Forest Health Monitoring

Program Overview

Borys M. Tkacz
National Program Manager

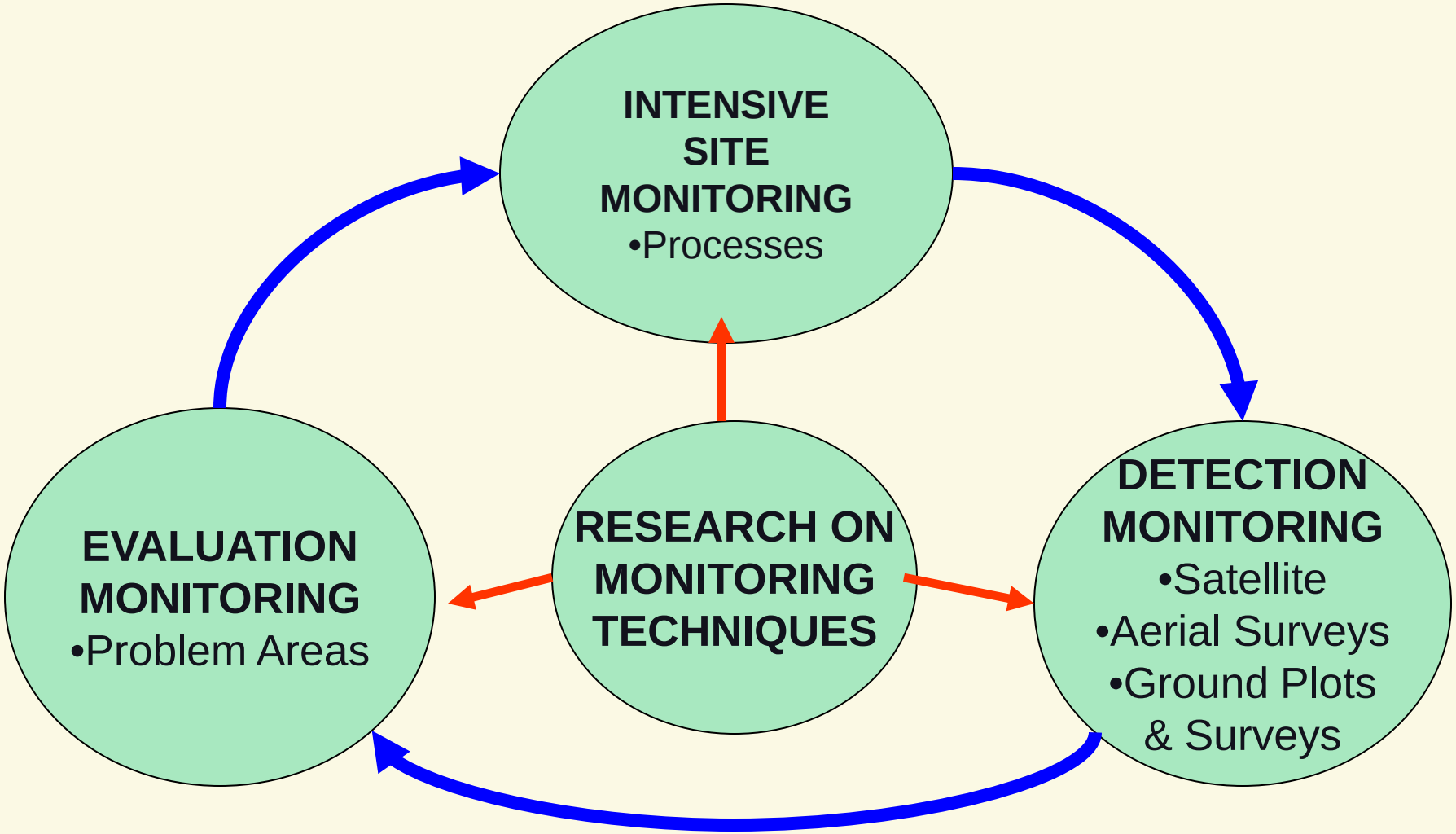
Forest Health Monitoring Program

- Initiated in 1990 to provide information on the status, changes, and trends in forest health and sustainability.
- The FHM program provides information on all forest lands to land-managers and policy makers that affects, directly or indirectly, all Americans.

FHM Objectives:

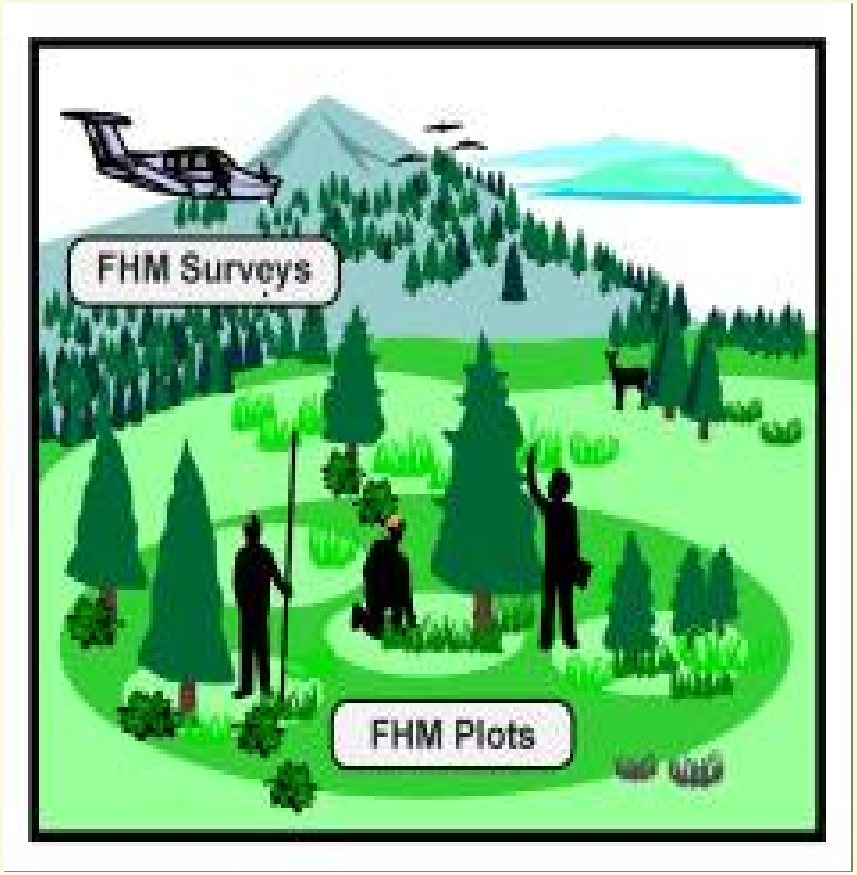
- Establish a monitoring system throughout the forests of the United States to determine detrimental changes or improvements that occur over time.
- Provide baseline and health trend information that is statistically precise and accurate.
- Report annually on status and changes to forest health.

Major Program Components

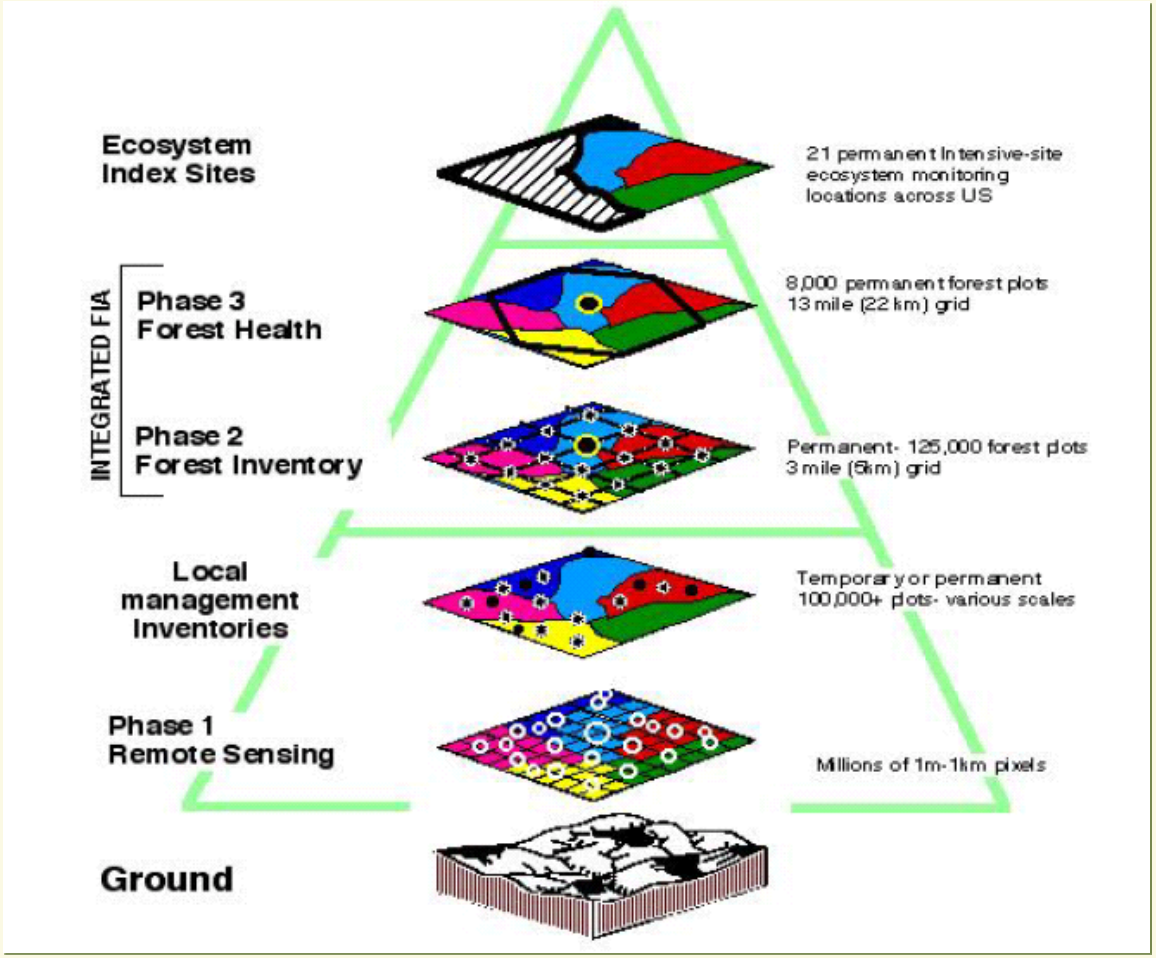


Detection Monitoring

- Nationwide grid of permanent sample points
- Aerial damage detection surveys
- Special ground surveys

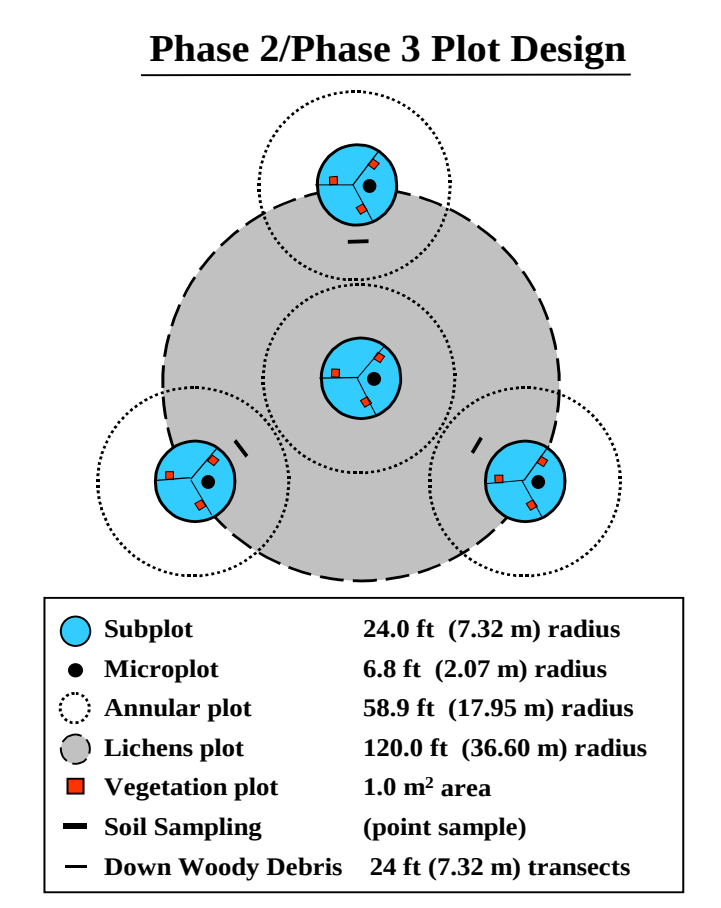


Integrated Monitoring Framework

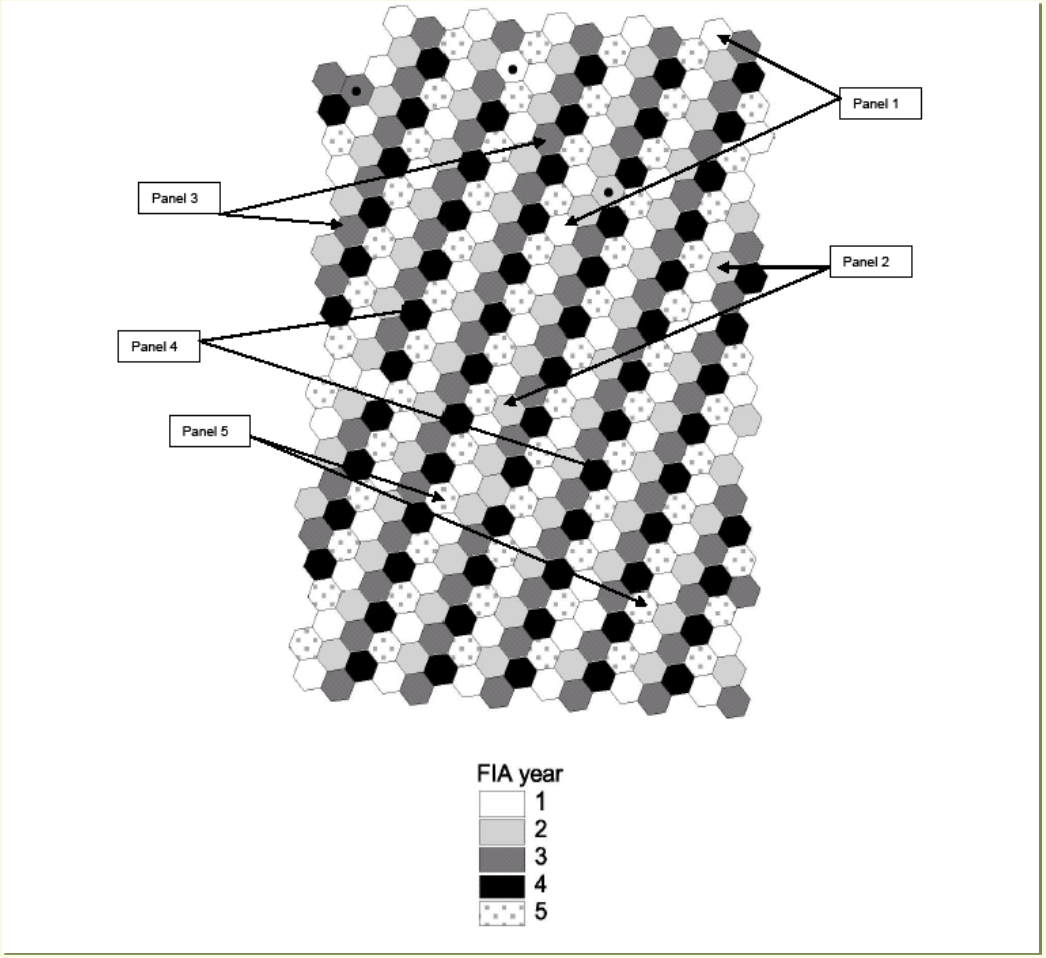


FHM/FIA Plot Integration

- Since 1999 FHM ground plots have been integrated with Forest Inventory and Analysis (FIA) plots
- Phase 2 – Tree Measurements (~125,000 plots, each representing ~6,000 ac.)
- Phase 3 – Health Indicators (~8,000 plots, each representing ~96,000 ac.)
- Each plot measured once every 5 to 10 years

