Effect of Site and Silvicultural Treatment on Insect and Disease Pests of Young Ponderosa Pine

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Effect of Site and Silvicultural Treatment on Insect and Disease Pests of Young (~20 yr) Ponderosa Pine

- D. Norlander MS Thesis, OSU, Forest Science
- Sampled Incidence and Severity of Insect Damage and Diseases
- On six of the Garden of Eden Study Sites
- Summer of 2006
Objectives

1) Determine if insects and diseases are impacted by
   - geographical location
   - silvicultural treatment

2) To identify causes of variation in needle retention.

3) Determine the presence of wave years in western gall rust.
Methods: Study Site

- The Garden of Eden study
  - Silvicultural study by the USDA Forest Service Pacific Southwest Research Station in Redding, California.

- Six installation sites
  - Planted in 1986, 1987 and 1988

- All on industrial land
## Methods: Study Sites

<table>
<thead>
<tr>
<th>Site</th>
<th>Site Index</th>
<th>Elevation (m)</th>
<th>Mean Ann. Temp (°C)</th>
<th>Annual Precip (mm)</th>
<th>Year Planted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elkhorn Ridge</td>
<td>17</td>
<td>1490</td>
<td>11</td>
<td>840</td>
<td>1988</td>
</tr>
<tr>
<td>Pondosa</td>
<td>20</td>
<td>1175</td>
<td>10.5</td>
<td>1180</td>
<td>1988</td>
</tr>
<tr>
<td>Chester</td>
<td>20</td>
<td>1465</td>
<td>8</td>
<td>1035</td>
<td>1987</td>
</tr>
<tr>
<td>Whitmore</td>
<td>23</td>
<td>730</td>
<td>14</td>
<td>882</td>
<td>1986</td>
</tr>
<tr>
<td>Jaws</td>
<td>23</td>
<td>1005</td>
<td>8</td>
<td>1311</td>
<td>1988</td>
</tr>
<tr>
<td>Feather Falls</td>
<td>30</td>
<td>1220</td>
<td>11</td>
<td>2094</td>
<td>1988</td>
</tr>
</tbody>
</table>
Methods: Study Site

- Each plot contains 20 core trees
- Two rows of buffer trees
- 8 foot spacing

Corner stake
Methods: Study Site

Uniform set of treatments on each site.
Each treatment replicated three times.

24 total treatment plots at each site
Plot layout uniform throughout the study

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>7</th>
<th>13</th>
<th>19</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HF</td>
<td>I</td>
<td>HFI</td>
<td>HF</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>8 C</td>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>FI</td>
<td>9 HI</td>
<td>15</td>
<td>21</td>
</tr>
<tr>
<td>4</td>
<td>HFI</td>
<td>10 HF</td>
<td>16</td>
<td>22</td>
</tr>
<tr>
<td>5</td>
<td>C</td>
<td>11 F</td>
<td>17</td>
<td>23</td>
</tr>
<tr>
<td>6</td>
<td>HI</td>
<td>12 H</td>
<td>18</td>
<td>24</td>
</tr>
</tbody>
</table>

C = Control
F = Fertilizer
I = Insecticide
H = Herbicide
Methods: Study Site

- Herbicides: Glyphosate, hexazinone, and triclopyr
- Insecticides: Acephate and dimehoate
- Insecticide converted to thinning after 8th growth year
- Fertilizers: Salts applied at an exponential rate
## Methods: Study Site

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Planting</th>
<th>Year 2</th>
<th>Year 4</th>
<th>Year 6</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>15.6</td>
<td>46.6</td>
<td>213.7</td>
<td>798.7</td>
<td>1074.6</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>7.9</td>
<td>23.2</td>
<td>103.4</td>
<td>395.2</td>
<td>529.7</td>
</tr>
<tr>
<td>Potassium</td>
<td>7.7</td>
<td>23.2</td>
<td>109.6</td>
<td>399.4</td>
<td>539.9</td>
</tr>
<tr>
<td>Calcium</td>
<td>10.1</td>
<td>23.6</td>
<td>118.6</td>
<td>264.0</td>
<td>416.3</td>
</tr>
<tr>
<td>Magnesium</td>
<td>5.5</td>
<td>16.8</td>
<td>61.7</td>
<td>137.2</td>
<td>221.2</td>
</tr>
<tr>
<td>Sulphur</td>
<td>5.2</td>
<td>28.3</td>
<td>16.0</td>
<td>62.4</td>
<td>111.9</td>
</tr>
<tr>
<td>Zinc</td>
<td>1.1</td>
<td>3.2</td>
<td>14.0</td>
<td>55.1</td>
<td>73.4</td>
</tr>
<tr>
<td>Copper</td>
<td>0.5</td>
<td>1.6</td>
<td>6.8</td>
<td>26.9</td>
<td>35.8</td>
</tr>
<tr>
<td>Boron</td>
<td>0.5</td>
<td>1.6</td>
<td>6.8</td>
<td>29.8</td>
<td>38.7</td>
</tr>
</tbody>
</table>
Elkhorn Ridge (SI 17, Elev 1490)

