Middle Fork Mixed Conifer Forest Type Overview

Middle Fork of the Willamette River Watershed updates

Middle Fork Ranger District
Willamette National Forest

Prepared by:
Tim Bailey
District Planner/Forester
Middle Fork Ranger District
March, 2008

Introduction

This paper has been compiled to help facilitate an update of the Hill's Creek Reservoir and Upper Middle Fork of the Willamette Watershed Analyses (WAs; USDA 1995 and 1996). This update is needed, in part, because the original watershed analyses were completed over 10 years ago and at that time the extent, unique nature, and history of the Middle Fork Mixed Conifer forest type were not fully known or appreciated. In addition, the concept and ramifications of Fire Regime Condition Class (see USDA, et. al., 2005) was not fully formulated and these WAs did not recognize the current Condition Class of the Mixed Conifer forest type has significantly departed from its historic condition. This once open forest ecosystem has, over the last 150 years, developed a much denser canopy resulting from lack of underburning and suppression of wildfires. The Upper Middle Fork WA was updated in 2002 (USDA, 2002). This update was narrowly focused on bull trout and changed habitat conditions for that species, but a brief discussion of the Mixed Conifer type conditions and related recommendations was also included, so that update will be addressed in this report as well.

This paper uses the general format of the watershed analyses (subsections consisting of Characterization, Reference Conditions, Current Conditions, Integration, and Recommendations); it describes the current conditions of this unique forest type and presents a strategy to determine how much of the Mixed Conifer forest type on the southern portion of the Middle Fork Ranger District ultimately needs to or should be restored to its reference, more open, condition. These WAs also developed a set of Issues and a list of Key Questions related to each issue. This entire discussion relates to the Issues of vegetation condition and patterns and how these have been affected by past vegetation management and fire suppression, and related key questions.

The WAs, to a greater or lesser extent, recognized a general need to restore this forest type to its historic density. Several site-specific projects have been implemented to

further that objective. Over the last several decades there has been a small amount of work done to remove encroaching conifers from several oak and pine dominated meadow types through tree cutting and prescribed fire. The Boulderdash Timber sale (USDA, 1993) was the first attempt to restore the forested portions of this ecosystem. This was done with about 100 acres of group selection harvest units ranging from 3 to 16 acres in size in which ponderosa pine were retained and released. More recently, implementation of the Jim's Creek Savanna Restoration project (USDA, 2006), located more or less in the center of the Mixed Conifer forest type, has just begun. That project will restore about 400 acres of the Mixed Conifer type through removal of excess younger trees. The Jim's Creek project is seen as a test case for restoration methods in anticipation of a more comprehensive restoration effort.

The question of how much of this habitat should ultimately be restored initially came up during the development of the Jim's Creek project. Considerable amounts of public interest and involvement developed in relation to that project. Comments and suggestions received indicate that we need to test the methods selected for open forest restoration, but the amount of restoration work ultimately needed exceeds the amount initially done with the Jim's Creek Restoration project. This report and the Watershed Analyses update will make a specific recommendation for the amount of Mixed Conifer forest restoration that needs to occur to accomplish biodiversity maintenance and ecosystem function goals.

The general locations and conditions of these watersheds are addressed in the original WAs and the final watershed update document and will not be repeated here. A comprehensive statement of the general purpose and need for restoration of the Mixed Conifer type was developed in the environmental assessment for the Jim's Creek Savanna Restoration project (USDA, 2006, pages 10 to 16), and will also not be repeated here.

Characterization

The Mixed Conifer forest type is so named because it contains a mixture of ponderosa pine, sugar pine, and incense cedar along with the more dominant Douglas-fir. This is a forest type unique on the Willamette National Forest, though it is similar to forest stands that occur more commonly on the Umpqua National Forest to the south of the Middle Fork watershed. Small patches of Oregon white oak habitat (usually associated with rocky meadows) occur throughout the Mixed Conifer type. The contiguous Mixed Conifer type (as delineated by Agar, 1998; see attached map) contains about 25,000 acres which typically occur south of Hills creek reservoir in lower elevations and southerly slopes. It occurs in the upper (southern) portion of the Hill's Creek Reservoir and the lower portions of the Upper Middle Fork 5th field watersheds, which together constitute the greater portion of the Middle Fork of the Willamette River watershed above the Hill's Creek dam.

Approximately half of the Mixed Conifer type has been harvested over the past ten to 50 years and about 8,000 acres of that is composed of private industrial forest lands. This

forest type was at one time a more open forest than it is now, and likely contained an open understory of grasses, forbs and some shrubs (Winkler, 1984; Hadley, 1997; Winkler and Bailey, 2002; Bailey and Kertis, 2002; and Bailey, 2005), as fully described below in the Reference (Past) Stand Conditions section.

Summary of Original Watershed Analyses Findings and Recommendations

The Watershed Analysis Report; Middle Fork Willamette River Downstream Tributaries Watershed (USDA, 1995; this watershed was subsequently renamed the Hill's Creek Reservoir of the Willamette River) recognized in a general sense the existence of what has become known as the Mixed Conifer forest type and recommends vague actions to maintain habitat structure and species diversity. Findings and recommendations of this analysis specific to the Mixed Conifer type were as follows:

- The ponderosa pine band in the lower Young's Creek and Deadwood Creek drainages is a unique feature (page 1-4);
- Fire suppression has altered the diversity of forest structure (page 2-3);
- There has been a gradual loss of meadow size and open forest habitat (page 3-4, 5-4);
- Early Pioneers claim the forest floor was open enough that stock and horses could be driven through the timber in many paces (page 3-17; Winkler, 1984);
- Areas with frequent fire would have a low concentration of large logs and snags and these areas had a more open understory. Such areas commonly existed on southern aspects (page 3-17)
- Annual underburning of the forest was intentionally used by native people throughout the watershed to increase the abundance of game and edible/useful plants (3-20);
- Special habitats such as meadows have decreased in size due to fire suppression. Some natural meadows have become fully forested by encroaching conifers (page 4-25);
- The overstory of mature old-growth ponderosa and sugar pine show stress and increased insect infestation due to moisture competition from the new understory (page 4-25);
- Fire exclusion has caused the gradual reduction in abundance and structure of hardwood trees in the mixed hardwood/conifer forests (page 4-25);
- Prescribed fire may be an effective way to perpetuate desired plant communities (page 5-9);
- Priorities – assess and develop management strategies to maintain the functions of open forest habitats in the ponderosa pine/Douglas-fir area. Develop, implement and monitor a prescribed fire plan to maintain open forest habitats. Develop management strategies in matrix lands to provide large blocks of forest habitats with priority emphasis to the ponderosa pine/Douglas-fir habitats (page 6-2);
- In Matrix Lands develop and implement fuel treatment plans to reduce fuels loadings especially in Fuel Model 10 areas and to perpetuate desired plant communities (page 6-5)

This analysis did not specifically recognize the need for mechanical treatments to reduce density of the Mixed Conifer type. As far as this author knows, no recommendations directly related to the Mixed Conifer type has been implemented in the 12 plus years since this WA was completed other than the site-specific Boulder Dash Timber Sale (USDA, 1993) and Jim's Creek Savanna Restoration projects (USDA, 2006). No comprehensive management strategies or plans have been developed to address maintenance of open forests or fuel treatments to perpetuate desired plant communities. An on-going meadow maintenance project is nearly ripe for decision; this project will be using a combination of prescribed fire and small tree cutting in several meadows in the Mixed Conifer type to remove young encroaching trees.

