Past, Current, and Future Forest Harvest and Regeneration Management in Interior Alaska Boreal Forest: Adaptation Under Rapid Climate Change

Miho Morimoto & Glenn P. Juday
EA conference, Fairbanks AK
August 24th 2016
Boreal Forest

• 30% of forest lands on the earth
• Ecosystem services
  ▪ Biodiversity
  ▪ Wildlife habitat
  ▪ Subsistence use
  ▪ Climate regulation
  ▪ Wood products
  ▪ Recreation etc...

Source: https://paulgreci.wordpress.com
Source: http://vilda.alaska.edu/
Source: http://www.adfg.alaska.gov/
Source: http://www.grida.no/
Changes in the Boreal Forests

Large-scale clearcutting in world’s boreal forests

Increasing natural disturbances and demand for wood biomass in Alaska boreal forest
Strong evidence of warming in boreal Alaska

Spring Ice Breakup Date 1917-2016
Tanana River at Nenana, Alaska

Mean Monthly Temperature, Apr.-Sep.
UES/Fairbanks, Alaska (1906-2015)

Predictive Index Temperature for white spruce
growth at Fairbanks (May, -1 Jul, -2 Jul)
(1908-2015)

Northern Hemisphere Sea Ice Anomaly
Anomaly from 1979-2008 mean

Source: Glenn P. Juday
Topics

1. Overview of historical harvest and regeneration management
2. Lessons for implementation of post-harvest regeneration management
3. An ecosystem approach to climate change and post-harvest regeneration
Study Area in Interior Alaska and Tanana Valley
Harvest in the study area (1969-2012)
13,000 ha harvested out of
1.2 million ha of total forest area (1%)
History of total annual volume harvested

State Forest Lands

- Continuous harvest activity
- Mostly white spruce sawlog

Other Forest Lands (MBF = 1000 board feet) *board foot is not compatible with metric

- Episodic but missing record in the late 1970s-80s
- All spruce sawlog
Annual allowable cut* and average annual harvested volume by species on lands set aside for timber harvest

State Forest Lands (m³)

Average annual harvested volume (1972-2012) (% of annual allowable cut)
- white spruce 10.9%;
- birch 1.0%;
- aspen 0.2%

*Allowable cut: the volume of timber that may be harvested during a given period (usually a year) that is specified by a sustained-yield forest plan (Society of American Foresters, Dictionary of Forestry)
Distribution of historical harvest units and roads

- 75.2% of harvest units are within 1 km of a road
- 90.8% of harvest units are within 4 km of a road
- Area within 1 km, harvested volume was 1.4 times higher than annual allowable cut level
History of annual area harvested by harvest type

- Salvage logging after Rosie Creek fire in 1983
- Clearcutting in 1990s
- Partial cutting in 2000s

State Forest Lands (ha)

Other Forest Lands (ha)
History of site preparation and harvest (annual area)

State Forest Lands (ha)

Other Forest Lands (ha)

Less than 20% of area
History of reforestation method of area harvested (annual total)

State Forest Lands (ha)

Other Forest Lands (ha)

About ½ area was planted

- Direct seed
- Plant
- Natural regeneration
Harvest units sampled for regeneration (n = 30)

SAMPLE CHARACTERISTICS

• White spruce harvest
• Year of harvest: 1975-2004
• Harvest type: clearcutting (16)/partial cutting (14)
• Site preparation: scarified (11)/none (19)
• Reforestation: natural regeneration (14)/planted white spruce seedlings (16)
Did the stands regenerate adequately?
Post-Harvest Tree Regeneration Density (2-yr. categories)

State regeneration standard

38 years since harvest

9 years since harvest

“All size” class

Sapling class (DBH > 2.5cm)

<table>
<thead>
<tr>
<th>Year of harvest</th>
<th>Black spruce</th>
<th>Balsam poplar</th>
<th>Aspen</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975-1976</td>
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<tr>
<td>1977-1978</td>
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<td>1981-1982</td>
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<td>1983-1986</td>
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<td>1999-2000</td>
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<td>2001-2002</td>
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<tr>
<td>2003-2004</td>
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</tr>
</tbody>
</table>

