# Finney Adaptive Management Area Assignments - Phyllis Reed

DRAFT - July 25, 2008 Update July 1, 2010

**Hypothesis or Question being explored:**
***Question 1:*** *Can certain structural attributes of late seral and old growth stands be created in young stands without compromising long-term development of old-growth forest characteristics?*
***Theme:*** *Creation of late and old seral characteristics in young second growth - murrelets*

- Identify structural characteristics of marbled murrelet nesting habitat suitability and test the development of suitable murrelet nesting habitat. Attributes of favorable murrelet nest trees are described for Washington state as large diameter dominant trees (>150 cm or approx. 60 inches dbh) with large lateral branches (>15 cm or approx. 5 inches), with canopy cover (>80%) for access, but limited exposure to nest predation, 34 meters above ground in Washington. (see Table 2 - Summary of nest height and height and diameter at breast height (DBH) of nest trees used by Marbled Murrelet in North America (after Burger 2002)Burger 2002)

**Feasibility of this theme: High for Murrelet nesting habitat:**
The Finney AMA emphasis is the restoration of late-successional forests and identifies special needs for the marbled murrelet. Since the Finney AMA is with 40 miles of saltwater, and includes a large portion of second growth forest stands, there is opportunity to target stand management for murrelet nesting habitat. Since the Finney AMA contains a large portion of forest cover in the Silver fir Plant associations Groups (PAGS), there is an opportunity to test stand treatments to develop suitable murrelet nesting habitat in both the western hemlock zone and the Pacific Silver-fir zone.
"It is also the opinion of the panel* that second-growth stands exist on many ownerships in California, Oregon, and Washington that provide excellent opportunities to accelerate the development of suitable nesting habitat for murrelet. … Natural stand development processes that would move existing second-growth stands into suitable murrelet nesting habitat are slow, however, and have limited predictability in time and space. Silvicultural treatment of stands and, perhaps, individual trees can accelerate the process by at least several decades in the panel's opinion." (A.B. Carey, et al, 2003)

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* 2002 Scientific Panel on Restoration of Marbled Murrelet Habitat - Members of panel were: Andrew B. Carey, College of Forest Resources, University of Washington; Steven P. Courtney, Sustainable Ecosystems Institute; Jerry F. Franklin (chair), College of Forest Resources, University of Washington; John M. Marzluff, College of Forest Resources, University of Washington; Martin G. Raphael, College of Forest Resources, University of Washington; John C. Tappeiner, School of Forestry, Oregon State University, and Dale A. Thornburgh, Humboldt State University

*Managing Second-Growth Forests in the Redwood Region to Enhance Marbled Murrelet Habitat.* 2003. Scientific Panel on Restoration of Marbled Murrelet Habitat, Andrew B. Carey, Steven P. Courtney, Jerry F. Franklin (chair), John M. Marzluff, Martin G. Raphael, John C. Tappeiner, and Dale A. Thornburgh. Sustainable Ecosystems Institute

**What is the research hypothesis?**
*The question is can manipulation of second growth forest stands (both within the western hemlock and Pacific silver fir zone?) result in the development of suitable nesting habitat for murrelets, while minimizing corvid nest predation?*

*The hypothesis is that branch structure within treated second growth stands will vary substantially from untreated stands, with the prediction that treated stands will have significant*

*greater number of large diameter trees, with large diameter branches than untreated second growth stands.*

The null hypotheses to be tested include:

**1. Branch diameter**: There are no differences between branch diameters in treated and untreated stands (within stands of the same forest zone or PAG). The desire is to create limbs greater than 15 cm., but due to the time to reach that size, this proposal will evaluate growth trends with comparison of branch sizes in the upper third of the tree canopy. **(**See Table 3. Characteristics of tree branches used as nest sites by Marbled Murrelet in North America (Nelson 1997); values are the mean +/- one standard deviation with the range and sample size in parentheses.

2. **Large branch numbers:** There are no differences between the number of large branches or platforms between treated and untreated stands (within stands of the same forest zone or PAG). In Oregon, an average of 24 limbs >15 cm. was found in murrelet nest trees (Nelson and Wilson 1999). Due to the time needed for development of desired large limbs, this study will evaluate growth trends in number of large branches in the upper third of the canopy projection. Number of limbs greater than 15 cm diameter will be tallied after 25 years following treatment. (See Table 4. Characteristics of nest trees (n = 24) compared with other trees with platforms in the nest plot (n = 284) and in other plots within the same stand (n = 640) in Oregon (Nelson and Wilson 1999).