Control

Herbicide, Fertilizer, Insecticide/Thinning
Pondosa (SI 20, Elev 1175)
Chester (SI 20, Elev 1465)

Control  
Herbicide, Fertilizer, Insecticide/Thinning
Whitmore (SI 23, Elev 730)

Control

Herbicide, Fertilizer, Insecticide/Thinning
Jaws (SI 23, Elev 1005)

Control

Herbicide, Fertilizer, Insecticide/Thinning
Feather Falls (SI 30, Elev 1220)

Control

Herbicide, Fertilizer, Insecticide/Thinning
Methods: Measurements

- Each of the core trees was studied for any and all insects and pathogens.
  - Percent of branches
  - Number attacks on branches and bole counted
  - Any root, butt, bole or branch pathogen recorded
  - Terminal and branch tips studied for any feeding

Western pine shoot borer damage
Methods: Measurements

- A sample branch was taken from mid-crown of five randomly chosen trees on each plot.
- Needle retention estimated in years (i.e. 2.6 yrs)
- % necrosis from foliar pathogens and % herbivory was estimated on one and two year old needles.
Methods: Measurements

- All western gall rust galls were studied.
  - Age determined by counting
    - Whorls to the base of the tree
    - Number of branch nodes to current year
  - Height of each gall measured
Methods: Analysis

- S-Plus used for ANOVA, linear regressions and Poisson log-linear regression
- Stepwise regression to determine variables that explain most variation
- Transformations used:
  - Arcsine $\sqrt{}$ for proportions/percent
  - Poisson for counts
Results: General

- 19 different insect pests and pathogens field identified
- No major outbreaks or epidemics
- Some sites had specific organisms at higher levels than others, i.e.:
  - Feather Falls: western gall rust
  - Pondosa: western pineshoot borers
## Results: General

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Frequency on trees %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Insects</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaf Hopper</td>
<td>Family <em>Cicadellidae</em></td>
<td>0.5</td>
</tr>
<tr>
<td>aphids</td>
<td>Family <em>Aphididae</em></td>
<td>1.0</td>
</tr>
<tr>
<td>Scale</td>
<td><em>Chionaspis spp.</em>, <em>Nuculaspis spp.</em></td>
<td>5.7</td>
</tr>
<tr>
<td>Sequoia Pitch Moth</td>
<td><em>Synanthedon sequoiae</em></td>
<td>7.6</td>
</tr>
<tr>
<td>Western pine shoot borer</td>
<td><em>Eucosma sonomana</em></td>
<td>2.5</td>
</tr>
<tr>
<td>Tip Moth</td>
<td><em>Rhyacionia spp.</em></td>
<td>2.5</td>
</tr>
<tr>
<td>Sugar pine tortrix</td>
<td><em>Choristoneura lambertiana</em></td>
<td>0.1</td>
</tr>
<tr>
<td>Leaf Miner</td>
<td><em>Coleotechnites spp.</em></td>
<td>1.0</td>
</tr>
<tr>
<td>Weevil</td>
<td><em>Magdalis gentilis</em>, <em>Scythropus elegans</em>, <em>Scythropus spp.</em></td>
<td>12.2</td>
</tr>
<tr>
<td>Bark Beetles</td>
<td><em>Ips spp.</em>, <em>Dendroctonus spp.</em></td>
<td>0.6</td>
</tr>
<tr>
<td>Gouty pitch midge</td>
<td><em>Cecidomyia piniipis</em></td>
<td>20.5</td>
</tr>
<tr>
<td>Saw fly</td>
<td><em>Neodiprion spp.</em>, <em>Acantholyda spp.</em></td>
<td>0.2</td>
</tr>
</tbody>
</table>
## Results: General

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Frequency on trees %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pathogens</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Armillaria</td>
<td><em>Armillaria ostoyae</em></td>
<td>0.1</td>
</tr>
<tr>
<td>Western Gall Rust</td>
<td><em>Endocronartium harknessii</em></td>
<td>10.3*</td>
</tr>
<tr>
<td>Dothistroma needle blight</td>
<td><em>Mycosphaerella pini</em></td>
<td>12.6</td>
</tr>
<tr>
<td>Elytroderma needle blight</td>
<td><em>Elytroderma deformans</em></td>
<td>0.2</td>
</tr>
<tr>
<td>Lophodermella/ Lophodermium needle cast</td>
<td><em>Lophodermella spp.</em>, <em>Lophodermium spp.</em></td>
<td>0.1</td>
</tr>
<tr>
<td>Diplodia needle blight</td>
<td><em>Sphaeropsis sapinea</em></td>
<td>0.3</td>
</tr>
</tbody>
</table>

