

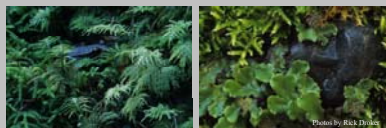
# PERSISTENCE OF FOREST-FLOOR BRYOPHYTES IN A STRUCTURAL-RETENTION EXPERIMENT: EFFECTS OF LEVEL AND PATTERN OF OVERSTORY RETENTION

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## Abstract

Relatively little is known about the effects of forest management practices on bryophytes. On federal matrix lands in Washington, Oregon, and northern California – an area that coincides with the range of the northern spotted owl and is managed under the Northwest Forest Plan – clearcut logging has been replaced by structural retention harvest. Partial retention of the overstory is hypothesized to moderate microclimatic conditions and to enhance species' survival and recovery. At four locations in western Washington, we examined short-term responses of forest-floor bryophytes to a range of retention levels (100, 75, 40, and 15% of original basal area) and spatial patterns (dispersed vs. aggregated in 1-ha patches). Declines in bryophyte cover and frequency were comparatively large at 40 and 15% retention. Pattern of retention had little effect on the magnitude of decline although declines in richness tended to be greater in aggregated treatments. Declines in species frequency and richness were consistently greater in the harvest areas of aggregated treatments than in dispersed treatments. Forest aggregates appear to be influenced by edge effects: within aggregates of the 15% treatment, richness declined relative to the controls. In addition, within aggregates of the 40% treatment, richness and abundance of liverworts declined with proximity to the forest edge; mosses did not show a similar response. For conservation of bryophytes in forests managed with structural retention, large aggregates and dispersed trees at levels considerably higher than current retention standards are likely to be required.



Photos by Rick Decker

## 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 moderating effects of canopy removal, partial retention of overstory trees may enhance species' survival and accelerate recovery of forest ecosystems, while allowing for some timber extraction. In 1994, a regional experiment, the Demonstration of Ecosystem Management Options (DEMO) Study<sup>(1)</sup>, was initiated in mature forests of Oregon and Washington to examine ecological responses to two aspects of structural-retention systems: level of retention (proportion of original basal area) and spatial pattern (dispersed vs. aggregated). Here we present results from two studies that examine initial responses of forest-floor bryophytes to these experimental treatments. We asked the following questions:

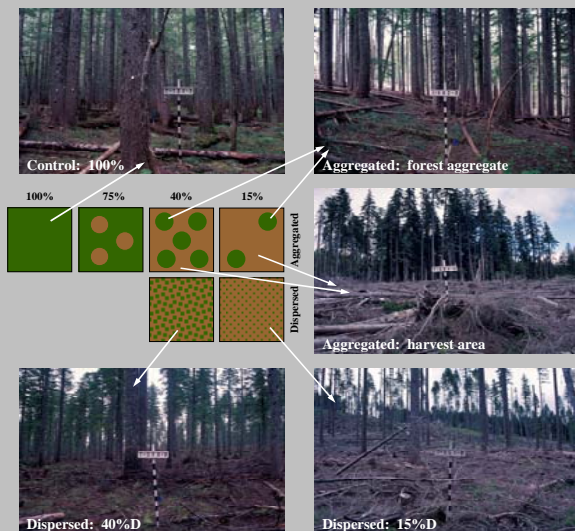
- How do level and pattern of retention affect treatment-scale changes in composition, abundance, and richness of forest-floor bryophytes?
- How does level of retention affect abundance and richness in the cut and uncut portions of harvest units?
- Are bryophytes susceptible to edge effects within forest aggregates? Do mosses and liverworts differ in their sensitivities to edge?

## Experimental Design

Bryophyte studies are ongoing at four sites (blocks) in SW Washington. All were dominated by mature Douglas-fir at the time of harvest, but stand age, structure, and understory vegetation differed among blocks. Within each block, six treatments were assigned randomly to 13-ha experimental units:

- **100% retention (100%):** control (no harvest).
- **75% aggregated (75%A):** all trees cut from three 1-ha harvest areas.
- **40% aggregated (40%A):** all trees cut except for five 1-ha aggregates.
- **40% dispersed (40%D):** same basal area retained as in 40%A, but as evenly dispersed dominants and co-dominants.
- **15% aggregated (15%A):** all trees cut except for two 1-ha aggregates.
- **15% dispersed (15%D):** same basal area retained as in 15%A, but as evenly dispersed dominants and co-dominants.

## Experimental design and examples of post-harvest conditions



## Statistical Analyses

### Bryophyte response variables:

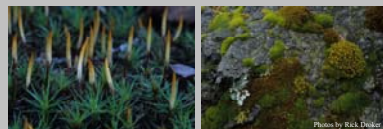
- Compositional changes (Study 1).
- Change in total cover of bryophytes (Study 1) or mosses and liverworts (Study 2).
- Changes in species richness (both studies).
- Proportion of species that declined in frequency (Study 1).

### Study 1: Effects of level and pattern of retention

- Compositional changes: NMS ordination based on species' frequency before and after harvest.
- Changes in cover and richness, and proportion of declining species: randomized block ANOVA (followed by Tukey HSD tests). Separate tests for: (1) treatment-level responses and plots representing (2) uncut areas and (3) harvest areas within treatments.

### Study 2: Gradients within forest aggregates

- Spearman rank correlations between changes in cover or richness of mosses and liverworts and proximity to forest edge (data from bands within aggregates only).



