OREGON SOCIETY OF AMERICAN FORESTERS ANNUAL MEETING
April 25-27, 2012, Seaside, Oregon

Role Of Genetics In Maintaining Productive Forests In A Changing World

Nicholas Wheeler and Glenn Howe
Dept of Forest Ecosystems and Society
Oregon State University

Tree Improvement Cycle

BREEDING

PRODUCTION

2nd generation

2nd generation

1st generation

1st generation

4 Progeny Testing

3 Clonebank/Breeding Arboretum

5 Reselect Parents

F Reforestation

E Seedling Production

D Cone and Seed Processing, Testing, Registration

2 Collection

7 Breeding

6 Collect and Graft Scions

A Seed Orchard Establishment

B Pollination

C Seed Production

1 Selection

Intensive Forestry and Genetics

Virtually all plantation forestry in the world today starts with genetically improved planting stock.

In the Northwest, our most advanced Douglas-fir breeding programs produce trees that grow >30% faster/larger than un-improved trees.

Tree form, wood properties, and traits of adaptive significance (drought and cold tolerance) are also being improved.

Tree Improvement Increasingly Relies on Molecular Genetic Tools

Genetic markers are used in many ways to enhance the tree breeding process.

- **Quality Control – Genetic Fingerprinting**

Quality Control In A Clonal Seed Orchard

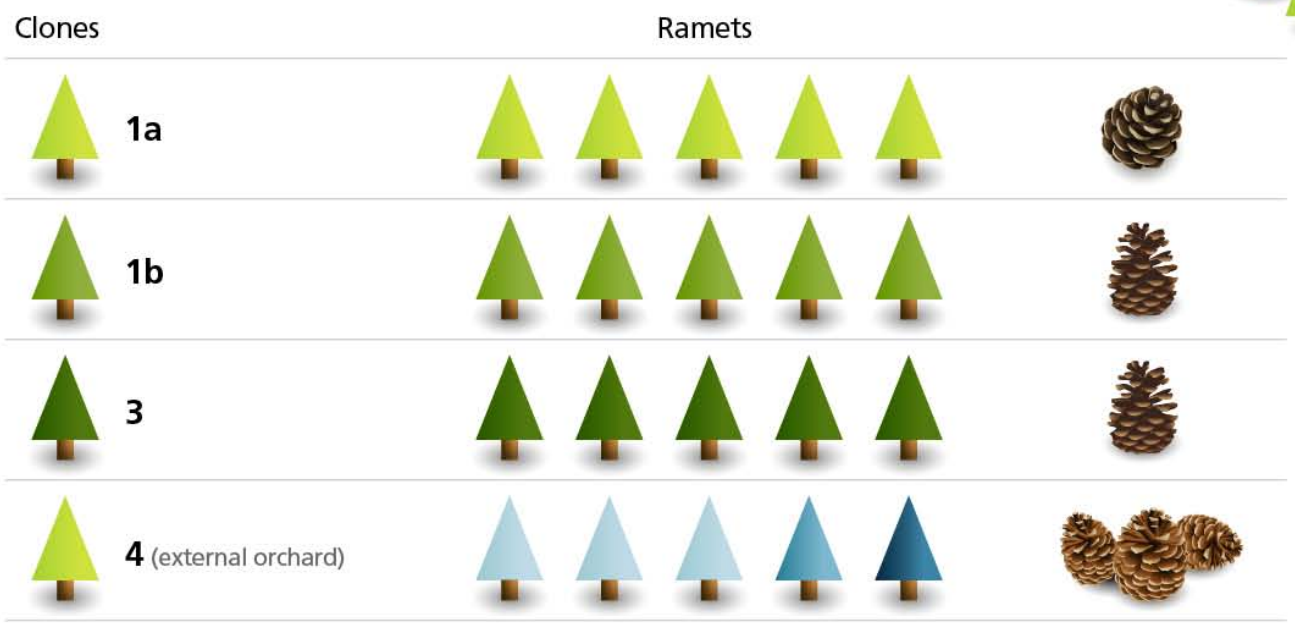


Figure credit: Nicholas Wheeler, Oregon State University

Tree Improvement Increasingly Relies on Molecular Genetic Tools

Genetic markers are used in many ways to enhance the tree breeding process.

- Quality Control – Genetic Fingerprinting

- Paternity Determination
  - ✓ Pollen contamination
  - ✓ More efficient breeding designs