The Upper Middle Fork Watershed Analysis (USDA, 1996) only peripherally addressed this forest type (pages 15 and 56 referred to it as "large block open forest") and recommended only that prescribed underburning be implemented to restore and retain non-forest vegetation types and within Late-Successional Reserves. Findings and recommendations of this analysis specific to the Mixed Conifer type were as follows:

- Periodic fire has been the principle, natural, recurring disturbance in the ecosystem that has shaped vegetation patch dynamics and stand characteristics (pages 15, 56);
- Due to the Calapooya Mountains rain shadow, dry site species such as ponderosa pine, sugar pine, incense cedar and tall Oregon grape occur in a fashion more typical of the southern Cascades (page 16);
- Fire suppression has altered landscape patterns (page 25);
- Plant associations with frequent underburning tended to have lower quantities of coarse woody material; they are now higher than historic levels (page 54, 56);
- Fire suppression has resulted in increased fuel loading across the landscape, increasing the risk of high fire intensity, and altering ecological processes in up-slope Douglas-fir stands in the "large block of open forest pattern areas" where fuel loading was kept low by frequent underburns (page 56);
- Open forest habitat is less common since fire suppression has created uncharacteristically dense understories. Fire intolerant and shade tolerant species have increased (pages 56, 62);
- Large Block Open Forest on slopes <60% are associated with Simpson Creek, Swift Creek, Pioneer Creek and Staley Creek basins (page 57);
- Low to moderate severity underburning removed surface fuels and understory with minimal overstory mortality (page 57);
- Open forests of primarily Douglas-fir with significant amounts of ponderosa pine occurred in very large blocks with dense multi-layered canopies forming between fires and serving open-forest species after fires (page 57);
- With continued fire exclusion fuels will continue to increase, resulting in a high probability of severe fire. Natural stands will continue to be unnaturally dense (page 62);
- Non-forest special habitats were maintained by regular fire return and fire exclusion has caused encroachment of many such dry and mesic habitats (page 64);

- Prescribe burn to restore and maintain fire-maintained and non-forest special habitats, and in non-harvest land allocations such as Late-Successional Reserves to re-establish open stand characteristics where site specific analysis determines an ecological need; primarily upland Douglas-fir stands with slopes <60% (pages 104, 109);
- Continue promoting stands with mixed conifers and hardwoods to maintain a greater diversity of wildlife guilds (page 107);
- Consider larger block management to provide for larger future blocks of interior habitat in previous large blocks of open forest – harvest several hundred acres with retained trees simulating historic residual overstory condition.

The Upper Middle Fork WA also did not recognize the role of Native Americans in the reference conditions fire regime. It generally did not fully recognize that overstories of these stands were once much less dense, nor the inability for reintroduction of prescribed fire to effectively reduce the density of these stands (see USDA, 2006, page 45). The Reference Conditions used for this WA were from the late 1940's (page 48); a time when most if not all the Mixed Conifer type had already become a closed canopy forest. This analysis also does not appear to have recognized the high fire frequency regime in the "large block open forest" type, as it states that dense understories developed between fires (page 57), implying that fires were infrequent enough that a dense stand of trees could develop in the interval between ground fires. The WA also implied that overstory densities in this type have always been at current levels.

As far as this author knows, no recommendations directly related to the Mixed Conifer type has been implemented within this watershed in the 12 plus years since the WA was completed.

<u>The Upper Middle Fork Watershed Analysis Update</u> (USDA, 2002) was done to address specific questions raised by the US Fish and Wildlife Service regarding changed watershed conditions in relation to the listing of bull trout as threatened, spotted owl habitat, and potential lynx habitat presence. This update made the following observations and recommendations regarding the Mixed Conifer forest type while addressing a question relating to identification of conflicts and opportunities to meet both aquatic and terrestrial objectives within Riparian and Late-Successional Reserves (LSR):

- Riparian Reserves overlay a diverse and unique mixed conifer vegetation type….stands in this type represent a legacy of this forest type left over from a drier, warmer period….thick, platy barked ponderosa pine, sugar pine and incense cedar dominate the overstory with Oregon white oak, Douglas-fir, Pacific madrone, and grand fir forming a second and third cohort (page 64);
- Many old growth pine are dying from disease and insect attack due to stress related to overstocking. Fire historically removed competing understories, reduced stand density, and exposed soil to favor pine regeneration (page 64);
- The biological capacity of the dry site climax species limits their ability to support multiple layered forests. Without fire or other disturbances, these sites will

convert to Douglas-fir or grand fir, then burn in a stand replacement event. This reality conflicts with riparian and LSR objectives (page 64);

- It is recommended that NW Forest Plan standards for incurring only short-term, neutral, long-term beneficial effects be changed to a standard that promotes future natural biodiversity and long-term forest health and stability while possibly incurring some short-term sacrifices of old-growth stand structure (page 64);
- An objective should be to create open growing space and suitable seedbed conditions for natural regeneration of pine in riparian and late-successional reserves. Mechanical treatments will probably be necessary to achieve these objectives. These treatments may consist of thinning, logging of excess trees, burning slash, followed by repeated prescribed burning (page 65);
- There is an opportunity on these sites to manage for both dry site species and provide commodities from these sites on a long rotation. Oak and pine should be managed for in matrix land in this vegetation type within the context of producing commercial wood products (page 65);
- Conservation does not exclude management or disturbance; moderate levels of ground and canopy disturbance serve to perpetuate the fire climax species. Land allocations that prescribed no actions put the open mixed conifer forest at risk if it converts to dense coniferous understories that can be completely killed if there is a fire. Management that disturbs this vegetation type needs to be encouraged across all land allocations. (page 65);
- Silvicultural prescriptions for droughty, Douglas-fir climax sites include mechanical removal of competing Douglas-fir which can be done in groups, over stand areas, or localized around residual ponderosa and sugar pine. A treatment zone of 75 feet from the drip line of a large pine is another option in LSRs or scenic areas. This treatment needs to be accomplished across the mixed conifer type. In the LSR it may be necessary to cut green trees in the co-dominant and intermediate crowns class to get stocking low enough to reduce competition (page 100);
- Due to elevated fuel accumulation and fuels ladders, mechanical removal of green trees and slash will be needed before repeated underburning can be implemented to maintain the open forest (page 100).

At the time of this WA update the nature and importance of the Mixed Conifer type had been more fully realized. As can be seen, the characterizations and recommendations above extend to matrix lands as well, even though the question being responded to was specific to riparian reserves and LSRs. It is not known how regulatory agencies might react to suggestions that currently dense forests in LSRs and riparian reserves be made less dense through management actions.

It should be noted that implementation of the recommended release of large pine (the second to last bullet above) would result in a 0.6 acre clearing around each such tree. If these legacy trees were evenly dispersed across the landscape (and they are not) and there were an average of two such trees per acre (there is likely somewhat more than that), such a recommendation would result in the retention of just two trees per acre.