State regeneration standard

1112

495
Main demand might be biomass energy:

Regeneration is largely composed of hardwood (requires a change in species used)
Ecosystem Approach to Implementation of Management Goals
(steady-state environment assumption)

1. **Maximize regeneration?**
   - YES → **Clearcut**
   - NO → **Large white spruce seed crop?**
     - YES → **Not scarify**
     - NO → **Large-dimension white spruce production?**
       - YES → **Scarify**
       - NO → **Biomass production?**
         - YES → **Maximize white spruce?**
           - YES → **Scarify**
           - NO → **Natural regeneration**
         - NO → **Natural regeneration**

2. **Different ecosystem outcomes by applying different management actions in different circumstances**
How will climate change affect these results in the future?
Distribution of sampled units and scenario units

**Approach:**
- Build model of regeneration
- Use 3 IPCC climate scenarios
- Calibrate regeneration model to climate
- Predict future regeneration

**ASSUMPTIONS FOR SCENARIOS**
- Scenario units: current white spruce sawlog stands
- Period of regeneration: 2015-2053 (projected scenario climate) 1975-2013 (historical climate)
Percentage of occurrence of natural regeneration under climate change scenario

**White spruce**

- Clearcut
- Partial cut

**Birch**

- Clearcut
- Partial cut

**Aspen**

**PROJECTIONS:**
- **Increase** in regeneration under modest warming (B1, A1B)
- **Substantial reduction of** regeneration under A2
Failure of white spruce natural regeneration under A2 scenario

Regeneration failure in low and moderate elevation on the south half of major ridges with high July temperature
Failure of white spruce natural regeneration under A2 scenario...and low to moderate July precipitation.
Failure of **birch** natural regeneration under A2 scenario

*Widespread regeneration failure across low elevation valleys and ridges with high July temperatures*
Failure of birch natural regeneration under A2 scenario...

...and low to moderate July precipitation
Ecosystem Approach to Adaptive Management Options

1. Monitoring
   - Study of drought stress on regeneration
   - Genetic study

2. Maintain forest and landscape
   - Assisted migration (new species)
   - Monitoring
     - Study of drought stress on regeneration
     - Genetic study
   - Gene study
   - Assess the risk of species introduction
   - Gene study

3. Allow biome conversion
   - Hot and dry area
   - Shrub/grass land for new products/wildlife species
   - Exploring new products (e.g. wood bison)
   - New products/wildlife species

North
Acknowledgement

• Major advisor: Glenn Juday
• Graduate Committee: David Valentine, Falk Huettmann, John Yarie, and Valerie Barber
• BAK LAP supported by appropriation to the Alaska Department of Natural Resources Division of Forestry, the McIntire Stennis Cooperative Forestry Research Program (ALK13-04), and the Bonanza Creek Long-Term Ecological Research program funded by the National Science Foundation (DEB-1026415)
• Alaska Department of Natural Resources, Division of Forestry, especially Brian Young and Doug Hanson, for databases, equipment, transportation, advises, reviews
• Tanana Chiefs Conference for databases
• People who helped me with fieldwork, especially Ryan Jess and Mary Guisa
• Friends and family who have supported and encouraged me
State of Alaska Management Areas

- *Tanana Valley State Forest*, plus
- *State “Forest Classified” Land*

Primary purpose of state forest lands is “... timber management ... while allowing other beneficial uses.” (AS 41.17.200a)
Methods: Field Sampling

Summer 2013/14
741 plots

Plot (1/450 acre)

White spruce
< 1.37 m height
Count
DBH
Total height

Birch
Aspen
Balsam poplar
Black spruce
≥ 1.37 cm height
Count
≥ 1 cm DBH

DBH = Diameter at breast height
White spruce
Or
Hardwood

9 years

Harvested in 2004

11 years

Harvested in 2002

36 years

Harvested in 1977
Post-harvest regeneration tree density 10-40 years after harvest compared to density within 7 years