(*) Rare to Very Common depending on the site
Results

- Six Abundant and Testable Groups emerged:
  - Needle Retention
  - Foliar Herbivory
  - Foliar Disease
  - Sequoia Pitch Moth
  - Gouty Pitch Midge
  - Western Gall Rust
# Results

<table>
<thead>
<tr>
<th>Response</th>
<th>Site</th>
<th>Treatment</th>
<th>Site X Treatment</th>
<th>Site index</th>
<th>Elevation</th>
<th>Precipitation</th>
<th>Mean Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Needle Retention</td>
<td>Yes</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>+</td>
<td>-</td>
<td>None</td>
</tr>
<tr>
<td>Total Foliar Herbivory</td>
<td>Yes</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>-</td>
<td>-</td>
<td>None</td>
</tr>
<tr>
<td>Gouty Pitch Midge</td>
<td>Yes</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Sequoia Pitch Moth</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>None</td>
<td>-</td>
<td>-</td>
<td>None</td>
</tr>
<tr>
<td>Total Foliar Pathogens</td>
<td>Yes</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>-</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Western Gall Rust</td>
<td>Yes</td>
<td>Yes</td>
<td>None</td>
<td>None</td>
<td>+</td>
<td>None</td>
<td>+</td>
</tr>
</tbody>
</table>
Results: Wave Years

Western Gall Rust Count

Year

Gall Count

Results: Wave Years

Western Gall Rust Count and El Nino Temperature Deviation

- Gall Count
- Oceanic Nino Index


Gall Count:
- 1989: 60
- 1990: 80
- 1991: 10
- 1992: 20
- 1993: 30
- 1994: 40
- 1995: 50
- 1996: 60
- 1997: 70
- 1998: 80
- 1999: 90
- 2000: 100
- 2001: 110
- 2002: 120
- 2003: 130
- 2004: 140
- 2005: 150
- 2006: 160

Oceanic Nino Index:
- 1989: -0.5
- 1990: -1
- 1991: -1.5
- 1992: 0
- 1993: 0.5
- 1994: 1
- 1995: 1.5
- 1996: 2
- 1997: 2.5
- 1998: 3
- 1999: 3.5
- 2000: 4
- 2001: 4.5
- 2002: 5
- 2003: 5.5
- 2004: 6
- 2005: 6.5
- 2006: 7
Results: Needle Retention

Mean Needle Retention in years for the Garden of Eden Study

Site (low to high productivity)
Results: Needle Retention

[Box plot showing needle retention (years) across different treatments labeled C, F, FI, H, HF, HFI, HI, I, with marked differences in retention across treatments.]
Results: Needle Retention

- No Treatment Effect

- Significant at a site level only.

- Site Productivity
  - Needle Retention decreases as site productivity increases
  - 3.48 years at lowest S.I.
  - 2.54 years at highest S.I.

- Environment
  - Needle retention also explained by elevation and precipitation
  - ↓ 0.08 years per 10cm ↑ in precipitation
  - ↑ 0.16 years per 100 m ↑ in elevation
Results: Foliar Herbivory

Total Foliar Herbivory at each Site

Site: Elkhorn, Pondosa, Chester, Whitmore, Jaws, Feather Falls

Total Foliar Herbivory (percent)
Results: Foliar Herbivory

Chester
Elkhorn Ridge
Feather Falls
Jaws
Pondosa
Whitmore

 simultaneo
us 95 % confidence limits, Tukey method
response variable: Total.Herb
Results: Foliar Herbivory

- No Treatment Effect

- Site Effect:
  - Feather Falls was significantly lower than all other sites.
    - No other sites were significantly different from each other
    - Feather falls: 9.5%
    - All others 14%-18%

- Environment:
  - Elevation: 3.95% ↓ per 100m ↑
  - Site index: 2.41% ↓ for each meter ↑ in S.I.
  - Mean temperature: 2.36% ↓ per °C ↑
Results: Foliar Pathogen Damage
Summary of mean percentage of foliage with infection symptoms.

