ECOLOGICAL FOREST MANAGEMENT

Northwest Natural Resources Group

Rolf Gersonde, 6/11/2016

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Ecological Forestry in 60 Seconds – The Element of Ecological Forestry

• Using site Adapted Species
• Based on Natural Processes
• Improve Soil Productivity
• Enhance Habitat and Biodiversity
• Improve Natural Capital
• Economic and Ecological Resilience
Ecological Forestry in 90 Minutes – Outline of the Presentation

• Forest Stand Dynamics
• Forest Ecology
• Silviculture and Multi-aged Management
  • Group Selection Example
  • Single Tree Selection Example
• Tools for Assessment and Management
• Operations
Forest Stand Dynamics
Stand Development Stages following a major disturbance

Franklin and Van Pelt 2004
Seedling/Sapling – Stand Initiation
Early Seral Vegetation
Canopy Closure in Young Forests
Competitive Exclusion Phase – Crown Differentiation and Self-thinning
Crown Differentiation – The development of crown classes during early stand development

Figure 1.—A typical Douglas-fir stand, with dominant (D), codominant (C), intermediate (I), and overtopped (O) trees. A wolf tree (W)—one that occupies more space than it warrants—also is part of the stand. The relative amount of crown, height, and diameter of each tree determines its crown class.

D – Dominant
C – Co-dominant
I – Intermediate
O – Overtopped
Biomass Production – Trees versus Stands

Volume Growth

Stand Density

Stand

Tree
Tree Diameter Growth –
The effect of stand density on diameter growth

Fig. 9.3. Effect of spacing on mean tree diameter at breast height and annual ring widths of Sitka spruce 32 years after planting. (From Savill and Sandels 1983.)
Tree Vigor and Stability -
Live crown ratio and height to diameter ratio as indicators

**Height : Diameter Ratio** *(H and D in same units)*

- **120** Poor Vigor
- **100** Weak
- **80** Stable
- **60** Vigorous
- **40** Very Vigorous
Tree Height Growth –
Height growth changes with age as it differs between species.
Understory Establishment – following overstory disturbance and gap creation
Competition versus Agent Based Mortality
Natural Regeneration
- Understory Establishment Stage

- Seed Source
  - Species, Seed Year, Predation

- Environment
  - Temp, Water, Light

- Seed bed
  - Soil, Competition, Mycorrhiza
Understory Light and Canopy Gap – Progressively more light in gap and shading of the gap edge
Identify Shade Tolerance by Branch Morphology – Shade and Light Adapted Conifers

- Grand fir
- Douglas-fir
- Western hemlock
- Western white pine
### Shade Tolerance – Ranking of Western Tree Species (Daniel et al. 1979)

<table>
<thead>
<tr>
<th>Tolerance Level</th>
<th>Western Hemlock</th>
<th>Pacific Yew</th>
<th>Pacific Silver Fir</th>
<th>Vine Maple</th>
<th>Western Redcedar</th>
<th>Grand Fir</th>
<th>Sitka Spruce</th>
<th>Big-Leaf Maple</th>
<th>Douglas-Fir</th>
<th>Western White Pine</th>
<th>Ponderosa Pine</th>
<th>Lodgepole Pine</th>
<th>Red Alder</th>
<th>Cottonwoods</th>
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</table>
Understory Growth – Morphological Plasticity

- Noble fir
- Pacific silver fir
- Western hemlock

- Sun and shade foliage
- Terminal vs. lateral growth
- Apical dominance
Site and Tree Species

Soil Nutrients

Soil Water
Tree species and Ecological Amplitude

Soil Nutrients

Very Poor  Poor  Medium  Rich  Very Rich

Very Dry
Dry
Slightly Dry
Fresh
Moist
Very Moist
Wet

Modified from: Klinka, Worrall, Skoda and Varga (2000): The Distribution and Synopsis of Ecological and Silvical Characteristics of Tree Species of British Columbia
www.for.gov.bc.ca/hfp/silviculture/compendium
Understory Species as Indicators of Site Conditions

**Site Classification - Edatopic Grid**

<table>
<thead>
<tr>
<th>CWHvm subzone</th>
<th>VP</th>
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<th>M</th>
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Modified from:
www.for.gov.bc.ca/hfp/silviculture/compendium
## Tree Species and Soil Moisture

### Modified from:
www.for.gov.bc.ca/hfp/silviculture/compendium

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<tr>
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<th>Red Alder</th>
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<th>B Cottonwood</th>
<th>Grant Fir</th>
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<th>WW Pine</th>
<th>B Cherry</th>
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- **Maximum Sustainable Productivity**
- **Crop Reliability**
- **(Silvicultural Feasibility)**
Soil Moisture and Topographic Position

Ridge
- Dry
- Thin soil

Upper Slope
- Fresh
- Thin soil
  (Colluvium)