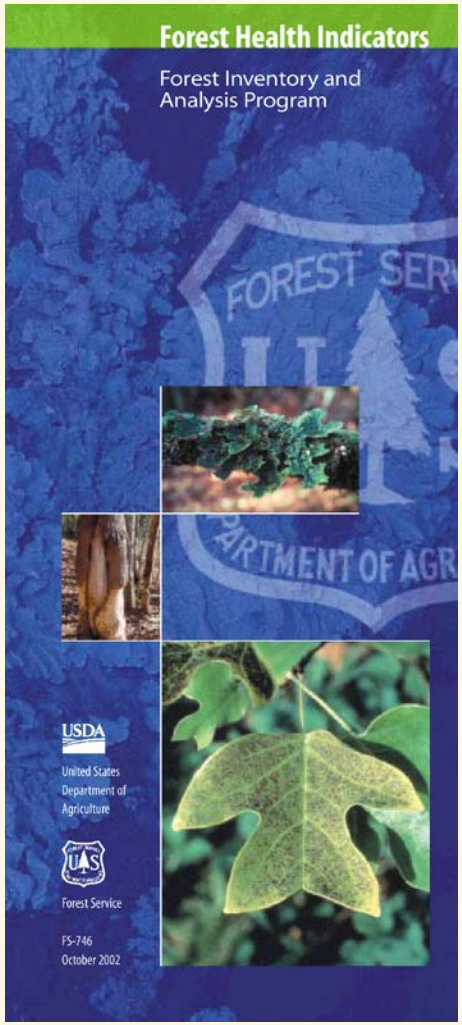


Rotating Panel Design



Forest Health Indicators

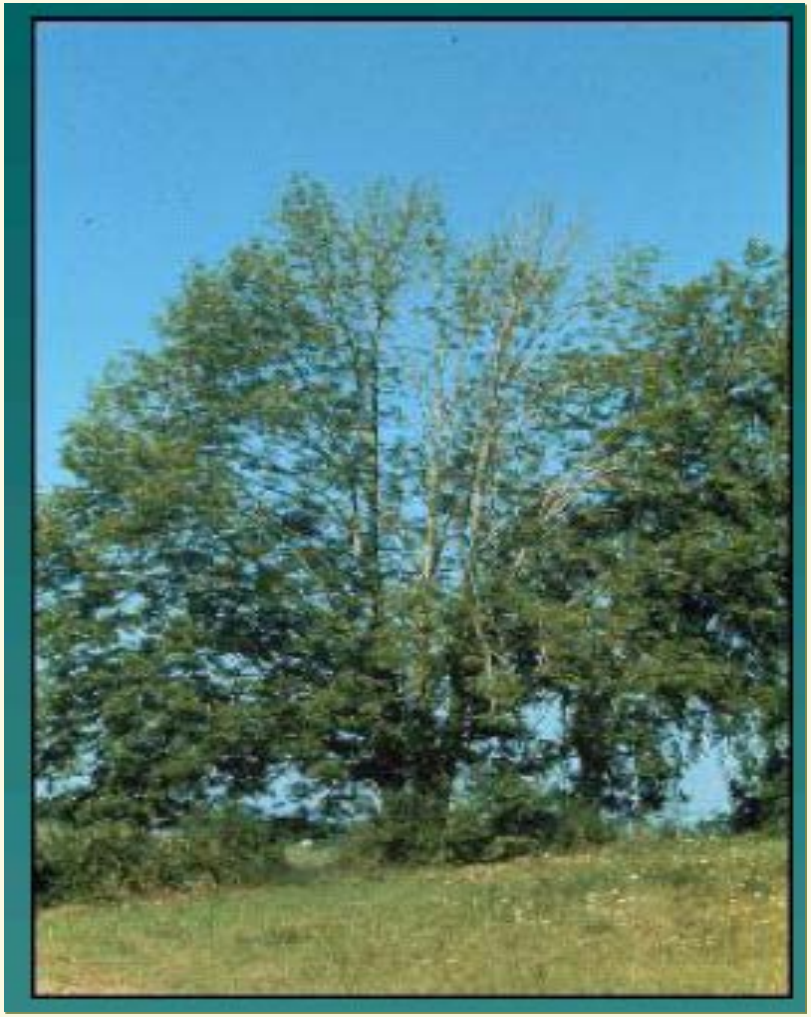
- Tree Growth
- Tree Regeneration
- Tree Crown Condition
- Tree Damage
- Tree Mortality
- Lichen Communities
- Ozone Bioindicator Plants
- Soil Morphology and Chemistry
- Vegetation Structure
- Plant Diversity



http://fia.fs.fed.us

Crown Condition

- Live crown ratio
- Density
- Foliage transparency
- Dieback
- Diameter



Lichen Communities

- Fungi that live in association with algae
- Sensitive to environmental stresses such as air pollution or climate change
- Indicators of forest biodiversity
- Biotic indexes are developed based on pollution and climate gradients

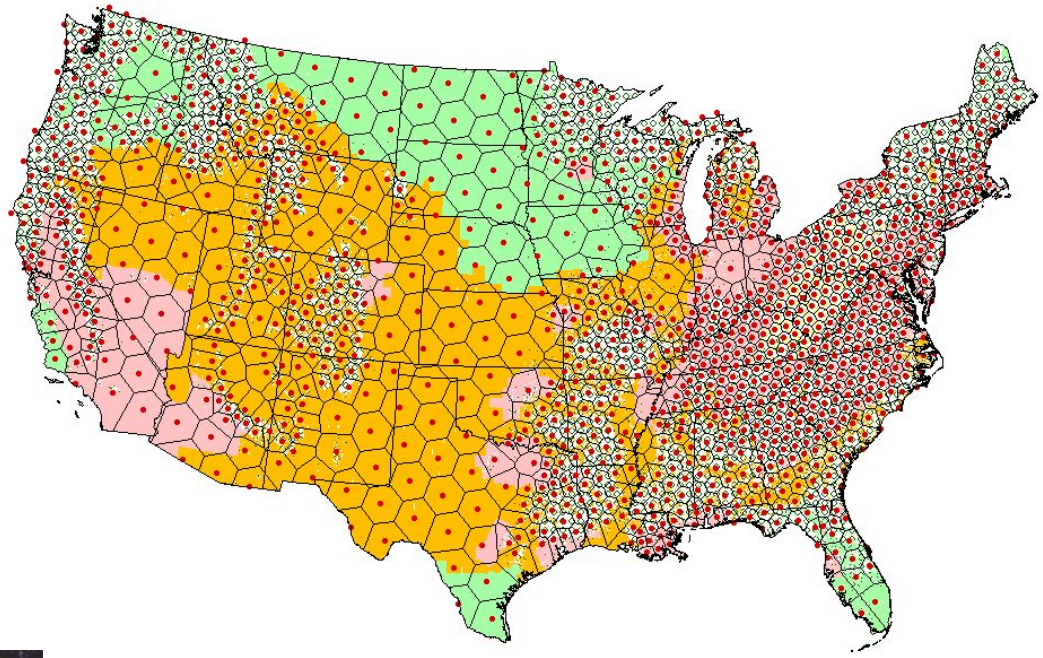
Photo by Stephen Sharnoff

Ozone Injury

- Ozone causes direct foliar injury to many species
- Bio-indicator plants are evaluated for severity of foliar injury
- Sampled on separate plots

Photo by Gretchen Smith

Ozone Biomonitoring



Down Woody Material

- Measurement of fallen trees, dead branches along transects
  - Diameter
  - Length
  - Stage of decay
  - Species
  - Cavities
- Assess fire risk, wildlife habitat, carbon

Photo by Chris Woodall

Vegetation Diversity and Structure

- Type, abundance, and arrangement of plants on plots
- Allows reporting on diversity of native and introduced species
- Monitoring for change over time will be possible by re-measurement

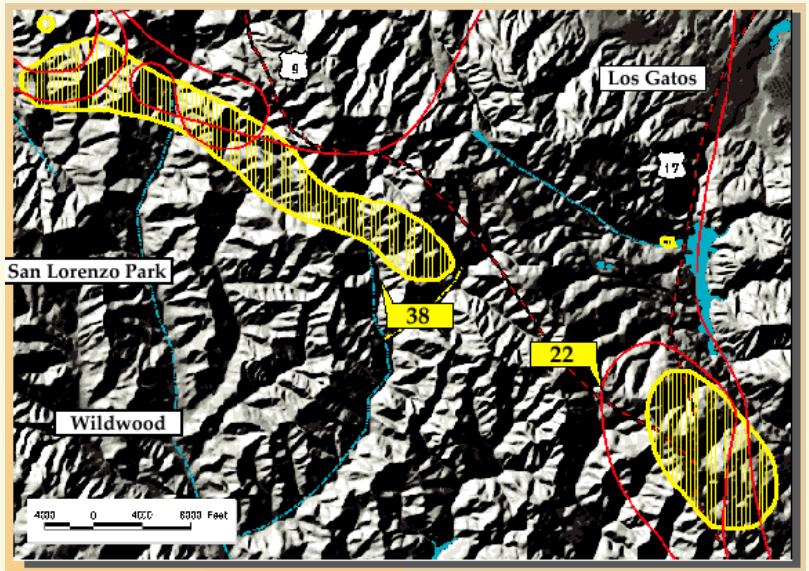
Photo by Will McWilliams

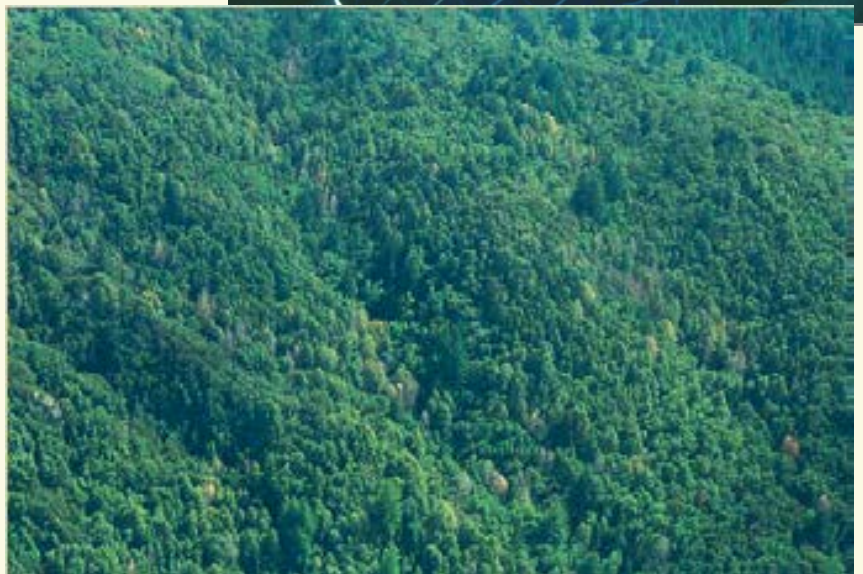
Soil Condition

- Measurement of soil physical properties, compaction, erosion potential
- Soil samples collected for chemical analyses
  - **Acidity**
  - **Exchangeable cations**
  - **Nitrogen and carbon**
  - **Toxics**
  - **Bulk density**

Detection Monitoring

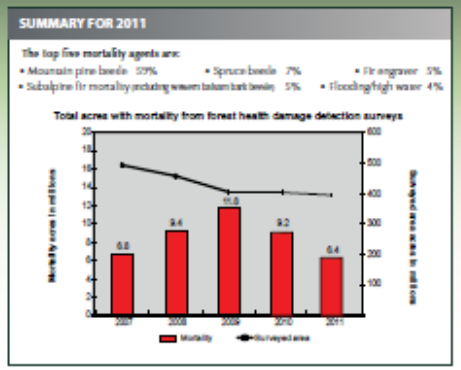
- Aerial Detection Surveys
  - Observers in aircraft at 1,000 to 2,000 ft. elevation
  - Create maps visible damage





