The Changing U.S. Forests: Human and Climate Impacts

James M. Vose

USDA Forest Service

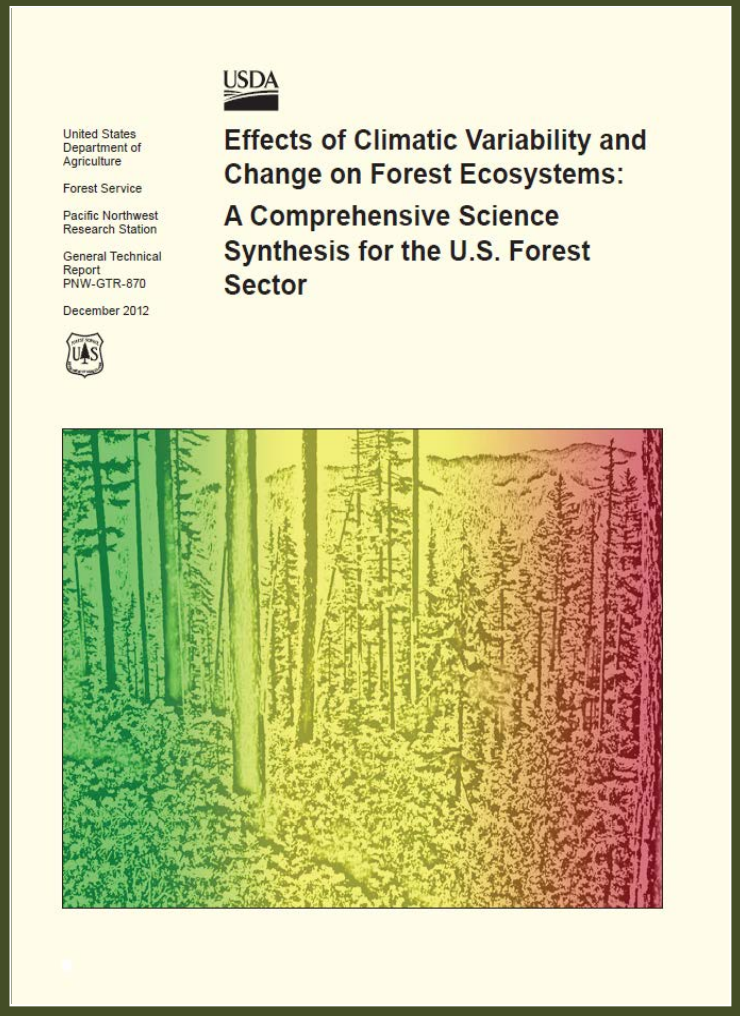
Southern Research Station

Center for Integrated Forest Science

Forest develop in response to the **physical environment, biological dynamics,** and **human decisions** regarding use….

Current science on climate and forests

- **2013 National Climate Assessment technical input document**
- **45 expert authors from federal agencies, universities, NGO's**
- **More than 1000 peer-reviewed citations**
- **Jim Vose, Dave Peterson, Toral Patel-Weynand**