Findings of Other Programmatic and Site-Specific Analyses

The Integrated Natural Fuels Management Strategy (USDA/USDI, 2000) also recognized the importance and rarity of pine and oak dominated sites (page 15) in the Pacific Northwest, established the need to maintain and restore such habitats (Appendix D-2), and recommended that oak and pine stands may need treatment, including mechanical treatments, to provide for retention of oak, pine and native vegetation (pages 16, 24, 27).

The Middle Fork Willamette Viewshed Corridor Study (USDA, 1988) also established the uniqueness of the large ponderosa pine in the river viewshed corridor and the desirability of maintaining these specimen trees, but contained no specific recommendations for treatment.

In 2006 the Middle Fork Ranger District produced a document titled "Watershed Prioritization Process, Priority I Watershed Opportunities" that covered both these watersheds. This paper presented Desired Future Conditions for the watersheds and developed a list of goals and objectives by resource, the objectives consisting of generally quantified activities to be accomplished over the next ten years. This current Watershed Analysis Update process is essentially an extension of this 2006 effort, and the recommendations this update will contain are essentially the same ones listed in 2006 with more specificity in terms activities and where they may occur.

While all the integrated resource analyses (including the WAs) recognized, in some sense, the importance of the open mixed conifer and oak forest for diversity, a general need to return fire regime condition class to its historic level, and recommended treatments of some kind be conducted to restore this forest type which has been changed so dramatically by fire exclusion, none identified any specific area within the Middle Fork mixed conifer type for any type of treatment.

The recent, site-specific analysis in the Jim's Creek Jim's Creek Savanna Restoration Stewardship project Environmental Assessment (USDA, 2006) was supported in large part by the general recommendations for needed actions in the Mixed Conifer type contained in the WAs discussed above. The analysis for this project determined (USDA, 2006, pages 45-47, and Bailey, 2005, pages 28 and 29) that prescribed fire alone cannot accomplish the goal of restoring open forests in many places within this type due to the size of the understory tree stems and the thickness of their bark. It also established that physical removal of most of the 100 to 150 year cohort of invaded trees is needed to facilitate full and appropriate restoration. This analysis also established the need to proceed with restoration of this forest type relatively quickly since key ecosystem components (as in the legacy ponderosa pine and Oregon White oaks, and remnant native bunchgrass plants) are being lost year by year (pages 15 and 49).

Reference (Past) Stand Conditions

Stand Structure

Prior to development of the 100-150 year old cohort of Douglas-fir, incense cedar, ponderosa pine, and grand fir, these forests were relatively open, with about 10 or less up to 40 large trees per acre, scattered variably across the landscape. There were areas possibly up to several acres in size which are not today associated with a meadow that appear to have been free of mature trees 100 to 150 years ago. The tree species distribution in this open forest was roughly evenly split between ponderosa pine and Douglas-fir, with occasional sugar pine and incense cedar and large, open-grown Oregon white oak in some places.

Judging from the extent of large dead braches on the lower stems of the legacy conifers, crown depth before the 100 plus year old cohort developed was probably in excess of 60% of total tree heights. Crown closure in the original savanna was likely quite variable, ranging from nearly zero where there were few trees to as high as 50 or 60 percent.

Since evidence of smaller trees no longer exists on these sites, it is not known to what degree smaller seedlings, saplings, or pole-sized trees might have existed in these stands 150 years ago. Given the fire frequency (see below) there were likely few small trees, or their abundance was episodic. Certainly some survived the periodic fires to replace the larger, more fire resistant trees as they succumbed to old age, windthrow, diseases or insects, and the occasional locally extreme fire.

Ground Vegetation

It can be surmised that this open forest contained a more or less dense understory of bunchgrasses. Sparse remnants of a native bunchgrass, *Festuca californicum*, still exist under the younger canopy. This grass is known to thrive in open forest conditions, and this is also the grass that has responded so well in some of the young plantations. It can also be surmised that since soil moisture and ground level sunlight levels were higher in the more open forest that a large variety of herbs and forbs were also present, such as camas, tarweed, mule's ear daisies, wood lilies, etc.

Fire regime

Based primarily upon commonly observed complex fires scars on old ponderosa pine and the widespread occurrence of charred bark on legacy Douglas-fir in these forests, 150 years ago this area had a regime of frequent, low intensity fires (Fire Regime I - see the interagency Fire Regime Condition Class (FRCC) website at www.frcc.gov for definitions and discussion of fire regimes, USDA, et. al., 2005 and UDA/USDI, 2007). From my field observations, triangular shaped basal fire scars on ponderosa pine are only forms by repeated fire scarring; such scars, while they do not occur on all ponderosa pine in this vegetation type, are ubiquitous across the landscape and often contain more than several visually obvious scars that have yet to be covered by live callus tissue. These frequent fires kept young conifer density low, providing growing space for ponderosa pine and Oregon white oak regeneration, and facilitated the persistence of native bunchgrasses and other herbs. The bunchgrass formed the fuel bed in which these fires

could burn frequently with a low severity. The fire scars on remnant ponderosa pine indicate the fire frequency prior to 150 years ago was at least every ten to 12 years and more frequent than that in some areas, especially those close to known high use Native American sites (Bailey, 2005, pages 21 to 23).

While there is no direct evidence other than casual or anecdotal historical accounts, this frequent fire regime appears to be partially if not entirely a result of intentional application of fire by the original inhabitants of this landscape (Winkler, 1984, Hadley, 1999, Bailey, 2005; USDA, 2006, page 99; USDA/USDI, 2000, pages C-4 and 5).

Current Stand Conditions

Stand Structure

Since this forest type occurs across a wide elevational range and on all slopes and aspects (see the attached map and USDA/USDI, 2005 description of the Southwest Oregon Mixed Conifer type) the remaining mature forest is quite variable in species composition, tree spacing, average diameter, and the spacing of the older trees, but the area can be generally characterized as a closed canopy forest of 100 to 150 year old Douglas-fir. These forests contain a scattered, emergent overstory of Douglas-fir and ponderosa pine and some sugar pine and incense cedar with diameters from 30 to over 72 inches. These are remnants of the previous open stand condition and range from less than one to very few, to 20 or more trees per acre.

About half or more of the original large ponderosa pine have died of old age, competition stresses from the dense younger cohort, or both, though the ultimate cause of death typically is mountain pine beetle attack. Most stands within the forest type experience older pine mortality every year; my suspicion is this pine mortality is accelerating and most legacy pine in these stands will die over the next several decades if actions are not taken to make them more vigorous. Most of the legacy Douglas-fir are still alive and doing relatively well. Older sugar pine and oaks have suffered a higher mortality rate than the ponderosa pine; many sugar pine have succumbed to white pine blister rust and most oaks (aside from those still associated with meadows) have been completely suppressed out by the younger cohort. Probably as much as 90 percent of the large, open-grown oaks that once populated this landscape have died.

The diameters of the 100-150 year old cohort of trees range from less than 8 inches to as large as 36 inches, averaging about 15 inches. This wide spread in diameters in this age class indicates the area seeded in over a period of time. Some trees appear to have become established before others and were then free to grow with little competition so as to achieve an early and rapid diameter growth. This originally open-grown condition is evidenced not only by the large diameter of the residual trees, but also by larger, persistent dead branches lower on these larger tree stems, indicating the trees grew with ample room for crown expansion. These large young cohort trees can be distinguished from legacy open forest trees without direct aging by the lack of fire scars or char on the

bark and their generally vigorous and pointed crown structure, indicating they are still growing in height.