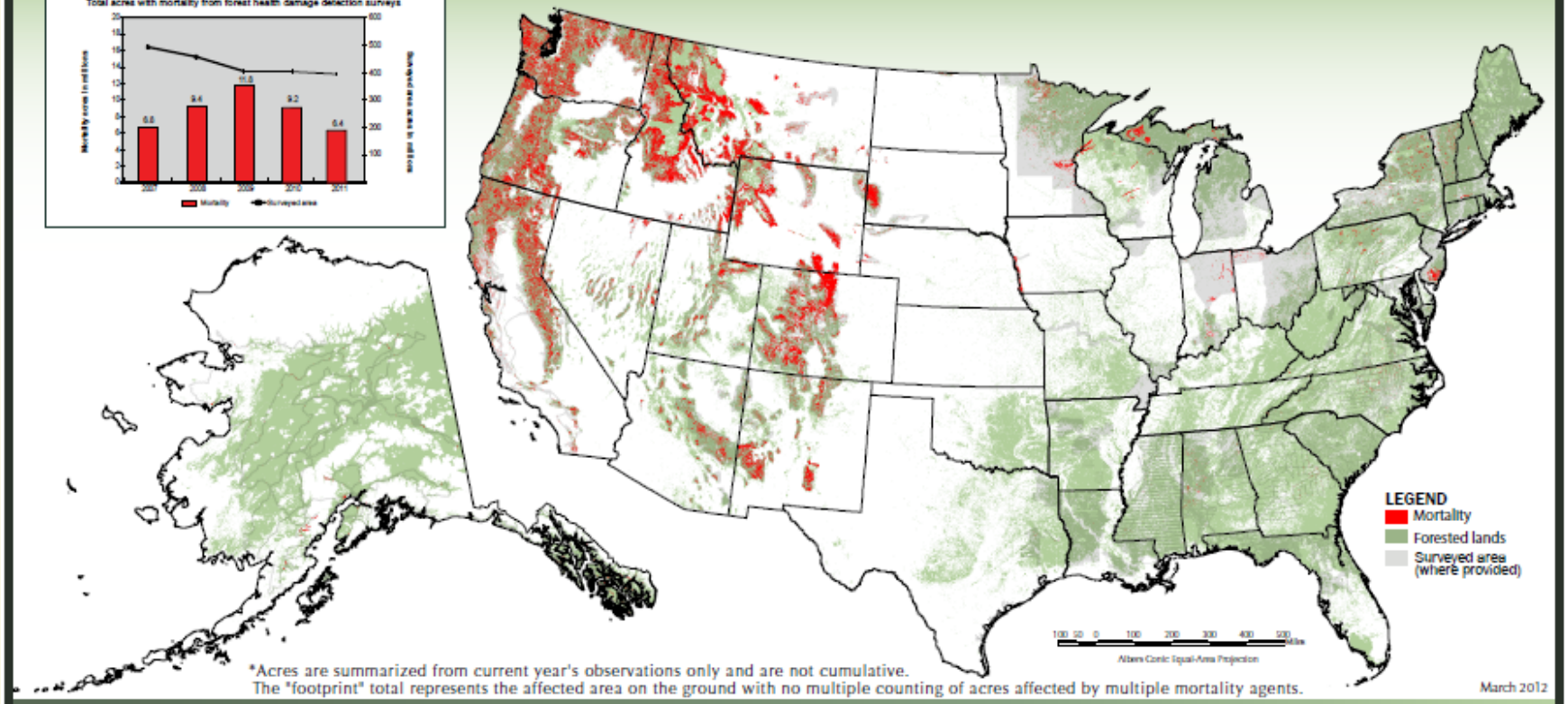
FOREST HEALTH PROTECTION

FHTET



2011 Acres with Tree Mortality

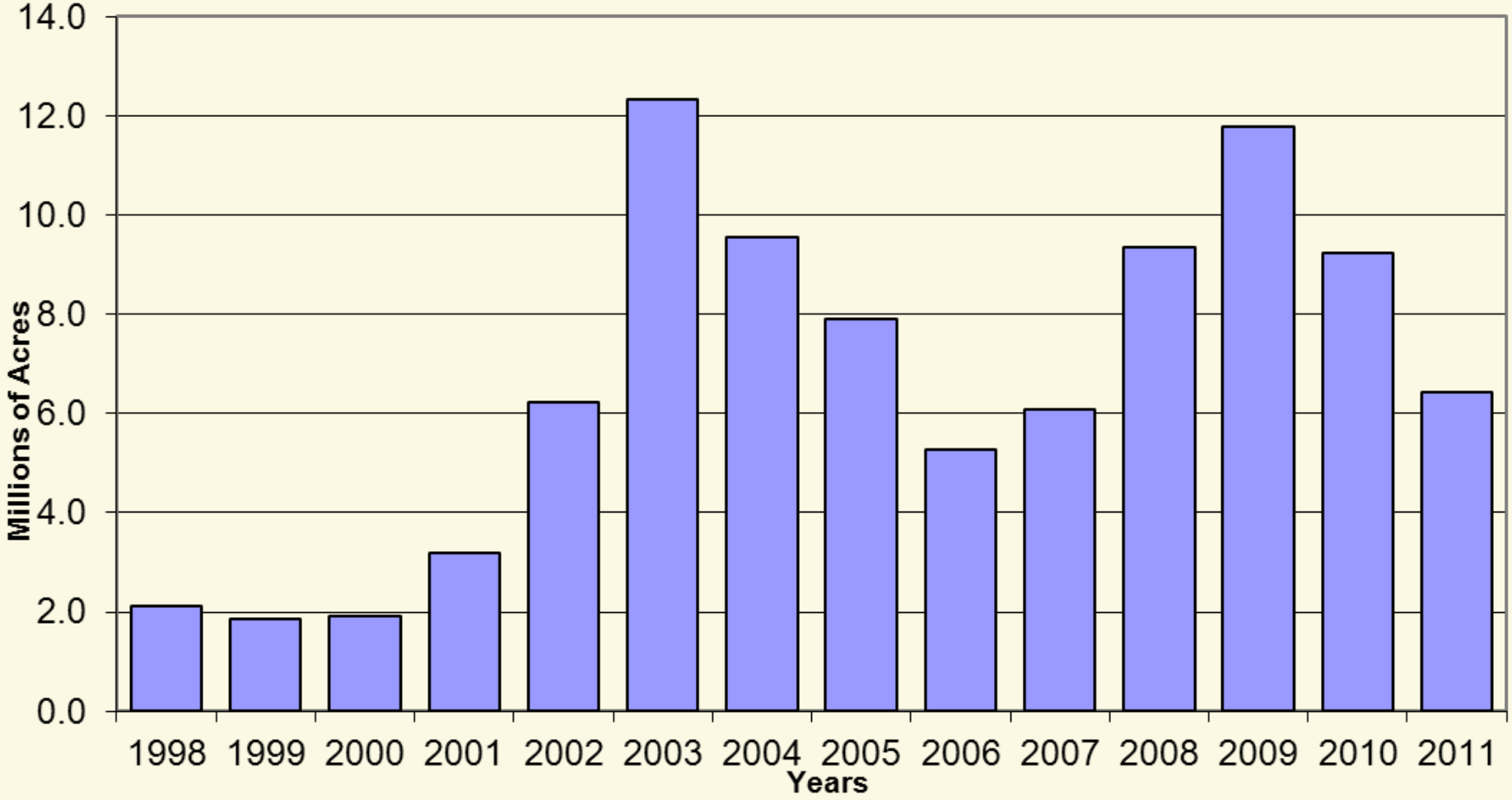
Approximate Footprint Acres with Mortality: 6.4 million*



*Acres are summarized from current year's observations only and are not cumulative.
The "footprint" total represents the affected area on the ground with no multiple counting of acres affected by multiple mortality agents.

March 2012

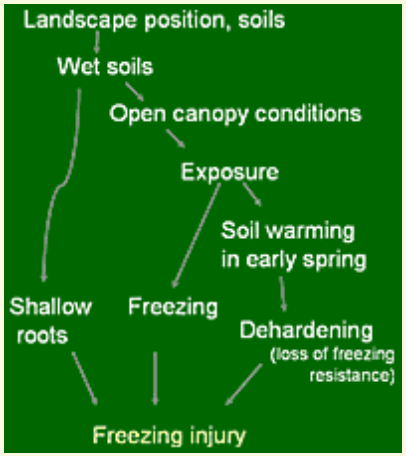
Tree Mortality Trends in the US



Evaluation Monitoring

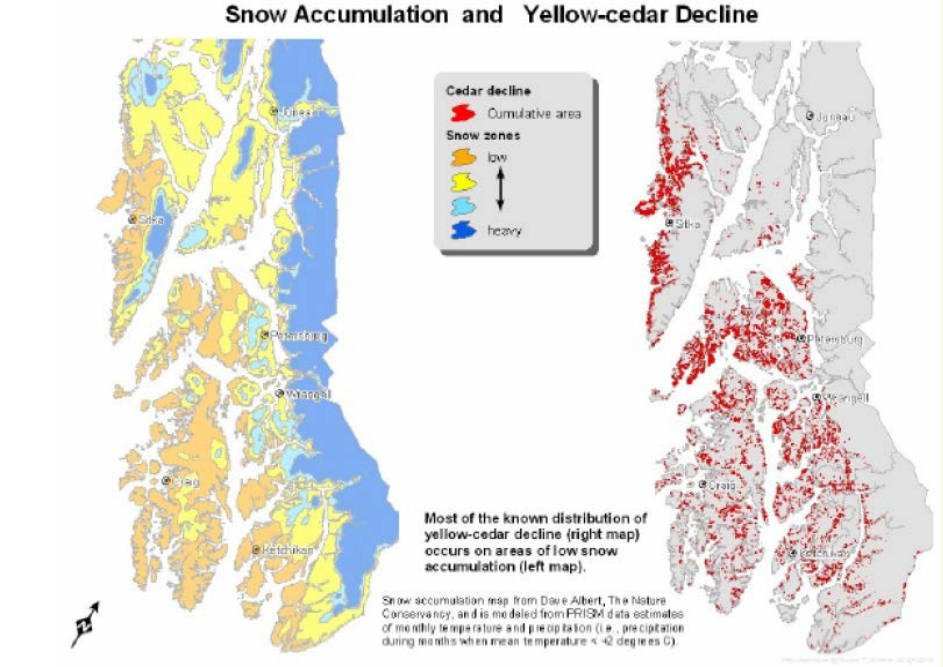
- Determine the extent, severity, and causes of undesirable forest health changes.
- Address likely cause-and-effect relationships, identify associations between forest health and forest stress indicators.
- Identify management consequences and alternatives for reducing the effects of forest stress.
- Identify research needs.

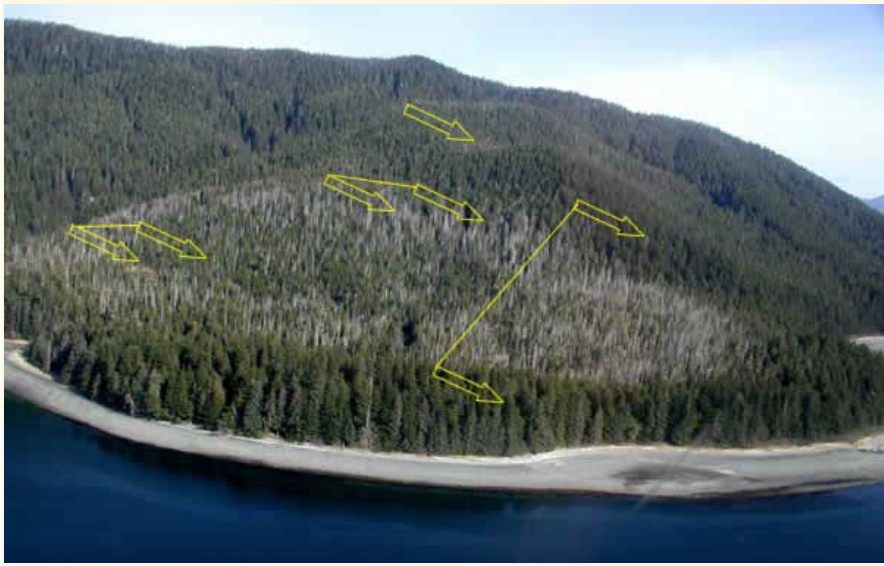
Evaluation Monitoring



Yellow-cedar decline:

- *Chamaecyparis nootkatensis* mortality on 200,000 ha in Southeast Alaska
- Linked to climate warming, reduced snow, and freezing injury of roots



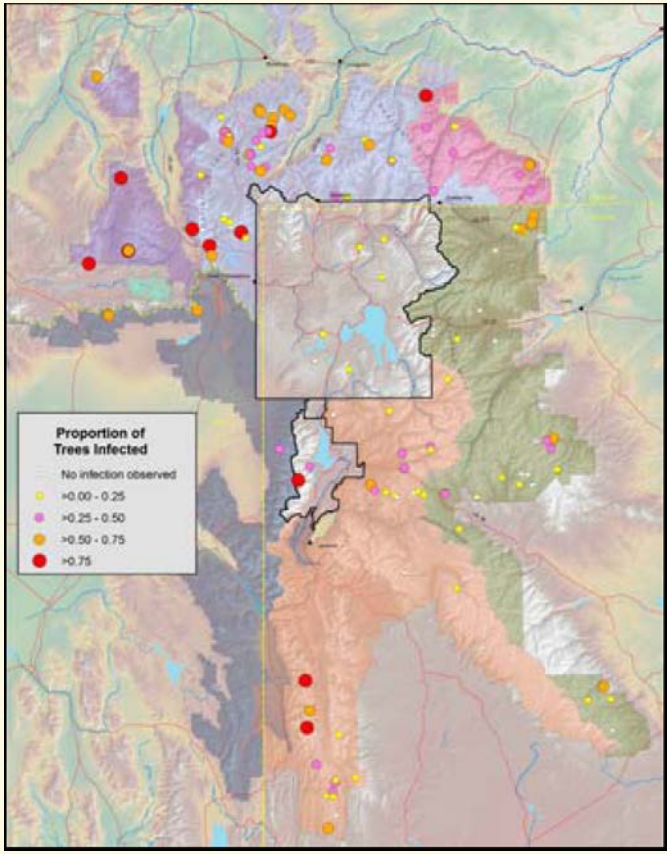


Paul Hennon, USFS, Juneau, AK

Evaluation Monitoring

Whitebark/High Elevation Pines – key climate change indicator species

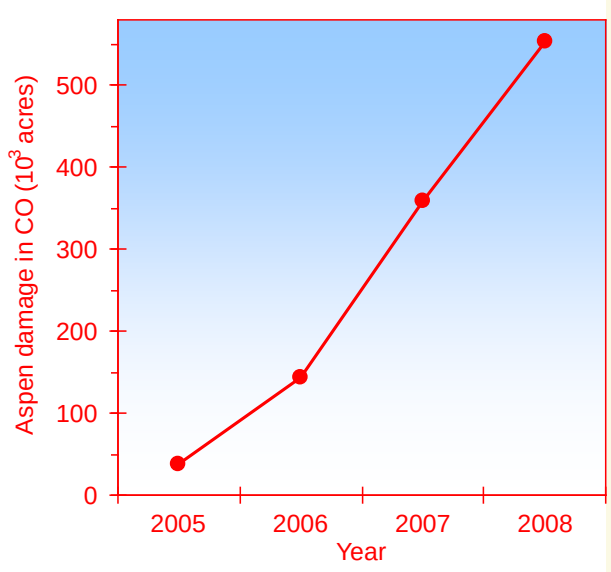
- Determine the distribution and condition of whitebark (*Pinus albicaulis*) and other high elevation pines throughout western US
- Assessment of white pine blister rust (*Cronartium ribicola*) on high elevation white pines
- Impact of mountain pine beetle (*Dendroctonus ponderosae*) on high elevation pines



Evaluation Monitoring

Sudden Aspen Decline

- Aspen forests in some areas of Colorado are experiencing widespread, severe, rapid dieback and mortality
- **Predisposing factors**
  Low elevations, south to west aspects, open stands, and mature trees
- **Inciting factors**
  Hot, dry conditions of 2000-2005
- **Contributing factors**
  Secondary insects and diseases are able to kill trees stressed by the other factors