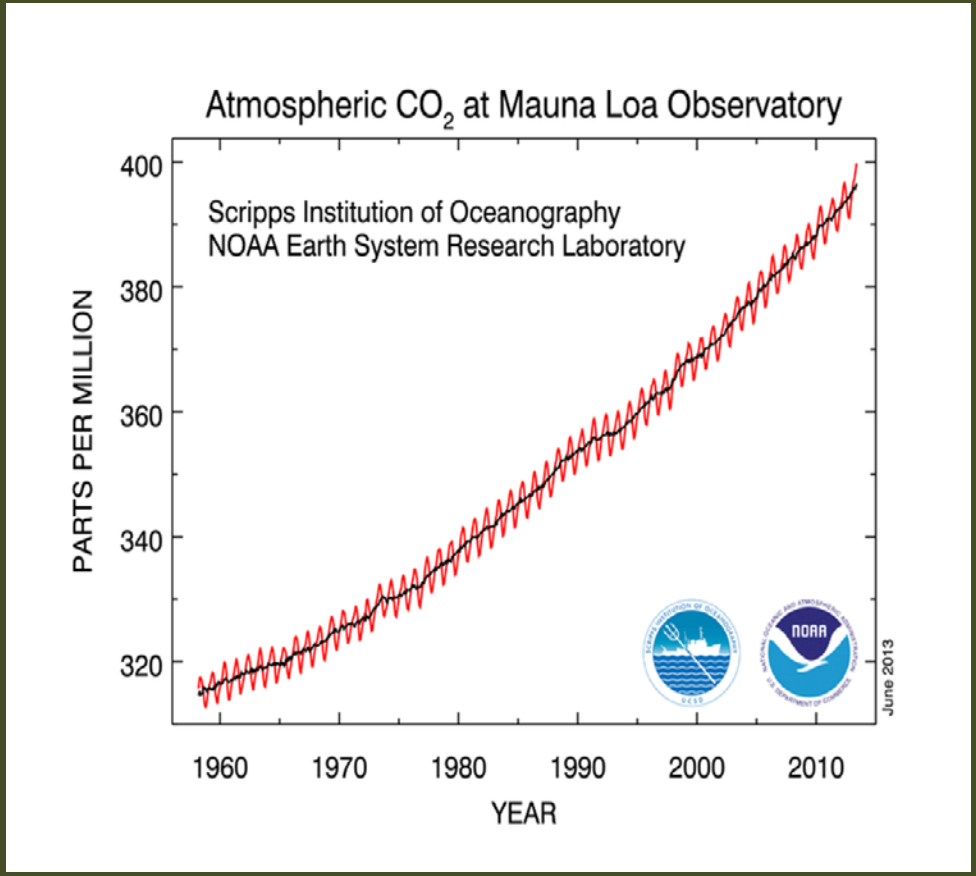
The National Climate Assessment report answers two key questions:

- How will climate change affect forest ecosystems in the United States?
- Which adaptation and mitigation strategies can be used to respond to climate change?