Pollen contamination

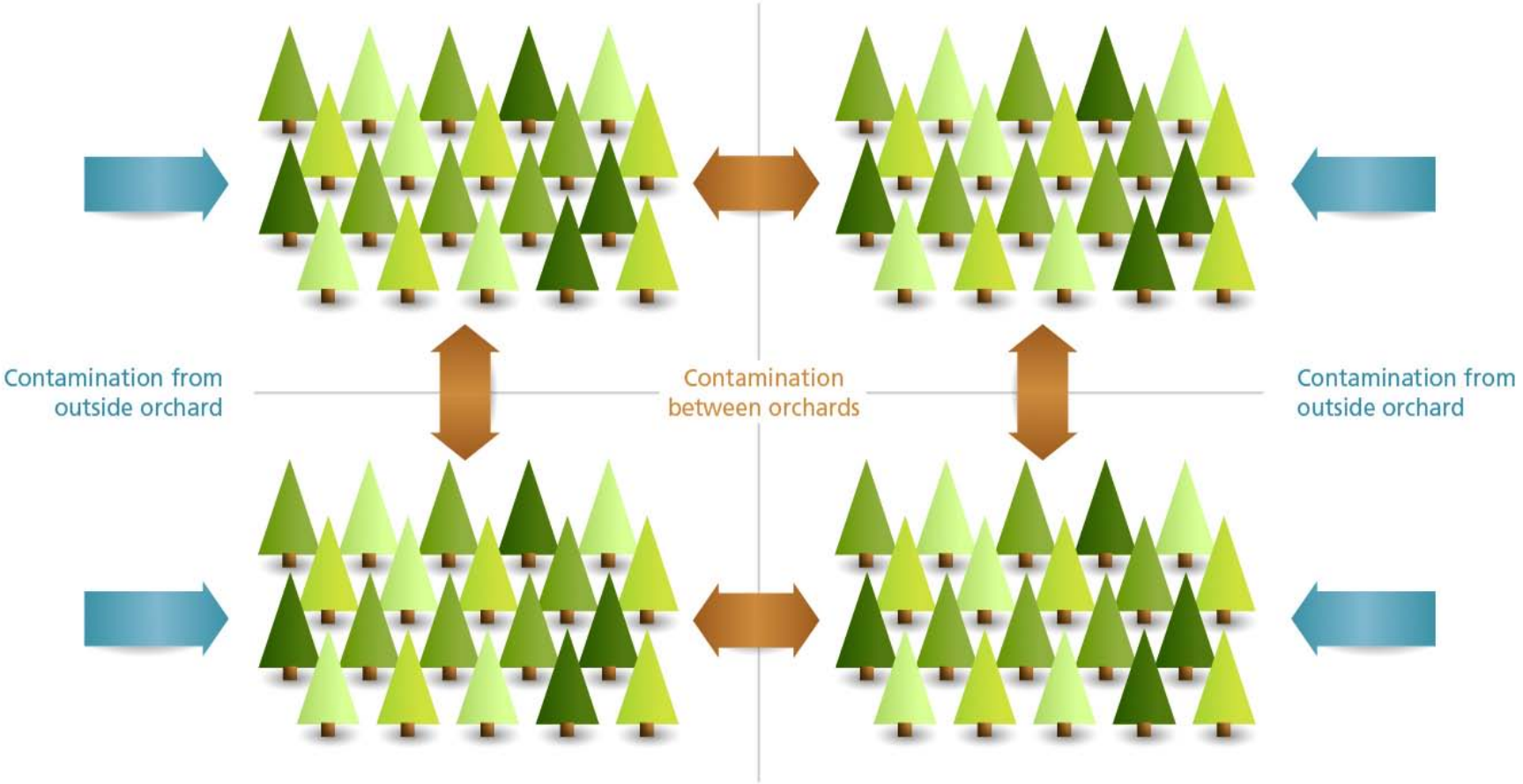


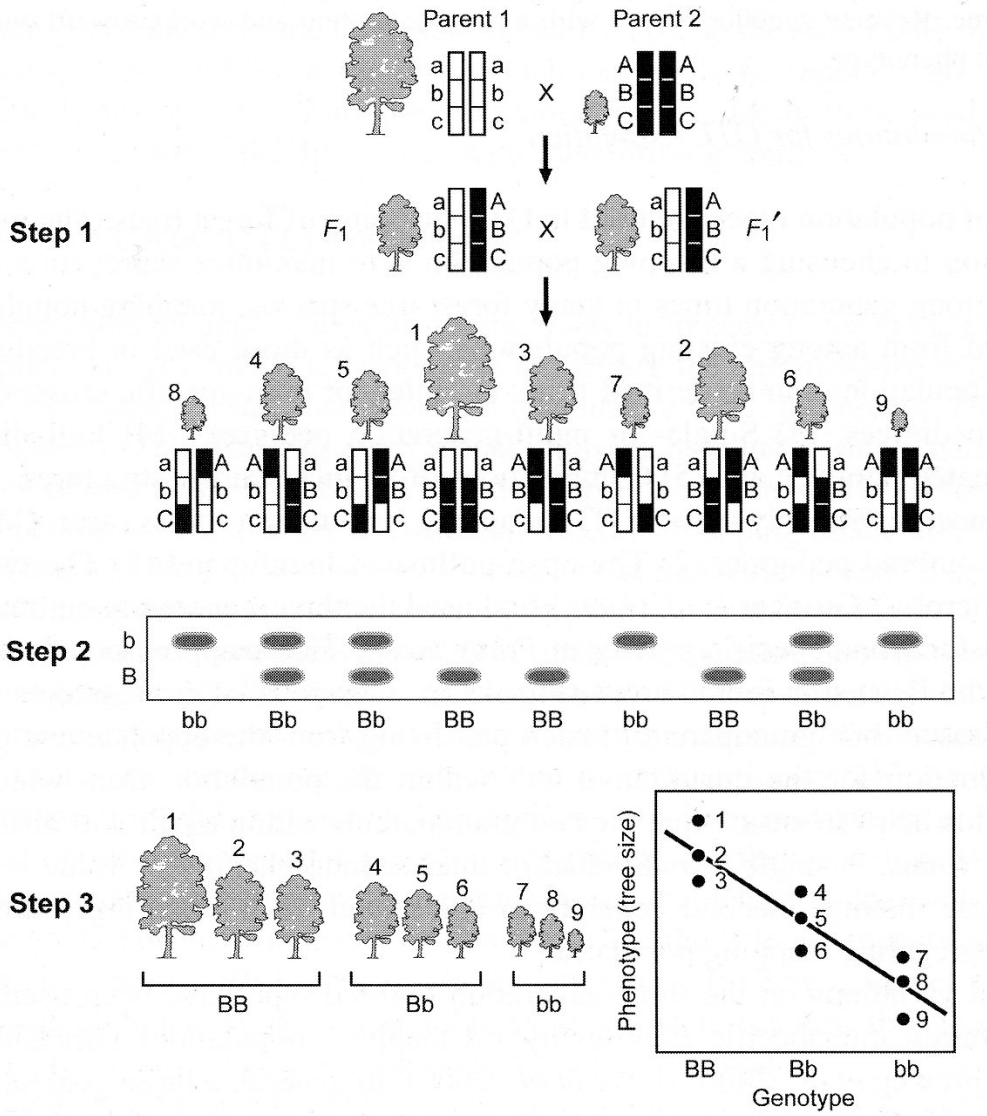
Figure credit: Nicholas Wheeler, Oregon State University

Tree Improvement Increasingly Relies on Molecular Genetic Tools

Genetic markers are used in many ways to enhance the tree breeding process.

