Strategy For Management Of Dry Forest Vegetation
Okanogan And Wenatchee National Forests

April 2000

I. Purpose

This Strategy for management of dry forest vegetation addresses the portions of the Wenatchee and Okanogan National Forests that support dry forest plant communities. The objective of the Strategy is to provide a framework for management of dense, dry forest vegetation. The framework is intended to identify management objectives appropriate to maintain, protect and enhance the health of dry forest environments. Further, it is meant to illustrate vegetation and fuel treatments potentially appropriate under various dry forest conditions. This Strategy is adaptive in nature. Refinements and modifications to the Strategy are anticipated as management objectives are met and new information becomes available through research and monitoring. Additionally, the Strategy is intended as an aid useful for work planning efforts and in establishing workforce priorities.

The Dry Forest Strategy was developed by the Wenatchee National Forest to address issues that emerged following the 1994 fire season. The initial Strategy was subjected to a blind protocol scientific review. While the reviewers substantially agreed with the initial Strategy, some suggestions and recommendations were offered to improve the Strategy. The comments and suggestions of the reviewers have been incorporated in this current version of the Dry Forest Strategy. In 1999, the Okanogan National Forest adopted the Dry Forest Strategy for use within appropriate dry forest types.

II. Dry Forest Definition

Dry forests are defined as forests that were historically open and supported widely spaced, large ponderosa pine western larch, and Douglas-fir in the overstory with little underbrush and only occasional clumps of smaller trees. These areas comprise about one-third of the Wenatchee National Forest and about one fifth of the Okanogan National Forest. Dry forests were maintained in this condition for centuries by fires that were predominantly low intensity, non-lethal and frequent, burning across the landscape every 6 to 20 years (Everett et al. 1996). This is the forest typified by the low fire severity regime as described in *Fire Severity Regimes of the Pacific Northwest* (Agee 1990). These dry forested areas dominate the eastern edge of the Wenatchee National Forest, generally on landscapes that receive less than 30 inches of annual precipitation, and elevations below 4,000 feet on the northern portion of the Forest and 4,500 feet on the southern portion of the Forest. On the Okanogan National Forest, areas considered as dry forest generally occur below 4,300 to 4,600 feet in elevation, and are located in proximity to the Methow, Chewuch, and Okanogan River Valleys or their major tributaries. Dry forest conditions in these areas were considered sustainable under the pre-settlement disturbance regimes (Everett 1995).

For purposes of this Strategy, dry forest types are identified and mapped to include all of the plant associations within the ponderosa pine and Douglas-fir series, and the drier plant associations within the grand fir series. They are included together because of their similar fire regimes and vegetation patterns (Williams and Lillybridge 1983; Agee 1994; Everett et al. 1997; Lillybridge, Kovalchik, Williams and Smith 1995; Johnson and Clausnitzer 1991; Hall 1976, Williams Lilybridge and Smith 1990). Further, dry plant associations within the grand fir series common on the Wenatchee National Forest are not considered transitional between disturbance patterns of the drier series and those of the more cool and moist series (Agee 1994); and therefore, are most appropriately included in the dry forest. The grand fir and ponderosa pine series do not occur on the Okanogan National Forest. Plant associations within the dry forest type are listed in Appendix A.

A map of dry forests for the Wenatchee National Forests was developed using the Forest Vegetation Series map (Figure 1). A model was developed as a means of segregating dry grand fir plant associations from mesic grand fir series. The model mapped dry grand fir plant associations in areas with less than 30 inches of annual precipitation, and the grand fir series in areas with more than 30 inches of annual precipitation on west, southwest, south, and southeast aspects. The modeling process estimated approximately 695,600 acres of dry forest within the Wenatchee National Forest boundary (Table 1). Site-specific analyses is likely to result in refinements to this general identification, particularly for areas in the grand fir series.

Table 1. Wenatchee National Forest
Acres of DRY FOREST by Northwest Forest Plan Allocation
(Post-Dinkelman and 1994 Fires) 11/14/1995

Northwest Forest Plan Allocation	Douglas Fir	Dry Grand Fir	Ponderosa Pine	Total
Administratively Withdrawn	25,300	12,400	7,200	44,900
Congressionally Withdrawn	27,700	30,400	4,100	62,200
Riparian Reserve[+]	16,000	5,700	5,700	27,400
Adaptive Management Area	500	11,000	0	11,500
Late-Successional Reserve	83,300	102,800	11,800	197,900
Managed Late-Successional Area	25,400	28,400	2,600	56,400
Matrix	170,800	59,900	64,600	295,300
Total	**349,000**	**250,600**	**96,000**	**695,600**

Figure 1. Dry Site Forests of the Wenatchee National Forest.

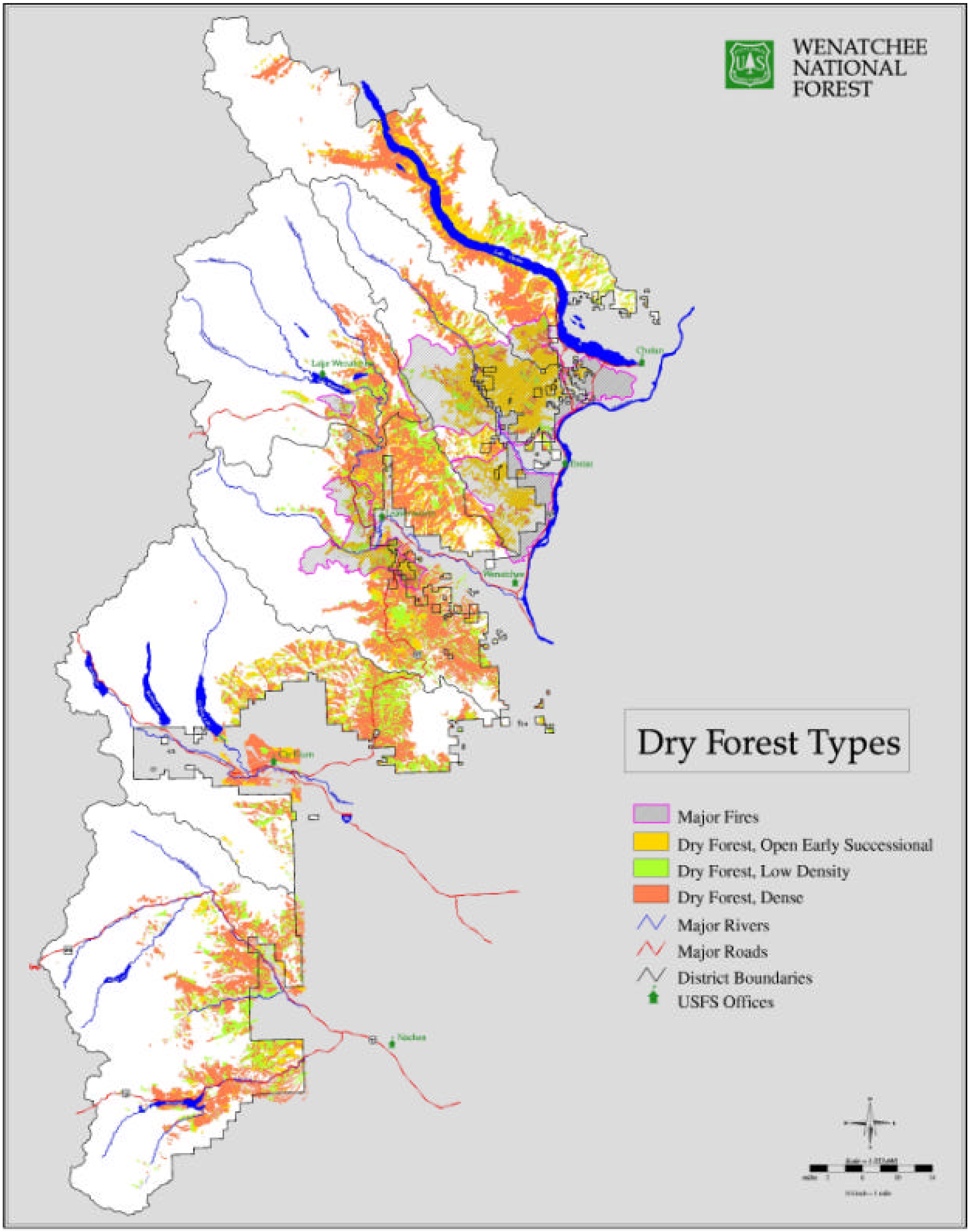
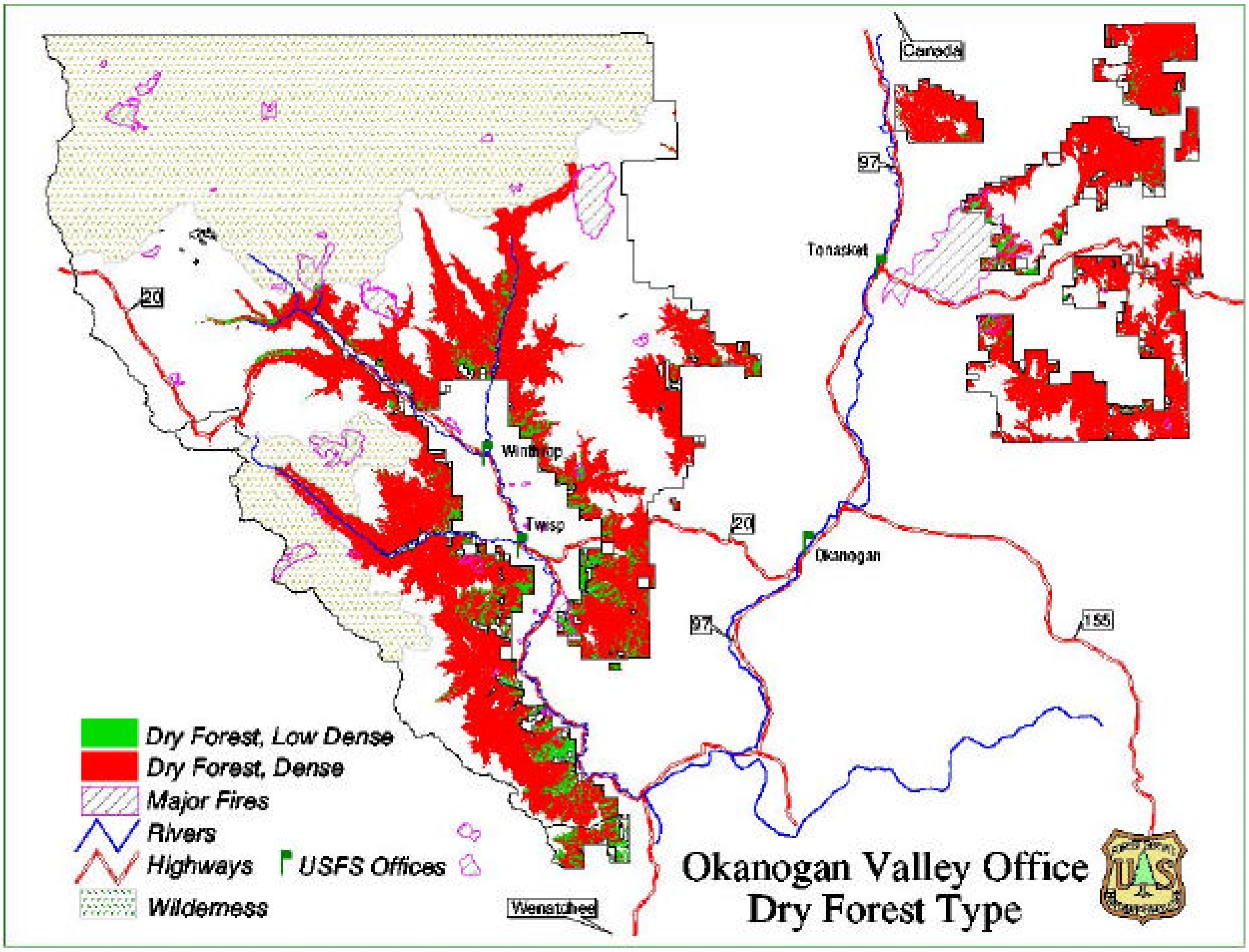


Figure 2. Dry Site Forests of the Okanogan National Forest.



On the Okanogan National Forest, the modeling process estimated approximately 407,600 acres of dry forest occurs on National Forest lands (Figure 2 and Table 2). The map of dry forests for the Okanogan National Forest was created using an elevation limit of 4,300 feet on northerly aspects, 4,600 feet on southerly aspects, and Douglas-fir Series (Figure 2, Table 2). Only National Forest lands are shown below in Table 2.

Dry forest vegetation types on both National Forests may occur at higher elevations than was mapped in this document where aspect, soils, and air drainage patterns combine to create suitable conditions. Appendix A displays plant associations where dry forest vegetation types occur.