3. **Habitat composition features correlated with murrelet predation:** There are no differences in the continuity and canopy cover between treated and untreated stands and the levels of murrelet predation from corvids (within stands of the same forest zone or PAG). Canopy of approximately 80 percent cover is typical of stands with murrelet occupancy. See Table 3. Characteristics of tree branches used as nest sites by Marbled Murrelet in North America (Nelson 1997**)**.

4. **Tree species Response:** There are no differences between branch diameters and number of platforms between treated Western hemlock zone stands and Pacific silver-fir zones. In Oregon, murrelet nest tress had three time the number of large platforms ( > 15 cm. than other trees in the nest stand and in other forest stands. See Table 4. Characteristics of nest trees (n = 24) compared with other trees with platforms in the nest plot (n = 284) and in other plots within the same stand (n = 640) in Oregon (Nelson and Wilson 1999)

Why is it important to the management of National Forest System lands? *The research of stand manipulation for murrelet nesting is important for the development of habitat improvement guidelines that can be tailored for use in site-specific prescription. With limited resources it is important for managers to understand where resources might be most effective in providing desired structure. If treatment results in the western hemlock zone are significantly different than Pacific –fir zone, than managers can better target where to apply efforts to move stands toward desired structure, or to avoid treatments with little impact. This would assist the National Forest in managing habitat to promote the recovery of marbled murrelets (management emphasis in the Finney AMA and other Late Successional Reserves) and effectively use limited resources.*

What methods would be used to test the hypothesis? See study design below adapted from the 2002 Scientific Panel on Restoration of Marbled Murrelet Habitat: *Managing Second-growth Forests in the Redwood Region to Enhance Marbled Murrelet Habitat*. While this study was designed for the Redwood Region, the principles of designing a study to test forest stand prescriptions to promote murrelet habitat are applicable to other regions

**Project Title:** *Managing Second-growth Forests in the Finney AMA to Enhance Marbled Murrelet Habitat*

**Nest Tree Characteristics:** The following tables provide information from 20 years on over 200 nests, most of these from studies in British Columbia (2002/2003 Scientific Panel on Restoration of Marbled Murrelet Habitat). While recent information includes a cliff and an alder nest site (Pacific Seabird Meeting, 2008) murrelets nest selection is highly associated with conifer trees (Table 1) and large trees with the associated large branch structure (See Tables 2, 3 and 4) as reported in the 2002/2003 Scientific Panel on Restoration of Marbled Murrelet Habitat, and other literature such as the General Technical Report on the Ecology and Conservation of the Marbled Murrelet, USDA Forest Service, 1995.

**Table 1. Tree species used for nesting by Marbled Murrelets in North America.**

| Tree species | British Columbia[a] | Alaska[b] | Washington[b] | Oregon[b] | California[b] | Total |
|---|---|---|---|---|---|---|
| Western hemlock | 19 | 6 | 3 | 11 | 1 | 40 |
| Mountain hemlock | 3 | 9 | 0 | 0 | 0 | 12 |
| Douglas-fir | 14 | 0 | 3 | 32 | 4 | 53 |
| Sitka spruce | 11 | 5 | 0 | 1 | 0 | 17 |
| Western red-cedar | 12 | 0 | 0 | 1 | 0 | 13 |
| Yellow cedar | 61 | 0 | 0 | 0 | 0 | 61 |
| Silver fir | 2 | 0 | 0 | 0 | 0 | 2 |
| Coast redwood | 0 | 0 | 0 | 0 | 9 | 9 |
| Red alder | 1 | 0 | 0 | 0 | 0 | 1 |
| Total | 123 | 20 | 6 | 45 | 14 | |

[a] Bradley and Cooke, unpublished data; Burger et al. 2000; Burger, unpublished data; Dechesne and Smith 1997; Hooper 2001. [b] Nelson 1997.

