark pine, mountain hemlock, alpine larch.

C-Western redcedar as the climax dominant

D-Douglas-fir as the climax dominant

E-Engelmann spruce as the climax dominant

G-Grand fir as tha climax dominant

H-Western hemlock as the climax dominant

P-Ponderosa pine as the climax dominant

S-Subalpine fir as the climax dominant

Subgroup

1-Warm, dry

2-Moderately warm, dry

3-Moderately cool, dry

4-Cool, moderately dry

5-Moderately cool, moist

6-Cool, moist

7-Wet

8-Cold, moderately dry

Habitat type and phase

Refer to Habitat Types of Montana (Pfister and others 1977), table 1, pages 6 and 7 for meaning of the data processing code.

APPENDIX C

APPENDIX C

Distribution of Tree Species in Lolo National Forest Habitat Types Showing Their Dynamic Status as Interpreted from Sample Stand Data (after Pfister and others 1977)[1]

Fire Group	Habitat type/ phase	JUSC	PIPO	PSME	PICO	LACO	PICEA	ABGR	PIMO	THPL	TSHE	ABLA	TSME	PIAL	LALY
	PIPO/AGSP	(c)	C	a	.	.	.	.	.	.	.	.	.	.	.
	PIPO/FEID, FEID	a	C	a	.	.	.	.	.	.	.	.	.	.	.
I	PIPO/FEID, FESC	a	C	a	.	.	.	.	.	.	.	.	.	.	.
	PIPO/PUTR, AGSP	a	C	a	.	.	.	.	.	.	.	.	.	.	.
	PIPO/PUTR, FEID	(c)	C	a	.	.	.	.	.	.	.	.	.	.	.
	PIPO/SYAL, SYAL	a	C	a	.	.	.	.	.	.	.	.	.	.	.
	PSME/AGSP	(c)	C	C	.	.	.	.	.	.	.	.	.	.	.
	PSME/FESC	a	C	C	.	.	.	.	.	.	.	.	.	.	.
	PSME/PHMA, CARU	.	S	C	a	a	.	.	.	.	.	.	.	.	.
2	PSME/SYAL, AGSP	.	S	C	.	.	.	.	.	.	.	.	.	.	.
	PSME/CARU, AGSP	.	S	C	.	.	.	.	.	.	.	.	.	.	.
	PSME/CARU, PIPO	.	S	C	.	.	.	.	.	.	.	.	.	.	.
	PSME/SPBE	.	(S)	C	a	a	.	.	.	.	.	.	.	.	.
	PSME/FEID	a	a	C	.	.	.	.	.	.	.	.	.	.	.
	PSME/VACA	.	(S)	C	S	(S)	a	.	.	.	.	a	.	.	.
	PSME/PHMA, PHMA	.	(s)	C	(s)	(s)	.	a	.	.	.	.	.	.	.
	PSME/VAGL, 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	.
	PSME/LIBO, SYAL	.	(s)	C	(s)	(S)	.	.	.	.	.	.	.	.	.
3	PSME/LIBO, CARU	.	(s)	C	(S)	(S)	.	.	.	.	.	a	.	.	.
	PSME/LIBO, VAGL	.	(s)	C	S	(s)	a	a	.	.	.	a	.	.	.
	PSME/SYAL, CARU	.	(S)	C	(s)	a	a	.	.	.	.	.	.	.	.
	PSME/SYAL, SYAL	.	(S)	C	(s)	.	.	.	.	.	.	.	.	a	.
	PSME/CARU, ARUV	.	S	C	s	(s)	.	.	.	.	.	.	.	.	.
	PSME/CARU, CARU	.	a	C	(S)	(s)	.	.	.	.	.	a	.	a	.
	PSME/CAGE	.	(s)	C	a	.	.	.	.	.	.	a	.	(c)	.
	PICEA/LIBO	.	a	S	S	.	C	.	.	.	.	a	.	a	.
	ABLA/VACA	.	.	(s)	S	a	(c)	.	.	.	.	c	.	a	.
	ABLA/CACA, CACA	.	.	a	S	.	s	.	.	.	.	C	.	a	.
4	ABLA/LIBO, VASC	.	.	s	S	a	s	.	.	.	.	C	.	a	.
	ABLA/XETE, VASC	.	.	(s)	S	.	s	.	.	.	.	C	a	(s)	.
	ABLA/VAGL	.	.	S	S	.	S	.	.	.	.	C	.	(s)	.