Table 2. Okanogan National Forest Acres of DRY FOREST by Forest Plan Allocation				
Northwest Forest Plan Allocation	**Douglas Fir**	**Dry Grand Fir**	**Ponderosa Pine**	**Total**
Administratively Withdrawn	10,335	0	0	10,335
Congressionally Withdrawn	14,332	0	0	14,332
Riparian Reserve+	20,379	0	0	20,379
Adaptive Management Area	0	0	0	0
Late-Successional Reserve	65,204	0	0	65,204
Managed Late-Successional Area	0	0	0	0
Matrix	106,982	0	0	106,982
Sub Total	196,853	0	0	196,853
Outside Northwest Forest Plan	**Douglas Fir**	**Dry Grand Fir**	**Ponderosa Pine**	**Total**
Administratively Withdrawn	4,359	0	0	4,359
Congressionally Withdrawn	3,116	0	0	3,116
Riparian Habitat Conservation Areas+	12,582	0	0	12,582
Developed Sites	3,014	0	0	3,014
Wildlife Management Areas	88,473	0	0	88,473
Other Forested Areas	114,830	0	0	114,830
Sub Total	210,778	0	0	210,778
Total	**407,631**	**0**	**0**	**407,631**

+Riparian Reserve and Riparian Habitat Conservation Area acres are shown separately for information only. The acreage shown for other allocations include both riparian and upland acres.

Dense dry forest seldom occurs as a continuous condition across a landscape. It more typically occurs interspersed with other vegetation types, conditions, and landscape features. Implementation of the Dry Forest Strategy on dense dry forest areas will also consider the implications to adjacent vegetation types, vegetation structures, and landscape features. Implementation will consider the effects of any activity or treatment on the associated plants or animals dependent upon those types.

Dense dry forests were delineated as those forested areas described above with a 30 percent or greater crown closure, as interpreted on the crown closure data layer done from satellite imagery for the Wenatchee National Forest, and 40% for the Okanogan National Forest (Golden 1996, O'Neal 1996, Anonymous 1999). Based on currently available data, there are approximately 346,200 acres of dense dry forest on the Wenatchee National Forest (Table 3 and Figure 1), and 334,700 acres of dense dry forest on the Okanogan National Forest (Figure 2 and Table 4). All forested lands on the Wenatchee National Forest and portions of the Okanogan National Forest west of the Chewuch and Methow Rivers are under the Northwest Forest Plan. Allocations

Table 3. Wenatchee National Forest
Acres of DENSE DRY FOREST by Northwest Forest Plan Allocation
(Post-Dinkelman and 1994 Fires) 11/14/1995

Northwest Forest Plan Allocation	Douglas Fir	Dry Grand Fir	Ponderosa Pine	Total
Administratively Withdrawn	8,000	5,500	1,000	14,500
Congressionally Withdrawn	17,600	21,500	1,000	40,100
Riparian Reserve	7,200	3,400	1,200	11,800
Adaptive Management Area	300	6,700	0	7,000
Late-Successional Reserve	53,600	73,700	5,500	132,800
Managed Late-Successional Area	16,900	18,700	1,400	37,000
Matrix	59,700	31,800	11,500	103,000
Total	**163,300**	**161,300**	**21,600**	**346,200**

+Riparian Reserve and Riparian Habitat Conservation Area acres are shown separately for information only. The acreage shown for other allocations include both riparian and upland acres.

found in the April 1994 Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Northern Spotted Owl (ROD) are shown below. The Okanogan National Forest has about 179,600 acres of dense dry forest located outside of the Northwest Forest Plan, in areas managed under the Regional Foresters Amendment Number 2 to Eastside Forest Plans (Eastside Screens), PACFISH, and INFISH.

Figures 1 and 2 are an accurate representation of the dense dry forest when used at the watershed scale or larger. This determination was based on comparisons with maps developed as part of separate Watershed Analyses that used more intensive techniques to map dense dry forest (e.g. stand examinations and aerial photo interpretation). Comparison of total acres of dense dry forest displayed in Tables 3 and 4 with maps developed as part of independent Watershed Analyses, showed relatively minor variation in total acres of dense dry forest. Additional information is presented in Appendix B.

Table 4. Okanogan National Forest Acres of DENSE DRY FOREST by Forest Plan Allocation				
Northwest Forest Plan Allocation	**Douglas Fir**	**Dry Grand Fir**	**Ponderosa Pine**	**Total**
Administratively Withdrawn	3,470	0	0	3,470
Congressionally Withdrawn	10,686	0	0	10,686
Riparian Reserve+	17,317	0	0	17,317
Adaptive Management Area	0	0	0	0
Late-Successional Reserve	59,350	0	0	59,350
Managed Late-Successional Area+	0	0	0	0
Matrix	81,628	0	0	81,628
Sub Total	155,134	0	0	155,134
Outside Northwest Forest Plan				
Administratively Withdrawn	3,657	0	0	4,017
Congressionally Withdrawn	3,094	0	0	3,094
Riparian Habitat Conservation Areas+	11,434	0	0	11,434
Developed Sites	2,983	0	0	3,014
Wildlife Management Areas	67,930	0	0	67,930
Other Forested Areas	101,938	0	0	101,938
Sub Total	179,602	0	0	179,602
Total	**334,736**	**0**	**0**	**334,736**

+Riparian Reserve and Riparian Habitat Conservation Area acres are shown separately for information only. The acreage shown for other allocations include both riparian and upland acres.

III. Management History in the Dry Forest

Pre-settlement natural and human caused disturbances generally resulted in stable stand and landscape patterns of dry forest vegetation because plants that comprised these ecosystems were adapted to the effects of fire, native herbivore grazing, and insect and pathogen disturbances. However, more recent management-induced activities have affected dry forest vegetation in ways both positive and detrimental to these environments. For example, fire exclusion has resulted in an elevation of the nutrient capital by allowing additional organic material to build up on site, but this positive effect is short-term and cannot be sustained (Cochran 1992). Fire exclusion has also resulted in a transition to shade tolerant species and stand structures less adapted to fire (Hessburg et al. 1999; Lehmkuhl et al. 1994). The effects of stand scale management are often cumulative over time and space, and therefore influence vegetation at the landscape scale (Hessburg 1999; Lehmkuhl et al. 1994).

A. Fire Exclusion

Beginning early in the 20th Century, fire prevention and suppression efforts greatly intensified in order to protect public resources and private property from the perceived risk of wildfire (Oliver et al. 1994). These efforts became increasingly successful, and by the 1930's nearly all fires were successfully suppressed (Oliver et al. 1994; Agee 1994, 1990, 1993).

Throughout much of the 20th Century, the success of these efforts effectively eliminated fire from these landscapes; leading to conditions favorable for the establishment of numerous small (often shade tolerant) trees, shrubs, and other vegetation (Hessburg et al. 1999; Lehmkuhl et al. 1994). The resulting increase in crown and ladder fuels from the presence of additional biomass is a direct contributor to the lethal effects of recent fires on these landscapes, as discussed later in this paper (Huff et al. 1995; Ottmar et al., In press).

B. Harvesting

Timber harvest early in this century was concentrated in accessible areas near settlements, and along railroads that were often located in valley bottoms near rivers and streams. Large ponderosa pine, larch, and Douglas-fir were harvested because of their fine wood qualities and the abundance of accessible park-like stands. Overstory removal harvests where larger early seral pine and Douglas-fir are removed leaving smaller, shade tolerant fir behind increased as the century progressed. Most of the larger ponderosa pine and Douglas-fir trees were removed from the most accessible dry forest areas on the Wenatchee and Okanogan National Forests by the 1960’s and late 1980’s, respectively. Progressive removal of these large trees, in combination with extremely efficient fire suppression on both National Forests created the forested landscapes we see today (Hessburg et al. 1994; Johnson et al. 1994; Lehmkuhl et al. 1994; Agee 1994, 1993).

C. Livestock Grazing

Livestock grazing began on the Wenatchee and Okanogan National Forests in the late 1880’s and increased until its peak between the 1930’s and the 1960’s. Domestic livestock grazing on National Forest lands has declined since the 1960’s. At present, permitted numbers are substantially less than during the peak years. Some of the effects of past intensive grazing include: (a) a general decline in vegetation cover in some areas and with associated impacts to soil conditions; (b) removal of highly flammable fine fuels (grasses and forbs) in some areas, (c) reduction in ground fire frequency that had previously controlled establishment of dense stands of tree seedlings (Hall 1977; Wissmar et al. 1994a, b; Skovlin et al. 1997; and, Hann et al. 1997, 1998); (d) increased siltation of some streams and reservoirs; and (e) an increased establishment of non-native plants, including noxious weeds in some areas (in combination with other human activities such as recreation, road management, logging, and mining) (Agee 1993; Johnson et al. 1993).

IV. Landscape Changes, Past to Present

Descriptions from official reports during the early years of settlement on the eastern slopes of the Washington Cascades described the forests of north and central Washington as "…*dense underbrush and thickly spaced trees in the higher elevations, gradually giving way to open spaces and a clean understory in the ponderosa-dominated stands at lower elevations*" (Cooper and Suckley, 1859). The botanical section of the 1855 railroad surveys through the northern Cascades, known as the "Stevens Report", has a particularly relevant passage:

> *"There is so little underbrush in these forests that a wagon may be drawn through them without difficulty, forming a striking contrast to the dense thickets of the western slopes... the level terraces, covered everywhere with good grass and shaded by fine symmetrical trees of great size, through whose open foliage the sun's rays penetrate with agreeable mildness, give to these forests the appearance of an immense ornamental park."*

This report also mentions the presence of large forest fires at the lower elevations (*The Natural History of Washington*, Cooper and Suckley, 1859). Including research completed in this area, a large number of publications exist which describe fire frequency and effects in dry eastside forest environments (Everett et al. 1995, 1996, 1997; Finch 1984). Prior to settlement by Euro-Americans, the fire return interval in the dry forest types tended to be short, approximately 20 years or less, and of low intensity (Hall 1976; Gast et al. 1991; Mutch et al. 1993; Agee 1994; Johnson et al. 1994; Finch 1984).

Under a frequent fire regime, patch sizes tended to be very large in the dry forests of north and central Washington. Tree regeneration occurred in small areas, sometimes less than an acre in size, predominantly in micro sites and patches where fire intensity was high enough to kill small clumps of trees (Hessburg et al. 1999; Lehmkuhl et al. 1994). Pre-settlement dry forest landscape patterns were dominated by a park-like structure of widely spaced trees with a continuous herbaceous understory (Hall 1976, 1980, 1984; Gast et al. 1991; Mutch et al. 1993; Agee 1994). Fire tolerant ponderosa pine was the dominant conifer species in dry forests. The occurrence of Douglas-fir within the Douglas-fir series and dry grand fir series depended on occasional patches and gaps where longer fire free intervals allowed time for Douglas-fir to develop thicker fire tolerant bark not found on younger trees (Agee 1991, 1994 A 1995).

A 1995 stand reconstruction administrative study conducted within the Pendleton Canyon area of the Mission Creek Watershed (located in the lower Wenatchee River Basin) inventoried old stumps and old trees to estimate historic density and composition. This inventory found an average historic stand density of approximately 21 trees per acre, an average diameter of 25 inches, and a species composition of approximately 92 percent ponderosa pine and 8 percent Douglas-fir (Harrod et al. 1997). This structure for the Wenatchee National Forest dry forests is very similar to forest structures described for other areas within the inland west (Covington and Moore 1994).

Similarly, research has shown that stand structure and composition across the dry forests of the Wenatchee and Okanogan National Forests are vastly different today from pre-settlement conditions (Everett et al. 1997, 1995, 1996). Currently, dry forests on the Wenatchee and Okanogan National Forests support significantly greater numbers of trees than in the past. At present, stocking levels range from 200 trees per acre in the ponderosa pine series to well over 600 trees per acre in the Douglas-fir series. Within the dry grand fir series**,** stocking levels can often exceed 1,000 stems per acre. Most of the trees on these sites are 12 inches or less in diameter (data from Methow, Tonasket, Leavenworth, and Naches Ranger Districts). Additionally, species composition has shifted from predominantly ponderosa pine to Douglas-fir or grand fir as the dominant species. The shift to dense forests with higher percentages of small trees, and a species composition higher in Douglas-fir and grand fir, has significantly increased the risk of lethal stand replacement fires where, prior to settlement by Euro-Americans, low intensity non-lethal fires occurred (Ottmar et al., In press; Huff et al. 1995; Ohlson et al. 1998).

The *Eastside Forest Health Assessment* addressed ecosystem sustainability in Eastern Oregon and Washington. It concluded, in part, that forests have become more dense in vertical and horizontal canopy structure; and that large scale restoration and maintenance of fire related processes through application of prescribed fire are needed (Everett et al. 1994, including references cited therein). One finding from this assessment specific to the Wenatchee River Basin measured a decrease in overstory ponderosa pine of 7 percent and increase in overstory Douglas-fir of 7 percent (Lehmkuhl et al. 1993). Similar reductions in ponderosa pine canopy cover were noted for the Methow River Basin. These changes were measurements across entire river basins, and likely would have been greater if stratified to the dry forest only.

There are also relevant findings from the Interior Columbia Basin Ecosystem Management Project (ICBEMP), a broad-scale ecosystem assessment begun in 1994 and still underway. One conclusion from this assessment is that fire exclusion, low and mid-elevation timber harvest activities, invasion of exotics, and livestock grazing practices have substantially altered fire susceptibility and behavior within the Northern Cascades and Northern Rocky Mountain Ecological Reporting Units (ERUs) that include the Wenatchee and Okanogan National Forests. As a result, fire severity has shifted from a mixture of non-lethal and mixed severity to lethal in dry forest areas (Hann et al. 1997, including references cited therein). This assessment found that within the dry forest potential vegetation groups (PVGs) located in the Northern Cascades and Northern Rocky Mountain ERUs, late-seral, single layered forests often described as ‘park-like ponderosa pine and Douglas-fir forests’ comprised the majority of the PVG prior to settlement. These forest structures now comprise a very minor proportion of the area. Concurrently, this assessment found a very large increase in the amount of mid-seral forests comprised of predominantly medium sized trees. These smaller, denser forests have increased dramatically to the point they now dominate the landscape. Hessburg et al. (1999) corroborates these findings.