12 harvest units compared
7-yr survey = 2 to 10* yrs *exception to 7-yr period
This study = 14 to 33 yrs

“All size” class

Sapling (DBH > 2.5cm) class

- 6 of 12 harvest units did not meet the standard in 7-yr survey
- All units met the standard at 10-40 yrs
- Tree recruitment appears to continue for longer than 7 years

- 11 out of 12 units met the standard of 495 ha\(^{-1}\) of sapling at 10-40 yrs
Methods

Response variables (Binary class)
- White spruce, birch, and aspen
  - Presence/absence
  - Any size
  - Sapling class (DBH ≥ 2.5 cm)
    \( (1 = \text{present}; \ 0 = \text{absent}) \)
- Basal area
  \( (1 = \text{high}; \ 0 = \text{low}) \)
  \( \text{Threshold} \)
  - White spruce = 0.5 \( m^2 \)
  - Birch = 1.0 \( m^2 \)
  - Aspen = 0 \( m^2 \)
- Aggregated species
  - Biomass
    \( (1 = \text{high}; \ 0 = \text{low}) \)
    \( \text{Threshold} = 5 \ t\cdot ha^{-1} \)

Predictor variables
- Management practices
  - Harvest type
  - Site preparation method
  - Reforestation technique
- Year of harvest
- Size of harvest
- Distance to various features
  - Edge of harvest unit
  - White spruce forest
  - Birch forest
  - Aspen forest
  - Water
  - Highway
  - Forest road
  - Urban area
  - Developed area
- Topography
  - Elevation
  - Slope
  - Aspect
  - Topographic position index
- Soil subgroup
- Climate of growing season (May-August)
  - Mean average monthly temperatures
  - Total monthly precipitation
## Results: predictive accuracies of presence/absence

<table>
<thead>
<tr>
<th></th>
<th>Predicted presence/absence</th>
<th>Specificity</th>
<th>Sensitivity</th>
<th>Mean accuracy</th>
<th>AUC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Any size</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Aspen</td>
<td>Absent</td>
<td>491</td>
<td>92</td>
<td>84.22%</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>Present</td>
<td>22</td>
<td>121</td>
<td>84.62%</td>
<td></td>
</tr>
<tr>
<td>Birch</td>
<td>Absent</td>
<td>176</td>
<td>91</td>
<td>65.92%</td>
<td>0.68</td>
</tr>
<tr>
<td></td>
<td>Present</td>
<td>138</td>
<td>321</td>
<td>69.93%</td>
<td></td>
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<tr>
<td>White spruce</td>
<td>Absent</td>
<td>196</td>
<td>74</td>
<td>72.59%</td>
<td>0.73</td>
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<tr>
<td></td>
<td>Present</td>
<td>123</td>
<td>333</td>
<td>73.03%</td>
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<tr>
<td><strong>Sapling class</strong></td>
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<td></td>
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<tr>
<td>Aspen</td>
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<td>653</td>
<td>43</td>
<td>93.82%</td>
<td>0.94</td>
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<tr>
<td></td>
<td>Present</td>
<td>2</td>
<td>28</td>
<td>93.33%</td>
<td></td>
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<tr>
<td>Birch</td>
<td>Absent</td>
<td>394</td>
<td>84</td>
<td>82.43%</td>
<td>0.82</td>
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<td></td>
<td>Present</td>
<td>47</td>
<td>201</td>
<td>81.05%</td>
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<td>422</td>
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<td>0.79</td>
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<tr>
<td></td>
<td>Present</td>
<td>44</td>
<td>152</td>
<td>77.55%</td>
<td></td>
</tr>
</tbody>
</table>

* AUC = area under curve
The effect of harvest type on post-harvest regeneration prediction

