Density Management Study - Proposal for follow-up treatments

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Introduction and Objectives

The Density Management Study (DMS) demonstrates and evaluates different approaches to managing 40-70-year old forest stands on low elevation sites in western Oregon to produce and maintain late-successional characteristics. Scientific and management objectives include:

- Evaluate effects of alternative forest density management treatments on important stand and habitat attributes (large trees; standing and down dead wood; understory trees, shrubs, and herbs; vertical distribution of tree canopy; and spatial distribution of trees, shrubs, herbs, and dead wood)
- Determine treatment effects on selected plant and animal taxa (amphibians, arthropods, mollusks, nonvascular plants, and fungi)
- Assess the combined effects of density management and alternative riparian buffer widths on aquatic and riparian ecosystems
- Use DMS sites to develop operational approaches to implementation of new prescriptions, and improve methods for effectiveness monitoring of plant and animal taxa
- Use DMS sites to share results of on-the-ground practices and findings with land managers, regulatory agencies, and policy-makers
- Use results from DMS to conduct a long-term adaptive management process where management implications and policy changes are regularly evaluated and changed as needed.

Desired Future Stand Conditions

The essential long-term goal is to accelerate the development of late-successional characteristics in these younger forests. To a significant extent the habitat requirements of the northern spotted owl underlie this goal. Stands with late successional characteristics provide better habitat, as spotted owls prefer old-growth and younger stands with remnant large diameter trees for nesting (Perkins 2000, Courtney et al. 2004). Preferred habitat attributes include vertical canopy layering, tree height or diameter diversity, canopy closure and volume, large trees, and large snags. All of these variables showed a positive relationship with owl habitat (Courtney et al. 2004). As the amount of owl habitat is still declining (average annual loss of 0.57% per year), management of young stands is considered a potential option to reverse this trend (Courtney et al. 2004)., Accelerating development of habitat characteristics may be crucial in maintaining viable owl populations, especially in regions of the Pacific Northwest that are dominated by large acreage of young, even-aged stands.

When treated stands reach 120-150 years of age, the desired stand conditions are as follows:

1. Large green conifer trees

    >8 Douglas-fir per acre >30 inches”

    2-6 TPA, diameter > 50 in.

    1 TPA, diameter > 50 in. with a broken top

2. Enhanced species and structural diversity

    25-35 TPA, diameter 15-30 in., hardwoods and conifers

    100-200 TPA, diameter < 15 in., hardwoods and conifers

    Two or more species to include at least one shade tolerant species, and two or more age cohorts

3. Snags

    8-12 snags/acre, 50% diameter 10-25 in., 50% diameter > 25 in.

    All decay classes present

4. Downed logs

    900 linear feet/acre of well-dispersed logs

    1/3 of logs > 24 in. diameter

    2/3 of logs 10-24 in. diameter

    All decay classes present

Rationale for follow-up treatments

Discussions about follow-up treatments among DMS site coordinators and scientists, and at the June 2004 DMS workshop and field tours, identified a need to define the experimental treatments in terms of management approaches to achieve late-successional habitat, i.e., address management of various stand structure components, such as understory vegetation and advanced regeneration, rather than focusing solely on residual tree densities. Based on our current expectations of ecosystem development the treatments are now defined as a set of overstory and understory manipulations over time. Detailed information about the treatments is provided later in this document. The treatment choices are designed to maximize potential information gained to help guide future management decisions for a wide range of conditions. Thus, the treatments allow tradeoffs to be quantified when choosing the management intensity (choice of residual densities, or speed of conversion to late-successional habitat) by using treatments that bracket possible management scenarios. This also ensures that the study design provides an opportunity to investigate various ecosystem processes under a wide range of conditions. All treatments are viewed in terms of meeting the general objectives of the DMS which includes evaluation of both the upland treatments and associated riparian buffer treatments. The potential feasibility of the selected treatments to achieve desired stand conditions has been confirmed by comparing treatments to results from several young stand modeling exercises, including Garman et al. (2003), Andrews et al. (in press), and Kintop (unpublished report). However, treatment selections will be assessed on a continuous basis as new information becomes available.