Insects and pathogens played a role in pre-settlement forest ecosystems, contributing to the development of important wildlife habitat, nutrient cycling, and stand and landscape level diversity. Prior to settlement, insects and pathogens within dry forest types operated at the individual tree or small patch level. Insects and pathogens acted in combination with fires to reduce tree density. Trees scorched, but not immediately killed, by low intensity ground fires were susceptible to attack by pine engraver beetles and Douglas-fir beetles. Armillaria root disease killed small numbers of trees weakened by overcrowding, drought or fire; this disease also increased individual tree susceptibility to bark beetle attack. Fire scars provided infection courts for decay organisms, which in turn created conditions favorable for macro invertebrate wood decomposers, especially carpenter ants. Freshly killed trees were soon invaded by wood borers that provided forage for woodpeckers and created tunnels that facilitated the entry of other wood-decomposing agents. Parasitic dwarf mistletoes were present in greatly reduced levels in pre-settlement forests because result of the frequent ground and mixed severity fire regime. Moderate to heavily infected trees were likely to torch as ground fires climbed into the crowns of infected trees on resinous stems, dead branches, and brooms (Weaver 1974**,** Lehmkuhl et al. 1994, Hessburg et al. 1994).

In addition to fire**,** western pine beetle was another important disturbance agent in pre-settlement dry forests. Large, old ponderosa pines were the preferred host of the western pine beetle (Keen 1943, Wickman and Eaton 1962). Beetles killed low vigor trees. Low vigor resulted when trees were struck by lightning, infected with root diseases, because of age or competition-induced stress. During periodic droughts that occurred in the western forests, large ponderosa pine consistently sustained outbreaks of this insect. Ponderosa pine snags provide nesting habitat for cavity excavators and secondary cavity users. Birds and other insectivores exploit the insects within beetle-killed trees. When they fall, these snags become down logs, providing habitat to other flora and fauna. Down wood longevity in pre-settlement pine forests is not well researched. However**,** frequent fires probably consumed most large down wood, within a decade or two of its occurrence.

Under pre-settlement fire regimes, defoliators, root diseases, and dwarf mistletoes played minor roles in the dry forest types on the Wenatchee and Okanogan National Forests, especially when considered at landscape scales (Hessburg et al. 1994). The effects on forest conditions of these organisms was limited to more mesic areas within the dry forest where longer fire return intervals allowed late-successional tree species to establish and grow.

The use of reference conditions reconstructed from pre-settlement forest structure and composition can be useful for managers trying to develop management strategies intended to create resilient forest ecosystems that are sustainable over time (Harrod et al. 1998; Morgan et al. 1994; Swanson et al. 1994; USDA 1995). An assessment of the natural range of variability can be used to develop multiple reference points for determining change in species composition and forest structure over time. Harrod and others (1999) used retrospective analysis in the Pendleton Study Area to estimate pre-settlement stand structures. In addition, Harrod and others (1998) modeled the natural variability of snags under pre-settlement conditions within dry forests on the eastside of the Cascade Mountains. Ohlson et al. (1999) reconstructed pre-settlement snag and down log conditions from several landscapes on the Okanogan National Forest.

These efforts provide information that may be useful in describing reference conditions to implement the Dry Forest Strategy. Retrospective studies and knowledge of pre-settlement disturbance regimes provide scientifically credible information to describe the structure, function and composition of dry forests (Agee 1993; Agee and Edmonds 1992; Camp 1995; Everett et al.1998). It is important to recognize that reference conditions provide estimates of pre-settlement conditions that may not translate into the desired future condition for a particular piece of land because of other resource objectives. Appendix C identifies a process to establish a range of reference conditions for use under the Dry Forest Strategy.

V. Lessons from Recent Fires

Changes in stand and landscape patterns in dry forests have resulted in a marked shift in fire frequency and severity from low intensity fires to large stand replacement fires. The Wenatchee and Okanogan National Forests have experienced a number of large stand replacement fires since 1970 that have often burned across dry forest landscapes. The 35,000 acre Barker Mountain Fire in 1985 and the 55,000 acre Dinkleman fire in 1988 burned almost entirely within dry forest and shrub steppe plant communities. In 1994, the Bannon, Poorman, Tyee and Hatchery/Rat fires burned 186,000 acres, much of which was located in the dry forest types. These fires burned with very high intensities. They were lethal to the dry forest stands where vegetation composition and structure were highly altered from pre-settlement conditions. The location of these fires is shown on the dry forest maps, Figures 1 and 2. These maps show large areas that now support early successional shrub, forb, and graminoid vegetation where trees once dominated. Prior to wildfire, much of the dry forest within the boundaries of these fires was in a dense condition. The dense nature of these stands contributed directly to the lethal effects of these fires by fueling the rapid spread of the fires through the forest canopy.

Two notable exceptions to the complete stand mortality mentioned above exist. In the vicinity of Mud Creek Summit within the Tyee Fire there is a 500 to 600 acre dry forest stand that survived. This stand had been commercially thinned and underburned several years prior to the Tyee Fire. The area is clearly seen in the attached photographs (Figure 3 and Figure 4). Another example of a stand of trees in the dry forest that survived the Hatchery/Rat Fire is located on the lower slopes of Icicle ridge southwest of Leavenworth. This stand had not been logged previously but was in a low-density condition due to the harsh rocky nature of the site. Most of the larger trees present on this site survived the fire with limited crown scorch. These two areas were in a low-density condition that reduced the lethal intensity of the wildfire. Agee et. al.

(2000) concluded that areas thinned to created “shaded fuel breaks” experience mediated fire intensities, and can serve as anchor points for prescribed burning or to reduce the “size, intensity, and effects of wildland fires.” They suggest that to be effective, shaded fuel breaks must be large, perhaps at least 400 meters wide. Graham et. al. (1999) similarly conclude that properly conducted thinnings reduce the risk of lethal crown fire.

Figure 3. Mud Creek Summit of precommercial thinning within the 1994 Tyee Fire, as it appeared in the fall of 1994. This stand survived the fire with much less damage than surrounding unthinned forests.

Figure 4. Precommercially thinned stand at Mud Creek Summit as it appeared in 1999. Most of the thinned trees have recovered from the effects of the 1994 wildfire.

VI. What Can Be Done

While it is clear that forest structure has been altered and something must be done, the specifics of what to do, where to do it first, and how fast to proceed, are less clear. It will take a combination of many actions to restore dense dry forests to conditions that are both resilient and sustainable over time. It will be necessary to reduce fuels by initially reducing the density of small trees on most areas (Arno 1993; Agee et al 2000; Graham et. al. 1999). Much of the thinning of trees can be accomplished most economically through commercial timber sales. Smaller trees now have value as wood products. Based on the results of recent timber sales on the Wenatchee and Okanogan National Forests, trees between 7 to 12 inches DBH (diameter breast height) now have commercial value. In some cases, depending on chip markets, tree species, accessibility, and location, trees 5 to 7 inches DBH or smaller may have commercial value. Timber sales and other innovative contracting tools can be used to most efficiently and economically reduce unwanted biomass and abate unacceptable fire hazard.

Landscape scale prescribed fire may also prove to be an effective management tool to reduce fuel and tree densities in some situations. Initial analysis of prescribed burning costs suggests that these treatments may have similar costs as fire suppression, typically $1,000 or more per acre. The Forest Service has very little experience with large, landscape level prescribed burns conducted in proximity to human habitation.

Many areas within the dry forest vegetation types do not have enough merchantable trees available for removal to allow for an economical timber sale. These areas will require expenditure of appropriated funds for treatments such as: (a) pre-commercial thinning of small trees; (b) fuel treatment of pre-commercial thinning slash; (c) pruning of tree branches to further reduce fuels; and (d) prescribed burning where current vegetation and fuels are suitable. Some areas may require some combination of commercial harvest and other work funded with appropriated dollars.

The Strategy for management of dense dry forest will follow existing laws and regulations, and be consistent with decisions made in the Records of Decision for the Wenatchee and Okanogan Forest Plans, as amended by the Northwest Forest Plan. The Strategy will also be implemented in a manner consistent with PACFISH, INFISH, the Eastside Screens, and ICBEMP when it is approved.

Although the landscape now characterized as dense dry forest is more extensive than can be sustained for the long-term, management actions must consider the role these forests play in providing habitat for some species and for other uses by society. Tiedemann et. al. (2000) argue that a cautious approach to managing dense dry forests should be adopted because of their use by wildlife and the possible implications for forest productivity of prescribed burning. There may be implications involving road use and the President's Roadless Policy Initiative, recovery of species under the Endangered Species Act, and management under the auspices of the Northwest Forest Plan. It may be necessary to retain higher amounts of the dense dry forest condition in the short-term than can be sustained for the long-term. These trade-offs, and the risks that society must be willing to accept, will be disclosed through site-specific project analysis conducted according to the National Environmental Policy Act (NEPA).

VII. Strategy Development

Science must form the foundation of the Dry Site Strategy. The Strategy must be viewed as legitimate by both Forest Service employees and by the public. In order to begin to build employee and public support, fourteen meetings were held for the Wenatchee National Forest regarding the Strategy for dealing with the dense dry forest condition. One meeting was held on each Ranger District, three at the Wenatchee Forest Headquarters, and one each with the Regional Office, the Yakama Nation, the North Central Washington Farm Forestry Association, Eastern Washington Cascades Provincial Advisory Committee, and the Yakima Provincial Advisory Committee. Additional meetings may need to be held with employees and stakeholders in Okanogan County.

The purpose of the meetings was to discuss the science involved in dry forest management, display the nature of the dense dry forest situation on the Wenatchee, and gather input regarding the focus for forest management in the dense dry forest. As a result of these meetings, issues related to management of dense dry forests were identified. Most of these fall within the 13 categories described below. Responses to these issues provided insight into aspects and priorities that need to be considered in the dense, Dry Forest Strategy.

A. Issue 1 - Public Understanding/Support

The public is not knowledgeable of the rationale behind the dry forest strategy. How will they be informed? Will they accept action at the scale necessary?

Response

Because of the 1994 fires on the local communities, public support, although certainly not unanimous, is at a high level. This provides a window of opportunity to initiate effort and make a difference. The public expects the Forest to take bold, but reasonable steps to protect local communities and forests from catastrophic fires, and they want to actively participate in this effort.

The Collaborative Learning Process utilized in the fire recovery effort provides an excellent tool to bring the public into project planning, and provides a meaningful way to utilize public input in developing specific strategies. The Provincial Advisory Committees can also be of help in building support.

The Forest currently has a number of public education efforts underway, particularly those tied to local schools and including a video called "Our Dry Forests, A Century of

Change". There is a need to continue to support and expand these efforts. Forest employees should take advantage of opportunities they have to discuss this issue one-on-one with friends, family, or whenever they have contacts with individuals who express interest. The video should be updated to incorporate the Okanogan portion of the Okanogan-Wenatchee National Forests.

B. Issue 2 - Resource Information

The situation is extremely complex and there are too many information gaps to begin now.

Response

Although there are many uncertainties related to the specifics of how to proceed, the Forest knows enough to get started now, to monitor and learn from the efforts, and adapt as needed. This concept of adaptive management is a major point of the overall Strategy. There is much information from natural resource research and academia supporting a need to take action. In addition, and most importantly, the on-the-ground knowledge of Okanogan and Wenatchee Forest scientists supports taking action.

The crux of the problem appears to be that normally some of the forest would be in a condition that has a high to moderate risk of disturbance from fire, insect, and disease. These areas would typically be imbedded in a matrix of other types having lower associated risks. Observed changes in risk profile are associated directly with altered landscape patterns of vegetation structure and composition.

Further, a variety of terrestrial and aquatic species indicates that these alterations are making it difficult for species to survive under these conditions. Fires, insects, disease and sensitive species are all leading to a diagnosis that landscape and stream structure, composition, and patterns in time and space are atypical for those environments; not what species have adapted to over long periods of time. Today, high-risk areas abut the landscape. This factor is an important consideration for the Strategy.

All of the Watershed Analyses and Late-Successional Reserve Assessments completed to date, as well as the Science Team Report done by the Wenatchee Forestry Sciences Laboratory, support the need to take action. The Strategy needs to be implemented with a bias for action, and recognition that action is better than avoidance.

C. Issue 3 - Ecosystem Approach

Projects need to be implemented on a landscape basis.

Response

The overall Strategy will be applied, and success measured, on a landscape basis. It will focus on outcomes, the vision of what the forest should look like, rather than outputs. At some time, analyses will need to be completed at various scales; including very large and general assessments such as those currently underway through the

Interior Columbia Basin Ecosystem Management Project, and more specific assessments such as documented in Watershed Analyses. Strategies for action and descriptions for desired outcomes will be based on the best available information. Site-specific conditions, species needs, and land allocations are important in shaping the projects to be implemented to achieve the outcomes.