- Quality Control – Genetic Fingerprinting
- Paternity Determination
  - ✓ Pollen contamination
  - ✓ More efficient breeding designs
- Marker Informed Breeding and Selection

Selection Based On Genetic Markers

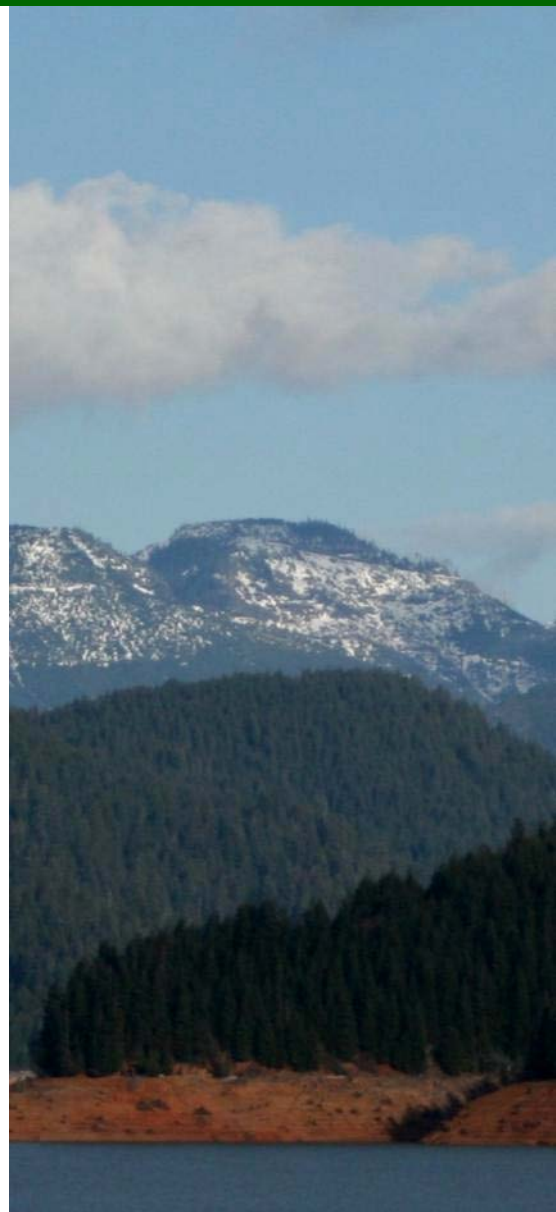


Tree Improvement of the Future

- ***Traditional tree breeding methods will always be required.***
- ***Genetic markers will play an increasingly significant role in tree improvement***
  - *Within 3 years geneticists will know the complete DNA sequence for loblolly pine, Douglas-fir, Sugar pine, Norway and White spruces, and several other conifers and hardwood species. Most tree genes will be identified, and , for many, their functions known.*
  - *Within 5 years, markers will be used in the selection of superior trees in most important tree species for traits such as growth, form, wood properties, adaptation to drought, cold and salinity, and so forth.*
  - *The value of markers will extend to management of natural populations*

Forests and Climate Change

- *Climate change: How much? When? Who says?*
- *How will forests respond?*
- *How can forest managers adapt?*
- *Summary and conclusions*



The earth is getting warmer

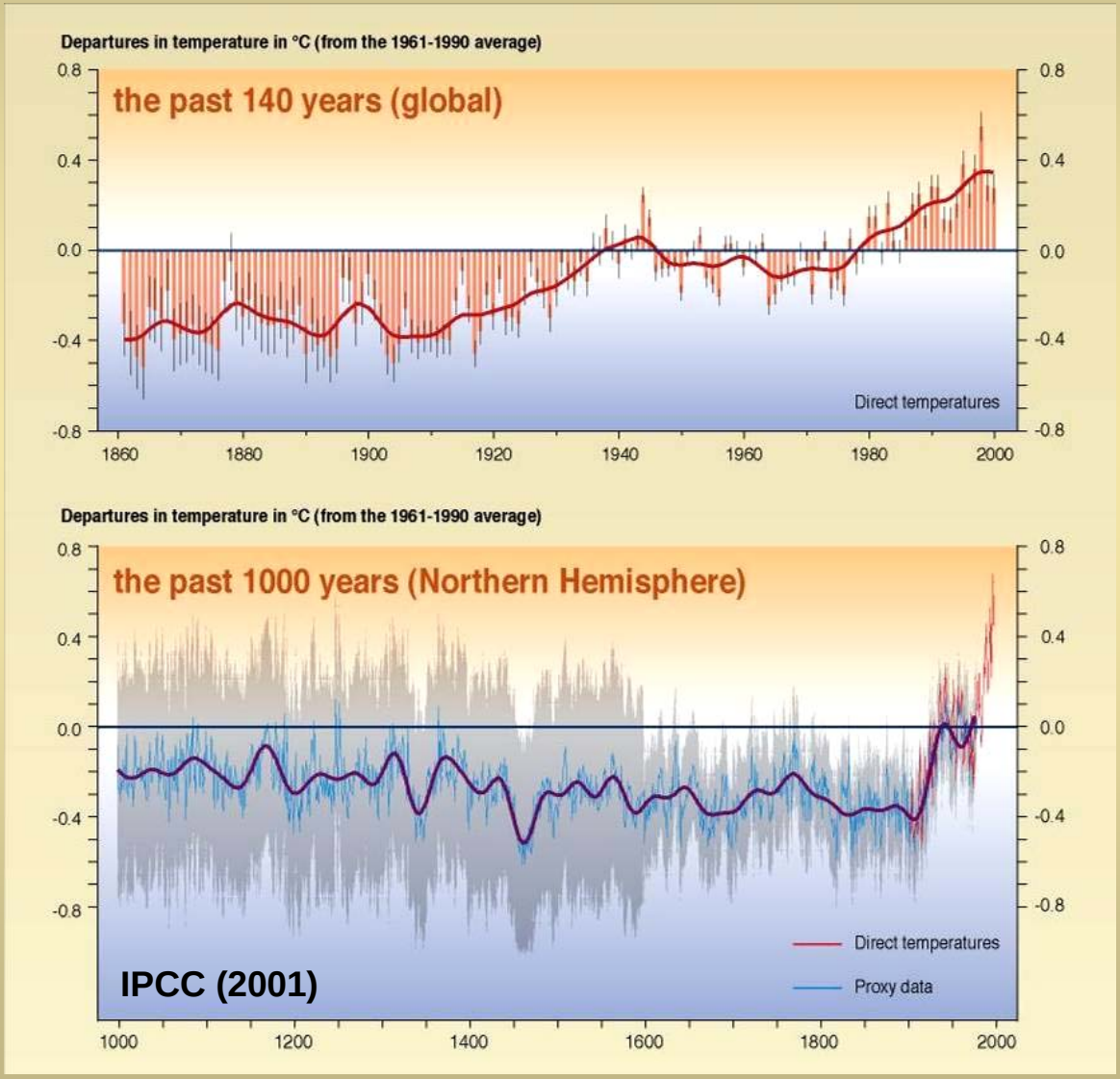
IPCC (2007)