The 150 year old trees average about 130 feet tall. The older legacy trees may approach 200 feet in height. Crown depths range from 25% to 35% of the total height of the 100-150 year old cohort and 30 to 50% for the remnant older trees. Crown closures range from 60 to 85% (exclusive of meadows and small forest openings that likely were meadows 50 or more years ago).

Ground Vegetation

Shrubby understory vegetation is generally very sparse in this type, consisting, where it exists, primarily of poison oak, tall Oregon grape, ocean spray, and hazelnut. In many places the shrub layer is non-existent and the forest floor is dominated by either mosses, litter, or both. Herbaceous ground vegetation is also very sparse, consisting primarily of very shaded remnants of the apparently original native bunchgrasses, tarweed, woodland star, bracken fern, Oregon grape, and a number of even more sparsely distributed forest floor herbs. Several species of Orchidaceae are also common in the forest floor vegetation; likely an artifact of recently increased shade and lack of competition.

Meadows

The Mixed Conifer landscape still contains a number of small to larger (up to ten acres), grassy openings. These meadows are typically rocky and thin soiled and become very dry during the summer, hence they resist conifer encroachment, but they contain a wide assortment of plants in the spring, including camas, various grass species, and some unusual forbs more typical of areas further to the south. These meadows often contain Oregon white oak, typically around the margins where soils are a bit deeper. Most of these meadows contain some amount of weedy, non-native annual plants, including some grass species, such as cheat grass, considered to be invasive. Since this entire area was grazed into the early part of the 20th century, these weedy species were probably brought in by livestock.

Plantations

As mentioned above, nearly 12,000 acres of this forest type consists of plantations from 10 to 50 years old created by past regeneration harvest. About 8000 acres of these plantations are composed of private industrial forest lands in a contiguous block. These harvested areas consist of clear cuts and shelterwoods, the former of which being more numerous, now containing trees from eight to 80 feet tall. Most of these stands are more or less fully stocked with conifers, though many do not comprise a closed canopy forest yet. Some of these plantations are nearly pure ponderosa pine and most have some pine component.

Some plantations also contain naturally regenerated Oregon white oak. Many of these young managed stands have developed a grassy understory vegetation, though the grass layer is denser in the clearcut stands. The grass consists mostly of California fescue, the native bunch grass that appears to have been common on this landscape before the open

stands closed canopy. This grass is being or will soon be shaded out as these stands continue to increase in canopy closure.

Condition Class

Based upon the fire scar evidence described above, and also according to the description of the Mixed Conifer – Southwest Oregon Potential natural Vegetation Group (USDA/USDI, 2007), this vegetation type, prior to fire suppression and cessation of Native use of prescribed fire, had a fire regime of frequent, low intensity fires (Fire Regime I) with a median fire return interval of 10 to 15 years. This fire regime of frequent low intensity fires described above was halted about 150 years ago. The mixed conifer stands described above have seen no fire for the last 100 to 150 years (aside from periodic and localized, and usually quite severe wildfire), so from 10 to 15 fire cycles have been missed on most acreage. While there have been some minor attempts over the past 20 years to use prescribed fire to maintain meadows (USDA, 2006, page 103), the original fire regime has been entirely prevented at the landscape level.

Wildfires do occur in this area (USDA 1995 page 1-4 and 5, 4-22 to 26; USDA 1996 pages 15 and 56-57; USDA, 2006, page 166) but are episodic, vigorously suppressed, and tend to be stand replacing since these stands contain more fuels than they ever had in the past, there are ladder fuels into the continuous canopy in some paces, and less severe ground fires are easily suppressed (thus significantly reducing their extent). This change in fire frequency has resulted in the development of the existing closed canopy stand of Douglas-fir and in some areas a spotty to moderate understory of conifers and/or shrubs. Accordingly, the Mixed Conifer forest type can now be said to have a fire regime of mixed to high severity (Fire regime group II and III, as per USDA/USDI, 2007), with return intervals from 35 to 50 years. The general landscape now has a Condition Class of III (USDA/USDI, 2007), based upon the large departure from the historic fire regime.

Regional Fire Regime Condition Class mapping (see USDA/USDI, 2007) indicates that most portions of the Mixed Conifer landscape are in Condition Class II (defined, in part, as having fire frequencies that have departed from natural levels by one or more return intervals with a resultant moderate risk of losing key ecosystem elements). This classification is in conflict with my conclusions above. The Regional classification is based upon remote aerial sensing and certain assumptions about where various Biophysical Setting/Potential Natural Vegetation Groups occur in landscapes. While such remote assessments may have value for depicting Regional conditions, they are not necessary accurate enough to have value for site specific analysis and determinations. I believe it is more appropriate to base determinations of condition class upon site specific conditions, specifically evidence that shows such a dramatic departure from historic median fire return intervals as presented above.

Additionally, when using the “Simple 7” Training Form (see the table on the next pages and USDA/USDI, 2007), the numbers for departures from the ideal successional stage conditions and amounts for this potential natural vegetation group, and final determination of fire regime conditions class shows this landscape as being in conditions

“Simple 7” Training Form - Fire Regime Condition Class (FRCC)

Project Code *(Field 2)* _____ Project Number *(3)* _____ Project Char. Date *(4)* _____

Project Name *(6)* **Middle Fork Willamette Mixed Confier** Size *(7)* **25,300 acres**

Lat *(10)* _____ Long *(11)* _____ Datum *(15)* _____

Stratum *(21)* _____ Date *(24)* _____ BpS *(25)*:R#CONsw – Mixed Conifer – Southwest Oregon

Stratum Comp *(41)* _____%

Stratum Lat *(43)* _____ Stratum Long *(44)* _____Stratum Datum *(48)* _____

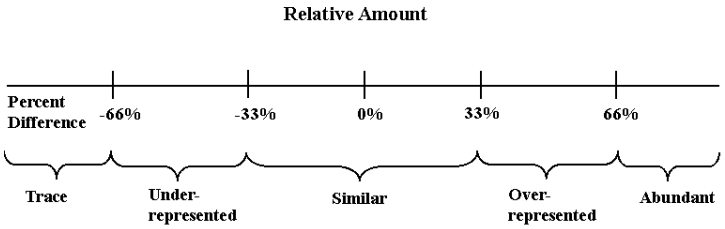
Fire Frequency-Severity	Reference *(51 & 53)*	Current *(52 & 54)*	Sim ((smaller/larger)*100)	Dep (100-Sim)
Fire Frequency (yrs) Sim = (smaller/larger)*100	10 to 12	20-40		
Fire Severity Sim = (smaller/larger)*100	low	Moderate to severe		
Fire Frequency-Severity Condition = (Frequency Dep + Severity Dep) / 2 *(87)*				
Fire Frequency-Severity Condition Class (0-33 = 1; 34-66 = 2; 67-100 = 3) *(88)*				