Initial thinning sites

1) Control: no manipulation treatment will provide data on development of unmanaged forests and will provide information about the benefits and costs of treatments. Controls provide baseline information crucial for comparison of the treatments on the different study sites, especially since only one replication of each treatment is present on a site.
2) High density (HD), or three-step conversion: includes multiple treatments aimed at opening the overstory canopy very gradually. The first entry opened the canopy to 120 trees per acre (TPA); the second is proposed to occur 12 years later to 60 TPA, and the third at a time to be determined later to 30 TPA.
3) Moderate density (MD), or two-step conversion: includes two intensive thinning treatments. The overstory will be thinned in two steps with the first entry to 80 TPA and

the second is proposed to occur 12 years later to 30 TPA. No further entries are planned with one exception described in the riparian buffer section.

4) Variable density (VD) treatment: provides the highest heterogeneity within a stand. It provides a cornerstone of what can be achieved with intensive forest management. The next re-thinning treatments for the 120 TPA and 80 TPA treatment components mimic the treatments described above in the HD and MD treatments. The 40 TPA areas are proposed to be thinned to 20 TPA at the next entry, i.e., 12 years after the initial thinning. The need or opportunities of a third thinning will be assessed after responses from the second thinning are available.

Residual density targets given above are for live trees; additional trees will be left for future snag recruitment. Thus, for marking purposes the residual density after thinning will be higher, i.e., 65 TPA, 35 TPA, and 25 TPA (see “Snags” below).

The riparian buffer component of the study will be retained and expanded. Existing buffers will remain with a couple of exceptions described below (see “Riparian buffers”).

The MD, HD, and VD treatments also provide a continuing opportunity to evaluate the effects of leave islands and gaps in the context of a managed stand. Existing leave islands and patch cuts will remain through the second round of treatments.

Other management considerations, such as downed wood and treatment of understory vegetation and regeneration, are applied consistently across all treatments and described below.

High density treatment

Reduce tree density in areas initially thinned to 120 TPA down to 60 TPA (65 TPA including snag allowance) 12 years after the initial thinning (see Appendix 1 for the site treatment schedule). Future plans include a third thinning lowering the density to 30 TPA (35 TPA including snag allowance).

This treatment is aimed at converting an even-aged, single-story stand structure to more complex late successional habitat by employing multiple, low-intensity thinnings. Our preliminary assessments indicate that the overstory and understory development in the initial HD treatment are not very different from control stands. Consequently, we view the initial treatment as quite conservative and repeated thinnings are necessary to ensure stands develop towards a diverse stand structure characteristic of late-successional forests. On the other hand, this treatment provides a high amount of protection for plants and animals that require overstory cover.

The initial treatment was originally designed to reflect “conventional” management strategies. Current practices on federal lands include thinning to lower densities than the 120 TPA initially left, even in stands managed for timber production. However, a slow, three step treatment provides information for strategies where protection of interior stand conditions is important during the process of converting even-aged stands into late-successional habitat, such as in areas with wildlife sensitive to open conditions. From an experimental point of view this treatment provides a “conservative” conversion option.

Since the initial treatment included leave islands and thus created spatial diversity, we plan to thin to an evenly spaced 60 TPA with the second thinning. The next entry will allow crown and stem form (taper) condition to adjust to more open canopy conditions and improve tree stability for the third thinning, which will open the stand to 30 TPA (35 TPA) and provide “open” growing conditions for the residual trees.

In summary, this treatment will provide information about a conservative management approach aimed at converting homogenous stands to diverse stand structure. The information will apply to stands that have been thinned conservatively in the past. The low-intensity repeated thinnings will allow trees to adjust to more open conditions fairly slowly. This treatment provides information directly usable in stands with fairly easy access, where risk of windthrow is high, continuous protection by overstory trees is desirable, and where multiple entries are economical.

Moderate density treatment

Reduce tree density in areas initially thinned to 80 TPA down to 30 TPA (35 TPA including snag allowance) 12 years after the initial thinning (see Appendix 1 for the site treatment schedule). This will be the last thinning for this treatment. Retain the existing riparian buffers, except as described below.

