DRAFT

Initial Responses of Forest Floor Vertebrates to Thinning in the Oregon Cascades

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In 1990, John Tappeiner, Loren Kellogg, and Brenda McComb from OSU met with silviculturists and wildlife biologists from the Willamette National Forest at the Lowell Ranger District office. The Forest Service managers wished to explore development of a manipulative study designed to test the hypothesis that active management of young, even-aged plantations in the Oregon Cascades would set the stands on a development trajectory toward an old-growth-like conditions sooner than if they were left to develop unmanaged. This hypothesis was an outcome of similar experiments that had been initiated at McDonald-Dunn Forest in older stands, and studies that were being initiated at that time in the Oregon Coast Range on the Siuslaw National Forest and nearby BLM lands. Further the hypotheses were supported by modeling simulations (McComb et al. 1993, Carey 2003) and some of those involved in the Lowell meeting had taken a continuing education course at OSU which demonstrated the potential effects of thinning on stand development to produce certain habitat elements. Thus began the Young Stand Study. In addition to manipulating stands to achieve habitat structure goals, harvesting systems were designed and monitored to assess the economics of each system and small diameter sawlogs were sold to local mills.

Experimental Design

Planning of the experiment was truly interdisciplinary and stakeholder driven. District silviculturists, harvest planners, and wildlife biologists designed the study with guidance from Tappeiner, Kellogg, and McComb and eventually a suite of other university and agency scientsts. The initial study design was based on 4 treatments to 30- to 40-year-old stands:

1. Light thin (LT) – Stand density was reduced to approximately 110 trees per acre (271/ha) and represented a typical stand density reduction in Douglas-fir plantations to promote rapid individual tree growth while maintaining a relatively closed canopy. This treatment tested the hypothesis that standard silivicultural practices would produce stand structure and composition more similar to old-growth over time more quickly than doing nothing at all.
2. Light thin with gaps (LTG) -- Stand density was reduced to approximately 110 trees per acre (271/ha) and in addition 20% of the stand had 0.5-acre (0.2 ha) openings evenly spaced throughout the stand. Gaps were designed to add horizontal heterogeneity to the stand similar to what might be expected from gaps formed by tree death in old-growth stands, leading to greater patchiness. Gaps were planted to a mixture of Douglas-fir, western hemlock, western redcedar, and western white pine; sprouts from bigleaf maple and golden chinkapin also contributed to gap regeneration. This treatment tested the hypothesis that standard

silivicultural practices modified to include gaps would produce stand structure and composition more similar to old-growth over time more quickly than a standard silvicultural thinning.

3. Heavy Thin (HT) – Stand density was reduced to 50 trees per acre (123 trees per ha) and seedlings of Douglas-fir, western hemlock, western redcedar, and western white pine. Such a heavy thinning opened the canopy considerably allowing sunlight to strike the forest floor and supposedly would allow planted regeneration to grow to form a second story in the stand, increasing vertical complexity. Studies from the Oregon Coast Range indicated that natural regeneration following fires often occurred slowly and at low tree density, producing low density stands where individual trees were free to grow rapidly early in stand development. Heavy thinning and underplanting was designed to set the stand on a trajectory more typical of what might have been expected following natural disturbances in the region. This treatment tested the hypothesis that these rapidly growing trees and associated second story would produce stand structure and composition more similar to old-growth over time more quickly than any other treatment.
4. No Thin (NT) – As a point of comparison to stands treated as described above, we also sampled stands similar in stand density and species composition to treated stands (before they were treated) to understand stand dynamics and associated habitat element dynamics without silvicultural treatments. In addition to providing a point of comparison, this treatment tested the hypothesis that no silivicultural treatments would take the longest time to produce stand structure and composition similar to old-growth, if at all.