Jim Worrall, FHP R2, Gunnison, CO

Evaluation Monitoring

Drought

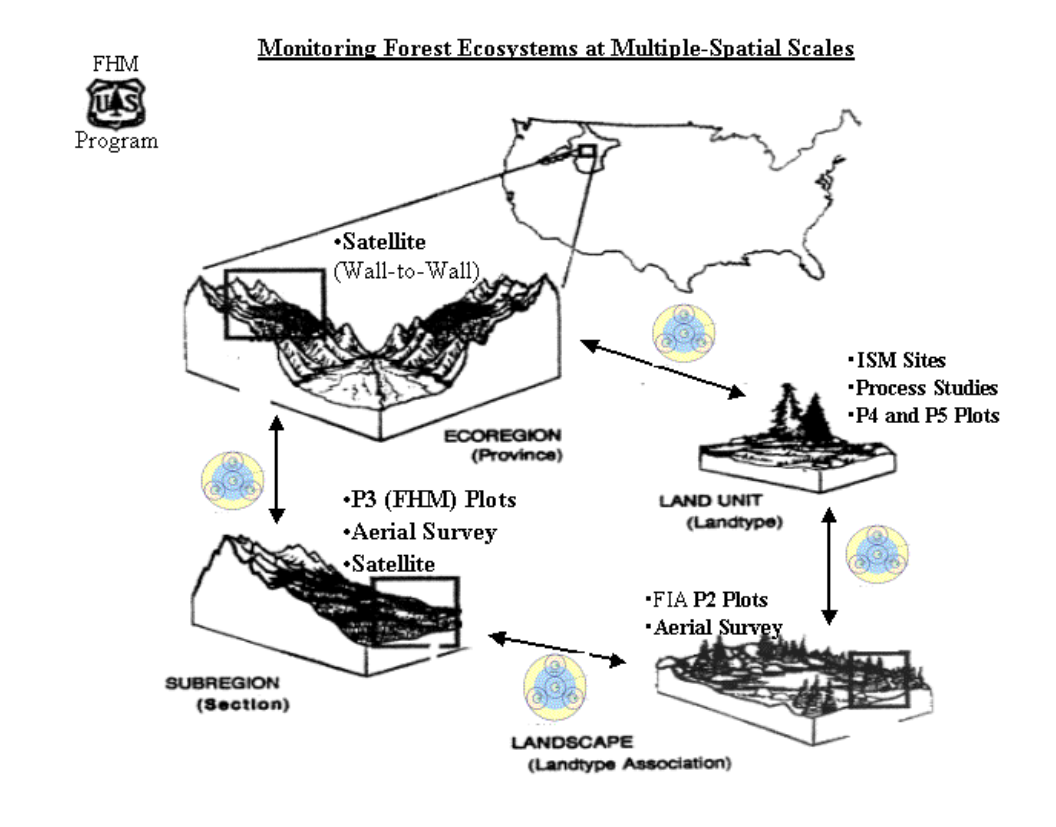
- Drought impact on forest heath in the southeast - an analysis based on FHM/FIA data
- Modeling the impact of drought on growth and mortality in eastern forests
- Southern California forest heath assessment - analysis of status and trend, post drought -induced bark beetle mortality events of 2002-2003
- Ecological impacts of drought stress in Alaska birch stands

Fire

- Modeling fire spread and intensity across bark beetle-affected landscapes
- Monitoring tree deterioration following stand-destroying wildfires
- Contribution of landscape level bark beetle outbreaks to fuel loading and fire behavior in pine forests of the Southwest

Intensive Site Monitoring
– Linking Multiple Scales

- In depth monitoring of indicators to determine detailed information on key components and processes of selected forest ecosystems

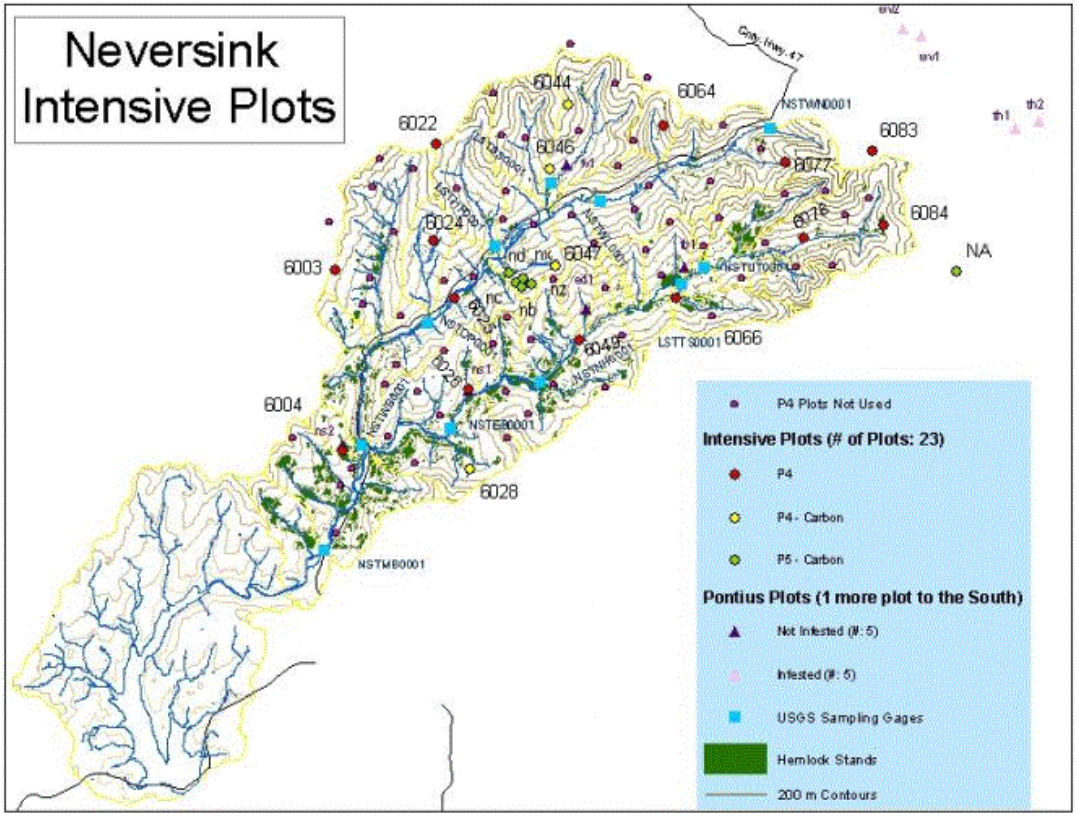


Intensive Site Monitoring Pilot

Delaware River Basin
Collaborative Environmental
Monitoring & Research Initiative
CEMRI

Linked intensified plot grid with process-level studies on:

- Water quality
- Total Carbon
- Calcium Depletion
- Invasive Species

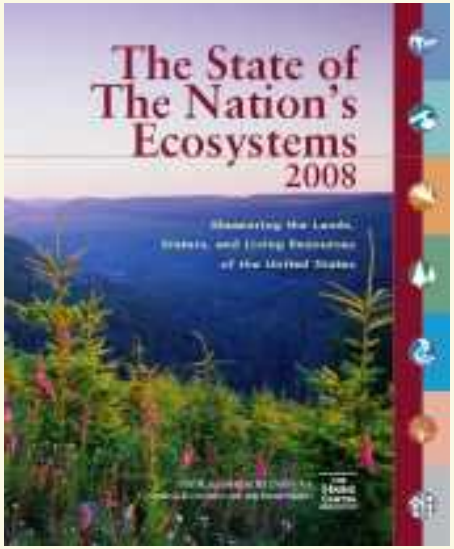


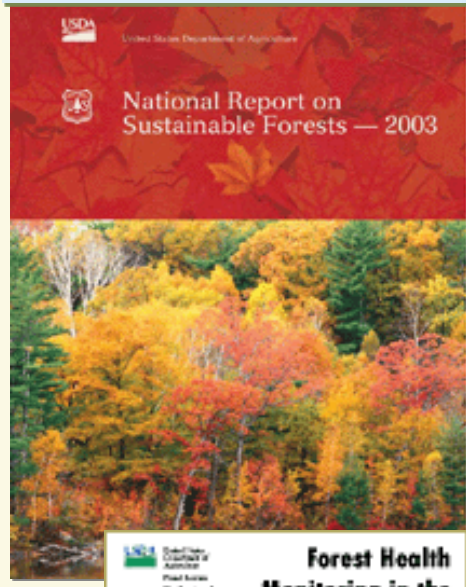
Foundation Document:
Murdoch, Jenkins, Birdsey. 2008.
Gen. Tech. Rep. NRS-25

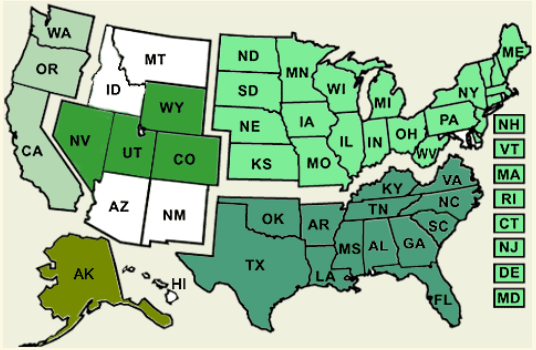
Reporting Highlights

- National Reports
  - FHM National Technical Reports
  - National Sustainability Report – Montreal Process Criteria and Indicators for Sustainable Forests
  - Heinz Center – The State of the Nation's Ecosystems
  - EPA – US/Canada Air Quality Agreement Progress Reports
- Regional Reports
  - Northeast Forest Stressor Report
  - Aspen Forest Cover Change in Rockies
- State Reports
  - Utah Baseline Report
  - Forest Health Highlights

http://www.fs.fed.us/foresthealth/fhm





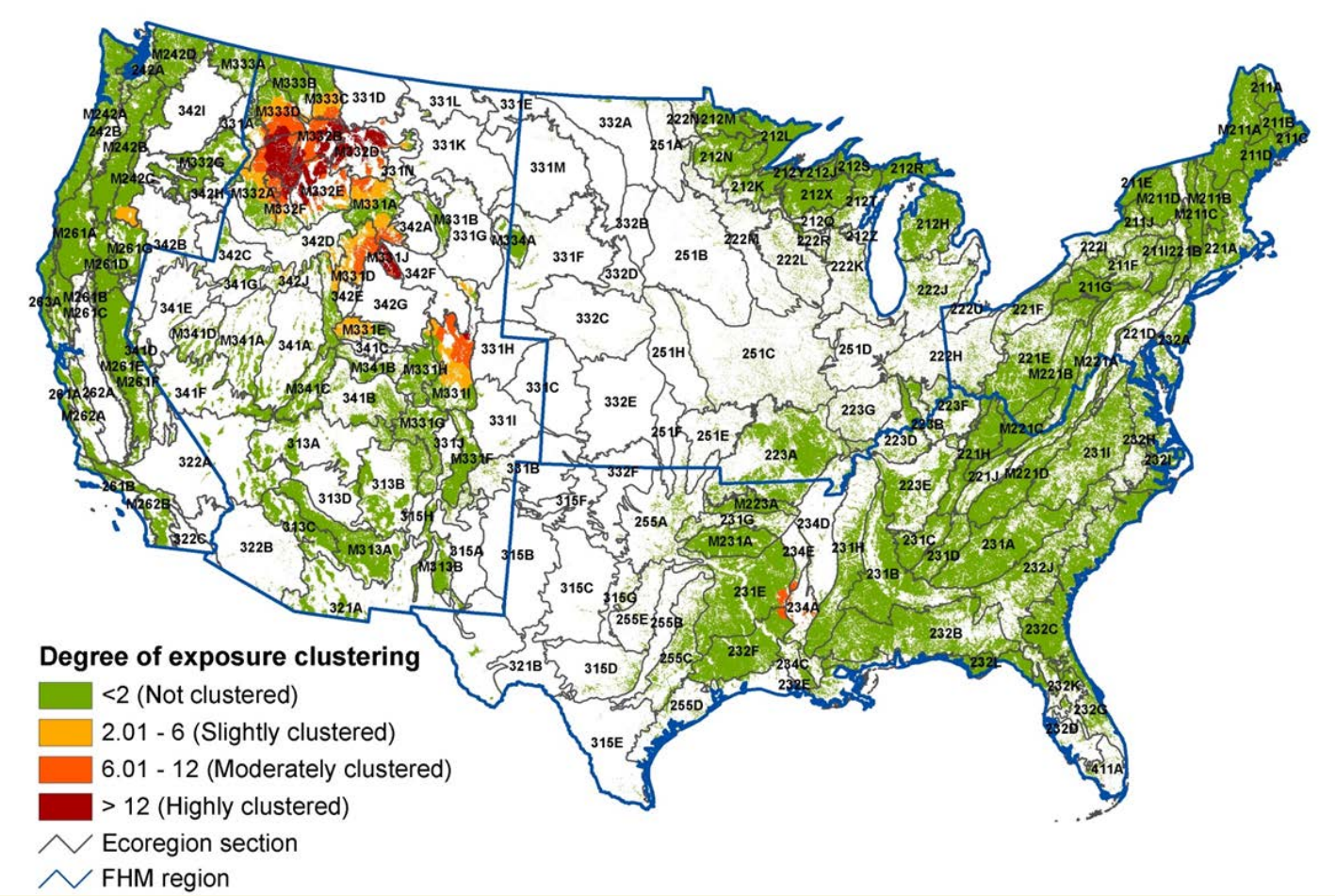


Analysis by Ecoregion Sections

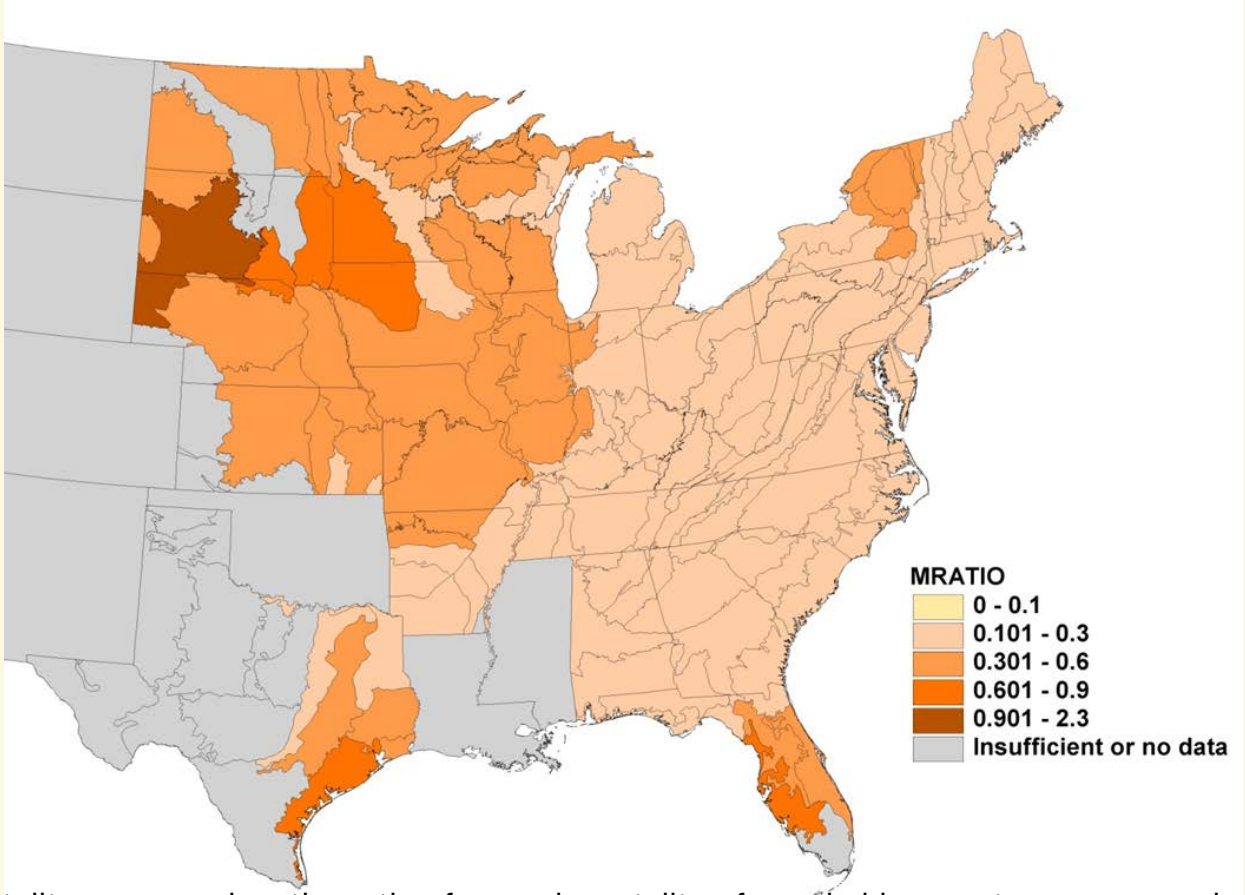
- National hierarchical system of ecological units
  - Climate
  - Vegetation
  - Soils