**Table 2. Summary of nest height and height and diameter at breast height (DBH) of nest trees used by Marbled Murrelet in North America (after Burger 2002).**

| | No. of | Nest height (m) | | Tree height (m) | | Tree DBH (cm) | | |
|---|---|---|---|---|---|---|---|---|
| | Nests | Mean ± SD | Range | Mean ± SD | Range | Mean ± SD | Range | Source |
| SW Vancouver Island | | | | | | | | |
| Carmanah-Walbran | 10 | 41 ± 8 | 31-54 | 69 ± 8 | 56-80 | 239 ± 66 | 133-370 | Burger, unpubl. |
| Clayoquot Sound (random climbing) | 5 | 31 ± 9 | 19-40 | 42 ± 4 | 38-48 | 171 ± 92 | 60-310 | Conroy et al. 2002 |
| Clayoquot Sound (telemetry) | 6 | - | - | 36 ± 12 | 26-58 | 90 ± 23 | 55-119 | R. Bradley, unpubl. |
| SE Vancouver Island | 3 | 33 ± 5 | 29-40 | 47 ± 12 | 40-61 | 134 ± 26 | 119-165 | Burger et al. 2000 |
| Sunshine Coast | | | | | | | | |
| Caren range | 1 | 17.4 | - | 30 | - | 93 | - | Jones 1993 |
| Bunster range | 52 | 20 ± 1 | 12-30 | 28 ± 1 | 17-45 | 100 ± 3 | 60-153 | Manley 1999 |
| Telemetry sample | 17 | 33 ± 9 | 18-45 | 47 ± 11 | 30-69 | 123 ± 54 | 36-250 | R. Bradley, unpubl. |
| Queen Charlotte Is. | 1 | 11 | - | 15 | - | - | - | Dechesne & Smith 1997 |
| Alaska | 20 | 15 ± 4 | 9-24 | 24 ± 5 | 15-34 | 66 ± 23 | 27-120 | Nelson 1997 |
| Washington | 6 | 34 ± 13 | 20-53 | 57 ± 8 | 45-65 | 150 ± 45 | 89-220 | Nelson 1997 |
| Oregon | 45 | 42 ± 15 | 14-75 | 62 ± 14 | 36-85 | 165 ± 53 | 76-279 | Nelson 1997 |
| California | 14 | 47 ± 12 | 32-68 | 73 ± 10 | 49 – 87 | 308 ± 156 | 139-533 | Nelson 1997 |

**Table 3. Characteristics of tree branches used as nest sites by Marbled Murrelet in North America (Nelson 1997); values are the mean +/- one standard deviation with the range and sample size in parentheses.**

| Characteristic | California | Oregon | Washington | British Columbia | Alaska |
|---|---|---|---|---|---|
| Branch diameter at trunk (cm) | 44 ± 13.1 (21-61; 8) | 25 ± 10.4 (12-56; 42) | 38 ± 13.9 (14-51; 6) | 29 ± 11.7 (8-62; 50) | 15 ± 5.8 (7-27; 17) |
| Branch diameter at nest (cm) | 25 ± 7.6 (16-37;6) | 34 ± 13.5 (10-63; 12) | 29 ± 15.3 (11-46; 4) | 18 ± 3.5 (15-20; 2) | 20 ± 5.0 (12-28; 17) |
| Branch length (m) | 4 ± 3.9 (1-15;13) | 5 ± 2.4 (1-12; 42) | 4 ± 2.7 (1-8; 5) | 3 ± 2.0 (1 – 10; 51) | |
| Branch crown position (%) | 64 ± 12.2 (50-91; 14) | 68 ± 17.5 (26-98; 44) | 63 ± 17.2 (41-82; 5) | 71 ± 12.8 (40-95; 51) | 60 ± 12.3 (40-79; 19) |
| Distance to nest from trunk (cm) | 23 ± 39.3 (0-122; 14) | 100 ± 130 (0-762; 44) | 22 ± 27.2 (0-57; 5) | 47 ± 78.5 (0-340; 50) | 80 ± 70.6 (0-224; 18) |
| Cover above nest (%) | 87 ± 28.5 (5-100; 13) | 78 ± 21.2 (5-100; 41) | 89 ± 10.7 (70-100; 6) | 78 ± 15.3 (30-100; 47) | 84 ± 20.6 (25-100; 12) |

"Presence of one or more suitable nest platforms is perhaps the most important single attribute in nest tree selection. Branch diameter is a key predictor of suitable platforms, although presence of moss, mistletoe, and branch deformities also contributes to platform suitability. Branch diameter at known nests averages 26 cm; branch diameter at the trunk averages 27 cm (Table 4, Nelson 1997). Observed branch diameters vary across the species range from 15 cm in Alaska to 44 cm in California (Table 4). Branch diameter does not appear to vary with tree species as much as tree size, perhaps reflecting selection of suitable branches by nesting birds. Nest branches from Douglas-fir in California average 39 cm and branches from coast redwood average 36 cm (Table 3). In Oregon, Nelson and Wilson (1999) compared characteristics of randomly selected nest trees with a sample of other trees with platforms in the same plot as the nest tree and in another sample of trees in the same general stand (Table 4 - below). Nest trees were larger, had more platforms and more large platforms, greater moss depth, and greater horizontal cover than other trees in the nest plot or stand." A.B Carey et al, 2003