The treatment choice was selected to maximize the scientific value of the DMS. Preliminary results of the vegetation and other analyses indicate that the initial DMS treatment selection was fairly conservative. In hindsight it is clear that a wider range of treatments may be desirable to bracket the possible range of conditions. Traditionally, the choice of thinning intensities was influenced by growth-growing stock relationships and stand stability considerations. The proposed thinning to 30 TPA goes below "conventional" density levels. The site will not likely be fully occupied by overstory trees and the treatment will result in lower growth (per acre) of the overstory. Thinning to levels below full site occupation provides a scientific baseline for conditions where lack of a closed canopy changes microclimatic conditions and a large amount of site resources are available for other (than overstory) stand components, such as understory vegetation or regeneration.

This proposal represents an attempt to accelerate the development of late successional habitat in two thinning entries. Even though not originally envisioned as such, the first entry can be viewed as similar to a "preparation cut". The stands grew at a fairly high density and trees had low crown ratios and taper. Concerns about tree stability after exposing trees in a high intensity thinning treatment were addressed by opening up the stand to 80 TPA and allowing the residual tree crowns to recover and taper to increase, thus increasing stand stability. At the same time, our measurements and observations indicate that the understory vegetation did not respond significantly to the initial thinning. With 12 years to adjust the tree architecture to more open conditions, rethinning to 30 TPA in one thinning entry may be more likely to succeed. At the same time, we expect the understory vegetation, which has developed rather slowly during the first 12 years, to quickly respond to the increased resources after the second thinning and the stands should start providing components of late-successional habitat fairly quickly.

From this treatment we expect to gain information useful for management of a wider range of stand conditions, including cases where stands are opened up with a single intensive thinning.

For example, in younger or low density stands with higher stability (i.e., fairly high live-crown ratios and lower taper) the initial entry may not be necessary to improve tree stability. While we will not be able to do replicated comparisons of a single entry with multiple thinning treatments, the responses to our proposed treatment may provide useful information to assess potential outcomes when dense stands are opened up with a single, very intensive thinning. The conversion of the two-tree height riparian buffer to a thin-through riparian area (see below) will provide further complementary information for these conditions.

A third reason for this treatment is the location of the alternative riparian buffers within the MD treatment areas. Initial analysis of microclimate and amphibian habitat indicated that all riparian buffer treatments were able to buffer impacts of thinning the upland area to 80 TPA. Thus, the study design did not provide the best opportunity to compare the different riparian buffers. Lowering the upland density to 30 TPA will result in a higher contrast between upland areas and the riparian buffers. We expect that differences between the riparian buffers will be more obvious under these conditions and a more powerful evaluation of the relative strengths and weaknesses of each buffer width will be possible.

Variable density treatment

This treatment was designed to provide another cornerstone of information by creating a very high level of structural diversity within a stand. It will be used to investigate the relative importance of the various treatment components (evenly spaced stand, gaps, leave islands). It provides a reference stand for evaluation of spatial scale relationships found in the other treatments. Thus, future treatments should be comparable to thinning treatments 2 and 3. We propose to duplicate the prescriptions listed in treatments 2 and 3 for the variable density treatments in areas with 120 TPA and 80 TPA, respectively. In addition, we propose to thin the area currently in 40 TPA to 20 TPA (25 TPA including the snag allowance). Thus, we maintain within stand diversity and differences within this treatment should be enhanced over time. A decision concerning whether or not to conduct a further thinning in the high density portion of this treatment will be made at a future date when the second round of thinnings have been completed and assessed.

All initial thinning treatments

Riparian buffers

The basic design of the riparian buffer component is focused on the MD treatment and will not be altered. However, all riparian buffers have to be viewed in the context of upland management. Rethinning in upland areas will greatly enhance the contrast between the buffer and the thinned areas and significantly alter edge conditions. Thus, by thinning the uplands we will gain additional information about the importance and effects of leaving unthinned areas near streams (also see discussion about riparian buffers under the MD treatment).