Intergovernmental Panel on Climate Change

*"Warming of the climate system is **unequivocal**, as is evident from observations of increases in average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level"*

*The **IPCC** is a scientific intergovernmental body set up by the World Meteorological Organization (WMO) and United Nations Environment Program (UNEP)*

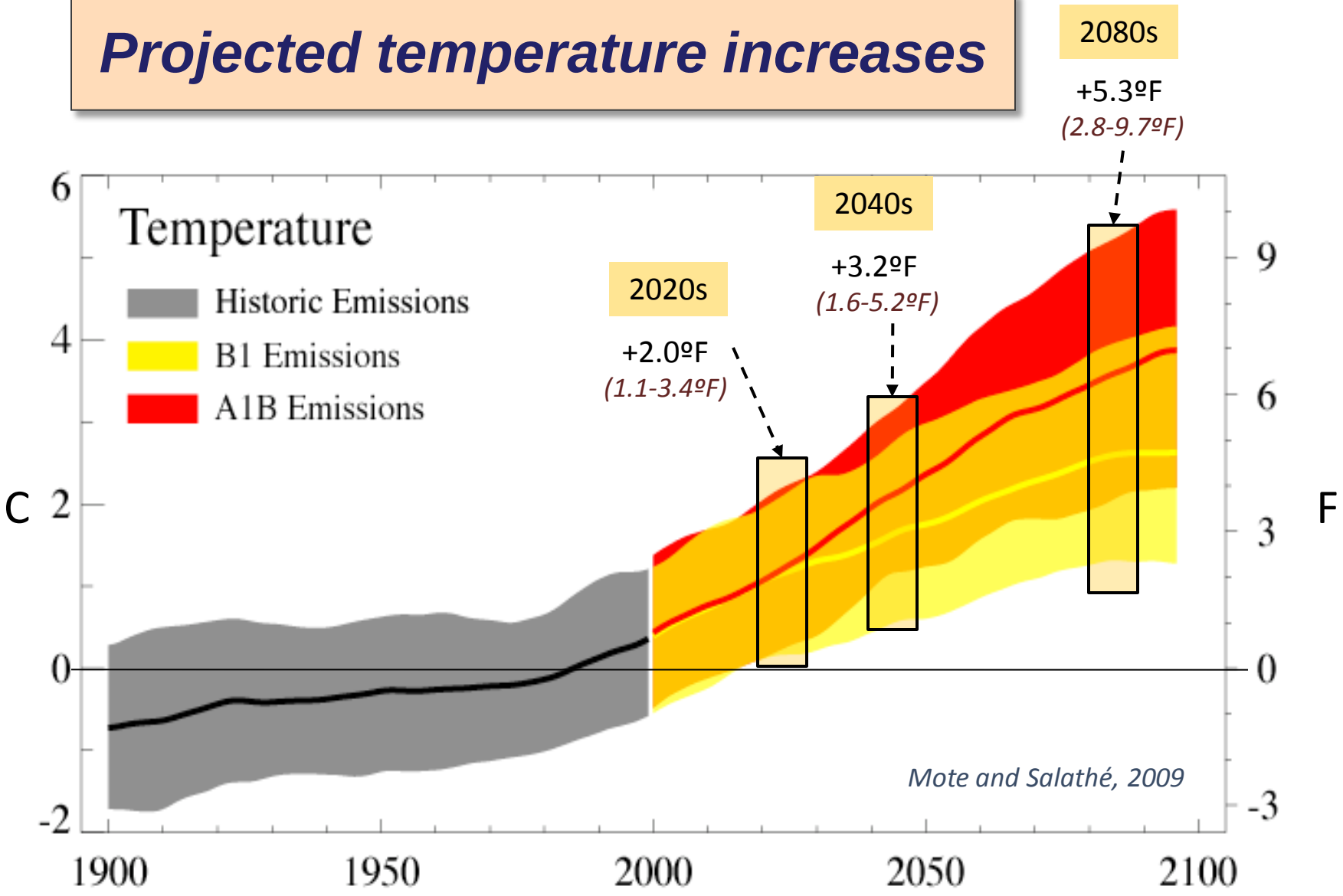
Earth's surface temperature for….