Photos by Rick Decker

## Sampling Design

In two complementary studies<sup>(2,3)</sup>, forest-floor bryophytes were sampled before and one year after harvest for species presence and total cover.

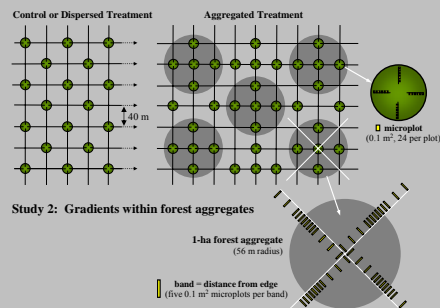
### Study 1: Effects of level and pattern of retention

- six treatments at each of four sites (blocks).
- permanent plots on a systematic grid of 40-m spacing.
- number and distribution of plots vary by treatment.
- 24 bryophyte microplots (0.1 m<sup>2</sup>) per plot.

### Study 2: Gradients within forest aggregates

- 40%A treatment at two blocks; two forest aggregates per block.
- four transects (81 m) per aggregate; 12 bands per transect.
- five bryophyte microplots (0.1 m<sup>2</sup>) per band.

### Study 1: Effects of level and pattern of retention

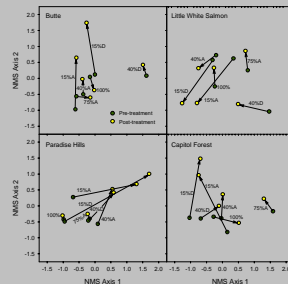


### Study 2: Gradients within forest aggregates

## Results: Study 1 – Effects of level and pattern of retention

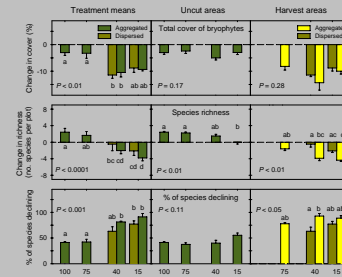
### Compositional changes

- A total of 78 bryophyte taxa (56 mosses and 22 liverworts) were observed in the pre-treatment sample. Of these, 23 were common to all blocks, but 22 were present in only one of four blocks.
- At each block, magnitude of compositional change increased with decreasing overstory retention.
- Direction of compositional change was similar at 15 and 40% retention, regardless of the spatial pattern of residual trees (aggregated vs. dispersed).



### Changes in cover, richness, and species abundance

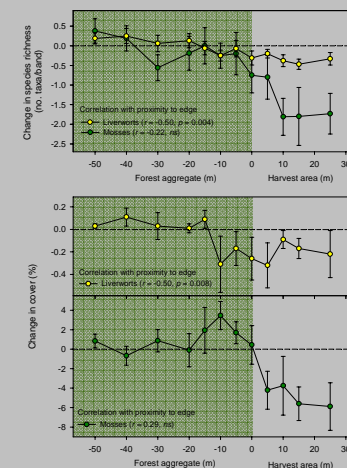
- **Treatment level:** large, comparable declines at 15 and 40% retention. Minimal response to pattern of retention.
- **Uncut areas (including controls):** comparable changes in richness and cover. Aggregates in 15%A experienced significant loss of richness relative to controls.
- **Harvest areas:** large, comparable declines at all levels of retention. Mixed responses to pattern of retention: comparable declines in dispersed and aggregated treatments at 15%, but greater declines in aggregated treatments at 40% retention.



## Results: Study 2 –

### Gradients within forest aggregates

- 36 bryophyte taxa (28 mosses and 8 liverworts) were identified among sample bands before harvest.
- Liverworts were considerably less abundant than mosses and showed small but significant declines in richness and cover with proximity to forest edge.
- Mosses did not show similar sensitivity to edge.



## Conclusions

- Our results suggest that 15% retention – the minimum standard for federal matrix lands in the Pacific Northwest – is not sufficient to prevent large and immediate declines in forest-floor bryophytes, regardless of the spatial pattern in which trees are retained.
- At the scale of harvest units, overstory retention must exceed 40% to retain the abundance and diversity of bryophytes found in mature, undisturbed forests.
- Forest aggregates may facilitate bryophyte conservation in the short term if they are sufficiently large (e.g., 1 ha) and occupy a significant portion of the harvest unit. These patches of remnant forest may serve as refugia for disturbance-sensitive species and as sources for recolonization of adjacent harvest areas once microclimatic conditions become suitable for establishment.
- In the long term, the effectiveness of forest aggregates as refugia may be diminished by edge effects especially for liverworts that are sensitive to changes in substrate quality, humidity, or temperature resulting from increased radiation. Aggregates as small as 0.2 ha (permitted under current federal standards) are not likely to retain the full diversity of species found in older forest.
- A combination of large aggregates and dispersed trees – at retention levels considerably greater than current standards – may be the most viable approach to conserving local diversity of bryophytes while allowing for some timber extraction. Ultimately, retention strategies that minimize loss of disturbance-sensitive organisms such as forest-floor bryophytes are likely to confer broader ecological benefits, including maintenance of other species and processes characteristic of older forests.

### Literature Cited

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- (2) Nelson, C.R., and C.B. Halpern. 2005. Short-term effects of timber harvest and forest edges on ground-layer mosses and liverworts. *Can. J. Bot.* 83:610-620.
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