(continued)

Fire Group	Habitat type/ phase	JUSC	PIPO	PSME	PICO	LACO	PICEA	ABGR	PIMO	THPL	TSHE	ABLA	TSME	PIAL	LALY
	PICEA/GATR	.	(s)	S	S	.	C	.	.	.	.	a	.	a	.
	ABLA/OPHO	.	.	s	.	s	S	.	s	.	a	C	.	.	.
	ABLA/CLUN, CLUN	.	(s)	S	(S)	S	S	(s)	(s)	a	a	C	.	a	.
	ABLA/CLUN, ARNU	.	a	s	(s)	S	S	(s)	(S)	.	a	C	.	.	.
	ABLA/CLUN, VACA	.	(s)	S	S	s	s	a	a	.	.	C	.	a	.
	ABLA/CLUN, XETE	.	.	S	S	S	S	a	(s)	.	a	C	(c)	a	.
	ABLA/CLUN, MEFE	.	.	S	s	s	S	(C)	(s)	a	a	C	(c)	a	.
	ABLA/GATR	.	a	S	S	(s)	S	.	.	.	.	C	.	.	.
	ABLA/CACA, CACA	.	.	.	S	.	S	.	.	.	.	C	.	(s)	.
	ABLA/CACA, GATR	.	.	.	s	.	S	.	.	.	.	C	.	.	.
	ABLA/LIBO, LIBO	.	(s)	S	S	(S)	S	a	.	.	.	C	.	a	.
5	ABLA/LIBO, 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/XETE, VAGL	.	(s)	S	S	(s)	s	a	(s)	.	.	C	a	(s)	.
	TSME/XETE	.	.	(s)	S	(s)	s	a	(s)	.	.	C	C	(s)	.
	ABLA/LUHI, VASC	.	.	.	(s)	.	S	.	.	.	.	C	a	S	.
	ABLA/LUHI, MEFE	.	.	.	a	.	S	.	.	.	.	C	.	s	(C)
	TSME/LUHI, VASC	.	.		(s)	.	s	.	.	.	.	C	C	s	.
	TSME/LUHI, MEFE	.	.	.	a	.	s	.	.	.	.	(C)	C	a	.
6	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	.
	ABGR/XETE	.	s	S	S	S	a	C	a	a	.	a	.	.	.
	ABGR/CLUN, CLUN	.	(s)	S	(s)	(s)	(s)	C	(s)	a	.	(c)	.	.	.
	ABGR/CLUN, XETE	.	a	S	s	S	(S)	C	s	a	a	c	.	.	.
	THPL/CLUN, CLUN	.	a	S	(s)	S	S	(c)	(s)	C	a	(c)	.	.	.
7	THPL/CLUN, ARNU	.	.	S	a	S	(S)	(c)	(s)	C	(c)	(s)	.	.	.
	THPL/CLUN, MEFE	.	.	S	S	S	S	a	(s)	C	.	c	.	.	.
	THPL/OPHO	.	.	s	.	a	s	(s)	a	(C)	(C)	(c)	.	.	.
	TSHE/CLUN, ARNU	.	a	(s)	a	S	(S)	(c)	.	c	C	(c)	.	.	.
8	SCREE	.	(C)	C	a	.	(c)	.	.	.	.	(c)	.	(c)	.