Based on strong feedback from scientists and managers we are also proposing more active management in areas near a limited number of stream reaches. Preliminary results from this study indicate very minor effects from the upland thinning regardless of buffer width and some managers are beginning to prescribe narrow riparian buffer widths. We propose thinning down to 60 TPA (65 TPA with snag allowance) through the existing two-tree height buffers on two stream reaches within the MD treatment. In addition, we plan to thin through half of the existing variable-width riparian buffers in the HD treatment, also down to 60 TPA (65 TPA with snag allowance), and retain half of the variable-width buffers in the HD treatment. These thin-through areas will bracket the alternative riparian buffer widths elsewhere in the study and help frame interpretation of results. We are also exploring the potential to add 5-6 new sites in the Coast Range to test the thin-through approach.

We realize that reducing stand density to 60 TPA (65 TPA with snag allowance) in unthinned areas may increase the potential for blowdown, but the limited mortality due to wind observed in the study sites to date and the relatively protected landscape position of these sites led us to conclude that the potential for producing useful information merits the increased risk. The thinning of the two stream reaches with two-tree height buffers will also provide an opportunity to document a case study of how stands respond when only a single entry is used to convert dense stands to open conditions favorable for development of late successional habitat.

Gaps

We intend to maintain the existing gaps created in the initial thinning entry in all proposed rethinnings. Although created gaps are steadily shrinking as stands develop, further gap manipulation (e.g., enlarge gaps or feather gap edges) will be confounded with the thinning treatments. In addition, the ability to increase gap size is very limited in most DMS stands due to space constraints. Although smaller gaps likely inhibit understory development, information from other studies about survival of conifer seedlings under various light conditions can be used in conjunction with our light measurements in the gaps to make some prediction about the impact of larger gaps on tree regeneration.

Existing gaps span a range of gap sizes and consequent environmental effects. Ongoing spatial analysis of gap size and neighborhood conditions will be enhanced and extended under this proposal as the neighboring stand is thinned to a lower residual density creating more open conditions. Rethinning will provide new data on gap closure rates, the effects of closure on vegetation in the gaps, and gap edge response to changing light environments. These data will facilitate predictions about the effects of creating gaps of alternative sizes and spatial arrangements and their effect on the development of late-successional habitat.

Small gaps may also have previously unappreciated effects, such as altering crown architecture of neighboring trees. Ongoing data collection will monitor crown and branch development on trees bordering gaps, i.e., with one-sided canopy openings. Rethinning these stands will allow comparison of one-sided vs. multiple-sided canopy openings on crown development.

Leave islands

We propose to maintain the leave islands created in the initial thinning entry in all proposed rethinnings for reasons very similar to those outlined above for gaps. Although initial analysis (preliminary findings, S. Wessell) of the effects of leave island size on low-mobility species indicates that small gap sizes may not be very effective in providing refugia or other benefits of dense forest cover, the value of these features may increase over time as stands are opened up through repeated thinning. In addition, leave islands will likely undergo future tree mortality and thus provide an important source of snags.

Understory trees, shrubs, and herbs

Understory vegetation contributes to species richness in the short term and to desired stand structure in the long term. Development of diverse and well established understory vegetation to support a variety of arthropod and wildlife species is one of the main goals of the overstory treatments. Many of the gaps created through patch cutting are sources of abundant shrubs and hardwood trees, although conifer seedlings of several species were planted in the gaps soon after the initial gap cuts. The main purpose of these plantings was to ensure that conifers were present in the gaps as part of the suite of species available to potentially colonize the gaps. Because of the importance of the gaps as sources of biodiversity; the limited spatial extent of the gaps (10% or less of the treated stands); and observations to date that indicate conifers will persist as a component of gap vegetation; we do not plan to implement any treatment of shrub and herb components of the understory at this time. Understory competition control treatments intended to promote conifers would reduce or eliminate desirable stand components that contribute to species and structural diversity, e.g., hardwoods.

Some areas within the treatments support dense patches of conifer reproduction. Dense conifer regeneration reduces understory vegetation, potentially leading to a depauperate understory. At this stage no treatment of the understory regeneration is planned. We expect seedling and understory mortality from logging damage due to the harvesting activities planned for 2009-2011. Development of tree regeneration will be monitored and the need for future treatments will be assessed following these harvests. Precommercial thinning (PCT) will be prescribed and implemented in thinned areas and gaps where dense conifer reproduction exceeds 80 trees per acre (TPA) in large patches summing to greater than 30% of the treatment area. Conifer understory density following PCT should be between 50 TPA and 60 TPA. The timing and size specifications will follow standard BLM PCT contracting specifications.

