Forest Health Monitoring

Program Overview

Borys M. Tkacz
National Program Manager

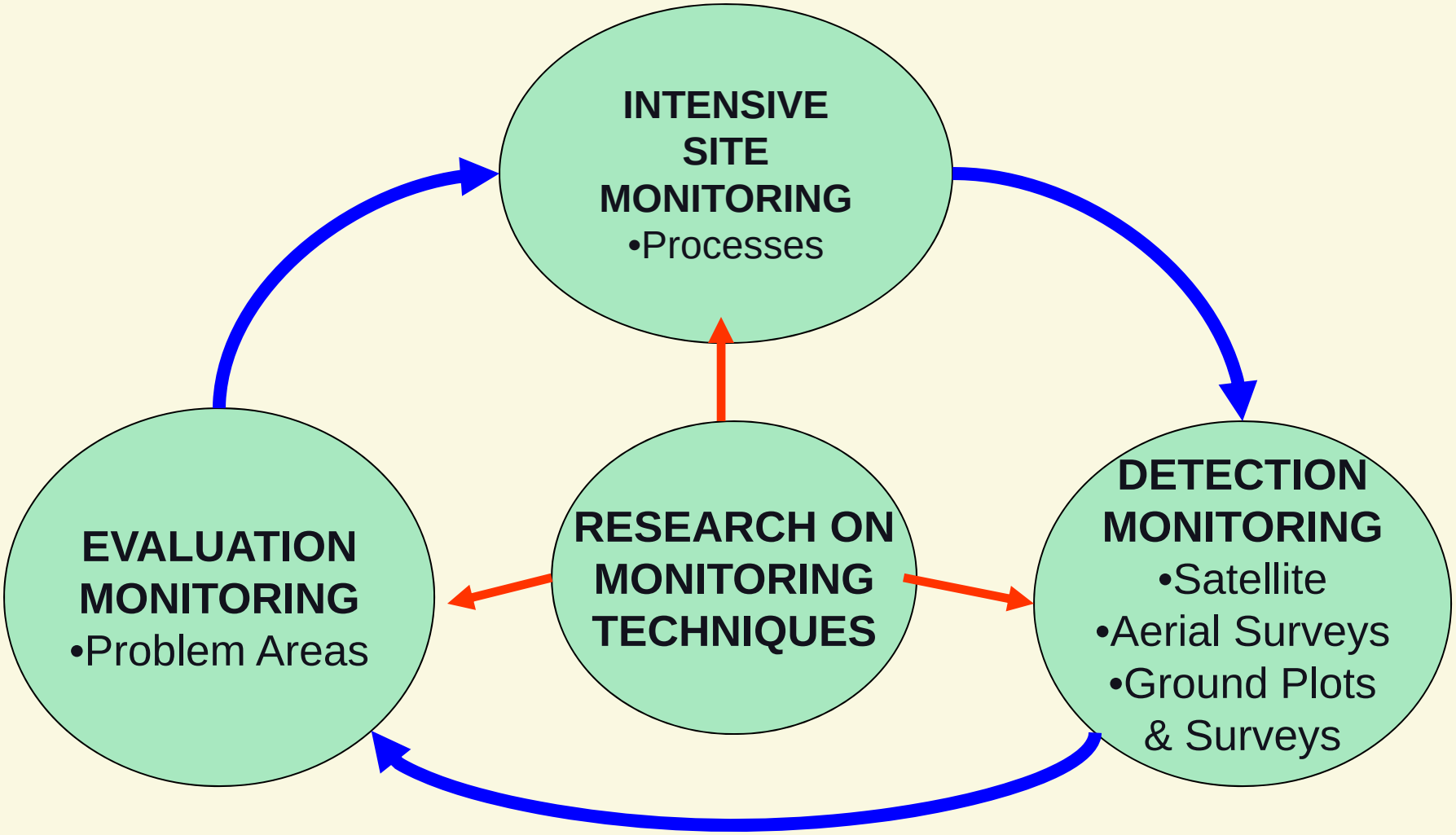
Forest Health Monitoring Program

- 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:

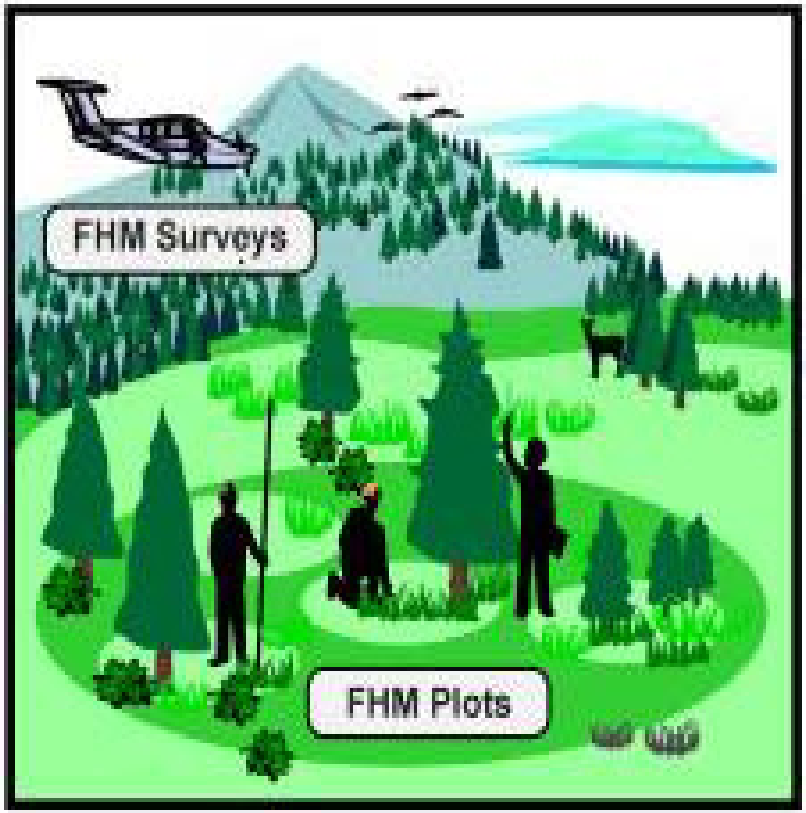
- Establish a monitoring system throughout the forests of the United States to determine detrimental changes or improvements that occur over time.
- Provide baseline and health trend information that is statistically precise and accurate.
- Report annually on status and changes to forest health.