Confining management to density, structure, and composition of dry forests alone would be too narrow of a focus because these forests have contexts. It is necessary to look at large areas that are comprised of significant dry forest area, which also include other vegetation types as well. To be most effective, implementation of the Dry Forest Strategy must simultaneously address the most important changes that have occurred in adjacent vegetation types and stream systems.

D. Issue 4 - Adjacent Areas

Do not forget about the portions of the forest adjacent to the dry forest plant community.

Response

The susceptibility of adjacent plant communities to fire and other disturbance events needs to be considered when making management decisions within dry forest stands. These areas include: (a) the shrub-steppe plant community that is more common on the eastside of the forest and often down-slope (and downwind) of the dry forest; and (b) some of the wet forest communities, particularly sub-alpine fir, that are common upslope of the dry forest. Specifically, the location and the type of action taken will be determined in part by the condition of adjacent plant communities, most importantly their susceptibility to wildfire. An even greater consideration in determining where action is taken first must be the wildland/urban and rural interface, those areas where flammable forests are adjacent to residences and other private property.

E. Issue 5 - Budgets

Sufficient funding to support this effort may not be available.

Response

Trust funds will be relied upon to the maximum extent possible since no increases in appropriated dollars can be expected. Appropriate trust funds include: Salvage Sale, KV (Knudsen-Vandenburg), and BD (brush-disposal) funds. The Forests' ability to generate these funds is becoming more limited, as there are fewer timber sales. Recent sales designed to remove small, low value material lack the ability to generate sufficient revenue to accomplish needed work. The Forests have typically not had access to sufficient appropriated funds to accomplish any more than a small amount of needed pre-commercial thinning of natural stands or for pruning. The Forests will work to raise awareness of this concern among members of Congress and the public. There may also be opportunities to complete needed work through partnerships and volunteer agreements. Actions such as pruning and hand piling may be appropriate projects for service clubs, school groups, and others, particularly in the wildland/urban and rural interface.

F. Issue 6 - Economic Feasibility

Removal of low value material with expensive logging systems is expected to be a significant part of implementation of the strategy. Given the Forests track record of selling salvage sales in the 94 fires, how do they expect to sell these sales and generate any money with this effort?

Response

There is an expectation that small diameter green sales will have higher values than those sales of similar sized burned material that were sold after the 1994 fires. The value of the burned material was low for two primary reasons: (a) the large amount of material available, both federal and private, in a short time period created an excess supply; and (b) the rapidly deteriorating nature of the wood introduced a high element of risk for purchasers, thereby limiting their desire to bid. Neither situation will exist with small diameter green sales.

Another factor that reduced value of fire salvage sales was the heavy reliance on expensive helicopter logging. This will also be a factor to some degree on the small diameter green sales. The Strategy must rely on judicious use of helicopters and use other less expensive options where appropriate. Partnerships with equipment development firms and with forest industry organizations can enhance the ability to be successful.

Innovative contracting tools such as removal rights in service contracts may be used in some circumstances to stretch appropriated dollars where product values are insufficient to justify use of a timber sale contract. These tools are being tested on the Methow and Tonasket Districts and, if successful, may be used on other Ranger Districts.

G. Issue 7 - Spotted Owls

Some of the most suitable spotted owl habitat on the Okanogan and Wenatchee Forests is in the dry forest and is the result of fire exclusion. How can this situation be resolved?

Response

Throughout efforts to improve forest health, we need to remember that while fire exclusion has had positive effects on some plant and animal species, such as the spotted owl, it has had negative effects on others. In addition, it is known that the positive effects of fire exclusion are short-term and cannot be sustained. Taking "no action" could have significant long-term negative impacts on this species.

The need to retain adequate suitable spotted owl habitat within Late-Successional Reserves and Managed Late-Successional Areas will be part of the Strategy. There may be an opportunity to prioritize actions for dense dry forest types that are not sustainable for suitable spotted owl habitat. There are nine different types of stand structures being used by successfully breeding spotted owls (Everett et al. 1997). Several of these stand types are more sustainable and allow more flexibility for management so that we need not manage for just one type of stand. By moving conditions on these parts of the landscape to the more open park-like ponderosa pine stands that once occupied more of the area, these stands could then act as fuel breaks within the Late-Successional Reserves. The results of the assessments currently underway in a separate effort will become part of this Strategy. See the response to Issue 8 also.

H. Issue 8 – Late-Successional Reserves (LSRs)

Much of the dense dry forest is located within Late-Successional Reserves. How will these be handled?

Response

An interim Forest-wide assessment of LSRs was completed in 1994. This assessment indicated that 10 of the 16 LSRs on the Wenatchee National Forest were at a high risk of loss from stand replacement fires. The 1994 fires burned significant portions of four of these LSRs. This information suggests a need to take action within the dry forest. Detailed assessments of each of the Wenatchee National Forest LSRs and Managed Late-Successional Areas (MLSA) completed in 1996-1997, and a Late-Successional Reserve assessment competed for the Okanogan Forest in 1998 further documented the high risk associated with these stands. These assessments were reviewed and approved by the Regional Ecosystem Office. The results of these assessments will guide any actions within Late-Successional Reserves and Managed Late-Successional Areas. See the response to Issue 7 also.

I. Issue 9 - Prescribed Fire

Fire is an important part of the ecology of the dry forest. Will prescribed fire be a part of the strategy?

Response

The primary objective of the Dry Forest Strategy will be reduction of fuels so that these plant communities function more similarly to their pre-settlement disturbance regimes (i.e. low severity fire and endemic levels of insect and disease pathogens).

Accomplishment of this desired outcome requires a combination of actions, including commercial thinning, treatment of thinning slash, and other cultural treatments such as pre-commercial thinning, pruning, and prescribed fire (Graham et. al. 1999). In most existing dense, dry forests, fuel levels are so high that prescribed fire cannot be used until other activities take place first. It is recognized that prescribed fire applications without prior mechanical treatment may be appropriate under some circumstances. Maintenance of existing, open ponderosa pine woodland conditions would be an example. Ultimately, achieving and maintaining a vegetative condition which is representative of the pre-settlement disturbance regime will depend, to varying degrees, on the application of prescribed fire as a disturbance agent in most dry forest areas.

J. Issue 10 - Air Quality

Given the need for prescribed fire, how will air quality be protected?

Response

This is a difficult challenge. To be successful, the Forest needs to make strong efforts to work with State and Federal regulatory agencies and to inform the public regarding the inevitability of smoke, whether it comes from prescribed fire or wildfire. Wildfire smoke generally has higher particulate levels and occurs during periods of poorer atmospheric dispersal than prescribed fire (Ottmar 1996). In addition, there is a need to expand the time in which prescribed fire is used to help mitigate limitations on putting smoke in airsheds. This should include all periods of time when atmospheric and fuel conditions are within prescription, including the summer months.

Because of all the concerns related to smoke, it is important that other options for treating ground fuels be considered wherever practical, leaving use of prescribed fire for situations where it is most beneficial.

K. Issue 11 - Soils

Much of the dry forest area has had a history of multiple timber harvest treatments. How will the Dry Forest Strategy affect the soil resource?

Response

Treatment of the dense, dry forest will need to meet the current Okanogan and Wenatchee Forest Plan standards for detrimental soil disturbance, including compaction, displacement and erosion. On the Wenatchee Forest, the *1996 Wenatchee Ground Based Harvest Policy* as updated and amended for new information will be applied. This policy is an adaptive strategy designed to trigger project-level assessments to identify timber management and rehabilitation practices to protect and/or improve soil productivity. Rehabilitation of site-specific areas where Standards have been exceeded in the past needs primary consideration. Sensitive soil conditions linked to surface erosion or mass wasting will be identified, and appropriate mitigation measures applied through project level assessments.

Although potential impacts to soils are a major factor in designing treatments, it is important to keep all options open, including road construction and ground based harvest systems where appropriate. It needs to be recognized that many of the soils have developed with frequent low intensity fires and having high intensity fires can have equal or greater detrimental effects on some soils. Standards for soil disturbance, like all other standards in the Forest Plans, can be amended when there is evidence that existing standards are not compatible with desired outcomes. This is the essence of an adaptive management process. As with Issue 6, partnerships with equipment development firms and forest industry organizations is needed.

On the Okanogan National Forest, the ground-based policy follows the guidelines established and revised by the Regional Office in 1998 which states: *Design and implement management practices that maintain or improve soil and water quality. Emphasize protection over restoration* (FSM 2520.3 - Policy).

When initiating new activities:

1) Design new activities that do not exceed detrimental soil conditions on more than 20 percent of an activity area, including the permanent transportation system.
2) In areas where less than 20 percent detrimental soil conditions exist from prior activities, the cumulative detrimental effect of the current activity following project implementation and restoration should not exceed 20 percent.
3) In areas where more than 20 percent detrimental soil conditions exist from prior activities, the cumulative detrimental effects from project implementation and restoration must, at a minimum, not exceed the conditions prior to the planned activity and should move toward a net improvement in soil quality.

In addition to the Wenatchee National Forest criteria and Regional Office criteria that the Okanogan uses, the following criteria are also being followed to reduce impacts that may result if subsoiling is considered as a treatment option following harvest activities:

1) Subsoiling, in most cases, will be limited to slopes that are 25 percent or less.
2) Subsoiling, in most cases, will be restricted to soil types that are NOT lithic (shallow to bedrock), are NOT classified as or have hydric (wet) soil characteristics, and where soil types are NOT classified as being stony or bouldery.

L. Issue 12 - Riparian Reserves/Water Quality

There are numerous Riparian Reserves spread throughout the dry forest. How will these be handled?

Response

Dry forest management will be consistent with the objectives of the Aquatic Conservation Strategy, including Riparian Reserve management, as outlined in the Northwest Forest Plan. Additionally, management will comply with PACFISH and INFISH as outlined in the 'Eastside Screens'. Riparian Reserves need to be addressed similarly to other land allocations; that is, on a landscape basis giving special attention to site-specific objectives for the allocation. Many of the dry forest riparian areas within the perimeter of the 1994 fires burned with very high intensity and resulting severe site impacts. The Strategy must balance this with short-term impacts associated with potential treatments. Doing this will likely result in action being taken in some riparian areas. Whatever the case, any treatment of riparian areas will have to be done with great sensitivity. In accomplishing this overall Strategy, there will be many areas that remain untreated given the large acreage within the dense dry forest. Management actions within Riparian Reserves will only occur when necessary to meet long-term, landscape scale objectives, and when the short-term effects on riparian areas are likely to be less than the long-term effects of no action. Appendix D describes a process for addressing the nature of hydrologic effects in dry forest projects.

M. Issue 13 - Snag Management

Snags are important components of dry forest communities. How will snags be managed under this strategy?

Response

Snags provide wildlife habitat (Thomas and others 1979) and affect fire behavior (Agee 1993), fish habitat (Platts 1983), and bank stability in streams (Platts 1983). In addition, snags eventually become down logs and provide important ecosystem functions, such as nutrient cycling (Maser et al. 1979), water storage (Maser et al. 1979), soil stabilization (Graham et al. 1994), and habitat for wildlife and numerous invertebrates, microbial and fungal species. Because snags provide important functions and affect a wide variety of ecosystem processes, their management is of considerable concern and interest relative to the implementation of the Dry Forest Strategy. Appendix E describes a strategy for management of snags.

VIII. The Strategy

For many years, forest managers have realized that in these dry forests our success at controlling wildfires, along with domestic livestock grazing and selective timber harvest, was having unintended consequences on the health of these forests. These actions over the past 70 years have interrupted the natural fire cycle and allowed dense stands of small ponderosa pine, Douglas-fir, and grand fir to develop where open stands of large trees once existed (Agee, 1993). This increase in fuels on these landscapes has created a fire condition where lethal fires now threaten these forests that once depended on predominantly low intensity fires.

A. Management Intentions

The eight statements listed below have emerged as important elements of the overall Strategy. They have been synthesized from responses to the 13 issues offered by Forest employees and citizens, and from the relevant science discussed in the first part of this paper.

1) The public expects the Forest to take bold, but reasonable steps to protect communities and forests from catastrophic fires, and they want to actively participate in that effort.
2) The Strategy needs to be implemented with a "bias for action" and recognition that taking action is better than avoidance.
3) There is much information from natural resource and ecology research supporting the need to take action, but on-the-ground knowledge of Wenatchee and Okanogan National Forest managers is also important in determining success.
4) The overall Strategy must be applied, and success measured, on a landscape basis. Site-specific stand conditions, species needs, and land allocations will shape the "how to's".
5) The susceptibility of adjacent plant communities, and landscape features such as riparian vegetation, to fire will influence management decisions within dry forest stands.
6) Trust funds will be utilized to the maximum extent possible, since no increase in appropriated dollars is expected. Because timber sale values will support only a portion of this post sale work, the Forests must take advantage of opportunities to increase competitiveness for appropriated dollars.
7) Throughout the efforts, it is important to keep in mind that while fire exclusion has had positive effects on some plant and animal species, it has had negative effects on others. Fire cannot be excluded permanently from these dry landscapes. Continued fire suppression will increase the potential for unacceptable resource damage because of excessive fire intensity on landscapes where there is no historic precedent.
8) Although there are many uncertainties related to the specifics of how to proceed, improvements and restoration must be started now. Improvement and restoration efforts will be monitored and adaptive management will be practiced. Monitoring should be both quantitative and qualitative.