Higher CO_2 and other greenhouse gases

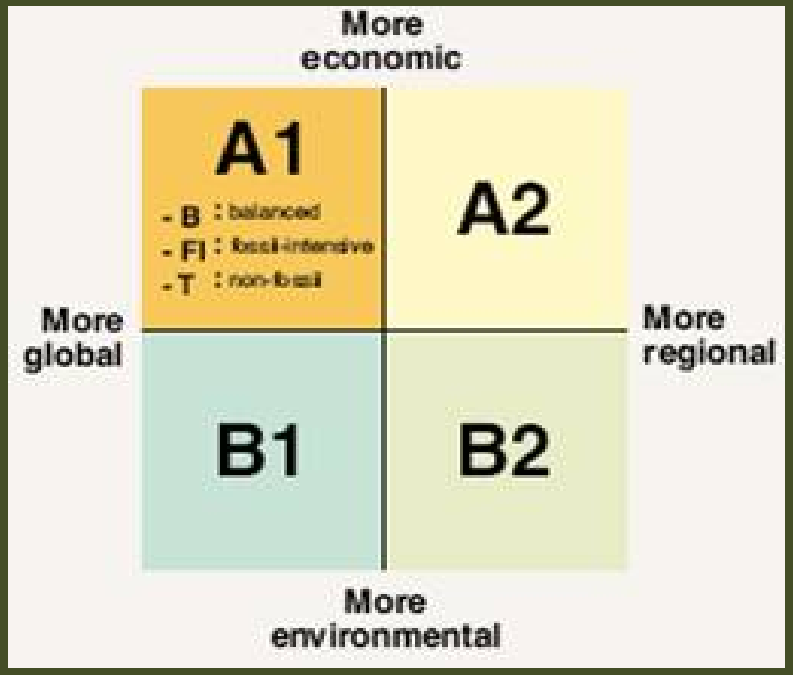
Changes in the Earth's climate system…

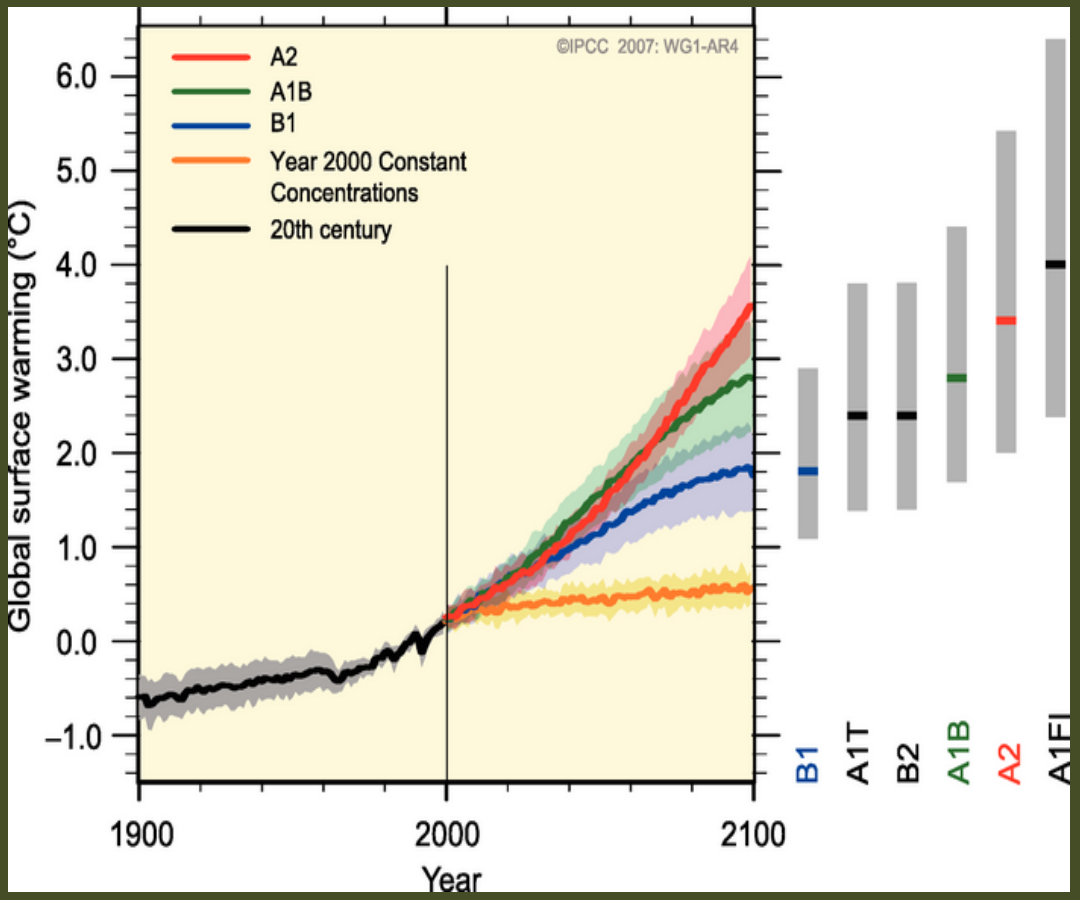
- 1.4º F increase over past 100 years
- Loss of Arctic ice
- Sea level rise (8" since 1870)
- Heat waves and extreme temperatures



What's going to happen in the future?