Major Program Components

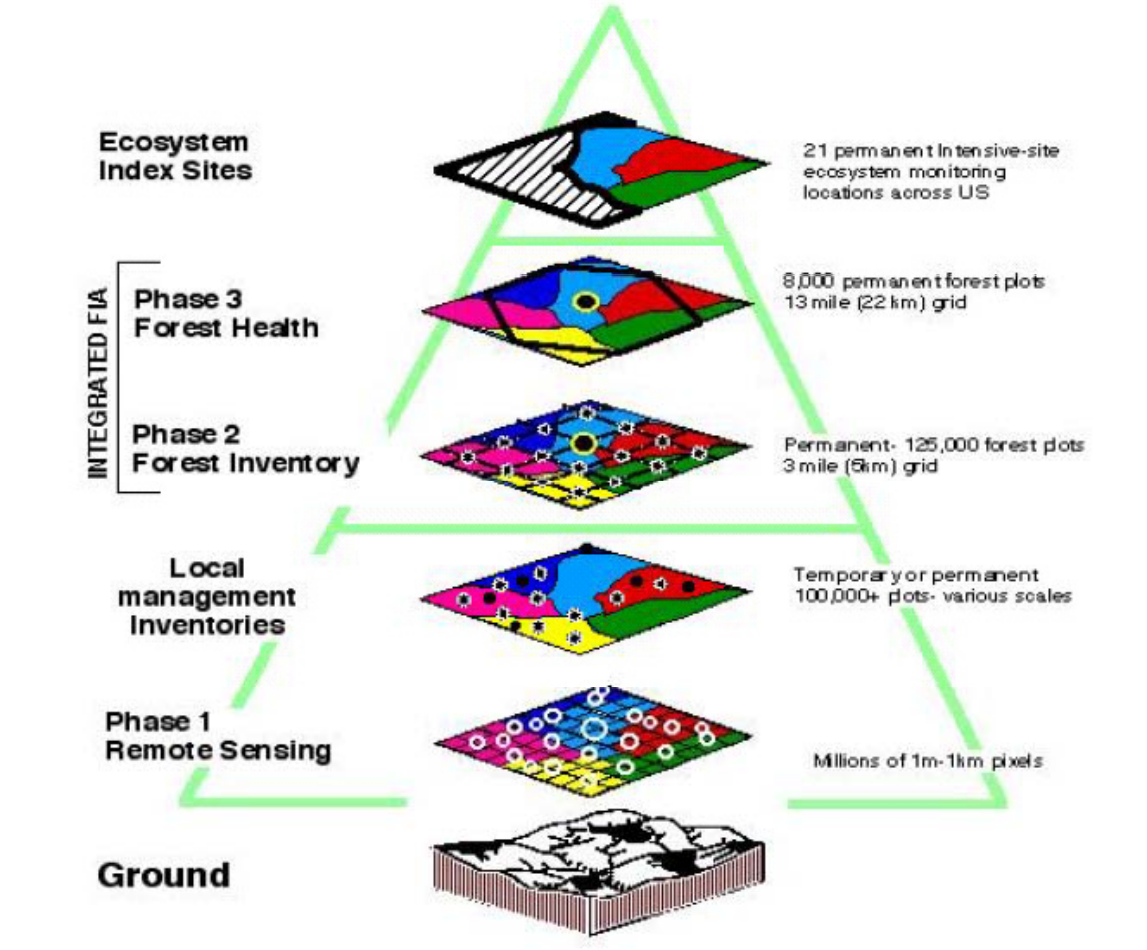


Detection Monitoring

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

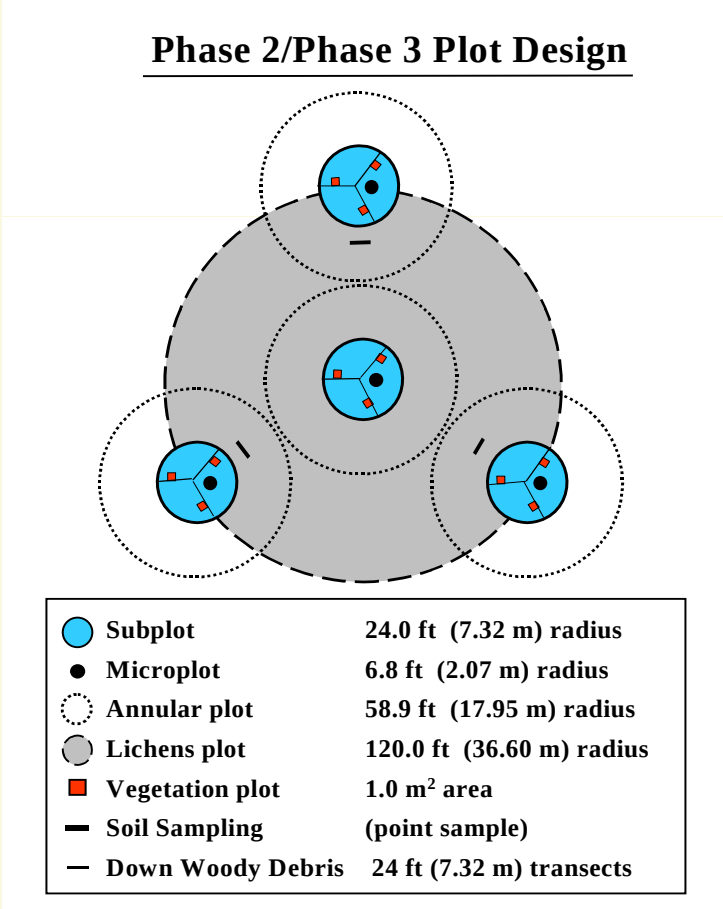


Integrated Monitoring Framework

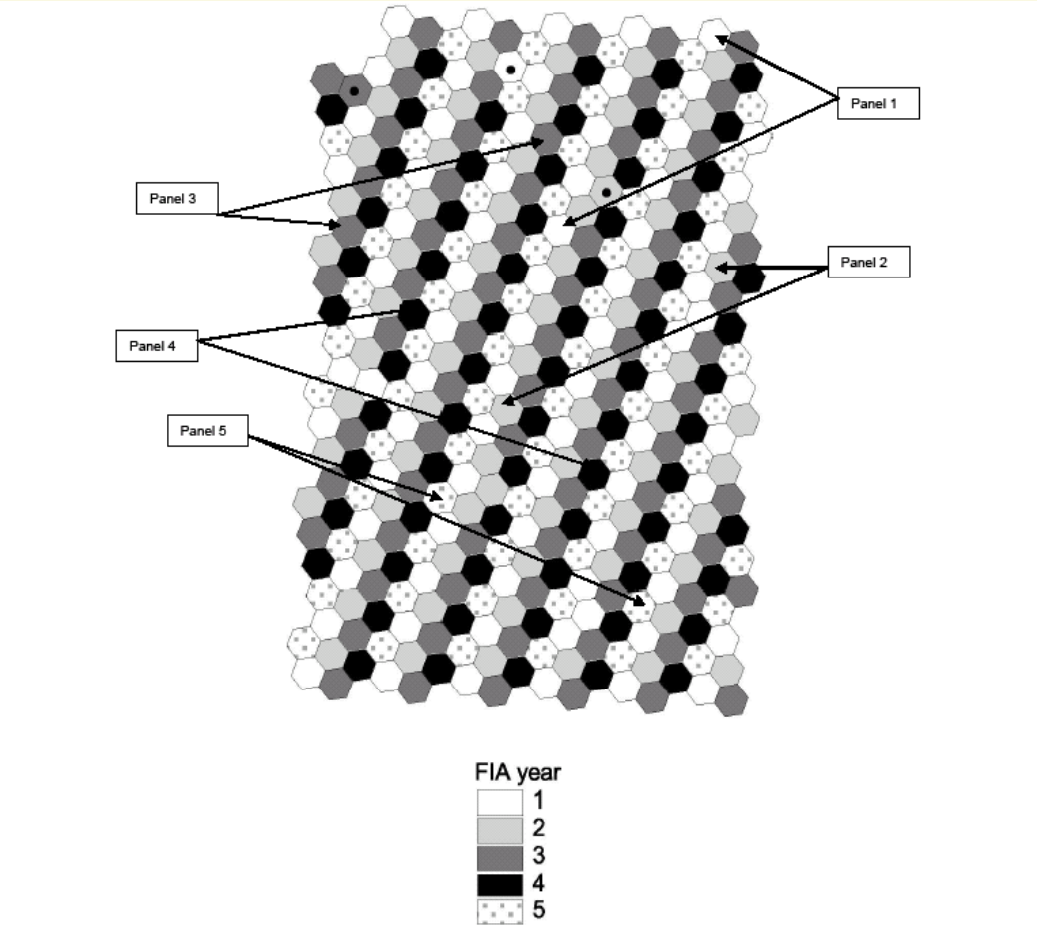


FHM/FIA Plot Integration

- 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

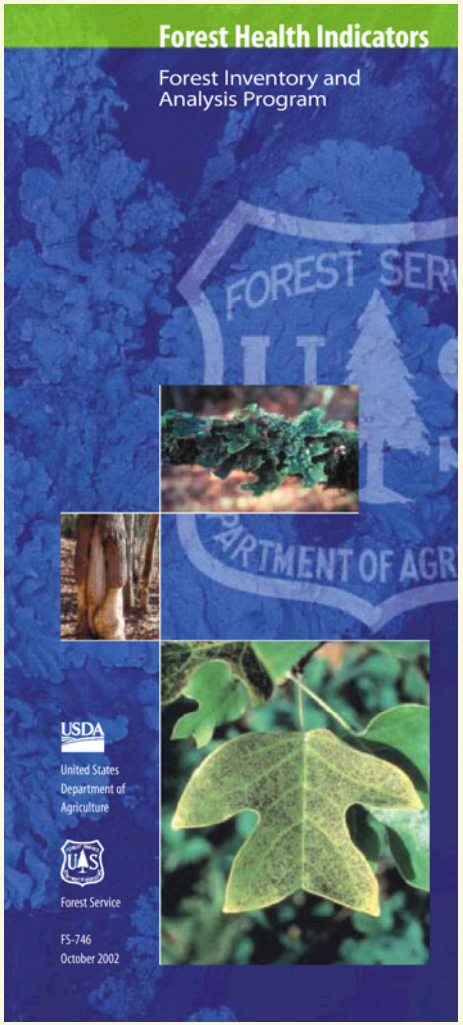


Rotating Panel Design



Forest Health Indicators

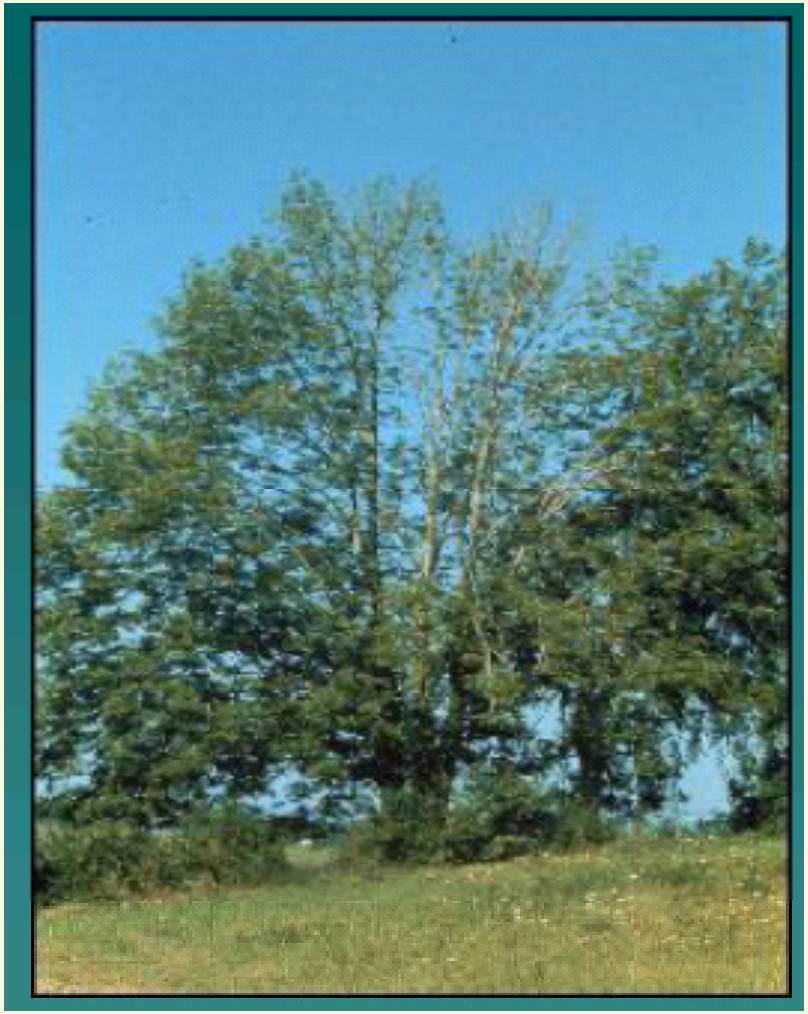
- Tree Growth
- Tree Regeneration
- Tree Crown Condition
- Tree Damage
- Tree Mortality
- Lichen Communities
- Ozone Bioindicator Plants
- Soil Morphology and Chemistry
- Vegetation Structure
- Plant Diversity



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

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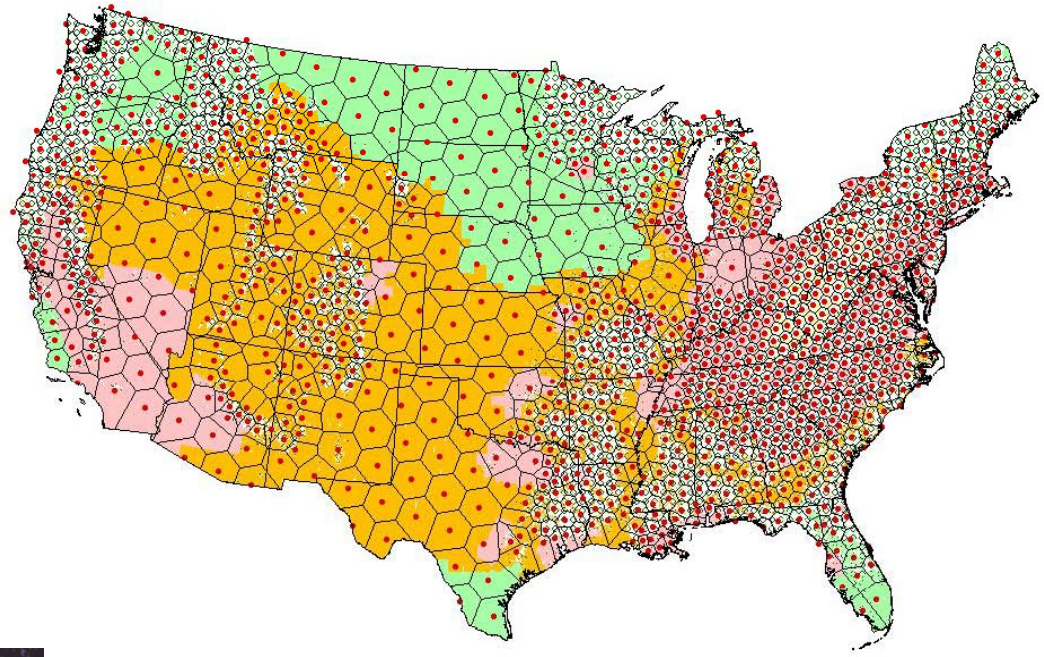
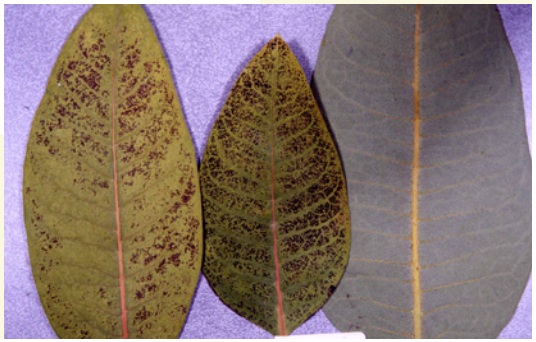
Ozone Biomonitoring





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

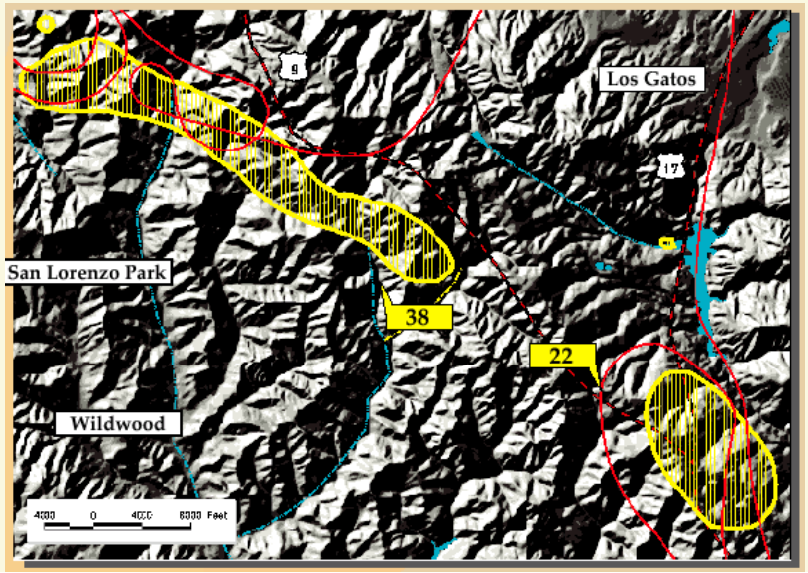
Photo by Will McWilliams

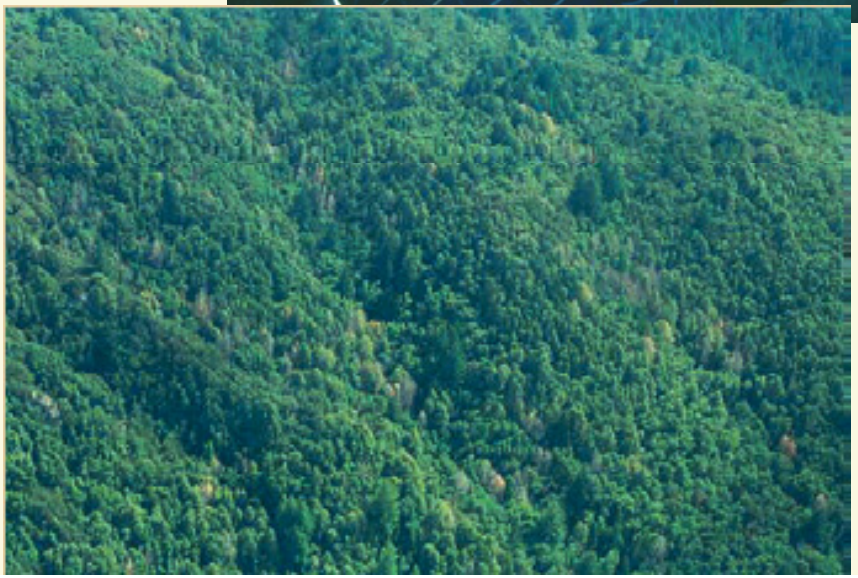
Soil Condition

- 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





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INSECT and DISEASE DETECTION SURVEY

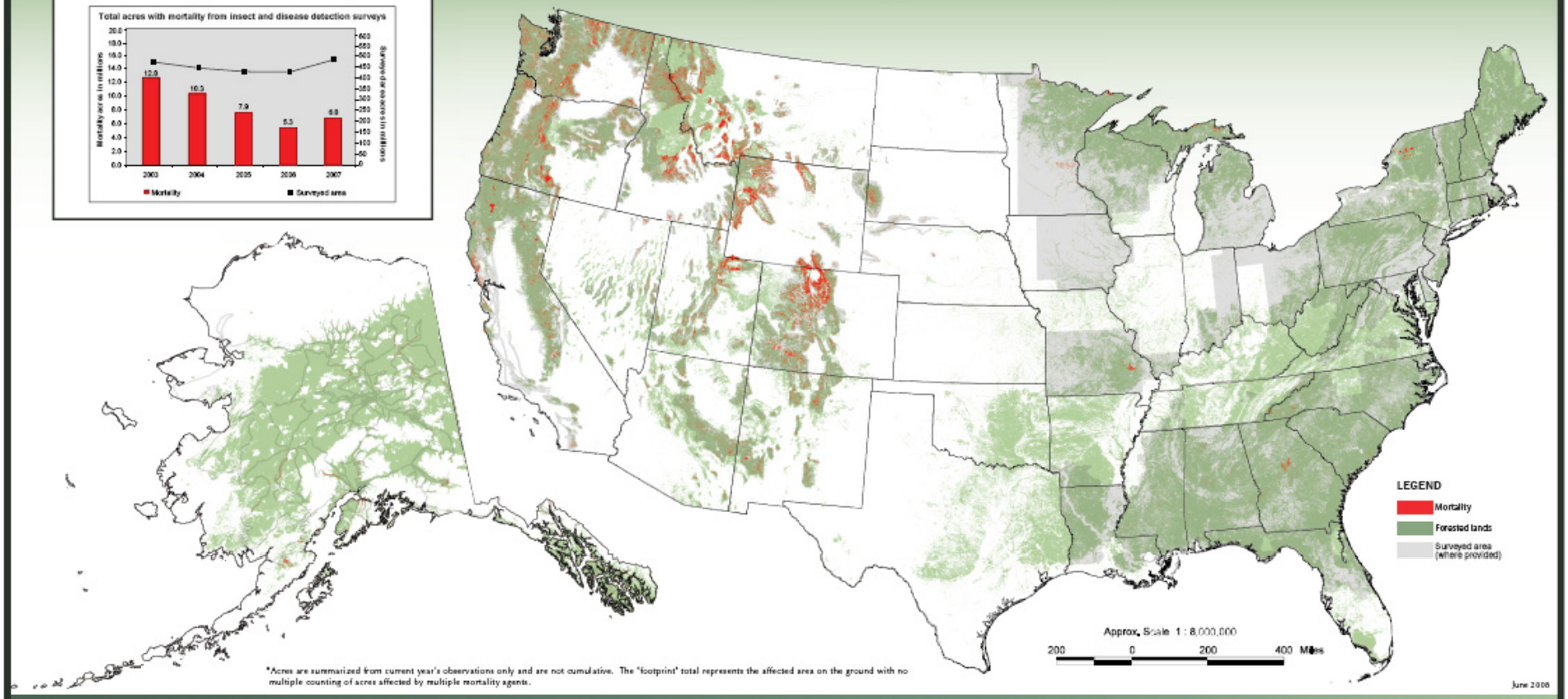
SUMMARY FOR 2007

The top five mortality agents are:

- Mountain pine beetle 35%
- Subalpine fir mortality (including western balsam bark beetle) 13%
- Fir engraver 6%
- Spruce beetle 5%
- Douglas-fir beetle 4%

2007 Acres with Mortality

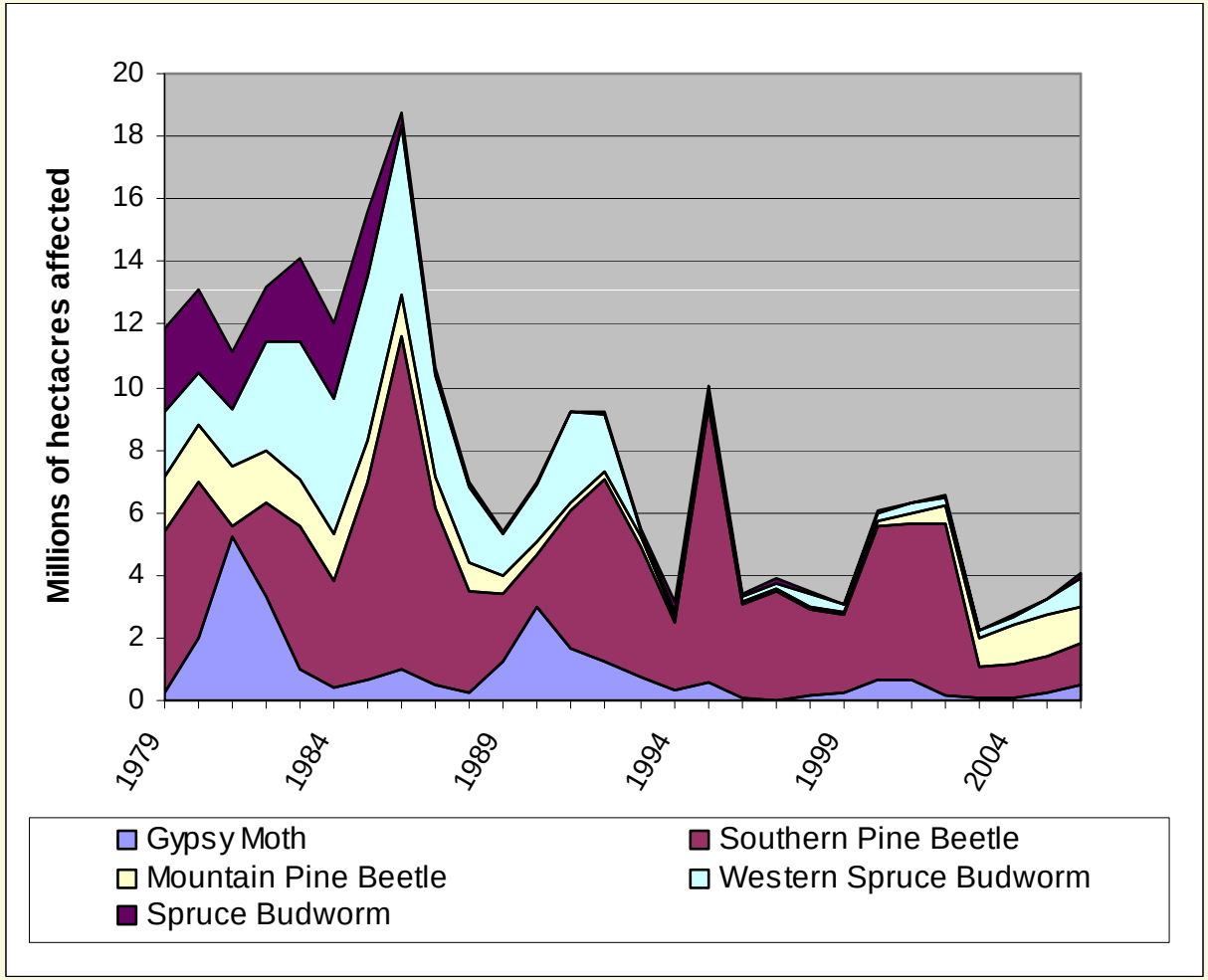
Approximate Footprint Acres with Mortality: 7 million*



*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.

June 2008

Major Forest Pest Trends US



Special Detection Surveys

Pine mortality in the Southwest

Piñon pine in New Mexico - 2003

Ponderosa pine in Arizona - 2003

Photos – FHP R3

Special aerial and ground surveys conducted in 2003 covering 15 million acres in AZ, NM, CO, UT, NV

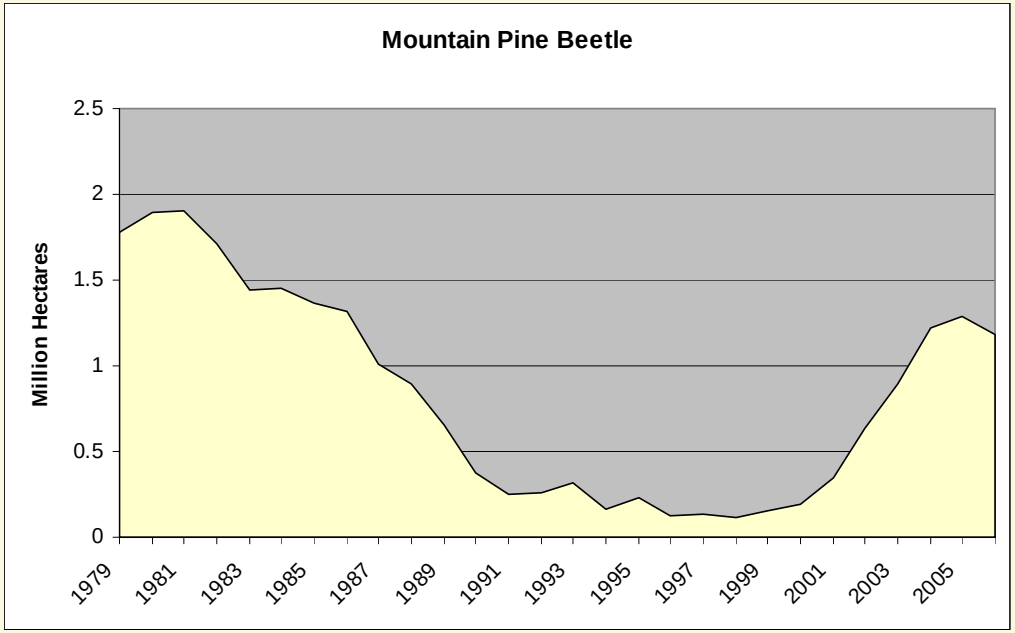
Special Detection Surveys

Sudden Oak Death

- Accelerated mortality of tanoak (*Lithocarpus densiflorus*) has been noted in California since 1995
- Extensive mortality of coast live oak (*Quercus agrifolia*) and CA black oak (*Q. kelloggii)* occurs in coastal areas of California
- Causal agent of disease identified as *Phytophthora ramorum* in 2000 by researchers at Univ. of California

Mountain Pine Beetle
(Dendroctonus ponderosae)

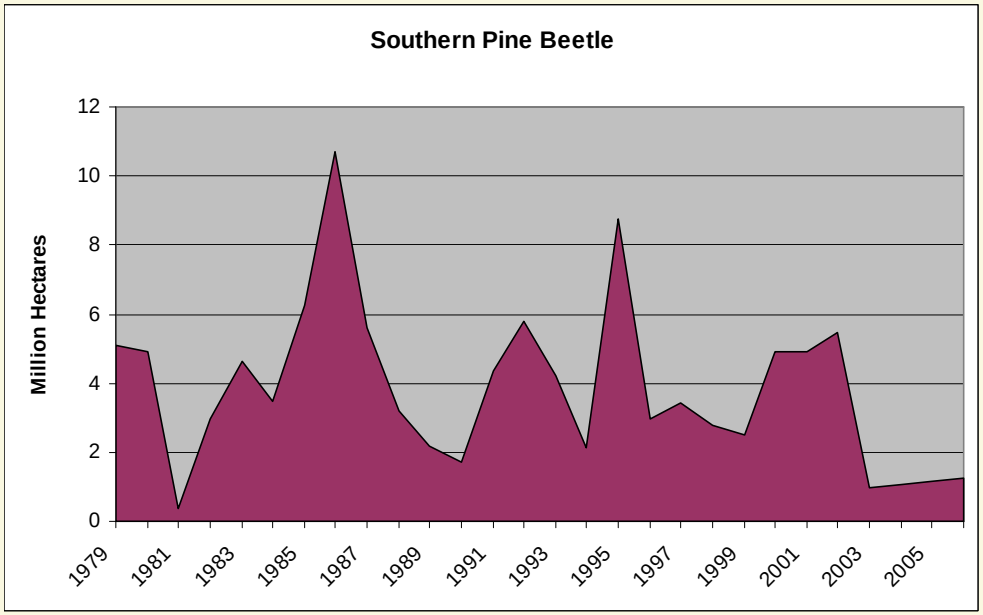
- Outbreaks increasing in area throughout the Western US
- Lodgepole pine forests hardest hit



William M. Ciesla, Forest Health Management International, www.forestryimages.org

Southern Pine Beetle (*Dendroctonus frontalis*)

- SPB populations remain at low levels since 2003.
- Treatment strategies now focus on prevention and restoration.

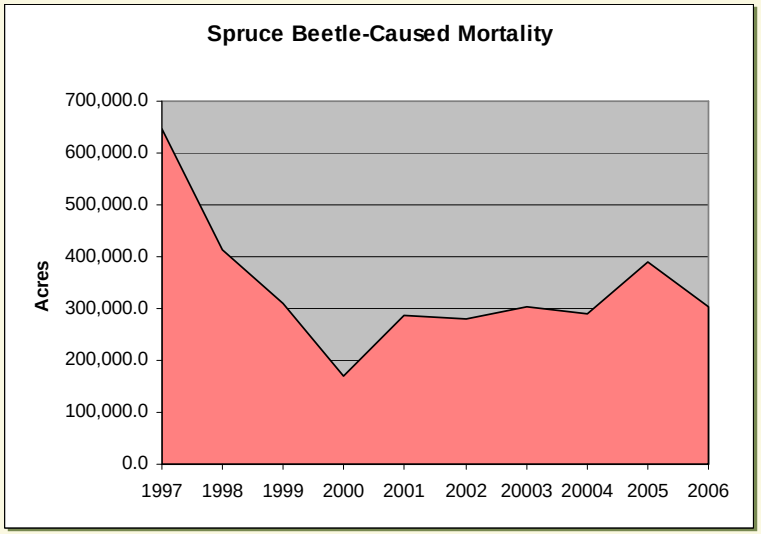


Tim Tigner, Virginia Department of Forestry, www.forestryimages.org

Spruce Beetle (*Dendroctonus rufipenis*)

- Alaska experienced large outbreak in the late 90's with mortality rates exceeding 90% in many areas
- Favorable weather conditions (mild winters and warm summers) have led to increasing populations in AZ, CO, MT, UT, and WY

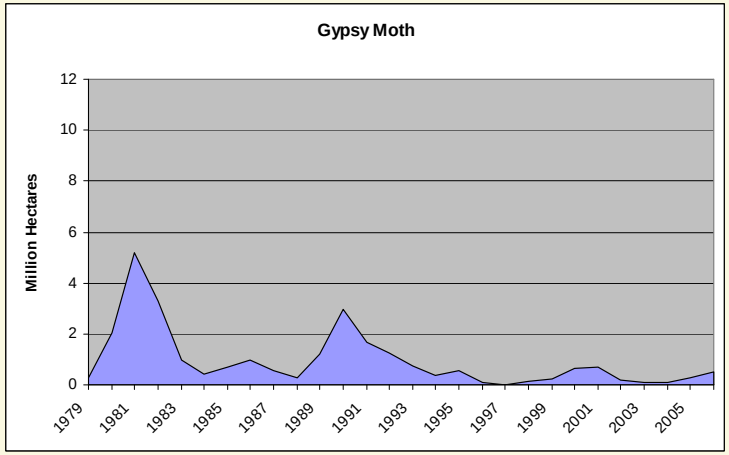
William M. Ciesla, Forest Health Management International, www.forestryimages.org

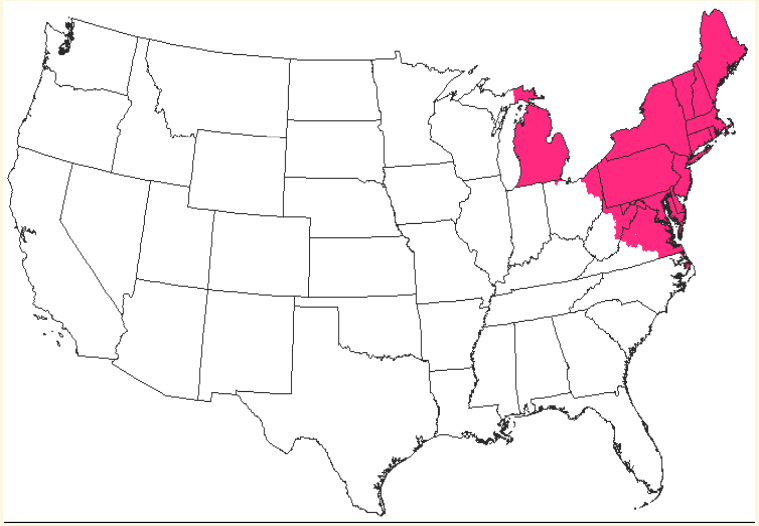


Gypsy Moth

(Lymantria dispar)

- Since introduction in 1869 has spread to 17 States and DC.
- Area infested is 25% of total susceptible area.
- Slow-The-Spread effort along the advancing edge is working.

