

# **Modeling Spatial Variation of Forest Biomass in Alberta**

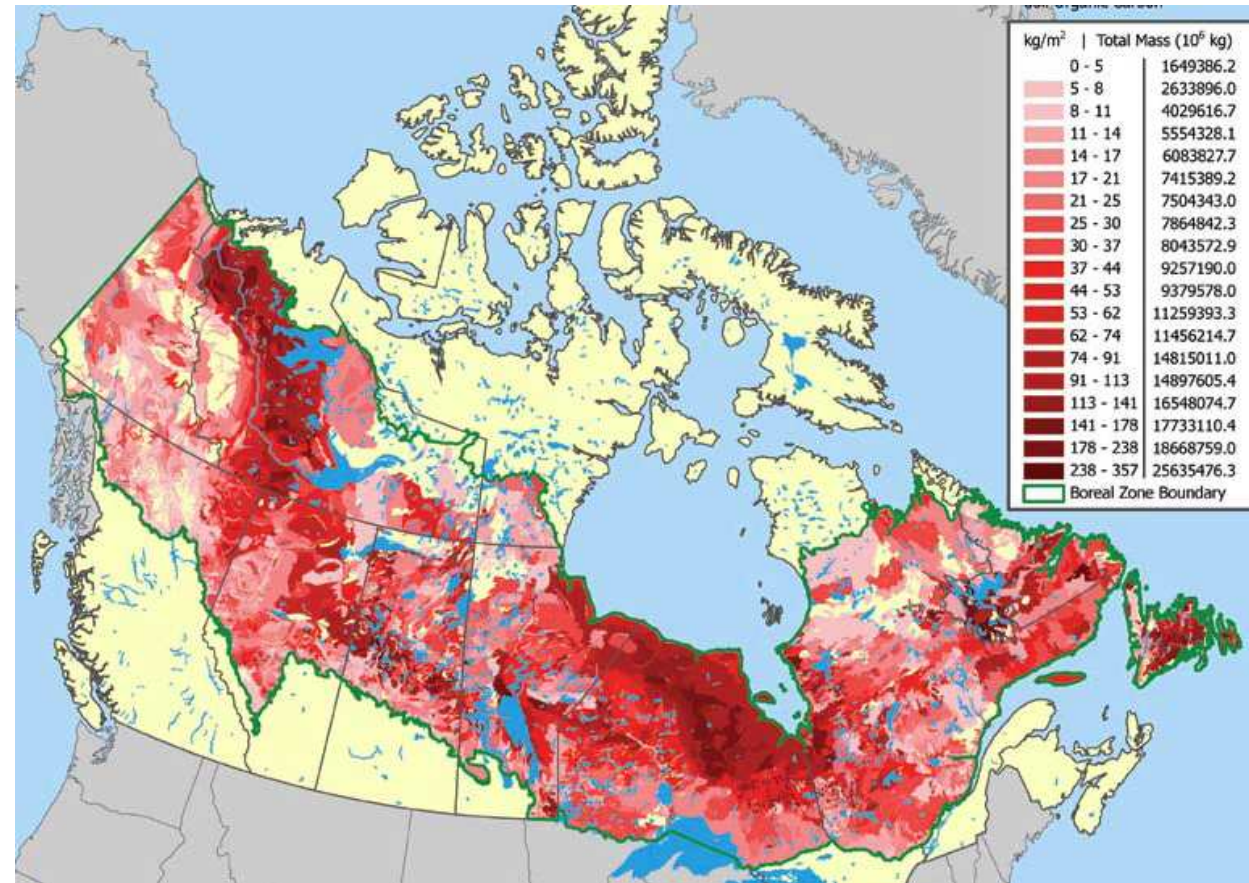
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# Soil Organic Carbon in the Canadian Boreal Forest

1. The boreal forest supports nearly 50% of the world's remaining intact forests.
2. The world's largest carbon storehouse – holding 22% of the total C stored on the earth's land surface, and twice as much C per unit area as tropical forests.
3. The Canadian boreal forest stores ~186 billion tons of C in forest & peatland ecosystems, equivalent to 27 yrs worth of the world's carbon emissions in 2003 from the burning of fossil fuels.



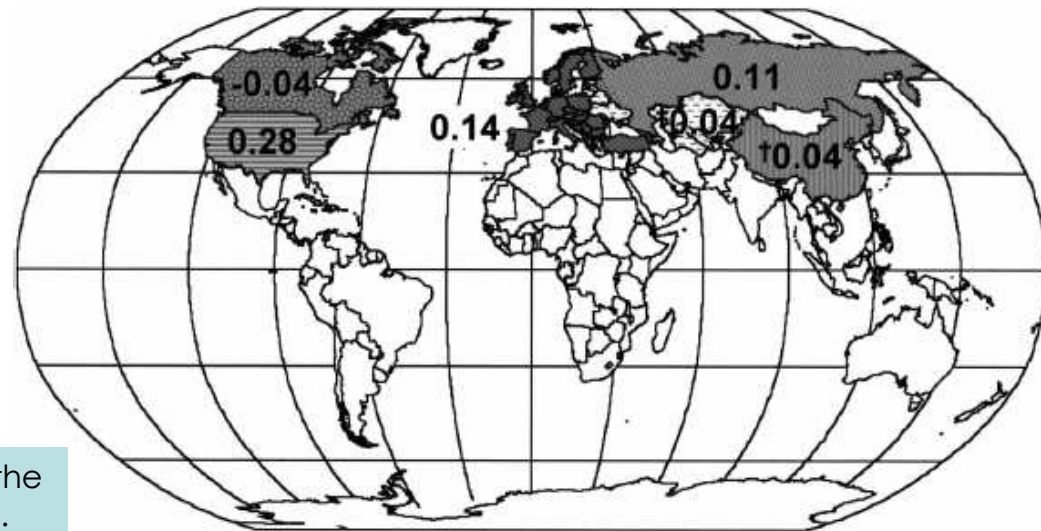
Global Forest Watch; <http://www.interboreal.org/globalwarming/ibcc-borealandclimate.pdf>

## Net Ecosystem Productivity and Biomass

- Net primary productivity (NPP): the net flux of carbon from the atmosphere into green plants per unit time. NPP refers to a rate process, i.e., the amount of vegetable matter produced (net primary production) per day, week, or year.
- One way to measure NPP is to collect and weigh the plant material produced on 1 m<sup>2</sup> of land over a given period of time.
- Biomass: the mass of living organisms, and dead matter such as wood, leaves, and other organic matter in a given area.
- In the Rocky Mountains/Foothill regions, biomass is estimated to be 50-350 Mg/ha (but maximum can be 425 Mg/ha).

# Carbon Sinks and Sources

- Carbon source or sink: depending on the balance between uptake of carbon through photosynthesis and release of carbon through respiration, decomposition, fires, or removal by harvest activities.
  - Terrestrial ecosystems in the Northern Hemisphere is a significant sink for atmospheric C.
  - A great uncertainty in the magnitude and distribution of this sink.
  - A single number of sink or source is not very useful from management perspective.
  - Need to know the magnitude, location, and causes of terrestrial C sinks.
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- Temperate & boreal sink in NH: 0.6-2.7 petagrams C/yr
  - European forests: [-0.10, 0.46] Pg C/yr.



Goodale et al. 2002. Forest carbon sinks in the Northern Hemisphere. *Ecol Appl* 12:891-899.