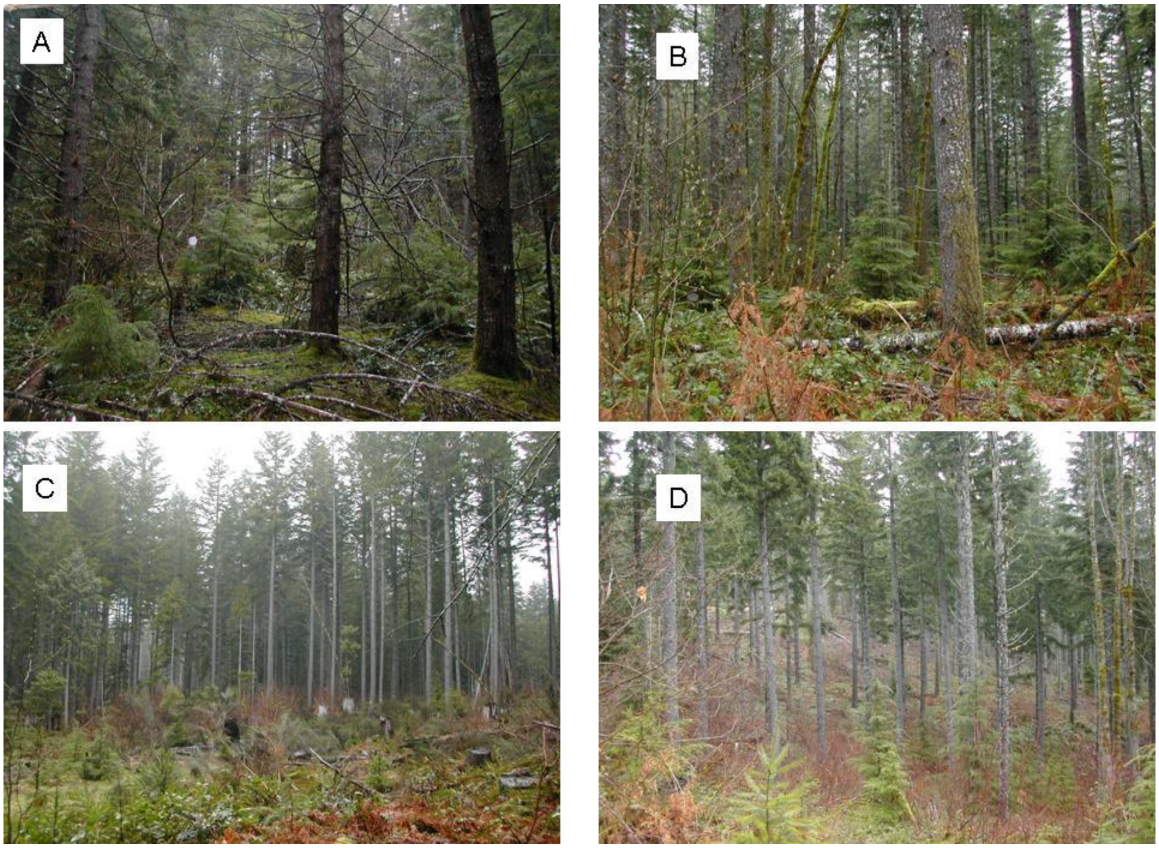

Figure 1. Several silvicultural approaches to increase complexity in 50-year-old Douglas-fir stands in the Oregon Cascades. A is an unthinned stand, B is a stand thinned to 110 trees per acre at age 45, C is a stand thinned to 110 trees per acre and with 0.5-acre gaps (foreground), and D is a heavily thinned stand to 50 trees per acre underplanted with Douglas-fir, western hemlock, western redcedar, and western white pine.

Each of the above treatments was replicated 4 times, and treatments were randomly assigned to stands. Stands averaged 75 acres (30 ha). In addition, 2 snags per acre were created by topping trees in each stand, and the tops were left on the forest floor to add to dead wood biomass.

Response variables

Plant community composition and structure, dead wood biomass, songbird community structure and forest floor vertebrate community structure was documented in each stand prior to and following treatments. This approach allowed the use of a Before-After Control-Impact (BACI) experimental design. Specifically, the relative abundance (captures per unit effort) and body mass (as an indicator of fitness) were used as indicators of forest floor vertebrate response to treatments (Garman 2001).

