Appendix 31

Disturbance Processes and Functions of Habitat Groups

The following descriptions of the ecological processes and functions of subbasin habitat groups are adapted from Gautreau (1999).

Habitat Group 1: Warm and Dry

Disturbance Processes

Recurrence of disturbance and recovery within ecosystems is an important mechanism for energy flow, maintenance of habitat diversity, vegetative succession, canopy reduction, etc. The long-term health of ecosystems is linked to disturbance.

Fire Regime: Historically, frequent low severity fire was the predominant disturbance type that maintained the open ponderosa pine stands and grasslands. The nature and impact of the light severity fires varied from underburning that essentially left the forest structure intact, to areas burned that reduced vegetation in a function that resembles natural thinning.

With a fire return interval from five to 25 years, these nonlethal, nonuniform burns regularly interrupted succession of Douglas-fir and largely determined the stand composition. During fire-free periods dense thickets of Douglas-fir commonly develop beneath the overstory. The overstory trees become very susceptible to crown fires when this situation occurs, as the ladder fuels provide access to an otherwise surface fire. Although rare, this condition can result in severe stand replacing fires. Mixed lethal fires were limited to small areas and resulted in a combination of underburning and stand replacement.

Fuels and Nutrient Cycling: Fuel loadings on representative habitat types range from 10 to 20 tons per acre (ave. 11) and are composed of herbaceous material, tree litter and some large woody fuels (Fisher and Bradley 1987). Levels have increased due to fire exclusion. Historic fuel loadings may have been significantly less (ave. 5-9). The frequent, low severity ground fires burned through light surface fuels, creating a mosaic of fuel conditions. The fuel loadings varied at any given time and increased where periodic deadfall and natural thinning occurred, as well as absence of fire. These nonlethal fires have less potential to cause erosion as fine-root biomass is largely intact. Many of the sites have shallow, rocky soils with a thin duff layer which, in addition to a short growing season, results in a relatively low to moderate level of site productivity. Decomposition rates are low as compared with moist sites.

Insects and Disease: In most sustainable forest ecosystems, insects and pathogens are also the major nutrient recyclers. Disturbances caused by insects and diseases occur in all terrestrial ecosystems and as a group probably are the most evident. In this HG, diseases don't play a major role in succession within the ponderosa pine cover type. Stem diseases such as western gall rust and atropellis canker affect tree growth and form but are not commonly problematic. However, root disease on these droughty sites can impact Douglas-fir, a major host species.

Mature ponderosa pine and Douglas-fir are highly susceptible to western pine beetle and Douglas-fir beetle, respectively. Bark beetle outbreaks are often brought about by prolonged dry weather, fire weakened trees, or in conjunction with root disease. Overmature, slow growing, decadent or otherwise nonvigorous trees are prime breeding habitat for bark beetles. Pine engraver beetles, though usually secondary attackers, can cause significant tree mortality during dry weather or following stand disturbances. Fortunately, the duration of this effect is seldom more than one season.

Weather: Isolated windstorms and lightning occur. Snow damage is generally minor at the lower elevations. Periodic drought on these warm, dry sites is characteristic and influential in the functioning of this HG and the resultant vegetation patterns. The most severe drought occurs in areas with abnormally low winter and spring rainfall, as summer water resources rely on winter snowpack. Due to low snow depths, this HG is not likely to experience rain on snow floods which are a result of heavy rain falling on and penetrating existing snow cover.

Successional Pathways

The accompanying illustration (Figure ___) depicts the generalized pathway for a forest community in Fire Group 4 that evolves beginning with a stand replacement event. (Fisher and Bradley 1987). Under natural fire regimes, a grass/forb community develops and is followed by the establishment of ponderosa pine and Douglas-fir seedlings. Ponderosa pine seedlings and saplings are often able to withstand frequent, low severity fires. However, Douglas-fir saplings do not fare as well due to clustered and highly flammable needles, thin bark, and resinous blisters. As a result, ponderosa pine retains dominance as a major seral species. The tendency of ponderosa pine to self-prune lower branches, the loosely arranged open foliage, and the thick bark contribute greatly to its fire-resistant characteristics. The accumulated needle litter favors slow moving, low severity ground fires that continue to reduce the stocking of Douglas-fir and understory vegetation while maintaining an open grasslike condition with overstory ponderosa pine. Most old growth forests, in this HG, likely evolved through this scenario.

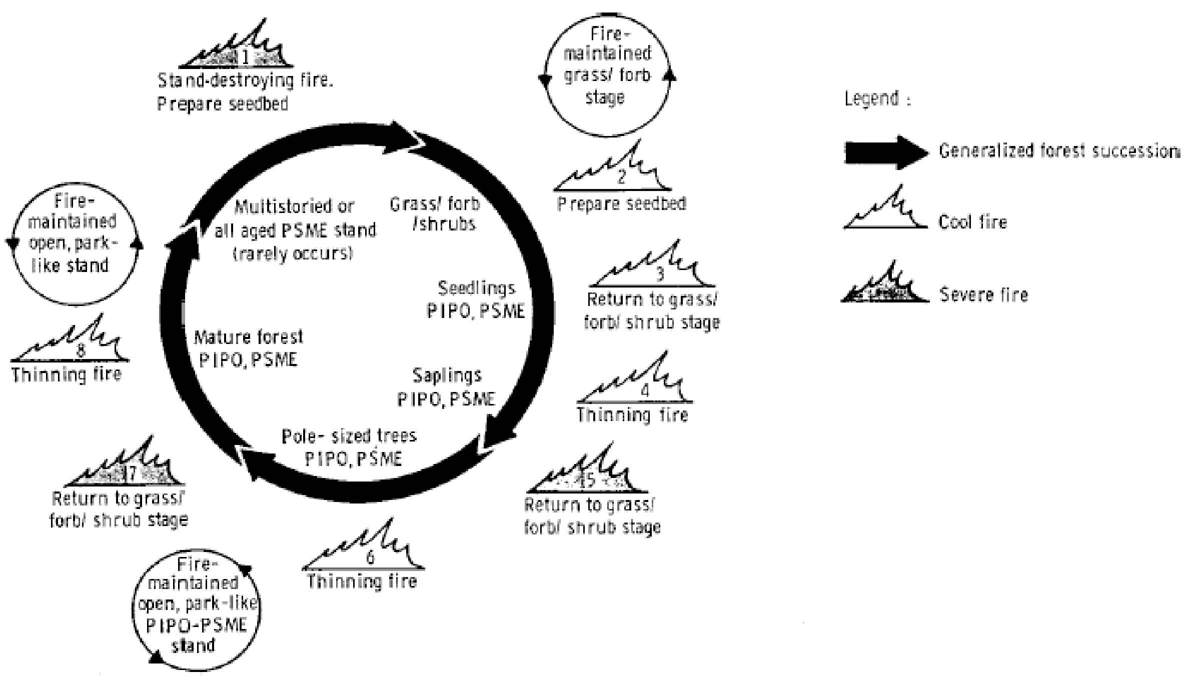

Figure___. Generalized successional pathway for a forest community in Fire Group 4

In the event that fire is absent, the herb/shrub stage is replaced by ponderosa seedlings and later Douglas-fir. The density of the trees and the mix of species depends a lot on site conditions, the timing of regeneration and how long fire has been absent. Competing vegetation is a significant deterrent to early survival and development of young ponderosa pine seedlings. In addition, moisture stress reduces seed germination as well as seedling survival and growth in these warm, dry types. In time, light to moderate fires will thin the developing stand and eliminate understory and trees less tolerant of fire. Without fire, Douglas-fir gains dominance through advancement into the overstory and eventually outcompetes ponderosa pine as the climax species. This theoretical climax forest is a multi-storied or all-aged Douglas-fir forest. Since a prolonged fire-free period is not realistic, this scenario is unlikely to develop. Of course, both successional scenarios are broad and recognize the existence of mosaic or patchy conditions that represent variation in species composition, forest types, and stocking levels.

Ecological Function and Habitat Features

Ecosystems consist of structures and elements that perform a number of functions. Insight into ecological function is important to our understanding of how the ecosystem operates and its relative measure of biological diversity. The ecological functions described include interactive processes that occur to varying degrees across the landscape.

Landscape Linkages: Within forested areas along the primary topographic ridges, connectivity is relatively high, which results in important wildlife corridors for seasonal wildlife movement. However, the overall open-canopied stand structure and the increased edge associated with irregular patches provides little to no interior habitat.

Old Growth and Interior Habitat: Although many of the stands within this HG do not fit the classic mixed conifer description of old growth, they do contain many of the physical and structural characteristics which are important to wildlife. The frequency of underburning in this habitat does not favor the retention and development of downed logs and small mammal habitat. However, gaps created by fire have value for wildlife species that prefer such small openings.

Wildlife Habitat: Habitat within this HG is considered valuable winter range habitat for elk, moose, whitetail deer, and bighorn sheep as snow levels are generally low in these areas. Upper elevations receive spring bear use and also may be important fall denning habitat. Hiding cover is provided in the many fir thickets that occur. Overall, thermal cover is scattered and located in timbered patches where crown closure is sufficient to intercept snow. Full crowned, individual overstory trees can also offer decent thermal cover. Where there are multi-storied conditions, large mammals can control body temperature without using fat reserves. Multi-storied conditions are also important for birds, as different species have adapted to using the various canopy layers.

Big game winter range use is one of the primary functions of this HG. These forage areas are open, fairly extensive and have high solar exposure. However, the openings are generally avoided by whitetail deer when snow depths are excessive (>18"). Forage under open forest canopies is very important and may be composed of forage species such as bluebunch wheatgrass, Idaho fescue, arrowleaf balsamroot, and western serviceberry. Snowberry is considered marginal forage but may be browsed by deer and elk in late summer/early fall. Due to the warm, dry habitat conditions and sparse vegetation on these south slopes, high quality forage is generally limited during the summer months. Following low severity fires, the quality of forage is usually improved. In many cases, species such as arrowleaf balsamroot, snowberry and western serviceberry respond by increasing their abundance as well as palatability.

Dead trees are used by dependent species for feeding, nesting, roosting and resting. Snags are generally scattered across the landscape, composed of broken-topped Douglas-fir, as well as scattered fire-scarred ponderosa pine trees. Soft ponderosa pine snags attract cavity nesting wildlife and can be expected to function as such for an average of 10 years. Following fire events, increased snag levels and insect activity provide favorable short term habitat for dependent species.

Dead and down woody material is important habitat for small vertebrate animals, reptiles, amphibians and insects. The diversity of habitat is generally low in this landscape due to the shortage of downed logs. However, small mammals are attracted to the debris and litter produced by old growth stands. As these sites typically have shallow soils, blowdown will create additional small mammal habitat, as will a susceptibility to disease, mistletoe and insect mortality.

Rare Elements and Specialized Habitat: Overall structural, vertical, and species diversity is low as compared to moist, mixed conifer habitat. However, nonforested, natural openings occur and contain shrub and herbaceous vegetation often uncommon elsewhere. Specialized habitat is limited as large, contiguous interior habitat is not as common when compared with warm, moist forest settings. Bogs and seeps are important habitat that exist in low elevations and depressions. Flammulated owls and other raptors utilize the habitat within this HG. Some areas are likely used as selected nest sites by many bird species because of available cavities and broken-topped trees. This would include a compliment of adapted, neotropical migrant birds. In addition, osprey and eagles favor the relatively dense foliage that provides seclusion, large and stable branches for nesting platforms and preferred height associated with large trees. Pileated woodpecker feeding occurs but nesting site availability varies from moderate to high. Wild turkeys show a preference for the open nature of old growth ponderosa pine stands.

Habitat Group 2: Moderately Warm and Dry

Disturbance Processes

Fire Regime: Vegetative conditions can represent large variations in moisture and temperature which are reflected in different frequency and intensity of fire regimes. A fire regime will usually follow elevational gradients and differing aspects and result in varying fire intensities and a mosaic of stand ages and types. The habitat type groups within this HG are primarily in Fire Group 6 with some Fire Group 4. The fire group concept is based on the response of various tree species to fire and the roles these species play in forest succession. As described below, three different fire regimes represent the environmental gradient within this fire group.
The first fire regime (nonlethal) is representative of moderately warm dry sites, while the latter (mixed lethal and high severity/ SR) are representative of cooler and more moist sites. Between these extremes are a mosaic of stand and age class structures that result in a unique landscape condition.

Prior to intensive fire suppression, fire was an important agent in controlling density and species composition in this HG. Low to moderate severity fires on a frequency of 15 to 45 years were the predominant disturbance, in the drier habitat types, playing a major role in maintaining the seral community of conifers. Nonlethal, nonuniform underburns were the most common type, typically on low elevations and on southerly aspects. These low severity fires would burn nonuniformly consuming the litter and undergrowth. This usually left an open overstory of larch, ponderosa pine and Douglas-fir largely intact and created small canopy gaps. Structural diversity remained high under these mosaic conditions. Mixed lethal, mosaic fires typically occurred at mid to upper elevations and northerly aspects, creeping along the surface and occasionally flaring up, killing trees in patches and aiding the creation of multiple age classes. Western larch and ponderosa pine were favored in this situation due to their inherent fire tolerance and ability to regenerate under these conditions.

In a third scenario, high severity fires occurred much less frequently on an average of every 225 years but ranged from approximately 150-400+ years (Arno et. al. 1995). The variability in this Fire Return Interval (FRI) is largely attributed to variations in topography, habitat type and species mix. These lethal fires very likely occurred within overstocked stands or in draws that may have contained heavy fuels due to long fire-free intervals. In many cases, a dense understory of trees creates a fuel ladder that carries fire up into the crowns and through a stand. Although not uniform or expansive, these patchy fires typically resulted in overall stand replacement with even-aged stands of westerrn larch, ponderosa pine, Douglas-fir and/or lodgepole pine. While considered outside of a representative range of variation, the stand replacement fires are important to consider, given the nature of existing stand conditions and their predisposition to high severity fires. This is of particular relevance on steep slopes where lethal fires are more common due to crowning effects.

Fuels and Nutrient Cycling: Forests evolve with a continual flux of coarse woody debris. The creation and accumulation of which vary according to forest type, stand density, insect and disease activity, decay rates, fire return interval, age and stand history. In most sustainable forest ecosystems, insects and pathogens are also the major nutrient recyclers. On sites such as these, fire will likely play a more dominant role in maintaining site productivity due to its more frequent presence.

Coarse woody debris performs many important physical, chemical, and biological functions in a forest setting. On moderately warm and dry sites this debris can be an important source of moisture for vegetation during periods of drought. In this HG, a frequent, low severity fire regime has generally kept duff depth low and reduced fine fuels, creating a mosaic of fuel conditions. In recent decades this situation has changed, as fire is not functioning in its historic role, and fuel accumulations have increased. In addition, decomposition rates are low compared with moist sites.

Within Fire Group 4 and 6 herbaceous material, tree litter and large woody fuels averaged 11-12 tons per acre in research plots of representative habitat types (Fisher and Bradley 1987). Heavier fuels existed where mortality from insects or disease was high and on the moist, more productive sites. The most hazardous conditions occur in well stocked stands with dense Douglas-fir understories. Under natural conditions it is likely that fuels would have been somewhat lighter due to more frequent fires that consumed some of this.

Insects and Disease: Disturbances caused by insects and diseases occur in all terrestrial ecosystems and as a group probably are the most evident. As ponderosa pine and western larch are the predominant stand components, diseases do not play a major successional role in this HG. Dwarf mistletoe is often endemic to the stand and appears in scattered relic overstory trees. Stem diseases such as western gall rust and atropellis canker affect tree growth and form but are usually not a major concern. Root disease on these droughty sites can impact Douglas-fir, a major host species, as well as grand fir.

Mature ponderosa pine and Douglas-fir are highly susceptible to western pine beetle and Douglas-fir beetle, respectively. Bark beetle outbreaks are often brought about by prolonged dry weather, fire weakened trees, or in conjunction with root disease. Overmature, slow growing, decadent or otherwise nonvigorous trees are prime breeding habitat for bark beetles. Pine engraver beetles, though usually secondary attackers, can cause significant tree mortality during dry weather or following stand disturbances such as blowdown. Fortunately, the duration of this effect seldom lasts more than one season. Dense pole-sized stands of ponderosa pine can be susceptible to mountain pine beetle during extreme epidemic conditions or in conjunction with drought. Mature lodgepole pine are a primary host for bark beetles as well, particularly where they have regenerated in patches and exhibit signs of low vigor.

Weather: Occasional thunderstorms occur during the summer as a result of late afternoon convection buildups. Severe storms with damaging winds seldom occur. Snow damage is generally minor at the lower elevations. Periodic drought is characteristic the drier parts of this HG and influential in its functioning and the resultant vegetation patterns. The most severe drought occurs in areas with abnormally low winter and spring rainfall as summer water resources rely on winter snowpack. Due to generally low snow depths, this HG is not likely to experience rain on snow floods which are a result of heavy rain falling on and penetrating existing snow cover.

Successional Pathways

The following scenarios and accompanying illustration (Figure 2) depict broad pathways that are generally representative of vegetation succession under the influence of both natural fires and periodic absence of fire (Fisher and Bradley 1987). The descriptions recognize the existence of mosaic or patchy conditions that represent variation in species composition, forest types, and stocking levels. In general, the associated plant communities that are disturbed by fire gradually regain their composition and structure similar to what existed before the event. Depending on the habitat type and the survival mechanism of the plant, most vegetation will renew itself with time.