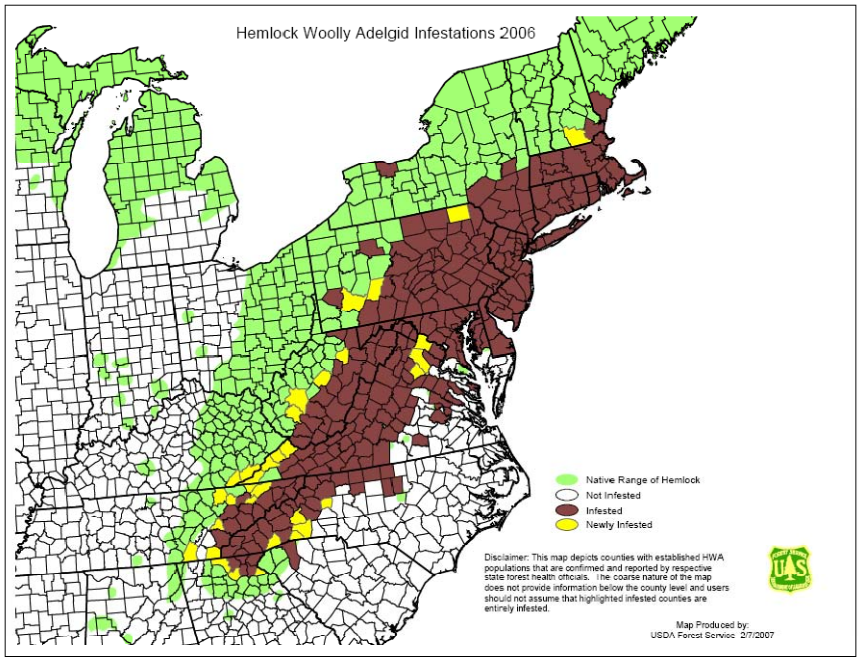




Hemlock Woolly Adelgid

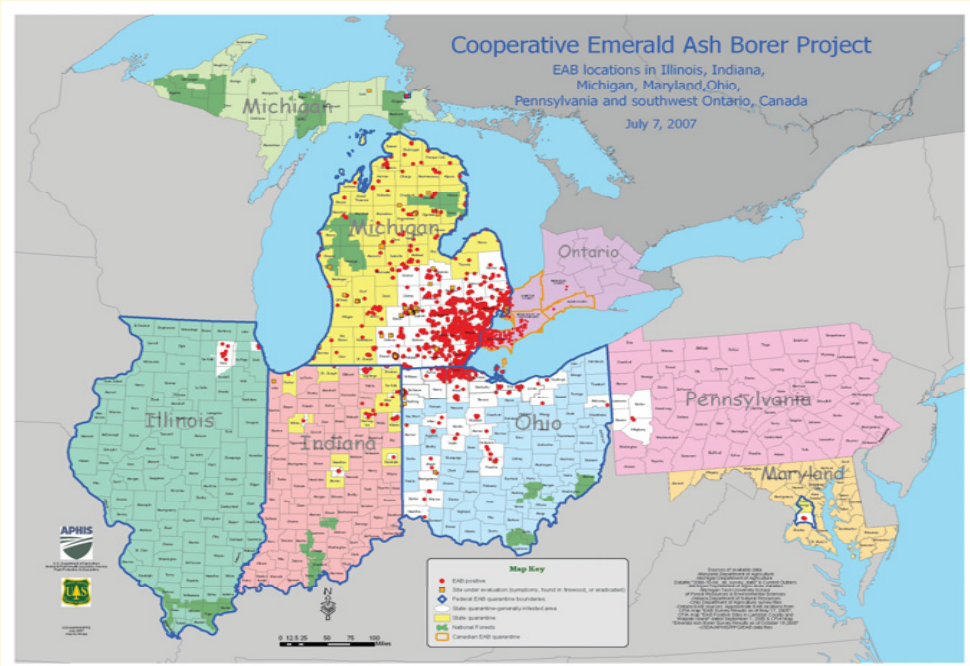
(Adelges tsugae)

- This introduced insect, believed to be a native of Asia, is a serious pest of eastern hemlock and Carolina hemlock.
- It has been in the United States since 1924.
- In the eastern United States, it is present from northeastern Georgia to southeastern Maine and west to eastern Tennessee.
- Biological control agents have been released to control populations.



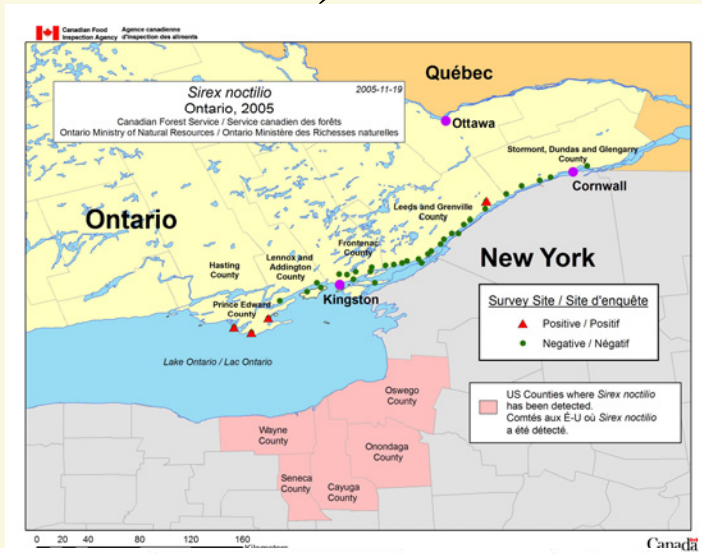
Emerald Ash Borer (*Agrilus planipennis*)

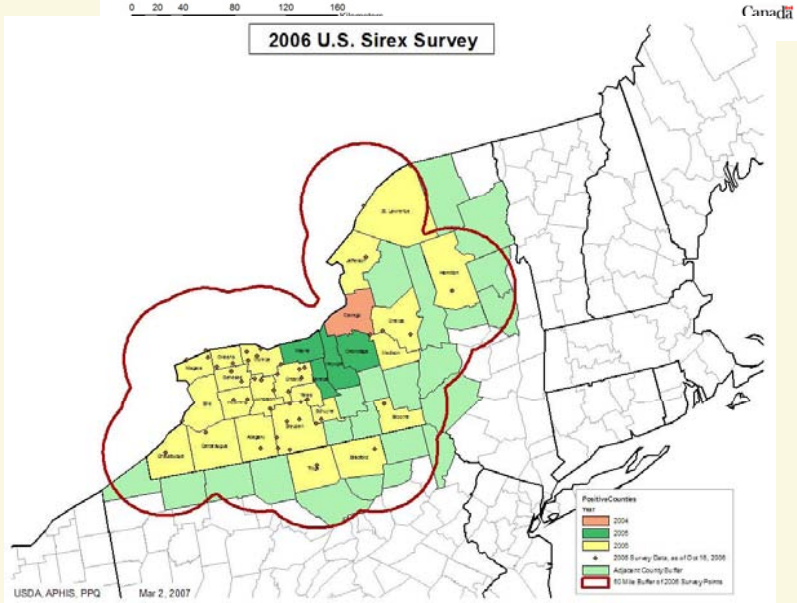
- Native range is in China, Mongolia, Russian Far East, Korea, Japan and Taiwan
- First reported killing ash (genus Fraxinus) trees in the Detroit and Windsor areas in 2002.
- Since then, infestations have been found throughout lower Michigan and neighboring areas in Ontario, northwest Ohio, and northern Indiana.
- Infestations were recently found in the Chicago area and in Pennsylvania.



Woodwasp
(Sirex noctilio)

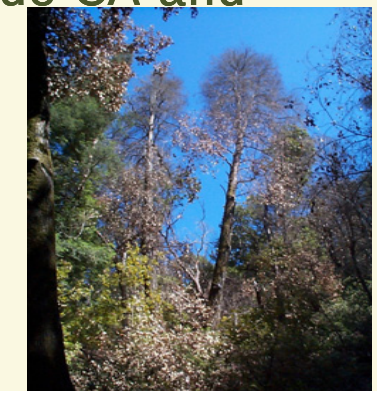
- Current known infestation is in natural forests in New York State and Ontario.
- Infestations of this insect in other countries have caused significant mortality in pine plantations.
- Monterey, lodgepole, ponderosa, jack and most species of southern pines (especially loblolly) are known to be susceptible.
- The susceptibility of other North American conifers is not known.





Sudden Oak Death (*Phytophthora ramorum*)

- Extensive mortality of tanoak (*Lithocarpus densiflorus*), coast live oak (*Quercus agrifolia*) and CA black oak (*Q. kelloggii)* occurs in coastal areas of California
- Isolated infestation in OR is being treated with goal of eradication
- National surveys of oak forests have not found infestations outside CA and OR



Distribution of Sudden Oak Death as of December 20, 2006

Map produced on 12/20/06 by UCB GIIF: http://kellylab.berkeley.edu/SODmonitoring/
For more information about Sudden Oak Death, please visit the California Oak Mortality Task Force website at http://www.suddenoakdeath.org/

California Oak Mortality Task Force GIIF

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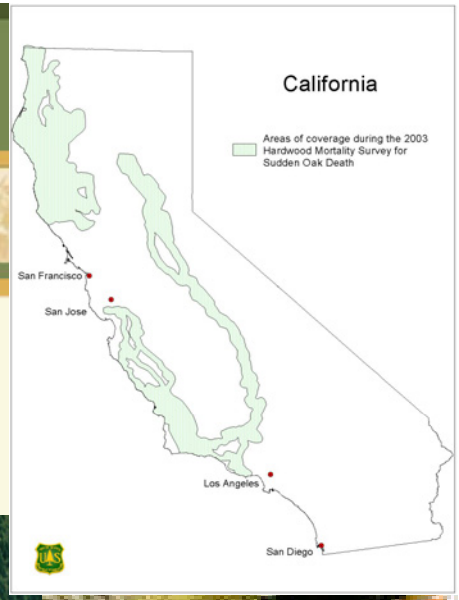
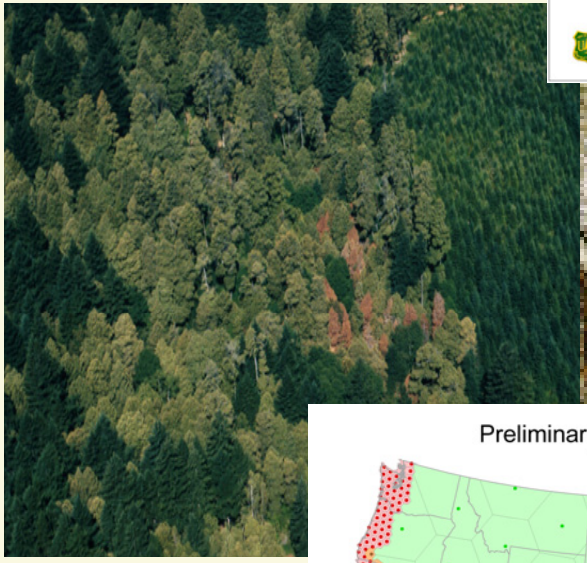
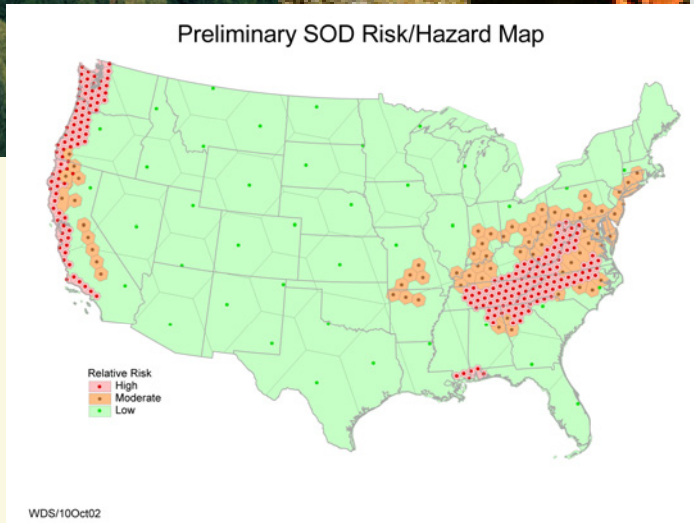
Sudden Oak Death Detection and Monitoring



- Objectives:
  - Multi-scale approach to distribution, incidence, and impact of SOD in CA
  - Detection, effectiveness of eradication in OR
  - Detection outside infested areas in CA and OR



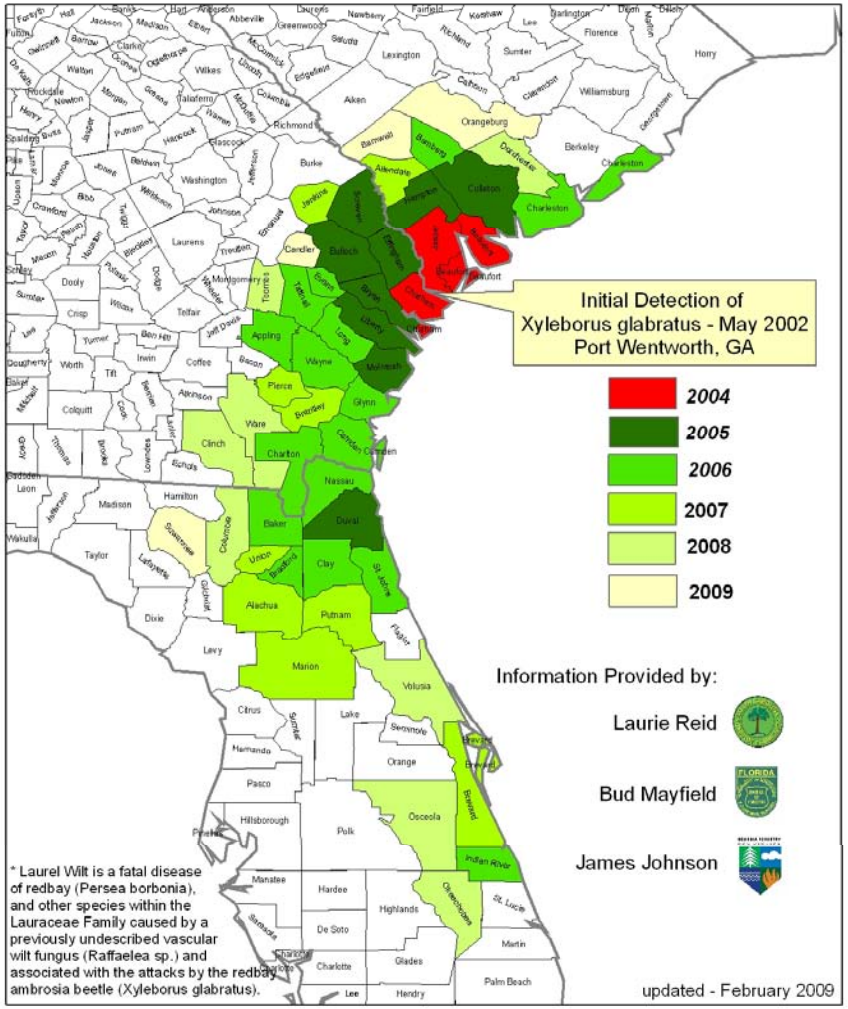


Maps and photos
Courtesy R5, ODF, SRS

Special Detection Surveys

Red Bay mortality –

- exotic ambrosia beetle *Xyleborus glabratus* vectoring *Ophiostoma sp.* in Southeastern coastal states, killing red bay, sassafras, and other Lauraceae

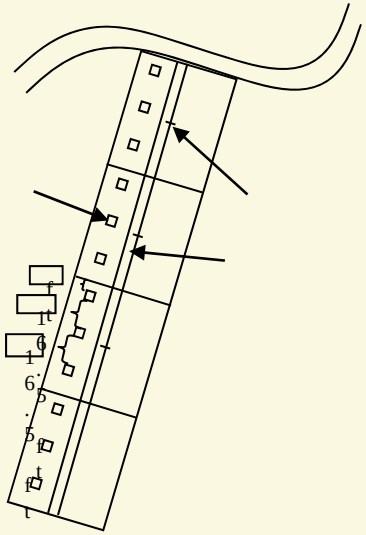


Evaluation Monitoring

- 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.

