VARIATION IN MICROCLIMATE ASSOCIATED WITH STRUCTURAL-RETENTION HARVESTS IN WESTERN WASHINGTON

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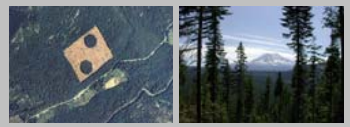
Abstract

Green-tree or structural retention is becoming increasingly common as a method of regeneration harvest in the Pacific Northwest. Amelioration of microclimatic stress is assumed to be one mechanism by which overstory retention enhances the survival of forest organisms and the potential for ecosystem recovery following timber harvest. We examined patterns of transmitted light, air and soil temperature, and soil moisture at three locations in western Washington.

We compared daily growing season microclimate in experimental harvest units representing 0, 15, 40, and 100% dispersed retention of original basal area. We also quantified spatial gradients in microclimate inside 1-ha forest aggregates, effects of aspect on these gradients, and how microclimate compared to conditions in adjacent harvest areas and larger tracts of undisturbed forest (controls).

Light and mean and maximum air temperatures were significantly greater at 0 and 15% dispersed retention than at 100%. Mean and maximum soil temperatures differed only between 0 and 100% retention. Inside 1-ha aggregates, light and temperature were greatest at the edge, but declined sharply inside the aggregate, with most change occurring within 15 m of the edge. Soil temperatures exhibited greater spatial variation and stabilized further from the edge (10-30 m).

Our results suggest that 15% dispersed retention does little to ameliorate microclimatic conditions relative to traditional clearcut logging. Conversely, our results suggest that 1-ha aggregates are sufficiently large to support areas in which microclimate is comparable to undisturbed forest.

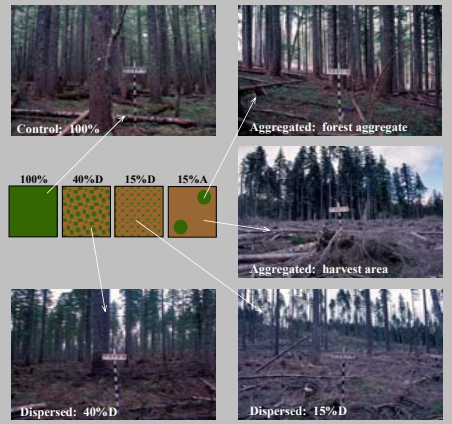


Introduction

Over the last decade, structural-retention harvest has replaced clearcut logging on National Forest matrix lands in the Pacific Northwest. Current regulations require a minimum of 15% overstory retention, with 70% of this as forest aggregates of 0.2-1.0 ha. By ameliorating microclimatic stress, partial retention of overstory trees may enhance species' survival and accelerate recovery of forest ecosystems, while allowing for some timber extraction. The Demonstration of Ecosystem Management Options (DEMO) Study examines the ecological responses of forest ecosystems to variable-retention harvests. Specifically, it tests how the level of tree retention and its spatial distribution (dispersed or aggregated) influence persistence and recovery of biological diversity. Here we present results from two studies that examine variation in microclimate across a broad gradient of dispersed retention, and in and around 1-ha residual forest aggregates. We addressed the following questions:

- How do treatment-scale patterns of light, air and soil temperature, and soil moisture vary with level of retention?
- Is the spatial heterogeneity (within-treatment variation) in microclimate greater at intermediate levels of retention, reflecting greater dispersion of trees?
- Which elements of residual forest structure explain local (plot-level) variation in microclimate?
- Do forest aggregates show consistently greater light availability, greater temperature, and lower soil moisture than larger blocks of undisturbed forest?
- Do forest aggregates support microclimatic conditions that differ significantly from those in adjacent harvest areas?
- How does microclimate vary with distance from forest edge and how do these gradients vary with aspect?

Experimental design and examples of post-harvest conditions



Experimental Design

Four of the six experimental treatments were sampled at three locations (blocks) in western Washington:

- **100% retention** (100%): control (no harvest).
- **40% dispersed** (40%D): same basal area retained as in 40%A, but as evenly dispersed dominants and co-dominants.
- **15% dispersed** (15%D): same basal area retained as in 15%A, but as evenly dispersed dominants and co-dominants.
- **0% retention** (0%): represented by the harvested portion of the 15% aggregated (15%A) treatment.
- **Forest aggregate**: 1-ha circular aggregates in the 15%A treatment.

Statistical Analyses

Study 1: Varying levels of dispersed retention:

- Randomized block ANOVA to compare microclimatic variables among treatments for mean responses and within-treatment variability (CV).
- Multiple linear regression to explore relationships between microclimate and forest structure.