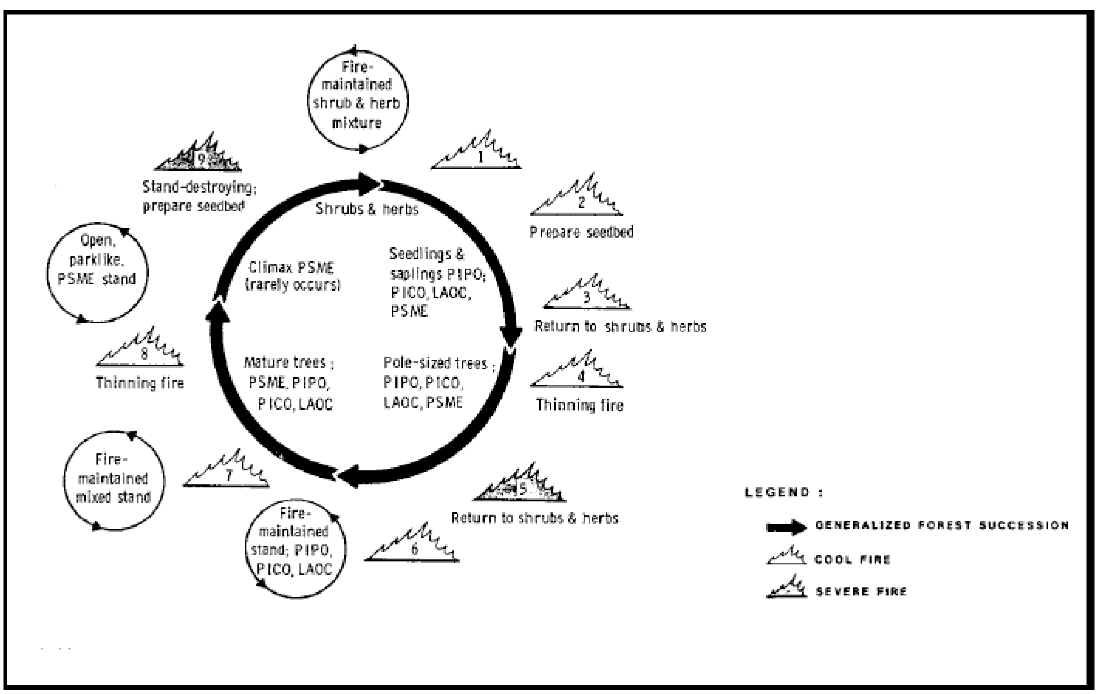

Figure 2: Generalized Forest Succession in Fire Group 6.

Under a nonlethal fire regime typical of the drier parts of HG2, ponderosa pine and western larch retain dominance over Douglas-fir as major seral species. On flat to moderate slopes (<25%) the natural accumulation of needle litter favors slow moving, low severity ground fires that reduce the stocking of Douglas-fir and understory vegetation to mosaic patches. This scenario maintains a relatively open stand condition with overstory ponderosa pine, western larch and scattered Douglas-fir. Openings contain grasses, forbs and shrubs. Most old growth forests in this HG likely evolved through this scenario. Steeper topography will create a different condition as vegetation burns more quickly and higher into the crowns.

On the cooler and more moist sites, succession following mixed lethal fires created a variety of conditions facilitated by the availability of growing space and sunlight. Stand conditions are open with western larch and Douglas-fir overstory interspersed with small openings created by patchy tree mortality. Larger openings allow regeneration to lodgepole pine in even-aged patches. The tendency for some sites to be frost pockets (i.e. DF/dwarf huckleberry) also favored lodgepole pine development. Another condition resulting from the mixed severity fires are the multi-storied stands of western larch and Douglas-fir overstory that develop with a younger cohort of the same species underneath. Without a fire event, these multi-storied conditions can convert to mostly single storied stands at high stocking levels. These stands often develop low levels of vigor and health due to poor regeneration and growth.

In general, low to moderate severity fires in early seral stands kill susceptible trees and convert dense stands of pole size and larger trees to a more open condition. If the fire intensity is very low, young ponderosa pine trees may survive due to fire-resistant characteristics. In these fairly young stands, competing Douglas-fir is also at risk from fire due to low, sweeping crowns and reduced fire tolerance. As ponderosa pine matures it develops characteristics such as open crowns, fire-pruned lower boles, large protected buds, high foliage moisture and thick insulating bark protecting it from the heat of fires.

After a long enough fire-free interval, stand replacement fires can occur in the more moist settings of this HG under varying forest conditions. Mature, multi-storied stands of Douglas-fir, mid seral stands of Douglas-fir and lodgepole pine, and mature Douglas-fir stands with scattered lodgepole pine are particularly prone to lethal fires. These three conditions all typically have an understory of Douglas-fir, with or without lodgepole pine and western larch, which can provide access for fire into the upper crowns of overstory trees. Stand replacement can also be facilitated by periods of extended drought.

Following a stand replacement fire in conditions such as these, openings of grass, forbs and shrubs would develop into contiguous areas of sapling and pole sized seral species. A scattered overstory of surviving western larch and occasionally Douglas-fir would likely be present. If vegetation development continues without a fire event, these two storied conditions would convert to mixed species with a moderate to high representation of lodgepole pine. Over time, if the fire-free interval is long enough, lodgepole pine may develop the physical characteristics that are attractive to bark beetles. This stagnated and overstocked condition can create heavy fuel loadings and significant threat of stand replacement, in the event a fire occurs.

Without fire, Douglas-fir gains dominance through advancement into the overstory and eventually outcompetes ponderosa pine as the climax species. Competing vegetation is a significant deterrent to early survival and development of young ponderosa pine seedlings and Douglas-fir is the only species that continues to regenerate in any abundance without disturbance. In addition, moisture stress reduces seed germination as well as seedling survival and growth. This theoretical climax forest is a multi- storied or all-aged Douglas-fir forest that develops after a prolonged fire-free period. In some cases, where Douglas-fir is the seral dominant (i.e. DF/ninebark and DF/pinegrass habitat types) frequent low to moderate severity fires can create open, parklike stands of Douglas-fir in a climax condition.

Ecological Function and Habitat Features

This HG is a transition between the warm dry environment containing open, multi-aged stands of ponderosa pine (HG 1) and the moderately cool and moist environment containing mixed conifer species such as grand fir, western hemlock and western redcedar (HG 5). With these unique and diverse habitat features, this landscape serves as important wildlife habitat that is utilized by most terrestrial species. The low elevation areas are important winter/spring range, while mid to upper elevations are utilized primarily in summer. In addition, a frequent low severity fire regime provides good nutrient turnover and enhanced soil productivity, a significant ecological role.

Landscape Linkages: How habitat features are connected relates directly to the resiliency of the landscape. Habitat linkages are important to such species as wolves and grizzly bear. Wide ranging carnivores such as wolverine, lynx, fisher and some old growth associated species rely on these corridors. At a finer scale, forested areas provide movement linkages for many species that travel from watering to feeding to bedding sites. Of course, these types of areas are commonly used by animals moving between seasonal habitat. Within this landscape, connectivity is relatively high and results in important corridors for wildlife movement. This is largely attributed to small but variable patch sizes which generally include primary topographic ridges within them.

Old Growth and Interior Habitat: This HG makes up a very small percentage of the functional old growth and interior habitat across the forest. Although many of the stands within this landscape do not fit the classic mixed conifer description of old growth, they do contain many of the physical and structural characteristics which are important to wildlife. The frequency of underburning in much of this landscape does not favor the retention and development of downed logs and storied stand structures which are characteristic of late seral forest conditions. Contiguous areas of vegetative cover provide specialized habitat to interior dependent wildlife species, while gaps created by fire have value for wildlife species that prefer small openings.

Wildlife Habitat: Low to moderate snow levels in this HG create valuable winter range habitat for elk, whitetail and mule deer, moose and bighorn sheep. Following hibernation, bears utilize upper elevation areas during early spring foraging and as fall denning habitat. Draws, dense Douglas-fir stands and shrub thickets provide good hiding cover. Full crowned overstory trees effectively intercept snow and can offer decent thermal cover in patchy openings. Where there are multi-storied conditions, large mammals can control body temperature without using fat reserves. Multi-storied conditions are also important for birds, as different species have adapted to using the various canopy layers.

While there is considerable canopy closure across this landscape, a good browse component is available to wildlife species and enhances the areas' value as big game winter and spring range. The primary forage areas are steeper, west and south exposures located on open ridges and natural openings within forest patches. Whitetail deer avoid openings where snow depths are excessive (>18"). Forage under open forest canopies is important to many species. South slopes have limited forage value in late summer due to the relatively warm, dry habitat conditions which tend to support less vegetation.

Important winter forage grasses for mule deer, elk and bighorn sheep include bluebunch wheatgrass and rough fescue. Elk sedge is an important forage for black bear, deer and occasionally elk in the early growing season. Western serviceberry is a key forage for whitetail deer, mule deer, elk, sheep and moose during the winter and early spring. Common snowberry is frequently found and is marginal as forage but is utilized by deer in the summer and fall. There is use by elk when other desirable forage species is not present. Buffalo-berry, bitter-brush, chokecherry and Rocky Mountain maple are not common, but have winter forage value as well. Kinnikinnick and Oregongrape are common and provide light to moderate big game winter forage. In addition, bears utilize the berries in spring and fall. Deer are also known to browse on Douglas-fir seedlings and saplings during winter months.

The frequent, low severity fire regime that is characteristic has a definite effect on wildlife habitat through its effect on vegetation. The combined result of killing overstory trees, reducing understory competition and rejuvenating plants through top kill can promote the availability and palatability of many browse and forage species such as western serviceberry, common snowberry, mallow ninebark, elk sedge and pinegrass.

Snags provide a portion of the life support system for many species of plants, invertebrates, birds, and mammals. Snags are utilized for feeding, nesting, roosting and resting. While snags and cavity habitat in HG2 is relatively low, as compared with moist sites, there is scattered distribution of suitable trees across this landscape. Douglas-fir and ponderosa pine snags are typically short term providers of cavity habitat, when compared with western larch, but are nonetheless important. Study of cavity nesters in northwest Montana (McClelland et al. 1979) found that 74% of sampled nests were in western larch, 30% in hardwoods, and 6% in Douglas-fir or ponderosa pine. Disturbances such as root disease, bark beetle infestation and fires of varying intensities created snags that contain cavity habitat in many species and potential nesting sites for raptors in ponderosa pine. Dead and down woody material in various stages of decay are important to small vertebrate animals, reptiles, amphibians, and invertebrates. Dense shrub thickets, draws, and heavily timbered areas provide a great setting as vegetation and woody material is readily available. As most sites within this habitat have moderately shallow soils, blowdown can create additional small mammal habitat, as will susceptibility to disease, mistletoe and insect mortality. In a landscape with frequent low severity ground fires, diversity of this type of habitat is generally low to moderate due to the shortage of downed logs. However, this habitat has increased in recent decades due to greater biomass accumulation and less frequent fires.

Rare Elements and Specialized Habitat: Habitat provided by unique topographic and biological features serve an important function that is not provided by plant communities or successional stages elsewhere. Snags, down woody debris and edge habitat have been discussed in previous comments and play a vital role in this. Unique habitat such as bogs, seeps, caves, cliffs, and talus slopes are not very common in this landscape, yet they are disproportionately important as wildlife habitat. As they are typically fragile environments, there is little or nothing that can be done to improve them and they should be recognized as rare. Nonforested, natural openings occur and contain shrub and herbaceous vegetation often uncommon elsewhere.

Flammulated owls and other raptors utilize habitat in HG2, but the increase in shade tolerant species and limited ponderosa pine has reduced suitability for flammulated owl use. Available cavities and broken-topped trees are likely used as selected nest sites by many bird species, including adapted neotropical migrants. In addition, relatively dense foliage provides seclusion, large and stable branches for nesting platforms and preferred height associated with large trees. Pileated woodpecker feeding occurs but availability of nesting sites varies from moderate to high. Big game mineral licks are scattered and may be found where lacustrine deposits are exposed in calcareous glacial till and outwash. Where riparian areas occur, they receive a tremendous amount of wildlife use, particularly in summer range areas.

Habitat Group 3: Moderately Warm and Moderately Dry

Disturbance Processes

Fire Regime: As very little of the Flathead is categorized as HG3 it is important to recognize the complex nature of defining the fire regime for this transitional HG. The Fire Groups that comprise this HG include both Fire Group 6 and Fire Group 11. This is largely due to the variation in temperature and moisture across this HG and the resultant diversity in fire regimes. The fire group is based on the response of tree species to fire and the roles they play in forest succession (Fisher and Bradley 1987).

The historic fire regime of a given ecosystem can be characterized by the average fire frequency, fire severity, and fire size (Perry 1994). This HG has been shaped by a combination of fire regimes, mainly low to moderate intensity fires. Moist upland sites containing mixed species and pure lodgepole pine stands experienced a high percentage of stand replacement fires. This is attributed to many factors that include higher humidities leading to longer fire return intervals, higher stocking levels, drought and heavy fuels. This fire regime is very similar to that described for more moist parts of HG2 except that stand replacement fires were more common and resulted in larger openings due to higher stocking levels and increased fuel loadings in this HG.

The fire free interval for low severity, nonlethal underburning is estimated at 25-50 years. On these drier, more open sites numerous fire-resistant western larch, Douglas-fir, and ponderosa pine remain following these events. Fire scar sampling data from the Meadow Creek landscape assessment (KNF 1997) suggest a mean fire return interval of 31 years for nonlethal fires. An exception is demonstrated in research in Abgr/Libo on the Bitterroot NF (Arno 1995) show a mean interval of 13 years, maintaining a long lived and multi-aged overstory of ponderosa pine, despite competition from grand fir and Douglas-fir. This frequent fire regime reduced fuels more often and reduced the site susceptibility to fire regimes of a higher intensity. Low intensity, frequent surface fires were an important agent in controlling species composition and density, particularly at low elevations and on southerly aspects.

Moderate severity**,** mixed lethal fires occurred at mid to upper elevations on north slopes every 70 to 250 years on cool and wet sites and every 30 years on warm and moist sites. Losensky found that where lodgepole pine dominated stands, these fires occurred on the average of 77 years. The greater likelihood of mixed severity fires burning on moist sites is perhaps because the drier sites (having nonlethal fires) are receptive to burning for a longer time period each year. The nature of these moderate severity fires resulted in large canopy gaps and mosaic conditions that included patches of even-aged stands, with surviving groups and individual trees. Multiple age classes also resulted, as the tendency of these mixed severity fires was to underburn trees as well as to flare up and torch out crowns. The presence of western larch is a good indicator of a moderate severity fire regime that occasionally opens up enough growing space for larch establishment.

Stand replacing fires were patchy and occurred within the range of 100 to 250 years in varying environmental conditions, but primarily in cool/wet sites and warm/moist sites. Often, these fires originated in overstocked stand conditions or draws with heavy fuels due to long fire-free intervals. Also, dense understory trees create a fuel ladder that often carries fire up into the crowns and through the stand. Fires occurring on steep slopes or wind prone areas can contribute to this occurrence. Following lethal fires, the vegetative conditions often result in a nonuniform distribution of even-aged stands containing scattered overstory western larch and Douglas-fir. Historic vegetation research (Arno et al. 1995) in a Abgr/Libo site on the Bitterroot NF did not indicate a stand replacement fire having occurred in the last few centuries. This may be attributed to the gentle topography and evidence of frequent low to moderate intensity fires which minimize fuel accumulations.

Fuels and Nutrient Cycling: Fuel loadings are highly variable due to the wide range of fire return intervals and forest types within this HG. Much of the downed fuels results from insect and disease caused mortality, accumulated deadfall, periodic natural thinning, and blowdown. The amount, distribution and flammability of these fuels largely determines the severity of fire. Dead woody material on the ground serves a number of ecological functions that include: protecting the soil from surface erosion, a site for nitrogen fixation, storage for energy and some nutrients. Ideal moisture conditions make downed material a favorable microsite for the growth of young trees, as well.

Research by Losensky (1993) in grand fir types of Idaho estimated historic fuel loadings of 13-30 tons per acre in Fire Group 6. Other studies (Fisher and Bradley 1987) display quite a range but averaged 14 tons per acre. While there is considerable variation, the tendency of habitat types within this group to be overstocked and contain understory thickets results in high hazard fuel conditions in many cases.

In Fire Group 11, fuel loadings were estimated to average 25 tons per acre in both studies. Despite the relatively high fuel loadings, fire hazard in group 11 is normally low to moderate, under normal conditions, due to fairly high humidity on the moist sites.

The nutrient cycle occupies a key position in ecosystem processes and can be directly affected by disturbances, both natural and human-caused. Dense thickets of fire intolerant grand fir and Douglas-fir are susceptible to fast moving crown fires, which can reduce the longevity and function of coarse woody debris (Dumroese, pers. comm). The dense, nutrient rich crowns are ideal settings for lethal fires to occur, with resultant mortality and nutrient loss. Where heavy residual fuels remain, second burns can occur and lead to soil damaging results. Natural decomposition rates are higher in this HG due to the increased site moisture.