100-year linear trend of 0.74ºC

Continued warming is virtually certain (IPCC 2007)

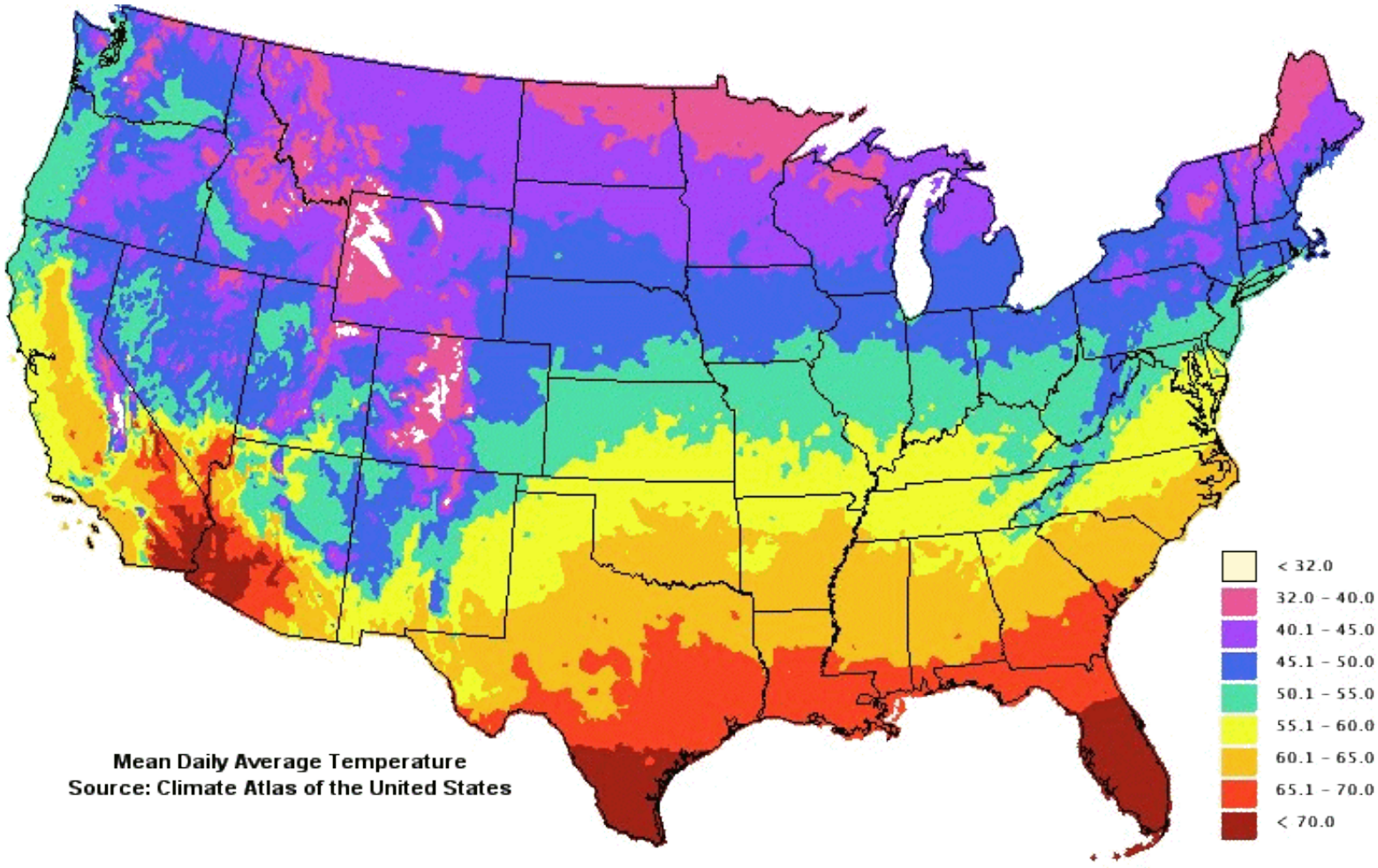
Projected temperature increases



** Compared with 1970-1999 average*

Slide from Jeremy Littell

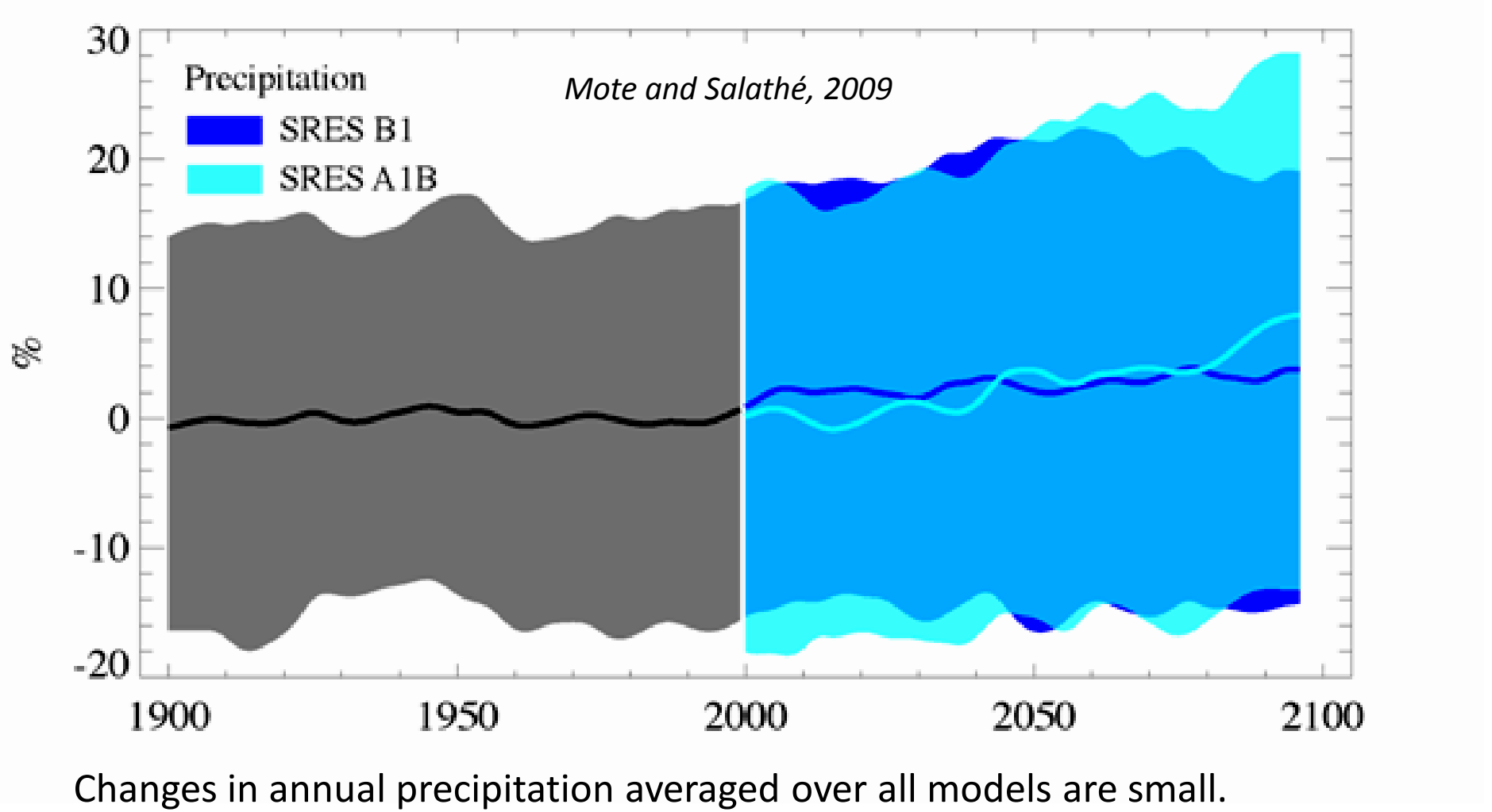
What does a change of 5°F look like?



Mean Daily Average Temperature