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

APPENDIX D

APPENDIX D

Index of Habitat Types and Phases
Occurring in the Lolo National Forest

ADP code[1]	Abbreviation	Fire Group	Page Number
100	*PINUS PONDEROSA* CLIMAX SERIES		
130	PIPO/AGSP	2	6
140	PIPO/FEID h.t.		
141	FEID phase	2	6
142	FESC phase	2	6
160	PIPO/PUTR h.t.		
161	AGSP phase	2	6
	FEID phase	2	6
170	PIPO/SYAL h.t.		
171	SYAL phase	2	6
200	*PSEUDOTSUGA MENZIESII* CLIMAX SERIES		
210	PSME/AGSP h.t.	4	13
220	PSME/FEID h.t.	5	19
230	PSME/FESC h.t.	4	13
250	PSME/VACA h.t.	6	20
260	PSME/PHMA h.t.		
261	PHMA phase	6	20
262	CARU phase	4	13
280	PSME/VAGL h.t.		
281	VAGL phase	6	20
282	ARUV phase	6	20
283	XETE phase	6	20
290	PSME/LIBO h.t.		
291	SYAL phase	6	20
292	CARU phase	6	20
293	VAGL phase	6	20
310	PSME/SYAL h.t.		
311	AGSP phase	4	13
312	CARU phase	6	20
313	SYAL phase	6	20
320	PSME/CARU h.t.		
321	AGSP phase	4	13
322	ARUV phase	6	20
323	CARU phase	6	20
324	PIPO phase	4	13
330	PSME/CAGE h.t.	5	19
340	PSME/SPBE h.t.	4	13
400	*PICEA* CLIMAX SERIES		
440	PICEA/GATR h.t.	9	38
470	PICEA/LIBO h.t.	7	30
500	*ABIES GRANDIS* CLIMAX SERIES		
510	ABGR/XETE h.t.	11	54
520	ABGR/CLUN h.t.	11	54
521	CLUN phase	11	54
523	XETE phase	11	54

(continued)

ADP code[1]	Abbreviation	Fire Group	Page Number
501	*THUJA PLICATA* CLIMAX SERIES		
530	THPL/CLUN h.t.		
531	CLUN phase	11	54
532	ARNU phase	11	54
533	MEEE phase	11	54
550	THPL/OPHO h.t.	11	54
502	*TSUGA HETEROPHYLLA* CLIMAX SERIES		
570	TSHE/CLUN h.t.		
572	ARNU phase	11	54
600	*ABIES LASIOCARPA* CLIMAX SERIES		
700	Lower subalpine h.t.'s		
610	ABLA/OPHO h.t.	9	38
620	ABLA/CLUN h.t.		
621	CLUN phase	9	38
622	ARNU phase	9	38
623	VACA phase	9	38
624	XETE phase	9	39
625	MEFE phase	9	39
630	ABLA/GATR h.t.	9	39
640	ABLA/VACA h.t.	7	30
650	ABLA/CACA h.t.		
651	CACA phase	9	39
653	GATR phase	9	39
654	VACA phase	7	30
660	ABLA/LIBO h.t.		
661	LIBO phase	9	39
662	XETE phase	9	39
663	VASC phase	7	30
670	ABLA/MEFE h.t.	9	39
680	TSME/MEFE h.t.	9	39
690	ABLA/XETE h.t.		
691	VAGL phase	8	38
692	VASC phase	7	30
710	TSME/XETE h.t.	8	38
720	ABLA/VAGL h.t.	7	30
800	Upper subalpine h.t.'s		
830	ABLA/LUHI		
831	VASC phase	10	48
832	MEFE phase	10	48
840	TSME/LUHI h.t.		
841	VASC phase	10	48
842	MEFE phase	10	48
890	Timberline h.t.'s		
850	PIAL-ABLA h.t.'s	10	49
860	LALY-ABLA h.t.'s	10	49
870	PIAL h.t.'s	10	49
	Miscellaneous		
010	Scree	0	4
n/a	Forested rock	0	4
n/a	Meadow	0	5
n/a	Grassy bald	0	5
n/a	Alder glade	0	5

[1]Automatic data processing code for National Forest use.

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Davis, Kathleen M., Bruce D. Clayton, and William C. Fischer. 1980. Fire ecology of Lolo National Forest habitat types. USDA For. Serv. Gen. Tech. Rep. INT-79, 77 p. Intermountain Forest and Range Experiment Station, Ogden, Utah 84401.

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

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The Intermountain Station, headquartered in Ogden, Utah, is one of eight regional experiment stations charged with providing scientific knowledge to help resource managers meet human needs and protect forest and range ecosystems.

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