**Presence (any size)**

- **White spruce**
  - Clear: 0.005
  - Partial: 0.000

- **Birch**
  - Clear: 0.000
  - Partial: -0.004

- **Aspen**
  - Clear: 0.004
  - Partial: -0.004

**Presence of sapling class**

- **White spruce**
  - Clear: 0.010
  - Partial: -0.005

- **Birch**
  - Clear: 0.000
  - Partial: -0.005

- **Aspen**
  - Clear: 0.2
  - Partial: -0.1

**Basal area**

- **White spruce**
  - Clear: 0.005
  - Partial: 0.000

- **Birch**
  - Clear: 0.000
  - Partial: -0.005

- **Aspen**
  - Clear: 0.10
  - Partial: -0.05

**Biomass**

- **White spruce**
  - Clear: 0.005
  - Partial: 0.000

- **Birch**
  - Clear: 0.000
  - Partial: -0.005

- **Aspen**
  - Clear: 0.05
  - Partial: -0.00

**Partial Dependence**

- **Clearcutting resulted in greater predicted stem presence, high basal area and biomass**
The effect of site preparation on post-harvest regeneration

Presence (any size)  Presence of sapling class  Basal area  Biomass

White spruce

Birch

Aspen

Site preparation resulted in greater predicted stem presence, high basal area and biomass overall
Site preparation in a high white spruce seed crop year can result in OVERSTOCKING

1987 – too dense

1989 – density OK

NC-305
Partial cut in 1987
Site preparation and planting white spruce seedlings

NC-705
Clearcut in 1989
Site preparation and planting white spruce seedlings
The effect of reforestation method on post-harvest regeneration

**Presence (any size)**

- **White spruce**
  - Natural: -0.0002
  - Planted: 0.0004

- **Birch**
  - Natural: -0.005
  - Planted: 0.002

- **Aspen**
  - Natural: -0.001
  - Planted: 0.002

**Presence of sapling class**

- **White spruce**
  - Natural: -0.0002
  - Planted: 0.0004

**Basal area**

- **White spruce**
  - Natural: -0.010
  - Planted: 0.000

**Biomass**

- **White spruce**
  - Natural: -0.0005
  - Planted: 0.0005

**Aggregated**

- **White spruce**
  - Natural: -0.02
  - Planted: 0.00

- **Birch**
  - Natural: -0.01
  - Planted: 0.01

- **Aspen**
  - Natural: -0.01
  - Planted: 0.00

- **Aggregated**
  - Natural: -0.002
  - Planted: 0.001

**Partial Dependence**

- Contribution of reforestation (planting/not planting) to the prediction was limited.
Planted white spruce seedlings are larger and better positioned for early canopy dominance but white spruce natural regeneration is present under hardwood canopy.
Conceptual diagram of post-harvest regeneration and landscape positions (developed from actual regeneration outcomes)
Methods

1. Same method and predictors as Chp 3 were used to build predictive models
   • Only presence/absence was analyzed (no basal area, biomass)
   • Birch and apen predictive models were the same as Chp 3, but for white spruce only natural regeneration was analyzed in Chp 4

2. Build post-harvest regeneration scenarios under historical and warming climate for different management practices
   • Management practices
     • Harvest type (clearcutting vs. partial cutting)
     • Site preparation method (scarify vs. none)
     • Reforestation technique (plant vs. natural)
Methods

- Climate scenarios
  - **B1** (*lowest emissions/warming*)
  - **A1B** (*mid-range*)
  - **A2** (*high emissions/strong warming*)
  - **Historical climate**

![Climate scenarios graph](image)
Results: predictive accuracies for basal area and biomass