Source: Climate Atlas of the United States

Projected Changes in Annual Precipitation

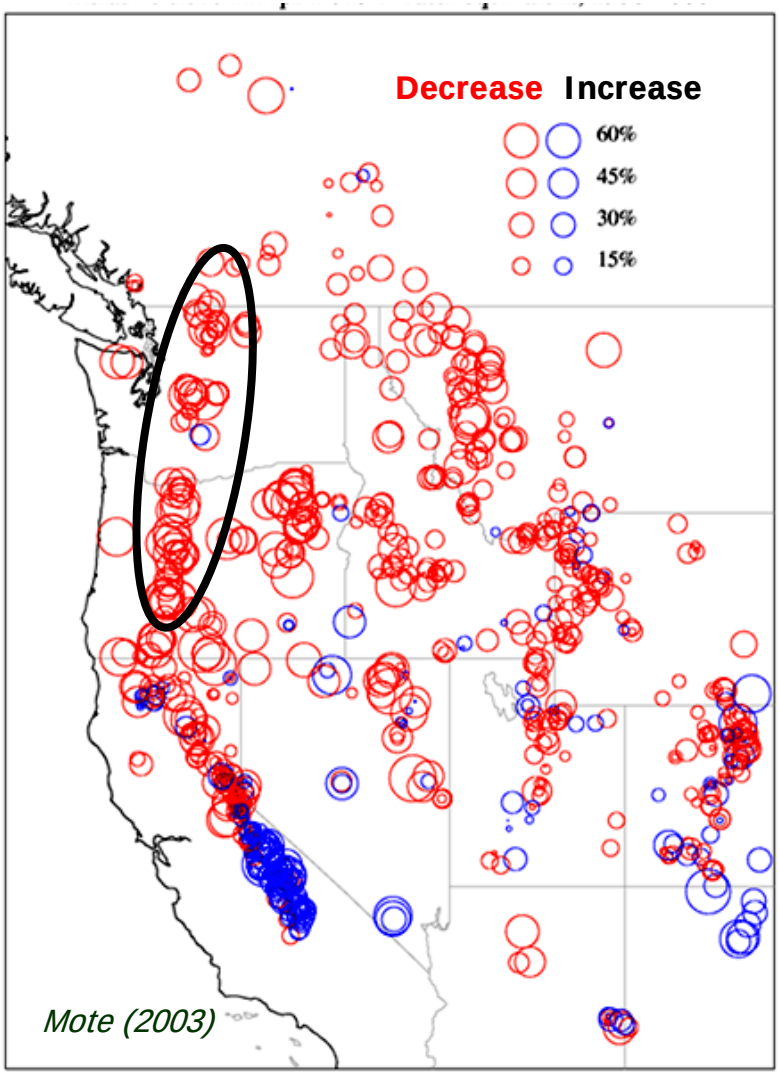
** Compared with 1970-1999 average*



Changes in annual precipitation averaged over all models are small.
Some models show large seasonal changes, especially toward *wetter autumns and winters* and *drier summers*.