These eight statements are summarized in the following management intent statement:

> *The Wenatchee* and Okanogan *Forest employees intend to manage for, and maintain, healthy forests. This means that they will provide goods, services, and values that people desire without jeopardizing the capacity of any ecosystem to maintain its structure, composition, and processes through time. When they recognize that any of these features may be in jeopardy as a result of management, or intention to manage, they will disclose those risks and uncertainties, and work with people to better match expectations with capacities of ecosystems. Their management approach will be adaptive and experimental; they will learn from mistakes and repeat successes. They will work to better understand the biophysical conditions of each forest environment, and with that knowledge improve maintenance of spatial and temporal patterns of those features.*

We recognize that this Strategy needs to be adaptive and molded by additional information as it becomes available. As the Forest continues to complete Watershed Assessments as directed by the Northwest Forest Plan and other applicable direction, the Dry Forest Strategy should be considered and synthesized into overall management within each watershed. The extent of dry forest areas within watersheds should be refined as Watershed Assessments are completed and revisited.

In addition, assessments addressing Late-Successional Reserves (LSRs) and Managed Late-Successional Areas (MLSAs) across the Forests were recently completed. Many of the LSRs and MLSAs include substantial amounts of dry forest areas. Consideration of the habitat needs of late-successional dependent species identified in these assessments must be a part of dry forest management.

B. Potential Treatments for Management of Dry Forest Environments

This section illustrates some of the potential management objectives that may be appropriate for protecting, maintaining, or enhancing forest health in dry forest environments, and some of the potential treatment options available for achieving these management objectives. The purpose is to illustrate what treatments might be appropriate given certain dry forest situations, not to guide site-specific project plans. When reviewing these it is important to keep in mind that the objectives and options are not all inclusive.

Also, these objectives and treatment options are keyed to the maps that show the dry forested area on the Wenatchee and Okanogan National Forests. These maps were developed using extensive techniques such as satellite imagery and aerial photo interpretation. They are accurate when viewed at the sub-watershed or larger scales. It is essential that site-specific stand level information be used when determining actual treatment options to apply. This is meant only to give some idea of what objectives and treatments might be appropriate when managing dry forests from a broad scale perspective.

Application of these treatment options must also be tempered by the land allocations of the Northwest Forest Plan, Eastside Screens, PACFISH, INFISH, and other appropriate direction. They are most appropriate in the matrix allocation of the Northwest Forest Plan, and to areas located outside of the Northwest Forest Plan. They may be applied to some degree in other allocations as guided by the Northwest Forest Plan Record of Decision. When using them in LSRs, MLSAs, and the Snoqualmie Pass Adaptive Management Area (AMA) the findings of the LSR and MLSA assessments and the AMA management plan must be considered.

In order to best understand the information that follows, first review the Management Objectives and Options for Achieving Management Objectives listed below and then use the Dry Forest Treatment Key to determine the forested conditions under which these objectives and treatments would apply. The information in Table 5 describes the vegetation classes used in the following treatment key and included maps.

1. Management Objectives for Protecting, Maintaining, or Enhancing Forest Health on Dry Forests

- Reduce stand density (number of trees per acre)
- Alter species composition
- Reduce fuel loads to conditions consistent with pre-settlement fire regimes
- Maintain tree density consistent with pre-settlement fire regimes
- Reforest created openings
- Maintain desired fuel levels consistent with inherent fire regimes
- Maintain native grass and shrub communities
- Reduce susceptibility to insects/disease occurrence outside of endemic levels

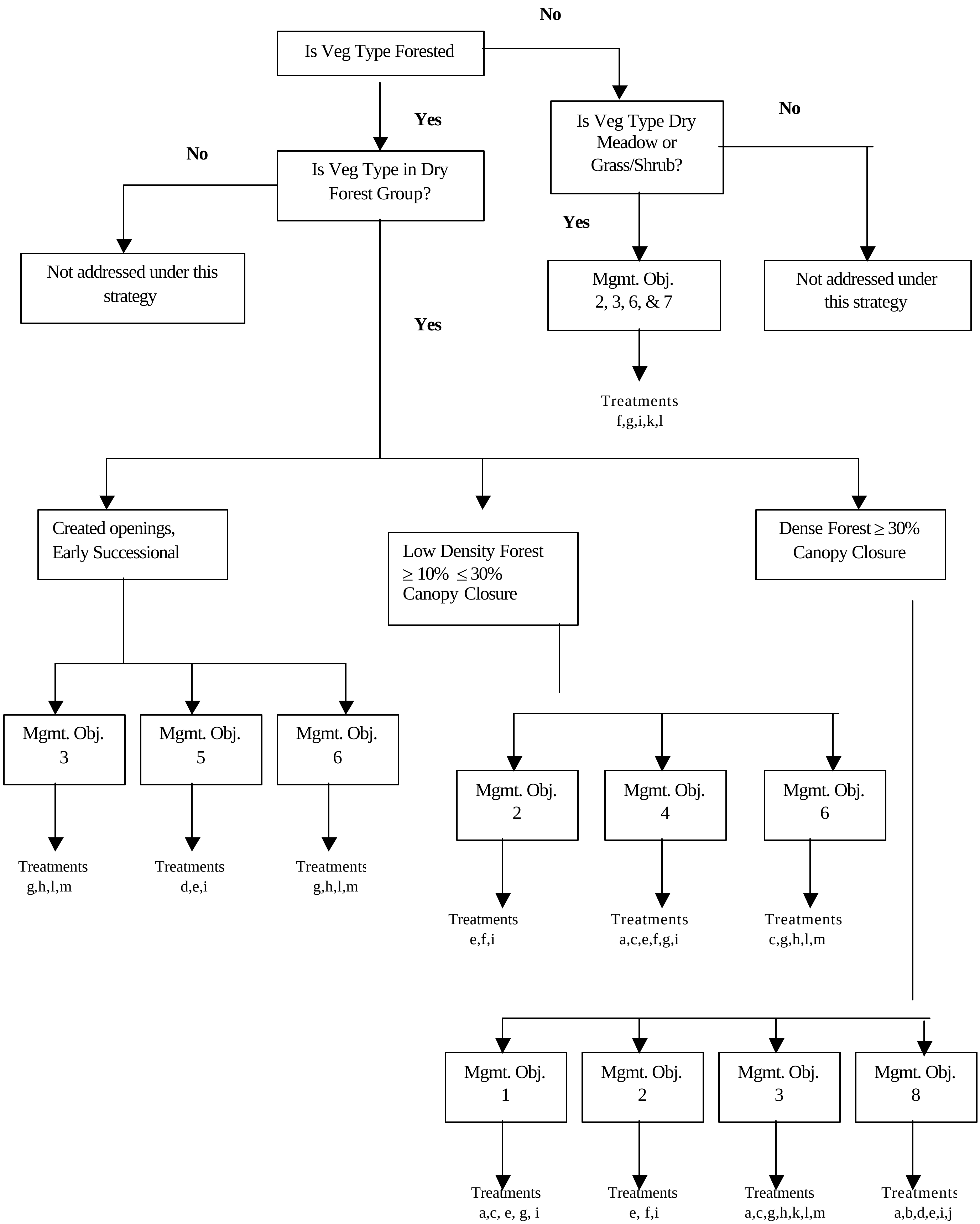
2. Options for Achieving Management Objectives

- Pre-commercial thinning or commercial thinning (PCT / CT)
- Thin to reduce adjacency of potential brood trees, to reduce spread potential of disease, and to increase tree resistance to insect/disease
- Pruning to reduce vertical continuity of fuels
- Plant seral/fire tolerant species
- Favor insect-disease resistant tree species
- Favor native undergrowth in woodland / steppe transition zone
- Prescribed Fire
- Fuelwood Collection
- Favor species that are consistent with pre-settlement disturbance regimes
- Regeneration harvest
- Develop or enhance fuel-breaks (shaded or otherwise)
- Mechanical fuels treatment
- Hand-piling fuels
- Short term methods for suppressing insect epidemics where necessary to provide time to implement a longer term strategy

Table 5. Structure/Density class used in the Dry Forest Treatment Key and the Dry Forest Maps for the Wenatchee and Okanogan National Forests	
Wenatchee National Forest portion: **Ponderosa pine and Douglas-fir series, and dry grand fir plant associations**	
Structure/ Density	**Descriptions**
Created openings, early successional	Includes seedling/sapling stand or recent pre-commercial thinning stands. May also include areas of recent fire. May have scattered remnants from previous stand. Includes heavily partial cut areas where overstory has been removed and residual pole-size trees occupy up to 30% of area.
Low density	Less than 30% canopy closure with no significant understory on at least 75% of area. Trees generally 12" dbh and larger. Includes remnant open parklike stands where tree invasion has been slow due to harsh site conditions. Includes areas that have been thinned from below.
High density	Generally over 30% canopy closure, usually with layered structure. Includes stands that have been lightly to moderately partial cut; less than 25% of stand is comprised of small openings, the result of tree cutting. In some cases, timber harvest removed only the larger trees.
***Okanogan National Forest portion*:** **Ponderosa pine and Douglas-fir series**	
Structure/ Density	**Descriptions**[1]
Created openings, early successional	Includes seedling/sapling stands or recent pre-commercial thinning stands. May also include areas of recent fire. May have scattered remnants from previous stand. Includes heavily partial cut areas where overstory has been removed and canopy cover of residual pole-size trees is up to 40%.
Low density	Less than 40% canopy closure with understory seedling/sapling crown closure less than 30%. Overstory trees are generally 12" dbh and larger. Includes areas that have been thinned from below.
High density	Over 40% canopy closure with layered structure as well as single canopy structure. Includes stands that have been lightly to moderately partial cut; less than 25% of stand is comprised of small openings because of tree cutting, disease, insects, or other disturbances.

[1] Crown closure from satellite derived imagery was used to estimate Dense Dry Forest. A crown closure break of 40% was used to best approximate 'dense' conditions. Other breaks available were 20% and 70%. In the field actual crown closures of dense forest may differ from what was modelled, and may be closer to 30% as was modelled by the Wenatchee National Forest.

Dry Forest Treatment Key



References

Agee, J.K. 1990. The historic role of fire in Pacific Northwest forests. In: Walstad, J.D., Radosevich, S.R., Sandberg, D.V., eds. Natural and prescribed fire in Pacific Northwest forests. Oregon State University Press, Corvallis, OR. pp. 25-38.

Agee, J.K. 1991. Fire history of Douglas-fir forests in the Pacific Northwest. Gen. Tech. Rep. PNW. GTR-285. p. 25-33. USDA Forest Service, Pacific Northwest Research Station. Portland, OR.

Agee, J.K., and R.L. Edmunds. 1992. Forest protection guidelines for the northern spotted owl. Pages 181-244 in USDI Recovery plan for the northern spotted owl-final draft. Vol. 2. U.S. Govt. Print. Office, Washington, D.C.

Agee, J.K. 1993. Fire ecology of Pacific Northwest Forests. Island Press, Washington D.C. 493p.

Agee, J.K. 1994. Fire and weather disturbances in terrestrial ecosystems of the Eastern Cascades. Gen. Tech. Rep. PNW-GTR-320. USDA Forest Service, PNW Station. Portland, OR. 52 pages.

Agee, J. K. et. al. 2000. The Use of Shaded Fuelbreaks in Landscape Fire Management. Forest Ecology and Management 127 (2000) 55-66.

Arno, S.F. 1980. Forest fire History in the Northern Rockies. Journal of Forestry, 78: 460-465.

Arno, S.F. and Ottmar, R.D. 1993. Reducing Hazard for Catastrophic Fire, Eastside Forest Health Assessment Vol. IV, Restoration of Stressed Sites, and Processes.

Arno. S. F.; Harrington, M. G.; Fiedler, C. E.; and Carlson, C. E. 1995. Restoring fire-dependent ponderosa pine forests in western Montana. Pacific Northwest Reports. PP 32-36.

Anonymous. 1999. Vegetation Mapping on the Okanogan and Colville National Forests Using Landsat Thematic Mapper Images. PR-593-1 Final Report for Contract 53-05M6-4-0005, Order Number 43-05H7-6-0235. Unpublished.

Bourgeron, P.S. and M.E. Jensen. 1994. An overview of ecological principles for ecosystem management. Volume 11: Ecosystem Management: Principles and Application. Gen. Tech. Rep. PNW-GTR-318. Pg. 45-57.

Camp, A.E. 1995. Predicting late-successional fire refugia from physiography and topography. Unpublished Ph.D. dissertation, University of Washington, Seattle, WA. 137 pp.

Camp, A.E., Oliver, C.D., Hessburg, P.F., and Everett, R.L. Manuscript in review - Can. J. For. Res. Predicting late-successional fire refugia pre-dating European settlement in the Wenatchee Mountains.

Covington, W.W.; Moore, M.M. 1994. Postsettlement changes in natural fire regimes and forest structure: ecological restoration of old-growth ponderosa pine forests. In: sampson, R. Neil; Adams, David L. eds. 1994. Assessing forest ecosystem health in the inland west. New York, Haworth Press Inc.: 153-181.