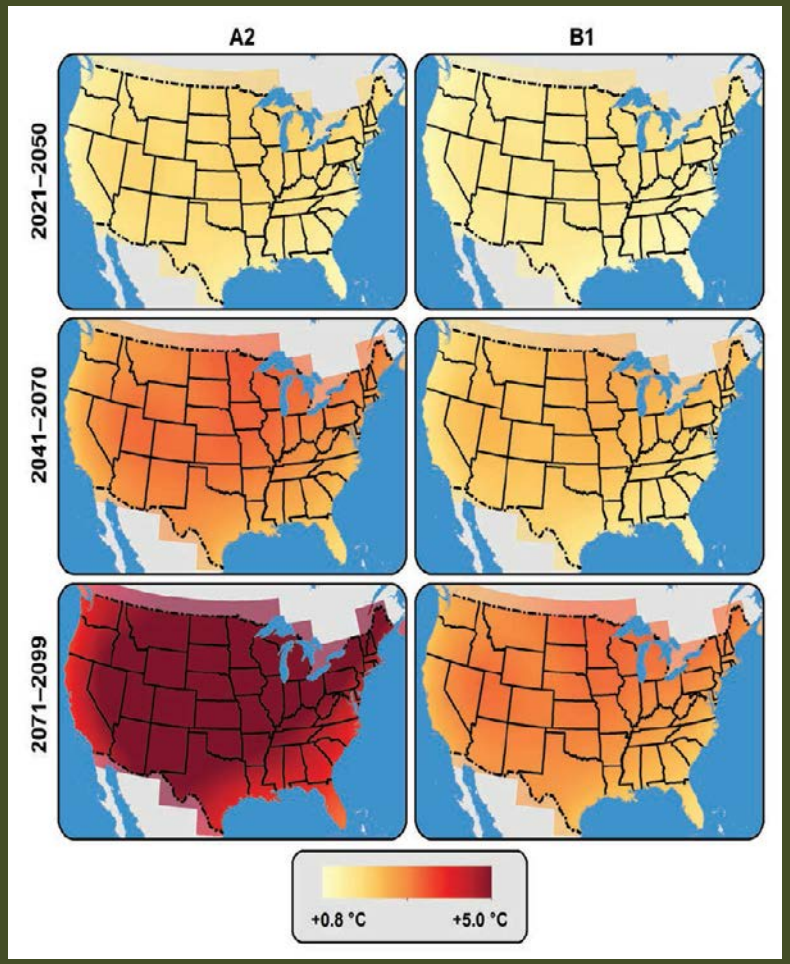
- Observations
- Experiments
- Forecasting models