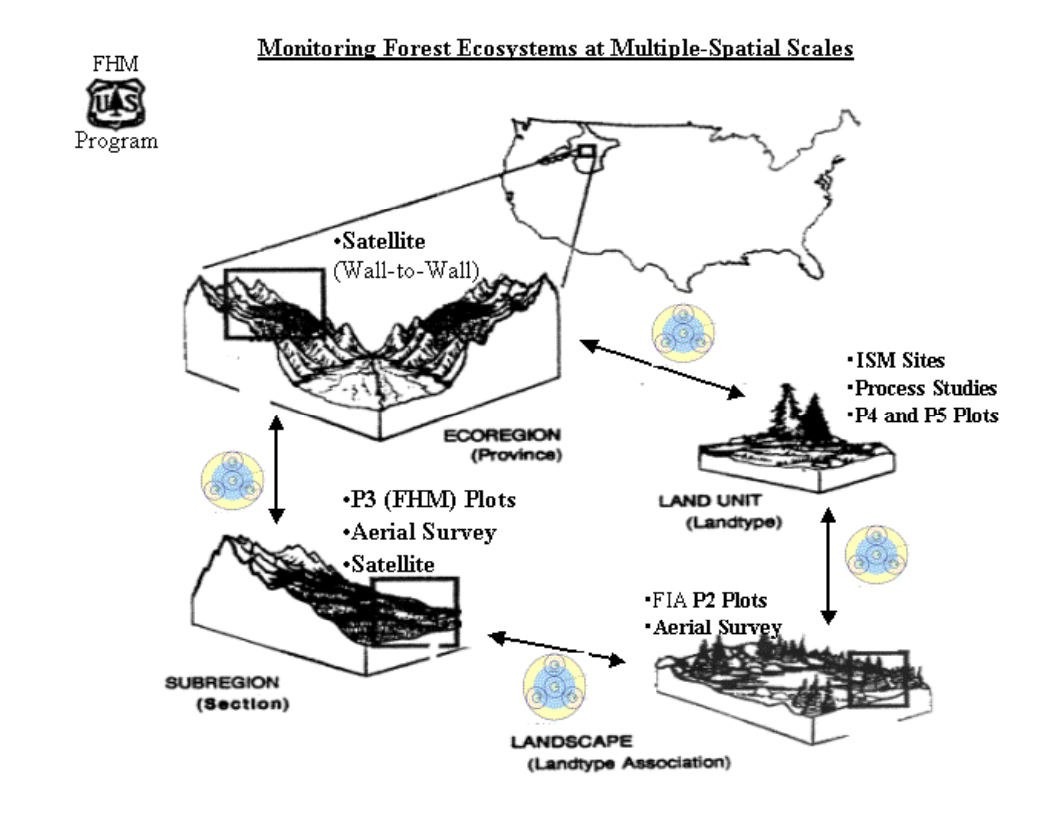
Research on Monitoring Techniques

- Urban Monitoring – design sampling strategies for urban forests and street trees
- Riparian Monitoring – design sampling strategies for riparian forests



Intensive Site Monitoring
– Linking Multiple Scales

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



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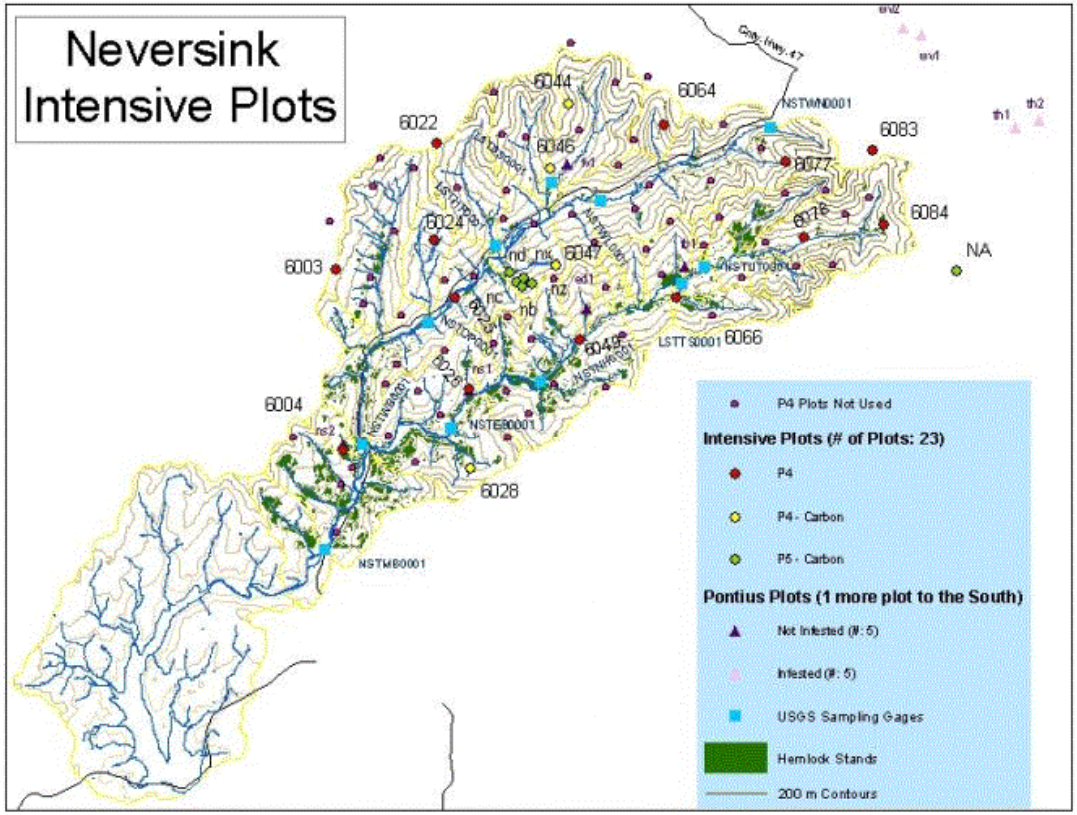
Delaware River Basin Collaborative Environmental Monitoring & Research Initiative CEMRI

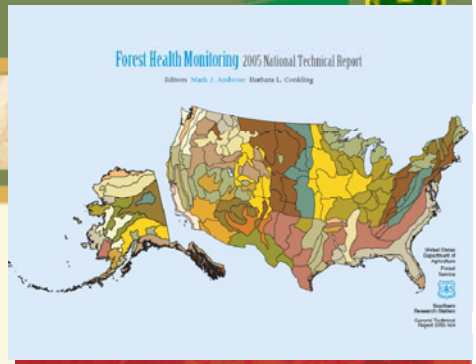
- Water quality
- Total Carbon
- Calcium Depletion
- Invasive Species

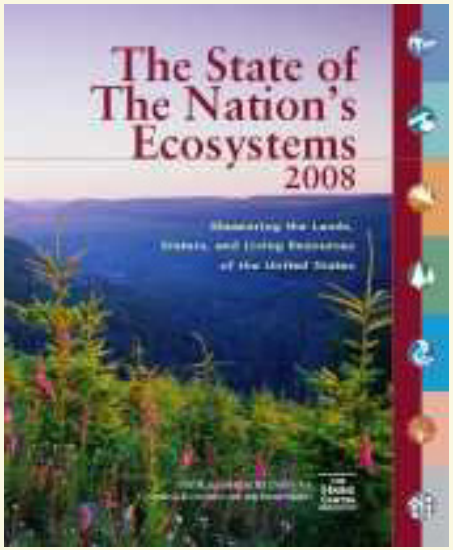


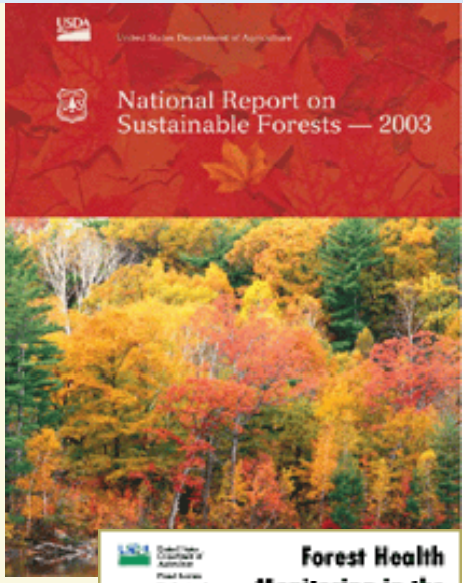
Reporting Highlights

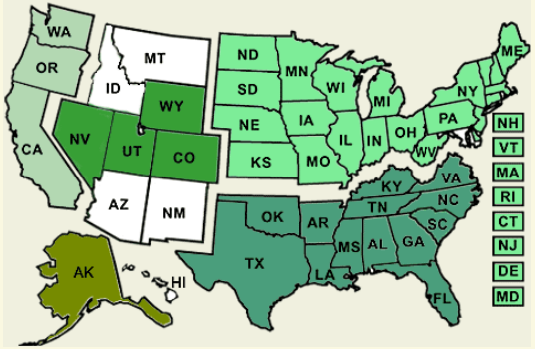
- National Reports
  - FHM National Technical Reports
  - 2003 Sustainability Report – Montreal Process Criteria and Indicators for Sustainable Forests
  - Heinz Center – The State of the Nation's Ecosystems
  - EPA – US/Canada Air Quality Agreement Progress Reports
- Regional Reports
  - Northeast Forest Stressor Report
  - Aspen Forest Cover Change in Rockies
- State Reports
  - Utah Baseline Report
  - Forest Health Highlights