Sampling Methods

The following methods and results are summarized from Garmans (2001) report. Unfortunately methods changed between pre- and post-treatment sampling, compromising the value of a true BACI design.

Pretreatment 1991-92

- 100 Sherman live traps in a 10x10 grid, 20-m spacing
- 25 pitfall traps in a separate 5x5 grid

Post-treatment 1998-99, 2001

- 100 Sherman live traps in variable-length transects, 30-m spacing
- 50 pitfalls located at alternating stations on variable-length transects
- 25 Tomahawk live traps (for larger mammals) at alternating stations along every other transect, 2001 only.

Trapping at each site occurred over a 6- to 8-day period during fall after the onset of the fall rains but before snowfall. All traps were baited with rolled oats, peanut butter and sunflower seeds; polyfiber batting was placed in traps to provide thermal cover for captured mammals. Traps were checked daily and animals were weighed, marked with individual tags, and released. Dead animals were stored for future analyses. Trapping protocols were approved by the OSU Institutional Animal Care and Use Committee.

Statistical Analyses

Steve Garman used repeated measure analysis of variance to assess response of various species to treatments. These results are summarized here. An additional approach would be to assemble the existing information on forest floor structure (litter, dead wood, soils), and vegetation structure and composition to develop alternative models to explain observed patterns of captures, Alternative model structures for each species would then be compared using information theoretic approaches (e.g., Akaike's criteria) to identify the most parsimonious and ecologically meaningful model to explain observed results, especially in light of the hypotheses proposed above.

Results

A total of 10321 captures of 5739 individual mammals (17 species), and 210 captures of 209 individual amphibians (9 species) was made over the course of the study. All tolled, the diversity of forest floor fauna was quite high in these young, even-aged stands, and many of the species found in old-growth stands were recorded in these stands.

Because each species differs in its abundance, use of space and trappability, both before and after treatment, the numbers of animals available for analyses and interpretation vary considerably among the species. I used Garman's (2001) results to explore potential effects of treatments. I describe responses (or lack thereof) by species for each of two groups: those with many captures allowing statistical comparisons, and those with few captures where statistical analyses were not possible.

Abundant species

Deer mice (*Peromyscus maniculatus*) were abundant prior to and following treatments. Capture rates on uncut controls were reasonably consistent at 10-30 captures per 1000 trap nights (a trap night is one trap set for one night). Although capture rates spiked during the first post-treatment sampling period in 1998 to 80-100 captures per 1000 trapnights, capture rates returned to levels similar to those on the control by 1999 and 2001. The spike was highest in LT and LTG treatments. If this increase is indeed a temporary spike in populations due to changes in vegetation following disturbance, then there would be clear benefits to this nocturnal species and its predators (e.g., owls, musltelids) for a few years following treatment. Suzuki and Hayes (2003) also reported deer mice increasing in abundance following thinning. Deer mice are often abundant in areas that are recovering from a recent disturbance such as clearcuts, fires, and windstorms. Any benefits of thinning to this species were not reflected in significant changes in body mass.

Figure 2. Deer mouse. Abundance increased for a few years after thinning. Photo by Mike Jones, UMass-Amherst.

Townsend's chipmunks (*Tamias townsendii*) also are often associated with early successional conditions, especially where dense shrub cover has recovered. Indeed, capture rates increased from 5-10 per 1000 trap nights prior to treatment to 50-70 per 1000 trapnights on treated areas following treatments. They seemed to be most abundant in LTG and HT treatments and least abundant in NT stands. Clearly the thinning treatments benefited this diurnal species and likely benefited the predators (e.g., hawks) of this species. Any benefits of thinning to this species were not reflected in significant changes in body mass.

