Appendix C

Gradient Transect Study (draft)
Density Management Study

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Study Objectives

The Density Management Study (DMS) revolves around variable density thinning treatments. These treatments are composed of areas of three densities (40, 80, and 120 trees per acre) interspersed with three sizes (¼, ½, and 1 acre) of leave islands (unharvested) and gaps (all stems removed).

This transect study investigates the role of gaps in creation of stand understory heterogeneity in these treatments. Understory vegetation and light conditions will be characterized along transects through these gaps and into the adjacent forest matrix. Vegetation data from plots randomly located in the treatments will be examined as well, to characterize a treatment effect at the stand scale. The primary questions the transect study will address include:

1) How does understory vegetation composition, structure, and diversity vary along transects through gap and into adjacent thinned forest? Does this variation conform to patterns of resource availability across transects?
2) Does distribution of understory vegetation follow a pattern consistent with the gap-partitioning hypothesis (i.e., is there evidence that vegetation distributions differ significantly between different portions of the gap)?
3) What is the extent of the gap influence on understory vegetation along the transect and into the adjacent forest?
4) Is the size of the gap directly related to the influence on vegetation distribution and resource availability?
5) Does extent of small-scale variation in species richness/diversity differ depending on transect position (i.e., is there greater small-scale variation in vegetation or resource availability at certain locations in the gap)?
6) Do measurements taken on a small scale (mini-transect, transect) show patterns consistent with those seen in large scale (stand scale) data at the treatment level? What portion of the between treatment variation in stand-scale species diversity/richness can be explained by variation in small-scale data?

Rationale

Recent variable-density thinning studies have included gap clear-cuts in thinning treatments to address diversity objectives (Young Stand Thinning and Diversity Study, DMS). Gaps create habitat heterogeneity within stands, which may alter species diversity and may improve the ability of some species to persist through the stem exclusion phase of stand development. However, the influence of these small gaps may be short lived because over time they will be filled in by advanced regeneration and expansion of the overstory canopy along the gap edge (especially if gaps are underplanted, as in the DMS). If habitat heterogeneity is truly being promoted by small gaps, it may be useful to preserve these features throughout stand development (especially along gap edges, e.g., L. Beggs and K. Puettmann 2005, *in prep*).

In this transect study, we will characterize variability in vegetation communities and light availability across these canopy gaps and into the surrounding forest matrix. Implications of this research will be used to make recommendations regarding the creation (and further management) of canopy gaps in stands as a management tool in young Douglas-fir forests. Data from the stand-scale survey will be used to illustrate the importance of gaps in creation of heterogeneity in understory vegetation and light conditions at the treatment level. These findings will be used to evaluate the effectiveness of the DMS treatments in creating understory heterogeneity in the stand and will guide future management efforts.

Study Location

The transect component study is focused on four of the seven DMS Initial Thinning sites: OM Hubbard, North Soup (see Figure C1 for the North Soup site), Bottomline, and Keel Mountain. Within each site transects were constrained to moderate density and variable density treatment areas. All sites are located in western Oregon. The Keel Mountain site is located in the western foothills of the Cascade Mountains and the other three sites are on the east slope of the Coast Range.

Sampling Methods

<u>Transect Installation</u>

All transects were permanently installed. Each transect consisted of a set of five or seven mini-transects (number depends on gap size), each of which was made up of five contiguous vegetation sampling plots (square plots; 2 m x 2 m or $4m^2$) (see Figures C2 & 3, Note: plots are square rather than circular as is depicted in the figures). Transects were installed in two of the three sizes of gap (¼ acre and 1 acre). Four replicates of each transect length were installed at each site (exception: only three replicates at the Bottomline site). Therefore a total of 8 transects (6 at Bottomline) were installed at each site. Transects followed a 45°/225° bearing between due north/south (with a few exceptions) through the gaps with mini-transects located at gap center, gap/forest-matrix edge, and within forest-matrix (see Figures C2 & C3).

At the center plot of each mini-transect, UTM coordinates, slope, and aspect were recorded and a 4.5 ft PVC post was installed. PVC posts 2.5 ft in height were installed at each of four other vegetation plots. Posts will be marked with transect number, plot number, and UTM coordinates.