Insects and Disease: Disturbance caused by insects and disease occur almost everywhere and to varying degrees. This is largely due to the nonuniformity of tree distributions and the sites containing host species. Indigenous pathogens certainly are natural and necessary and perform important functions in natural ecosystems (Hagle 1993a). Management efforts intended to suppress disturbance from insects and disease have the potential to reduce biodiversity and ecosystem health. Our perception and acceptance of this role has changed in recent years with an acknowledgment that endemic levels of insects and disease are a desirable level to manage for.

Some insects and pathogens may attack only healthy host trees. Others affect only host trees that have been weakened by stress from some other disturbance. Stress induced pathogens eventually kill these weakened trees, thereby releasing growing space and nutrients to the replacement vegetation. Drought prone areas not only are more susceptible to root disease but are also prone to Douglas-fir beetle outbreaks. Mature patches of lodgepole pine are also a primary host for bark beetles, particularly where they are low in vigor. Endemic levels of dwarf mistletoe commonly appear in stands containing scattered, large diameter western larch and Douglas-fir.

While Douglas-fir survived frequent fires, they often did not attain great longevity, perhaps as a result of decay hastened by fire injury (Arno et al. 1995). Also, resin deposits often contribute to the enlargement of old fire scars during subsequent fires (Fisher and Bradley 1987).

Where grand fir survive the effects of fire, they typically have severe heart rot that has entered through fire scars.

In some cases, the conditions brought about by human influence are having undesirable effects. For example, fire exclusion has increased stocking levels and shifted some areas to more Douglas-fir and grand fir which favors root disease. This condition can also exacerbate mortality from the fir engraver beetle in grand fir. In some areas, previous harvest entries have caused basal wounding in residual trees resulting in an increased level of heart rot in mature grand fir, western larch and, to a lesser extent, Douglas-fir.

Weather: The key determinant of fire severity is probably weather (Johnson and Larsen 1991). In particular, droughts set the stage for small fires to become large ones. Historic records confirm this by noting that the most extensive fires in North American forests occur during dry periods (Clark 1988). The most severe drought occurs in areas with low winter and spring rainfall. Occasional east winds may cause a drying trend and in fire season lead to critical burning conditions (Barrett 1995).

Wind can be a major force in this HG, creating gaps of various sizes by blowing down trees that are adjacent to existing openings or currently affected by root disease. The susceptibility to blowdown has a lot to do with crown support of adjacent trees, as this influences the amount of crown sway.

Occasional thunderstorms occur during the summer, accompanying late afternoon convection buildups. These storms can bring sporadic and intense rain or simply dry lightning. Stream runoff peaks in the spring, with rapid snowmelt from mountain watersheds. When snowmelt coincides with the high spring runoff, floods may occur as stream banks are full.

At a different level, cold air drainage in narrow mountain valleys leads to dew formation during the night in areas where cold air pools. The influence of this microclimate can be important in reducing transpiration stress and in helping seedling survival on flat ground. However, the same conditions can cause frost related regeneration problems. While Douglas-fir is particularly vulnerable to foliar damage from frost, lodgepole pine is considered one of the most frost hardy species.

Successional Pathways

Vegetation that exists following a fire is largely dependent on the severity of the event, the vegetation that existed prior to the disturbance, the seed stored on the site, survival of seed trees, and the degree that natural regeneration is successful. While the nature of fire is important to plant community establishment, these accompanying factors are largely responsible for post-fire succession. The diagram below (Figure __) represents a conceptual basis for illustrating the successional trends that are described for Fire Group 6 (Fisher and Bradley 1987). Different scenarios are inevitable and include conditions where ponderosa pine and western larch are seral dominants, where Douglas-fir is a seral dominant throughout succession, and where lodgepole pine and Douglas-fir are co-dominant serals.

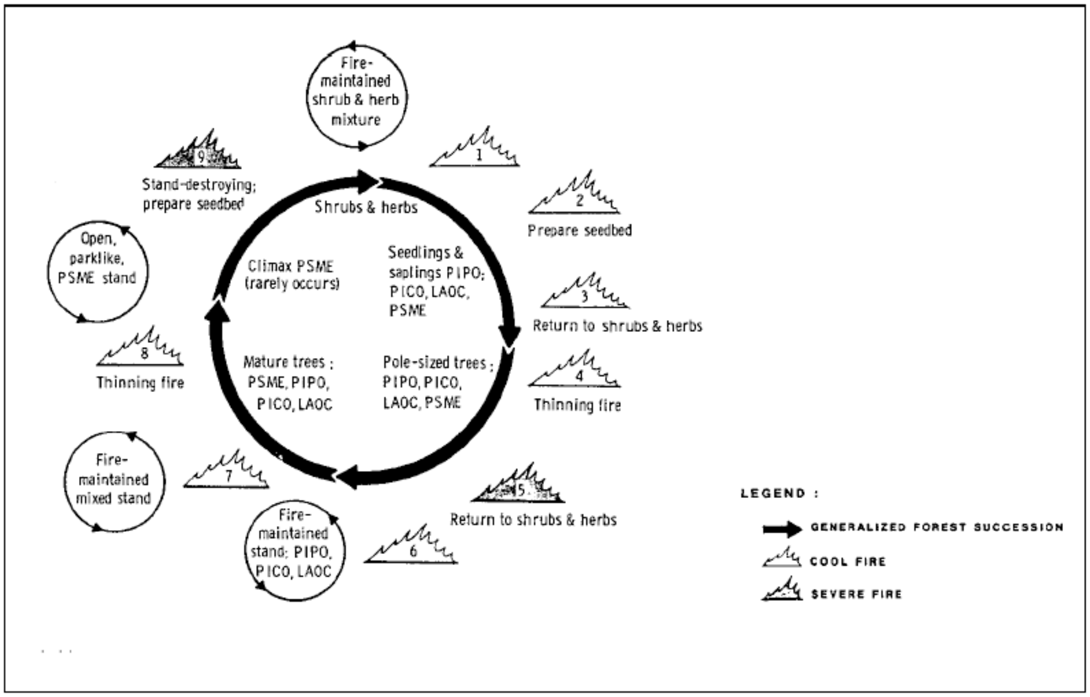

Figure ___ - Generalized Forest Succession in Fire Group 6

In the event that a severe, stand replacing fire occurs in a hypothetical stand in this HG, a mix of shrubs, forbs, and grass establish on the site. In time, seral species such as western larch, lodgepole pine, ponderosa pine and Douglas-fir become established as a single cohort. Relic overstory trees are scattered throughout the landscape. Low intensity fires that occur during early seral stages can act as a thinning agent, in many cases converting overstocked stands of pole size and larger trees to a more open condition. Intermediate sized western larch, Douglas-fir and ponderosa pine are usually favored in these circumstances. Ponderosa pine is a bit more fire-resistant than larch at this point. Lodgepole pine and Douglas-fir may be significantly reduced or eliminated if they in are densely stocked conditions. These maintenance fires 'prune' lower tree branches, reduce understory competition and rejuvenate browse and forage plants. A long interval between underburns will allow a tall understory to develop, which has a high probability of crowning (Davis et al. 1980).

Although the growth of residual Douglas-fir and lodgepole pine can be significantly reduced for at least two years after wildfire (Peterson 1991), it is possible that the thinning effect of the maintenance fires will eventually increase growth on the residual trees (Oliver and Larson 1990). Where fire has access to the canopy, heavily stocked pole-sized stands have a high crown fire potential (Davis et al. 1980). A high intensity fire will kill almost all trees in this mid-seral development stage. This could result in a shift back to the herb/shrub phase or facilitate the development of dog-hair lodgepole pine stands from serotinous cones. If an area experiences a double burn within a relatively short interval, the site may revert to a brushfield. Neither western larch or lodgepole pine will likely survive such fires in the pole stage.

Mature**,** mixed-species stands that experience fires of low to moderate intensity are naturally thinned, favoring western larch and ponderosa pine, with patches of other species where fires are less intense or excluded. In the larger diameter classes, western larch exhibits greater fire resistance than ponderosa pine. In studies that monitored growth response following prescribed underburning (Reinhart and Ryan 1988), individual tree growth was not reduced despite some fire damage. However, overall stand growth was reduced as projected growth was distributed among fewer, larger trees. If the overstory remains relatively intact following a fire, the new cohort will develop as predominantly shade-tolerant species, including grand fir (Larson 1982). This understory reinitiation begins the formation of a multi-aged structure, characteristic after low to moderate severity fires and/or the break-up of overstory canopies. In the unlikely event that Douglas-fir is of both the climax species and the dominant seral, frequent low to moderate intensity fire can maintain these conditions by cleaning out competing open understories.

If these mature stands experience a lethal fire, tree mortality is very high and the vegetative conditions are replaced by early successional plants and scattered overstory relics, individually or in clumps. Western larch has light winged seeds, which can easily blow onto a burned site from adjacent stands or from lightly scorched cones in the fire-killed stands. If present on the site, lodgepole pine will develop from serotinous cones in the area. Often, lodgepole pine will dominate under these conditions, particularly towards the center of large burns (Cooper 1991). Both lodgepole pine and western larch have exceptionally fast juvenile height growth and, along with other species developing at the same time, create different strata over time.

Ecological Function and Habitat Features

This HG is a transition between the relatively open landscape of the warm, drier environments (i.e. HG 2) containing dispersed openings and mosaic conditions, and the cooler moist sites (i.e. HG 5) with contiguous areas of dense, similarly structured stands. This habitat diversity is important to many wildlife species that utilize it for a variety of functions, including cover and browse. These habitat features contribute to the biological diversity of the landscape as a whole.

Landscape Linkages: Adjacent riparian areas provide a valuable forested linkage between different types of habitat. Wildlife may seasonally use these areas as cover between unforested areas and also as sources of food and water. Overall, the forest composition in this landscape provides suitable connectivity for many wildlife species such as wolves, grizzly bear, lynx, fisher and wolverine.

Old Growth and Interior Habitat: Structural diversity varies from low in commonly occurring single-layered forest conditions to moderate in multi-storied stands. Both conditions occur and are controlled by fire, site conditions and seed source. Stands with old growth characteristics are not evenly distributed in this HG.

Long fire-free interval on these moist sites enable the old growth conditions to persist. The exception is sites with predominantly lodgepole pine, a seral species. The commonly occurring large, even-aged patches do function as interior habitat and provide habitat for neo-tropical migratory birds, big game security and travel for many species.

Wildlife Habitat: Big game use is high as this habitat generally provides excellent cover. Openings within this habitat are generally small and hiding cover is provided by shrub thickets and the overall density of the trees. Thermal cover is well distributed in much of these dense, mixed conifer and lodgepole pine stands.

This HG is important summer range for bighorn sheep, elk, whitetail and mule deer. Some winter range occurs on the low elevation areas and open ridges of this landscape where solar exposure is higher. Forage areas vary from gaps in the canopy to larger, natural openings that may border riparian areas or meadows. Vegetation that is important wildlife forage occurs in this HG. Oregongrape has a high protein content and is valuable winter forage for whitetail deer. Bears and other wildlife eat the berries as well. The leaves and twigs of the Rocky Mountain maple are important winter food for big game. Small mammals eat the seeds, buds and flowers. Huckleberry is an important early summer browse for elk, mule deer and whitetail. Bears consume the berries, an important food source. The abundance of common snowberry provides an important food source for wildlife, particularly by deer in the summer and fall. Elk have been known to utilize this where little else is available. *Pachistima* (mountain-lover) is considered to be an important forage for elk, deer and moose although palatability and nutritional value is low. Heart-Leaf arnica is an important browse for elk. The flowers are preferred by some ungulates.

Some of the drier portions of this HG, that often function as winter range, contain browse such as pinegrass which is an early growing season forage for deer, elk and black bear. Elk sedge is important forage for elk during the spring and summer. During the winter and early spring elk, bighorn sheep, moose and deer utilize western serviceberry. The berries of kinnikinnick are important to bears in spring and fall. The plant is moderately important winter browse for mule deer, elk, bighorn sheep and moose. When other forage is not available, is utilized year-round by deer and elk. Both grizzly and black bear eat the berries. Where fires occur, they have an effect on wildlife habitat by opening up stands, reducing understory competition and rejuvenating plants to increase availability of palatable browse.

Snag levels vary from low in areas regenerating, to a single age class following stand replacement fires, to fairly high where mixed-severity fires retain diverse structural components. Dead trees are used for feeding, nesting, roosting and resting depending on their physical characteristics. Snags provide a lifeline for many plants, birds, mammals, and invertebrates. Black-backed woodpecker occupy mixed conifer, grand fir and lodgepole pine stands for reproduction and feeding purposes. The abundance of western larch, Douglas-fir and ponderosa pine in most areas provides reasonable habitat options for cavity-dependent species.

Dead trees or portions of trees lying on the forest floor perform a variety of functions. For example, woodpeckers eat insects that inhabit downed logs, and mammals use logs for foraging, cover and reproduction. In general, this HG provides moderate habitat for small vertebrate animals, reptiles, amphibians, and invertebrates. Fairly low levels of downed trees and woody debris exist due to the nature of this fire regime. However, dense shrub thickets, draws, and heavily treed areas provide small mammal habitat as well. During fire-free intervals or following incidents of tree mortality higher levels of habitat suitability exist. Blowdown does occur but is not as significant as neighboring landscapes with shallow soils or in settings more susceptible to windthrow.

Rare Elements and Specialized Habitat: Diversity and uniqueness of this landscape varies but is generally low in areas of primarily single storied and even-aged stands. These contiguous areas offer refuge for some species of wildlife such as owls and bears. Specialized habitat may also be present where unique vegetation occurs within springs, wallows and nonforest natural openings. For example, some areas may be very suitable as prime calving and fawning habitat. They are usually located on gentle topography containing hiding cover and forage within a reasonable distance to water.

Habitat Group 4: Moderately Warm and Moist

Disturbance Processes

Fire Regime: The predominant habitat types within HG 4 are in Fire Group 11. Although moist site conditions and infrequent fires predominate, the occasional periods of summer drought can create some conditions very conducive to severe fires. There is a wide range of fire free intervals within this group due to the wide moisture gradient and the influence of surroundings stands. Fire severity varies from minor ground fire on moist sites to stand replacement fires (Fisher and Bradley 1987).

Within the Abgr/Clun habitat type in the Swan Valley a mean fire return interval (FRI) was estimated at 100-200 years between stand-replacing fires (Antos and Habeck 1981). A later study in the same valley (Freedman and Habeck 1985) estimates a 30 year interval between fires, very likely an extreme example for these forest conditions. A fire history in Rathdrum Prairie of Idaho (Zack 1996), that includes a grand fir and Douglas-fir cover type, indicates a mean FRI for lethal fires at 149 years and a mean FRI of 55 years for all fires (lethal, mixed, nonlethal) prior to 1880. This study occurred in mountainous terrain with varying aspects, and a range of elevations and slope.

There are numerous other fire studies that can be examined for information on fire regimes and return intervals comparable to a typical landscape in HG 4. Looking at these studies in total it is evident that the historic fire severity was nonuniform, including both mixed severity types on an average of every 30-85 years on drier sites with less frequent lethal fires occurring on an average frequency of 200 years on more moist sites. Nonlethal underburns also occurred at varying intervals on the drier exposures sometime between the more common fire events. It is important to highlight that mixed severity fires can range from low intensity, creeping fires that kill primarily shade tolerant trees to severe stand replacing fires that create favorable conditions for seral tree growth and regeneration. In terms of stand structures and species composition, a regime of mixed severity fires promotes highly diverse landscapes because of widely varying fire frequencies, severities, and spread patterns (Barrett 1996).

Fuels and Nutrient Cycling: Fuel loadings for studies in a range of habitat types within Fire Group 11 averaged 25 tons per acre and duff depths from 2 to 4 inches (Fisher and Bradley 1987). This mean is also characteristic of stands sampled in the Abgr/Clun habitat type with a range of fuel loadings from 13 to 38 tons per acre. Moist sites such as these typically have some of the highest fuel loadings due to accumulated deadfall and natural thinning. The humidity of the sites tends to reduce microbial activity due to anaerobic conditions, but decomposition of organic matter still occurs. Nutrient cycling through the litter and back to the plants occurs more readily than cooler or drier sites. All size classes of fuels are higher in Fire Group 11 than any other group. The bulk of the fuel loading is older, rotten material of a larger size class. Depending on the nature of the tree density and canopy closure, the presence of understory fuels is quite variable.

Insects and Disease: With the very high species diversity present, there is an increased level of potential exposure to insects and pathogens. In addition, with relatively long fire free intervals the increased development of shade tolerant species presents additional opportunities for insects and pathogens that prefer these host species. Diseases can cause abnormal growth or development of trees and predispose areas to attack by other agents. Insects can create conditions somewhat similar by chewing, sucking, boring, or mining portions of the particular host trees. In some cases, such as a cone worm, the feeding habit of this pest can stop development of cones and result in infertile seed. Trunk rots, primarily Indian paint fungus, can be common on most moist sites containing grand fir, subalpine fir and western hemlock. Most common in slow growing dense forest conditions, the fungus often remains inactive within branchlet stubs for many years but has the potential for infections to reactivate from mechanical injury. Laminated root rot and armillaria root rot are the primary root-rot pathogens. The latter fungus is the most common type causing mortality in centralized areas and in scattered, individual trees. While its primary host is grand fir, Douglas-fir, lodgepole pine, and ponderosa pine, the fungus can impact all conifers. Laminated root rot is most common in grand fir and Douglas-fir; western hemlock and subalpine fir are less susceptible. It also causes tree mortality in large or small central areas. The conditions brought about by both root disease pathogens often sets the stage for later attack by bark beetles.