# Objectives

1. Estimate net primary production among the PSP and ABMI sites in Alberta
2. Map the distribution of forest biomass (to identify hotspots/coldspots for C, mortality, growth and recruitment)
3. Identify the factors that would contribute to C sources/sinks
4. Investigate the relationship between biodiversity and forest productivity across the ABMI sites

# Estimating Net Primary Production/Biomass

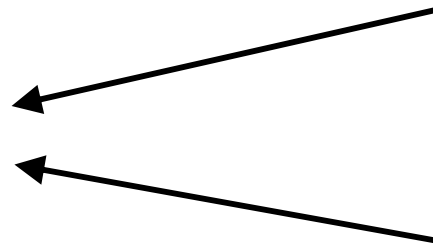
Many methods are available for estimating NPP, depending on the sources of data:

- Remote sensing data
- Carbon budget models/Atmospheric-transport models
- Eddy-covariance sites or networks
- Inventory data (permanent sample plots)

The Net Primary Production is determined by:

- Recruitment
- Growth
- Mortality

1. Forest type
2. Stand age
3. Species
4. Climate
5. Soil condition
6. Management
7. Disturbances
8. ...



## Allometric Regression Models

Estimation by components: stem wood, stem bark, branch and foliage.

$$Y = a + bD^2H + \varepsilon$$

where  $a$  and  $b$  are constants,  $D$  is DBH in cm and  $H$  is height in m.

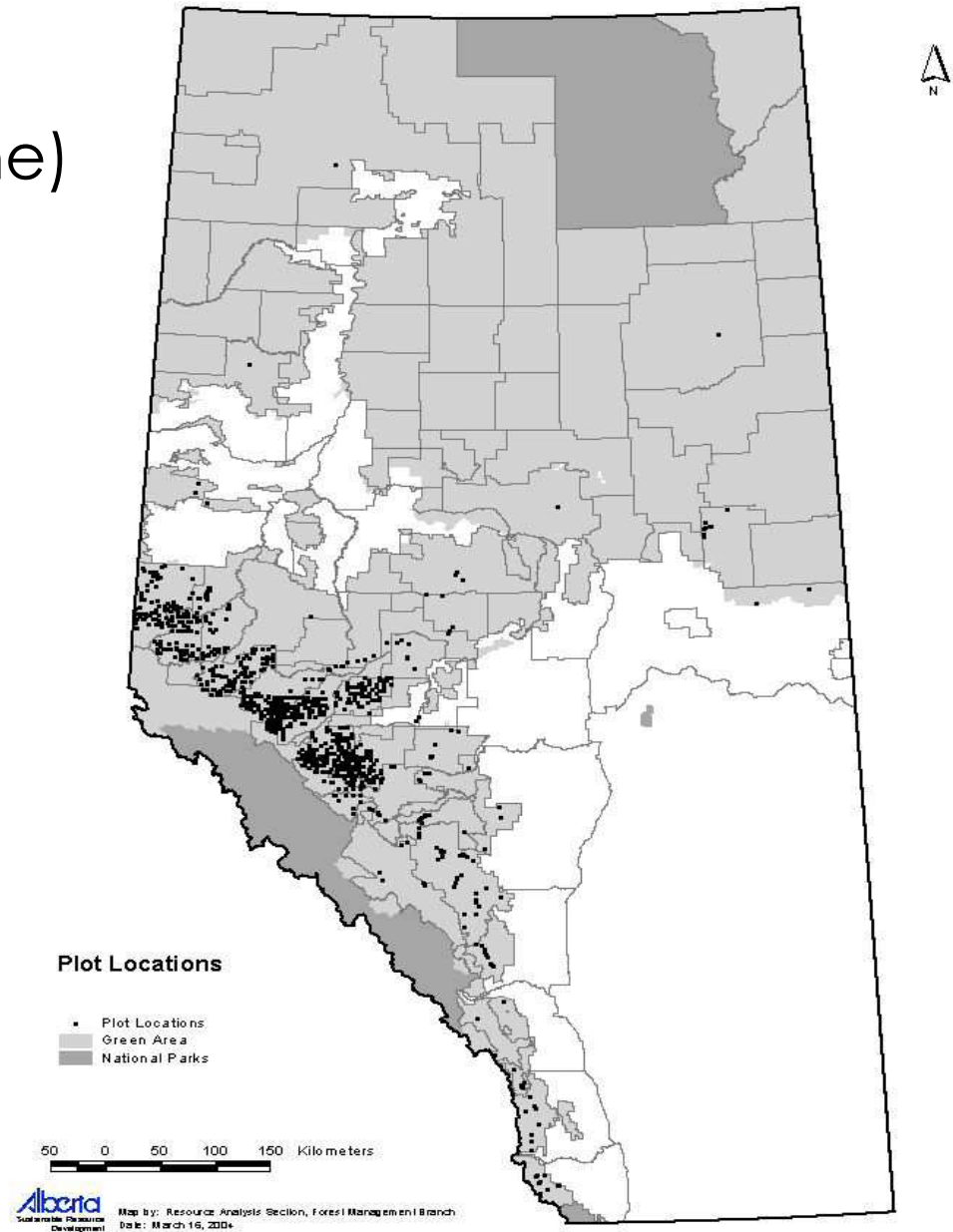
Estimation by whole tree (and across species, used for tropical species):

$$Y = F\rho\left(\frac{\pi D^2}{4}\right)H$$

where  $F$  is a multiplicative factor describing tree taper,  $\rho$  is wood specific gravity (wood density, oven-dry wood over green volume, g/cm<sup>3</sup>)

## Alberta PSP (lodgepole pine)

- 1800 plots
- Measured 1 to 7 times
- Cover all species
- All stand types

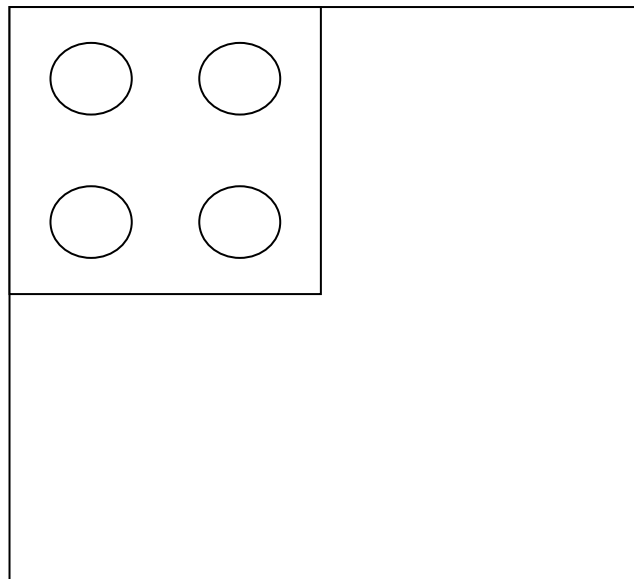


Courtesy of Dr. Shongming Huang (ASRD)



# Plot Size & Configuration

- Tree: main plot ( $\geq 9.1$  cm DBH), mostly 1000 m<sup>2</sup>
- Sapling: one sapling plot ( $0 < \text{DBH} < 9.1$  cm)
- Regeneration: 4 regeneration plots ( $0.3 < H < 1.3$  m)