<table>
<thead>
<tr>
<th></th>
<th>Predicted low/high</th>
<th>Specificity Sensitivity</th>
<th>Mean accuracy</th>
<th>AUC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basal area</strong></td>
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<tr>
<td>Aspen</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Low</td>
<td>103</td>
<td>6</td>
<td>94.50%</td>
<td>0.94</td>
</tr>
<tr>
<td>High</td>
<td>2</td>
<td>32</td>
<td>94.12%</td>
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</tr>
<tr>
<td>Birch</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Low</td>
<td>194</td>
<td>30</td>
<td>86.61%</td>
<td>0.86</td>
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<tr>
<td>High</td>
<td>33</td>
<td>201</td>
<td>85.90%</td>
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<tr>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Low</td>
<td>190</td>
<td>43</td>
<td>81.55%</td>
<td>0.81</td>
</tr>
<tr>
<td>High</td>
<td>45</td>
<td>177</td>
<td>79.73%</td>
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</tr>
<tr>
<td><strong>Biomass</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aggregated</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>319</td>
<td>87</td>
<td>78.57%</td>
<td>0.78</td>
</tr>
<tr>
<td>High</td>
<td>72</td>
<td>261</td>
<td>78.38%</td>
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</table>
Results: predictive accuracies of presence/absence developed from actual regeneration outcomes

<table>
<thead>
<tr>
<th></th>
<th>Predicted presence/absence</th>
<th>Specificity</th>
<th>Sensitivity</th>
<th>Mean accuracy</th>
<th>AUC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Absent</td>
<td>Present</td>
<td></td>
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<tr>
<td>Aspen</td>
<td>Absent</td>
<td>491</td>
<td>92</td>
<td>84.22%</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>Present</td>
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<td>0.68</td>
</tr>
<tr>
<td></td>
<td>Present</td>
<td>138</td>
<td>321</td>
<td>69.93%</td>
<td></td>
</tr>
<tr>
<td>White spruce</td>
<td>Absent</td>
<td>239</td>
<td>93</td>
<td>71.99%</td>
<td>0.72</td>
</tr>
<tr>
<td></td>
<td>Present</td>
<td>108</td>
<td>286</td>
<td>72.59%</td>
<td></td>
</tr>
</tbody>
</table>
Results: relative importance of predictors to presence

- Harvest type
- Site preparation
- Reforestation
- Year of harvest
- Size
- Dist. to edge
- Dist. to white spruce
- Dist. to Birch
- Dist. to aspen
- Dist. to water
- Dist. to development
- Dist. to urban
- Dist. to forest road
- Dist. to highway
- Elevation
- Slope
- Aspect
- TPI
- Soils
- May temp
- June temp
- July temp
- Aug temp
- May precip
- June precip
- July precip
- Aug precip

Importance 60 % or greater

- White spruce
- Birch
- Aspen

Relative importance (%)

Aspen
Birch
White spruce
(e) Distance to birch forest

(f) Distance to white spruce forest

(g) Distance to aspen forest

(h) Distance to water
(i) Distance to urban area

(ii) Distance to development

(iii) Distance to forest road

(iv) Distance to highway
(m) May precipitation

(n) July precipitation

(o) August precipitation

(p) August temperature
64.4% of harvest units are within 1 km of a road
94.0% of harvest units are within 4 km of a road
Accessibility of stands of sawlog white spruce on state forest lands

Potential area for white spruce harvest expansion
Accessibility of stands of larger **birch** on state forest lands

Potential areas for birch harvest expansion
Accessibility of stands of larger **aspen** on state forest lands

**Potential areas for aspen harvest expansion**
Key Factors in Climate Adaptive Management

Plan for the next step

- **Hypothesis:** regeneration failure under climate warming (Chp 4)
- **Uncertainties:** species adaptability, rate of warming, resource availability, fire occurrence and effectiveness of suppression, demand for wood
- **Risks:** failure due to low input management, assisted migration
- **Challenges:** laws and policies, limited resources, stakeholder issues, actions, collaboration

Implementing adaptive management is not easy but the tools and findings of this research and the cumulative monitoring would help achieve the goal

**Move it or lose it? The ecological ethics of relocating species under climate change**

Ben A. Mitscher and James P. Collins
School of Life Sciences, Arizona State University, Tempe, Arizona 85287-4501 USA