Vegetation-Fuel *(62)*	Reference % *(72)*	Current % *(73)*	Similarity (lower of Ref or Cur) *(77)*	Difference *(79)* if (cur<ref) diff = ((cur-ref)/ref)*100 if (cur ≥ref) diff = ((cur-ref)/cur)*100	Relative Amount[1] *(80)*	Stand Condition Class[2] *(82)*
A – Early	15	31	15	52	O	2
B – Mid Closed	5	14	5	64	O	2
C – Mid Open	10	3	3	-70	T	1
D – Late Open	50	1	1	-98	T	1
E – Late Closed	20	50	20	60	O	2+
U – Uncharacteristic	0		0	100 %	abundant	3
Sum	100	100				
Departure = (100%-Sum Similarity) *(83)*						56
Vegetation-Fuel Condition Class (0-33 = 1; 34-66 = 2; 67-100 = 3) *(84)*						2
Stratum Fire Regime Condition Class *(89)* = Higher of Vegetation-Fuel *(84)* or Frequency-Severity *(88)*						

Comments _____

_____

[1]Amount based on Difference
T – TRACE (<or=-66% departure)
U –UNDER REPRESENTED (>-66% and <or= -33% departure)
S - SIMILAR (> -33% and < +33% departure)
O – OVER REPRESENTED (>or= +33% and <+66% departure)
A - ABUNDANT (>or= +66% departure or > 0% uncharacteristic classes)



[2] Determine Stand Condition Class (1, 2, or 3) Using the Following Rules:
If VFC Relative Amount (f80) is T, U or S enter 1 for Condition Class 1.
If VFC Relative Amount (f80) is O enter 2 for Condition Class 2.
If VFC Relative Amount (f80) is A enter 3 for Condition Class 3.

(#) = Field number corresponding to the FRCC Worksheet and Software.

---

class II. Again a classification implies only a moderate departure from natural median fire return intervals and in that sense is misleading in terms of describing the changes that have occurred. Note that the Simple 7 calculations puts the departure for this landscape near the upper end of Condition Class II; implying that not much more additional change would be needed to move that conditions into Class I. Much of the early seral acreage will be moving into mid-seral condition and most of those acreages will be mid-seral closed, further aggravating the departure of this seral component.

Though this potential natural vegetation group apparently had a considerable acreage in a late-seral closed condition in pre fire suppression, these types of stands certainly underburned occasionally, given the fire regime of the landscape, and as evidenced by the fire scars that still can be seen in such stands. Such underburns would have significantly reduced the amount of ground vegetation and/or secondary canopy levels. These late-seral closed canopies stands now contain fairly dense understory vegetation and may be subject to uncharacteristically intense fires since they contain some amount of ladder fuels that could lead to a stand-replacing crown fire. Additionally, the current small number of late-seral open forest acreage is entirely the result of past shelterwood harvest

where the shelter overstory was not removed after reforestation has been accomplished. All 350 acres of this seral stage has developed a more or less dense young conifer understory and as such do not have the same structure and function as the historic late-seral open stands they are representing. Fire has still not played its proper role in modifying the fuel level and structure of these open forests. In both open and closed conditions, late-seral stands are more departed from historical conditions than would be recognized by the Difference value (Field 79) on the "Simple 7" training form.

Finally, regardless of the absolute magnitude of the acreage discrepancies between reference and current conditions, key ecosystem components, primarily the ponderosa pine and Oregon white oak, are being lost from this ecosystem at a relatively rapid rate. Not only are these species threatened by stand replacement fire but the current density of the stands they are embedded in has and continues to cause mortality from competition and insect activity aggravated by the stress these trees are currently and will continue to experience. In recognition of these factors and the historical fire frequency visible in all mature stands in this landscape, I believe it is most appropriate to consider the landscape in a Fire Regime Condition Class 3; with a high departure from the natural (historic) regime and severity and there is a high risk of losing key ecosystem components, particularly the legacy pines and oak.

Integration

Goals and Objectives

The basic goal of current management in this area is to restore aquatic and terrestrial biodiversity. There is a secondary goal to manage National Forest System lands to be within fire regime Condition Class I, with fuels loading, vegetation structure, and fire return intervals that are within the historic ranges for the vegetation types in the area. This would constitute a measure of satisfactory ecological conditions and would keep future wildfire severity at levels that would not compromise other values (including biological and social). The current Condition Class is III, implying a significant departure from the natural range of fire frequency, creating a high risk of losing key ecosystem components due to wildfire severity. These key ecosystem components include legacy conifers (particularly ponderosa and sugar pines), mature oaks and all the wildlife species dependant upon them, riparian vegetation, and water quality. In order to accomplish the goals above there is a need to move the entire forest type towards Condition Class I status. Focus on individual stands may provide site specific biodiversity benefits but may not prevent landscape level wildfire damage in untreated stands.

Objectives for this vegetation type analysis:

- Determine how many acres of the mixed conifer treatment need to be restored to bring the forest type's Fire Regime Condition Class back to I;

- Determine if future Forest Plan allocation changes need to be made; the type of actions that are needed to accomplish the goals may eventually require a Forest Plan Management Area amendment since the results of those actions needed to accomplish restoration may conflict with current allocation direction. We need to determine how much needs to be restored, in part, so that a future Forest Plan amendments could address all future landscape needs;
- Determine what limitations there may be on how much of the mixed conifer acreage can be restored;
- Develop and prioritize site-specific restoration treatments.

Strategy for Determining the Extent of Needed Restoration

It seems intuitive, especially given the current emphasis on restoration in public land management, that this area should be restored. But the question of how much of this forest type should be returned to its past, more open forest condition is still relevant. There are many resource concerns that exist today that did not exist in the past. Restoration of this forest's original condition could affect spotted owl dispersal and water quality for two listed fish species which inhabit the Middle Fork of the Willamette River running through the middle of this forest type. Given that we may not be able to restore the entire forest type due to funding constraints, lack of personnel availability, and environmental concerns, the question becomes how much needs to be restored to change the Fire Regime Condition Class of the area back to a I.

One approach to determine how much of the Mixed Conifer type should be restored to its previous, more open conditions would be to refer to the amount of early seral, mid- and late seral open and closed canopy forest structure that typically occurred in the past in this type of forest and fire regime. The Interagency LandFire website (USDA/USDI, 2005) contains Reference Condition Characteristics for a number of Forested Potential Natural Vegetation Groups (PNVGs). These reference conditions give such percentages of historic seral stages and conditions. These percentage distributions reflect a Condition Class of I. Perhaps this information can be used to determine how many acres of the Middle Fork Mixed Conifer forest type would need to be treated to bring the landscape Condition Class from a III to a I.

Based upon the vegetation assemblage and the historic fire frequency as evidenced by fire scars on legacy trees, the Mixed Conifer area in the Middle Fork watershed is most accurately represented by a single PNVG Group, the California Mixed Conifer - Southwest Oregon type (PNVG code MCONsw, as in USDA/USDI, 2007), which encompasses, geographically, southwestern Oregon and northern California from the Klamath/Siskiyou region to the southern Cascades in the Rogue, Umpqua and southern Willamette Valley. The following table presents the historic average distribution of seral stages and conditions in such a landscape, the current distribution for the Middle Fork Mixed Conifer landscape, and its degree of departure from those historic conditions.