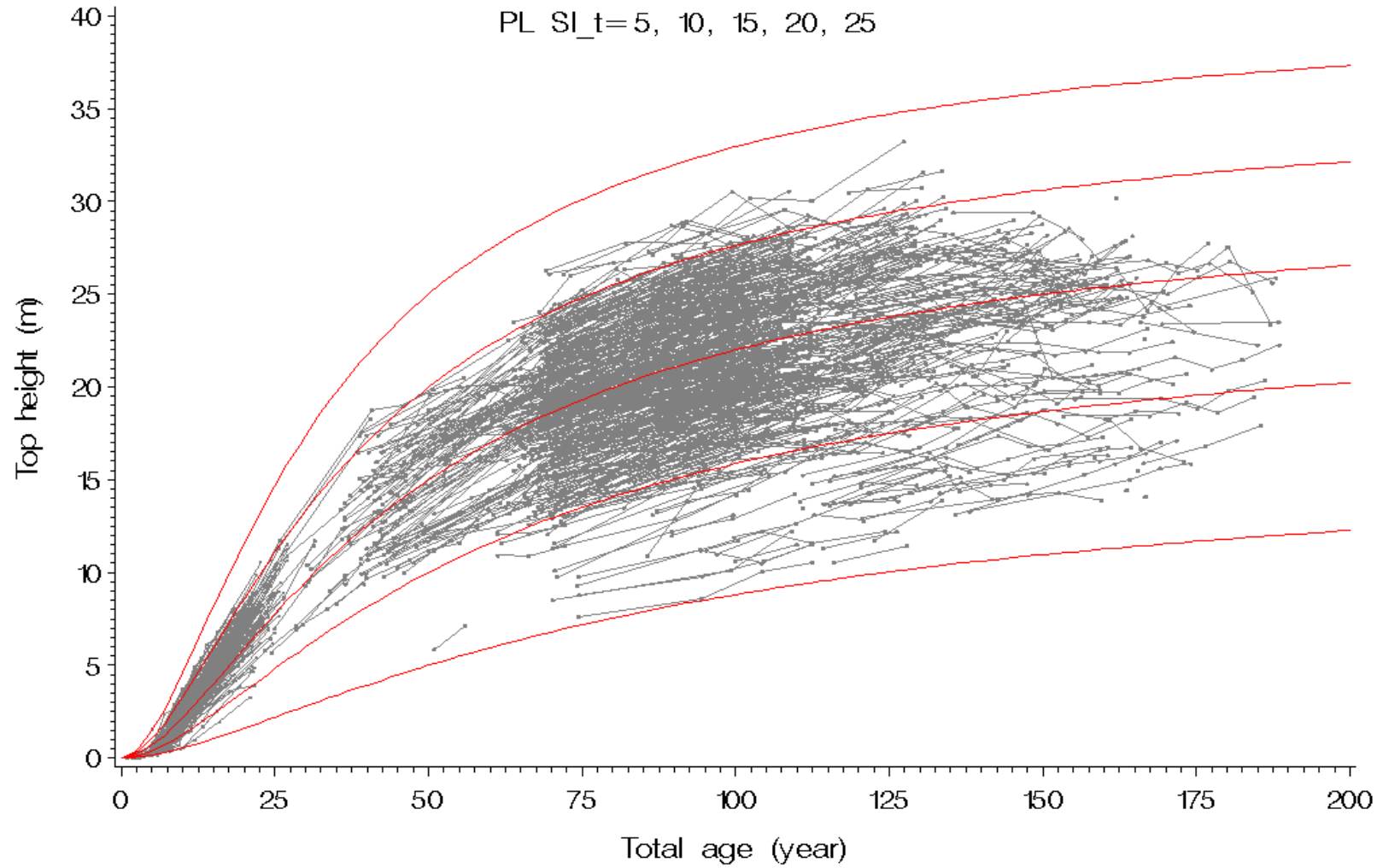
# Plot Measurements

- Species
- Tree diameter at breast height (DBH)
- Tree height
- Live crown length
- Crown widths (since 2000)
- Crown class
- Tree condition code
- Age
- Tree azimuth & distance (stem map)

## Measurement Schedules

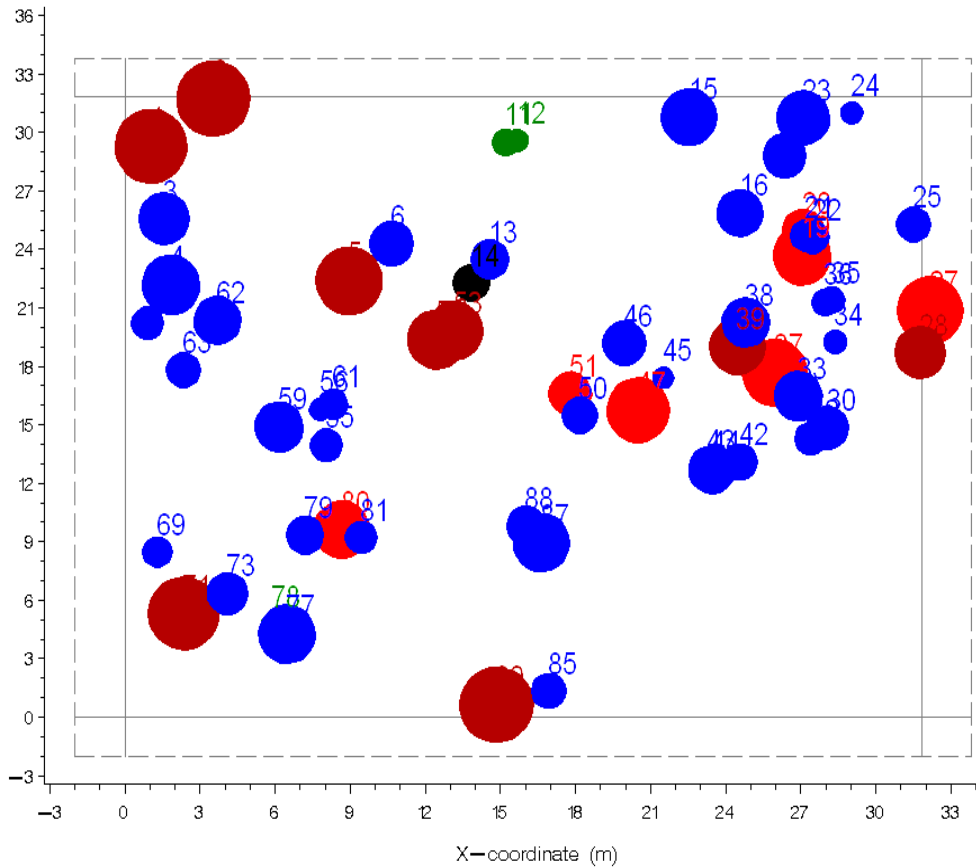
- Before 40 years (total age): every 5 years
- After 40 years: every 10 years
- Measured at 8 & 14 years
- Re-measurements close to the same day/week/month