Abstract. Managed relocation (also known as assisted colonization, assisted migration) is one of the more controversial proposals to emerge in the ecological community in recent years. A conservation strategy involving the translocation of species to novel ecosystems in anticipation of range shifts forced by climate change, managed relocation (MR) has divided many ecologists and conservationists, mostly because of concerns about the potential invasion risk of the relocated species in their new environments. While this is indeed an important consideration in any evaluation of MR, moving species across the landscape in response to predicted climate shifts also raises a number of larger and important ethical and policy challenges that need to be addressed. These include evaluating the implications of a more aggressive approach to species conservation, assessing MR as a broader ecological policy and philosophy that departs from longstanding scientific and management goals focused on preserving ecological integrity, and considering MR within a more comprehensive ethical and policy response to climate change. Given the complexity and novelty of many of the issues at stake in the MR debate, a more dynamic and pragmatic approach to ethical analysis and debate is needed to help ecologists, conservationists, and environmental decision makers come to grips with MR and the emerging ethical challenges of ecological policy and management under global environmental change.

(Source: Nature “Forestry: Planting the forest of the future” (Marris 2009))
# Results: Predictive Accuracies of Dominance

<table>
<thead>
<tr>
<th>Dominance group</th>
<th>All size” group</th>
<th>Low</th>
<th>High</th>
<th>Specificity</th>
<th>Mean accuracy</th>
<th>AUC</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;All size&quot; group</td>
<td>Aspen</td>
<td>Low 580</td>
<td>79</td>
<td>88.01%</td>
<td>0.88</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>High 9</td>
<td>58</td>
<td>86.57%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birch</td>
<td>Low 296</td>
<td>84</td>
<td>77.89%</td>
<td>0.78</td>
<td>0.85</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High 78</td>
<td>268</td>
<td>77.46%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White spruce</td>
<td>Low 377</td>
<td>115</td>
<td>76.63%</td>
<td>0.76</td>
<td>0.83</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High 58</td>
<td>176</td>
<td>75.21%</td>
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</table>

<table>
<thead>
<tr>
<th>Sapling</th>
<th>Aspen</th>
<th>Low 656</th>
<th>44</th>
<th>93.71%</th>
<th>0.94</th>
<th>0.97</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High 2</td>
<td>24</td>
<td>92.31%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birch</td>
<td>Low 423</td>
<td>83</td>
<td>83.60%</td>
<td>0.84</td>
<td>0.90</td>
<td></td>
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<tr>
<td></td>
<td>High 36</td>
<td>184</td>
<td>83.64%</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>White spruce</td>
<td>Low 472</td>
<td>111</td>
<td>80.96%</td>
<td>0.81</td>
<td>0.88</td>
<td></td>
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<tr>
<td></td>
<td>High 27</td>
<td>116</td>
<td>81.12%</td>
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</tbody>
</table>
Results: Relative Importance of Predictors for Dominance

“all size”  sapling

Harvest type
Site preparation
Reforestation
Year of harvest
Size
Edge
White spruce
Birch
Aspen
Water
Development
Urban
Forest road
Highway
Elevation
Slope
Aspect
TPI
Soils
May temp
June temp
July temp
Aug temp
May precip
June precip
July precip
Aug precip

Relative importance value (%)
### Results: relative importance of predictors to presence

#### “any size”

<table>
<thead>
<tr>
<th>Management factors of interest</th>
<th>Relative importance value (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvest type</td>
<td></td>
</tr>
<tr>
<td>Site preparation</td>
<td></td>
</tr>
<tr>
<td>Reforestation</td>
<td></td>
</tr>
<tr>
<td>Year of harvest</td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td></td>
</tr>
<tr>
<td>Dist. to Edge</td>
<td></td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td>Dist. to birch</td>
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</tr>
<tr>
<td>Dist. to aspen</td>
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<td>Dist. to water</td>
<td></td>
</tr>
<tr>
<td>Dist. to development</td>
<td></td>
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<tr>
<td>Dist. to urban</td>
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<tr>
<td>Dist. to forest road</td>
<td></td>
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<tr>
<td>Dist. to highway</td>
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<td>Elevation</td>
<td></td>
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<tr>
<td>Slope</td>
<td></td>
</tr>
<tr>
<td>Aspect</td>
<td></td>
</tr>
<tr>
<td>Topographic position</td>
<td></td>
</tr>
<tr>
<td>index</td>
<td></td>
</tr>
<tr>
<td>Soils</td>
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<td>June temp</td>
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<td>July temp</td>
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</tr>
<tr>
<td>July precip</td>
<td></td>
</tr>
<tr>
<td>Aug precip</td>
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</table>