Daubenmire, R. F., and J. B. Daubenmire. 1968. Forest vegetation of eastern Washington and northern Idaho. Wash. Agric. Exp. Sta. Tech. Bull. 60. Washington State University, Pullman, WA. 104 pp.

Daubenmire, R. 1975. Plant succession on an abandoned field, and fire influence in a steppe area in southeastern Washington. Northw. Sci. 49: 36-48.

Daubenmire, R. 1988. Steppe vegetation of Washington. EB1446. Washington State University, Cooperative Extension, Pullman, WA. 131p.

Everett, R.L.; Lehmkuhl, J.; Schellhaas, R.; et al. In press. Snag dynamics in a chronosequence of 26 wildfires on east slope of the Cascade Range in Washington. Journal of Forest Ecology and

Management. Everett, R.L.; Schelhaas, D.; Spurbeck, D. et al. 1997. Structure of northern spotted owl nest stands and their historical conditions on the eastern slope of the Pacific Northwest Cascades, USA. Forest Ecology and Management. 94: 1-14.

Everett, R.L.; R. Schellhaas, D. Spurbeck, In press. Fire history in the ponderosa pine/Douglas-fir forests on the east slope of the Washington Cascades. Research Paper PNW-RPxx. Portland, OR. USDA Forest Service, Pacific Northwest Region Research Station.

Everett, R.L.; Schellhaas, D.; Anderson, T.; et al. 1996. Restoration of ecosystem integrity and land use allocation objectives in altered watersheds. Watershed restoration management physical, chemical, and biological considerations. American Water Resources Association, July 1996.

Everett, R.L.; Camp, A.E.; Schellhaas, R. 1995. Building a new forest with fire protection in mind. A paper present at the Fire Protection Working Group Technical Session at the SAF National Convention: Portland, ME. October 28- November 1, 1995.

Everett, R.L.; Hessburg, Paul F.; Jensen, Mark E.; Bormann, Bernard. 1994. Eastside forest ecosystem health assessment. Gen. Tech. Rep. PNW-GTR-317, Portland, OR: USDA Forest Service, Pacific Northwest Research Station.

Everett, R.L.; Hessburg, P.F.; Jensen, M.E.; Bormann, B. 1994. Volume I: Executive summary. Gen. Tech. Rep. PNW-GTR-317. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 61 p.

Finch, Richard B. 1984. Fire history of selected sites on the Okanogan National Forest. Unpublished. USDA Forest Service, Okanogan National Forest.

Fischer, W. C., and A. F. Bradley. 1987. Fire ecology of western Montana forest habitat types. Gen. Tech. Rep. INT-GTR-223. USDA Forest Service, Intermountian Forest and Range Experiment Station. Ogden, UT. 32 pp.

Gaines, W.L., R.J. Harrod, and J.F. Lehmkuhl. 1999. Monitoring biodiversity: Quantification and Interpretation. USDA Forest Service. PNW-GTR-443.

Graham, R.T., A.E. Harvey, M.F. Jurgensen. 1994. Managing coarse woody debris in forests of the Rocky Mountains.

Golden, Michael D. 1996. No subject. Pacific Meridian Resources memo to Chris Fayad, Pacific Northwest Region, USDA FOREST SERVICE for delivery of updated Wenachee National Forest Pixel data. .

Hall, F. C. 1976. Fire and vegetation in the Blue Mountains. - Implications for land managers. Pages 155-170. In: Proceedings of the 15th annual Tall Timber fire ecology conference; Oct. 16-17, 1974; Portland, OR. Tall Timbers Res. Sta. Tallahassee, FL.

Hall, F.C. 1977. Ecology of natural underburning in the Blue Mountains of Oregon. GTR-R6-ECOL-79-001.

Hall, F. C. 1980. Fire History - Blue Mountains, Oregon. In: Proceedings of the fire history workshop; Oct. 20-24, 1980; University of Arizona, Tucson, Arizona. Gen. Tech. Rep. RM-GTR-81. USDA Forest Service, Pacific Northwest Experimental Station. Portland, OR.

Hann, W.J.; Jones, J.L.; Karl, M.G.; et al. 1997. Landscape dynamics of the Basin. In: Quigley, T.M.; Arbelbide, S.J., eds. An assessment of ecosystem components in the Interior Columbia Basin including portions of the Klamath and Great Basins: Volume 2. Gen. Tech. Rep. PNW-GTR-405. USDA Forest Service, Pacific Northwest Research Station. Portland, OR

Hann, W.J.; Jones, J.L.; Keane, R.E.; et al. 1998. Landscape dynamics. Journal of Forestry: 96: 10-15.

Harrod, R.J., B.H. McRae, and W.E. Hartl. 1999. Historical stand reconstruction in ponderosa pine forests to guide silvicultural prescriptions. Forest Ecology and Management 114:433-446.

Harrod, R.J., W.L. Gaines, W.E. Hartl, and A. Camp. 1998. Estimating historical snag density in dry forests east of the Cascade Range. USDA Forest Service. PNW-GTR-428.

Graham, R.T, A. E. Harvey, T. B. Jain, and J. R. Tonn. 1999. The Effects of Thinning and Similar Stand Treatments on Fire Behavior in Western Forests. USDA Forest Service, PNW-GTR-463.

Harrod, R.J., B. McRae, and W.E. Hartl. 1997. Historic stand reconstruction in ponderosa pine forest to guide silviculture prescriptions. USDA Forest Service, Wenatchee National Forest, Leavenworth Ranger District. Chelan County, WA. Unpublished Report.

Hessburg, P.F.; Smith, B.G.; Kreiter, S.G.; et al. In press a. Historical and current forest and range landscapes in the Interior Columbia River Basin and portions of the Klamath and Great Basins. Part II: Linking vegetation patterns and landscape vulnerability to potential insect and pathogen disturbances. Gen. Tech. Rep. PNW-GTR-XXX. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. xxx p.

Hessburg, P.F.; Smith, B.G.; and R.B. Salter. 1999. Using estimates of natural variation to detect ecologically important change in forest spatial patterns: a case study, Cascade range, eastern Washington. USDA Forest Service, PNW-RP-514.

Hessburg, P.F. and Flanagan, P.T. 1992. Forest health on the Wenatchee National Forest: an analysis of the current management situation. USDA Forest Service, Pacific Northwest Region, Wenatchee National Forest. 37 p.

Hessburg, P.F., R.G.Mitchell, and G.M.Filip. 1994. Historical and current roles of insects and pathogens in eastern Oregon and Washington forested landscapes. USDA Forest Service, Pacific Northwest Research Station. Gen. Tech. Rep. PNW-GTR-327. 72p.

Huff, M.H.; Ottmar, R.D.; Alvarado, E. et al. 1995. Historical and current forest landscapes of eastern Oregon and Washington. Part II: Linking vegetation characteristics to potential fire behavior and related smoke production. Gen. Tech. Rep. PNW-GTR-355. USDA Forest Service, Pacific Northwest Research Station. 43 p. Portland, OR

Johnson, C.G., Jr., and R.R. Clausnitzer, 1991. Plant associations of the Blue and Ochoco Mountains. R-6-ER-TP-036-92. USDA Forest Service, Pacific Northwest Region. Portland, OR. Pg 163.

Johnson, C.G.; Clausnitzer, R.R.; Mehringer, P.J.; Oliver, C.D. 1994. Biotic and abiotic processes of eastside ecosystems: the effects of management on plant and community ecology, and on stand and landscape vegetation dynamics. Gen. Tech. Rep. PNW-GRT-322. Portland, OR: USDA Forest Service, Pacific Northwest Station. 66 p.

Keen, F.P. 1943. Pondersoa pine tree classes redefined. Journal of Forestry, 34: 919-927.

Lee, D.C.; Sedell, J.R.; Rieman, B.E.; et al. 1997. Broadscale assessment of aquatic species and habitats. In: Quigley, T.M.; Arbelbide, S.J., tech. eds. An assessment of ecosystem components in the interior Columbia basin and portions of the Klamath and Great Basins: Volume 3. Gen. Tech. Rep. PNW-GTR-405. USDA Forest Service. Portland, OR, Pacific Northwest Research Station: 1057-1496. Chapter 4.

Lehmkuhl, J.F., Hessburg, P.F., Everett, R.L., Huff, M.H., and Ottmar, R.D. 1994. Historical and current forest landscapes of eastern Oregon and Washington. Part 1: Vegetation pattern and insect and disease hazard. USDA Forest Service, Pacific Northwest Research Station, PNW GTR 328. Portland, OR. 88 p.

Lillybridge, T.R., B.L. Kovalchik, C.K. Williams, and B.G. Smith. 1995. Field guide for forested plant associations of the Wenatchee National Forest. USDA Forest Service, PNW-GTR-359. Pacific Northwest Research Station, Portland, OR.

Maser, C., R.G. Anderson, K. Cromack, Jr. 1979. Dead and down woody material. In J.W. Thomas, ed. Wildlife habitat in managed forests: the Blue Mountains of Oregon and Washington. Agric. Handbook 253. USDA Forest Service.

Miller, J.M., and F.P. Keen. 1960. Biology and control of the western pine beetle. A summary of the first fifty years of research. Misc. Pub. 800. USDA Forest Service, Washington DC. 381 pp.

Morgan, P.L., G.H. Aplet, J.B. Haufler, (and others). 1994. Historical range of variability: a useful tool for evaluating ecosystem change. In: R.N. Sampson and D.L. Adams (eds.). Assessing forest ecosystem health in the Inland West. The Haworth Press, Inc. Pp. 87-111.

Mutch, R.W., S.F. Arno, J.K. Brown, (and others). 1993. Forest health in the Blue Mountains: a management strategy for fire-adapted ecosystems. Gen. Tech. Rep. PNW-GTR-310. USDA Forest Service, Pacific Northwest Research Station. Portland, OR.

Mutch, Robert W. 1970. Wildlife fires and ecosystems: A hypothesis. Ecology. 51(6): 1046-1051

Northwest Forest Plan, 1994. Record of decision (ROD) for amendments to Forest Service and Bureau of Land Management planning documents with the range of the northern spotted owl. Portland, OR.

Ohlson, P.; Leuschen, T.; Everett, R.; Anderson, T. 1998. Fire hazard of spotted owl neighborhoods on the east slope of the Washington Cascades. A paper presented at the Fire Effects on Rare and Endangered Species and Habitats conference: Coeur d' Alene, ID. March 29- April 1, 1998.

Oliver, C.D. 1981. Forest development in North America following major disturbances. Forest Ecology and Management 3: 153-168.

Oliver, C.D., Irwin, L.L. and W.H. Knapp. 1994. Eastside forest management practices: historical overviews, extent of their application, and their effects on sustainability of ecosystems.

Oliver, C.D. and B.C. Larson. 1990. Forest Stand Dynamics. McGraw-Hill, Inc. New York.

O'Neal, Sonny J. 1996. Pacific Meridian Resources. Memo reply to: 1900/6320. Wenatchee National Forest, USDA FOREST SERVICE.

Ottmar, R. D.; Alvarado, E.; Hessburg, P.F. et al. In press. Historical and current forest and range landscapes in the interior Columbia River basin and portions of the Klamath and Great basins. Part II: Linking vegetation patterns to potential smoke production and fire behavior. Gen. Tech. Rep. PNW-GTR-XXX. USDA Forest Service, Pacific Northwest Research Station. Portland, OR. xxx p.

Peterson, D.L. and Ryan K.C. 1986. Modeling post-fire conifer mortality for long-range planning. Environmental Management 10: 797-808.

Pickett, S.T.A. and P.S. White (eds.) 1985. The ecology of natural disturbance and patch dynamics. Academic Press, New York.

Platts, W.S. 1983. Vegetation requirements for fisheries habitat. USDA Forest Service. INT-GTR-157.

Plummer, F.G. 1902. Forest conditions in the Cascade Range, Washington. Professional Paper No.6, USDI, United States Geological Survey, Washington D.C.

Quigley, T.M., Arbelbide, S.J.; eds. 1996. An Assessment of Ecosytem Components in the Interior Columbia Basin and Portions of the Klamath and Great Basins: Volume II, Pp. 592-601. PNW-GTR-405.

Schellhaas, R. (Unpublished report). Spotted owl nesting habitat. USDA, Forest Service. Pacific Northwest Forest and Range Experiment Station, Wenatchee, WA. 10 pp.

Skovlin, J.M.; Thomas, J.W. 1995. Interpreting long-term trends in Blue Mountains ecosystems from repeat photography. Gen. Tech. Rep. PNW-GTR-315. USDA Forest Service, Pacific Northwest Research Station. Portland, OR. 102 pp.

Swanson, F.J., J.A. Jones, D.O. Wallin, and J.H. Cissel. 1994. Natural variability-implications for ecosystem management. USDA Forest Service PNW-GTR-318.

Swetnam, T.M. and J.M. Dieterich. 1983. Fire History of Ponderosa Pine Forests in the Gila Wilderness, New Mexico. Wilderness Fire Symposium, Missoula, MT. Nov: 15:18, 1983.

Tiedemann, A.R., J.O. Klemmendson, and E. L. Bull. 1999. Solution of Forest Health Problems with Prescribed Fire: Are Forest Productivity and Wildlife at Risk? Forest Ecology and Management 127 (2000) 1-18.