**Table 4. Characteristics of nest trees (n = 24) compared with other trees with platforms in the nest plot (n = 284) and in other plots within the same stand (n = 640) in Oregon (Nelson and Wilson 1999). Different letters in each row indicate significant differences; the same letter indicates no difference. Values are means +/- one standard error.**

| Characteristic | Nest trees | Platform trees in nest plot | Platform trees in other plots | ANOVA P-value |
|---|---|---|---|---|
| Tree diameter (cm) | 116 ± 10 a | 94 ± 2 b | 102 ± 1 ab | <0.001 |
| Platforms per tree | 31 ± 5 a | 17 ± 1 b | 20 ± 1 b | <0.001 |
| Large (= 15 cm) platforms per tree | 24 ± 6 a | 7 ± 1 b | 8 ± 1 b | <0.001 |
| % moss on tree | 71 ± 5 ab | 73 ± 1 a | 69 ± 1 b | 0.042 |
| % moss on platforms | 84 ± 2 a | 80 ± 1 ab | 79 ± 1 b | 0.018 |
| Moss depth on platforms (index) | 2.8 ± 0.09 a | 2.5 ± 0.03 b | 2.4 ± 0.03 b | <0.001 |
| Horizontal cover (index) | 1.8 ± 0.06 a | 1.6 ± 0.03 b | 1.6 ± 0.02 b | 0.047 |
| Vertical cover (index) | 2.1 ± 0.07 a | 2.1 ± 0.03 a | 1.8 ± 0.02 b | <0.001 |

Marbled murrelets are described as selecting large trees for nesting, with sufficient height to allow landing and taking off from nesting branches. Canopy should be sufficiently opening for unobstructed access to the large limbs with overhead cover to reduce threat of nest predation. Large numbers of limbs for suitable nesting platform with suitable nesting substrate also appear to be characteristic of stands used by nesting murrelets (Nelson and Wilson 1999, Hamer , 1995).

**Nest predation:** Stellar's jays are frequently associated with edges and patches while ravens are less associated with edges. Crows are reported as relatively common and found in association with ready food sources, from agriculture and settlements to roadways and campgrounds. Given the various corvid forage patterns, nest sites that are well concealed at intermediate height (upper 1/2 of tree) in the tree are less likely to be preyed upon (Marzluff et al from the 2002/2003 Scientific Panel on Restoration of Marbled Murrelet Habitat). See Table 4. Characteristics of nest trees (n = 24) compared with other trees with platforms in the nest plot (n = 284) and in other plots within the same stand (n = 640) in Oregon (Nelson and Wilson 1999).

**Objectives of stand treatments:** Treat stands to accelerate development of a) additional nest sites (trees with large branches, > 15 cm), b) maintain or develop protective cover (80%) for marbled murrelet nesting habitat and c) create suitable Marbled Murrelet nesting habitat within the LSRs. Specific objectives in treating second-growth stands will include the following:

- Accelerate development of a population of large, dominant trees that will provide :
  - Large branch structures (> 15 cm) needed for nesting sites; and
  - Protective cover (80% canopy closure) along edges of existing occupied or suitable Marbled Murrelet habitat;
- Reduce overall stand density to provide less competition for residual trees
- Increase uniformity (size and spacing) of trees in stands that are not selected as dominants so as to provide cover (80% canopy closure) ;
- Enhance stand stability with regards to wind and other disturbances

See Tables 2, 3 and4 for reference to the above characteristics.