Middle Fork Mixed Conifer Departure from historic seral stage distribution for the Mixed Conifer – Southwest Oregon PNVG

Seral Stage/Condition	**Ave. pre-settlement condition**	**Ideal acreag**e (on 25,300 acres)	**Existing Condition** acres(%)	**Discrepancy** in acreage
Post replacement (dia. < 5”)	15%	3,795	7,957 (31%)	+4,162
Mid-development - open (dia. 5 to 20”; CC < 30%	10%	2,530	744 (3%)	-1,786
Mid-development - closed (dia. 5 to 20”; CC > 30%	5%	1,265	3,539 (14%)	+2,274
Late-successional – open (dia. >20”; CC < 30%	50%	12,650	352 (1%)	-12,298
Late-successional – closed (dia. >20”; CC > 30%	20%	5,060	12,708 (50%)	+7,648

USDA/USDI, 2007 (page 12) indicates an overall landscape departure percentage value can be calculated from departure values expressed as a percentage of the ideal acreage weighted by the ideal acreage for each seral class and condition. A weighted average of zero indicates no departure and one of 100 percent indicates the landscape has totally departed from its historic condition. This weighted average departure for the numbers above is 99.88%. This is a fairly intuitive result given the absolute magnitude of the departure acreages and the fact that the landscape has departed from historic conditions in all seral stage categories. This result is also supported by field observations that this landscape has missed ten or more natural fire cycles.

Alternatively, the “Simple 7” form, as discussed above, indicates the area is not quite so significantly departed from historic (natural) conditions; the total departure (Field 83) is only 56 out of a possible 100, putting this landscape into the Condition Class II category (see Field 88). This is a bit counter-intuitive for the reasons discussed above

<u>How much should be restored?</u> The simplest approach to how much restoration needs to occur in the Middle Fork Mixed Conifer forest type is to look at the acreage of departure presented in the table above. A positive number in the last column indicates the landscape now contains more of that seral stage/condition than it did in the past. A negative number means the landscape is short that amount of seral stage and condition. To the extent that one can logically establish that this forest type had, 100 to 150 years ago, that sort of seral stage distribution, and to the extent that it is desirable (which is implied by the fire regime condition class ratings) to return to this historic condition, it

seems clear that over 7,600 acres of late-successional forest and 2,300 acres of mid-seral forest need to be made less dense.

Alternatively, according to the numbers on the "Simple 7" form above, a Similarity sum (Field 77) of 70 results in a total departure (Field 83) of 30, generating a Condition Class of I (though a "high" I, indicating it could move back to Class II relatively quickly). This amount of departure could be generated by restoring about 2,500 acres of the late-seral closed forest to a more open condition (less than 40% canopy closure). Interestingly, restoration of any amount of mid-seral closed canopy forest to a more open condition would not materially change the overall landscape condition class without dropping considerably below the reference percentage for mid-seral closed stands.

There also needs to be less acreage of post-replacement forest, but there is not much to be done about that in the sort-term aside from making sure these forests are free to grow and attain diameters greater than five inches. Many of the post-replacement stands are close to becoming Mid-development – closed stands, so as that progression occurs, additional acreage of Mid-development-open stands will need to be created.

The extent of needed restoration based upon historic conditions may be constrained by social or overriding biological factors such as the listing of various species as threatened or endangered, the need to maintain later-seral forest connections, the presence of private lands within and adjacent to the mixed conifer forest type, the amount of past forest management that has occurred in the forest type, and the degree to which it may not be socially acceptable to apply frequent prescribed fire to large acreages in some areas (which would be necessary to maintain open forest conditions and a desirable condition class). Certain geographic areas may also better lend themselves to prescribed fire application in terms of ease of control and smoke dispersal.

Objectives relating to maintenance of late-successional forest conditions conflict with mixed conifer restoration goals. Late-successional habitat typically consists of dense, multi-layered canopies where canopy closures exceed 40 percent by a considerable amount. Most of these mixed conifer forests, if restored to their previous conditions, would likely have canopies with a 10 to 30 percent coverage, and secondary canopies would consist only of scattered clumps of young conifers and Oregon white oak.

Another consideration in determining where restoration treatment should occur might also be the presence of young, managed stands that have had some components of the natural vegetation assemblage. Examples are the plantations scattered throughout the forest type which have seen redevelopment of bunchgrass and oak regeneration. Further restoration activities and treatments could build off these existing restored elements by folding plantations with such characteristics in to a larger, adjacent restoration effort.

Conclusions and Recommendations

The most basic indicator of the need to restore the Mixed Conifer landscape is the Fire Regime Condition Class, which is III and represents a significant departure from historic conditions. From a strictly biological/biodiversity standpoint, to fully restore historic vegetative types and patterns and to maintain the landscape in a condition that is less vulnerable to catastrophic fire, the answer to the question posed above is answered by the figures in the above Table. Somewhere around 2,274 acres of closed canopy, mid-development young forest and 7,648 acres of closed canopy late-successional forest need to be treated in some fashion to make them considerably less dense. This amount of restoration would result in a weighted average departure from historical seral stage conditions of 69.5% (100% being totally departed), since there is no immediate remedy for having too much post replacement acreage and not enough total late-successional open and closed acreage. The answer to this question is muddied somewhat by the various ways can be quantified, as discussed above. If the "Simple 7" form numbers and evaluations are relied upon, one could get to a Class I status by opening up only 2500 acres of late-seral closed canopy forest but the time the landscape would remain in that conditions could be relatively short as these stands continue to grow and close canopy.

One important point to consider when contemplating restoration of this unique forest type is the potential for climate change and the need to maintain this plant association's resiliency should the climate change. Without density reduction, these mixed conifer forests are at risk on several different fronts in the face of a potentially warmer, drier climate. The sites on which these stands occur currently seem capable of supporting a healthy, closed canopy forest in the climate regime of the recent past, though the legacy pine are adversely affected by current stand densities. However, in a warmer and drier climate regime these dense stands could very well experience some to considerable mortality from insect outbreaks and various diseases as the many trees become stressed due to a competitive lack of moisture. A warmer, drier climate would also puts these dense forests at increased risk from wildfire. If the density of these stands is substantially reduced they would be more resilient in the sense that they would more likely survive a severe fire event, and the remaining trees would be more vigorous and better able to fend off insect attacks and diseases.

The biodiversity enhancement and maintenance purpose and need for action as articulated by the Jim's Creek Savanna Restoration project is related to restoring the Mixed Conifer type to a condition that would be more resilient to climate change, and that analysis did peripherally mention that retention of oaks and pines more resilient to warm and drier conditions would create a refugia for that plant association that could expand it's range in the face of that sort of climatic change. A more complete restoration of this forest type could very well be the only way to assure that there are fully functioning forests in this landscape if the climate indeed does change to a warmer and drier regime.

Recommended Actions: From a Fire Regime Condition Class and biodiversity restoration standpoint, all the acreage mentioned above should be restored to its originally more open condition (See USDA 2002 Ref.#9e, USDA 1996 Ref. # 21a, and

USDA 1995 Ref #s 35a and c in the Appendix to the Watershed Update document). Given the constraints mentioned above and further discussed below, this may not be a very realistic action to propose. If those constraints cannot be overcome, I recommend that as much of the acreage mentioned above be restored without compromising other resource values through stand density reduction, re-establishment of the historic forest floor vegetation, and periodic application of prescribed fire. Resource values that may constrain the amount of such restoration will be described by other resources specialist reports prepared for this Watershed Analysis update and subsequent analyses for future project proposals. Specific prescriptions for this density reduction should be based on site-specific stand conditions and objectives. Such a density reduction would be most economically accomplished by selling the 100 to 150 year old cohort of trees that need to be removed, as most have considerable commercial value. This sale would help fund the equally important forest floor revegetation, and maybe even the also equally important prescribed fire regime that is needed to return this landscape to a Fire Regime Condition Class I and maintain the open nature of the restored forests.