Study 2: Gradients within forest aggregates

- Plotted microclimatic means (and SEs) vs. distance from edge for two aspect groups (S/W and N/E).
- Generated 95% CIs for 0 and 100% treatments from 20 random points within each treatment.
- Tested for overlap between means and 95% CIs.

Sampling Design

Response variables: light, air and soil temperature, and soil moisture (6-7 yr after harvest)

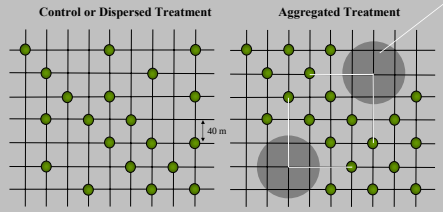
Study 1: Varying levels of dispersed retention

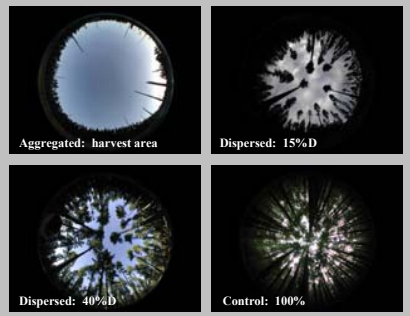
- Four treatments at each of three locations (blocks).
- Permanent plots on a systematic grid of 40-m spacing.
- Microclimatic stations at 20 random points.

Study 2: Gradients within forest aggregates

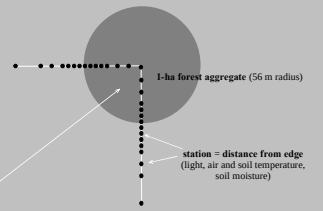
- 15%A treatment at three blocks; two forest aggregates per block.
- Two transects (109 m) per aggregate; 15 stations per transect.
- 20 points in both 0 and 100% (same as above).

Study 1: Effects of level of retention



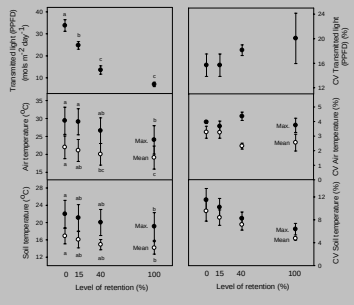


Study 2: Gradients within forest aggregates



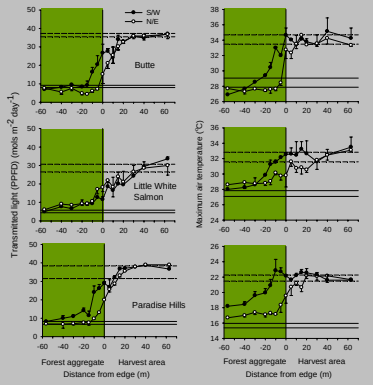
Results: Study 1 – Varying levels of dispersed retention

- Light and mean and max. air and soil temperatures decreased with level of retention.
- Light did not differ between 40 and 100% retention.
- Mean and max. air temperatures were significantly greater at 0 and 15% retention than at 100%.
- Mean and max. soil temperatures differed only between 0 and 100% retention.
- Late-summer soil moisture did not differ among treatments.
- Within-treatment variability (CV) did not differ among treatments.



Results: Study 2 – Gradients within forest aggregates

- Light and temperature declined sharply inside the aggregate; with most change occurring within 20 m of the edge.
- Light was similar to controls within 20 m of the edge.
- Soil temperature (not shown) was more variable and stabilized further from the edge (10-30 m).
- Soil moisture (not shown) showed no spatial trends and was comparable among aggregates, harvest areas, and controls.
- Aspect had large effects on light and temperature, especially near the edge.
- Where tree density was low (Little White Salmon), aggregates were more susceptible to edge effects.



Conclusions

- Our results provide direct evidence that at 15% dispersed retention, the potential for ameliorating air or soil temperatures in harvest areas is very limited. Although average levels of light are reduced, air and soil temperatures are no different from those found in clearcut environments.
- For dispersed harvest patterns, overstory retention must meet or exceed 40% to retain microclimatic conditions found in mature, undisturbed forests.
- Aggregates that are 1-ha in size appear sufficiently large to contain areas with light, temperature, and soil moisture that are comparable to those in undisturbed forest.
- Aggregates as small as 0.2 ha (permitted under current federal standards) are not likely to retain microclimates found in older forest.
- Microclimate trends within and among treatments are consistent with many observations of biological response. Aggregates appear sufficiently large to allow for the persistence, at least in the short-term, of shade-dependent plants.

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