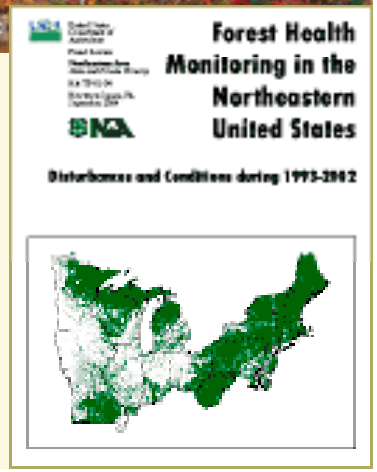
http://www.fs.fed.us/forestheatlh/fhm









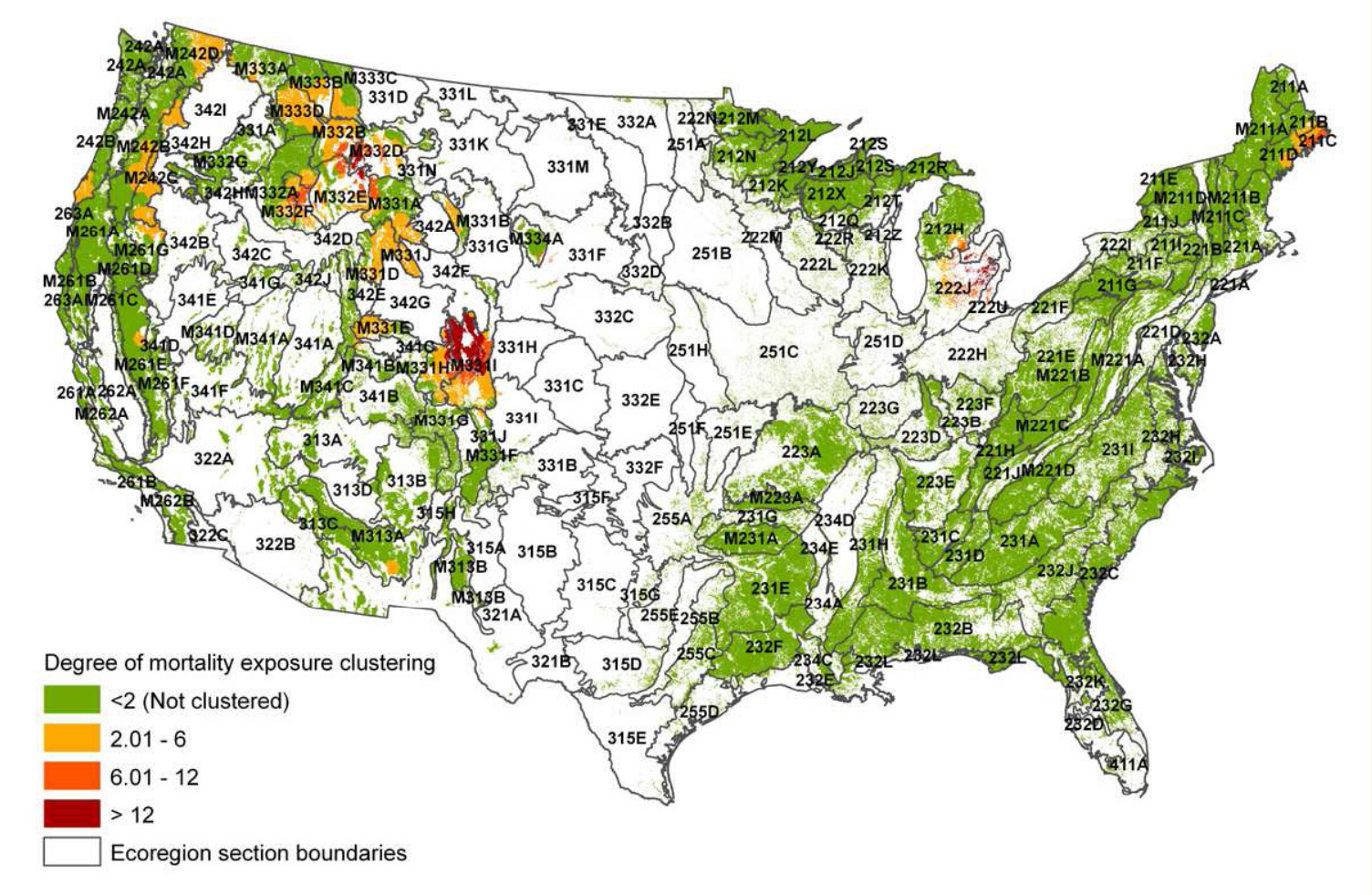


Analysis by Ecoregion Sections

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

R.G. Bailey, 1995

Hot Spots of Tree Mortality from Aerial Surveys 2006



Mortality from Plots

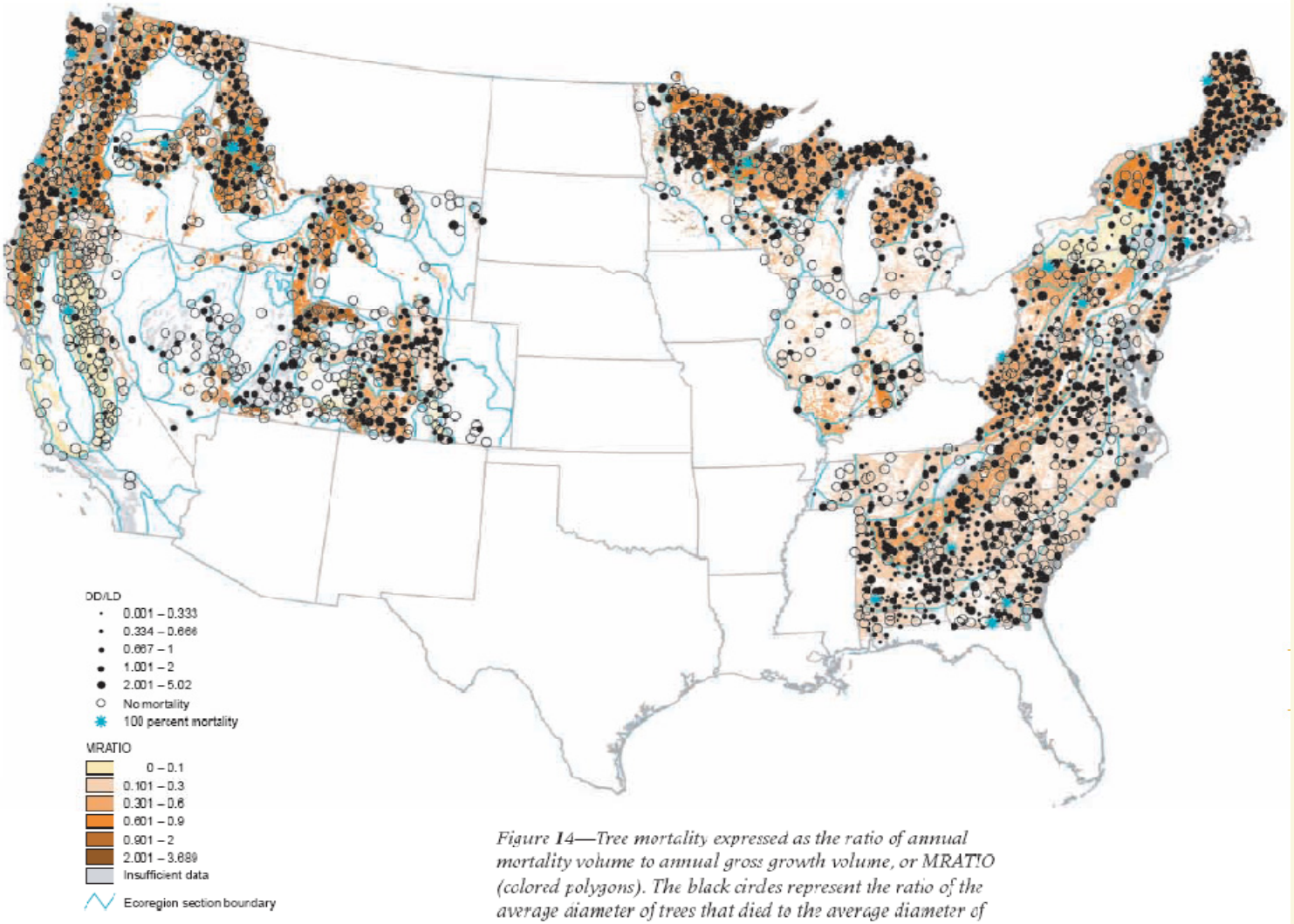
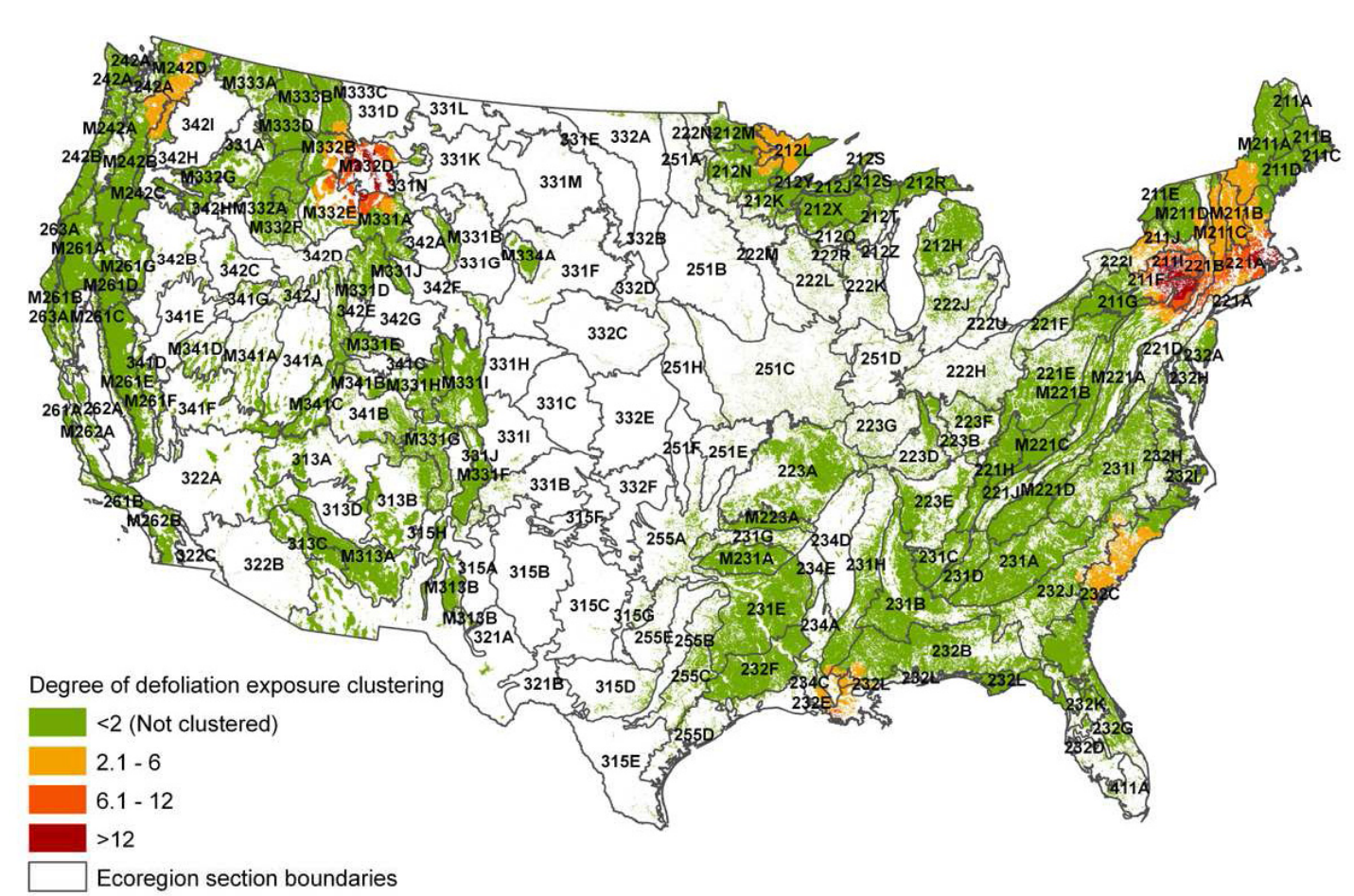


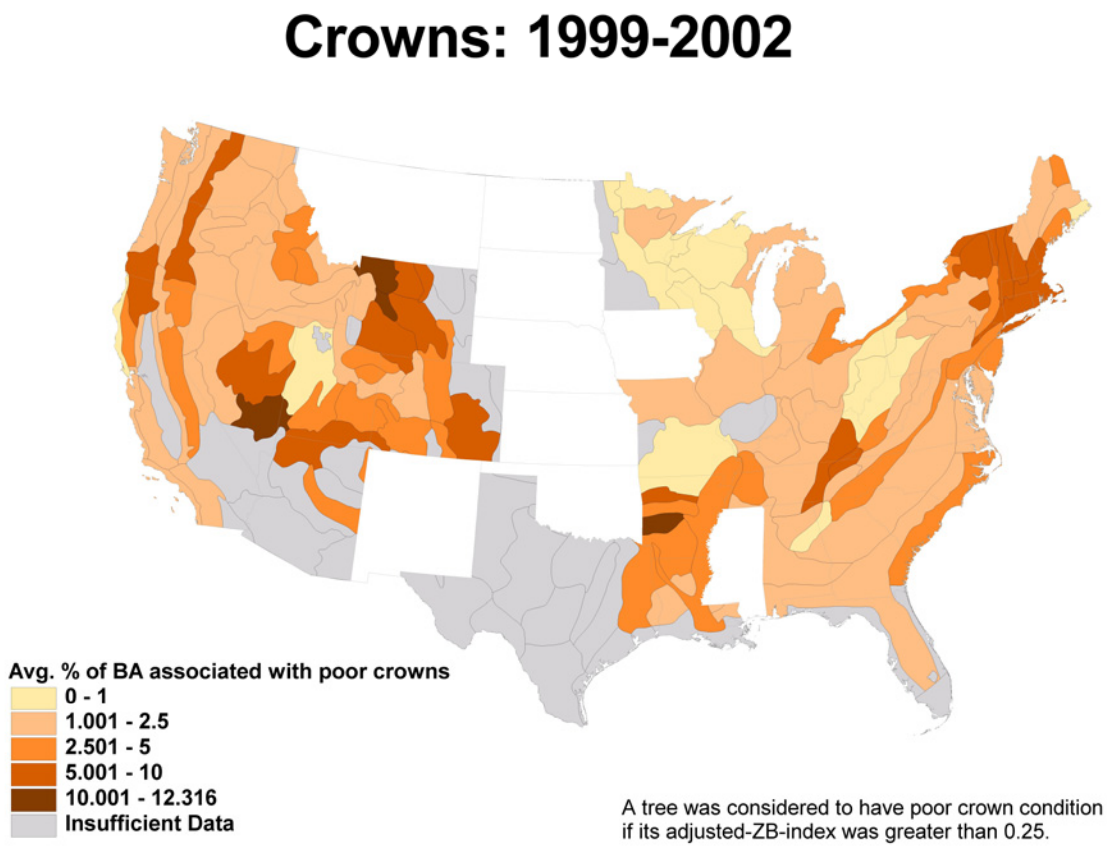
Figure 14—Tree mortality expressed as the ratio of annual mortality volume to annual gross growth volume, or MRATIO (colored polygons). The black circles represent the ratio of the average diameter of trees that died to the average diameter of surviving trees as of the most recent measurement of each plot, or DDLD. Plot locations are approximate.

Hot Spots of Tree Defoliation from Aerial Surveys 2006



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



Wet Sulfur Deposition

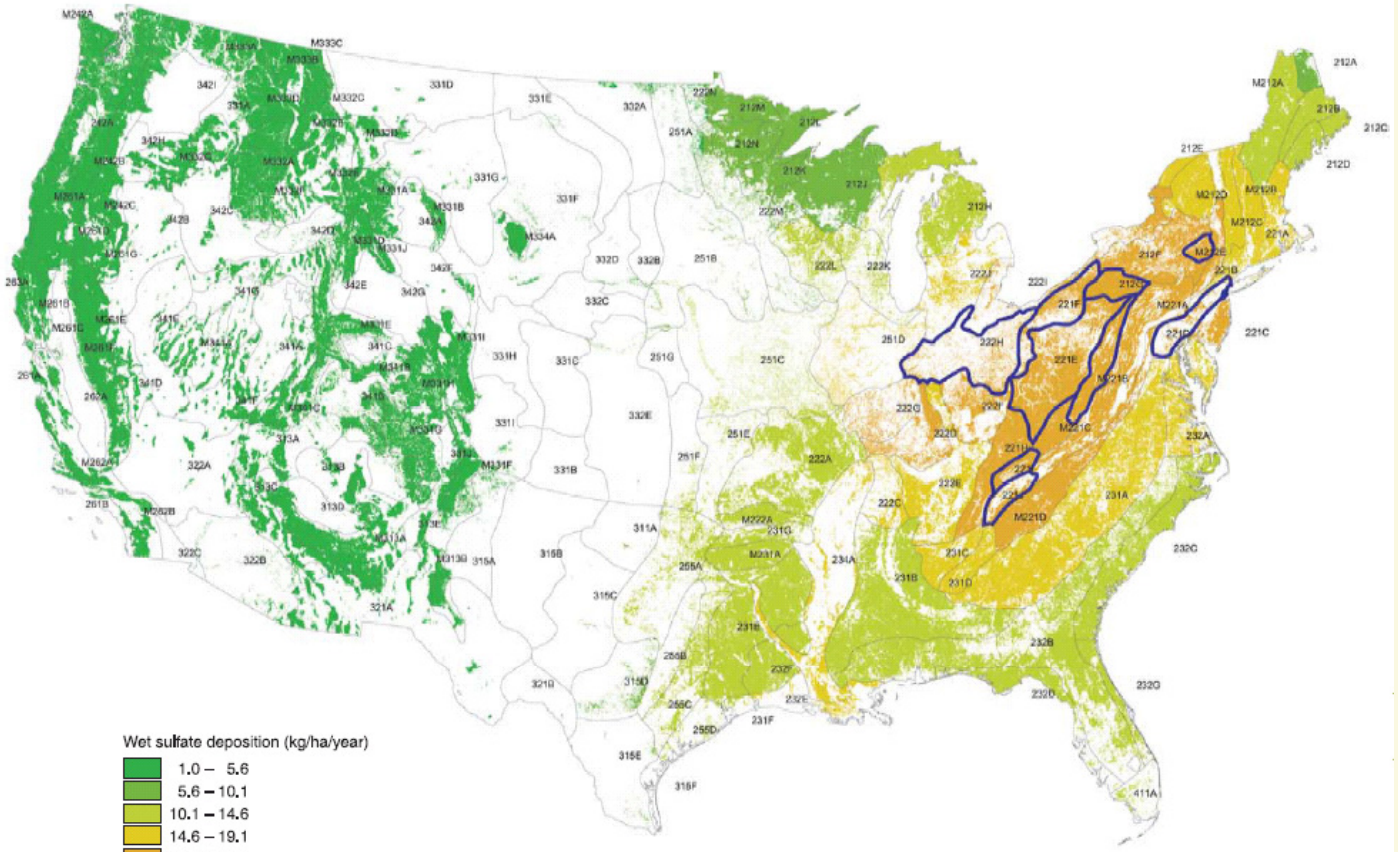


Figure 18—Average annual wet sulfate deposition (1994 to 2001) by ecoregion section. The areas outlined in blue highlight ecoregion sections whose deposition rates exceed the 95th percentile.