Weather: Unusual weather patterns act as a disturbance in a stand (Oliver and Larson 1990) by influencing plant growth and development of species composition. Short term weather events can result in wind damage on a very local level. This disturbance occurs in most terrestrial ecosystems and can be a major force in creating gaps as trees are blown down. In HG 4, trees exposed on ridges, on sites with a high water table, or affected by root disease are particularly vulnerable to wind-caused damage. As these events are not easily predicted and are sporadic, there have been few measurements of their frequency and severity. However, site specific locations within this landscape are more prone to wind-caused damage and their risk can be generally determined by land managers familiar with the area.

Drought is not considered a concern on most areas delineated as HG 4. Moisture and temperature conditions are extremely favorable for promoting vegetative growth and diversity. When drought does occur, it can increase the fire hazard by rapid drying of fuels and increased tree mortality as a result of foliage desiccation.

Snow damage is a common occurrence due to the density of many stands and the resulting stem breakage. Ice storms have been known to occur during the late fall and early spring as warm, moist air produces rain that falls through a subfreezing layer of air at the ground level. When this freezing rain attaches to branches or limbs it can result in considerable breakage.

Successional Pathways

The following illustration (Figure 4) and descriptions characterize forest community development for an area with the attributes of HG 4, within the context of Fire Group 11 (Fisher and Bradley 1987). It includes pathway descriptions that are somewhat similar to HG 5, an associated HG. It is important to recognize that forest community succession on these moist sites is governed by more than the characteristics of a particular fire event. More depends on the potential seed source, existing species composition, and time since stand initiation. The time elapsed until a distinct overstory develops is primarily a function of the rapidity of tree regeneration following disturbance. Many sites within this HG are prime candidates for shrubfield development following stand replacement fires or management activities that do not include site preparation and prompt reforestation.

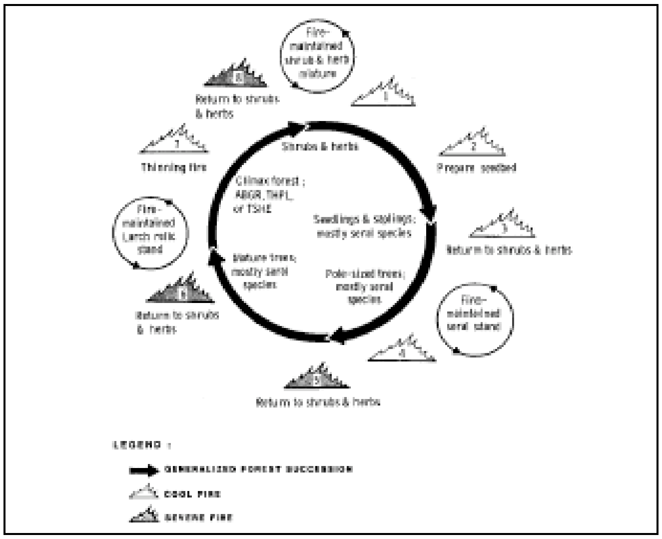

Figure 4 - Generalized Forest Succession in Fire Group 11

In the event that a stand replacing fire occurs, succession begins with a dominant shrub or herb field that essentially occupies the available growing space. Within a given 'burn' there would be areas containing scattered surviving overstory trees, patches of unburned areas and conditions resulting from mixed severity fire effects. The duration of this 'brush' phase can be prolonged if reburn occurs and conifer seed availability is diminished. In time, seedlings and saplings initiate development on these moist, productive sites. Grand fir can be a major recolonizer following stand replacement fires on moist sites (Cooper, et al. 1991). The initial survival and growth of grand fir seedlings is favored by a moderate overstory shading. However, under full sun its slower initial establishment and growth result in grand fir being subordinate to Douglas-fir, western larch, and Engelmann spruce.

Fire history studies indicate that low to moderate fires do occur periodically between this stand initiation stage and less frequent lethal fires which may occur during a late seral forest condition. When occurring within the closed stem exclusion stage, shade intolerant seral species have an advantage due to their relative fire-resistance. Being one of the few species able to successfully reproduce beneath a full canopy, grand fir is generally well represented during the stem exclusion stage. When severe fires occur in these conditions the forest community is again replaced with early seral conditions and stand initiation resumes with an shrub/herb stage. If the replaced stand has a surviving seed source in the form of relic overstory or serotinous lodgepole pine cones, seedling development occurs fairly well.

This simplified expression of succession illustrates how difficult it is for a given area to develop conditions conducive to dominant seral or climax grand fir. Despite a relatively long interval without significant fire disturbance, grand fir is ordinarily not the realized climax species. Fire tolerant species are generally long lived and maintain the site in a seral condition. However, if mixed severity fires do not occur, a long fire free interval will enable the theoretical climax stage to develop. This condition can also take place despite low intensity underburns, which can occur even on moist sites.

Endemic root disease plays an integral role in shaping forest succession by killing trees in large open patches and causing scattered, individual tree mortality. Forest structural change occurs as species composition and stand densities are altered. As root disease patches seem to be perpetually in early successional stages, young trees may never grow beyond the seedling and sapling stage. Even after stand replacement fires, root pathogens appear to remain in place as regeneration establishes, although potentially being prevented from achieving a climax stage. Although permanently established, endemic root disease is often distinguished as having little variation in severity within a particular area. In addition, there is often little expression of root disease outside the discrete patches of mortality.

Ecological Function and Special Habitat Features

Major processes regulate or influence the structure, composition and pattern of ecosystems. Many of these processes have been described (e.g. producing, cycling, storage of resources) as well as the relative importance of their biological role. The following information describes, at a coarser scale, the habitat features of HG 4 that may serve a distinctive role in contributing towards the biological diversity of the overall landscape. While this HG is not well represented on the Flathead, it is nonetheless important to species that utilize its unique habitat components.

Landscape Linkages: The diversity of vegetative composition and wildlife habitat is high in HG 4, resulting in substantial use by big game and non-game species. With respect to wildlife, there is not a lot of functional difference between the south and north aspects in this HG. As a whole, this HG is an important link between summer and winter range and provides habitat for reproduction.

Old Growth and Interior Habitat: As described, this landscape has the potential to provide many old forest features within fairly large, contiguous interior habitat. This habitat can also contain prime sites for sensitive plant species. Current conditions indicate that many areas are in an early seral condition as timber management has been a focus on these highly productive sites. Future silvicultural practices may be able to advance structural development in young stands through stocking control that emphasizes nonuniform techniques and retention of a varied composition of crop trees.

Wildlife Habitat: This HG is important thermal cover for wildlife, particularly along riparian areas. The presence of shrubs and dense canopy cover offer weather protection for a number of species by reducing snow depths. Escape cover from predators is also provided in the multi-storied conditions afforded by this habitat.

This habitat is utilized by most wildlife species, particularly as summer range. Early successional stages of most sites can produce high quality browse for elk and deer. Low elevation areas with solar exposure provide transitional winter range for deer and moose. Winter range value in HG 4 is negligible due to lack of low elevation, south slopes in this landscape. Domestic livestock also utilize some areas within this landscape as transitional forage habitat. The fire regimes in HG 4 historically favor a more closed canopy which often shades understory browse species. This is particularly true during the stem exclusion stages of forest development. Where sunlight does penetrate the canopy or where early seral communities exist in managed forests, forage plants are more available to wildlife. In addition, root disease creates openings in otherwise closed canopies. This provides a unique stand structure not created by any other means. These openings create habitat for forage that may prove to be very valuable to wildlife survival. Many riparian areas continue to provide forage for deer during later successional stages, as palatable forage becomes available.

Pinegrass serves as an important early season forage for black bear, deer and elk where it occurs. Elk sedge is important spring and summer forage for elk and also utilized by bear, sheep and deer. Western serviceberry is a key forage for most big game species during winter and early spring. *Pachistima* (mountain-lover) is important forage for elk, deer and moose despite its low palatability and nutritional value. Common snowberry is often utilized by deer in the summer and fall. When nothing else is available, elk are also apt to browse on snowberry. Huckleberry is an important early season browse plant for elk and deer on summer ranges. Bear feed on the berries, an important food source.

This HG typically has an abundance of snags for cavity nesting species, particularly in western larch, Douglas-fir and ponderosa pine. The structural diversity in this landscape enables this habitat requirement for dependent wildlife to be easily attainable on most sites. Specialized birds such as the black-backed woodpecker utilize snags and downed logs as feeding and reproduction habitat within grass/shrub forest settings.

With the amount of dead, dying and downed woody debris available, this HG provides good, diverse habitat for a number of small game and non-game species. Dead and downed trees provide a food base for insect-seeking birds. Some mammals use the logs for foraging, cover and reproductive habitat. Recurrent blowdown, root disease killed trees and storm breakage enhances the suitability of HG 4 as favorable small mammal habitat.

Rare Elements and Specialized Habitat: The diversity in stand structure, species composition and topographic position offer some unique features. Many sites within HG 4 provide interior habitat that is used for security by many big game species, as well as neotropical migratory birds, pileated woodpecker, etc. Some habitat conditions in HG 4 are desirable as calving or fawning areas. Areas with downed logs and low shrubs are particularly useful for concealing young from predators. Mature, relatively closed canopies are important reproductive habitat where succulent forage is nearby.

Habitat Group 5: Moderately Cool and Moist

Disturbance Processes

Fire Regime: The predominant habitat types within HG 5 are in Fire Group 11 (Fisher and Bradley 1987). Within this group there is a range in fire free intervals due to the wide moisture gradient. Fire severity varies from minor ground fire to stand replacement fires. Due to its proximity to riparian areas along with moist and humid site conditions, fire frequency is relatively low. However, the occasional periods of summer drought can create some conditions very conducive to severe and possibly extensive fires. Quite often the origin of a fire, in these moist settings, is wind carrying fire from adjacent forested stands.

Fire frequencies for cedar-hemlock stands in northern Idaho have been estimated to range from 50 to over 200 years (Arno and Davis 1980). Other studies indicate an estimate of mixed lethal fires varying from a frequency of 17-113 years, with half of these averaging 85 years (Losensky 1993), to a range of 50-100 years (Agee 1994). Estimates of lethal fires vary from 280 years (Losensky 1994), every 200 years (Barrett et al. 1991), 150-300 years (Barrett 1996), and 100-200 years (Fisher and Bradley 1987). A fire history in the North Fork of the Coeur d'Alene River (Zack and Morgan 1996) indicates a mean fire return interval for lethal fires at 212 years and a mean FRI for all types of fire at 65 years. Results of the Smeads Bench pollen core study (Chatters and Leavell 1994) compliment the referenced studies of stand replacement fires in the cedar/hemlock types, estimating a FRI of 110-340 years (mean 200).

Based on this research, fires in this HG can be characterized as nonuniform with infrequent but often extensive stand replacing fires on a frequency averaging 250+ years (110-340 yr. range), sometimes interspersed with mixed severity fires on an average frequency of 75 years (17-113 yr. range). These mixed severity fires can be quite variable, ranging from low intensity, creeping underburns that kill primarily shade tolerant trees to severe stand replacing fires that create favorable conditions for tree growth and regeneration of seral species. The more exposed upper slope ridges and the more protected riparian areas, north slopes, toe slopes and benches are the areas with the highest likelihood of avoiding lethal fires (Zack 1996). The rapid drying of exposed sites increases the probability of more frequent understory fires. In contrast, moist sites experience patchy lower severity underburns during upland lethal fire events and long interval lethal fires.

Fuels and Nutrient Cycling: Fuel loadings for studies in habitat types representative of HG 5 and Fire Group 11 averaged 18 tons per acre (9-30) and duff depths of 3 inches (Fisher and Bradley 1987). Moist sites such as these typically have some of the highest fuel loadings due to accumulated deadfall and natural thinning. While these humid site conditions tend to reduce microbial activity due to anaerobic conditions, decomposition of organic matter still occurs. Nutrients cycling through the litter and back to the plants occurs more readily than cooler or drier sites. All size classes of fuels are higher in Fire Group 11 than any other. The bulk of the fuel loading is older, rotten material of a larger size class. Depending on the nature of the tree density and canopy closure, the presence of understory fuels is quite variable.

Insects and Disease: Effects caused by insects and pathogens are very similar to that described in HG 4. The very high species diversity increases the level of potential exposure to insects and pathogens. In addition, with relatively long fire free intervals, the increased development of shade tolerant species presents additional opportunities for insects and pathogens that prefer these host species. Diseases can cause abnormal growth or development of trees and predispose areas to attack by other agents. Insects can create conditions somewhat similar by chewing, sucking, boring, or mining portions of the particular host trees. These sites are susceptible to white pine blister rust infection. Production and dispersal of rust spores from Ribes species plants is optimum along draws and moist bottoms.

Trunk rots, primarily Indian paint fungus, can be common on most moist sites containing grand fir, subalpine fir and western hemlock. Most common in slow growing dense forest conditions, the fungus can remain inactive within branchlet stubs for many years but the potential to increase due to reactivation of infections by mechanical injury. Laminated root rot and armillaria root rot are the primary root-rot pathogens in this HG. The latter fungus is the most common type causing mortality in centralized areas and in scattered, individual trees. While its primary host is grand fir, Douglas-fir, lodgepole pine, and ponderosa pine, it can impact all conifers. Laminated root rot is most common in grand fir and Douglas-fir; western hemlock and subalpine fir are less susceptible. The conditions brought about by both root disease pathogens often sets the stage for later attack by bark beetles.

Weather: Unusual weather patterns act as a disturbance in a stand (Oliver and Larson 1990) through the influence on plant growth and development of species composition. Drought is not considered a concern on most areas delineated as HG 5. Moisture and temperature conditions are extremely favorable in promoting vegetative growth and diversity. In the event that drought conditions occur within an adjacent HG, there is an increased risk of wildfire spreading onto these moist sites due to a rapid drying of fuels and increased tree mortality as a result of foliage desiccation.

Short term weather events can result in wind damage on a very local level. This disturbance occurs in most terrestrial ecosystems and can be a major force in creating gaps as trees are blown down. In HG 5, trees on sites with a high water table and affected by root disease are particularly vulnerable to wind-caused damage. Very little of this HG occurs on exposed ridges, thus blowdown is less common in these conditions. As these events are not easily predicted and are sporadic, there have been few measurements of their frequency and severity. However, site specific locations within this landscape are more prone to wind-caused damage and their risk can be generally determined by land managers familiar with the area.

Snow damage is a common occurrence due to the density of many stands and the resulting stem breakage. Ice storms have been known to occur during the late fall and early spring as warm, moist air produces rain that falls through a subfreezing layer of air at the ground level. When this freezing rain attaches to branches or limbs it can result in considerable breakage.

Successional Pathways
In the following illustration (Figure __) and accompanying descriptions, an attempt has been made to characterize forest community development for an area with the attributes of HG 5, within the context of Fire Group 11 (Fisher and Bradley 1987). It is important to recognize that forest community succession on these moist sites is governed by more than the characteristics of a particular fire event. As the discussion intends to demonstrate, a lot depends on the potential seed source, existing species composition, and time since stand initiation. The time elapsed until a distinct overstory develops is primarily a function of the rapidity of tree regeneration following disturbance.

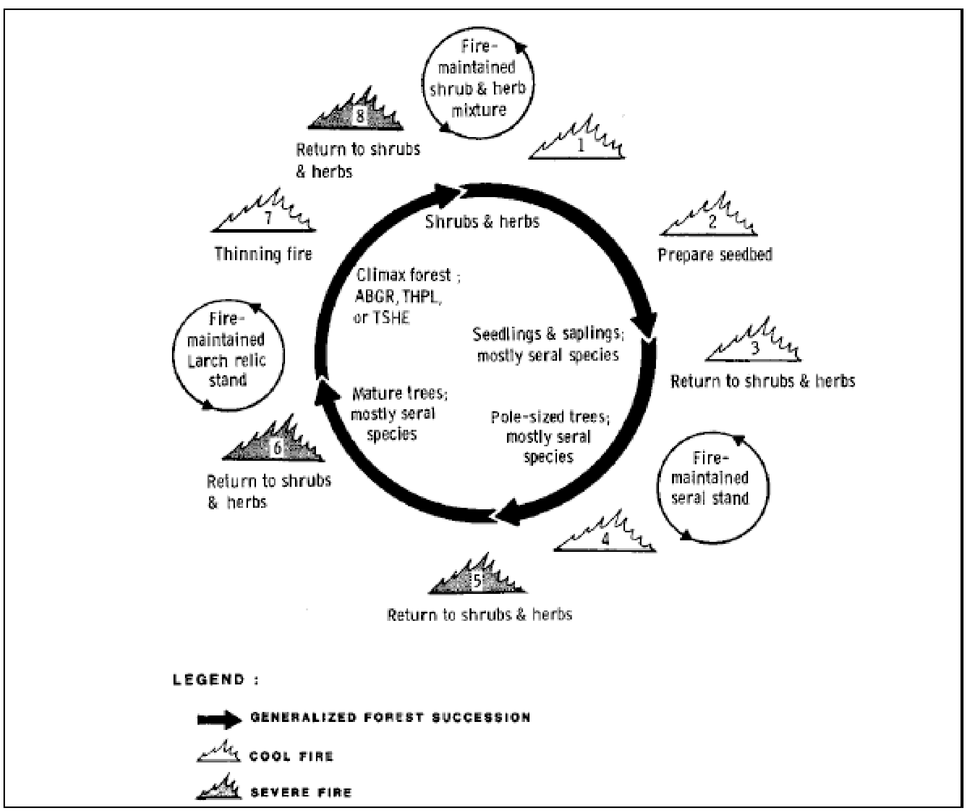

Figure 5: Generalized Forest Succession in Fire Group 11

In the event that a stand replacing fire occurs, succession begins with a shrub or herb field that essentially occupies the available growing space. Within a given 'burn' there would be areas containing scattered surviving overstory trees, patches of unburned areas and conditions resulting from mixed severity fire effects. The duration of this 'brush' phase can be prolonged if reburn occurs and conifer seed availability is diminished. In most situations, seedlings and saplings of many conifer species quickly initiate development on these moist, productive sites. Western redcedar and hemlock regenerate on these disturbed sites along with seral species, however it is usually subordinate to Douglas-fir and western larch due to slower initial establishment and growth.