Rethinning sites

The rethinning study should be viewed in conjunction with the initial thinning study. A primary goal of the rethinning study is to provide a context for predicting future response of the initial thinning sites. Thus, matching the treatments to the Initial Thinning Study is very important. While a direct comparison is not possible (e.g., the rethinning sites don't have gaps and leave islands) the rethinning sites provide information about long-term development of various stand structural components. For example, the continuous "recovery" of live crown ratio or stem taper can be assessed on the rethinning sites and helps put the initial thinning treatments in perspective. We will use the response on the rethinning sites as a reference or validation point when we predict development of the initial thinning sites or use growth models to simulate overstory development of alternative treatments. Also, while a number of studies investigate development of young seedlings under various overstory densities, this information cannot be directly used to predict long-term future development. Seedlings are expected to become more light demanding as they get older and few studies investigate the growing conditions of saplings and they transition to the overstory. Thus, the re-thinning sites are also very helpful in predicting future development of advanced regeneration and understory vegetation.

Rethinning study treatments include:

1) Control (CON): once-thinned control with a single commercial thinning that reduced overstory density to 100+ TPA. Preliminary assessment indicated that the development of over-and understory conditions to meet late successional habitat does not seems to be accelerated appreciatively at this stage. However, this treatment provides baseline data. We feel that this baseline information is necessary as it allows us to link the different study sites in the statistical analysis. This is especially important since the study was replicated across sites, i.e., each site has only one replication of the treatments. Because of the relatively high residual density of overstory trees, we do not expect the conifer regeneration to become a significant component of stand structure and are not planning to thin the understory at this stage.

2) Rethin (RET): This treatment includes the initial thinning to 100+ TPA and a second thinning conducted as part of the DMS that reduced the density to a clumpy distribution of 40 to 60 TPA. We now propose a third thinning to reduce the overstory to 30 TPA, plus an additional five trees left for snag recruitment. This treatment is "paired" with the MD and HD treatments on the initial thinning sites in that the final residual density target

(30 TPA) is the same in all three treatments. This pairing will facilitate analysis and modeling of future stand trajectories. The primary goal of the treatment is to maintain and encourage the development of structural diversity, especially in the understory layers. The two thinnings already implemented facilitated understory regeneration of various species, including Douglas-fir and western hemlock. To maintain the growth of the advanced regeneration and avoid unstable conditions, i.e., unfavorable height/diameter ratios of the seedlings, requires more growing space. The additional thinning is intended to open the canopy to a level that seedlings can maintain strong growth and vigor. In many spots the advanced regeneration is clumpy and dense. Thinning the stand again will damage some seedlings, especially seedlings of larger size classes. However, with careful logging we expect that advanced regeneration will still be sufficient to provide a significant component of future stand structure, i.e., will be > 30 TPA. The PCT prescription (see below) will take the harvesting damage into account.

Understory vegetation

Understory trees, shrubs, and herbs

Understory vegetation contributes to species richness in the short term and to desired stand structure in the long term. Development of diverse and well established understory vegetation to support a variety of arthropod and wildlife species is one of the main goals of the overstory treatments. Because of the importance of the shrubs and herbs as sources of biodiversity, and because tree regeneration has become established in many portions of the stands, we do not plan to implement any treatment of shrub and herb components of the understory at this time. Understory competition control treatments intended to promote conifers would reduce or eliminate desirable stand components that contribute to species and structural diversity, e.g., hardwoods.

Natural regeneration on the rethinning sites is extremely variable, from very dense in some spots to very sparse in others. Dense conifer regeneration, particularly of western hemlock, reduces understory vegetation, potentially leading to a depauperate understory. We expect seedling and understory mortality in seedling patches from logging damage due to the harvesting activities planned for 2009-2011. The status of tree regeneration will be monitored immediately following the third thinning and the need for precommercial thinning will be assessed. PCT will be prescribed and implemented where dense conifer reproduction exceeds 80 trees per acre (TPA) in large patches summing to greater than 30% of the treatment area. Conifer understory density following PCT should be between 50 TPA and 60 TPA. The timing and size specifications will follow standard BLM PCT contracting specifications. To ensure tree species diversity, thinning will focus on cutting "majority" and retaining "minority" species (see "Species choice" below).