Slide from Jeremy Littell

Effects of climate change are evident



Snow water equivalents (SWE) 1950-2000

- SWE declined at 73% of stations
- Many sites in Cascades have declines of 30-60%

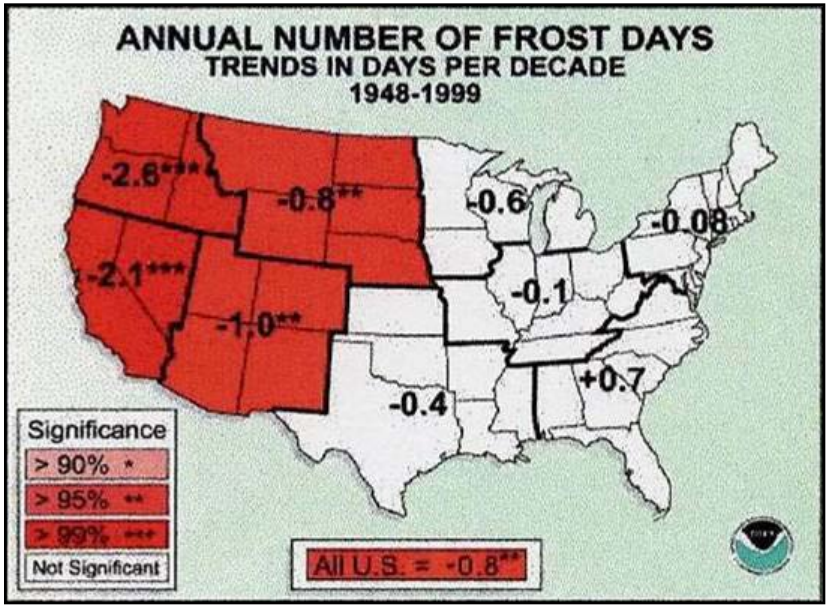
CLIMATE IMPACTS GROUP

Effects of climate change are evident

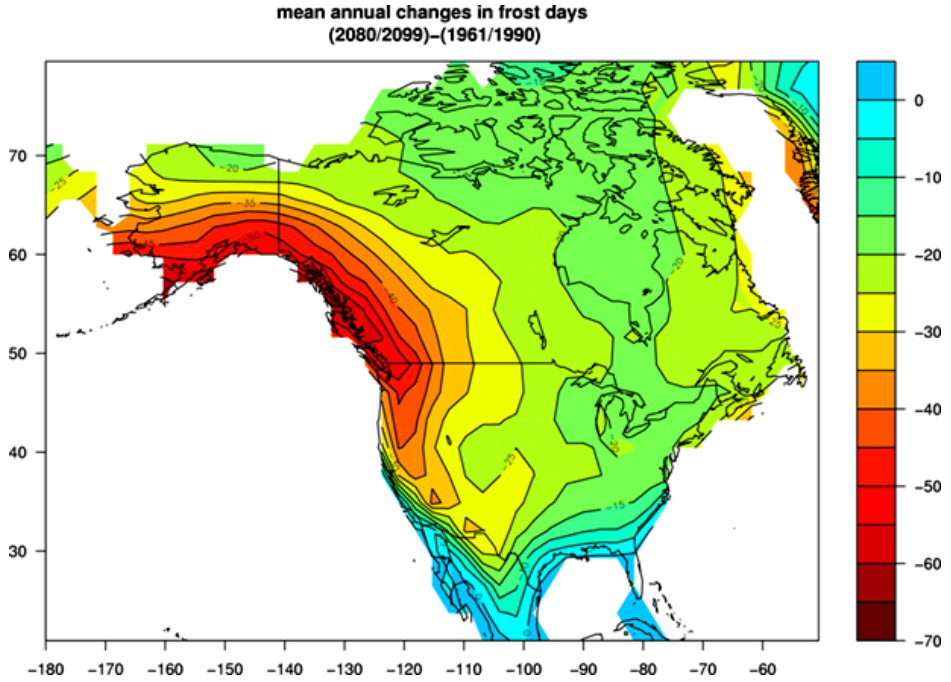
Growing seasons are longer

(number of frost days has declined)

Past: 1948-1999



Projected: 2090



Effects of climate change are evident

Mountain pine beetle infestation projection (http://www.for.gov.bc.ca/hre/bcmpb/)

Beetle image, USFS R4 Archive, Bugwood.org

Mountain pine beetle in BC

- Climatically suitable habitat has increased:
  - *Higher minimum winter temps*
  - *Higher summer temps*
  - *Spring drought*
- Outbreak expanded northward and into higher elevation forests
- Outbreak is an order of magnitude larger in area and severity than previous outbreaks
- Due to Global warming and positive phase of Pacific Decadal Oscillation (PDO)

Kurz et al (2008) Nature 452, 987-990.

Summary

Probable and potential effects (likelihood varies)

- Temperatures will increase
- Warming will probably be greater in summer than winter
- Frost-free seasons will be longer
- Winters may be wetter and summers drier
- Snowpack will decrease and snowmelt will occur earlier
- Extreme events will be more frequent

Primary impacts of climate change

1. Tree reproduction, survival, and growth

2. Disturbances from fire, insects, pathogens

3. Species distributions and forest composition

Pictures from Jeremy Littell

How can forest managers respond?

Genetic options

Silvicultural options

Genetic options for adaptation

Maintain species and within-species genetic diversity

- *In situ (on site)*
- *Ex situ (outside)*
- *Plant a mixture of species and seed sources to hedge your bets?*

Help natural populations migrate

- *Maintain forested corridors for stepping-stone migration*

Plant adapted species and seed sources

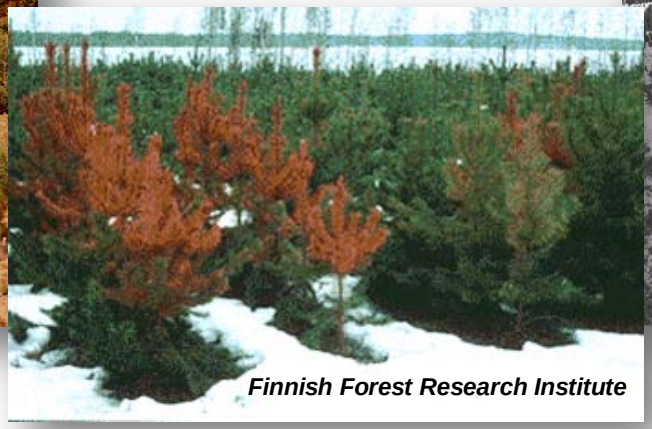
- *Practice 'assisted migration'*
- *Genetic outposts*
- *Develop new seed zones and breeding zones for future climates*