<table>
<thead>
<tr>
<th>Site</th>
<th>Mean</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elkhorn Ridge</td>
<td>11.8</td>
<td>1.4</td>
</tr>
<tr>
<td>Pondosa</td>
<td>9.4</td>
<td>1.1</td>
</tr>
<tr>
<td>Chester</td>
<td>5.1</td>
<td>0.6</td>
</tr>
<tr>
<td>Whitmore</td>
<td>23.6</td>
<td>2.8</td>
</tr>
<tr>
<td>Jaws</td>
<td>23.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Feather Falls</td>
<td>11.4</td>
<td>1.1</td>
</tr>
</tbody>
</table>
Results: Foliar Pathogen Damage

- No Treatment Effect

- The site is significant.
  - Jaws had the highest (23.6%)
  - Chester had lowest (5.1%)

- Elevation was the only environmental variable that was important.
  - Foliar infection ↓ 8.9% per 100m ↑
  - The lowest elevation sites had the highest % damage from foliage disease
Results: Sequoia Pitch Moth

Number of Sequoia Pitch Moths Attacks per Plot

Sequoia Pitch Moth Attacks

Elkhorn  Pondosa  Chester  Whitmore  Jaws  Feather Falls

Site (low to high productivity)
Sequoia pitch moth attacks per plot by treatment.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Estimate</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.8</td>
<td>-1.250</td>
<td>2.80</td>
</tr>
<tr>
<td>F</td>
<td>2.2</td>
<td>0.195</td>
<td>4.25 *</td>
</tr>
<tr>
<td>FI</td>
<td>0.7</td>
<td>-1.360</td>
<td>2.69</td>
</tr>
<tr>
<td>H</td>
<td>4.4</td>
<td>2.420</td>
<td>6.47 *</td>
</tr>
<tr>
<td>HF</td>
<td>4.4</td>
<td>2.420</td>
<td>6.47 *</td>
</tr>
<tr>
<td>HFI</td>
<td>3.2</td>
<td>1.140</td>
<td>5.19 *</td>
</tr>
<tr>
<td>HI</td>
<td>2.4</td>
<td>0.417</td>
<td>4.47 *</td>
</tr>
<tr>
<td>I</td>
<td>1.1</td>
<td>-0.972</td>
<td>3.08</td>
</tr>
</tbody>
</table>

Values significantly different from “0” indicated by *
Results: Sequoia Pitch Moth

- Site, treatment and site:treatment interaction all statistically significant.
  - Treatments that had vegetation control had more attacks
  - Sites at environmental extremes had more attacks

- Environment:
  - Mean temperature, elevation and site index all influence the amount of SPM
    - Mean temperature: ↓ 14.7% per °C ↑
    - Elevation: ↓ 2.7% per 100m
    - Site index: ↓ 18% per meter ↑
Results: Gouty Pitch Midge

Gouty Pitch Midge Attacks in the Garden of Eden Study Sites

Site
Elkhorn Pondosa Chester Whitmore Jaws Feather Falls

Gouty Pitch Midge infestations (percent of branches attacked)
Results: Gouty Pitch Midge

- **No treatment effect**

- **Site**
  - Lowest productive site had highest level
    - 5.21% at Elkhorn

- **Environment**
  - Elevation, precipitation, and mean temperature were significant in a regression analysis
    - Elevation: ↑ 18% per 100 meters ↑
    - Precipitation: ↓ 273% per centimeter ↑
    - Mean Temperature: ↑ 13% per °C ↑

- **All sites statistically higher than zero**
Results: Western Gall Rust

Western Gall Rust Infections per Site in the Garden of Eden Study

- Site: Elkhorn, Pondosa, Chester, Whitmore, Jaws, Feather Falls

Western Gall Rust Infections per plot

Site (low to high productivity)
## Results: Western Gall Rust

Mean and total gall count on treatments throughout the entire Garden of Eden study.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mean # of Galls</th>
<th>St. Err.</th>
<th>Total galls</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>3.7</td>
<td>1.8</td>
<td>67</td>
</tr>
<tr>
<td>F</td>
<td>3.6</td>
<td>2.2</td>
<td>65</td>
</tr>
<tr>
<td>FI</td>
<td>4.8</td>
<td>2.1</td>
<td>87</td>
</tr>
<tr>
<td>H</td>
<td>3.8</td>
<td>1.7</td>
<td>69</td>
</tr>
<tr>
<td>HF</td>
<td>6.2</td>
<td>2.4</td>
<td>111</td>
</tr>
<tr>
<td>HFI</td>
<td>4.1</td>
<td>1.4</td>
<td>73</td>
</tr>
<tr>
<td>HI</td>
<td>2.7</td>
<td>1.4</td>
<td>48</td>
</tr>
<tr>
<td>I</td>
<td>3.7</td>
<td>2.0</td>
<td>66</td>
</tr>
</tbody>
</table>
Results: Western Gall Rust

- **Site**
  - Only Feather Falls and Chester were significantly different from zero
  - Feather Falls had 477 galls, Chester had 74
  - A one meter ↑ in the site index ↑ gall abundance 44.8%

- **Treatment**
  - Accounting for elevation, temperature, and site index:
    - FI, HF, and HI were different from the control

- **Environment**
  - Elevation and mean annual temperature important
  - ↑ elevation 100m ↑ gall rust 0.49%
  - ↑ mean temperature one degree ↑ gall abundance 13.7%
General Conclusions

- Treatments are not very important
- Site productivity and associated environment key
- Local areas have issues the whole lacks