<u>Vegetation and Substrate Measurements</u>

Measurements made on 4 m^2 vegetation plots included:

- Absolute percent cover for each understory vascular plant species (not to exceed 100% for any one species). Cover of vegetation above 6.1m (20 ft) in height was not included. All shrub, forb, and fern species shading the plot were included in cover estimates.
- Average height (cm, rounded to nearest whole number) for each species.
- Total percent cover for the following lifeform groups (cover estimates do not exceed 100% for each group).
    - Forbs
    - Ferns
    - Grasses (including sedges and rushes)
    - Shrubs
    - Hardwood trees (< 20 ft shading the plot)
    - Conifer trees (< 20 ft shading the plot)
    - Bryophyte – ground dwelling (not including arboreal species displaced from the canopy)
    - Lichen – ground dwelling (not including arboreal species displaced from the canopy)
- Total percent cover for following substrate conditions:
    - Rock
    - Bare soil
    - Duff
    - Log
    - Stump/Bole

<u>Hemispherical Canopy Photography Measurements</u>

At each vegetation sampling plot center along the mini-transects, a canopy photograph was taken in order to determine overstory cover and understory light conditions. All photographs were taken at 1.2 m height and understory vegetation directly influencing photograph was moved aside (Frazer et al. 2000). This height was chosen to best characterize light available to the understory community. One photo was taken at the center point of each subplot (900 total photos across all sites).

Equipment used to collect photographs consisted of a Nikon Coolpix 4500 digital camera with FC-E8 Fisheye Converter Lens attachment. Photos were taken at 2272 x 1704 pixels, at “fine” resolution. The camera’s internal light meter was used to select correct shutter speed and aperture for each photograph. The camera was set to “high contrast” setting to increase distinction between sky and foliage and to reduce effects of chromatic aberration associated with the digital photograph system (Frazer et al. 2001).

All photographs were taken in uniform overcast light condition, during either early dawn or late dusk, or on days with uniform cloud cover to reduce effects of chromatic aberration. All photographs were also taken with camera facing geographic south, such that the top of each image corresponded with geographic north. The camera was leveled using a bubble level built into the tripod head.

<u>Lab Preparation and Analysis of Hemispherical Canopy Photographs</u>

Photos were analyzed using Gap Light Analyzer 2.0 (GLA) (Frazer et al.1999). The FC-E8 lens has been shown to closely follow a standard Polar projection; however, Frazer et al. (2001) describe an alternative projection function that minimalizes any distortion. A third order polymnomial was used to describe the projection:

$$Y = 6.6380X - 0.0025X^2 - 2.4014\text{E} - 0.5X^3,\ 0^\circ \leq X \leq 90^\circ$$

Photos were analyzed according to this projection. Modifications of photos (when necessary) were made using Adobe Photoshop CS. Measurements of canopy openness and leaf area index (LAI) were obtained for each photograph using GLA. In addition local climate data was obtained for each site (Oregon Climate Service web site, <http:/www.ocs.oregonstate.edu/>) which made it possible to calculate above and below canopy direct and diffuse light and percent transmitted light using GLA.

Data Analysis

Data analysis will focus on both illustrating the spatial variation in the vegetation community at different scales and assessing the relationships between transect position and community composition and structure. We will also evaluate whether gap-partitioning is occurring among understory plant communities in either (or both) sizes of gaps.

- Analysis for Objective 1:
    - Comparison of species distributions and their relation to environmental factors (light and soil moisture) will be carried out using ordination techniques in PC-ORD (McCune and Medford 1999).
    - Distributions of species groupings and individual species of interest will be analyzed also using ordination, these will include:
        - Exotic/invasive species
        - Rare/endangered/threatened species
        - Old-growth associated species
        - Life history groupings (e.g., early seral, late seral, persistent forest understory)