The forest floor will likely need to be actively revegetated in most places with appropriate grasses and forbs, since most stands are dense enough that the original open forest floor vegetation has been shaded out. Prescribed fire would need to be applied at least every five or ten years to maintain the open forest, its historic fire regime, and its Condition Class I status. This fire regime cannot be reinstated until the original grassy understory vegetation is reestablished; it is this fine fuel bed that will provide for the frequent, short duration, and low flame-length fires that are integral to maintaining the open forest without unduly damaging the residual mature trees.

Many of the 4,000 plus acres of publicly owned plantations in the Mixed Conifer type have some components of the original forest; most contain some pine species, many have developed relatively dense stands of the native bunchgrass, and some have Oregon white oak regeneration. To fully restore this landscape and to facilitate as close a return to a Condition Class of I as possible, these plantations should also be restored. Such restoration would entail considerable reduction in stand densities, and replanting Oregon white oak and native ground vegetation where these species are appropriate and absent. A prescribed fire regime should also be applied to the plantations to facilitate their restoration.

Constraints: As mentioned above, the presence of habitat for threatened or endangered species, the need to maintain later-seral forest connections and riparian reserves, the presence of private lands, the amount of past forest management that has occurred in the forest type, and the degree to which it may not be socially acceptable to apply frequent prescribed fire to large acreages in some areas all may constrain the amount of restoration that could occur, overriding general biodiversity maintenance objectives. In this case the number of acres to be restored will be determined by a mapping exercise rather than the analytical process presented here.

Regarding the objective to maintain late-successional habitat, about 22 percent of the type is currently classified as Late-Successional Reserves. An additional 16 percent of

the Mixed Conifer type is classified as a northern spotted owl Critical Habitat Unit (CHUs – there is considerable overlap between the LSR and CHU). The overgrown Mixed Conifer forests in the LSR or CHU generally do not constitute typical or classic late-succession habitat. While they do contain scattered older trees with defect and complex crown structures, the forests do not contain an abundant, secondary, and shade tolerant canopy; usually do not have a well-developed ground vegetation layer; contain low levels of large snags and down wood; and due to site limitations will likely never develop such structures. If these stands are left in their current condition, they are at risk of stand replacement wildfire. Such an event would remove marginal habitat for late-successional habitat dependant species as well as kill the legacy structure and species from the original more open forest. This risk may be increasing due to climate change.

Restoration may be constrained for one reason or another on about 38 percent of the Mixed Conifer forest type (not including riparian reserves). Restoration of the remaining acreage would roughly result in half the total acreage of potential restoration, so the weighted average departure from historical seral stage conditions would be anywhere from 80 to 90%. With this degree of departure, and only a 10 to 20 percent improvement of the current totally departed condition, we may not be able to legitimately claim that the Condition Class of this landscape has been materially improved. However, such an amount of restoration would still have considerable ecosystem biodiversity and habitat benefits.

Forest Plan Amendment: Should a substantial proportion of the Mixed Conifer forest type be managed to promote historic conditions, a number of Forest Plan (USDA, 1990) Management Area allocations and standards and guidelines would no longer be appropriate or could not be complied with fully. For example, such restorative management would not provide for maximum wood fiber production (the stands would not be maintained in a "fully stocked" condition, at least in terms of coniferous tree species), and prescribed fire could preclude retention of prescribed levels of snags and down woody material. Ideally, if what ever portion of the Mixed Conifer type is restored, the Management Area allocations of areas to be managed as open forest should be changed. Experience with the Jim's Creek Savanna Restoration project indicates this would not have to be done immediately, or as a condition of the restoration commencing. Considering that there are really not any existing Management Area prescriptions in the current Forest Plan that fit well with the goals and objectives for restoring and maintaining an open forest type for biodiversity enhancement, it would probably be best if the crafting and designation of a Management Area with associated standards and guidelines for the Mixed Conifer type be developed at the time of the next Forest Plan revision, which is currently scheduled to begin in 2012.

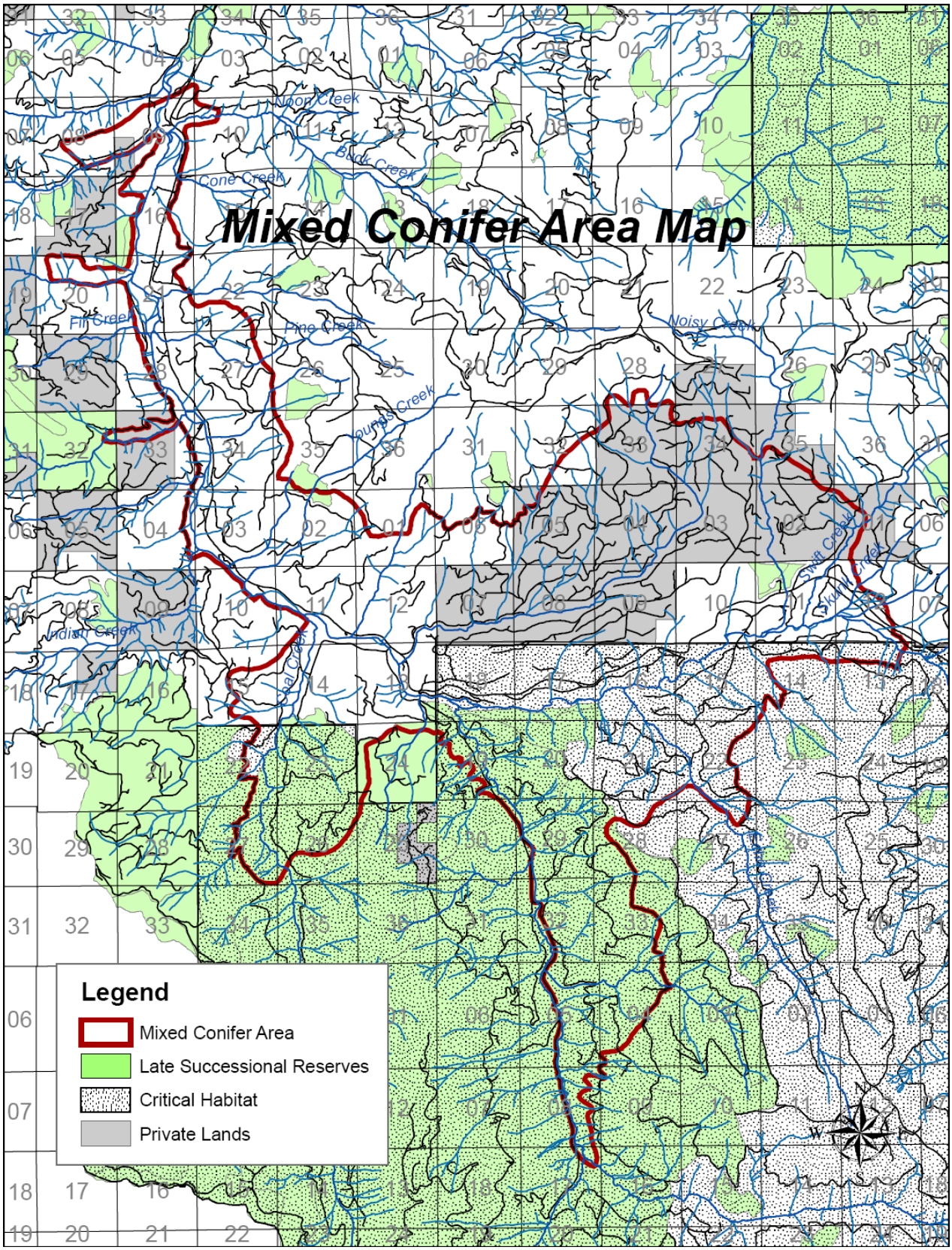
Prioritization of Treatments: There does not appear to be any one area within the Mixed Conifer forest type that needs restoration sooner or more urgently than other areas. Key ecosystem components are being lost throughout the landscape at a relatively rapid rate through competition from dense coniferous canopies. I suggest prioritizing treatment in areas not encumbered by conflicting land uses such as Critical Habitat Units or Late-Successional Reserves since considerable time may be required for analysis of proposals