Thomas, J.W., R.G. Anderson, C. Maser, and E.L. Bull. 1979. Snags. In J.W. Thomas, ed. Wildlife habitat in managed forests: the Blue Mountains of Oregon and Washington. Agric. Handbook 253. USDA Forest Service.

USDA Forest Service. 1994. Record of Decision for the management of late-successional species within the range of the northern spotted owl. USDA Forest Service. Portland, OR.

USDA Forest Service. 1995. Late-successional reserve standards and guidelines for forest service lands in the eastern Washington Cascades and Yakima provinces. USDA, Forest Service, Wenatchee National Forest, Wenatchee, WA. 127 pp.

USDA Forest Service. 1995. Ecosystem analysis at the watershed scale. Federal guide for watershed analysis, version 1.2. Portland, OR.

USDA Forest Service and USDI Bureau of Land Management. 1994a. Final supplemental EIS on management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl. Portland, OR. 322 pp and appendices.

USDA Forest Service. 1995. Region 1. Fire and fish - a 1994 post-fire strategy. Unpublished. 11 pp.

USDA Forest Service Aerial Photos. 1949. Project FS 6-97.

Weaver, H. 1974. Effects of fire on temperate forests: western United States. In: Kozlowski, T.T., Ahlgren, C.E. eds. Fire and Ecosystems. Academic Press, New York, N.Y. pp. 279-320.

Weaver, H. 1951. Observed effects of prescribed burning on perennial grasses in the Ponderosa Pine Forests. Journal of Forestry, 49: 267-271.

Wickman, B.E., and C.B. Eaton. 1962. The effects of sanitation salvage cutting on insect-caused mortality at Blacks Mountain Experimental Forest 1938-1959. Tech. paper 66. Pacific Southwest Forest and Range Experiment Station. Berkley, CA. 33 pp.

Williams, C.K. and Smith, B.G. 1991. Forested plant associations of the Wenatchee National Forest, USDA Forest Service, Pacific Northwest Region, Wenatchee National Forest. Wenatchee, WA.

Wischnofske, M.G. and Anderson, D.W. 1983. The natural role of fire in the Wenatchee Valley. USDA Forest Service, Pacific Northwest Region, Wenatchee National Forest. Wenatchee, WA.

Wissmar, R.C.; Smith, J.E.; McIntosh, B.A.; et al. 1994a. A history of resource use and disturbance in riverine basins of eastern Oregon and Washington (early 1800s- 1990s). Northwest Science, 68: 1-35.

Wissmar, R.C.; Smith, J.E.; McIntosh, B.A.; et al. 1994b. Ecological health of river basins in forested regions of eastern Oregon and Washington. Gen. Tech. Rep. PNW-GTR-326. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 65 p. (Everett, R.L. assessment team leader: Eastside forest ecosystem health assessment; Hessburg, P.F. science team leader and tech. ed.: Volume III: assessment.)

Appendix A

Plant Association Groups Identified as Dry Forest Vegetation

GUIDE	Plant Association
Wenatchee Field Guide	All of PIPO series
	PSME/AGSP
	PSME/AGSP-ASDE
	PSME/ARUV-PUTR
	PSME/CARU
	PSME/ARUV-CARU
	PSME/CARU-AGSP
	PSME/PEFR3
	PSME/PUTR
	PSME/PUTR-AGSP
	PSME/PUTR/CARU
	PSME/SPBEL
	PSME/SYAL/AGSP
	PSME/SYOR
	PSME/VACA
	ABGR/CARU-LUPIN
	ABGR/HODI-CARU
	ABGR/ARNE
	ABGR/SYOR
	ABGR/CARU
	ABGR/SPBEL-PTAQ
	ABGR/SYAL-CARU
	ABGR/ARCO
	ABGR/BENE-CARU
Colville Field Guide	PIPO-PSME/AGSP
	PSME/SYOR
	PSME/CARU
	PSME/PHMA
	PSME/PHMA-LIBOL
	PSME/VACA
Okanogan Field Guide	PIPO-PSME/AGIN
	PSME/ARUV-PUTR
	PSME/ARUV
	PSME/SYOR
	PSME/CARU
	PSME/PHMA
	PSME/VACCI

Appendix B

Table B-1. Wenatchee National Forest

Acres of DENSE DRY FOREST* by NORTHWEST FOREST PLAN ALLOCATION by DISTRICT

(Post-Dinkelman and 1994 Fires) 11/14/1995

District	NWP Allocation	Douglas Fir	Grand Fir	Ponderosa Pine	TOTAL
Chelan	Administratively Withdrawn	4,598	0	929	5,526
	Congressionally Withdrawn	16,643	691	945	18,278
	Riparian Reserve	2,334	2	146	2,482
	Late-Successional Reserve	13,362	74	1,907	15,344
	Matrix	17,490	6	929	18,424
	Private**	302	0	949	1,251
Total		**54,728**	**773**	**5,805**	**61,306**
Cle Elum	Adaptive Management Area	276	6,653	0	6,929
	Administratively Withdrawn	72	1,113	0	1,185
	Congressionally Withdrawn	22	514	0	536
	Riparian Reserve	110	218	0	328
	Late-Successional Reserve	14,167	34,477	24	48,668
	Matrix	1,295	2,540	2	3,837
	Private**	2,730	11,187	10	13,927
Total		**18,672**	**56,702**	**36**	**75,411**
Entiat	Administratively Withdrawn	1,591	38	22	1,651
	Congressionally Withdrawn	2	0	0	2
	Riparian Reserve	693	24	132	849
	Late-Successional Reserve	3,741	3,026	0	6,767
	Matrix	6,379	368	777	7,524
	Private**	344	150	44	538
Total		**12,750**	**3,607**	**975**	**17,331**
Lake Wenatchee	Administratively Withdrawn	366	759	4	1,129
	Congressionally Withdrawn	8	188	0	196
	Riparian Reserve	194	518	14	727
	Late-Successional Reserve	2,616	11,297	18	13,931
	Managed Late-Successional Area	496	46	8	550
	Matrix	4,189	6,273	310	10,772
	Private**	2,172	1,994	977	5,142
Total		**10,042**	**21,074**	**1,331**	**32,447**
Leavenworth	Administratively Withdrawn	624	2,050	6	2,680
	Congressionally Withdrawn	260	3,381	12	3,653
	Riparian Reserve	1,575	773	767	3,114
	Late-Successional Reserve	18,540	9,641	3,547	31,729
	Managed Late-Successional Area	4,806	1,195	1,153	7,154
	Matrix	17,568	7,284	8,953	33,804
	Private**	12,636	5,508	6,025	24,169
Total		**56,009**	**29,831**	**20,462**	**106,303**
Naches	Administratively Withdrawn	693	1,499	2	2,194
	Congressionally Withdrawn	647	16,775	0	17,422
	Riparian Reserve	2,300	1,811	136	4,247
	Late-Successional Reserve	1,143	15,178	0	16,321
	Managed Late-Successional Area	11,539	17,454	230	29,223
	Matrix	12,674	15,310	456	28,440
	Private**	3,691	1,819	212	5,722
Total		**32,685**	**69,846**	**1,037**	**103,568**

Table B-1. Wenatchee National Forest

Acres of DENSE DRY FOREST* by NORTHWEST FOREST PLAN ALLOCATION by DISTRICT

(Post-Dinkelman and 1994 Fires) 11/14/1995

District	NWP Allocation	Douglas Fir	Grand Fir	Ponderosa Pine	TOTAL
Forest	Administratively Withdrawn	7,944	5,459	963	14,366
	Congressionally Withdrawn	17,582	21,549	957	40,088
	Adaptive Management Area	276	6,653	0	6,929
	Riparian Reserve	7,206	3,346	1,195	11,747
	Late-Successional Reserve	53,569	73,693	5,496	132,758
	Managed Late-Successional Area	16,841	18,695	1,391	36,927
	Matrix	59,595	31,781	11,427	102,803
	Private**	21,875	20,650	8,217	50,742
Total		**184,888**	**181,826**	**29,646**	**396,360**

* Dense Dry Forest, Post-Fires includes: Dry Forest with > 50% Crown Closure.

** Includes only that private land that is located within the Wenatchee National Forest boundary.

Table B-2. Okanogan National Forest[2] **Acres of DENSE DRY FOREST by DISTRICT** *(Post- 1994 Fires)*					
District	**NWP Allocation**	**Douglas Fir**	**Grand Fir**	**Ponderosa Pine**	**TOTAL**
Methow Valley	Administratively Withdrawn	3,470	0	0	3,470
	Congressionally Withdrawn	10,686	0	0	10,686
	Riparian Reserve+	17,317	0	0	17,317
	Late-Successional Reserve	59,350	0	0	59,350
	Matrix	81,628	0	0	81,628
	Private**	5,864	0	0	5,864
Sub Total++		160,998	0	0	160,998
	Outside of Northwest Forest Plan				
	Administratively Withdrawn	1,378	0	0	1,378
	Congressionally Withdrawn	3,094	0	0	3,094
	Riparian Habitat Conservation Areas+	5,196	0	0	5,196
	Developed Sites	2,696	0	0	2,696
	Wildlife Management Areas	25,375	0	0	25,375
	Other Forested Areas	23,424	0	0	23,424
	Private	5,776	0	0	5,776
Sub Total++		64,243	0	0	64,243
Total++		**225,241**	**0**	**0**	**225,241**
Tonasket	**Outside of Northwest Forest Plan**				
	Administratively Withdrawn	2,279	0	0	2,279
	Congressionally Withdrawn	0	0	0	0
	Riparian Habitat Conservation Areas+	6,238	0	0	6,238
	Developed Sites	287	0	0	287
	Wildlife Management Areas	42,555	0	0	42,555
	Other Forested Areas	78,514	0	0	78,514
	Private**	4,273	0	0	4,273
Total++		**127,908**	**0**	**0**	**127,908**
Forest Total++		**353,149**	**0**	**0**	**353,149**

+Riparian Reserve and Riparian Habitat Conservation Area acres are shown separately for information only. The acreage shown for other allocations include both riparian and upland acres.

++Riparian Reserves, Riparian Habitat Conservation Areas, and Private acres excluded from sub totals and totals.

[2] Acres included in this table include only National Forest System Lands and private ownership.

Table B-3. Wenatchee National Forest – Dense Dry Forest by Watershed[3] (arranged by acres of dense dry forest condition)					
Watershed Name	**Dense/Dry (Ac.) NF only**	**Dense/Dry (Ac.) Total**	**Dry (Ac.) Total**	**% Watershed Dense/Dry**	**Watershed (Ac.) Total**
Chelan	56,400	57,800	135,600	19	306,400
Wenatchee	38,600	54,000	128,300	33	164,300
Swauk	31,100	34,400	52,300	42	81,500
Mission	23,100	27,400	40,900	63	43,600
Naches	23,300	24,100	58,500	32	74,600
Peshastin	22,500	29,400	59,000	37	79,300
Lower Tieton	20,600	24,900	46,700	42	58,900
Teanaway	15,800	19,700	54,700	25	78,200
Upper Tieton	15,000	15,100	40,300	13	118,100
Entiat	14,900	15,400	94,800	8	189,400
Chiwawa	13,600	15,200	29,000	13	119,800
Rattlesnake	12,900	13,000	37,400	17	76,200
Little Naches	11,700	11,800	28,500	12	95,400
Taneum/ Manastash	8,300	11,200	28,800	20	55,100
Bumping	7,700	7,800	21,400	11	73,500
American	5,400	5,400	13,500	11	50,900
Cle Elum	4,000	6,600	15,100	5	129,400
Icicle	3,900	4,000	22,600	3	134,800
Nason	3,800	4,700	21,200	7	68,300
Stehekin	3,400	3,500	4,800	4	91,000
Columbia Breaks	2,800	4,400	40,900	10	44,800
Upper Yakima	2,400	3,600	11,800	3	133,500
Mad	1,800	2,100	29,600	4	58,000
White/Little Wenatchee	1,800	1,900	7,200	1	175,200
Wenas	1,400	1,600	6,800	15	10,300
Total	**346,200**	**399,000**	**1,029,700**	**16**	**2,510,500**

[3] Watershed acres located within the national forest boundary.