# Pine Height-Age Data & Model



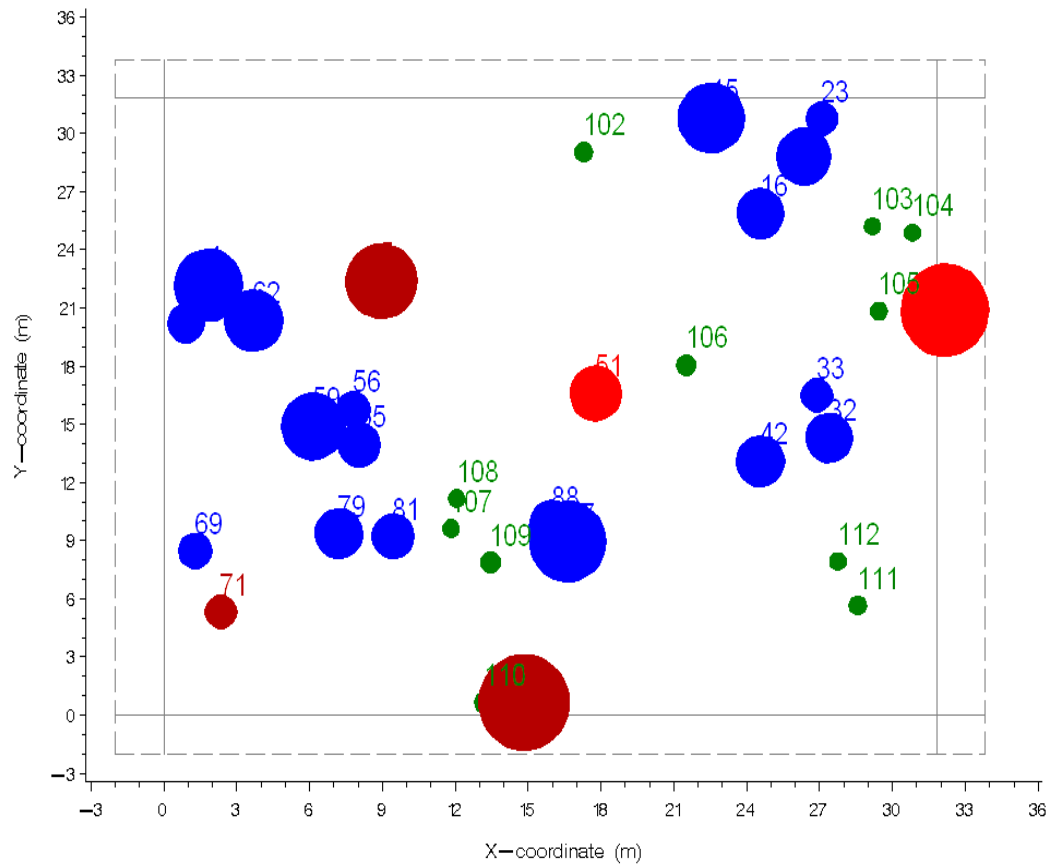
# Stem Map and Crown Cover

PLOT=1 LPSPSUB=1 MEASURE=0 YEAR=1960 plotsize=1012 dist\_s=31.81 PTREAT=0



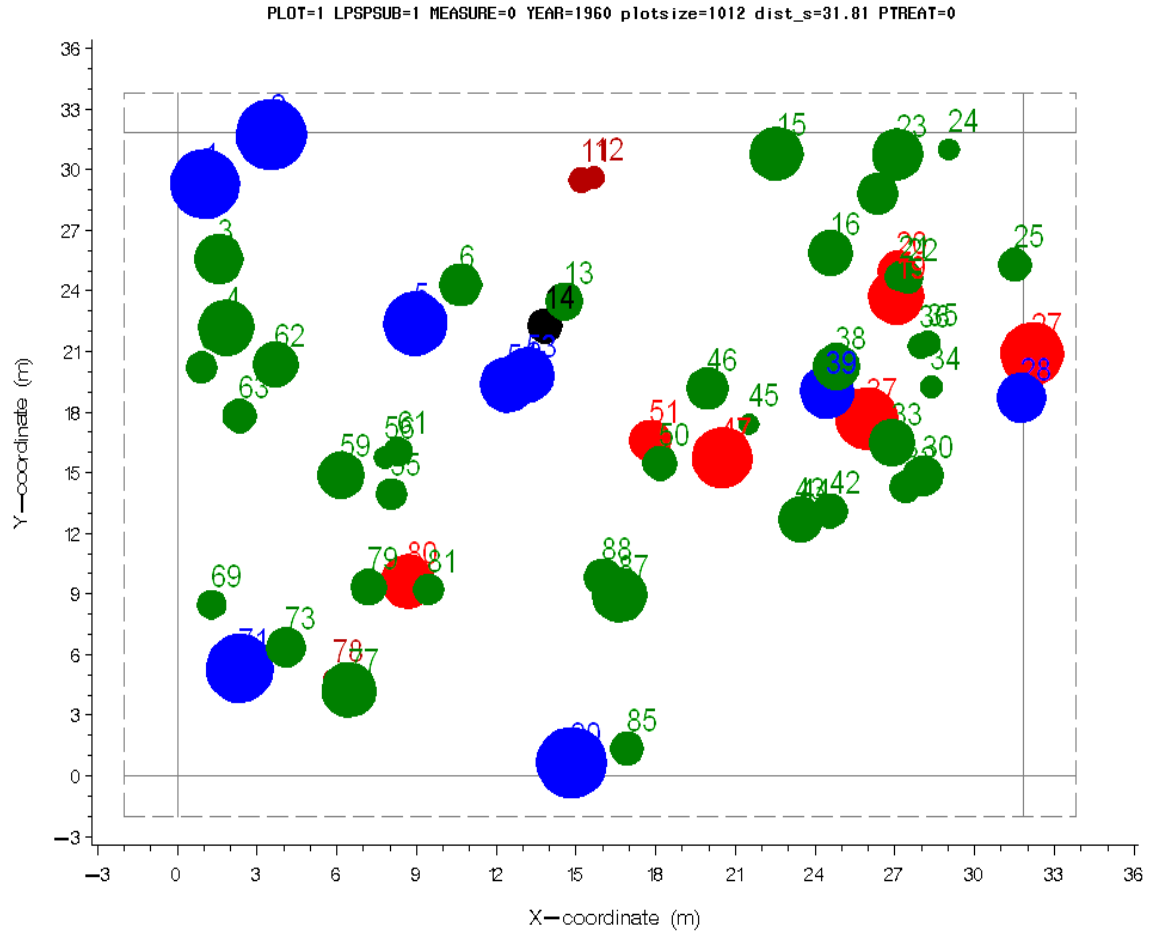
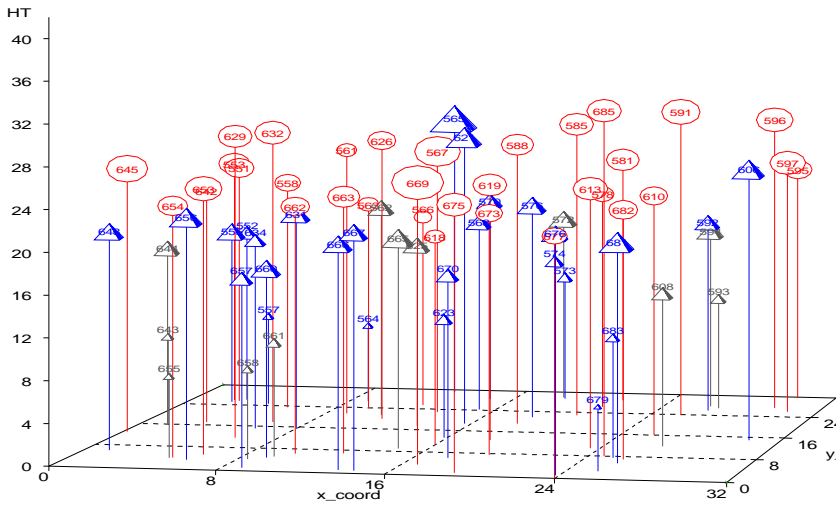
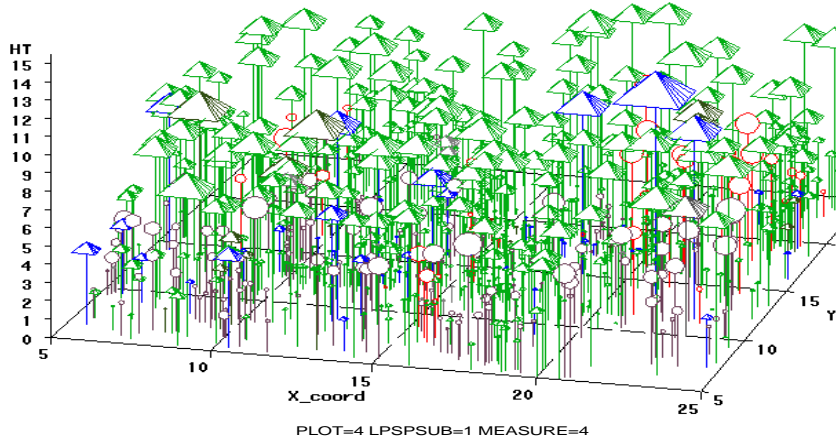
PSP #1 - 1960