R.G. Bailey, 1995
Cleland et al., 2005

Hot Spots of Tree Mortality from 2010 Aerial Surveys

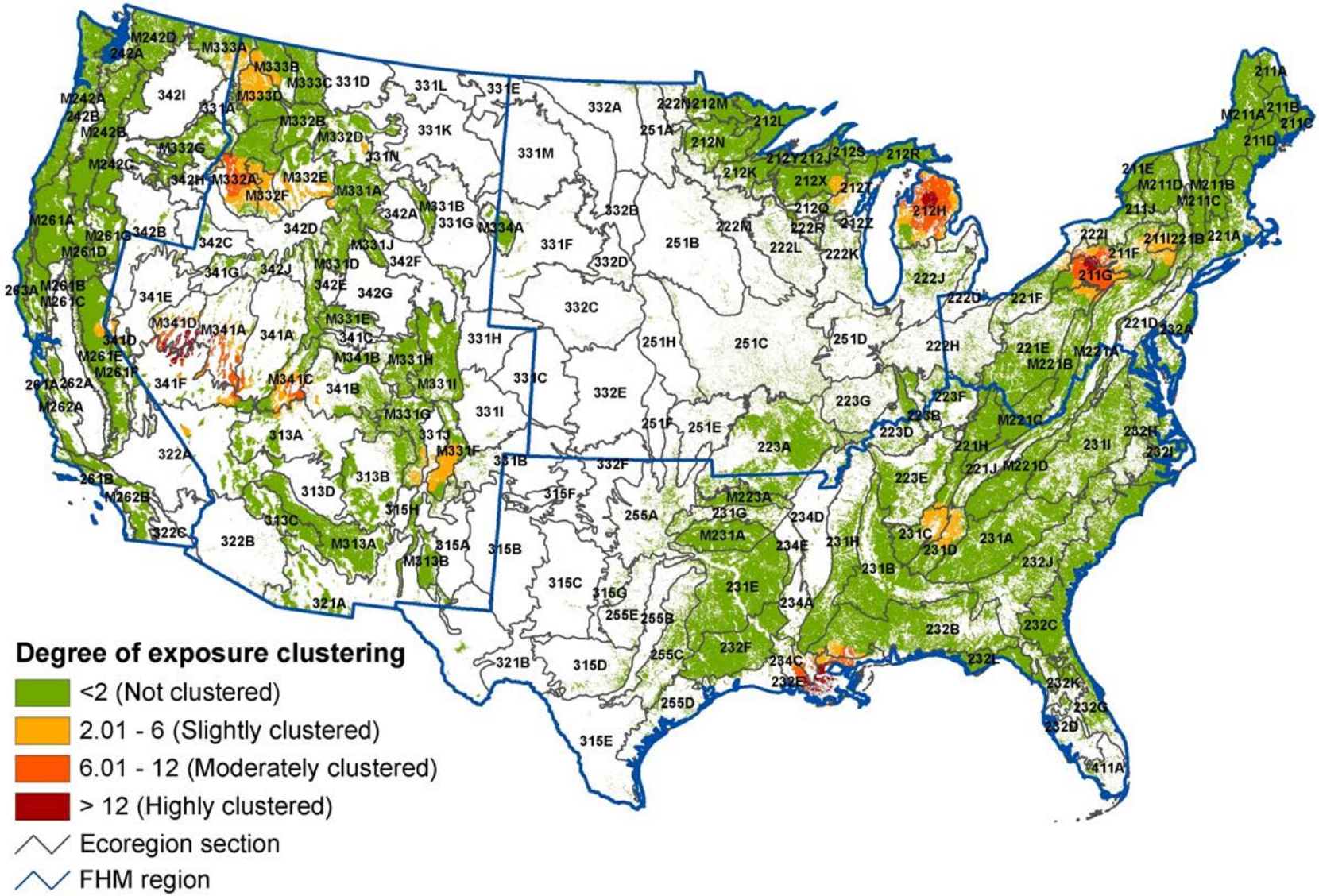


Mortality from FIA Plots

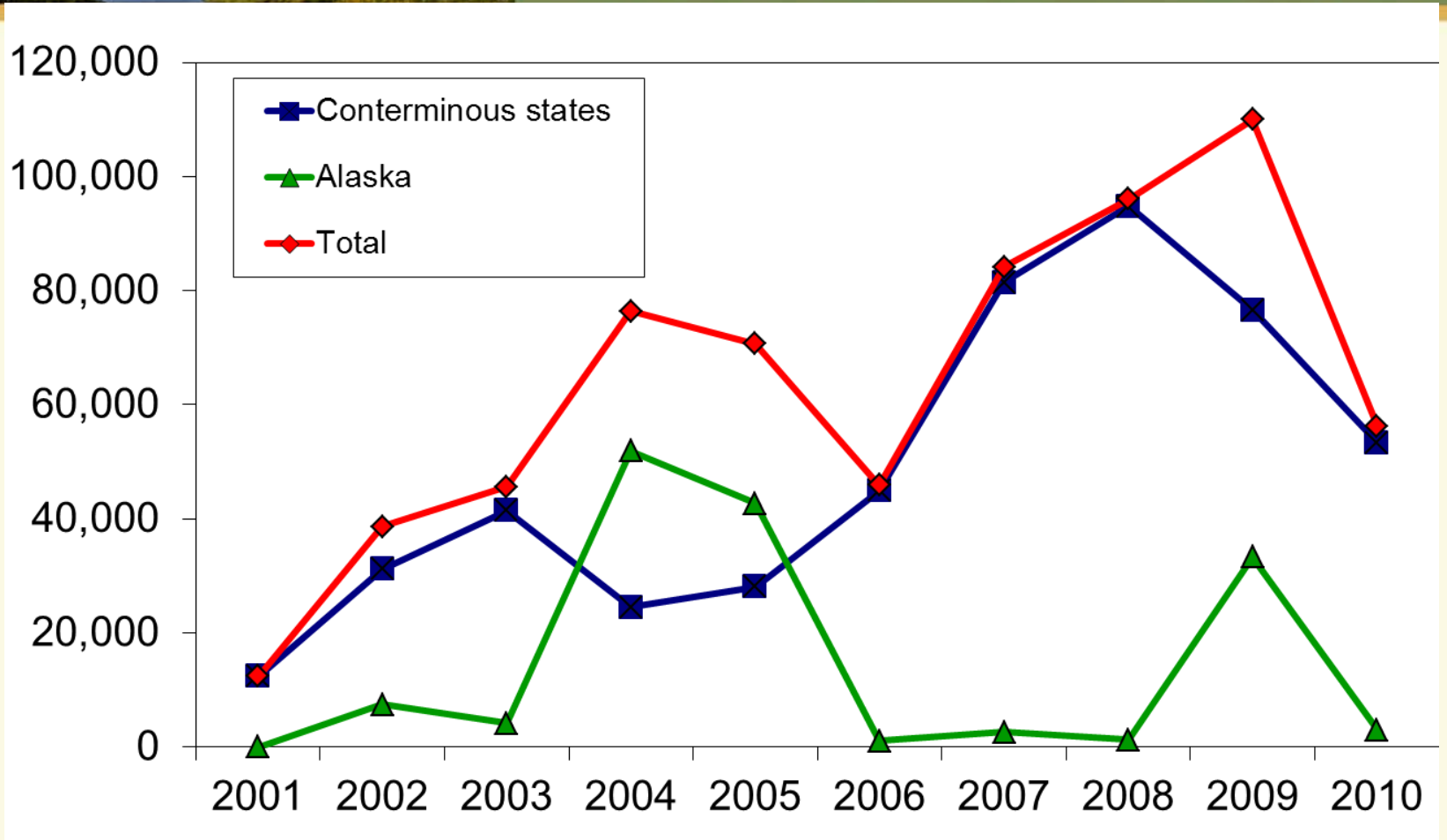


Tree mortality expressed as the ratio of annual mortality of woody biomass to gross annual growth in woody biomass (MRATIO) by ecoregion section (Cleland and others 2005). (Data source: U.S. Department of Agriculture, Forest Service Forest Inventory and Analysis Program).

Hot Spots of Tree Defoliation from 2010 Aerial Surveys



Fire Occurrence

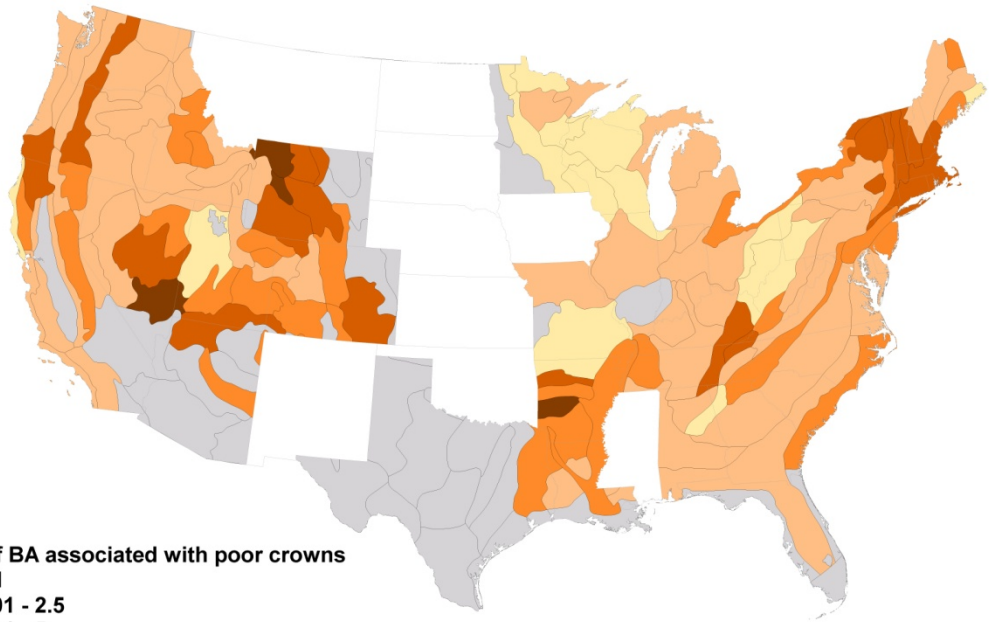


Forest fire occurrences detected by MODIS from 2001 to 2010, for the conterminous United States, Alaska, and the two regions combined. (Data source: U.S. Department of Agriculture Forest Service, Remote Sensing Application Center.)

Crown Conditions

- Crown dieback and foliar transparency were used to calculate a crown index
- Overall, < 15 percent of the basal area was associated with unhealthy crowns
- Ecoregion sections having > 10 percent average basal area associated with unhealthy crowns were mostly located in the Interior West

Crowns: 1999-2002



Avg. % of BA associated with poor crowns
- 0 - 1
- 1.001 - 2.5
- 2.501 - 5
- 5.001 - 10
- 10.001 - 12.316
- Insufficient Data

A tree was considered to have poor crown condition if its adjusted-ZB-index was greater than 0.25.