Fire history studies indicate that periodic low to moderate severity fires occur sometime between this stand initiation stage and less frequent, lethal fires which may occur during a late seral forest condition. When occurring within the closed stem exclusion stage, shade intolerant seral species have an advantage due to their relative fire-resistance. However species such as western hemlock, western redcedar, grand fir and subalpine fir can successfully reproduce beneath a full canopy and are often well represented during the stem exclusion stage. It will ordinarily take several hundred years for western hemlock and western redcedar to assume dominance in the overstory due to the longevity of the seral component. When severe fires occur in these conditions the forest community is again replaced with early seral conditions and stand initiation resumes with a shrub/herb stage. The success and timing of seedling development depends on a seed source provided by the surviving overstory or serotinous lodgepole pine cones.

This very simplified expression of successional development illustrates how difficult it is for a given area to develop conditions where western hemlock and western redcedar occupy a dominant role as climax species. Despite a relatively long interval without significant fire disturbance, fire adapted species are generally long lived and maintain the site in a seral condition. However, if mixed severity fires do not occur, a long fire free interval will enable the theoretical climax stage to eventually develop. This condition can also take place despite the occurrence of low intensity underburns which could occur sometime, even on moist sites.

Root disease plays an integral role in shaping forest succession by killing trees in large open patches as well as scattered individual trees. Forest structural change occurs as species composition and stand densities are altered. Root disease patches seem to perpetually be in an early successional stage. In some cases, young trees never grow beyond the seedling and sapling stage. Even after stand replacement fires, root pathogens appear to remain in place as regeneration establishes although the stand may be prevented from achieving a climax stage.

Ecological Function and Special Habitat Features

Major processes regulate or influence the structure, composition and pattern of ecosystems. Many of these processes have been described (e.g. producing, cycling, storage of resources) as well as the relative importance of their biological role. The following information describes, at a coarser scale, some distinctive habitat features of HG 5 that contribute towards the biological diversity of the overall landscape. This HG is not very well represented on the Forest, but these areas are important to species utilizing these unique habitat components.

Landscape Linkages: As a whole, this HG is an important travel/forage link between summer and winter range. Habitat for reproduction is also important. The diversity of vegetative composition and wildlife habitat is high in HG 5, resulting in substantial use by big game and non-game species. With regard to wildlife use, there does not appear to be significant functional difference between the south and north aspects of these moist sites. In addition, this HG is a link with many important riparian areas that are in proximity to these broad valley bottoms and moist, upland sites.

Old Growth and Interior Habitat: As described, this landscape has the potential to provide many old forest features within fairly large, contiguous interior habitat. Historically, old forest characteristics were fairly common due to the long interval fire events that facilitate the development of multi-strata stand conditions. Current conditions indicate that many areas are in early and mid-seral condition as timber management has been a focus on these high productivity sites. Future silvicultural practices may be able to advance structural development in young stands through stocking control that emphasizes nonuniform techniques and retention of a varied composition of crop trees.

Wildlife Habitat: This HG is important thermal cover for wildlife, particularly along riparian areas. The presence of shrubs and dense canopy cover offer weather protection for a number of species by reducing snow depths. Escape cover from predators is also provided in the storied conditions afforded by this habitat.

This habitat is utilized by most wildlife species, particularly as summer range. While limited in scope, low elevation areas with solar exposure provide transitional winter range for deer and moose. Domestic livestock also utilize some areas within this landscape as transitional forage habitat.

The long interval fire regimes in HG 5 favor a more closed canopy which often shades understory browse species. This is particularly true during the stem exclusion stages of forest development. Where sunlight does penetrate the canopy or where early seral communities exist in managed forests or following wildfire, high quality browse for deer and elk becomes more available. In addition, root disease creates openings in otherwise closed canopies. This provides a unique stand structure not created by any other means. These openings create habitat for forage that may prove to be very valuable for wildlife survival. Many riparian areas continue to provide forage for deer during later successional stages as succulent plants are available.

Rocky Mountain maple is a highly valued big game browse species. Leaves and twigs are an important food source. Seeds, buds, and flowers provide food for birds and small mammals. Scouler willow and red-osier dogwood have a generally high forage value for wildlife. Moose tend to use the streambottoms while deer and elk forage on upland sites. Upland game, such as grouse, feed on willow buds. Western serviceberry is a key forage for most big game species during winter and early spring. *Pachistima* (mountain-lover) is important forage for elk, deer and moose despite its low palatability and nutritional value. Common snowberry is often utilized by deer in the summer and fall. When nothing else is available, elk are also apt to browse on snowberry. Huckleberry is an important early season browse plant for elk and deer on summer ranges. Bear feed on the berries, an important food source. Although not very common on these sites, pinegrass is an early season forage for black bear, deer and elk where it occurs. Elk sedge is important spring and summer forage for elk and is also utilized by bear, sheep and deer. Big game have been known to feed on branches of cedar and hemlock, particularly during winter months.

Moist habitat types and multi-storied forest conditions with considerable stand decadence and breakage create generally abundant snag habitat for cavity nesting species, particularly in large western larch, Douglas-fir and western redcedar. Topographic settings such as exposed ridgetops, prominent spur ridges, and breaklands are particularly likely to have old residual trees. This HG is also suitable to having patches of aspen, cottonwood and birch which are favored hardwood species for cavity development. The structural diversity in HG 5 enables this habitat requirement for dependent wildlife to be easily attainable on most sites. Specialized birds such as the black-backed woodpecker utilize snags and downed logs as feeding and reproduction habitat within grass/shrub forest settings.

With the amount of dead, dying and downed woody debris available, this HG provides good, diverse habitat for a number of small game and non-game species. Dead and downed trees provide a food base for insect-seeking birds. Some mammals use the logs for foraging, cover and reproductive habitat. Recurrent blowdown, root disease killed trees and storm breakage enhances the suitability of this setting as favorable small mammal habitat.

Rare Elements and Specialized Habitat: The diversity in stand structure, species composition and topographic position offers some unique features. Many sites within HG 5 provide interior habitat that is used for security by many big game species, as well as use by neotropical migratory birds, pileated woodpecker, etc. Some habitat conditions are desirable as calving or fawning areas. Areas with downed logs and low shrubs are particularly useful for concealing young from predators. Mature, relatively closed canopies are important reproductive habitat where succulent forage is nearby. Habitat for sensitive plants exists within HG 5.

Habitat Groups 6 and 8: Wet Riparian Habitats

Disturbance Processes

In this setting, the primary ecological processes are infrequent events such as flooding, windthrow, and wind-driven fire from adjacent drier sites. Stand densities are periodically reduced by bark beetles, windthrow, or fire. In general, fire is not a significant disturbance agent on these sites due to the moist fuel beds, lush undergrowth, high humidity, and influence of the inland maritime climate.

Fire Regime: Fire history information in Montana is very limited in the wet habitat types commonly occurring in HGs 6 and 8. Research conducted in their respective Fire Groups (11 and 9) are focused on the drier settings and provide little quantified insight into this fire regime. However, a generalized portrayal can be made utilizing information available from adjacent HGs as well as research on forested riparian sites in northern Idaho.

Available evidence indicates that fire frequency during average moist and moderate summers is generally low and mostly low severity or stand replacing. These mesic sites are a deterrent to ground fires that burn up to the edge of these settings, possibly scarring some trees, but generally burn out upon reaching the moist duff layer. Research by Losensky (1994) also confirmed that underburning was not a major impact in these cover types. Because of the high level of fuels, severe and widespread fires could occur following a severe summer drought. When fires do occur, the nature and extent depends largely on the stream bottom characteristics and the influence of fire occurring in adjacent stands. In general, the steepened side slopes and narrow extent of stream bottoms in HG 8 makes them particularly vulnerable to stand replacement fires that move in from adjacent upland slopes. Lethal fires that enter these valley bottom stands often decrease in severity and become low or mixed severity fires (Smith and Fisher 1997). The broad and wider settings of HG 6 tend to have much longer fire return intervals. In fact, research in spruce bottoms (Losensky,1993) found nonuniform, lethal fires occurring on a 300 to 400 year FRI. Moderate to high severity fires can impact riparian ecosystems despite an infrequent occurrence.

Barrett (1991) found lethal fires in moist cedar bottoms occurring on a 150-250 frequency. Similar sites investigated by Arno and Davis (1980) found an average FRI >200 years for all fires, noting the occurrence of mostly nonlethal, low intensity fires and rare stand replacement fires. Arno and Barrett (1991) reported lethal, nonuniform fires in riparian stringers, dominated by cedar, on a frequency of 197 years. In another study of spruce-fir habitat types (Steele 1994) a FRI of 140-400 years was reported.

Based on the discussed research, fire frequency for lethal fires in riparian settings is estimated to range from 150-400 years. More specifically, lethal fires in HG 8 are expected to occur at the low end of this range, averaging a 220 year FRI. Lethal fires occurring in HG 6 occur at very long intervals estimated to average 300-400 years. It is interesting to note that Agee (1993) suggests that average fire return intervals are not particularly meaningful in forests where fire history rarely extends far enough in the past to record several intervals, and climatic change during that history would have altered the fire regime. He uses the term ' episodic' rather than 'cyclic' to describe fire return intervals in western hemlock forests of the Pacific Northwest.

Fuels and Nutrient Cycling: In Fire Groups 9 and 11 fuels averaged 25 tons per acre in sampled research plots (Fisher and Bradley 1987) but may be higher. In one old growth Thpl/Opho stand on the Kootenai (Fisher 1981a) approximately 58 tons per acre was measured. Most of this downed, dead material is accumulated blowdown, deadfall and natural thinning. In contrast, high rates of decomposition, especially in old growth stands, often contribute to relatively low woody fuel loadings (Shiplett and Neuenschwander 1994). Under normal circumstances, lush undergrowth serves as an effective barrier to rapid fire spread.
Downed woody material is important to the site, creating microsites for plants and young trees, storage for energy and nutrients, site protection from soil erosion, sites for mycorrhizae fungi, etc. Woody material in riparian areas is important, serving a vital role in landscape recovery and upstream channel stability.

Insects and Disease: These HGs contain a diversity of vegetative types that, at times, are predisposed to different levels of insects and pathogens. When the nature and intensity of these conditions exceeds endemic levels, concern for ecosystem health may bring about management action. Mature stands in highly productive, moist settings are susceptible to high levels of heartrot, root disease, white pine blister rust, dwarf mistletoe, etc. In stands with root disease, fir engraver beetles may be evident as well.

Weather: One of the most significant influences in this setting is the cool air drainage that create a climate more suitable to subalpine species in areas where maritime species would ordinarily predominate. Where this occurs a shorter growing season is very typical and lower vegetative productivity a result. Susceptibility to blowdown is a concern due to high water table, shallow-rooted species, and presence of root disease or other decay-causing pathogens.

Erosion and Siltation: As a natural function following heavy rains or snowmelt, stream channels within these HGs carry soil particles and transport them downstream. The extent of this disturbance varies with the texture of the soil, topography, and the effects of any nearby land use activity. When this movement of soil undermines vegetation, growing space can be altered as trees or shrubs fall over. In this case the bank stabilizing function of the vegetation has been reduced or eliminated and downstream impacts begin to take place. Where siltation occurs (e.g. floodplain) trees can be damaged or killed as oxygen to the rooting zone is reduced. Trees weakened by siltation can be predisposed to insect and disease attack, and spread to adjacent healthy trees (Oliver and Larson 1990). Again, these are generally natural occurrences that are beneficial site-specific impacts to riparian ecosystems. Both described natural processes can have greater scope and intensity following an infrequent, yet lethal wildfire.

Successional Pathways

Descriptions of successional pathways for forested bottomlands of Montana are limited, as is information on early seral stands. A brief description of vegetative development is based on work in Northern Idaho, providing some insight into succession following disturbance. Stand development after fire depends on fire size and severity, as well as changes in microclimate and drainage (Smith and Fisher 1997). On these wet sites, a rise in the water table following a severe fire creates ideal conditions for Scouler willow to dominate. The effects of extensive tree mortality would very likely increase the level of cold air on site resulting in frost impacts on conifer regeneration. The delay in conifer establishment creates a condition that favors shrub development and dominance. This very likely diminishes the successful establishment of forbs and ferns, which are common in late seral stands, characteristic of riparian settings.

The successful regeneration of conifers following a major fire on wet sites can be delayed for many decades, given the conditions described. When it occurs, the establishment of trees following a severe fire vary with site conditions. Ordinarily shade tolerant species are favored in small openings, especially where duff is still intact. Rotting logs and root crowns of fallen trees are very good seedbeds generally above the influence of the very wet soils. In the larger openings, shade intolerant species and hardwoods can dominate early seral stages by overtopping the tolerant species. Black cottonwood may be very successful in these situations. Where there is adequate site drainage, western white pine, western larch, and Douglas-fir all occur (Cooper et al. 1991). The cold conditions of many sites generally favor Engelmann spruce, some lodgepole pine, and subalpine fir where it is well drained. In general, cold temperatures, wet soils, and lush undergrowth (e.g. HG 8) favor early dominance by spruce and other climax species. This is also true where long fire return intervals have excluded lodgepole pine.

In time, the canopy cover of the developing forest moderates temperature and moisture conditions to favor establishment of species such as cedar, hemlock and grand fir (e.g. HG 6). On sites above the cold threshold for these species (e.g. HG 8), spruce and subalpine fir predominate. On Picea/Eqar habitat types spruce seems to be the only conifer in seral and climax conditions. The regeneration of many species is assisted by the creation of small canopy gaps caused by wind, disease, blowdown, or mixed severity fire. Western white pine, western larch and Douglas-fir may be present in low numbers in the early seral stages. It is not unusual for the shade intolerant species to fall out of the stand composition over time, as late seral stands of climax species continue to dominate in these wet, very shaded valley bottoms. These stands may tolerate low severity fire, but will usually return them to the shrub or herb stage. Seral stands are likely to have black cottonwood and/or aspen which regenerate following fire from root suckers. In the absence of fire, these species are replaced by spruce on cooler sites and cedar/hemlock on the more moderate sites.

Generalized pathway diagrams can be viewed for Fire Group 11 (HG 6) in the description of HG 5, and for Fire Group 9 (HG 8) in the description of HG 7. These pathways capture succession on landscapes with well-drained sites, experience more frequent fire than these wet settings and consequently have more seral species.

Ecological Function and Special Habitat Features

Previous sections have described the major ecological processes that occur within these HGs. As they occur, these processes change the pattern, composition and structure of the landscape setting as well as influence the biological function that is characteristic. While HGs 6 and 8 are very limited in scope on this Subbasin their contribution to biological diversity is very important to both aquatic and terrestrial ecosystems.

Landscape Linkages: Valley bottom stands are unique and burn with less frequency than upland sites (Habeck 1973). As a result, natural change occurs very slowly in these riparian areas, providing a potentially stable environment for dependent species. Where intact forested areas exist, they provide value as travel corridors or migration routes from low elevations to higher sites, especially to wet meadows. Wildlife also use these areas to move between unforested areas.

Old Growth and Interior Habitat: The common occurrence of stands with old growth characteristics make these sites very important. In conjunction with adjacent habitat, these areas can be part of a fairly large, contiguous block of interior habitat. Where high levels of early and mid seral stages are present within potentially suitable habitat, silvicultural practices may be able to advance structural development in young and middle-aged stands to meet desired habitat characteristics.

Wildlife Habitat: Whitetail deer and moose commonly use this habitat. Elk have been known to wallow in these areas and are attracted to the abundance of thermal cover and the microclimate produced by riparian vegetation. The thermal cover offered by these dense full-canopied forests has value during winter months given its ability to intercept snow and retain heat. The cover is also important at higher elevations for providing a cooler environment during the summer. As described, riparian areas provide migration routes for many wildlife species moving from summer to winter range.