#### sapling

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<tr>
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<tr>
<td>July precip</td>
<td></td>
</tr>
<tr>
<td>Aug precip</td>
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</table>

*Factors with best predictive power*
## Results: relative importance of predictors

### Management factors of interest

<table>
<thead>
<tr>
<th>Factor</th>
<th>Relative importance value (%)</th>
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<tr>
<td>Year of harvest</td>
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</tr>
<tr>
<td>Size</td>
<td>10</td>
</tr>
<tr>
<td>Dist. to Edge</td>
<td>80</td>
</tr>
<tr>
<td>Dist. to white spruce</td>
<td>60</td>
</tr>
<tr>
<td>Dist. to birch</td>
<td>40</td>
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<tr>
<td>Dist. to aspen</td>
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<td>Dist. to water</td>
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<td>Dist. to development</td>
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<td>Dist. to highway</td>
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<td>July precip</td>
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### Basal area

<table>
<thead>
<tr>
<th>Species</th>
<th>Relative importance value (%)</th>
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<tr>
<td>Aspen</td>
<td>50</td>
</tr>
<tr>
<td>Birch</td>
<td>30</td>
</tr>
<tr>
<td>White spruce</td>
<td>20</td>
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</table>

### Biomass

<table>
<thead>
<tr>
<th>Relative importance value (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregated</td>
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</table>
Wildfire and Harvest: Landscape-Level Biodiversity

- Landscape-scale diversity contribute substantially to sustaining habitats for a full range of species
- Wildfire creates landscape mosaic with various size and shape of disturbed patches
- Fire occurrence and severity are largely controlled by vegetation type
- Forest harvest is generally small in size and concentrated near road and in white spruce
Wildfire and Harvest: Stand-Level Biodiversity

Fire produces coarse woody debris for carbon balance, nutrient retention, wildlife species

Harvest *traditionally* removes coarse woody debris

[Images of wildlife and forested areas]
Comparison of fire and harvest disturbance (size of continuous area harvested versus fire perimeter (1969-2012))

DIFERENCE
Harvests (to date) are only small.
Fires are small to very large

# of disturbances

Area (ha)

Fire
Harvest

0 100 200 300 400 500 600 700 800
0-10 10-100 100-1000 1000-10000 10000-100000 100000-1000000
Average annual area burned by decade (1000 ha)

Fire is increasing

<table>
<thead>
<tr>
<th>Year</th>
<th>Area (ha)</th>
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<tbody>
<tr>
<td>1943-50</td>
<td>200</td>
</tr>
<tr>
<td>1951-60</td>
<td>300</td>
</tr>
<tr>
<td>1961-70</td>
<td>300</td>
</tr>
<tr>
<td>1971-80</td>
<td>200</td>
</tr>
<tr>
<td>1981-90</td>
<td>200</td>
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<tr>
<td>1991-2000</td>
<td>200</td>
</tr>
<tr>
<td>2001-10</td>
<td>700</td>
</tr>
<tr>
<td>2010-15</td>
<td>500</td>
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</table>
Historical wildfires around state forest lands
Historical wildfires within and outside of state forest lands

Fire suppression has been modestly effective on state forest lands (1972-2012)

- 31% of total Interior Alaska burned
- 22% of state forest lands burned
Eliminated by repeated short cycle disturbances.