Figure 2. Townsend's chipmunk abundance increased with thinning being highest in the LTG and HT treatments. Photo from: http://www.fs.fed.us/r6/centraloregon/wildlife/species/mammals/images/ro-townsendschip.jpg

Western red-backed voles (*Clethrionomys californicus*) were reasonably abundant in all stands prior to treatment with capture rates of 5-15 captures per 1000 trap nights. Following treatment, capture rates dropped to < 4 captures per 1000 trap nights in all stands, but remained most abundant in NT treatments. This species has declined following thinning in other studies (Suzuki and Hayes 2003) and seems to respond poorly to activities that disrupt a continuous canopy cover or disrupt the forest floor vegetation. Although we anticipate that the species will recover as canopy cover closes and forest floor vegetation recovers, that recovery was not seen during the first 5-7 years after treatment. Red-backed voles are an important food source for many nocturnal predators and are dispersers of mycorrihzal fungal spores, so their decline is a point of concern and their recovery, should it occur, is important to document.

Figure 3. Western red-backed voles (similar to this Gapper's red-backed vole) decreased in abundance with thinning. Photo from: http://www.washington.edu/burkemuseum/collections/mammalogy/mamwash/clga.html

Northern flying squirrels (*Glaucomys volans*) capture rates were highly variable among stands prior to treatment, but in general increased in NT stands and declined in LT, LTG, and HT stands following treatment. As with red-backed voles, these declines are a concern, because flying squirrels are the primary food of northern spotted owls (*Strix occidentalis caurina*) in the northern and central Oregon Cascades. Documenting the recovery of this species, should it occur, is critical information when considering the potential value of thinned stands to spotted owls. However, managers should be cautious when interpreting the results for this species. First, sampling did not target flying squirrels. Tree-traps were not used and tomahawk traps were only used in 2001. More targeted sampling for this species should be conducted using tomahawk traps placed both on trees and on the ground to obtain a reliable sample. Further, thinning increased flight space beneath the corwns for predators of this species. Hence if declines following thinning are real, and not an artifact of sampling techniques, then it is not if the declines are due to changes in habitat (e.g., den sites, food resources), or increased predation pressure. Future sampling should include focused sampling on this species.

Figure 4. Northern flying squirrels seemed to decrease in abundance with thinning. Photo from: http://wdfw.wa.gov/wlm/diversty/soc/wgraysquirrels/graphics/nflying_squirrel.jpg

Oregon voles (*Microtus oregoni*) are most often associated with recent stand-replacement disturbances such as clearcuts and fires. Their abudance increased following thinning in the Oregon Coast Range (Suzuki and Hayes 2003). Capture rates in this study were low prior to and for the first five years after treatment (< 2 captures/1000 trap nights). During 2001, capture rates rose on all sites to 3-6 captures per 1000 trap nights, including increases in the NT stands. Such fluctuations in vole populations are common but it makes it difficult to assess responses to treatment. At the very least we can conclude that thinning quite likely did not adversely affect abundance of this species.

Figure 5. Oregon vole populations seemed to occur and low but consistent levels on both thinned and unthinned sites. Photo from: http://www.washington.edu/burkemuseum/collections/mammalogy/mamwash/Images/orvole.jpg

Trowbridge's shrews (*Sorex trowbridgii*) are the most common insectorous mammal in forests of western Oregon. Capture rates prior to treatment averaged 10-20 captures per 1000 trap nights, but rose to 40-60 captures per 1000 trapnights following treatments, even in NT stands. These increase in uncut stands confounded interpretation of the results, but at the very least we can say that it is very unlikely that thinning had any negative effects on this species. Any effects of thinning on this species were not reflected in significant changes in body mass among treatments over time.

Figure 6. Trowbridge's shrews seemed to persist through all levels of thinning. Photo from: http://www.fs.fed.us/r6/centraloregon/wildlife/species/mammals/shrews-moles.shtml

Shrew-moles (*Neurotrichus gibbsii*) are uncommon insectivores and were only rarely captured in this study. Nonetheless the highest capture rates (0.5-2.0 captures/1000 trap nights) occurred in the thinned stands in 2001. Hence one could conclude that it is unlikely that thinning had a negative effect on this species.