            - Life form groupings (e.g., herb, low shrub, tall shrub, fern, graminoid, etc.)
    - Species richness will be determined for each subplot, mini-transect, and transect and will be related to transect position and resource levels.
    - Indicator Species Analysis will be carried out to relate species distributions to transect position.
- Analysis for Objective 2:
    - Species composition will be related to transect position using ordination techniques in PC-ORD.
    - Indicator species will be tested for specificity to transect positions.
    - Species groupings (described above) will be analyzed in relation to transect positions.
- Analysis for Objective 3:
    - Distributions of indicator species found to be associated with gap positions (or gap plots in larger study) will be analyzed in order to determine the extent of the occurrence of these species along transects.
- Analysis for Objective 4:
    - Results from Objectives 1-3 will be analyzed in relation to gap size.
- Analysis for Objective 5:
    - Beta-diversity will be calculated for mini-transects and full transects, results will be related to transect position and scale of measurement.
    - Variation in resource levels will be determined across mini-transects and full transects. Level of variation will be related to beta diversity and richness values.
- Analysis for Objective 6:
    - Species richness and diversity measures along transects will be compared to those obtained in stand-scale measurements.
    - Results of stand-scale ordinations and indicator species analyses relating plots located in gap and forest matrix locations will be compared to transect analysis results.

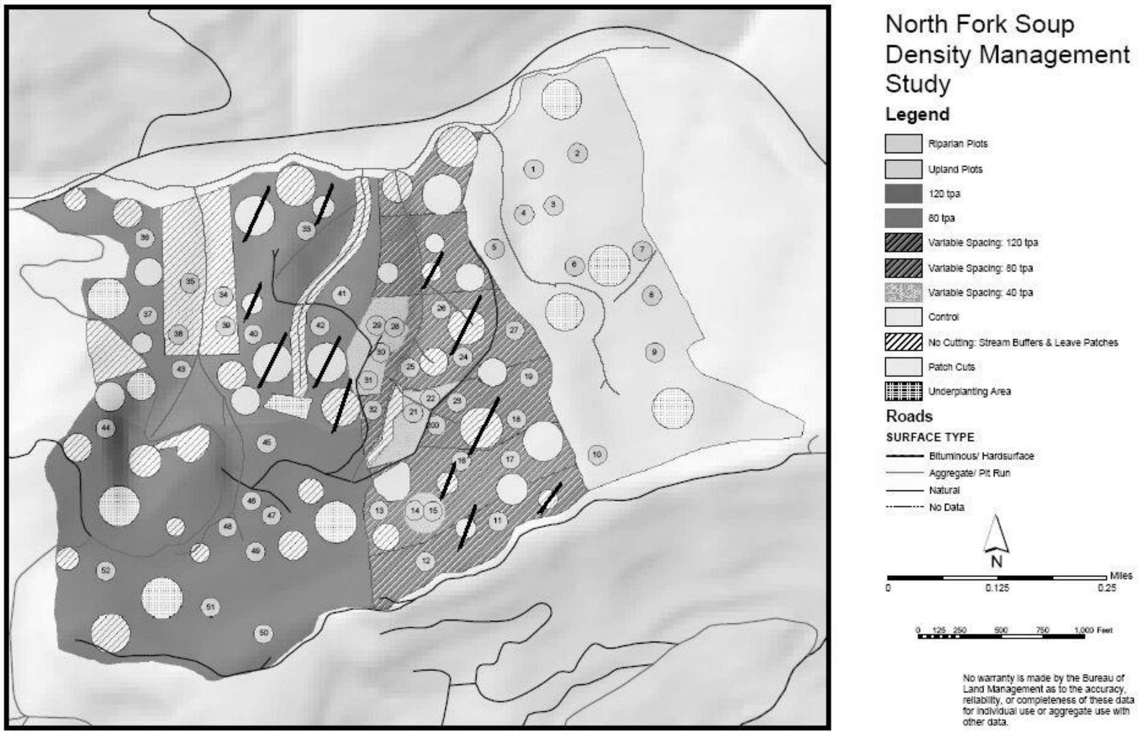

Figure C1. North Soup DMS Site showing potential transect locations.