Silvicultural treatments to meet the objectives would focus on:

1) Reduce overall stand density to a recommended basal area developed with a silvicutluralist so as to enhance development of the stand as a whole; (see Tables 2,3 and 4 for development of silvicultural prescription)
   - Replication of various average basal area reductions would be apportion the experimental work across 4 or more independent stands within the western hemlock zone to achieve desired stand densities in densely stocked 40 to 60 year old stands to promote stand and tree characteristics as listed in tables 2,3, and 4.
2) Additional release (by removal of neighboring trees – 1 tree height at time of treatment) for selected dominant trees (upper 10% of tree diameters in stand) selected for their potential to develop large branches and deep crowns could be another subset of the thinned from below stands or separate trials within unthinned stands and within both of the major forest zone plant association groups:
   - Western hemlock zone -
   - Silver fir zone – "gapmaking"(Ken Lertzman-PSF forest studies)

**Prescriptions elements**:

1. **General thinning from below**-i.e., removal of smaller diameter trees throughout the stand so as to bring overall stand densities down to levels that will provide for sustained growth rates on the remaining dominants and co-dominants. Stand density targets could be tested with various prescriptions depending on existing stand conditions.
2. **Trial release for potential murrelet nest trees**-i.e.,
   a) **Remove competitors around a well distributed set of strongly-dominant second-growth Western hemlock, Western Red Cedar, Douglas-fir trees, which have the potential to develop large branches and deep crowns**. The removal of competing trees would meet a desired stand density goal with the objective to provide additional light, moisture and nutrients to the residual trees in 60 to 80 year-old-stands. The

selected dominant trees should be well distributed through the stand with selection of clusters of 2 to 4 trees as well as singletons; clusters would be counted as single trees in assessing target tree/acre densities. Replication trial release could distribute the experimental work across independent stands within the western hemlock zone of the Finney AMA.

b) **Remove competitors within stands of second-growth Pacific Silver fir trees.** The removal of trees would utilize a "gapmaking" approaching of removal of 15-16 trees, leaving clumps of residuals in the 40 to 60 year old stands. Replication of trial release could distribute the experimental work across independent stands within the Pacific silver fir zone of the Finney AMA.

**Silvicultural Justification for Treatments**

Stand development models for the western hemlock zone show that average stand diameter growth is slowed at densities typically encountered in dense second-growth stands that have not been thinned. Stand development models provide guidelines that can be used to calculate appropriate stand densities to achieve desired sustained tree growth rates. In the 40 to 70-year-old stands, thinning to overall stand densities of for example 90 to 120 tpa may be desirable to sustain desired average stand diameter growth rates. The thinning from below of a 50-year-old stand would have a goal of retaining 25% and 50% of the preharvest basal area based on studies within the region where increases in diameter growth rates were obtained (cite studies).

Dominants with complex crowns and large branches are potential nest trees. Thinning or competition removal has the goal of accelerating tree development and to stimulate development of secondary leaders or epicormic branches, to provide nesting sites in new branch structure. Additional sunlight penetration may assist in branch development.

In attempting to develop dominant trees, releasing more resources to both the root system (moisture and nutrients) and canopy (light) of the residual is considered important. Removal of neighboring dominants and co-dominants, up to ½ tree height to south of the trees selected for release, would provide additional direct sunlight to developing side branches and epicormic branch systems as well as overall tree growth. Removal of neighboring trees immediately adjacent to the selected trees will provide additional moisture and nutrients.

Douglas-fir, Western red cedar, and Western hemlock are the primary candidates as potential nest trees given the history of murrelet nest locations. Douglas-fir has the advantage of rougher branch bark, which assists in developing epiphytic communities. Hemlock frequently has mistletoe infestations that lead to branch thickening and platform development. Western red cedar supports a branching structure with multiple leaders. Initiation of branches as tree leaders is a process that provides a large diameter "elbow" that can provide high-quality nesting sites. Silver fir and grand fir have less potential to develop suitable nest sites, given tree morphology, but have not been studied as much as the western hemlock zone.

**Number of Stand Entries**

Another hypothesis to test is in regards to the number of stand entries advantageous to developing the desired branch structure for murrelets. The null hypotheses to be tested:

**Branch diameter:** There are no differences between branch diameters in single stand treatments and multiple stand treatments (within stands of the same forest zone or Plant Association Group)

The question on number of stand entries may depend on the age and forest zone of the proposed treated area, as to what will accelerate development of murrelet nesting sites. Early stand treatment may be advantageous for keeping the stand structure relatively simple and preserving

later options for developing a more complex structure with many of the attributes of old-growth stands in the future. As the stand develops, stand characteristics should be reviewed for potential need of increased density reduction around the selected large trees to provide space for crown and nest site development

Second entries to reduce densities around the selected trees may be appropriate, however, in stand restoration efforts (see Garman, Cissel, and Mayo 2003, for example). A specific example is in stands where there is poor canopy differentiation or the crowns and canopies close quickly. Another example is when young stands develop at high densities, when natural regeneration from sprouts and natural seeding following logging was particularly successful. In young dense stands a pre-commercial thinning may be appropriate to prevent stands from developing under very high densities. This could be followed in two decades by a commercial thinning or gap making to develop dominant trees as previously described.