PLOT=1 LPSPSUB=1 MEASURE=5 YEAR=2002 plotsize=1012 dist\_s=31.81 PTREAT=0

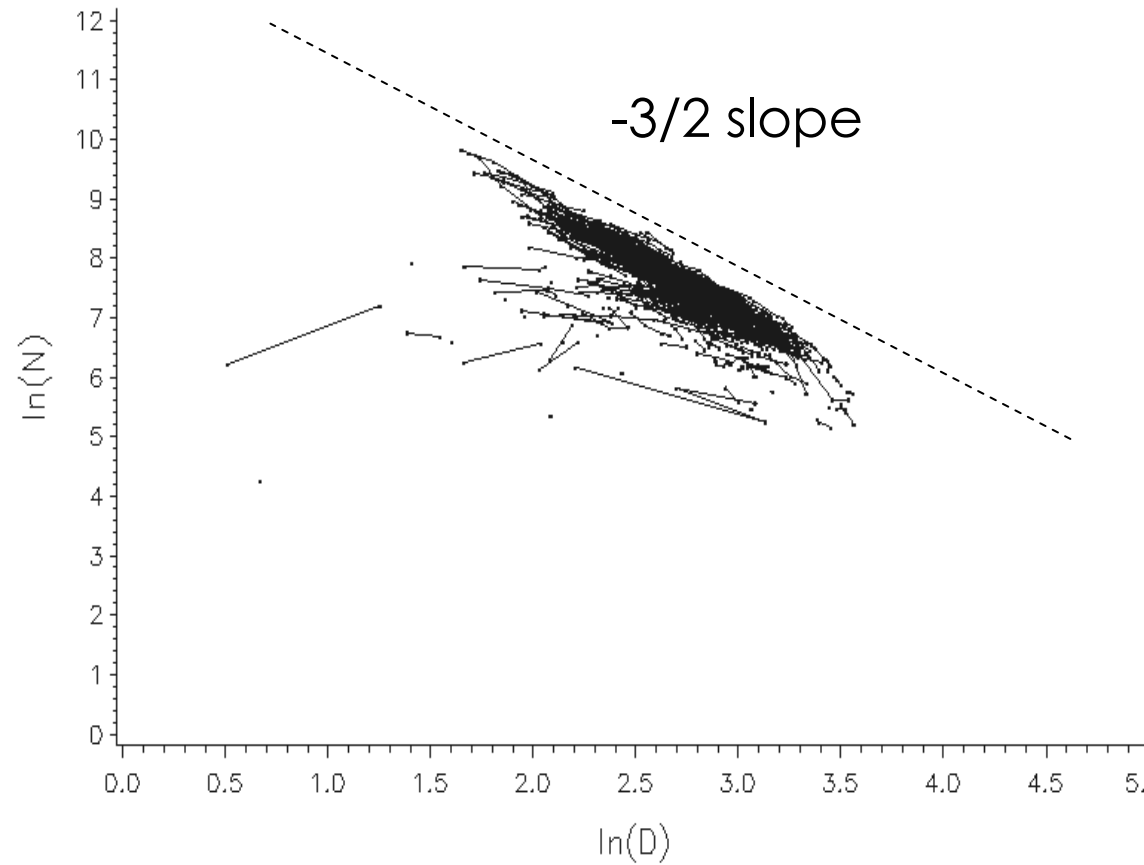
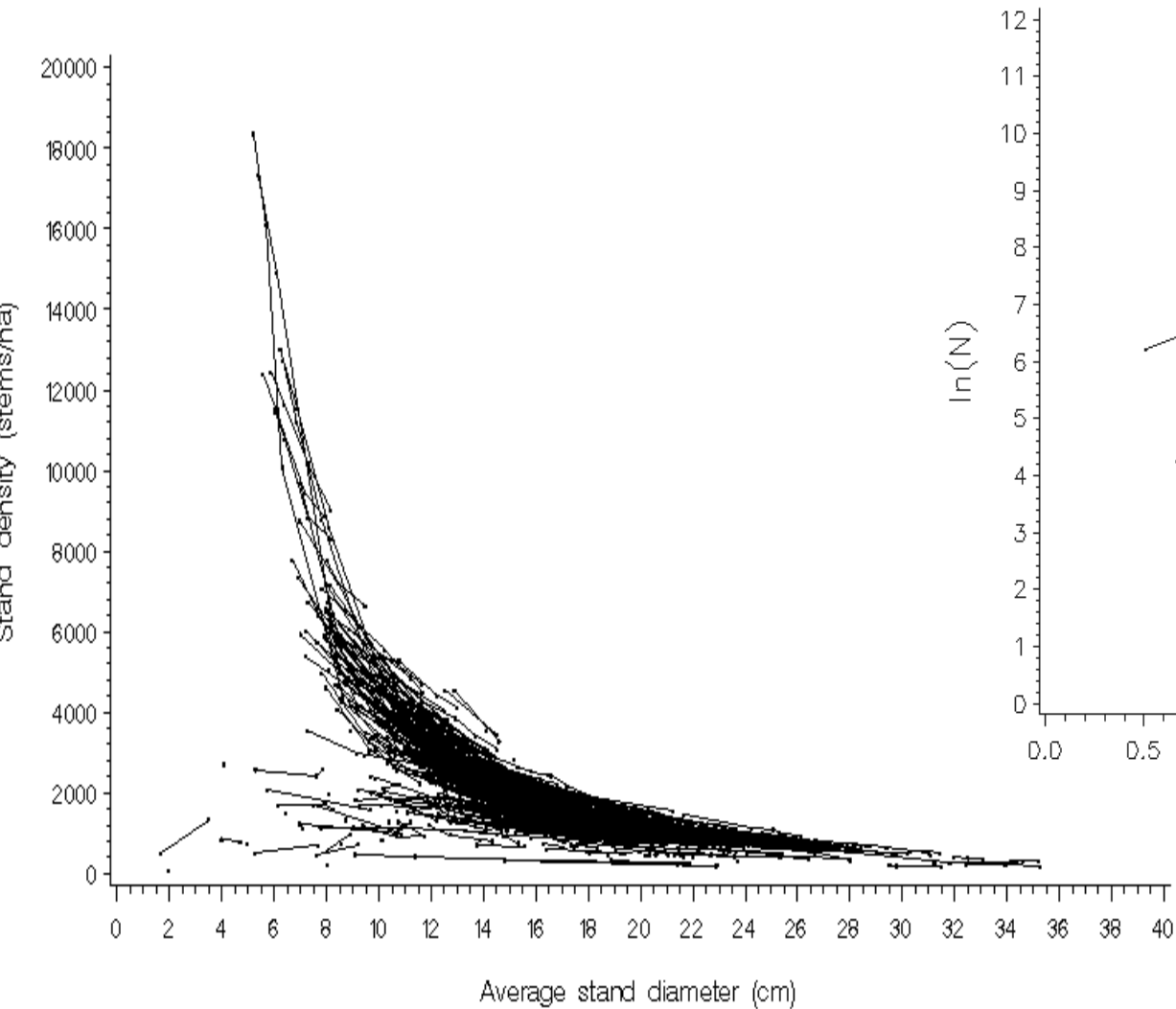