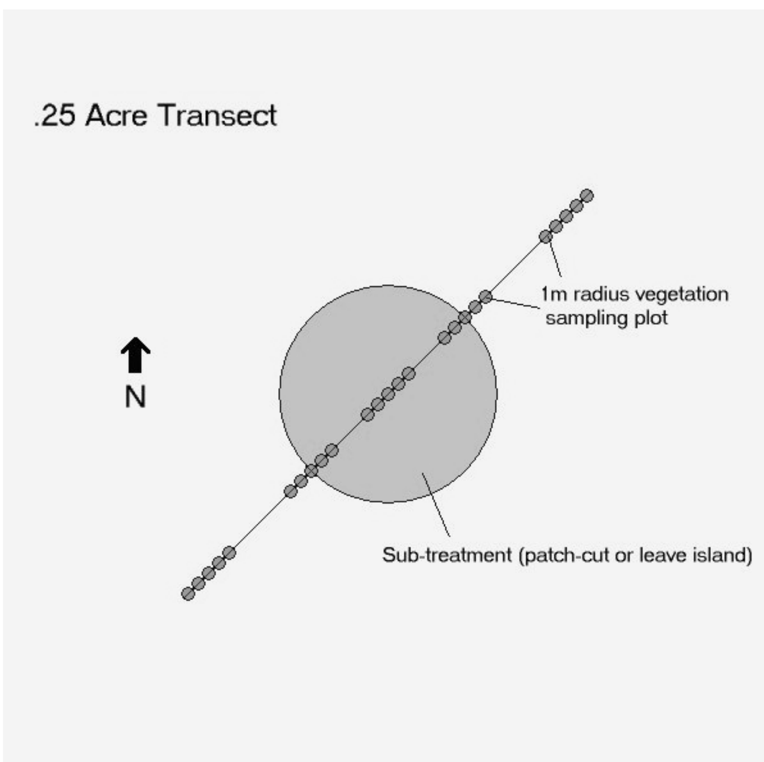

Figure C2. Transect set-up for ¼ acre gaps.

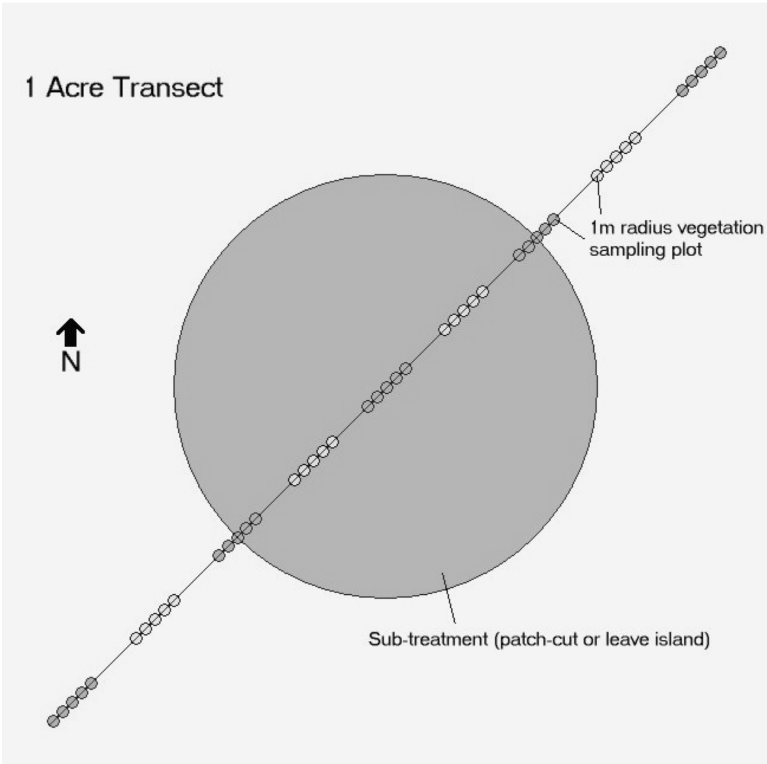

Figure C3. Transect set-up for 1 acre gaps.

Table C1. Site summary of transects and vegetation plots (50% of transects at each site are in 1 acre gaps and the other 50% are in ¼ acre gaps).

Site	Bottomline	OM Hubbard	North Soup	Keel Mountain	Total
# Transects	6	8	8	8	30
# Veg Sampling Plots	180	240	240	240	900
# Species encountered	114	135	136	101	182

References

Frazer, G.W., Canham, C.D., and Lertzman, K.P. 1999. Gap Light Analyzer (GLA), Version 2.0: Imaging software to extract canopy structure and gap light transmission indices from true-colour fisheye photographs, users manual and program documentation. Copyright © 1999: Simon Fraser University, Burnaby, British Columbia, and the Institute of Ecosystem Studies, Millbrook, New York.

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