Drought

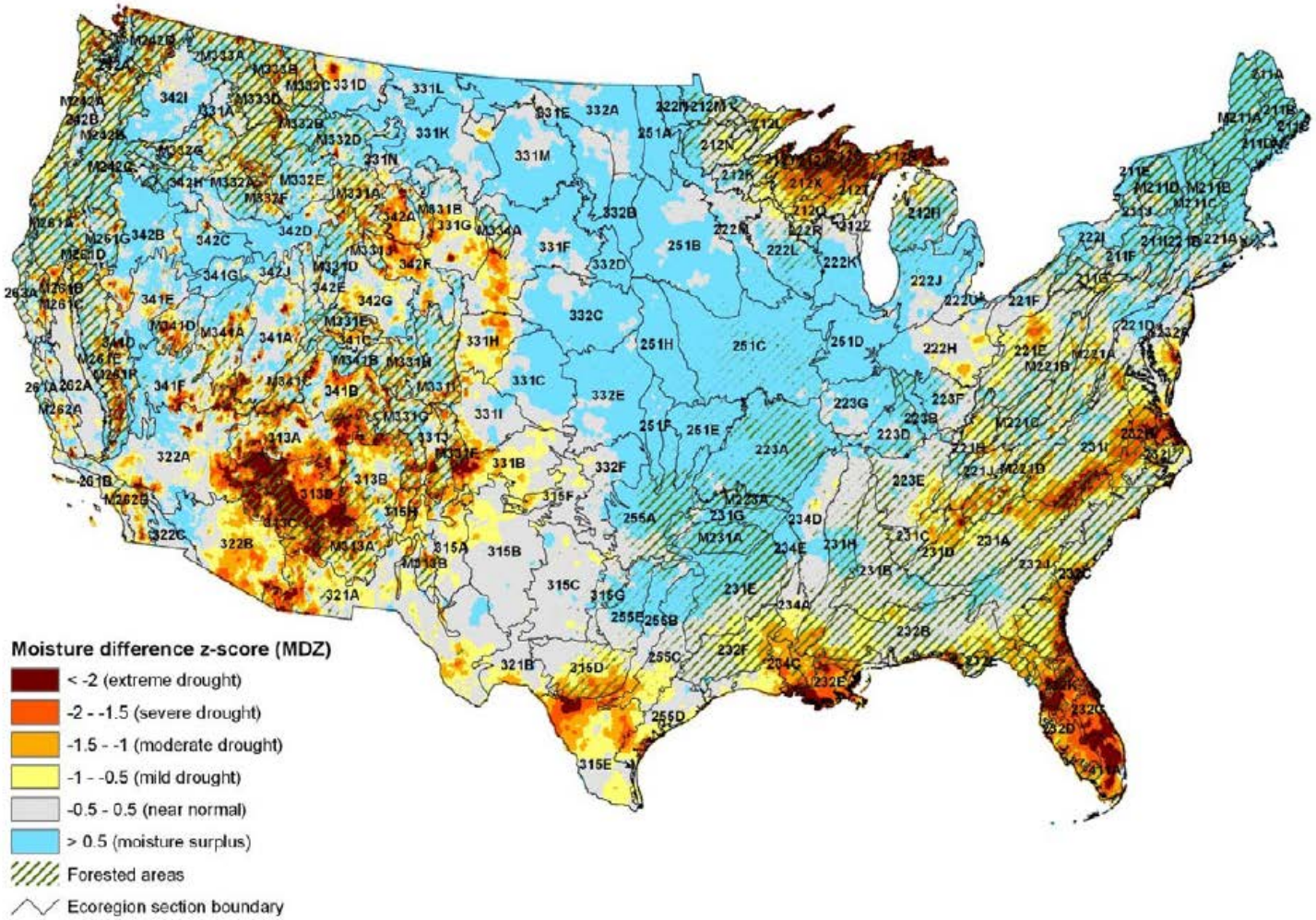
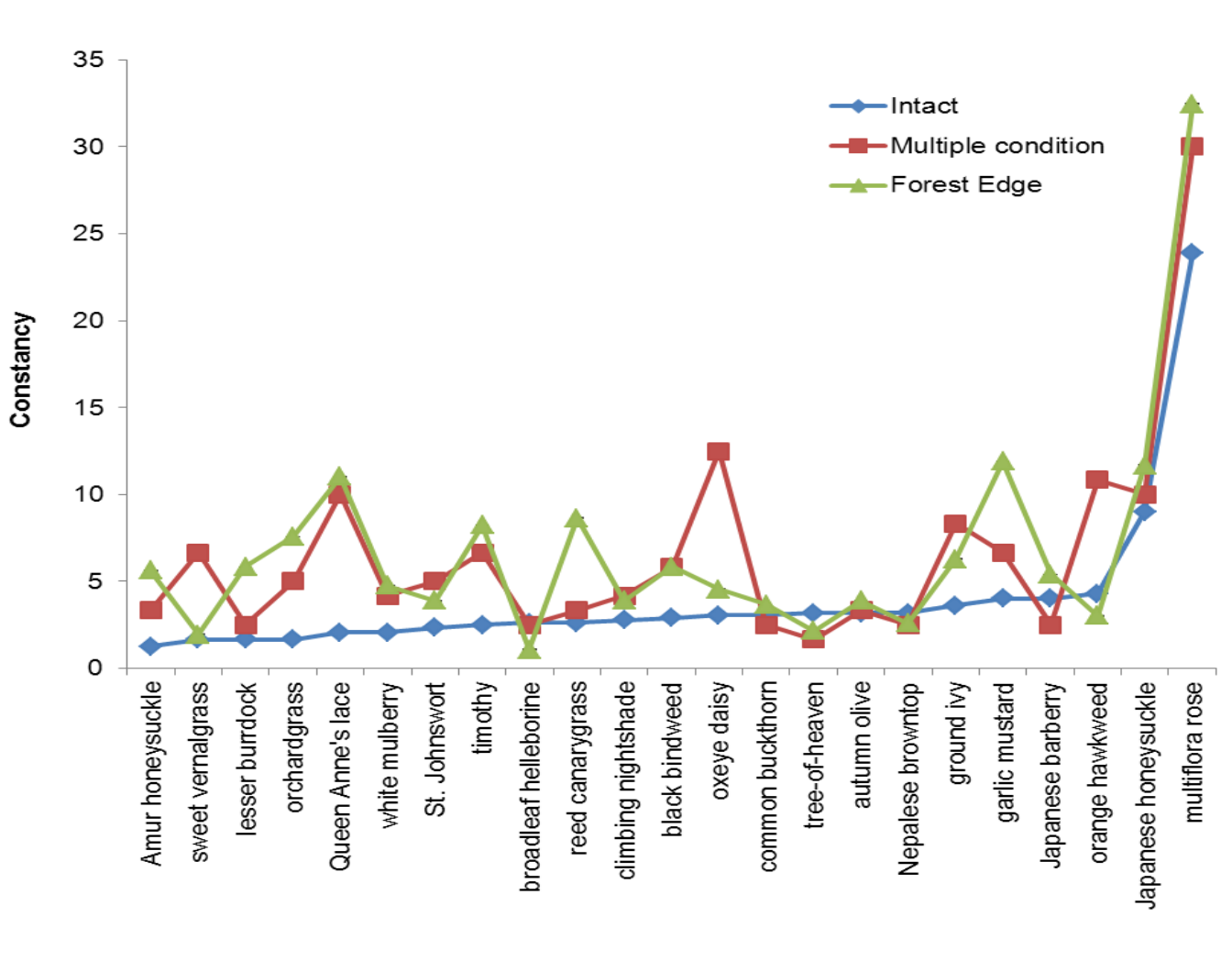
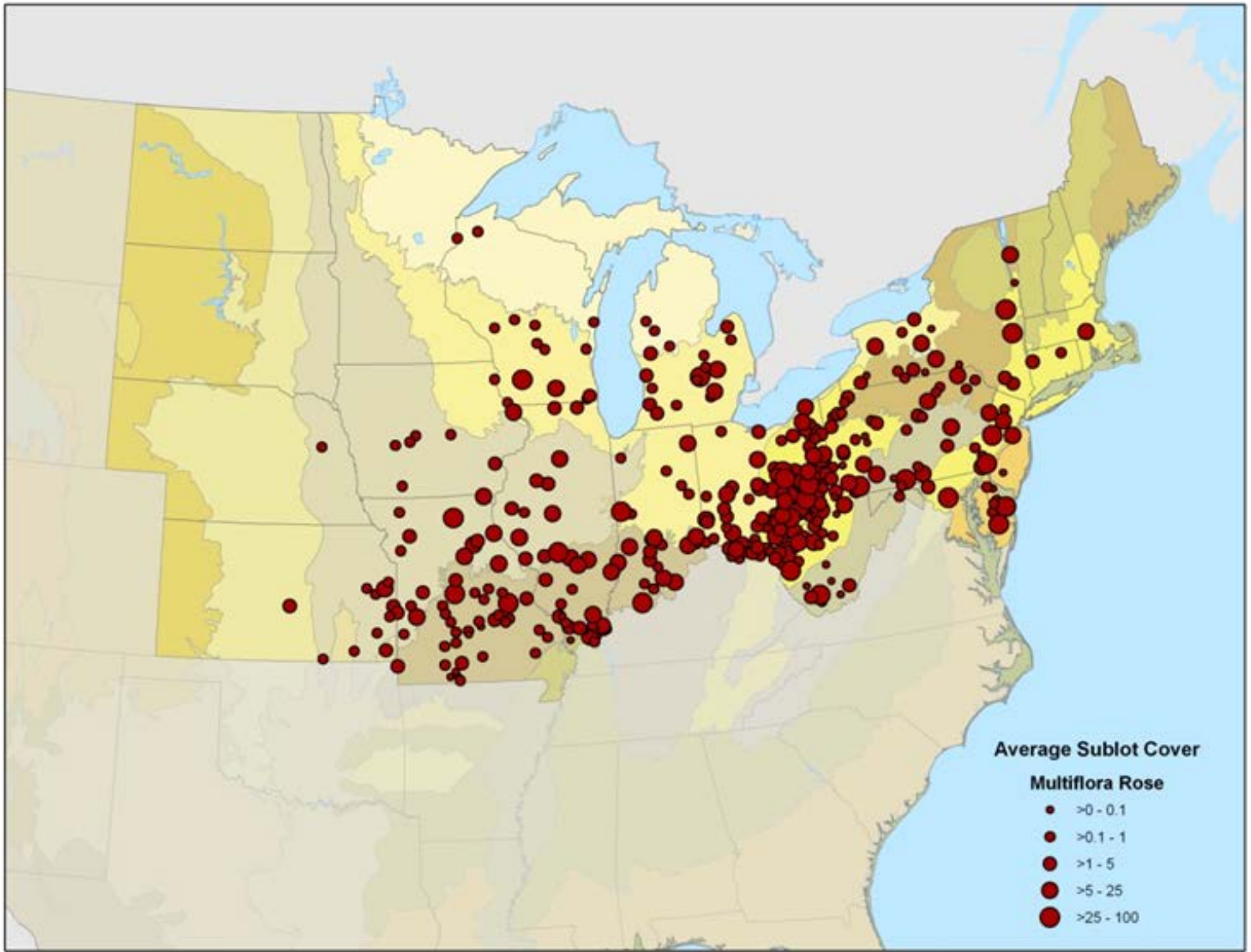


Figure 4.4 - The 2006-2010 (i.e., five-year) moisture difference z-score, or *MDZ*, for the conterminous United States. Ecoregion section (Cleland and others 2007) boundaries are included for reference. Forest cover data (overlaid green hatching) derived from MODIS imagery by the U.S. Department of Agriculture, Forest Service, Remote Sensing Applications Center. Data source: PRISM Group, Oregon State University.

Invasive Species on P3 Plots in the Northeast



Distribution of Multiflora Rose



Wet Sulfur Deposition

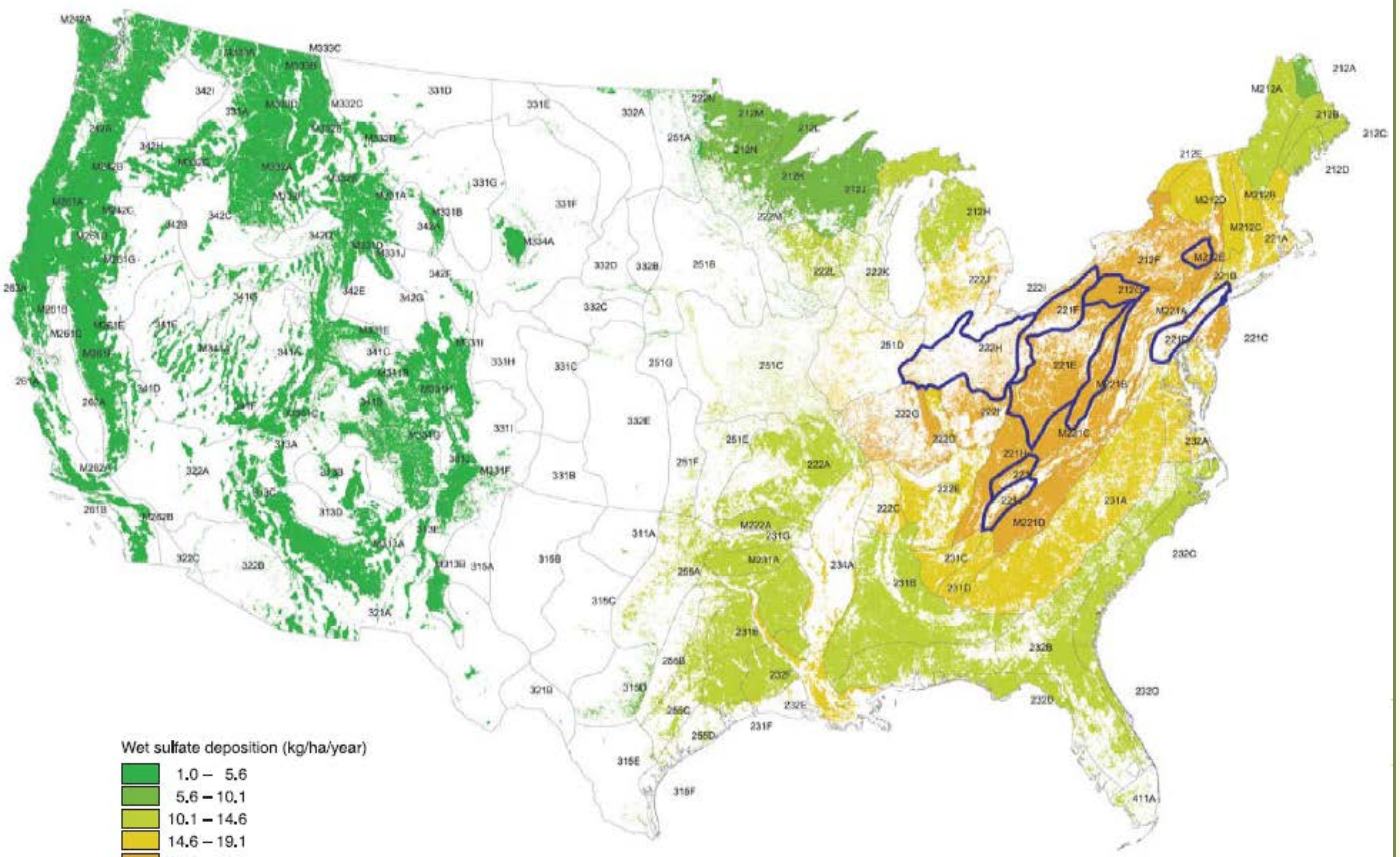


Figure 18—Average annual wet sulfate deposition (1994 to 2001) by ecoregion section. The areas outlined in blue highlight ecoregion sections whose deposition rates exceed the 95th percentile.