Table B-4. Okanogan National Forest - Dense Dry Forest By Watershed[4]
(arranged by acres of dense dry forest condition)

Watershed Name	Dense/Dry (Ac.) NF only	Dense/Dry (Ac.) Total	Dry (Ac.) Total	% Watershed Dense/Dry	Watershed (Ac.) Total
Ashnola River	0	0	0	0	44,806
Bonaparte Creek	10,242	11,602	15,409	33	35,120
Bridge Creek	0	5	10	0	9,423
Chewuch River	52,473	52,783	61,076	17	316,019
Chief Joseph	1,564	1,564	3,321	35	4,490
Early Winters Creek	5,226	5,272	5,986	10	51,492
Granite Creek	0	36	36	0	134,599
Lightening Creek	0	0	0	0	64,113
Lost River	5,500	5,594	9,174	5	107,397
Lower Methow River	49,942	51,816	72,906	36	144,891
Main Stem Okanogan River	5,993	6,198	7,393	45	13,914
Middle Methow River	39,429	41,411	59,182	30	136,107
Myers Creek	12,382	13,163	13,501	52	25,426
NE Okanogan River	9,245	9,904	12,851	32	30,983
Pasayten River	3,727	3,727	3,728	3	133,903
Salmon Creek	18,408	19,204	21,429	32	60,814
SE Okanogan River	823	979	1,043	26	3,843
Similkameen River	57	57	123	0	35,006
SW Okanogan River	1,860	2,079	3,262	48	4,347
Toroda Creek	23,793	24,965	30,367	51	48,736
Twisp River	38,581	40,378	44,333	27	149,740
Upper Methow River	16,132	17,667	21,555	17	104,415
West Fork Sanpoil River	32,966	33,577	36,182	50	67,480
West Fork Granite Creek	6,841	7,037	7,530	38	18,783
Total	**335,184**	**349,018**	**430,397**	**20**	**1,745,847**

[4] Watershed acres located within the national forest boundary. Ownerships include Department of Natural Resources, Department of Fish and Wildlife, Private, and public lands managed by the Mount Baker-Snoqualmie, Wenatchee and Okanogan National Forests.

Appendix C

Establishing Reference Conditions for the Dry Forest Strategy

Estimates of vegetation conditions (species composition, stand structures, tree densities, and the juxtaposition of stand types across landscapes) reconstructed from various pre-settlement and post-settlement periods may be useful as reference points to assess modern management strategies intended to create resilient forest ecosystems that are sustainable over time (Harrod et al.1998, Morgan et al.1994, Swanson et al.1994, USDA 1995). In general, reference conditions must be established at the 5th field watershed or basin scales. Project scales are too small to capture the range of variation expected to occur within pre-settlement landscapes. A process that may be used to develop reference point information is described below:

Step 1

Review available scientific information. Note specific research or administrative studies from the east Cascade dry forests types (see references for a partial list of important publications). Summarize descriptions of vegetation conditions, ecosystem processes, and disturbance regimes described within relevant literature.

Step 2

Collect and summarize available historical information about the watershed within which the project area occurs. Useful information may include items such as range reports, past logging history, old aerial photographs, etc. These data may be useful in describing management history within a specific watershed. Establishment reports, original survey reports, and early photographs may provide useful information on vegetation and watershed conditions that existed early in the period of Euro-American settlement. Understand that data specific to a project area may not be useful for describing natural ranges of variation, nor may it be sufficient to describe natural processes or disturbance regimes that would act upon the vegetation and other biota within the context of the larger landscape.

Step 3

Based upon a synthesis of the above information describe forest vegetation types found within the 5th field watershed and basin, including tree density, structure and species composition. Reference conditions can be described in terms of the proportion of the landscape in which typical pre-settlement tree densities, forest structures, and species compositions occurred.

Step 4

Describe the current forest vegetation types within the watershed in terms of tree density, structure and species composition. Compare the current conditions and reference conditions in order to identify the differences that occur. This step begins to quantify the change in vegetation conditions that has occurred since Euro-American settlement. Since pre-settlement conditions are believed to be resilient to disturbance and sustainable over time, a large change from pre-settlement conditions is indicative of potential dry forest restoration projects. Greater changes from pre-settlement conditions are indicative of more urgent need for restoration.

Step 5

Identify other resource objectives that would be important in describing the desired condition for the project area. These may include land allocations, wildlife habitats, urban interface, road access, etc. Understand that complete restoration of pre-settlement conditions may be neither possible nor desirable, given current human needs and preferences.

Step 6

Describe the desired condition (tree density, structure, and species composition) and juxtaposition of vegetation across the landscape within watershed and project area. Begin with reference conditions and overlay other resource objectives. Evaluate whether resource objectives are attainable while achieving the goal of sustainable, resilient vegetation at the landscape scale by comparing the desired condition to the reference condition. This should help to guide the identification and prioritization of restoration projects, as well as highlight trade-offs for the Decision Maker and for the Public.

Appendix D

Addressing the Nature of Hydrologic Cumulative Effects in the Dry Forest Projects

There are a number of watershed management issues that are pertinent to discussion of dry forest management and should be a part of the site-specific project analysis. These issues are complicated by: (a) the changes in vegetation that have occurred historically over large portions of the watersheds due to reduction in fire frequency and increase in fire intensity; (b) changes in soils by repeated stand entries and historic grazing impacts; and (c) resulting cumulative changes to the watershed as a whole affecting the water regime.

It is well understood that these dry forest watersheds have been altered. In addition to the changes in stand structure and composition previously discussed, other alterations are present. Dry forests are often located along the eastern boundary or at the lower margin of national forest lands, on lower slopes, and close to the wider valley bottoms where historic settlement has been located. Landscapes in which dry forests occur typically have roads up the narrow "V shaped" valley bottoms that may have resulted from historic use. Several stands within the dry forest may have had many stand entries*.* Multiple stand entries may have resulted in soil compaction from repeated heavy equipment use and domestic livestock grazing, particularly where slopes are less than 40%. There is a network of old roads that may have some hydrologic effect on both subsurface and surface water relations. In many areas, historic driveways and current grazing may have also *resulted in changes to* hydrologic effects

Many of the dry forest watersheds on the Wenatchee are unglaciated with sandstone parent material in a lower elevation drier climatic regime. A common landsystem description is that these systems are "flashy" meaning they have high per unit area spike peak flow volumes with low baseflow.

The classic cumulative effects analysis is therefore complicated by a change in vegetative structure, and a more subtle change in soil condition from pre-settlement conditions. Cumulative effects analysis is not just a matter of evaluating a proposed stand entry given historic entries and an existing or proposed road system. The background structure of the watershed on which the proposed impacts will be superimposed is very dynamic. Specifically the water balance may be changed given the fact that these are moisture limited environments and vegetation has increased significantly. Certain assumptions as to the nature of the soil profiles current ability to handle water, and cycle nutrients and organic matter, may not be valid when put in a systems framework.

The analytical approach is divided into two major steps: (1) Modeling a water balance, water yield, sediment, and mass failure frequency regime prior to management activities (pre-vegetative and soil horizon impacts of the past hundred plus years); and (2) Superimposing over this modified environment effects of understory removal treatments.

The following topic areas might be considered in a discussion of cumulative effects. The extent of a cummulative effects analysis will be dependent on the scale and complexity of the specific project under consideration.

1) Site-specific water balance analysis at a first order system level with effects routed through third and fourth order watershed systems;
2) Site-specific flood analysis at a first order system level with effects routed through third and fourth order watershed systems;
3) Water balance changes applied over an entire fourth order system and specific to aspect, elevation and vegetation zonation;
4) Comparison of historic and current soil profile properties, trend of watershed condition, and both in relation to the proposed action.
5) Sediment regime given both long and short term changes in soils, applied over the first order and cumulated to the fourth order scale, both historically and from current management;
6) Sustainability of watershed functions including hill slope routing of water and sediment, riparian interactions with aquatic and stream channel environments, and stream channel geomorphology.
7) Effects of early travel routes, current and proposed road systems;
8) Comparison of watershed system response with and without the proposed action and with a major wildfire event;
9) Cumulative impacts of all the above to localized site productivity, riparian zone function and condition, stream channels, and resident anadromous fish species as the most restrictive beneficial use of the aquatic system.

The cumulative effects analysis should clearly document the approach used, including key assumptions. The analysis should contribute to both the formulation and evaluation of alternatives to the proposed action, and should influence the selection of the preferred alternative.

Appendix E

Snag Habitat Management Strategy

Goal

The goal for snag habitat management for the Dry Forest Strategy is to restore snag habitat to a more sustainable condition, and to a density and composition more similar to conditions under which dry forest wildlife species have adapted and evolved. Snag habitat management for the Dry Forest Strategy attempts to balance short, medium, and long-term habitat goals. Management of snag habitat will consider the inherent disturbance regime of current and desired forest vegetation.

Assumptions

The approach is built upon the following assumptions:

1. The pre-settlement snag levels described are assumed to be sustainable under inherent disturbance regimes of desired vegetation.
2. Long-term snag recruitment potential cannot exceed the rate of tree growth on a landscape (see Harrod and others 1998 for additional details).
3. Pre-settlement snag densities and recruitment rates in dry forest landscapes of the east Cascades were relatively predictable, based on an inherent disturbance regime of frequent, low intensity fires (see Harrod and others 1998 and Hessburg et al. 1999, 1992, and 1994 for additional details).
4. The pre-settlement snag densities described represent the density and composition of snag habitat with which wildlife species associated with dry forests have adapted and evolved.
5. In many areas, large snags are in deficit across the landscape and in order to restore large snags, large trees must first be grown.

Snag Management

It is important to identify consistently sized areas and criteria upon which snag management goals are developed. For the Dry Forest Strategy, snag management units of approximately 40 acres have been used to develop goals and to monitor snags numbers. Goals for snags within the 40-acre units would be based upon: the land allocation, site potential, and snag habitat conditions within adjacent units (to address cumulative effects). For example, in a land allocation with a goal of 100% population potential (such as in a LSR) and high site productivity, the goal would be on the high end of the range of variability described by Harrod and others (1998). The arrangement of these snags within the unit would depend upon the harvest system. Some systems are more conducive to clumping snags and some allow snags to be scattered. Ideally a combination of clumped and scattered snags could be retained in each 40-acre snag management unit.

Short Term (0-20 years) Snag Habitat Management Strategy

1. In general, snags >25 in DBH that are currently present on the dry forest landscape would be retained.
2. Mesic sites and riparian reserves, which are embedded in dry forests, may be areas in which snag densities could be managed above those described for historical landscapes and may be sustained for a longer period of time. These are areas in which additional snags that are needed to address specific issues could be located.
3. Small untreated areas within the treatment units would be retained to provide snags and green tree recruitment. In general these would be 5-10% (<1-4 acres) in every 40 acres that are treated. Whenever possible, these areas would be synonymous with site used to protect survey and manage species or rare plants.
4. Monitoring would be implemented in order to adapt the management strategy to meet snag habitat objectives. Specifically, monitoring would address: 1. the uncertainty of current scientific knowledge of snag fall rates that result from different tree mortality sources (stand replacement fire, prescribed fire, insects, disease, tree harvest), 2. snag densities of different size classes across temporal and spatial scales, and 3. the relationship between snag numbers and bird populations.
5. Monitoring results may suggest necessary adjustments to treatment methods, or the application of new techniques (such as burning under prescriptions to create snags, or other tools to induce tree mortality) to address areas of snag deficits.

Medium Term (20-80 years) Snag Habitat Management Strategy:

1. Identify dead top, broken top, deformed and cull trees as part of the overall snag density goals because these trees may remain on the landscape longer and provide habitat through the length of the medium term period.
2. Mesic sites and riparian reserves, which are embedded in dry forests, may be areas in which snag densities could be managed above those described for historical landscapes and may be sustained for a longer period of time. These are areas in which additional snags that are needed to address specific issues could be located.
3. Monitoring would be implemented in order to adapt the management strategy to meet snag habitat objectives. Specifically, monitoring would address: 1. the uncertainty of current scientific knowledge of snag fall rates that result from different tree mortality sources (stand replacement fire, prescribed fire, insects, disease, tree harvest), 2. snag densities of different size classes across temporal and spatial scales, 3. and the relationship between snag numbers and bird populations.

4. Monitoring results may suggest necessary adjustments to treatment methods, or the application of new techniques (such as burning under prescriptions to create snags, or other tools to induce tree mortality) to address areas of snag deficits.

Long Term (>80 years) Snag Habitat Management Strategy

1. The use of thinning, pruning, and prescribed fire would be used at a landscape scale in order to develop contiguous areas of old pine forests that would eventually provide large (>25 in. DBH) snag habitat.
2. The desired future condition of dry forest structure, including the availability of snag habitat, could be based on the historical reference conditions described in publications such as Harrod et al. (1999) or other applicable documentation.
3. Monitoring would be implemented to adapt the management strategy to meet long-term snag habitat objectives. Important long-term monitoring items to address include population trends of snags and viable populations of snag dependent species.

Monitoring For An Adaptive Management Approach

Monitoring has been identified as an important aspect of ecosystem management and is neccessary for an adaptive management approach (Gaines et al. 1999). Gaines et al. (1999) provide an approach to monitoring that includes three phases: (1) identification of monitoring questions; (2) identification of monitoring methods; and (3) data analysis, interpretation and management integration. This approach may be applied in order to determine if snag habitat objectives are being met over time. It is important to monitor snag numbers and composition in areas where active management has occurred and in control (no treatment) areas.

There are several efforts currently underway to monitor snag habitat within dry forest habitats. For example, within the areas burned in the 1994 fires studies are being conducted in dry forests to determine the effects of different snag densities on woodpecker abundance, diversity and nesting, and to estimate snag fall rates when stand replacement fires were the mortality agent. These studies were designed to monitor the snag management approaches used in fire recovery projects within dry forests, The woodpecker study should be completed in 1999 and results would be available in January of 2000.

In the Pendleton and Mission Creek areas, a total of twenty-four 40 acre units have been identified to monitor snags (along with other resources) that will be treated using thinning only, prescribed burning only, thinning and burning, and no treatment (control) areas. This study will provide information on snag fall rates where beetles and prescribed fire are the primary mortality agents. Some results from these studies will be available in the fall of 2000.