Breed and plant new genotypes

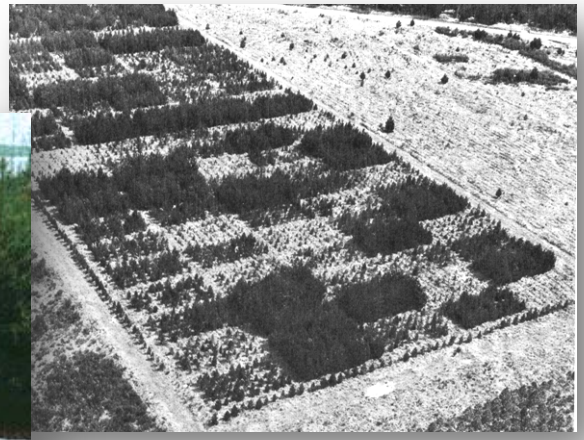
- *E.g., trees resistant to new insects or diseases*
- *Traditional selection and breeding*
- *Genetic engineering*

Seed source adaptability is critical

Superior adaptability of a Douglas-fir seed source from California growing in Spain (Hernandez et al 1993)



Lodgepole pine provenances from maritime areas are not adapted to the winters of eastern Finland

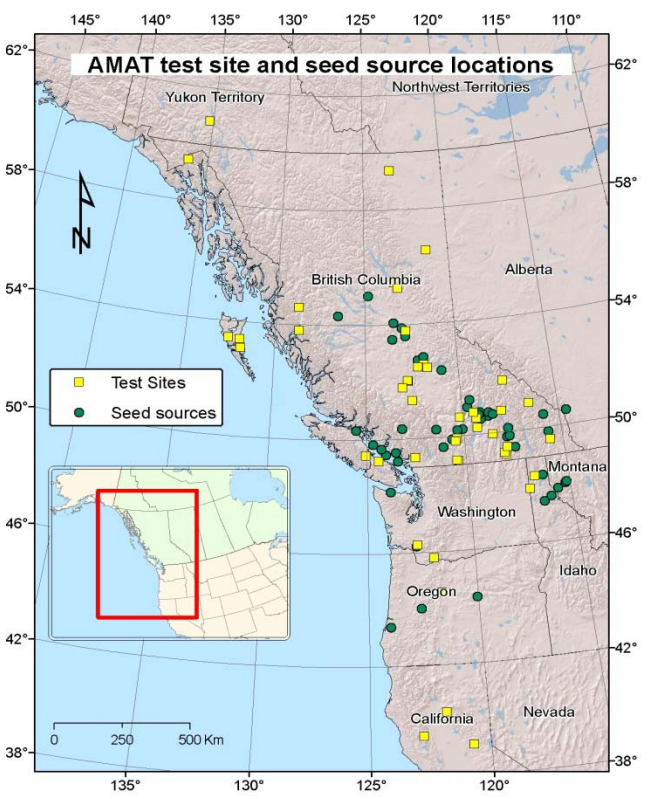


Lodgepole pine provenance test in New Zealand (Wright 1976)

- Large climatic transfer distances can result in maladapted plantations
- Transfer limits can be determined directly from provenance tests
- Sufficiently large provenance tests are rare
- Sufficiently large transfer distances are rarely tested

Assisted Migration Adaptation Trials

Sub-alpine Fir
Amabilis Fir
Grand Fir
Western Redcedar
Yellow Cedar
Western Hemlock
Trembling Aspen
Paper Birch
Sitka Spruce
Interior Spruce
Western Larch
Douglas-fir
Lodgepole Pine
White Pine
Ponderosa Pine



Seeds from 15 species growing in BC and neighboring US states have been planted at 48 reforestation sites from central Yukon to northern California. Their growth and health will be monitored, and related to the climate of the plantations, enabling researchers to identify the seed sources most likely to be best adapted to current and future climates.

Seedlot Selection Tool (SST)

Given a specific <u>planting site</u> …

<u>Which seedlot</u> is well adapted today?…

And in the future given a climate change scenario?

http://sst.forestry.oregonstate.edu/PNW/

Silvicultural options for adaptation

- Regenerate - planting provides greater control
  - *Plant alternative species and seed sources*
  - *Plant more stress-resistant stock types*
  - *Control initial density (trees/acre)*
  - *Increase the intensity of vegetation control*
- Thin and use prescribed fire
  - *Manage for "fire-smart" landscapes*
  - *Reduce stand density to increase tree vigor*
  - *Remove species maladapted to future climate*
- Increase insect and disease control
- Directly control site resources
  - *Fertilize and irrigate to increase resistance to stress*

TAFCC Taskforce on Adapting Forests to Climate Change

F.G. Jones, UK, Bugwood.org

Summary

- Climate is changing – direction is more certain than the magnitude
- The effects of climate change are evident
- Trees and forests will experience more stresses in the future, probably leading to reduced growth and vigor in many areas
- Adaptation can be enhanced via forest management
- Climate change risk can be reduced: Implement a range of adaptive options to hedge your bets, then monitor results and change course as needed

TAFCC Taskforce on Adapting Forests to Climate Change

Thank you

Glenn Howe

Forest geneticist
Dept of Forest Ecosystems and Society
Oregon State University

glenn.howe@oregonstate.edu
541-737-9001

And

Nicholas Wheeler

nickwheeler@scattercreek.com

TAFCC Taskforce on Adapting Forests to Climate Change