Because they are biologically very productive, riparian areas can be a great source of biological diversity within a forest. During the stand initiation stage, understory vegetation such as alder, Scouler willow and western serviceberry are common browse species that generally persist until canopy begins to close. Managed areas in early seral condition also provide important summer range features for some big game species, particularly moose. Seeps and meadows within and adjacent to this habitat often have red-osier dogwood and Rocky Mountain maple, important food sources for wildlife. Some birds utilize the seeds, buds, flowers and berries of the shrubs.

These older, storied forests provide good snag habitat for cavity nesting species, along with good prospects for future replacement. There is excellent snag habitat where hardwoods such as cottonwood and aspen are present. HG 8 tends to have more larch and cedar snags with less of the hardwood species.

High degree of stand decadence and multi-storied forest structure provides moderate to high levels of down woody material for species such as fisher and marten. These moist bottomlands also have habitat for amphibians, reptiles and invertebrates. Some of the upper elevation settings in HG 8 have less of these species. These sites are in proximity to wetland environments and are likely important beaver habitat.

Rare Elements and Specialized Habitat: Wildlife use riparian areas disproportionately more than any other type of habitat (Thomas et al. 1979). Overall vertical and structural diversity is high, making many sites important for their contribution to maintaining or improving species diversity. These settings may be important to maintenance of bull trout populations, given their proximity to streamcourses. Many areas transport materials to lower stream segments. Areas with accessible floodplains are important for flood sediment storage and energy dissipation. Large downed-woody material is very important in HG 6 for channel formation, maintaining natural processes, and dissipating flood energy. Vertebrates that either reproduce in water or feed in water are totally dependent on riparian and adjacent aquatic zones (Thomas et al. 1979).

Habitat Group 7: Cool and Moist

Disturbance Processes

Fire Regime: The inland maritime climate exerts a strong influence on forest development and the role of fire in this HG. Moisture and temperature gradients create a complex influence on the fire ecology and the vegetation response. Most habitat types within HG 7 are considered to be in Fire Group 9 (Fisher and Bradley 1987), based on the response of tree species to fire and the roles they play in forest succession. Fires in this HG generally burn nonuniformly and are more intense but less frequent than that of HG 9. Cool and moist conditions coupled with broken topography and lush understories undoubtedly limit fire spread and create these mosaic conditions. With fuels drying out slowly, under most conditions fires either burn very small areas or burn large areas in a patchy pattern (Smith and Fisher 1997). However, because much of this HG is relatively narrow and is often flanked by riparian areas this fire regime is strongly influenced by that of neighboring landscapes such as HG 9. Although lightening strikes may be frequent in this fire group, few large fires apparently originated in these stands (Barrett 1982). Most large fires probably moved in from drier sites during severe fire weather.

The historic fire regime of this ecosystem can be characterized by the average fire frequency and intensity. Research demonstrates that nonuniform, infrequent stand replacement fires were the most common, occurring within a mosaic of nonlethal and mixed lethal burning. Within the LP/DF cover type a 100+ year fire return interval was found (Arno 1980). In other research (Losensky 1993) a FRI of 120-268 years was noted for L/DF cover types, up to 300 years in spruce bottoms. On similar habitat types on the Selway-Bitterroot Wilderness these lethal fires were documented on an average of 174 years (Barrett and Arno 1991). Fire scar analysis from Meadow Creek (Triepke, pers comm) suggests one stand replacement FRI of 134 years. The Harding Lake sediment analysis study (Chatters and Leavell 1995 Draft) suggests a FRI from 110-310 years, with an average of 220 years.

Lethal fires in HG 7 create a mosaic of vegetative conditions as a result of burns that were impactive in uniform and nonuniform patterns. Well drained upland sites experienced a high percentage of stand replacement fires. This is attributed to many factors that include higher humidities leading to longer fire return intervals, higher stocking levels, deep duff, drought and heavy fuels in draws. Fires on steep slopes or wind-prone areas can contribute to this occurrence.

Nonuniform mixed lethal fires were less prevalent in these settings, but occurred on a frequency of 38-120 years in L/DF cover types, 50-70 years in LP/DF, and up to 120 years in ES (Losensky 1993). Bark beetle-caused mortality in lodgepole pine stands was often the trigger for these disturbances. Studies in Coram Experimental Forest found FRI for fires of moderate severity from 117 years to 146, depending on topography (Fisher and Bradley 1987). Sampling data from Meadow Creek and Trego (Triepke, pers comm) suggest a mean FRI of 44 and 47 years for these areas, respectively.

Mixed severity fires burned in patches due to discontinuous fuels and occasionally crowned out, particularly on ridge tops. The greater likelihood of mixed severity fires burning on moist sites is perhaps because the drier sites (having nonlethal fires) are receptive to burning for a longer time period each year. Moderate severity fires resulted in large canopy gaps and mosaic conditions that included patches of even-aged stands, with surviving groups and individual trees.

Multiple age classes also resulted as the tendency of these mixed severity fires was to underburn trees as well as to flare up and torch out crowns. Also, dense understory trees create a fuel ladder that often carries fire up into the crowns and through the stand. The presence of western larch is a good indicator of a moderate severity fire regime that occasionally opens up enough growing space for larch establishment.

Nonlethal fires were rare but did occur on drier, southerly aspects with western larch and Douglas-fir cover types on a FRI that ranged from 20-40 years. In mature Abla/Mefe stands in western Montana evidence of nonlethal underburning occurred in only seven of 50 stands sampled (Arno et al. 1985). In general, underburning was not a significant influence due to the high fuel moistures and humidity which have a tendency to reduce fire spread. In addition, lush undergrowth and moist fuels are an effective deterrent to fire spread, under normal conditions.

Fuels and Nutrient Cycling: Fuel loadings are highly variable due to the wide range of fire return intervals and forest types within this response unit. Much of the downed fuel results from insect and disease-caused mortality, accumulated deadfall, periodic natural thinning, and blowdown. The amount, distribution and flammability of these fuels largely determines the severity of fire. Dead woody material on the ground serves a number of ecological functions that include: protecting the soil from surface erosion, a site for nitrogen fixation, storage for energy and some nutrients. Ideal moisture conditions make downed material a favorable microsite for the growth of young trees, as well. Natural decomposition rates are higher on these sites due to the increased site moisture.

Research by Losensky (1994) estimated natural fuel loadings of 20-30 tons per acre in moderate to heavy accumulations. Other studies (Fisher and Bradley 1987) display quite a range (ave. 25 tons/ac) but highlight the potential for some very high fuel accumulations. Despite the relatively high fuel loadings, fire hazard in Fire Group 9 is normally low to moderate, under normal conditions due to fairly high humidity on these moist sites.

The nutrient cycle occupies a key position in ecosystem processes and can be directly affected by disturbances, both natural and human-caused. Under the right conditions, dense thickets of fire intolerant trees can make the site more susceptible to fast moving crown fires (Dumroese, pers comm). Although the fire return interval for lethal fires is infrequent, when they do occur there is potential for reduction in longevity and function of coarse woody debris. Extensive tree mortality and loss of downed woody can result in significant nutrient loss. Where heavy residual fuels remain, second burns can occur and lead to soil-damaging results.

Insects and Disease: Heartrot is prevalent in overmature stands that typically contain western larch and grand fir. Root disease is also very common, particularly in subalpine fir, Douglas-fir and grand fir. These sites can also be susceptible to blister rust infection in western white pine as the cool and moist settings are optimum for the production and dispersal of rust spores from Ribes plants.

Disturbance caused by insects and disease occurs almost everywhere and to varying degrees. This is largely due to the nonuniformity of tree distributions and the sites containing host species. Indigenous pathogens certainly are natural and necessary parts of ecosystems (Hagle 1993a). In most forest ecosystems they are also the major nutrient recyclers. Our perception and acceptance of this role has changed in recent years with an acknowledgment that endemic levels of insects and disease are a desirable level to manage for.

Some insects and pathogens attack only healthy host trees. Others affect only host trees that have been weakened by some other stress caused by other disturbances. Stress induced pathogens eventually kill these weakened trees, thereby releasing growing space and nutrients to the replacement vegetation. Management efforts intended to suppress disturbance from insects and disease have the potential to reduce biodiversity and ecosystem health. Some organisms and vegetation may exist largely because of the conditions created by insects and diseases.

In some cases, the conditions brought about by human influence are having undesirable effects. For example, fire exclusion has increased stocking levels and shifted some areas to more subalpine fir and grand fir. This condition can exacerbate mortality from the fir engraver beetle in these host species. In some areas, previous entries have caused basal wounding in residual trees resulting in an increased level of heart rot in mature grand fir, western larch and Douglas-fir. Mature patches of lodgepole pine and Engelmann spruce are a primary host for bark beetles, particularly where they are low in vigor. Dwarf mistletoe is at endemic levels commonly appearing in stands containing scattered, large diameter western larch and Douglas-fir.

Rather than view conditions resulting from insects and pathogens as static and unpredictable, we should manage the land with a better understanding of the process of change, recognize the probability of its occurrence and manage for vegetation that has resiliency to insects and diseases.

Weather: Since fire starts are less frequent and fire spread is less extensive in this setting than many others, weather as a disturbance factor may be easily overlooked in this HG. However, when unusual weather patterns occur they can influence plant growth and alter species composition to a certain degree. For example, snow damage is common due to stem breakage within dense and overmature stands. Ice storms occurring in the early spring and late fall can also result in considerable tree damage.

Ordinarily, drought is not a concern in these cool, moist settings and does not play much of a role in determining fire severity. The more exposed spruce-fir types can be particularly vulnerable to windthrow. These events create gaps of various sizes by blowing down trees that are adjacent to existing openings, are shallow rooted, or currently affected by root disease. Crown support of adjacent trees influences the amount of crown sway and the susceptibility to blowdown.

Occasional thunderstorms occur during the summer accompanying late afternoon convection buildups. These storms can bring sporadic and intense rain or simply dry lightning. The latter storm type is a significant hazard causing many of the forest fires. Stream runoff peaks in the spring, with rapid snowmelt from mountain watersheds. When snowmelt coincides with the high spring runoff, floods may occur as stream banks are full. Many areas of the forest have also experienced damaging floods resulting from heavy rains falling on the snowpack. In addition, some areas become prone to blowdown when tree roots are not secure and soils are supersaturated following rain on snow events.

At a different level, cold-air drainage in narrow mountain valleys leads to dew formation during the night in areas where cold air pools. The influence of this microclimate can be important in reducing transpiration stress and in seedling survival on flat ground. However, the same conditions can cause frost-related regeneration problems. While Douglas-fir is particularly vulnerable to foliar damage from frost, lodgepole pine is considered one of the most frost hardy species. Both species are present and an important part of this HG.

Successional Pathways

Vegetation that exists following a fire or other major disturbance is largely dependent on the intensity of the event, the vegetation that existed prior to the disturbance, the seed stored on the site and the degree that natural regeneration is successful. While fire is important to plant community establishment, these accompanying factors are largely responsible for post-fire succession. The diagram below (Figure 6) represents the successional trends that are described for Fire Group 9 where a mixture of seral species develops (Fisher and Bradley 1987). This scenario is also applicable to Fire Group 8 with the understanding that fire return intervals in HG 7 is presumably longer than drier upland sites, characteristic of Fire Group 8. Of course, different successional scenarios are inevitable as wildfire in these settings is infrequent and unpredictable.

In a hypothetical scenario, the combination of deep duff, large amounts of downed fuels and unusually dry conditions has led to a severe crown fire. The existing forest is composed of mature stands, near climax and characterized by a dense understory of subalpine fir, spruce, some mountain hemlock with a Douglas-fir, lodgepole pine, western larch, western white pine and spruce overstory. Due to the dense stocking of the stand and rapid drying of fuels the fire easily spreads through the crowns and kills most trees in the stand. Numerous, large diameter western larch often survive as scattered individuals. Patches of unburned areas are left relatively intact. Within the burned areas mixed severity fires also occur, killing fire intolerant trees and creating small canopy gaps. Even where crown fires do not occur, the intense radiant heat on the surface will kill additional trees by overheating the cambium.

By the next growing season, a mix of shrubs, forbs, and grass establish on the site. On very moist sites (e.g. Abla/Mefe) wet meadow species may appear and dominate the site until tree regeneration gets to the pole stage. In this stand initiation stage, seral species such as western larch, lodgepole pine, and some Douglas-fir become established as a single cohort. The forest has scattered overstory relics, individually or in clumps. The light, winged seeds of western larch can easily blow onto a burned site from adjacent stands or from lightly scorched cones in the fire-killed stands. If present on the site, lodgepole pine develops from serotinous cones in the area. Often, lodgepole pine dominates under these conditions, particularly towards the center of large burns (Cooper 1991). Both western larch and lodgepole pine have exceptionally fast juvenile height growth and, along with other species developing at the same time, create different strata. It is not uncommon for western white pine and Engelmann spruce to also seed in at this time. Depending on the site and elevation, subalpine fir may be present. A surface fire that would occur during this time would likely kill these trees and start the process over.

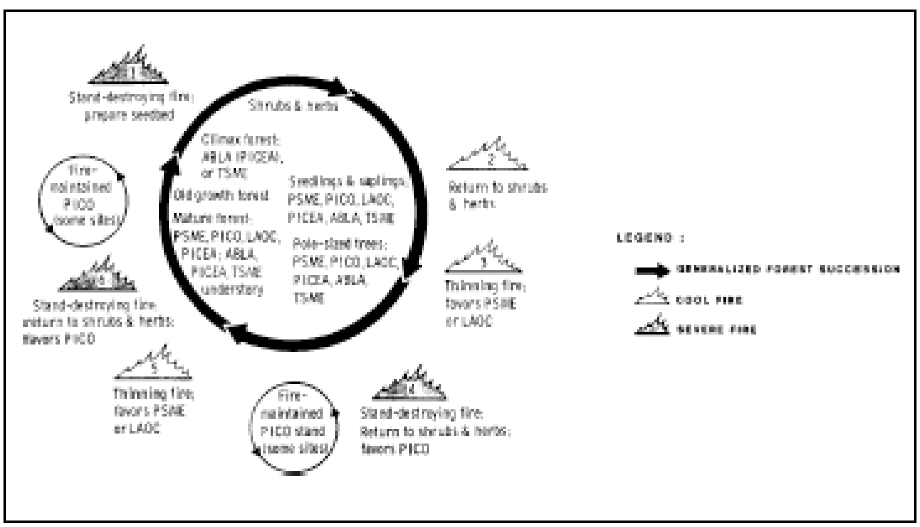

Figure 6 - Generalized Forest Succession in Fire Group 9

Once the forest develops into a mid-seral stage, competition for light and moisture limits establishment of a new cohort. In this stem exclusion stage, light to moderate intensity surface fires can act as a thinning agent in these dense pole size stands, converting overstocked stands to a more open condition with fire-adapted species. Intermediate sized western larch, Douglas-fir and some western white pine are usually favored in these circumstances. Lodgepole pine, subalpine fir and spruce may be significantly reduced or eliminated if they are in densely stocked conditions. These occasional maintenance fires reduce understory competition and rejuvenate browse and forage plants.

Heavily stocked, pole-sized stands have a high crown fire potential (Davis et al. 1980). A high intensity fire will kill almost all trees in this mid-seral development stage. This could result in a shift back to the herb/shrub phase or facilitate the development of dog-hair lodgepole pine stands from serotinous cones. If an area experiences a double burn within a relatively short interval, the site may revert to a brushfield, particularly habitat types such as Abla/Mefe. Neither western larch nor lodgepole pine will likely survive high severity fires in the pole stage.

Maturing, mixed species stands of western larch, lodgepole pine, Douglas-fir, western white pine or spruce that experience fires of low to moderate intensity are naturally thinned. This favors western larch and Douglas-fir, with patches of other species where fires are less intense or excluded. Western larch exhibits greater fire resistance in these large diameter classes than any of its associates. While fires of this type generally reduce the basal area of other species, radial growth of western larch will often increase (Reinhart and Ryan 1988). Residual Douglas-fir may show no change in radial growth increment. If the overstory remains relatively intact following a fire, the new cohort will develop as predominantly shade-tolerant species. In time, the lodgepole pine matures and along with other naturally occurring overstory mortality, some shade tolerant species begin to regenerate.

This understory reinitiation stage begins the formation of a multi-aged structure, characteristic after low to moderate severity fires and/or the break-up of overstory canopies. This stand development phase can feature a dense understory of trees including subalpine fir, lodgepole pine and occasionally mountain hemlock. A cool mixed lethal fire during this stage would essentially eliminate this understory and some lodgepole pine, while providing a favorable seed bed for the regeneration of Douglas-fir, western larch and potentially western white pine. A more severe fire would have also eliminated much of the Douglas-fir and the site would largely be regenerated with seed from serotinous lodgepole pine cones and relic larch. Of course, these fires have the potential to spread in size and intensity killing many of the dominant overstory larch as well. This would essentially replace the existing conditions and revert forested areas back toward stand initiation. There would be a mosaic of conditions, representing the nonuniform nature of most burns. Many snags would be present, and islands of unburned areas would be present. Many spruce basins in this HG would be protected during some of these disturbances and would not follow a stand initiation pathway.

In the absence of fire, forested stands mature and stand development continues toward climax condition with characteristics of an old forest stage. Despite the moist conditions of these settings, stand decadence occurs in time and vegetative health declines while fuel loadings increase. These site factors create the eventuality of a stand replacement fire somewhere and the return to the stand initiation stage.