Wet Nitrogen Deposition

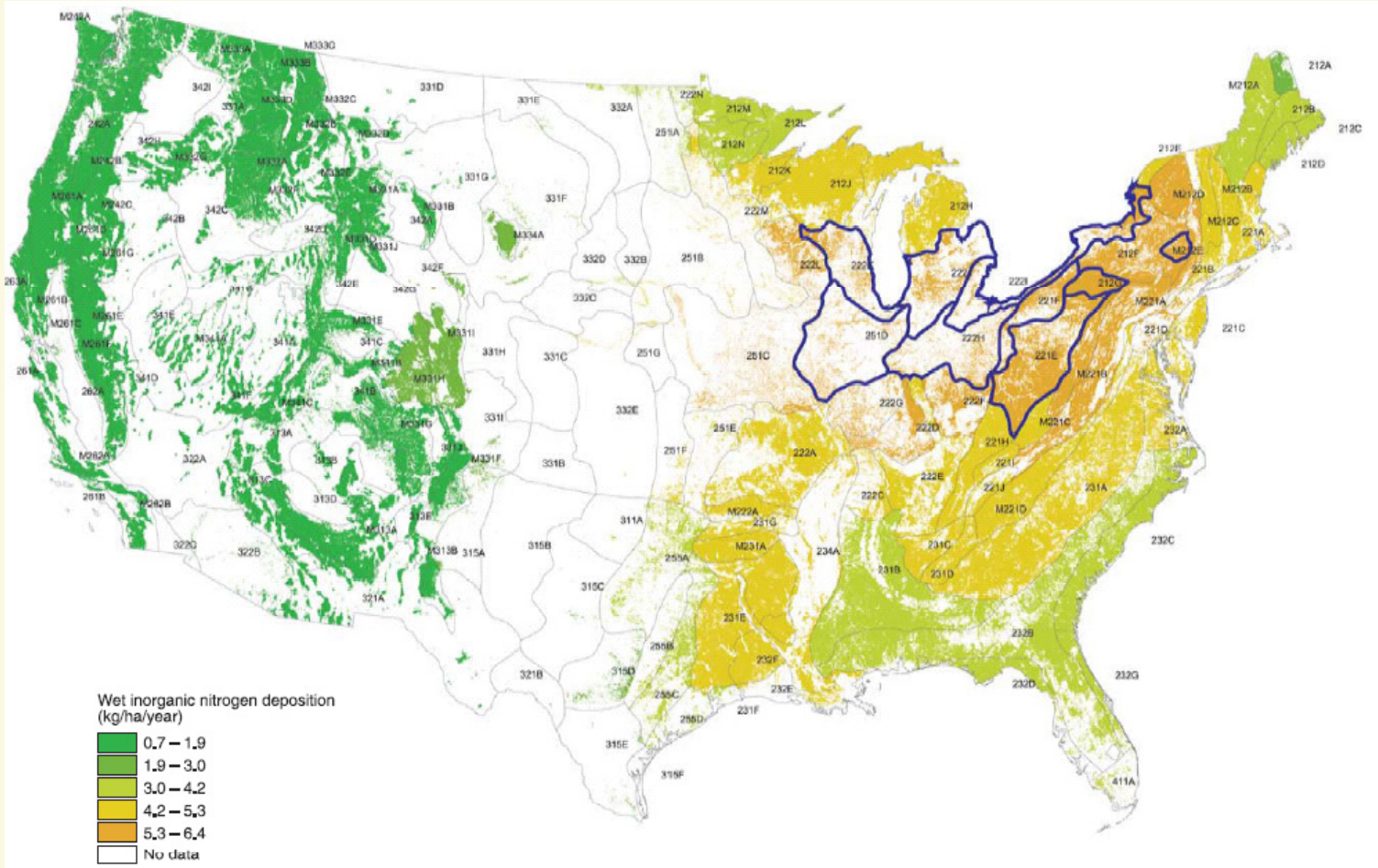
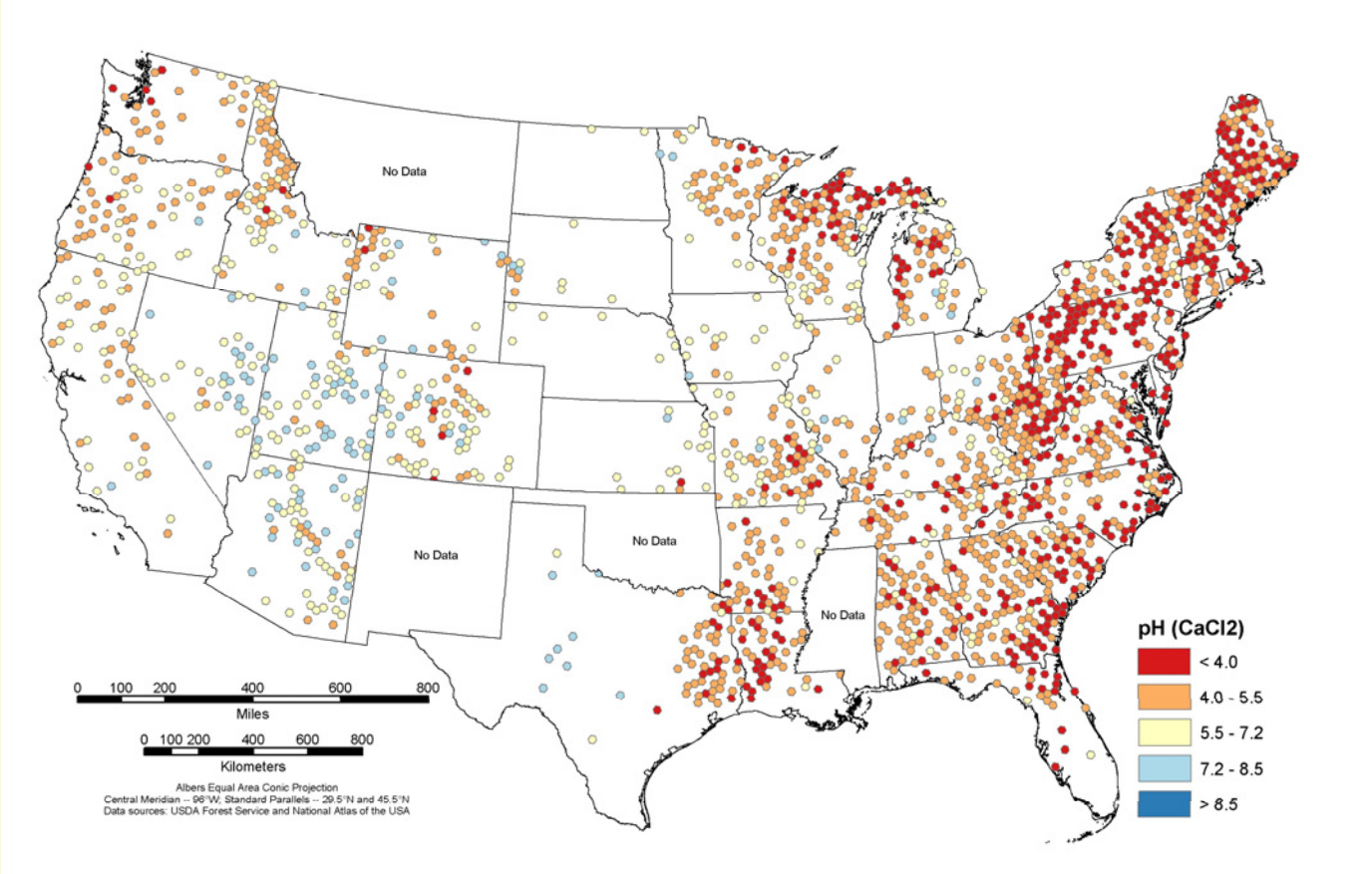


Figure 19—Average annual wet nitrogen deposition (1994 to 2001) by ecoregion section. The areas outlined in blue highlight ecoregion sections whose deposition rates exceed the 95th percentile.

Soil pH

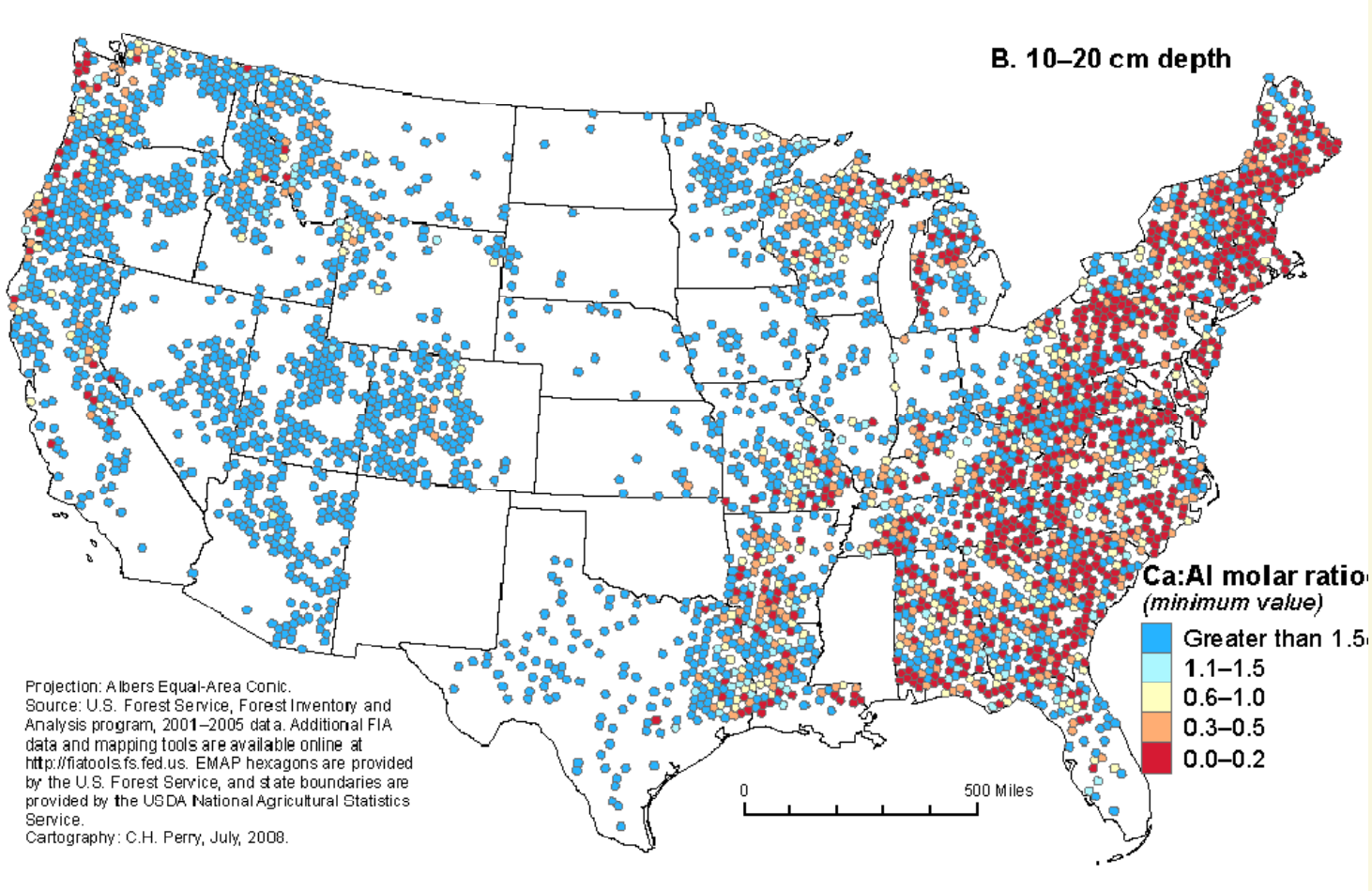
- Mean soil pH value is 4.8
- Acidic tendency of soil pH is most clear east of the Mississippi River