Lower Slope
- Moist
- Thicker soil

Valley
- Wet – Deep rich soil
  (Alluvium)
Mixed-species Forests
Percent hardwood mixture in conifer forests affects songbird density

From Ellis and Betts, 2010, Western Forester 55(2)
Benefits of Mixed-species Stands

Hardwood plant litter with high decomposition rates improves soil development and is forage for many species.
Mixed-Species Stands

- Species specific
  - Growing space
  - Height growth
  - Shade tolerance
  - Senescence
  - Disease & Pests
Mixed-Species Stands

- Symbiosis
- Nutrient enrichment
- Resilience

Mycorrhiza

Frankia alni bacteria
Root Disease Indicators

Photos: www.forestryimages.org and www.fs.fed.us
Armillaria root disease

- Widespread
- Most tree species
  - Manage for Tree Vigor

Phellinus or Laminated Root Rot

- Localized
- Species specific
  - Manage for Species Conversion

Ecological Forestry manages for Species Diversity
Bark Beetle Indicators
Positive Feedback Cycle in Disturbance Agent Complex: Forest – Wind – Insects - Drought – Pathogens

Daniel Miller, USDA Forest Service, Bugwood.org
Kenneth E. Gibson, USDA Forest Service, Bugwood.org
Landscape level effect of tree species diversity on disturbance propagation
Silvicultural System —
System of coordinated regeneration, tending, control, and harvest treatments

Even-aged System
- Clear Cut
- Seed Tree
- Shelterwood
- Thinning

Two-aged System
- Variable Retention
- Coppice with Reserves

Uneven-aged system
- Group Selection
- Thinning
- Single Tree Selection
Stand Volume and Rotation in Even-aged System
Seed-Tree and Shelterwood Regeneration Methods
Continuum of Silvicultural Approaches –
A- individual tree selection, B-group selection, C- mixture of individual tree and group selection
What is Uneven-aged Management?

Even-aged “age-class” Forestry

Uneven-aged Management System
Origins of Uneven-aged forest management:

Henry Biolley (France)
Alfred Möller (Germany)

“Dauerwald”
“Continuous Cover Forestry”
Ecological Basis

- Small-scale disturbance regime and species composition lead to characteristic diameter distribution of natural stands

Meyer 1952
History of Uneven-aged Management in the Pacific Northwest

Kirkland and Brandstrom 1936
Leo Isaac 1956
Managing Multi-aged Stands
Managing Uneven-aged Stands

Manage stand density to:

1. Sustain growth of all stand components
2. Maintain stand structure
3. Replace tree mortality and harvest through regeneration

Transformation of even-aged to multi-aged stands
Cutting Cycle
– cutting cycle length depends on cutting intensity and growth rates
Cutting Cycle

1. Age 40
   - Stand Volume: 200 TPA
   - Basal Area (BA): 120

2. Age 60
   - Stand Volume: 180 TPA
   - Basal Area (BA): 180

3. Age 60
   - Stand Volume: 90 TPA
   - Basal Area (BA): 120

4. Age 80/20
   - Stand Volume: 200 TPA
   - Basal Area (BA): 160
Single Tree Selection –
Age classes are mixed at fine scale, growth and regeneration are regulated by removal of individual trees
While individual trees are removed, the stand structure remains the same.
Single Tree Selection
– developing a guide curve from tree count and diameter
Single Tree Selection

Guide Curve:
Total basal area
Maximum Diameter “slope”

At each cutting cycle we thin trees in classes that exceed the guide curve.
Group Selection System - A Systematic Approach to Diverse Forests
Group Selection System –
Age classes are mixed at group scale (1/2 – 2 acres), growth and regeneration are regulated by removing groups of trees AND thinning individual trees.

The group selection system allows for mixture of shade and intolerant species in the same stand.
Group Selection System
- Age-class mixture and management activities

Activities:
- Group-Selection Harvest
- Natural Regeneration Planting
- Pre-comm. Thinning
- Commercial Thinning
- Understory Thinning

Regeneration

Thinned Matrix

PCT

Un-thinned Large Tree
Scheduling Group Selection Treatments

Area Control Method – Stand is divided into even areas, these areas are treated during the cutting cycle (e.g. 20% regenerated in one-acre group selection cuts, 40% commercial thinning, 20% pre-commercial thinning of regeneration in previous group selection cuts).

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<th>Cutting Cycle</th>
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<td>Group Selection</td>
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Cutting Cycle:

- 1
- 2
- 3
- 4
- 5
- 6

Stand Age:

- 40
- 60
- 80
- 100
- 120
- 140
The Silviculture Toolbox —
Commercial and Ecological Forestry use the same tools. The difference is in when and how they are applied.