Wet Nitrogen Deposition

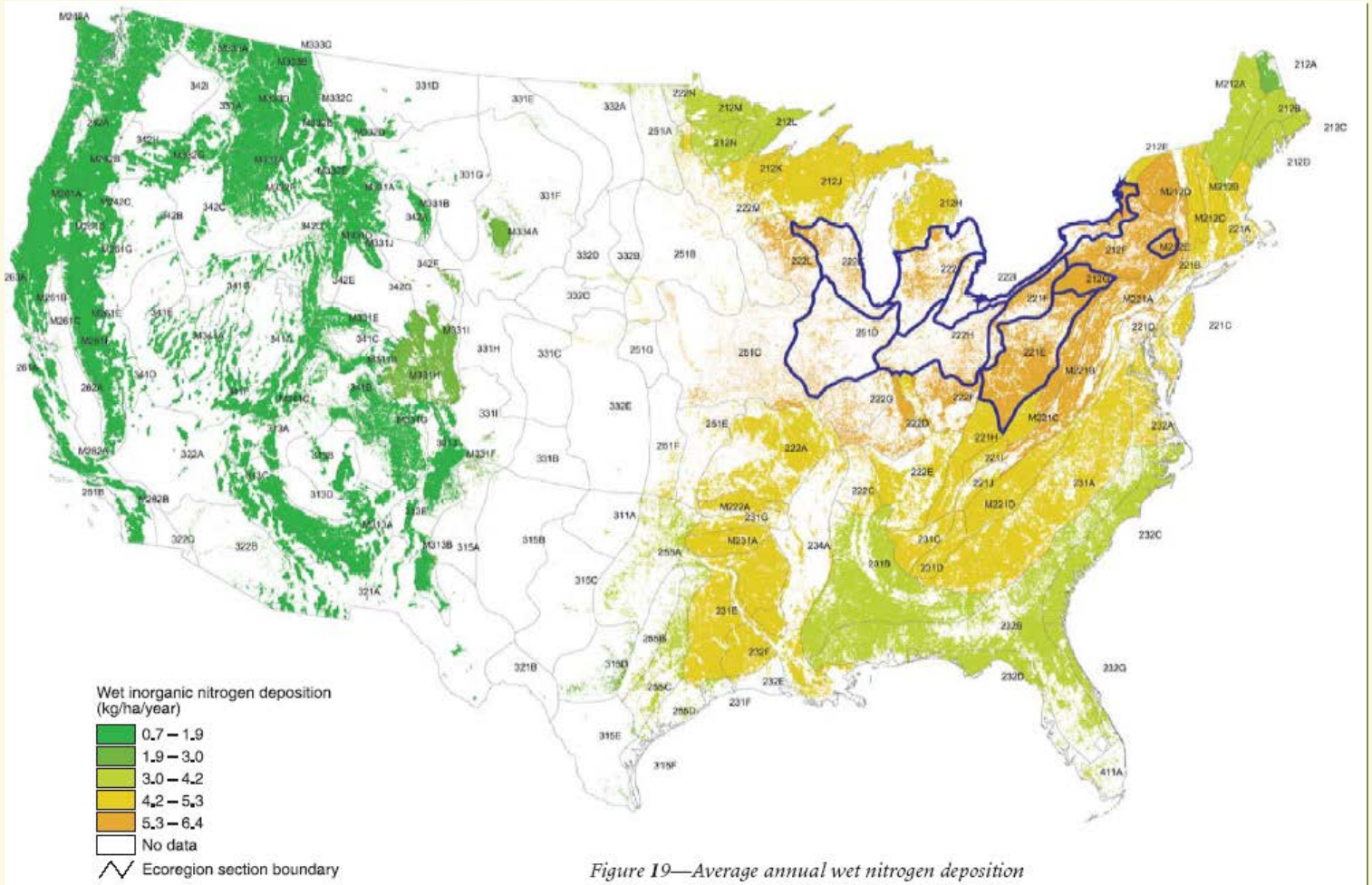
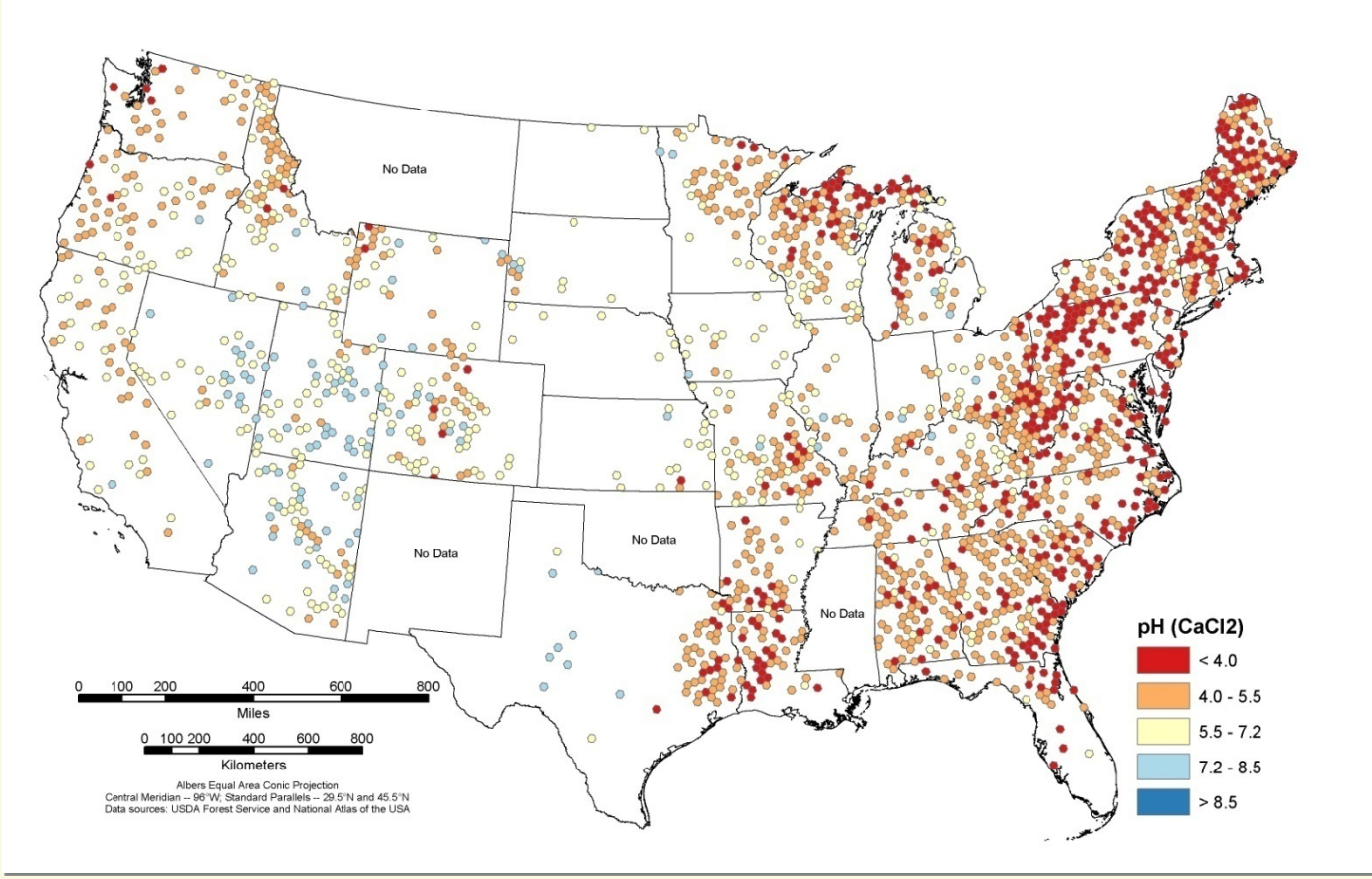


Figure 19—Average annual wet nitrogen deposition (1994 to 2001) by ecoregion section. The areas outlined in blue highlight ecoregion sections whose deposition rates exceed the 95th percentile.

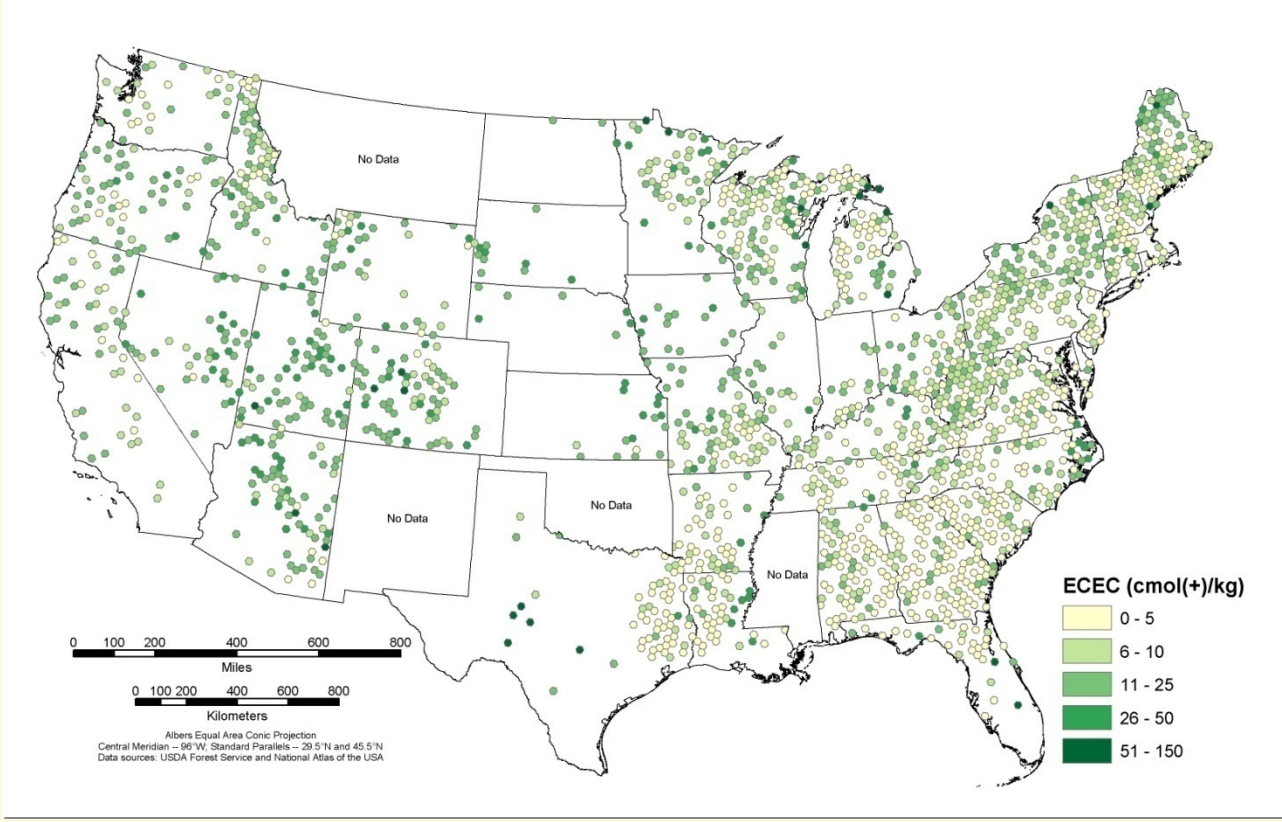
Soil pH

- Mean soil pH value is 4.8
- Acidic tendency of soil pH is most clear east of the Mississippi River

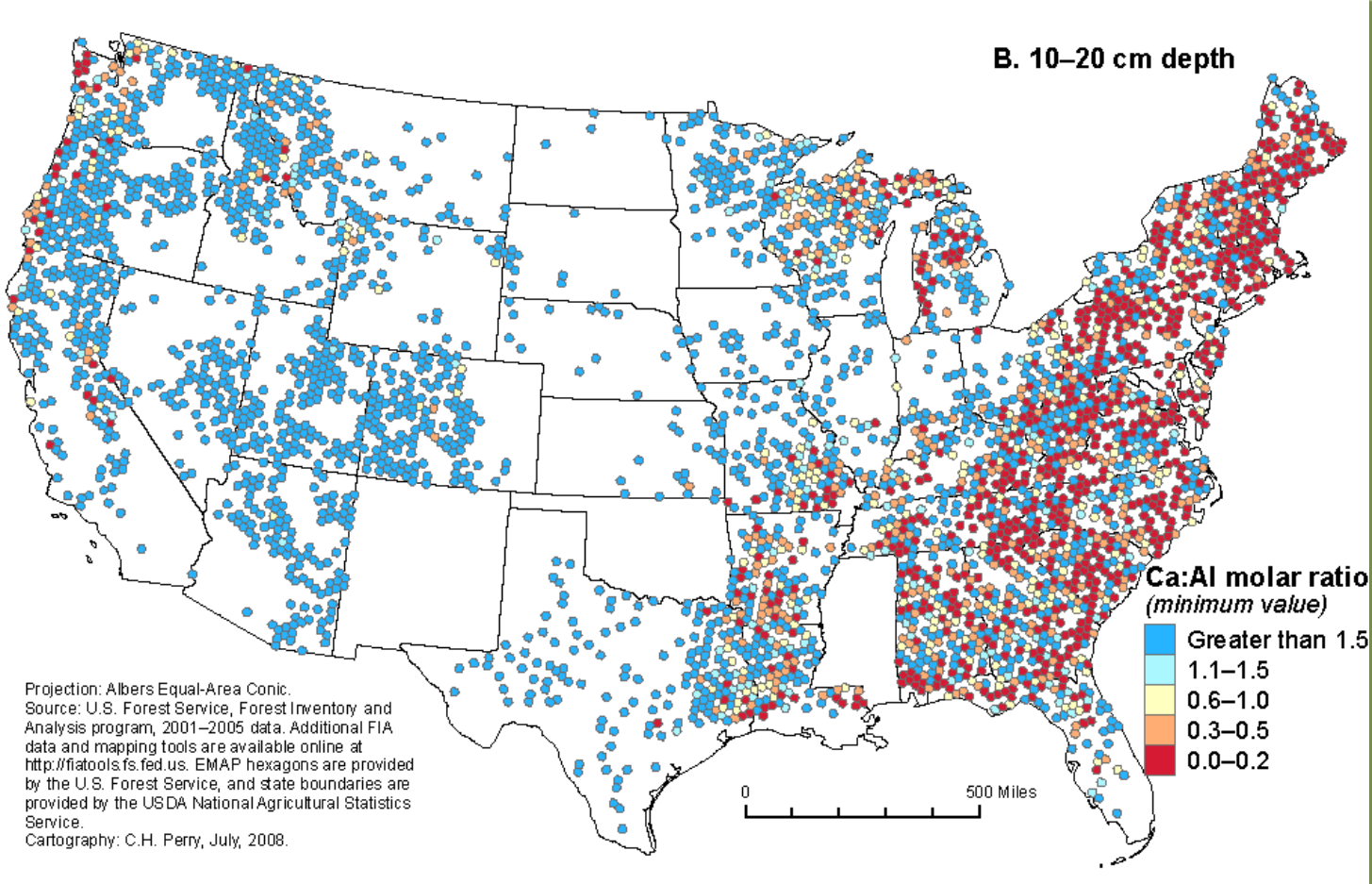


Effective Cation Exchange Capacity

- Southeastern United States tended to have the greater proportion of forest soils with low ECEC levels.