Stands also exist that have grown several decades at very high densities and have small crowns and tree diameters. Such trees are typically "spindly" with high height to diameter ratios. They are very susceptible to damage by wind, snow, and ice (Wilson and Oliver 2000, Wonn and O'Hara 2001). Here a light (low intensity) initial thinning from below should be considered to develop tree and stand stability. A second thinning, which follows our general prescriptive guidelines, would follow in 10 to 20 years to promote development of murrelet nesting structures.

**Quantification of Effects of Treatments**

Quantifying the effects of the thinning treatments proposed is possible with regards to some, but not all, of the stand and tree attributes of interest. Qualitative statements would be made about the direction and general level of response based upon basic scientific studies of tree and stand development processes and some empirical data. Various stand models can be used and developed for certain stand attributes, such as growth in basal area and quadratic mean diameter (QMD) and changes in diameter distribution.

**Monitoring:**

**"The effectiveness of management depends on the quality of information on which it is based. One of the concerns of managers who must balance uncertainties with the benefits of action is to determine what information might reduce uncertainty and preclude unintended consequences. Monitoring of the results of management is one way to gain such information and allows management to be adaptive. To be efficient monitoring should focus attention on issues of greatest concern. Note that these are not necessarily the areas of greatest uncertainty; the level of risk may be the most appropriate issue. For instance, there is general agreement that thinning will increase limb growth and murrelet habitat development. We lack however detailed information on the timescale at which benefits will accumulate (although our best professional judgment is provided above). Hence there is some uncertainty on this issue – but little risk. Managers may feel more compelled to monitor for effects that, although unlikely, carry some risk.**

**We stress that monitoring should address management needs. Although scientists can identify uncertainties, and can devise monitoring programs, it is managers who must articulate their needs, and how they will respond to potential results. Monitoring should itself be adaptive. As information accumulates it may not be necessary to continue monitoring of some issues, while other data may become more important."**

**Growth responses of trees:** *The issue here is the rate at which benefits accumulate. Existing best professional judgement is that such benefits (new nesting habitat) will accumulate beginning in approximately the 40th year post-treatment (although growth responses should be apparent before then). Monitoring of tree responses is unlikely to change the professional judgement of the panel or the relatively firm panel conclusion of the benefits of thinning; the response of forest stands to thinning is well established (citations).*

*Moreover there can be no reasonable expectation of feedback between monitoring and changes in e.g. treatment design. Hence in this case we see relatively little benefit in monitoring responses, beyond those measures that can be made at low cost. If such data are collected they might include development of limbs suitable as nesting platforms, and changes in the crown of selected trees from fixed points on roads using laser instruments.*

**Definition of Experimental/Sample Unit**:
**Proposed sample size or number of experimental replicates**:

- **Thinning from below -** Replication of various average basal area reductions would apportion the experimental work across 4 or more independent stands within the western hemlock zone to achieve desired stand densities in densely stocked 40 to 60 year old stands. Stocking reduction is expected to influence tree diameter, and crown development, as branch development.
- **Remove competitors within stands PSF Zone-** The removal of trees would utilize a "gapmaking" approaching of removal of 15-16 trees, leaving clumps of residuals in the 40 to 60 year old stands. Replication of trial release could distribute the experimental work across independent stands (4 of more) within the Pacific silver fir zone of the Finney AMA.
- **Remove competitors within W.Hemlock zone**. The removal of competing trees would meet a desired stand density goal with the objective to provide additional light, moisture and nutrients to the residual trees in 60 to 80 year-old-stands. The selected dominant trees should be well distributed through the stand with selection of clusters of 2 to 4 trees as well as singletons; clusters would be counted as single trees in assessing target tree/acre densities. Replication trial release could distribute the experimental work across independent stands (4 or more) within the western hemlock zone of the Finney AMA.

<u>Feasibility Analysis</u>
**Capability**: Are there enough locations to implement a sampling design?
Yes – based on a strategy of using 4 independent stands within the western hemlock and Silver-fir zone for testing ideas on stand density or trial release of dominant trees.

**Cost/Revenue/workforce:** Budget: thinning from below may have potential for revenue generating to offset the cost of implementation. Release of dominants might also have the potential for revenue generation with trees removed to be sold.