PSP #1 - 2002

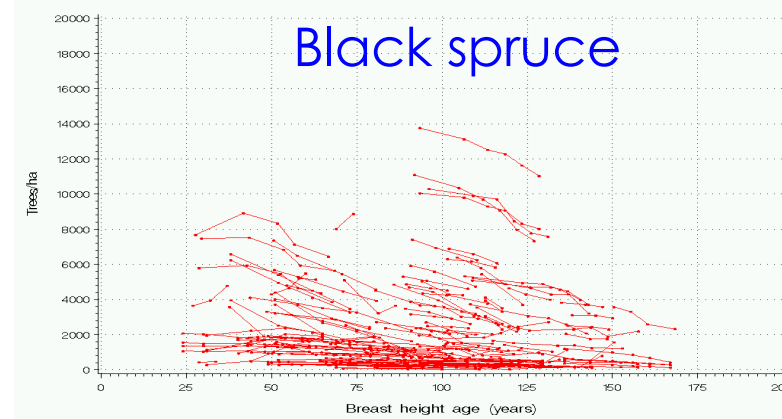
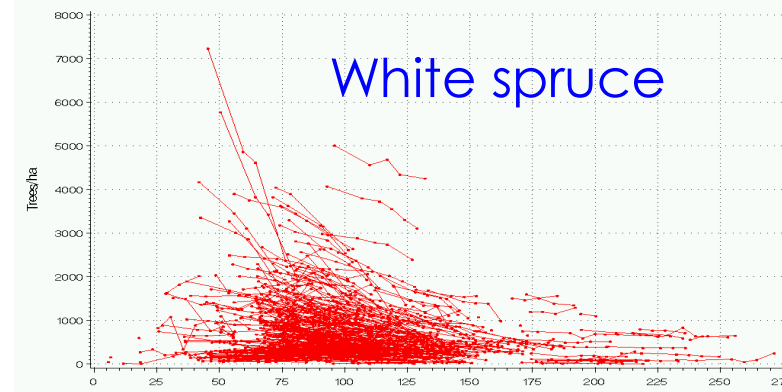
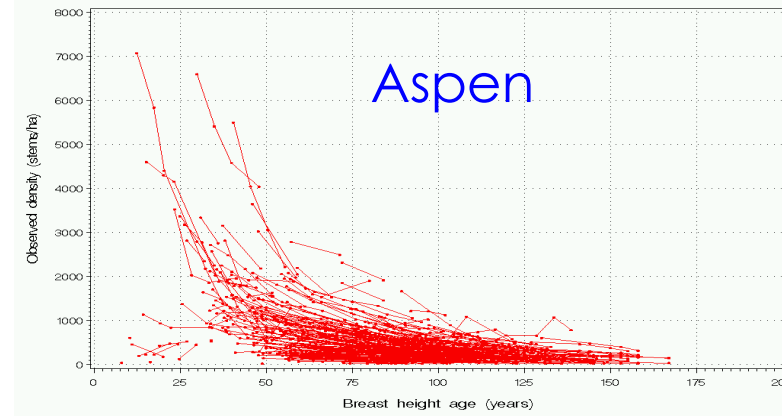
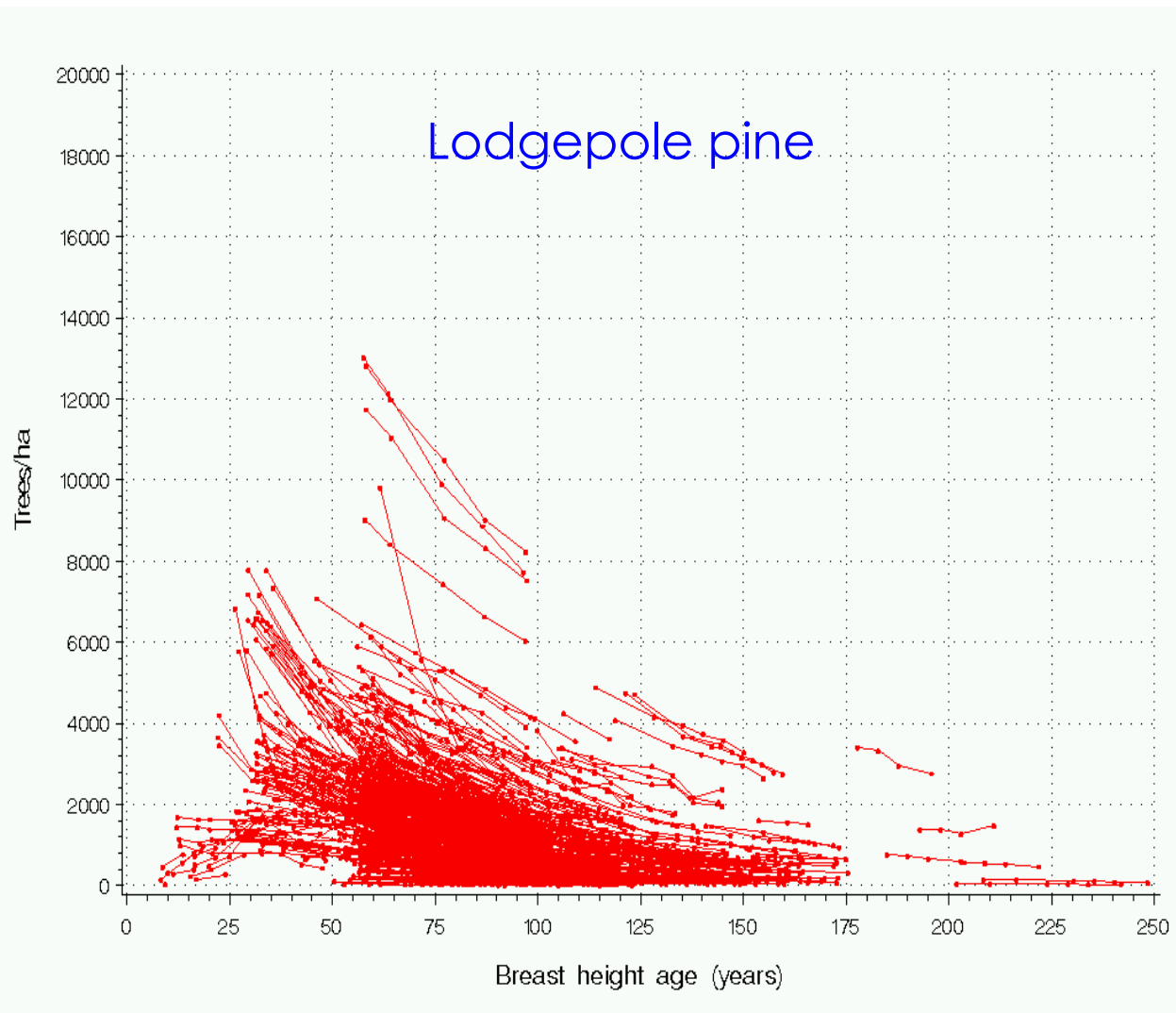
# Stem Map and Crown Cover