- Protect
- Regenerate
- Redistribute
- Select
Pure Hardwood Stands - Alder

Planted 1200 TPA
Age 9

Thinned to 230 TPA
Age 12

Planted 230 TPA, Age 13

Hardwood Silviculture Cooperative
http://www.cof.orst.edu/coops/hsc/
Naturally Regenerated Hardwood Stands
Red alder, Darrington, WA, Hardwood Silviculture Cooperative,
Hardwood Thinning Regime

- Planting 500-600 TPA
- PCT to 200-250 TPA (age 12)
- Pruning to retain 60% of crown
- Life branch pruning only
- 25-30 year harvest age
- 16 foot logs, 12 inch diameter
- High price of knot-free lumber
- Snow and ice damage

From John Belton 2004, Northwest Woodlands
Assessing growth and controlling density of all tree sizes and species in the same stand
Assessment of Growth – Overstory diameter increment
Assessment of Growth – Mid-canopy trees

- Crown ratio
- Height-diameter ratio
Assessment of Growth – Understory trees

Growth of terminal shoot versus lateral branches - Douglas-fir

Large Gap >30% Light

Small Gap ~20% Light

Under Canopy >20% Light
Assessment and Monitoring

Multi-aged Sustainability Indicators:

1. Sustain growth of all stand components
2. Maintain stand structure
3. Replace tree mortality and harvest through regeneration
# Inventory Design

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<th>Decisions</th>
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<td>Cutting Intensity</td>
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<td>Distribution</td>
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<tr>
<td>Length</td>
<td>Species Composition</td>
<td>Species</td>
</tr>
<tr>
<td></td>
<td>Growth of Stand Components</td>
<td>Diameter and Height</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increment</td>
</tr>
</tbody>
</table>

- Permanent Sample Plots or Mixed-Design

- Timing
- Cutting Intensity
- Cutting Cycle
- Length

- Regeneration
- Diameter Distribution
- Allocation of Growing Space
- Species Composition
- Growth of Stand Components

- Density
- Diameter
- Distribution
- Species
- Diameter and Height
- Increment
Permanent Sample Plots

- Species composition
- Size classes
- Stand volume
- Diameter growth
- Height growth
- Mortality
- Harvest
**Tools For Assessment – Sampling to establish a diameter distribution**

<table>
<thead>
<tr>
<th>DBH Class (Inches)</th>
<th>Plot 1 Count</th>
<th>Plot 2 Count</th>
<th>Plot 3 Count</th>
<th>Sum Tree Count</th>
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<tbody>
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<td>0-4</td>
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<td>0</td>
<td>0</td>
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<tr>
<td>4-8</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>8-12</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>12-16</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>16-20</td>
<td>2</td>
<td>2</td>
<td>8</td>
<td>12</td>
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<tr>
<td>20-24</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>24-28</td>
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<td>5</td>
<td></td>
<td>6</td>
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<td>28-32</td>
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<td>32-36</td>
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<td>2</td>
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</table>
Diameter Distribution of Even-aged Stand
Diameter Distribution of Multi-aged Stand

![Tree Count vs Diameter Class](image)

Tree Count

Diameter Class (Midpoint, Inch): 2, 6, 10, 14, 18, 22, 26, 30, 34
Growing Space Allocation

Resource requirements are proportional to size

- 80% Growing Space in Overstory
- 20% Growing Space in Understory
Growing Space Allocation – Overstory versus Understory

Tree Growth vs. Overstory Density

- Understory
- Overstory
Basal Area as proxy for growing space
- Stand basal area is the sum of the tree discs at breast height expressed in square feet per acre, and relates to leaf area, growing space, and resource allocation.
While there is a high number of small trees in the smaller diameter classes, they occupy a small amount of growing space (basal area) compared to the larger overstory trees.
Thinning and Harvest

- **Objectives**
  - Stocking Control, Regeneration, and Timber

- **Timing**
  - Recover investment, market conditions, boat payments

- **Make a Plan**
  - Long-term plan as Guide not Rule

- **Create Habitat**
  - CWD, snags, canopy layers
Tree Selection and Marking

- Creating Growing Space
- Selection Guide
- Basal Area
- Diameter Distribution

- Mark your Trees
Group Selection System – Planning Operations

- Units and Boundaries
- Forest Practices
- Roads and Trails
- Collaboration
Group Selection System – Planning Operations

- Layout for thinning and group selection harvest
- Location for yarding corridors
- Tracking regeneration
- Prescriptions for matrix thinning
- Estimating stocking and ingrowth
Implementation

Mechanized and hand-held cutting systems
Ground-base logging systems
Cable yarding system and yarding corridor
Impact of temporary skid tails and mitigation
Forest Products –
Marketing product diversity from small to large diameter wood
Non-Timber Forest Products

Medicinal Herbs, Fungi, Edible Fruits and Nuts, and Other Natural Products from the Forest

Maria R. Emery, Rebecca J. McLain

Diverse Canopy

Fruiting Vines
Wildcraft Fruit
Flowering Natives
Herbs
Living Soil Biome
Medicinal Roots

WOODS of PLENTY

www.woodsofplenty.com
Harvest impacts can be opportunities for creating habitat

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