Effective Cation Exchange Capacity

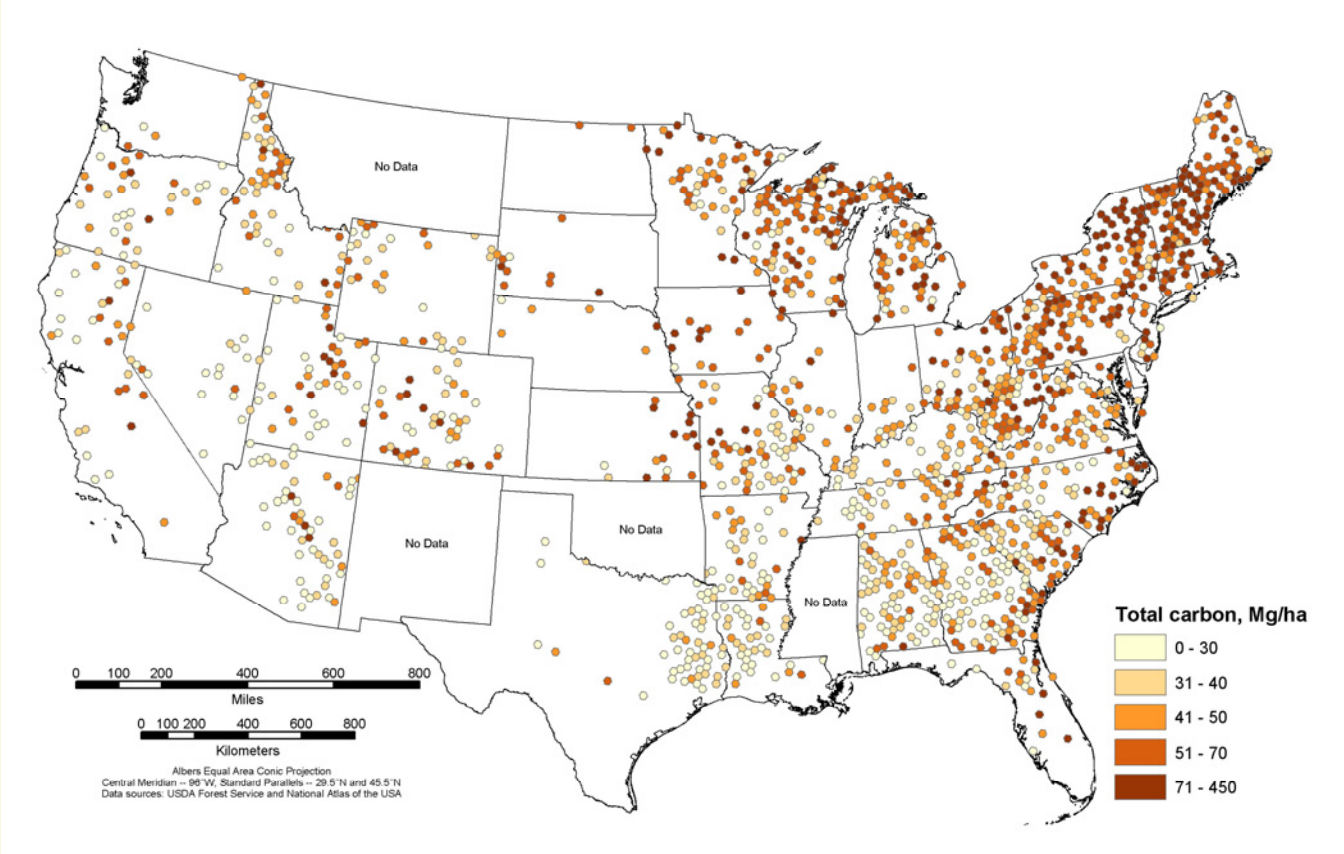
- Southeastern United States tended to have the greater proportion of forest soils with low ECEC levels.

Ca:Al Molar Ratio

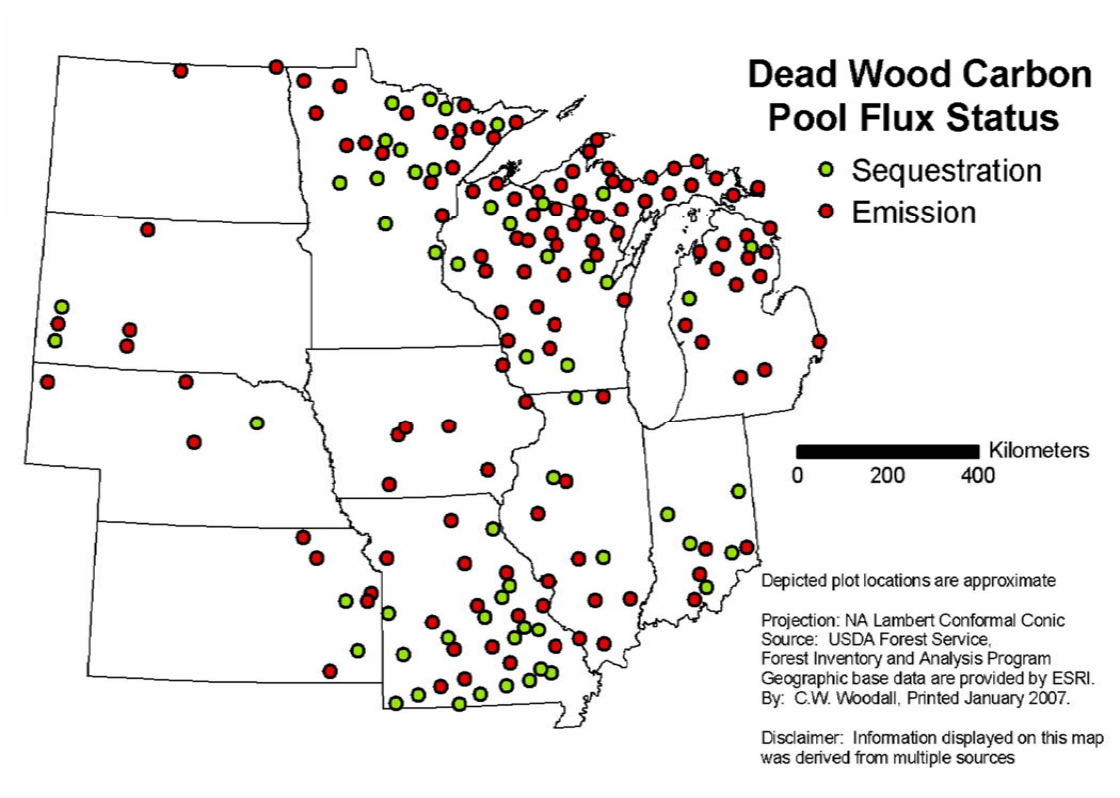


Total Soil Carbon

- 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

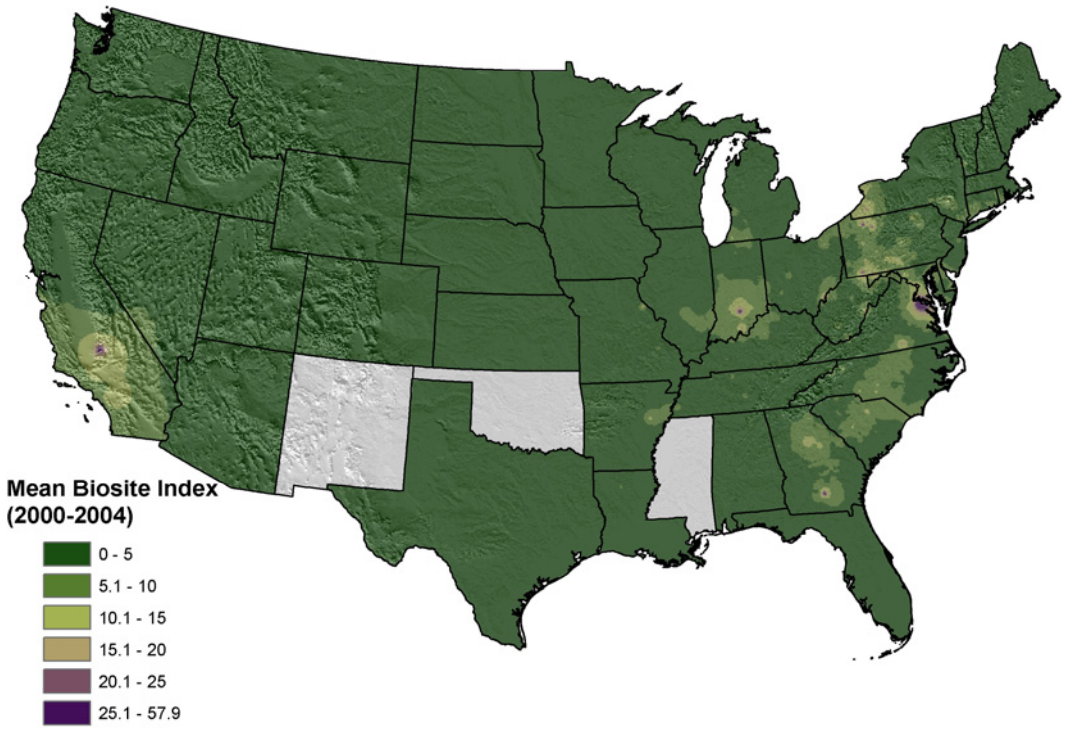


Ozone Exposure

- **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



Risk Mapping

NATIONAL INSECT and DISEASE RISK MAP

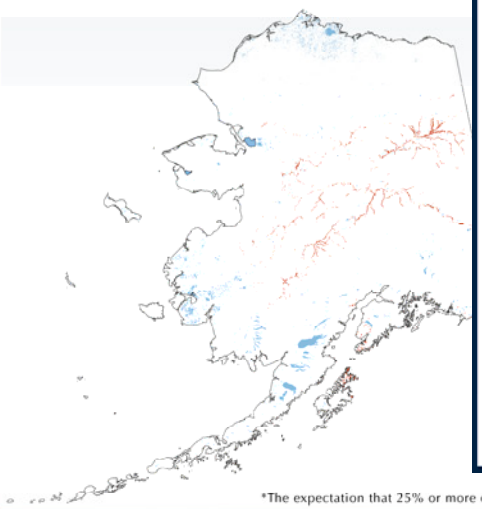
TOP AGENTS BY RANK

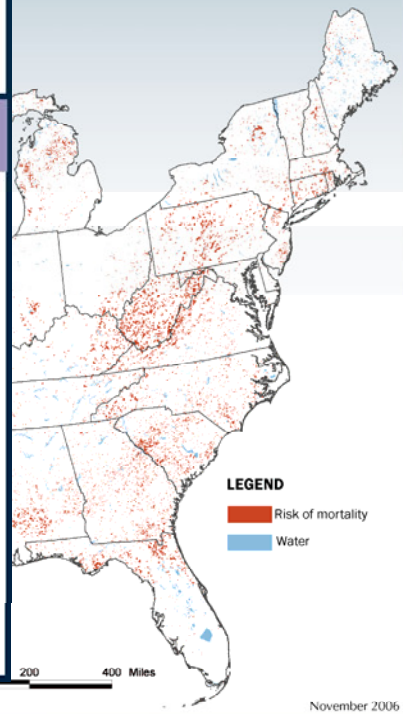
1. Mountain Pine Beetle
2. Red Oak Decline
3. Southern Pine Beetle
4. Root Diseases - All
5. Gypsy Moth
6. Pine Engraver Beetle
7. Fir Engraver Beetle
8. Douglas-Fir Beetle
9. Spruce Beetle
10. Hardwood Decline
11. Western Pine Beetle

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

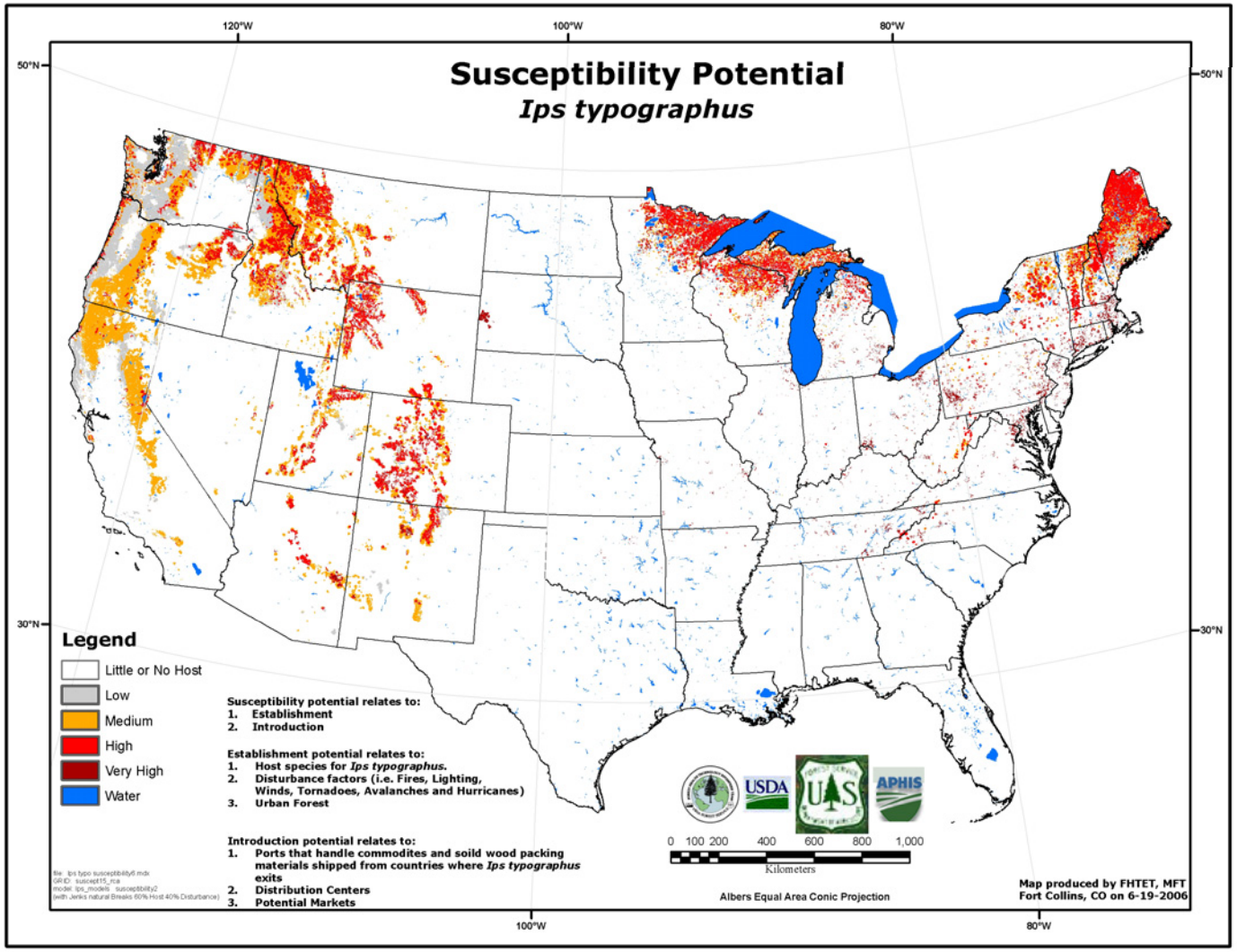




*The expectation that 25% or more of the standing live volume of trees greater than 1" in diameter will die over the next 15 years.

November 2006

Risk of Invasive Forest Pests



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
  - Design new approaches for detection of invasives