Ecological Function and Habitat Features

How the landscape functions has a lot to do with the nature of disturbance, successional development of vegetation, and the flow of energy and nutrients through these landscape structures. This HG is an important part of a rich biological setting with a mosaic of habitat conditions that vary from small dispersed openings to contiguous areas of similarly structured stands. This habitat diversity is important to many wildlife species that utilize this area for a variety of its functions, including cover and browse. These habitat features contribute to the biological diversity of the landscape as a whole.

Landscape Linkages: Riparian areas within and adjacent to this cool and moist habitat provide a valuable forested linkage between different types of habitat. Grizzly bear often use this area in fall and winter for the habitat components that it offers. Other wildlife may seasonally use these areas as cover between unforested areas and as sources of food and water. Overall, the forest composition in this landscape provides suitable connectivity for many wildlife species such as wolves, grizzly bear, lynx, fisher and wolverin**e.**

Old Growth and Interior Habitat: Structural diversity is generally high due to the multiple age classes, abundance of multi-storied stand structures, and large patch size. Stands with old growth characteristics are not uniformly distributed but do have the potential for longevity due to a long fire-free interval.
Where contiguous, these landscape settings are also important interior habitat due to their relatively stable nature and tendency to be less influenced by a changing environment normally associated with edge conditions. Commonly occurring large, even-aged patches can also function as interior habitat for neo-tropical migratory birds, big game security and travel corridors for many species.

Wildlife Habitat: Big game use is high as this habitat generally provides excellent cover. Openings within this habitat are generally small and hiding cover is provided by shrub thickets (e.g. Sitka alder and fool's huckleberry) and the overall density of the trees. Thermal cover is well distributed in much of these dense, mixed conifer and lodgepole pine stands.

This response unit is important summer range for elk, whitetail and mule deer, particularly in areas with seral vegetation. Low elevation sites within the Mefe phase are an important portion of moose winter range in some areas. Forage areas vary from gaps in the canopy to larger, natural openings that may border riparian areas and meadows. In many of these densely stocked habitats, understory vegetation is sparse and does not provide much forage value. Where fires occur, they have a demonstrable effect on wildlife habitat by opening up stands, reducing understory competition and rejuvenating plants to increase availability of palatable browse and forage.

This HG contains some important understory vegetation that functions as wildlife forage. Fool's huckleberry and Sitka alder are utilized primarily by mule deer but elk, small mammals and birds can also forage in the summer months. Western serviceberry is a key seasonal forage for whitetail deer, mule deer, moose and elk. The leaves and twigs of the Rocky Mountain maple are important winter food for big game. Small mammals eat the seeds, buds and flowers. Huckleberry, whortleberry, and thimbleberry are used to varying degrees as summer browse by elk, mule deer and whitetail. Bears, birds and small mammals consume the berries, an important food source. *Pachistima* (mountain-lover) is considered to be an important forage for elk, deer and moose although palatability and nutritional value is low. Birds also utilize *pachistim*a as a source of general forage. Heart-Leaf arnica is an important browse for elk. The flowers are preferred by some ungulates. Queen's cup beadlily is summer forage for birds, small mammals and some big game species. Some of the drier portions of this HG, that often function as winter range, contain browse such as pinegrass which is an early growing season forage for deer, elk and black bear. Elk sedge is important forage for elk during the spring and summer.

The cool and moist sites of HG 7 have high vegetative diversity and biological productivity. The nature of this setting tends to create very good habitat for cavity-dependent species. Snag levels vary from low in single age class lodgepole pine stands to fairly high where moderate-intensity fires retain diverse structural components. Dead trees are used for feeding, nesting, roosting and resting depending on their physical characteristics. Snags provide a lifeline for many plants, birds, mammals, and invertebrates. Black-backed woodpecker utilize western larch and lodgepole pine stands for reproduction and feeding purposes. The abundance of large diameter western larch and Douglas-fir, in most areas, provides reasonable habitat options for cavity-dependent species. Subalpine fir and spruce snags and culls also provide feeding and nesting habitat.

Dead trees or portions of trees lying on the forest floor function in a variety of ways. For example, woodpeckers eat insects that inhabit downed logs, and mammals use logs for foraging, cover and reproduction. In general, this HG provides good to excellent habitat for small vertebrate animals, reptiles, amphibians, and invertebrates. Generally high levels of downed trees and woody debris accumulate due to the nature of the long interval fire regime. In addition, dense shrub thickets (e.g. Mefe, Alsi), draws, and heavily treed areas provide hiding and thermal cover habitat for bird sand small mammals as well. During fire-free intervals or following incidents of tree mortality higher levels of habitat suitability exist. Blowdown is a contributor to small mammal habitat, particularly where shallow-rooted spruce are vulnerable to windthrow.

Rare Elements and Specialized Habitat: Biological diversity and uniqueness of this landscape varies but is generally good in mature stands that are spatially contiguous. These conditions offer refuge for some species of wildlife such as boreal owls, lynx and bears. Specialized habitat for elk and moose may also be present where unique vegetation occurs within springs, wallows and nonforest natural openings. For example, some spruce-subalpine fir basins may be very suitable as prime calving and fawning habitat. They are usually located on gentle topography containing hiding cover and forage within a reasonable distance to water. Some sensitive plants are likely to be found in specific microsites within this HG and, in particular, old growth forest conditions.

Habitat Group 9: Cool and Moderatley Dry

Disturbance Processes

Fire Regime: Most of the habitat types within this response unit occur in Fire Group 7. These are typically mixed species stands that have a significant component of lodgepole pine. However, dry lower subalpine habitat types (i.e.: AF/beargrass) are in Fire Group 8, which has some important distinctions but is also composed of mixed species that include lodgepole pine.

Historically, fire was the predominant disturbance type in this habitat setting and played a major role by regularly interrupting succession and perpetuating the presence of lodgepole pine. This is especially true following large scale, stand replacing fires that generally originated at lower elevations in HG 9 on a frequency from about 100 years in lodgepole pine stands to about 500 years between events in areas with mountain hemlock (Fisher and Bradley 1987). These severe fires may have been extensive due to extreme weather conditions such as high winds. It would not be uncommon for the risk of reburn to be high during early successional stand development due to the amount of available fuels.

Losensky (1993) noted that in this climatic section of western Montana/northern Idaho (Pend Oreille) mixed severity, nonuniform burns were common occurrences every 93 years on 45% of the lodgepole pine types with typically dry summers. About 30% of the area experienced lethal, nonuniform burns every 230 years and 23% had a lethal, uniform burn every 188 years.

On the moist lodgepole pine sites, his research shows that 80% of the areas had lethal nonuniform burns every 113 years and 20% had a mixed severity, nonuniform burn every 50-71 years. The nature of the moderate intensity fires resulted in some areas underburned, leaving the forest structure intact, while other mixed severity fires set back succession to a forb or shrub stage. While mixed lethal fires may have occurred more frequently, stand replacement fires accounted for the majority of area burned in lodgepole pine forests (Turner et al. 1994).

Nonlethal underburns occurred during mild summers or mild burning periods, along the edges of large burns, and on sheltered or moist locations with severe burns (Brown 1975; Green 1994). These fires would likely have resulted in a natural thinning of trees as the fire crept through the forest understory community. Intervals between these nonlethal fires averaged 30 to 50 years (Smith and Fisher 1997). Research by Arno (1985) reported that almost 40 to 67% of the mature stands in AF/beargrass habitat types in western Montana showed evidence of periodic underburns, particularly in upper elevations of the lodgepole pine cover type (Barrett 1982). Barrett (1982) found that fires originating at high elevations in this fire group tended to be small and to burn with low severity.

Fuels and Nutrient Cycling: Average fuel loadings on representative habitat types averaged 15-20 tons per acre (Fisher and Bradley 1987) but can be highly variable. Much higher fuel loadings are common where tree mortality, caused by bark beetles or previous fires, is a factor and fire suppression has been effective. In addition, breakage from snow damage and high stocking levels do contribute to increased fuel loadings. Based on studies that used ectomycorrhizae as an indicator of healthy, productive soils, it is recommended that forest practices in this HG retain 12-25 tons/acre in AF/beargrass and AF/twin- flower habitat types and 7-15 tons/acre in the AF/whortleberry type (Graham et al. 1994).

Since the nature of the fire regime in this response unit is that of intense or repeated stand replacement fire, conditions of low organic matter accumulation are common. In addition, intense fires can increase erosion by reducing fine-root biomass that held marginally stable soil in place. Many of the sites have shallow, rocky soils with a thin duff layer. That, in addition to a short growing season, results in a relatively low to moderate level of site productivity. Decomposition rates are low.

Insects and Disease: Disturbances caused by insects and diseases occur in all terrestrial ecosystems and as a group probably are the most evident. In most sustainable forest ecosystems, insects and pathogens are also the major nutrient recyclers. For example, the mountain pine beetle has a close association with the nature of this fire regime, having played an historic role in the dynamics of lodgepole pine ecosystems. By periodically invading stands and creating large accumulations of fuels to be consumed by fire, the bark beetle has increased the probability that lodgepole pine will reoccupy the site at the expense of other species. The beetles' continued role in seral lodgepole pine stands will depend upon the presence of fire.

Dwarf mistletoe is a native component of our coniferous forests and is largely concentrated where host species such as lodgepole pine and western larch occur. The damage from this parasitic plant is gradual and scattered across the landscape. Dwarf mistletoe plants extract water and nutrients from the living hosts causing reduced growth, reduction in seed and cone crops, and direct tree mortality. Over time this could result in a shift in species composition as seral host trees are replaced by shade-tolerant, climax species. Fire is one of the forces that has significant effects on dwarf mistletoe, because host trees are killed or stressed by the fire damage. Individual trees that survive a fire can provide a ready source of mistletoe seed for the infection of newly-developing regeneration. Large and numerous brooms on trees that are heavily infected can increase the flammability of the site, thus increasing the chances of a stand replacement fire.

Lodgepole pine is very susceptible to stem rusts that can cause extensive mortality, growth loss, and loss of value. The most common type in this HG is western gall rust, which can also affect ponderosa pine.

Weather: Isolated windstorms and lightning occur. As this HG is typically at higher elevations, snow damage is fairly common. In dense, stagnated lodgepole pine stands this is a natural form of thinning. Periodic drought on these cool, dry sites would also be characteristic.

Successional Pathways

A scenario of forest succession that would likely follow a stand replacing fire in Fire Group 7 is depicted in Figure 7 (Fisher and Bradley 1987) and begins with a short-lived herb/shrub stage. Stand initiation occurs as lodgepole pine readily establishes and overtops the understory vegetation. Due to the shallow roots and rhizomes many of the understory plants (e.g. Vaccinium) experience reductions in numbers and volume following high severity fire. While scattered fire-tolerant trees dot the landscape, a single age class of lodgepole pine essentially dominates and continues to fill in for a few years as growing space is available.

A stem exclusion stage follows during the mid-seral period when growing space is fully occupied and ingrowth is excluded. As individual trees experience natural mortality some trees gain competitive advantage and take over the available growing space. This process (differentiation) results in individual trees achieving different growth rates, crown size and relative crown position. Lodgepole pine stands with high stocking levels experience early crown closure and reduced diameter growth. As height growth typically continues, without differentiation these trees become unstable and bend over. In stands where stocking levels are reduced, growth patterns are more divergent and lead to trees asserting dominance and the development of crown classes.

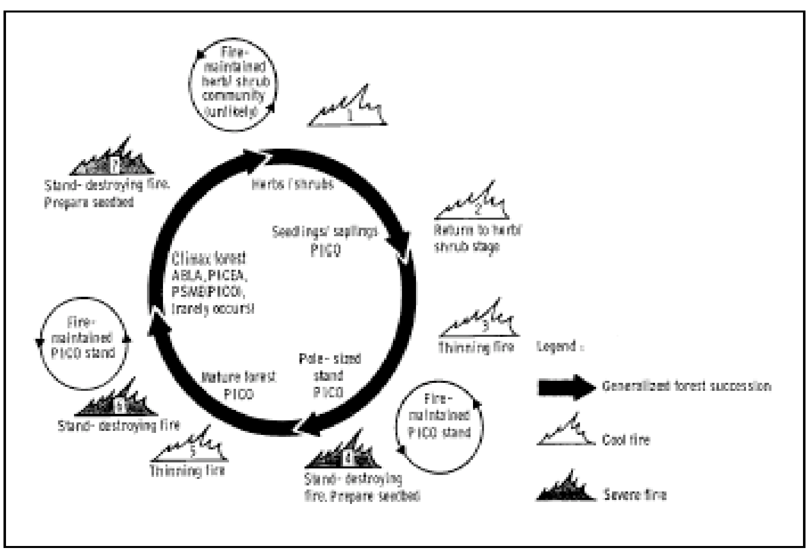

Figure 7 - Generalized Forest Succession in Fire Group 7

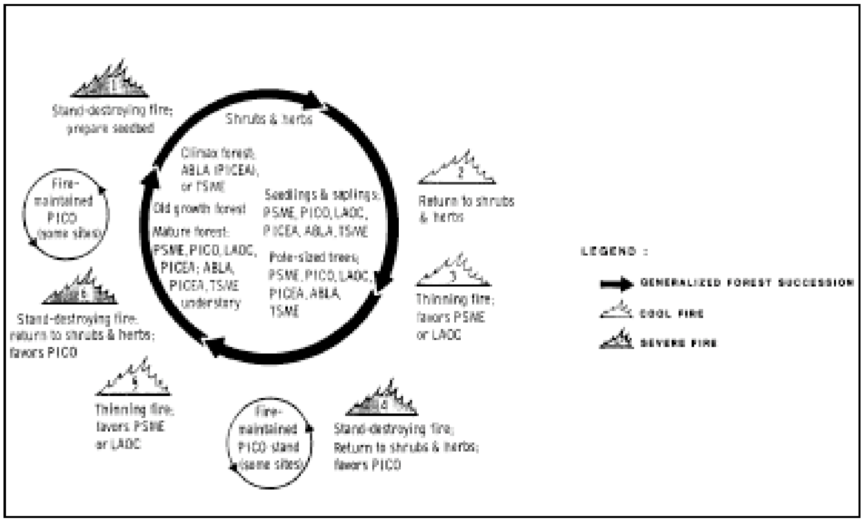

Figure 8 - Generalized Forest Succession in Fire Groups 8 and 9

During this mid-seral stage and in later seral periods, a nonlethal fire would generally have the same outcome of thinning the stand and opening up growing space for a new cohort of lodgepole pine. In the event of a lethal fire, the majority of trees present would be killed and succession would revert back to a herb/forb stage and a perpetuation of the lodgepole pine type. Even under a high severity fire some areas would simply be missed or underburned, leaving the stand relatively intact.

As a stand matures, the probability of a stand-replacing fire greatly increases as fuels build up due to weather damage, beetle mortality, and the development of a shade tolerant understory. Moist sites would likely see a more mixed species understory than is typically found.

In the absence of fire, stands would experience considerable bark beetle-caused mortality and eventually be succeeded by subalpine fir and Engelmann spruce. Where it is not frost stunted, some low elevation sites will occasionally have Douglas-fir persist as a seral dominant. The succession to climax dominated by subalpine fir is often very slow either because of lack of seed source or apparent low vigor. With time, surviving lodgepole pine increase in growth and become susceptible again to bark beetle attack.

In Fire Group Eight (Figure 8) the pathway differs in that more frequent fires of low to moderate severity maintain seral stands of lodgepole pine and Douglas-fir with occasional western larch and western white pine. Without periodic disturbances less fire tolerant species such as subalpine fir and spruce develop dense understories and eventually predominate.

Ecological Function

Ecosystems consist of structures and elements that perform a number of functions. Insight into ecological function is important to our understanding of how the ecosystem operates and its relative measure of biological diversity. The ecological functions described include interactive processes that occur to varying degrees across the landscape.

Landscape Linkages: Within this HG, connectivity is relatively high and results in important wildlife corridors for seasonal wildlife movement. This is largely attributed to patch sizes which are generally large and include primary topographic ridges within them. Where suitable hiding cover and structurally complex mid-seral and mature forest conditions are present, movement of lynx between forage and denning habitat can occur.

Old Growth and Interior Habitat: The lodgepole pine ecosystem typically did not produce high quality old growth habitat. Large, even-aged patches do function as interior habitat and provide big game security, travel cover, and habitat for neotropical migratory birds. Gaps created by fire have value for wildlife species that prefer such small openings, such as black-backed woodpecker.

Wildlife Habitat: This HG provides valuable summer range habitat for elk, lynx, moose and mule deer as well as summer and fall bear use and fall denning habitat for bears. Generally good hiding cover due to high stocking levels. Young, dense lodgepole pine stands offer decent thermal cover.

Due to the high elevation and cool-dry conditions, understory vegetation and high quality forage are limited. However, beargrass and huckleberry are commonly available for bears.

Following expansive stand replacement fires characteristic of this HG, increased snag levels and insect activity provide favorable short term habitat for dependent species. The snags are typically small to medium sized subalpine fir and lodgepole pine with occasional large Douglas-fir and western larch. The low quality of most snags and their limited distribution is also influenced by the high reburn potential of these settings. Nearby, moist streamsides can have more continuity of snags and down wood material providing greater inherent species and structural diversity.

Diversity of habitat is generally low in the typical even-aged stands. Overstocked conditions and jackstrawing of beetle-killed trees contributes to habitat security for small mammals in older lodgepole pine stands.