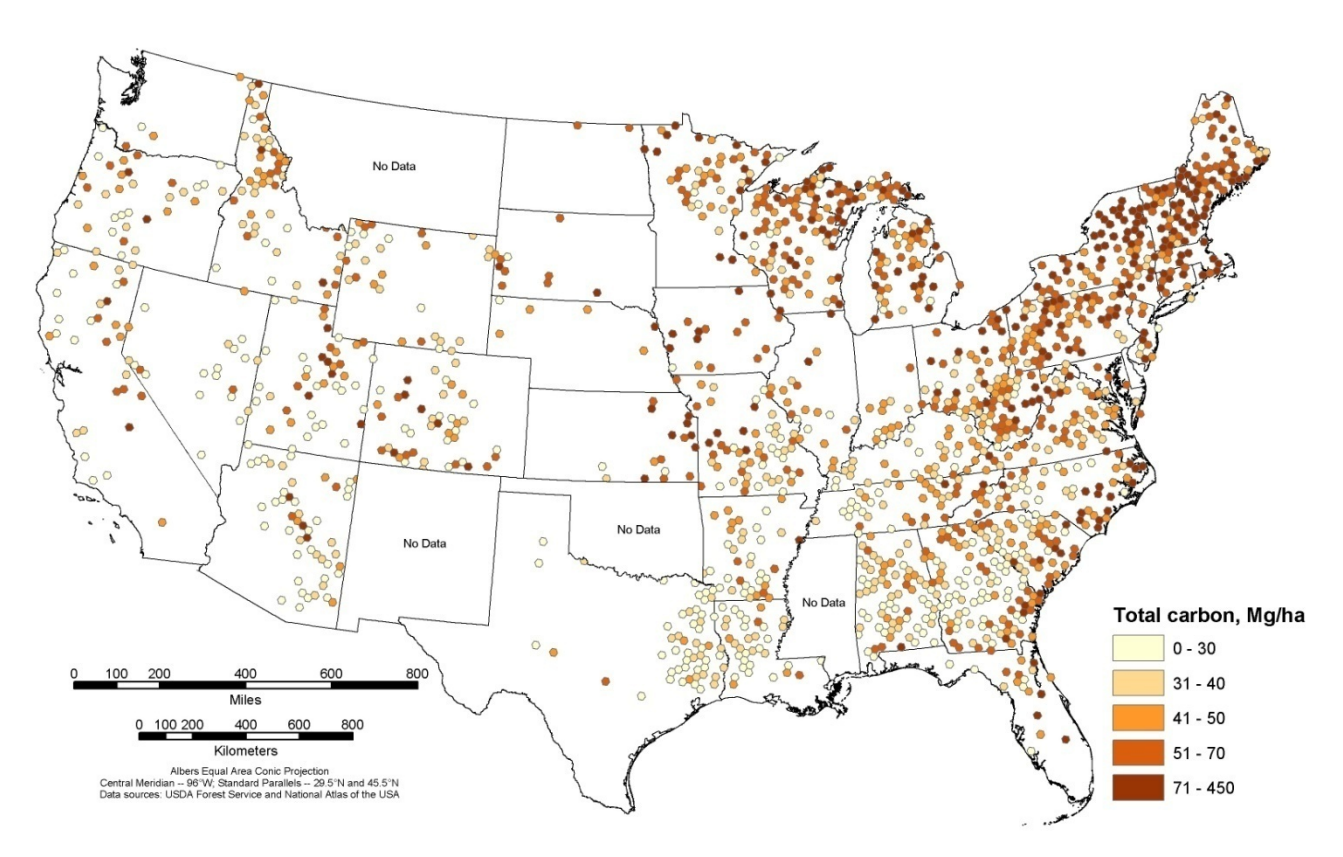


Ca:Al Molar Ratio

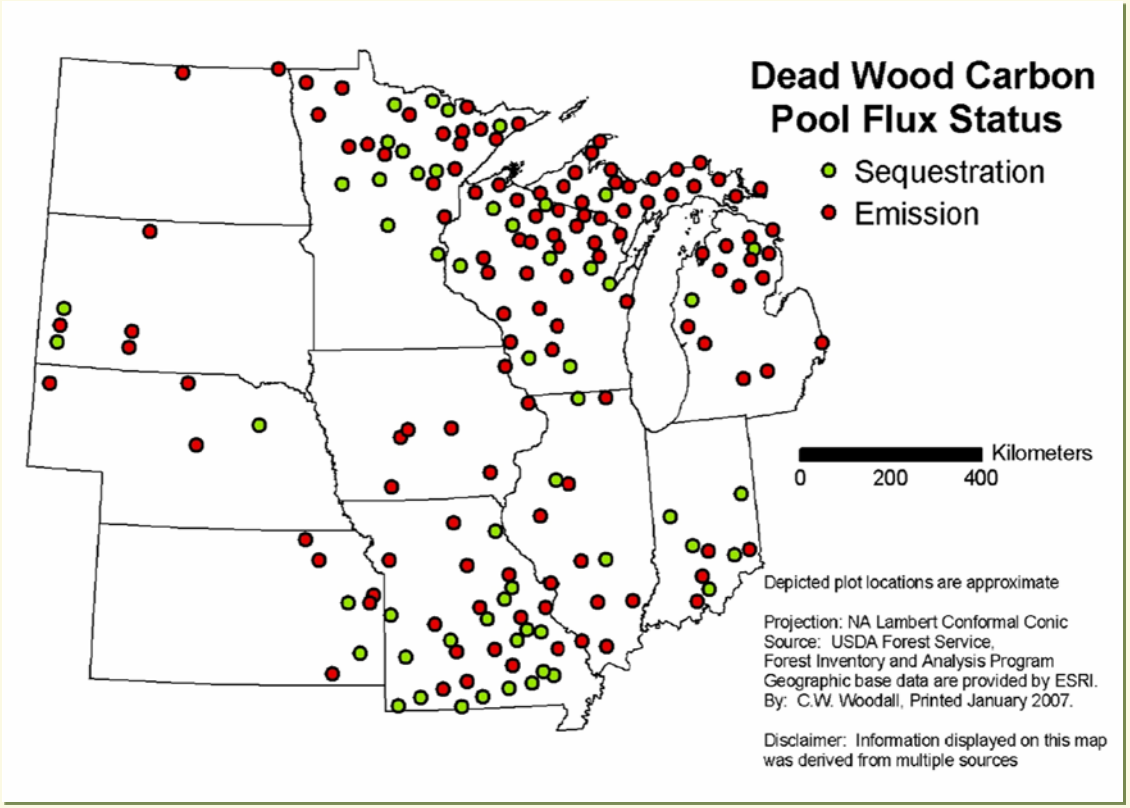


Total Soil Carbon

- Total soil carbon content is generally the highest in the Northeastern and Northern United States where decay rates are very low



Carbon Pool Flux in DWM 2001 to 2006

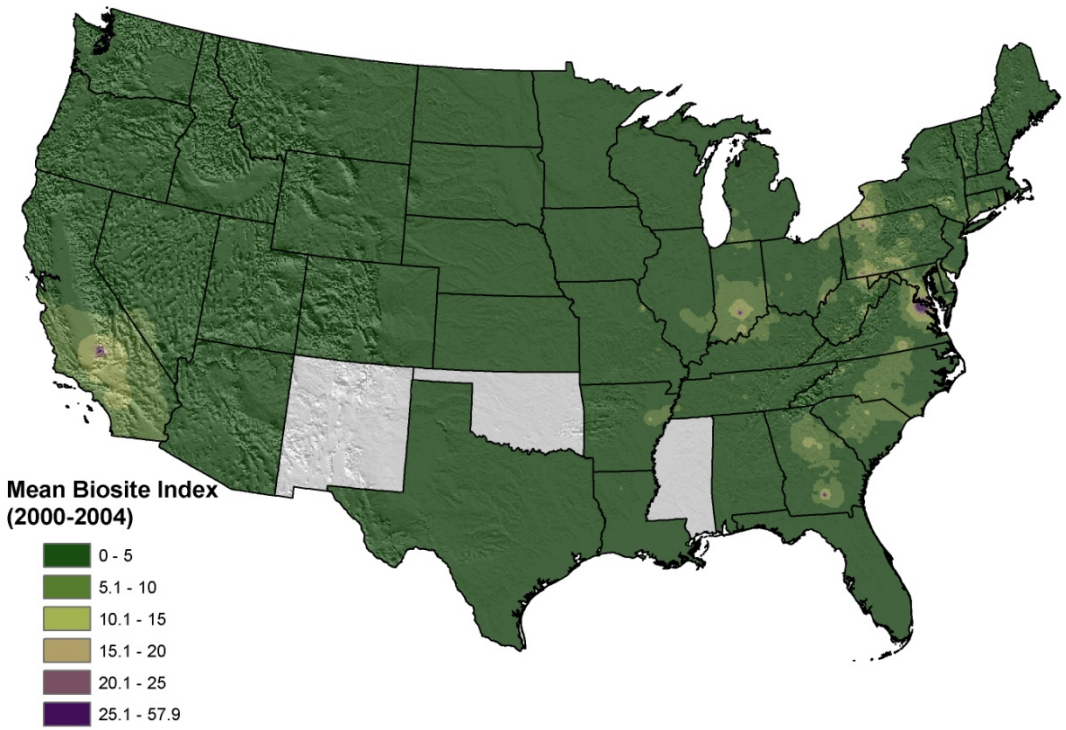


Ozone Exposure

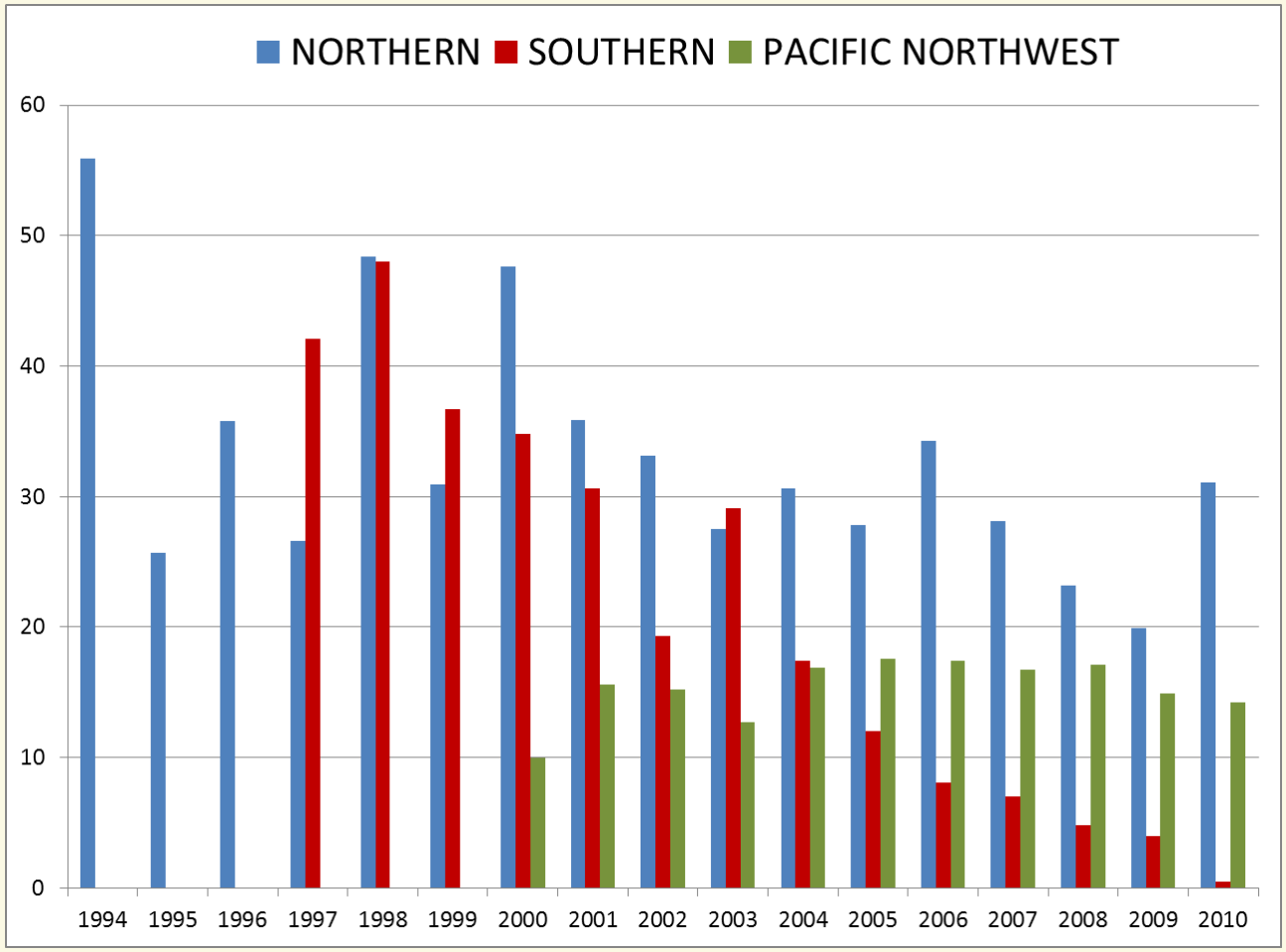
- **Ozone concentrations highest in Sierra Nevada, southwest, Appalachian piedmont, along east coast and Great Lakes**

Ozone Biosite Index

- Foliar injury on ozone plots showed similar trends
- The highest occurrences in the Sierra Nevada, the southeast, and near Washington, DC



Trends in Ozone Injury



– Ozone injury to forest plants in the U.S. by FIA Region: Percent injured plots by year, 1994 to 2010.

Risk Mapping

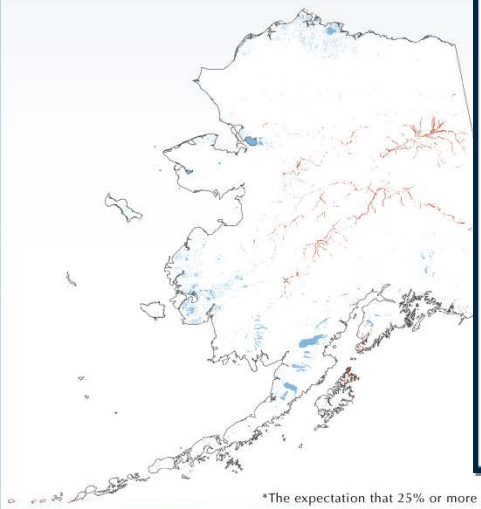
NATIONAL INSECT and DISEASE RISK MAP

TOP AGENTS BY RANK

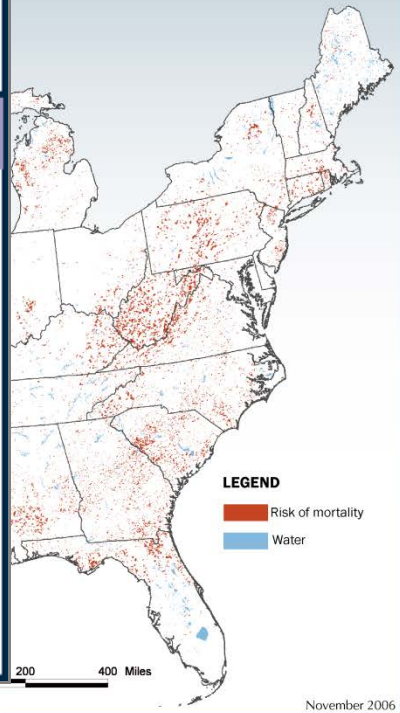
1. Mountain Pine Beetle
2. Red Oak Decline
3. Southern Pine Beetle
4. Root Diseases - All
5. Gypsy Moth
6. Pine Engraver Beetle
7. Fir Engraver Beetle
8. Douglas-Fir Beetle
9. Spruce Beetle
10. Hardwood Decline
11. Western Pine Beetle

ADDITIONAL AGENTS BY RANK

Spruce Budworm
Beech Bark Disease
Douglas-Fir/White/Grand Fir Def.
Jeffrey Pine Beetle
Dwarf Mistletoes
Aspen Decline
Western Balsam Bark Beetle
Sudden Oak Death
Hemlock Looper
Western Red Cedar Mortality
Balsam Woolly Adelgid
Hemlock Woolly Adelgid
White Pine Blister Rust
Roundheaded Pine Beetle
Fusiform Rust
Oak Wilt
Aspen Forest Tent Caterpillar
Dutch Elm Disease
Northern Spruce Engraver Beetle
Jack Pine Budworm
Douglas-Fir Tussock Moth
Bronze Birch Borer
Alaska Yellow Cedar Decline
Western Spruce Budworm
Emerald Ash Borer
Butternut Canker
Eastern Larch Beetle
Asian Longhorn Beetle
Pacific Silver Fir Beetle
Spruce Aphid
Pacific Madrone Decline



Risk* Map



*The expectation that 25% or more of the standing live volume of trees greater than 1" in diameter will die over the next 15 years.

November 2006

Future Challenges

- Stress key strengths of FHM
  - Partnership-based
  - Innovative
  - Comprehensive
  - Science-based
- Be "Real Time"
  - Timely detection, analysis, and reporting of adverse changes in forest health to facilitate effective management response
- Look Beyond the Grid
  - Look back – analyze trends, integrate diverse data sources
  - Look forward – forecast future conditions, analyze risks associated with climate change and invasive species
  - Design new approaches for detection of invasives