Figure 7. Thinning did not seem to have a negative effect on Shrewe-moles. Photo from http://www.fs.fed.us/r6/centraloregon/wildlife/species/mammals/shrews-moles.shtml

Fog shrews (*Sorex sonomae*) were reasonably abundant prior to treatment (2-8 captures/1000 trapnights) but by 2001 their capture rates had declined in all stands to less than 3/1000 trap nights, including declines in NT stands. Hence inter-annual variability in abundance obscured any clear effects due to treatments, but it is important to note that very few fog shrews were captured in HT stands during 1999 and 2001. Any effects of thinning on this species were not reflected in significant changes in body mass among treatments over time.

What may apparently be a near loss of this species from the HT stands should be monitored carefully to see if the low capture rates represent a negative effect of the treatment, or random chance in a species whose populations fluctuates widely. If there is indeed a negative effect of HT on this species, then documenting recovery rates would also be of importance, especially when considering effects of thinning on contributions to forest floor biodiversity.

Ensatina salamanders (*Ensatina eschscholtzii*) are the most abundant salamander in young, closed canopy stands. Capture rates for most amphibian species are highly variable from year to year and place to place, because above ground activity is so much affected by weather conditions. Consequently all we can conclude from our sampling is that this species was present (1-17 captures per 1000 trap nights) on all treatments over all years that were sampled. Hence it seems unlikely that there were any short-term negative effects of thinning on their abundance.

Figure 8. Ensatina salamanders persisted through all levels of thinning. Photo from: http://www.californiaherps.com/salamanders/images/ensatinass053.jpg

Uncommon Species

Many additional species were captured in this study, but at rates too low to allow meaningful comparisons among treatments. Unfortunately I do not have access to the original data so I cannot examine which species were captures in which treatments following treatment. Some species were captured only post-treatment because the sampling design changed. Use of tomahawk traps allowed sampling of Virginia opossum (*Didelphis virginiana*), snowshoe hare (*Lepus americanus*), Douglas squirrels (*Tamisasciurus douglasii*), bushy-tailed woodrat (*Neotoma cinerea*), California ground squirrel (*Spermophilus beechyii*) and western spotted skunk (*Spilogale gracilis*). Continued use of tomahawks, especially both ground and tree sets, would allow continued sampling of these species and provide better estimates of northern flying squirrel populations.

Uncommon amphibians such as northwestern salamander (*Ambystoma gracile*), clouded salamander (*Aneides ferreus*), and Dunn's salamander (*Plethodon dunnii*) could be sampled both by pitfalls as well as time-constrained sampling so gain a better understanding of patterns of abundance among treatments. Nonetheless some species such as coast moles (*Scapanus orarius*), marsh shrews (*Sorex bendirii*), red-legged frogs (*Rana aurora*), tailed frogs (*Ascaphus trueii*), western toads (*Bufo boreas*), and Pacific giant salamanders (*Dicamptodon tenebrosus*) simply occur in such low numbers that the only conclusions that could be drawn from sampling them is when they are found in a certain treatment.

Conclusions

Populations of many species of forest floor vertebrates are highly variable from year to year confounding interpretation of results. Nonetheless the following generalized conclusions can be drawn from the data collected to date and for those species in common, are generally consistent with results presented by Carey and Wilson (2001) in Washington, and Suzuki and Hayes (2003) in the Oregon Coast Range.

Light thinning seemed to produce a temporary increase in abundance of deer mice and possibly more long-lasting increases in abundance of Townsend's chipmunks. Potential negative effects of light thinning were noticed on northern flying squirrels and western red-backed voles. Other common species seemed to at least tolerate light thinning.

Light thinning with gaps produced responses in common species similar to that observed in light thinning without gaps. Apparently the matrix condition in these stands, thinning to 110 trees per acre, allowed resident forest floor vertebrates to persist despite any potential negative effects of gaps punctuating the stands. Nonetheless those species adversely affected by light thinning, northern flying squirrels and western red-backed voles, seemed to be similarly affected when gaps were added to this treatment.

