Overstory and understory vegetation dynamics in response to thinning in coniferous stands in Oregon

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Current forest landscape
Disturbance

Closed canopy ⟷ Discontinuous canopy

Overstory

Understory

Richness

Abundance

Forest floor/soil

Structure

Diversity

Function
Uncertain global change scenario

Stand density management

Species diversity

Functional diversity

Resilience
Objectives

1. Assess forest stand structure
2. Examine tree regeneration response
3. Determine changes in overall vascular plant abundance (cover) and richness in the understory
Objectives

- 4. Determine compositional shifts in understory communities
- 5. Assess changes in plant functional effect (e.g., N-fixation) and functional response (e.g., water requirement) groups
Methods

Study sites

Oregon

Delph Creek

Keel Mt.

Green Peak

Ten High

Bottomline

North Soup

OM Hubbard

N

0 200 km
Study sites

- Conifer-dominated stands age 45-65 years
- Mean annual precipitation = 1250 to 1750 mm
- Elevation = 240-780 m
- Soils = Deep, well drained Ultisols or Inceptisols from sedimentary or igneous rocks
Treatments

- **Control** (unthinned)
  300 trees/ha, leave islands (3-13%)

- **High density** (HD)
  300 trees/ha, leave islands (3-13%)

- **Moderate density** (MD)
  200 trees/ha, gaps (4-18%), leave islands (4-13%)

- **Variable density** (VD)
  300 trees/ha (25-30%), 200 trees/ha (25-30%), 100 trees/ha (8-16%), gaps (4-18%), leave islands (4-18%)
Bottomline
Density Management Study Site
T 21 S, R 5 W, Sec 1
Stands thinned in 1997.
Photo taken in 1998.
Data analyses

- **Mixed model ANOVA** (Treatment effects on overstory and understory variables)

- **Percent dissimilarity (PD)** (Changes from year 6 to year 11)

\[
PD = 100 \times \left\{ 1 - 2 \times \frac{\sum_{j=1}^{p} \text{MIN}(X_{y6j}, X_{y11j})}{\sum_{j=1}^{p} X_{y6} + \sum_{j=1}^{p} X_{y11}} \right\}
\]

\(X = \text{Cover or richness}; y_6 = \text{year 6, } y_{11} = \text{year 11}\)
Results

Basal area and tree height by canopy stratum (Objective 1)
Seedling regeneration: abundance and species richness (Objective 2)
Overall understory species cover and richness (Objective 3)
Relative abundance of understory species at Bottomline (Objective 3)

Control – 360 TPH
47 species

Species rank:

Trailing blackberry

Moderate density – 200 TPH
87 species

Salal

Trailing blackberry

1 ___________

87
Cover and richness of early seral species (Objective 4)

Campanula scouleri (Pale bellflower)
Cover and richness of native and introduced understory species (Objective 4)
Cover and richness of tall shrubs 
(Objective 4)

*Holodiscus discolor* 
(Oceanspray)
Cover and richness of clonal low shrubs (Objective 4)

Mahonia nervosa (Oregon grape)
Understory N-fixing species

Lotus micranthus
(Desert deervetch)

L. Koepke

Lupinus rivularis
(Riverbank lupine)

A. Brousseau

Vicia americana
(American vetch)

S. McDougall

Vicia nigricans
(Giant vetch)

G. Monroe
Cover and richness of understory N-fixing species (Objective 5)
Cover of understory species sorted by water requirement (Objective 5)
Concluding remarks

- Thinning contributed to the development of a diverse plant understory in terms of overall species richness, successional groups, growth forms and structure, without decreasing plant regeneration or triggering plant invasions.
Concluding remarks

- Thinning may also enhance functional effect and response diversity leading to increased resilience
- Variable thinning with gaps and leave islands appear to be a promising silviculture alternative to improve young coniferous forests in western Oregon
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Alternative hypotheses

- Understory richness and cover will increase with increased stand complexity
- Understory plant composition will become more variable within more structurally-complex treatments
- Understory plant richness will be gaps > leave islands > forest matrix
Pre-settlement forests
Forest interior

Gap
**Ecosystem stability**: Capacity of an ecosystem to persist in the same state (in fact a state of relative equilibrium). It has two components:

- **Resistance**: Ability to persist in the same state in the face of perturbation.
- **Resilience**: Ability to return to its former state following perturbation; or the amount of disturbance that a system can absorb without changing state (Holling 1973), or the time required for a system to return to an equilibrium or steady-state following a perturbation (Ives 1995, MacGillivray et al. 1995). The network of species, their dynamic interaction between each other and the environment, and the combination of structures that make reorganization after disturbance possible has been termed “ecological memory” (Bengtsson et al. 2003).

To estimate resilience, it is necessary to specify (a) the states and spatial scale of the system (Decocq 2002; the synusial approach in Decocq, 2000), (b) the perturbation of interest, and (c) the temporal scale of interest (Drever et al. 2006).

One component of resiliency is the diversity of species (and associated traits) as they affect ecosystem functions, labeled *functional diversity* (Peterson et al. 1998; Norberg and Cumming 2008).

Functional diversity assumes a partial overlap in resource use or overlap in contribution to ecosystem processes. Coexistence of multiple species with similar functional attributes may be caused by complementary resource use (Tilman et al. 1997, Hooper 1998) or spatial or temporal separation (Pacala and Levin 1997).

*Functional diversity* is more important than *species richness* for ecosystems (Figure 1; Diaz and Cabido 2001). Functional diversity relates to functional types.

- **Functional types**: Sets of species non-phyllogenetically grouped showing similar response to the environment and similar effects on ecosystem functioning (Lavorel et al. 1997) (examples on Tables 1 and 2). They include:
  - Functional response types: Groups of plant species that respond similarly to the environment (e.g., gap versus forest interior species; fire tolerant versus fire intolerant).
  - Functional effect types: Groups of plants that have similar effects on dominant ecosystem processes (e.g., nitrogen fixers, nurse species).

The *response diversity* is the diversity of response traits within functional groups. Changes in environmental conditions will favor specific response types, thus shifting ecosystem composition to adapt to new conditions. Ecosystems with high variability in response types and wide range of attributes are better able to respond to a wider variety of changes in conditions than ecosystem with limited set of response types.
Ordination
- Non-metric multi-dimensional scaling ordination (NMS) (Gradients in understory vegetation and environmental characteristics)
- Blocked multiple-response permutation (Differences in species composition among treatments)
- Indicator species analysis (Fidelity of species to treatments)