# Density-Diameter Data (Pine)



# Density Change Over Time



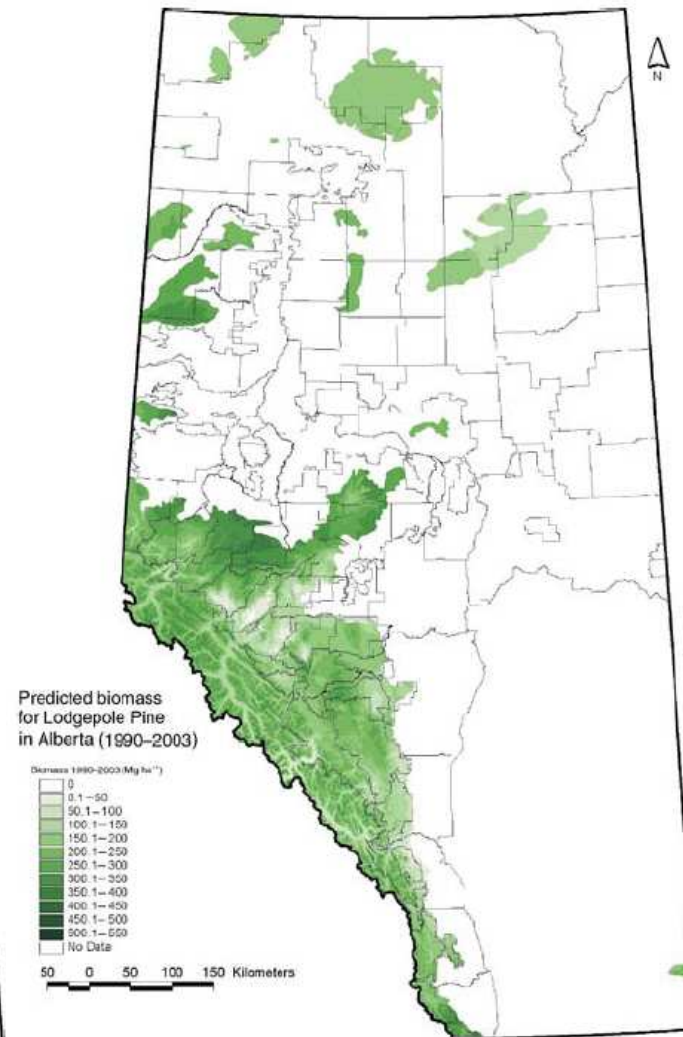


# Biomass distribution (Mg/ha) across the lodgepole pine forest in Alberta. Harvest removals have been subtracted.

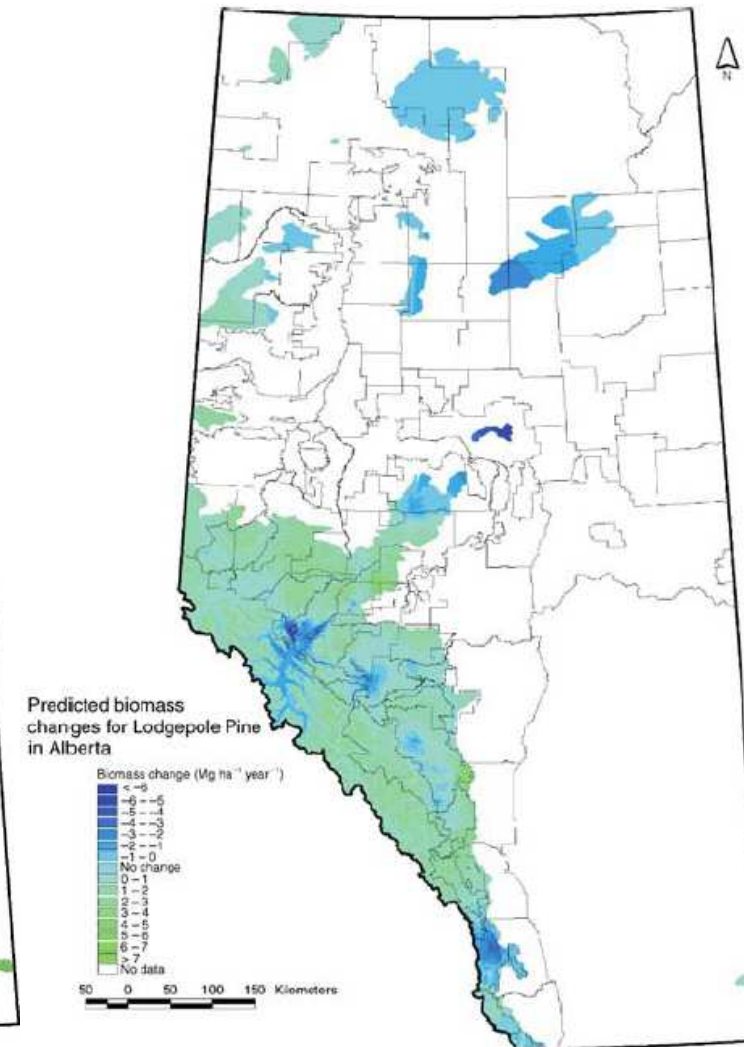
1980-1989



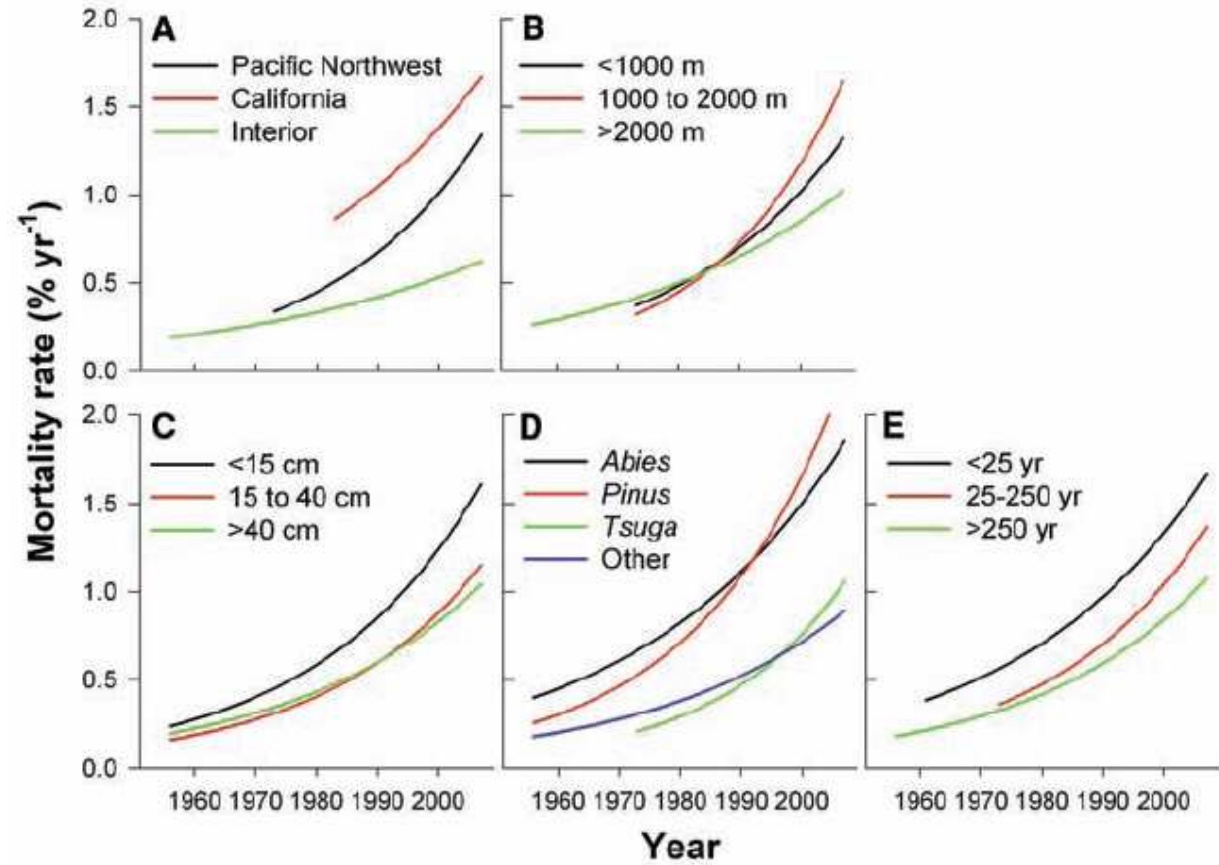
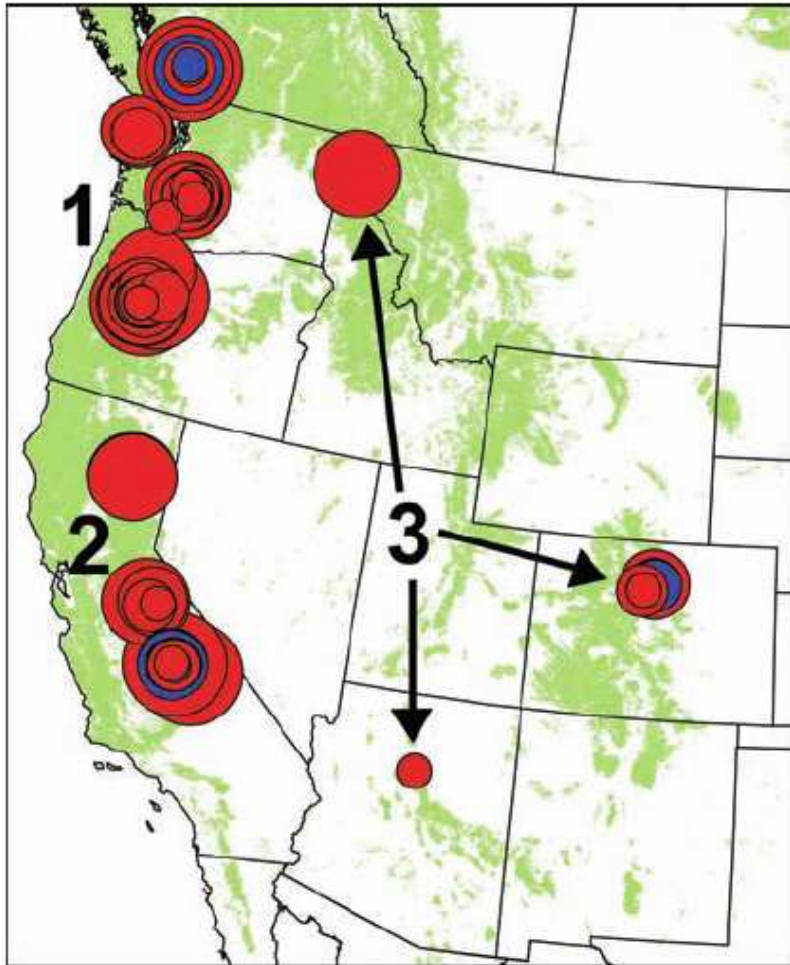
1990-2003



Change (+0.99 Mg/ha/yr)

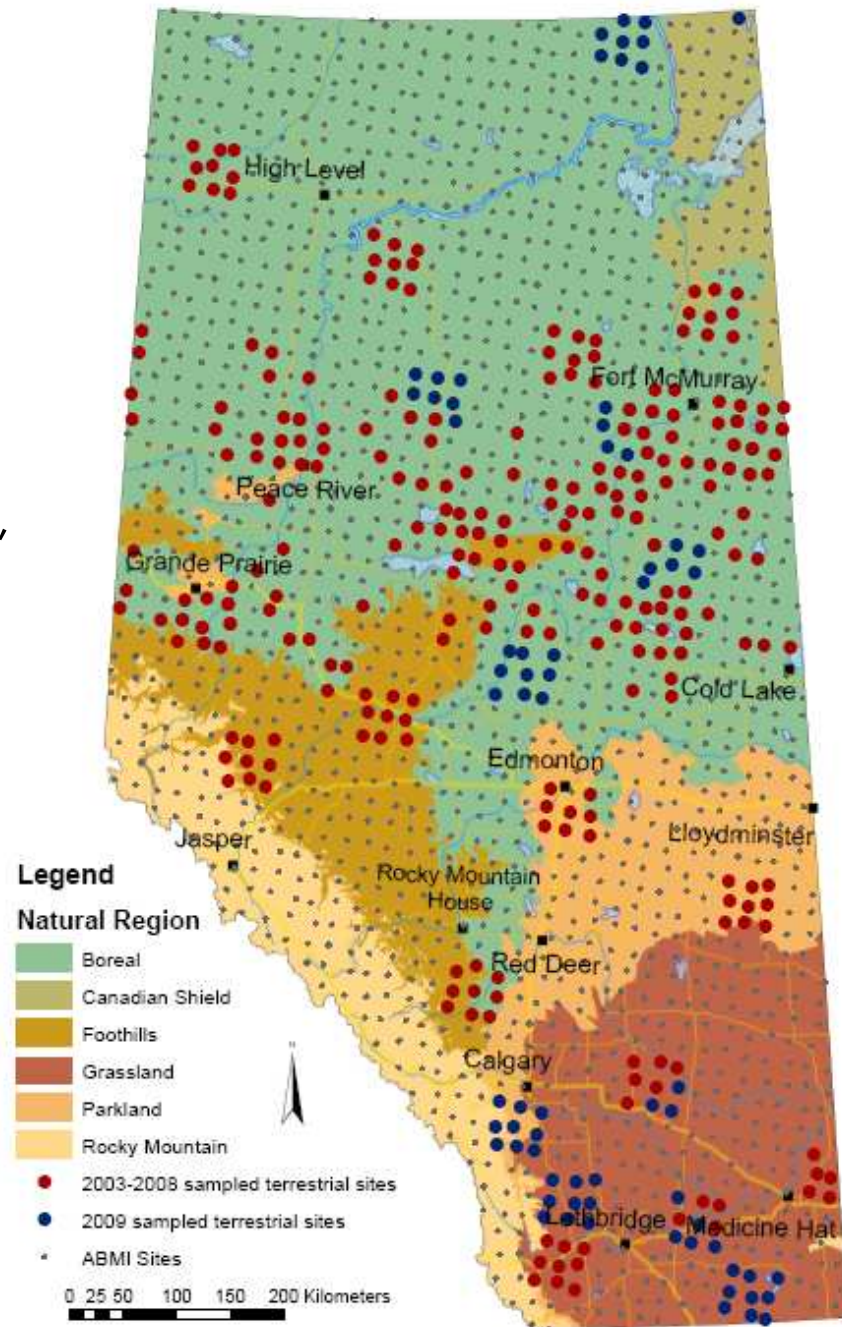


# Tree Mortality in Relation to Climate Change



# Alberta Biodiversity Monitoring Institute

1 650 20×20 km grid cells where  
survey for birds, vascular plants,  
mosses, and lichens were  
conducted. Recensus rotation:  
every five yrs.



## For Discussion

1. Modeling tree demographic rates
2. Developing/testing spatial interpolation methods for mapping biomass
3. Impact of climate change on dynamics of forest ecosystems
4. Assessing propagation errors in biomass estimation

$$Y = a + bD^2H + \varepsilon$$

$$Y = F\rho\left(\frac{\pi D^2}{4}\right)H$$