Heavy thinning seemed to benefit deer mice (temporarily) and Townsend's chipmunks, but not northern flying squirrels, western red-backed voles, and fog shrews. If indeed HT allows development of old-growth like conditions more rapidly than other treatments then it may come at a cost to several species associated with closed-canopy conditions, at least during the first 5-8 years after treatment. If these negative effects are indeed temporary then it is important to document the duration of these negative effects.

No thinning seemed allowed the persistence of species originally present in these young unmanaged stands. Consequently any thinning strategy designed to accelerate the development of old-forest conditions that might adversely affect some species (e.g., HT) should either retain unthinned patches or be interspersed with unthinned stands until the duration of the negative effects can be more clearly understood.

Recommendations

Based on the results and patterns described above, I recommend:

1. assemble the existing information on forest floor structure (litter, dead wood, soils), and vegetation structure and composition to develop alternative models to explain observed patterns of captures, Alternative model structures for each species would then be compared using information theoretic approaches (e.g., Akaike's criteria) to identify the most parsimonious and ecologically meaningful model to explain observed results

2. Sample again in 2007-2008 and continue sampling over 2-year periods every 10 years unless new treatments are imposed (see below). Vegetation changes are likely to occur slowly enough now that sampling more frequently than every 10 years will not likely produce results illustrating significant changes from one sampling interval to the next. Future sampling should use methods consistent with the most recent sampling with exceptions noted below.
3. Adding a more focused sampling of northern flying squirrels by using both ground and tree traps within each stand and expanding the grid sizes to at least 50 traps per stand as was done in the DEMO study (Lehmkuhl et al. 1999).
4. Adding time constrained sampling to each stand to better detect forest floor amphibians as was done by Butts and McComb (2000).
5. Examine growth and survival of residual trees and regeneration to assess when or if a next entry is needed to allow stands to continue to develop as intended. Sampling of forest floor vertebrates should be scheduled to be not more than 5 years prior to future treatments so that those samples can serve as pretreatment data to any new treatments.
6. Habitat is a species-specific concept, so it is not surprising that we observed differential responses of species to treatments. At this point LT and LTG responses were similar, but if additional gaps and thinning should occur, then the observed responses to these two treatments may diverge, especially as the lightly thinned matrix condition is further perforated by gaps. Hence if mainenence or enhancement of habitat for the species observed thus far is a goal, then a variety of thinning approaches should be considered. Further maintaining unthinned patches in stands or unthinned stands within a watershed is probably prudent based on the potential for loss of a few species from stands due to thinning, even if temporarily. Animals present in unthinned patches then would be sources for colonization of thinned stands as they continue to develop.

References

Butts, S. R. and W. C. McComb. 2000. Associations of forest-floor vertebrates with coarse woody debris in managed forests of western Oregon. J. Wildl. Manage**.** 64:95-104.

Carey, A.B. 2003. Managing for wildlife: A key component for social acceptance of compatible forest management. Pages 401-425 in R.A. Monserud, R.W. Haynes, and A.C. Johnson (eds.) Compatible Forest Management, U.S. Government, Printed in The Netherlands.

Carey, A.B., and S. M. Wilson. 2001. Induced spatial heterogeneity in forest canopies. Responses of small mammals. J. Wildlife Manage., 65:1014-1027.

Garman, S.L. 2001. Response of ground-dwelling vertebrates to thinning young stands: The young-stand thinning and diversity study. Unpubl. Report. Cascade Center for Ecosystem Management, Blue River, OR

Lehmkuhl, J. P., S. D West, C. L. Chambers, W. C. McComb, D. A. Manuwal, K. B. Aubry, J. L. Erickson, R. A Gitzen, and M. Leu. 1999. An experiment for assessing vertebrate response to varying levels and patterns of green-tree retention. Northwest Sci. 73: 45-63

McComb, W. C., T. A. Spies, and W. H. Emmingham. 1993. Stand management for timber and mature-forest wildlife in Douglas-fir forests. J. Forestry 91(12):31-42.

Suzuki, N., and J. P. Hayes. 2003. Effects of thinning on small mammals in Oregon coastal forests. J. Wildlife. Manage. 67:352-371.