Provisions common to both the Initial Thinning and Rethinning Sites

Snags

Large snags are an important characteristic of late-successional habitat and typically in short supply in young managed forests. Several considerations complicate decisions regarding snag recruitment and management in young stands. Snags will likely form immediately following timber harvest due to harvesting damage, increased respiration demands on residual trees, sudden exposure of needles formed in the shade to direct sun, and other factors such as bark beetles. The extent of short-term mortality following harvest varies, but timber harvest-induced mortality should subside within three to five years. Chronic mortality will contribute a low level of snags throughout the life of the stand as a result of competition, root pathogen pockets, and other sources. Episodic mortality will also likely contribute to the total snag pool through periodic blowdown, snow and ice breakage, insect or pathogen outbreaks, or fire. Although the likelihood of episodic mortality over the life of the stand is high, snag recruitment from such sources is highly variable and unpredictable. In addition, trees killed to provide snags at or near the time of thinning when the trees are 10"-16" in diameter are not available later as potential larger diameter snags that supply greater ecological and habitat values.

Because of the importance of snags to late-successional habitat and substantial deficits of snags in the existing stands we established a goal of five large snags per acre in the thinned areas five years after timber harvest. Large snags will also form over time in control areas and within leave islands and stream buffers, but we have not established specific numerical objectives for these unthinned areas. Thus, thinning prescriptions call for leaving five additional trees per acre to ensure the snag goal can be attained (for a total of 25, 35 or 65 TPA corresponding with the 20, 30, or 60 TPA live tree targets). We will monitor whether mortality in the residual overstory meets this objective within the first post-treatment measurement interval (5 years). If snag objectives are not met we will initiate management actions to create sufficient large snags to fill the deficit. We expect that in most treatments natural mortality will provide for snags and no further snag creation will be needed. By documenting which snags were "natural" versus "created", we will be able to quantify natural snag recruitment and compare development, usage, and longevity of the two types of snags.

Small snags also contribute to wildlife habitat and ecological functions. Control areas, leave islands, stream buffers, and other unthinned areas contain a range of tree sizes at fairly high densities, likely leading to high mortality in the smaller size classes. We anticipate that abundant small snags will be created through competition and other factors in these areas, and have not established numerical objectives for smaller snags. We will monitor the number and development of small snags as part of our overstory monitoring protocol.

The final residual live tree density target following commercial thinning of 30 TPA in the moderate and high density treatments, and in most of the variable density treatment, also provides a pool of trees for potential long-term snag recruitment. These trees function as live and dead tree habitat, as sources of regeneration, and as future snags and down wood. We suggest an analysis comparing the amount of snags present relative to desired future stand conditions be conducted at every re-measurement. Additional snags can be created in the future if needed to achieve the desired future stand conditions. However, we expect that in most cases natural mortality processes will provide sufficient large snags over the next 50 to 100 years.

<u>Downed wood</u>

Downed wood is generally lacking in intensively managed landscapes and a crucial part of late successional habitat. Many of the same considerations discussed above under "Snags" apply to the discussion of downed wood as well. The DMS "Desired Future Stand Conditions" call for 900 linear feet of logs, 1/3 greater than 24" in diameter and the rest coming from logs 10"-24" in diameter, when the stands are age 120-150. All decay classes are to be represented. While some ecological values are associated with small logs, larger logs provide habitat for a greater range of organisms and ecological services. Stands in the DMS have not yet attained sufficient diameter to provide logs of 24” in diameter, and almost all trees are currently in the lower portion of the 10”-24” bracket. Our primary approach is to target attainment of the down wood objective for later in stand development. The study objective is to reach half of the Desired Future Stand Condition targets at year 100, and full attainment by year 150. Analysis of remeasurement data will determine if additional logs will need to be created by management actions to meet this objective.