Rare Elements and Specialized Habitat: The relatively high precipitation and deep snowfall on these lower subalpine environments also make them an important for water storage. Springs and wallows are undoubtedly present and function as valuable habitat for dependent wildlife species. Nonforested, natural openings also occur and contain shrub and herbaceous vegetation often uncommon elsewhere in the response unit. Specialized habitat exists between large, contiguous interior habitat and can be of benefit to bears and some species of owls.

Many areas above 4,000 feet in elevation that ate mostly lodgepole pine, subalpine fir and Engelmann spruce may provide suitable forage and denning habitat for lynx. Young lodgepole pine stands are particularly important for lynx due to the high quality prey base that depends on early successional habitat. Late seral stands with abundant downed, woody debris are suitable denning habitat.

Ecological role of Lodgepole Pine: This HG is very unique and has important biophysical attributes that define the successional role of lodgepole pine as a dominant seral species. While lodgepole pine is considered to have the widest range of environmental tolerance of any conifer in North America, its successional role depends upon the continuum of fire. This is especially relevant where repeated fires have eliminated a seed source for other species. The ability of lodgepole pine to produce persistent, serotinous cones that provide a regeneration source following fire is testimony to its adaptation to this disturbance mechanism. Serotinous cones produce seeds that are protected beneath resin-sealed cone scales and can remain viable until a fire passes through and melts the resin seal. The trees may die but the seeds are largely undamaged and fall to a newly fertilized ashbed.

Habitat Group 10: Cold and Moderatley Dry

Disturbance Processes

Site factors such as climate and soils play an important part in forest development on these sites. The cold, moist, rocky, snowbound, unproductive, and otherwise fire-resistant environment that characterizes many of the sites limits the extent and frequency of fire (Fisher and Bradley 1987). Lightning-caused fires often do not spread due to accompanying rains and the lack of continuous fine surface fuels. Stand replacing disturbances are infrequent and may be caused by snow and wind damage, rock slides, and talus slippage as well as by fire (Fisher and Smith 1997). Losensky (1993) found only 2 percent of areas sampled for historic vegetation information had been burned.

Fire Regime: Fire Group 10 dominates this vegetative group. Fires are typically of low or mixed severity, except where canopy cover is dense and fuels are heavy. Most fires are of low severity because of discontinuous fuels (Arno 1989). As fires often burn few trees in a stand, determining fire frequency is difficult and does not apply well in upper subalpine and timberline sites (Fisher and Bradley 1987). Stands are susceptible to severe fires that originate at lower elevations (Arno 1986; Arno and Hoff 1989). Arno (1980) reported great variation in presettlement fire regimes on high elevation sites in the Northern Rocky Mountains; average fire-free intervals ranged from 60 to 300 years. Other historical fire frequencies range from 35-300 (Romme 1980) and over 200 years for stand replacement fires in more continuous forests of this group (Fisher and Bradley 1987). Crane and Fisher (1986) report a frequency of 100-300 years for stand replacement fire. Extensive fire spread may be most likely in early succession, when fine fuels are available, and in late succession, when fuel loadings increase and shade tolerant species provide fuel ladders (Arno and Petersen 1983; Morgan and Bunting 1990). Lethal fires may also occur as a result of microbursts or sustained upland wind events, and extended summer drought followed by episodes of dry lightning (pers. comm. Triepke 199). Mixed severity fire was typical in stands with seral whitebark pine (Keane 1992). In the Selway-Bitterroot Wilderness, whitebark pine stands experience stand replacing fires every 180 years. Nonlethal underburns occurred at an average interval of 56 years (Brown et al. 1994).

Fuels and Nutrient Cycling: Inventory data of fuels in these forest types is scarce. This fire group is characterized by relatively sparse fine fuels and moderate to heavy loadings of widely scattered large diameter fuels, estimated to range from 7 to 25.8 tons per acre (Fisher and Bradley 1987). The upper end of this range is generally a result of increased dead and down fuels following mountain pine beetle mortality. When fires do occur, they burn unevenly through the patchy fuels (Barrett and Arno 1991).

Insects and Disease: The ecology of whitebark pine is interwoven with that of lodgepole pine, mountain pine beetle, and white pine blister rust (Hoff and Hagle 1990; Kendall and Arno 1980). When beetle-caused mortality is high in lodgepole pine stands, it is followed by high mortality in neighboring whitebark pine stands (Gibson 1994; Kendall and Arno 1990). Heavier fuels have the potential to increase fire severity and cause mortality in whitebark pine, reducing seed sources necessary for stand regeneration. This seed source has also been severely impacted by loss of mature trees due to blister rust infection. In general, endemic levels of associated insects and pathogens also occur in these settings.

Weather: Snow damage, isolated windstorms and lightning are a common occurrence. Drying winds, cold temperatures during the growing season, and either persistent snowpacks or droughty soils are also characteristic.

Successional Pathways

Changes in stand development following disturbance will vary depending on whether whitebark pine or a mixture of seral species dominate. In general, secondary succession begins with a mix of herbs and shrubs that dominate the site for an extended period. Fire may initiate secondary succession, but is unlikely to have a role in maintaining it (Fisher and Bradley 1987). As discussed, stand replacing disturbances caused by snow and wind damage, and rock slides may be more of an influence than fire in maintaining early stages of succession. This is particularly true on north slopes and moist sites. It may take many decades for conifers to dominate the site, and considerably longer to attain a mature forest condition. During this phase, surface fires occurring on south slopes and ridges reduce fuels and kill some of the overstory trees. Other sites that experience lightning-caused low severity fires can occur most anytime without a substantial effect on succession. While the occurrence of lethal fires is unlikely at this time, their presence would be limited and result in a vegetative mosaic. Over time the maturing forests will develop some breakage, windthrow, insect and disease-caused tree mortality, etc. Stand replacing fires, especially those that advance from adjacent lower elevation stands become a more assured possibility during extended drought.

If disturbance doesn't occur, mature trees eventually progress into a climax stand. Low to moderate severity fires rarely have much of an impact on these mature stands because of the open structure and lack of continuous fine fuels. However, lethal fires that enter the crowns and kill the cambium revert the conditions to a stand initiation stage.

Compared with the lower subalpine forest (i.e. HG 9), vegetative recovery following most fires is usually slow because of the short growing season and cold climate. This disturbance is an important means of perpetuating the abundance of whitebark pine. The effects of blister rust infection on whitebark pine seed production and establishment may be creating different patterns of succession than would historically occur.

Ecological Function

Landscape Linkages: Within this HG, connectivity is relatively high and results in important wildlife corridors for seasonal wildlife movement. This is largely attributed to patch sizes which are generally large and include primary topographic ridges within them. Where suitable hiding cover and structurally complex mid-seral and mature forest conditions are present, movement of lynx between forage and denning habitat can occur.

Old Growth and Interior Habitat: This HG makes up a very small percentage of the functional old growth and interior habitat across the forest, while trees frequently reach ages greater than 150 years. The high elevation subalpine ecosystem typically did not produce quality old growth habitat. Large, multi-aged patches do function as interior habitat and provide big game security, travel cover, and habitat for neotropical migratory birds. Gaps created by fire have value for wildlife species that prefer such small openings.

Wildlife Habitat: This HG provides valuable summer range habitat of elk, moose and mule deer, as well as summer and fall bear use and fall denning habitat for bears. Hiding cover is generally good due to high stocking levels and clustered trees. Young, dense subalpine fir stands offer decent thermal cover.

Due to the high elevation and cold and moderately dry conditions, understory vegetation is limited as is high quality forage. However, beargrass and huckleberry are commonly available for bears.

Although snow and wind breakage creates numerous opportunities for the creation of snags, they are of generally low quality with limited distribution. Preferred snag species such as western larch are available in adjacent landscapes and typically offer high quality habitat for dependent species.

Availability of habitat for small mammals is good in numerous downed trees, broken-topped snags, and because of an abundance of cones.

Rare Elements and Specialized Habitat: The relatively high precipitation and deep snowpack on these upper subalpine environments also make them important for water storage. Springs and wallows are undoubtedly present and function as valuable habitat for dependent wildlife species. Nonforested, natural openings also occur and contain shrub and herbaceous vegetation often uncommon elsewhere in the response unit. Specialized habitat exists between large, contiguous interior habitat and can be of benefit to bears and some species of owls.

Many alpine areas with a species mix of lodgepole pine, subalpine fir and Engelmann spruce may provide suitable forage and denning habitat for lynx. Young lodgepole pine stands are particularly important for lynx due to the high quality prey base that depends on early successional habitat. Late seral stands with abundant downed, woody debris are suitable denning habitat.

Unique Ecological Importance: Habitat types at these high elevations are named for their dominant tree component rather than an indicated climax species. Where whitebark pine occurs, it provides an important food source for Clark's nutcrackers, red squirrels, grizzly bears and black bears. Nutcrackers cache the seeds, and squirrels cache the cones during the fall.

Habitat Group 11: Cold

Disturbance Processes

Site factors such as climate and soils play a dominant role in forest development on these sites. The cold, rocky, snowbound, unproductive, and otherwise fire-resistant environment that characterizes many of the sites limits the extent and frequency of fire (Fisher and Bradley 1987). Lightning caused fires often do not spread due to accompanying rains and the lack of continuous fine surface fuels. Stand replacing disturbances are infrequent and may be caused by snow and wind damage, rock slides, and talus slippage as well as fire (Fisher and Smith 1997). Research of historic vegetation (Losensky 1993) found only 2 percent of the alpine areas sampled for historic vegetation information had evidence of burns. Fire appears to be secondary to environmental factors in its influence on stand dynamics in the upper subalpine environment.

Fire Regime: Fire Group 10 dominates this vegetative group. As fires often burn few trees in a stand, determining fire frequency is difficult and does not apply well in upper subalpine and timberline sites (Fisher and Bradley 1987). The fire free interval varies considerably from 35 to over 300 years (Romme 1980). Fires are typically of low or mixed severity because of discontinuous fuels (Arno 1989). Where canopy cover is dense and fuels are heavy, stand replacement fires can occur after intervals of more than 200 years (Fisher and Bradley 1987). Stands are susceptible to severe fires that originate at lower elevations (Arno 1986; Arno and Hoff 1989). Arno (1980) reported great variation in presettlement fire regimes on high elevation sites in the Northern Rocky Mountains; average fire-free intervals ranged from 60 to 300 years. Crane and Fisher (1986) report a frequency of 100-300 years for stand replacement fire. Extensive fire spread may be most likely in early succession, when fine fuels are available, and late succession, when fuel loadings increase and shade tolerant species provide fuel ladders (Arno and Petersen 1983; Morgan and Bunting 1990). The short snow-free period, high moisture, low site productivity, low fuels accumulations, and slow recovery of regenerating stands predisposes the upper subalpine ecosystem to lethal fires only in circumstances involving: microbursts or sustained upslope wind events, fuels accumulations associated with insect and disease outbreaks, and extended summer drought followed by episodes of dry lightning (Triepke 1999). Mixed severity fire was typical in stands with seral whitebark pine (Keane 1992). In the Selway-Bitterroot Wilderness, whitebark pine stands experience stand replacing fires every 180 years. Nonlethal underburns occurred at an average interval of 56 years (Brown et al. 1994).

Fuels and Nutrient Cycling: This fire group is characterized by relatively sparse fine fuels and moderate amounts of widely scattered, large diameter fuels, estimated to average 11 tons per acre (Fisher and Bradley 1987). Inventory data of fuels in these forest types is scarce. When fires do occur they burn unevenly through the patchy fuels (Barrett and Arno 1991).

Insects and Disease: The ecology of whitebark pine is interwoven with that of lodgepole pine, mountain pine beetle, and white pine blister rust (Hoff and Hagle 1990; Kendall and Arno 1980). When beetle-caused mortality is high in lodgepole pine stands, it is followed by high mortality in neighboring whitebark pine stands (Gibson 1994; Kendall and Arno 1990). Heavier fuels have the potential to increase fire severity and cause mortality in whitebark pine, reducing seed sources necessary for stand regeneration. This seed source has also been severely impacted by loss of mature trees due to blister rust infection. In general, endemic levels of associated insects and pathogens also occur in these settings.

Weather: Snow damage, isolated windstorms and lightning are a common occurrence. Drying winds, cold temperatures during the growing season, and either persistent snowpacks or droughty soils are also characteristic. These and other site factors are a primary influence on forest development.

Successional Pathways

Changes in stand development following disturbance will vary depending on whether whitebark pine or a mixture of seral species dominate. In general, secondary succession begins with a mix of herbs and shrubs that dominate the site for an extended period. Fire may initiate secondary succession, but is unlikely to have a role in maintaining it (Fisher and Bradley 1987). As discussed, stand replacing disturbances caused by snow, wind damage, and rock slides may be more of an influence than fire in maintaining early stages of succession. This is particularly true on north slopes and moist sites. It may take many decades for conifers to dominate the site, and considerably longer to attain a mature forest condition. During this phase, surface fires occurring on south slopes and ridges reduce fuels and kill some of the overstory trees. Lightning-caused low severity fires can occur most anytime without substantial effect on succession. While the occurrence of lethal fires is unlikely at this time, their presence would be limited and result in a vegetative mosaic. Over time the maturing forests will develop some breakage, windthrow, insect and disease-caused tree mortality, etc. Stand replacing fires, especially those that advance from adjacent lower elevation stands become a more assured possibility during extended drought.

If disturbance doesn't occur, mature trees eventually progress into a climax stand. Low to moderate severity fires rarely have much of an impact on these mature stands because of the open structure and lack of continuous fine fuels. However, lethal fires that enter the crowns and kill the cambium revert the conditions to a stand initiation stage. Because of its thin bark, alpine larch is easily damaged by fire but is moderately resistant because it occupies the generally moist but cold rocky sites. Fires enter these high elevation sites from adjacent lower elevation sites, with more continuous fuels, but often do little damage to alpine larch stands.

Compared with the lower subalpine forest (i.e. HG 9), vegetative recovery following most fires is usually slow because of the short growing season and cold climate. This recovery is not much different from that of the upper subalpine forest setting (i.e. HG 10). Fire is an important means of perpetuating the abundance of whitebark pine. The effects of blister rust infection on whitebark pine seed production and establishment may be creating different patterns of succession than would historically exist.

Ecological Function

Landscape Linkages: Within this HG, connectivity is relatively high and results in important corridors for seasonal wildlife movement. This can be attributed to patch sizes which are generally large and include primary topographic ridges within them. Movement of lynx might occur from suitable denning habitat to forage or cover areas, particularly early seral lodgepole pine stands within the lower subalpine settings.

Old Growth and Interior Habitat: This HG makes up a very small percentage of the functional old growth and interior habitat across the forest. The high elevation subalpine ecosystem typically did not produce quality old growth habitat. Large, multi-aged patches do function as interior habitat and provide big game security, travel cover, and habitat for neotropical migratory birds. Gaps created by fire have value for wildlife species that prefer such small openings.

Wildlife Habitat: The area provides summer range habitat for mountain goat, elk, and mule deer, summer and fall grizzly bear use and fall denning habitat for bears. Hiding cover varies due to generally low stocking of trees, but can be good due to the clustered trees. Young, dense subalpine fir stands offer decent thermal cover.

Due to the high elevation and cold dry conditions, understory vegetation is limited as is high quality forage. However, beargrass and huckleberry are commonly available as seasonal food sources for grizzly bears.

Although snow and wind breakage creates numerous opportunities for the creation of snags, they are of generally low quality with limited distribution. Preferred snag species such as western larch are available in adjacent landscapes and typically offer high quality habitat for dependent species.

Availability of small mammal habitat is good in numerous downed trees, broken-topped snags, and abundance of cones.

Rare Elements and Specialized Habitat: Glacial cirque lakes can contain important habitat for cutthroat and rainbow trout. Nearby streams can provide important spawning habitat for these trout species. The relatively high precipitation and deep snowpack on these upper subalpine environments also make them important for water storage. Springs and wallows are undoubtedly present and function as valuable habitat for dependent wildlife species. Nonforested, natural openings also occur and contain shrub and herbaceous vegetation often uncommon elsewhere in the response unit. Specialized habitat exists between large, contiguous interior habitat and can be of benefit to bears and some species of owls. Some areas may be used by lynx as denning cover, where suitable hiding cover and structurally complex forest conditions are present. Late seral stands with abundant downed, woody debris are suitable denning habitat. The absence of early seral lodgepole pine stands makes it unlikely that there would be an adequate prey base for lynx in this HG.

Unique Ecological Importance: A fair number of unique traits exist for sites in HG 11. As described, fire is secondary to site factors as an influence on forest development on these sites. Another interesting characteristic of this area is that alpine larch is closely restricted to the outer fringe of the maritime mountain environments throughout its distribution in the northern US, southern BC, and along the eastern slope of the northern Cascades (Arno and Habeck 1972). Some unique forest structural traits are that trees in this setting characteristically grow in groups with open area in between. Competition among tree species due to differences in tolerance is not as pronounced at timberline as it is in lower forests (Fisher and Bradley 1987). Finally, where whitebark pine occurs, it provides an important food source for Clark's nutcrackers, red squirrels, grizzly bears, and black bears. Nutcrackers cache the seeds, and squirrels cache the cones during the fall.