within those areas in order to overcome administrative and regulatory obstacles. Accordingly, the area to focus on would be the northwestern portion of the forest type; that area from Deadhorse Creek to Hill's Creek Reservoir which includes the Buck, Cone, Estep, Pine, Boulder, and Young's Creek drainages. Additionally, the Jim's Oak Patch and surrounding area (the lower portions of the Coal and Indian Creek drainages) should also be considered for immediate restoration.

There are also several areas outside the contiguous Mixed Conifer forest type (and hence outside of the Seral Stage Condition Class analysis presented above) that exhibit similar vegetative characteristics and are not encumbered by other land use classifications. Those areas could generate some biodiversity benefits if restored, but would likely not have a large effect on the Fire Regime Condition Class of the landscape. These areas include portions of the Willow, Little Willow, and Bull Creek drainages east of the Hill's Creek Reservoir, and the areas adjacent to and including Packard Creek Campground on the west shore of the Reservoir.

Postscript: After this paper was completed the long awaited Northern Spotted Owl Recovery Plan was released. This plan essentially eliminated Critical Habitat Units that are not overlain by Late-Successional Reserves. Rumor has it this plan will be legally challenged but if this new guidance persists, additional acreage in the Mixed Conifer forest type would be freed up to be restored without considerable interagency involvement, consultation, and concern.

This scenario would make restoration of the south slopes between Big Pine Openings and Swift Creek a more likely proposition. These slopes that occur in the heart of the Mixed Conifer forest type contain some classic mixed conifer stands that still retain a considerable old ponderosa pine component, and are also immediately south of a large block of private, second-growth forest land. This area may well provide a high priority for initial restoration, as the sort of restoration envisioned would protect, to some extent, National Forest lands from any intense fires that start and spread from the contiguous areas of dense second-growth forest. Additionally, the stands in this area tend to be less fragmented, would be somewhat more visible to the public, and likely most importantly, restoration in this area would generate less concern (and hence provide for a greater and more ecologically significant amount of restoration) over late-successional connectivity due to the adjacent large block of early to mid-successional habitat on the private land to the north.


Mixed Conifer Area Map
Noon Creek
Cone Creek
Fir Creek
Pine Creek
Noisy Creek
Indian Creek
Legend
Mixed Conifer Area
Late Successional Reserves
Critical Habitat
Private Lands

Literature Cited

Agar, John, 1998; Analysis File, Young'n Final Environmental Impact Statement. Middle Fork Ranger District, Willamette National Forest, USDA Forest Service. September, 1998.

Bailey, 2005. Stand Diagnosis of Treatment Needs, Silvicultural Prescription and Background Paper (effects analysis) August, 2005. In: Analysis File for the Jim's Creek Savanna Restoration Project Environmental Assessment, Middle Fork Ranger District, Willamette National Forest, Westfir, Oregon, June, 2006

Bailey, T. and J. Kertis, 2002. Jim's Creek Savanna: The Potential for Restoration of an Oregon White Oak and Ponderosa Pine Savanna – Current, Past, and Desired Future Conditions. Unpublished report, Middle Fork Ranger District, Willamette National Forest; Westfir, Oregon, 2002.

Hadley, Keith S., 1999 Forest History and Meadow Invasion at the Rigdon Meadows Archaeological Site, Western Cascades, Oregon. *Physical Geography* 20, 2:116-133

USDA, 1988. Middle Fork Willamette Viewshed Corridor Study. Rigdon Ranger District, USDA Forest Service, Willamette National Forest Oakridge, Oregon. Prepared by Jody Stix, April, 1988.

USDA, 1990. Willamette Nations Forest Land and Resource Management Plan. Willamette National Forest, Eugene, Oregon. , 1990.

USDA, 1993. Boulderdash Timber Sale Environmental Assessment. Rigdon Ranger District, Willamette National Forest; Oakridge, Oregon. August, 1993

USDA, 1995. Middle Fork Willamette River Downstream Tributaries Watershed Analysis. Rigdon Ranger District, Willamette National Forest; Oakridge, Oregon. August, 1995

USDA, 1996. Upper Middle Fork of the Willamette Watershed Analysis. Willamette National Forest, Eugene, Oregon. , August, 1996.

USDA, 2002. Upper Middle Fork of the Willamette Watershed Analysis Update. Middle Fork Ranger District, Willamette National Forest; Oakridge, Oregon. January, 2002.

USDA, 2006. Environmental Assessment for the Jim's Creek Savanna Restoration Project, Middle Fork Ranger District, Willamette National Forest, Westfir, Oregon, June, 2006

USDA/USDI, 2000. Integrated Natural Fuels Management Strategy. Willamette National Forest and the Eugene and Salem offices of the Bureau of Land Management. November, 2000.

USDA/USDI, 2005. Mixed Conifer–Southwestern Oregon Potential Natural Vegetation Group Rapid Assessment Reference Conditions Model at: www.landfire.gov/models_EW.php. August, 2005. USDA Forest Service and USDI Bureau of Land Management, Pacific Northwest Region

USDA/USDI, 2007. Fire Regime Condition Class (FRCC) Documentation to Accompany Northwestern Oregon FRCC Grid (Veg_fuel_cc) June, 2006, updated October, 2007. At: Ecoshare Interagency Clearing House of Ecological Information; USDA Forest Service and USDI Bureau of Land Management, Pacific Northwest Region - www.reo.gov/ecopshare.

USDA, USDI, USGS, and TNC, 2005. Interagency Fire Regime Condition Class Guidebook, Version 1.2. USDA Forest Service, UDAI Bureau of Land Management, USDI Fish and Wildlife Service, USDI National Park Service, US Geographical Service, and The Nature Conservancy http://ccc.frcc.gov/docs/1.2.2.2/Complete_Guidebook_V1.2pdf. May, 2005.

Winkler, Carol, 1984. A site Location Analysis for the Middle Fork of the Willamette River. Paper submitted in fulfillment of a Master of Arts degree. University of Oregon, May 14, 1984.

Winkler, Carol, and T. Bailey, 2002. Restoring the Cultural Landscape At Jim's Creek: Challenges to Preserving a Spirit of Place. Paper presented at the 55th Annual Northwest Anthropological Conference, Eugene, Oregon. April 11-13, 2002