In addition to measurements and actions aimed towards reaching the down wood targets in the long term, we also prescribe a minimum level of downed wood in the short term. Two dominant or co-dominant trees per acre should be felled from thinned areas as down wood during thinning operations. Current downed wood levels vary across and within sites, and additional logs will be created naturally from snag fall, storm damage, or other sources over time. These factors combine to create spatially and temporally variable levels of downed wood in keeping with the high variability in dead wood found in natural stands. Provision of two additional logs per acre also applies to the third thinning in the High Density treatment and in the high density portions of the Variable Density treatment when future operations are conducted.

Species choice

To ensure maximum tree species diversity, thinning will focus on cutting “majority” and retaining “minority” species. Thinning operations should not remove any trees of species that make up less than 10% of the overstory. Overstory tree species making up greater than 10% of the overstory should generally be removed in proportion to their abundance. Residual overstory trees of all conifer species, but not hardwood species, will be counted towards target tree density.

Measurement and treatment timing

Study treatments are now defined by multiple, sequential manipulations. Ecosystem responses measured after this round of treatments is installed can not be attributed to a single management activity, but will be the result of a set of manipulations that together make up the treatments.

Vegetation measurements are collected on a five-year remeasurement schedule (years 1, 6, and 11 post treatment, see Appendix 1). To minimize problems due to confounding manipulations, we plan to document the response to the initial manipulations 11-years after they were implemented. These measurements will also be used to characterize pre-manipulation conditions and, in conjunction with post-manipulation surveys, will be used to document the extent and intensity of the second manipulation. Thus, implementation of the second set of manipulations in year 12 following the initial manipulations is critical. Any delay will lead to lower data quality and should be avoided.

Appendix 1 - Measurement and treatment schedule

The remeasurement schedule has been constructed to standardize measurements on the same year of post-treatment stand development so that measurements are on a comparable basis across the study. The basic remeasurement interval is every five years, i.e., post-treatment years 1, 6, and 11. Follow-up treatments are planned for year 12 post-treatment immediately following the year 11 remeasurement. This schedule will simultaneously provide year 11 post-treatment data for the first round of thinning and pre-treatment data for the second entries.

Initial thinning sites

Site name	Majority initial harvest completed	Initial measurement (date/growing seasons post harvest)	Reinstall plots (year/growing seasons post harvest)	Remeasure plots (year/growing seasons post harvest)	Second thinning planned
Bottomline	11-97	9-98/1	2003/6	2008/11	2009
OM Hubbard	11-97	9-00/3	2003/6	2008/11	2009
Keel Mtn	12-97	9-99/2	2003/6	2008/11	2009
Callahan Cr*	1-98			2008	2009
North Soup	8-98	9-00/2	2004/6	2009/11	2010
Green Peak	1-00	4-02/2	2005/6	2010/11	2011
Ten High	1-00	4-02/2	2005/6	2010/11	2011
Delph Creek	4-00	3-03/3	2005/6	2010/11	2011

* Although Callahan Creek does not contain the full set of treatments it is integral to the riparian buffer component of the study

Rethinning sites

Site name	Majority harvest completed	Initial measurement (date/growing seasons post harvest)	Reinstall plots (year/growing seasons post harvest, fall 2003)	Remeasure plots (year/growing seasons post harvest)	Third thinning planned
Sand Creek	11-97	9-98/1	2003/6	2008/11	2009
Little Wolf	9-98	7-00/2	2004/6	2009/11	2010
Blue Retro	3-99	8-99/1	2004/6	2009/11	2010
Perkins Creek	3-00	10-00/1	2005/6	2010/11	2011

NOTE: Keel Flat and Ward Creek have been dropped as rethinning study sites

Appendix 2 - Response to review comments

1. Need to model stand treatments to see if stated desired conditions are achievable over long time frames; does 30 TPA leave enough trees for long-term green and dead tree objectives?

We agree that this is an important question and we need to link the thinning prescriptions to long-term live and dead tree goals. Stand growth models can do an adequate job of assessing overstory dynamics, but recruitment and mortality are usually the weakest components. We reviewed results from three relevant young stand modeling exercises for west-side Douglas-fir dominated stands: Garman et al (2003), Andrews et al. (in press), and Kintop (unpublished report). While none of the modeled prescriptions exactly match the prescriptions in the proposal, all three studies indicate that the proposed treatments are "in the ballpark". It is important to keep in mind that the goal of the selected treatments in this study is not necessarily to find the "best" treatment, but the study is designed with treatments to bracket desired future conditions. This will ensure the maximum amount of information gained for a variety of stand conditions and objectives. We are still open to more stand modeling to validate proposed treatments.

2. Need to learn more about aquatic and riparian response to these treatments, including sediment production.

We agree that there are many needs and opportunities. We are open for cooperation with interested scientists. If high priority needs are identified and funds are available we are eager to add new components to the study. We will be briefing agency leaders in an attempt to promote study visibility and additional collaborations.

3. Is 12 years long enough to adequately assess the responses of organisms that we are interested in monitoring?

A second round of treatments is consistent with the original intent of the study, as communicated by John Tappeiner. The intent was not to investigate the long term impact of a single treatment. Instead we are interested in comparing the impacts of different management approaches to accelerate late successional habitats. Like any silvicultural system, these approaches consist of multiple treatments. The question is not only a research issue, but an issue of when managers feel they have enough information to make decisions. The certainty of information varies by topic. Some trends are evident in the short term. For example, analysis of first five-year post-treatment vegetation responses are underway now, but preliminary results are not showing major shifts following moderate or high density thinning, nor are they showing major effects to aquatic systems even with reduced riparian buffers. With the overstory closing in, we don't expect to see more dramatic differences in the future. On the other hand, other trends, such as wildlife populations may not be detectable at this time.

We also feel that testing management approaches (with multiple treatments) makes more sense as on-the-ground practices are commonly implementing heavier thinnings then the current treatments. The proposed treatments will match these conditions more closely.

Clearly, this is a balancing act. Overall, we feel there is more to learn by implementing another round of treatments than by continuing to monitor responses that are likely to converge (among treatments) and stabilize over time.

4. Should re-treatment timing be triggered by a stand development criterion, e.g., unfavorable height-diameter ratio, rather than an arbitrary timing (i.e., 12 years post-treatment).

A stand development criterion as a trigger makes good sense for an operational prescription. Experimental design and logistical considerations make this approach somewhat impractical for a large, complex study. The proposal was based in part on study team field trips to study sites where observations of stand conditions and development trends such as height-diameter ratios were discussed. Thus, the implementation in year 12 is not arbitrary but directly linked to stand development. Also, post-treatment re-measurements are scheduled every five years (i.e., post-treatment years 1, 6 and 11) and it is important to have a re-measurement just prior to treatment implementation.

5. Still need to assess planted conifer performance in gaps and in underplant plots

We all agree that we need to build this into our monitoring plans. A proposal is currently pending to implement this monitoring.

Measurement questions

1. Can we define treatments by relative density rather than TPA?

We can describe treatment using relative density, but at this stage decided to keep TPA for designing and defining treatments. The main reason is that TPA provides direct information about potential for future snag and downed wood component, which is a major concern in treatment selection. We will however, present the results using TPA and relative density to provide information in a form that can be applied for stands with different initial stand structures.

Editorial issues

1. The Density Management Study stand condition goal for snags is higher than the Old-Growth Definition Task Group minimum standard for snags.

Study management issues

1. Need a way (e.g., a land allocation in the RMPs) that protects these sites for the long term to meet study objectives

References:

Andrews et al. submitted

Garman, S. L.; J.H. Cissel, and J.H. Mayo. 2003. Accelerating development of late-successional conditions in young managed Douglas-fir stands: A simulation study.. USDA Forest Service, Pacific Northwest Research Station: Portland, OR. PNW-GTR-557. 57pp.

Perkins, J.P. 2000. Land cover at northern spotted owl nest and non-nest sites, east-central coast ranges, Oregon. M.S. thesis. Department of Forest Resources, Oregon State University, Corvallis, OR.

Courtney, S.P.; J.A. Blakesley; R.E. Bigley; M.L. Cody; J.P. Dumbacher; R.C. Fleischer; A.B. Franklin; J.F. Franklin; R.J. Gutiérrez; J.M. Marzluff; and L. Sztukowski. 2004. Northern Spotted Owl Status Review. Sustainable Ecosystems Institute, Portland, Oregon. http://www.sei.org/owl/finalreport/finalreport.htm

Kintop (unpublished report)