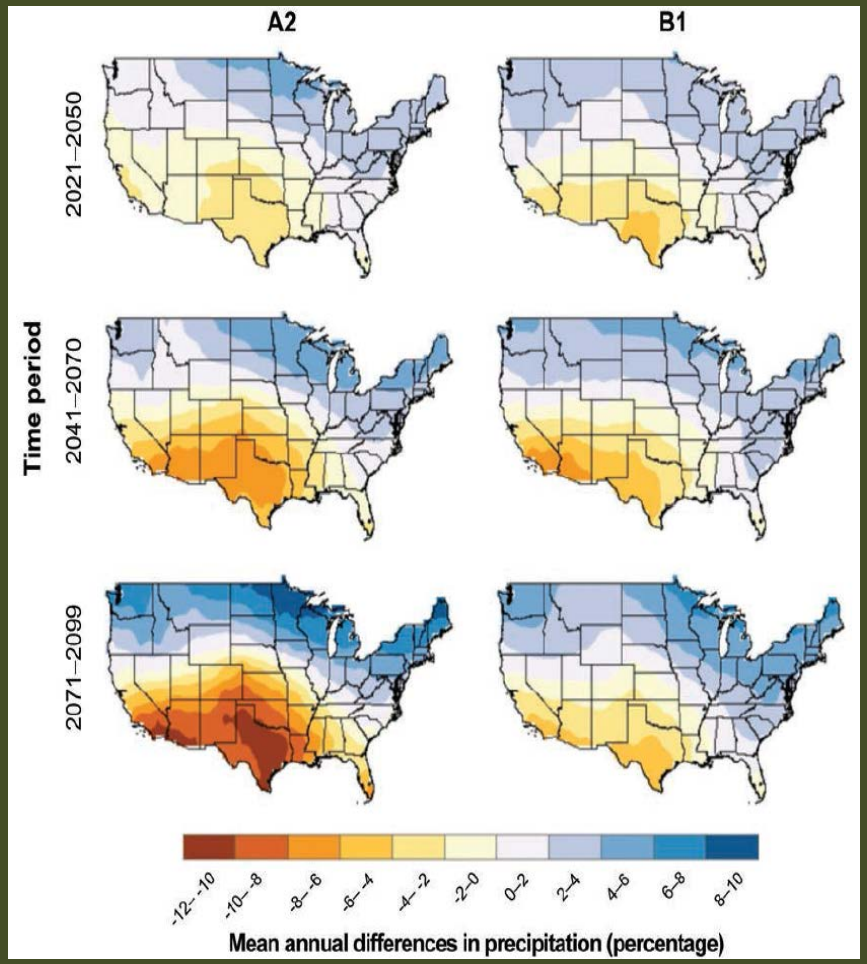


Future climate

Temperature

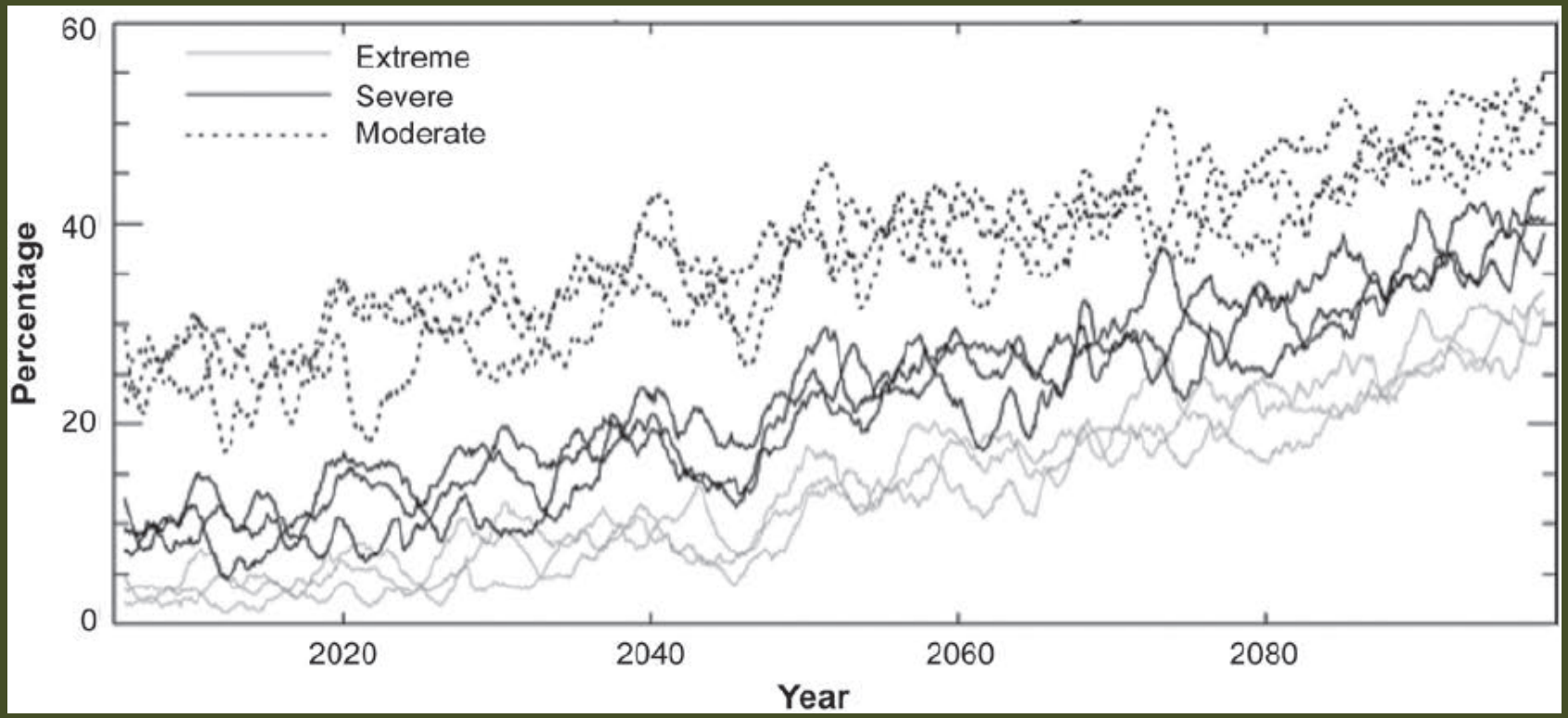


Precipitation



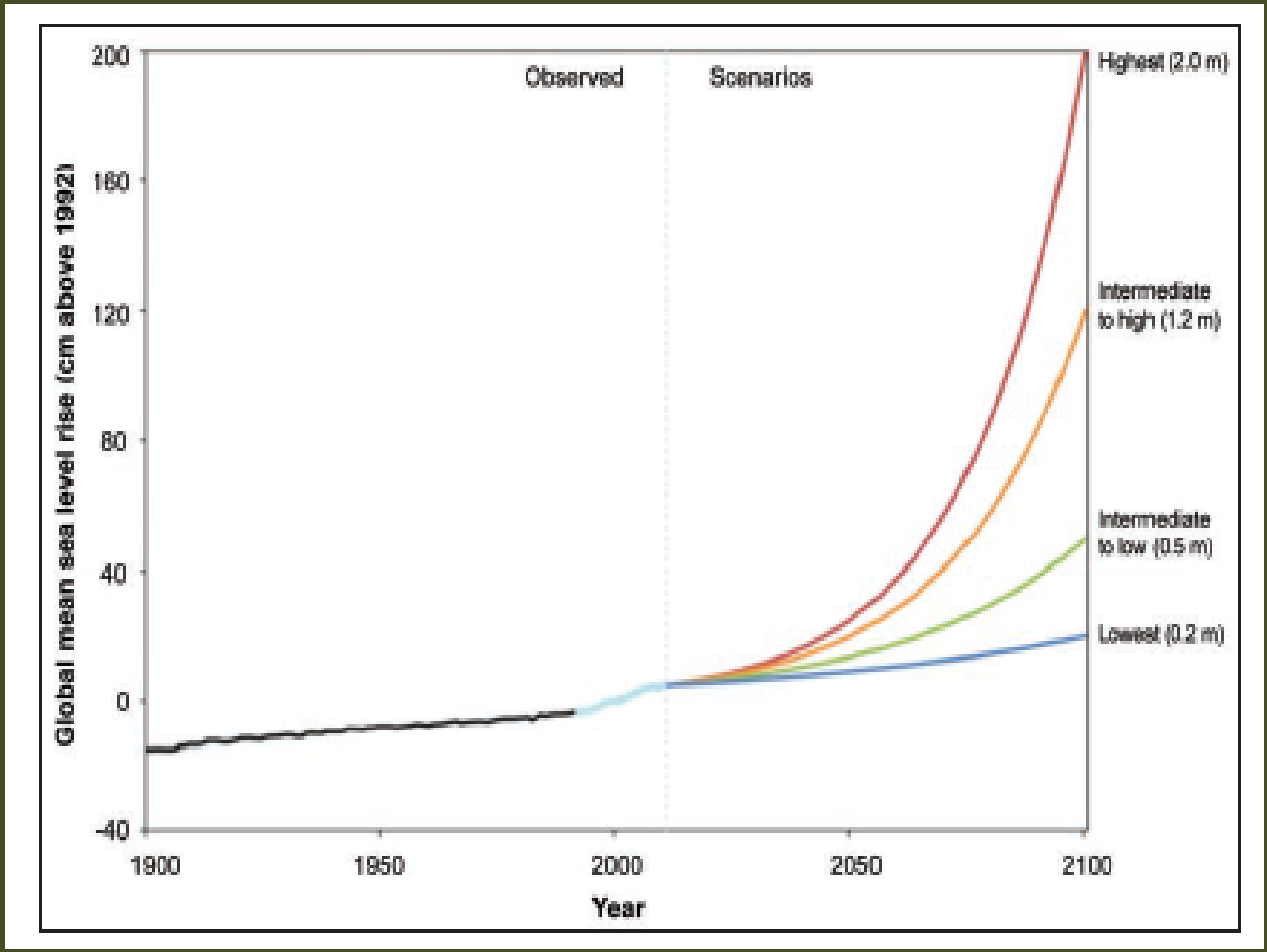
From Kunkel et al. (2013)

Drought severity will increase



From Burke et al. (2006)

Sea level will rise



From Paris et al. (2011)

Climate change will have significant effects on U.S. forests

Direct effects

- Warming
- Changing precipitation (amount and extremes)
- Elevated CO_2
- Sea level rise

Indirect effects

- Fire
- Insects and pathogens
- Invasive species

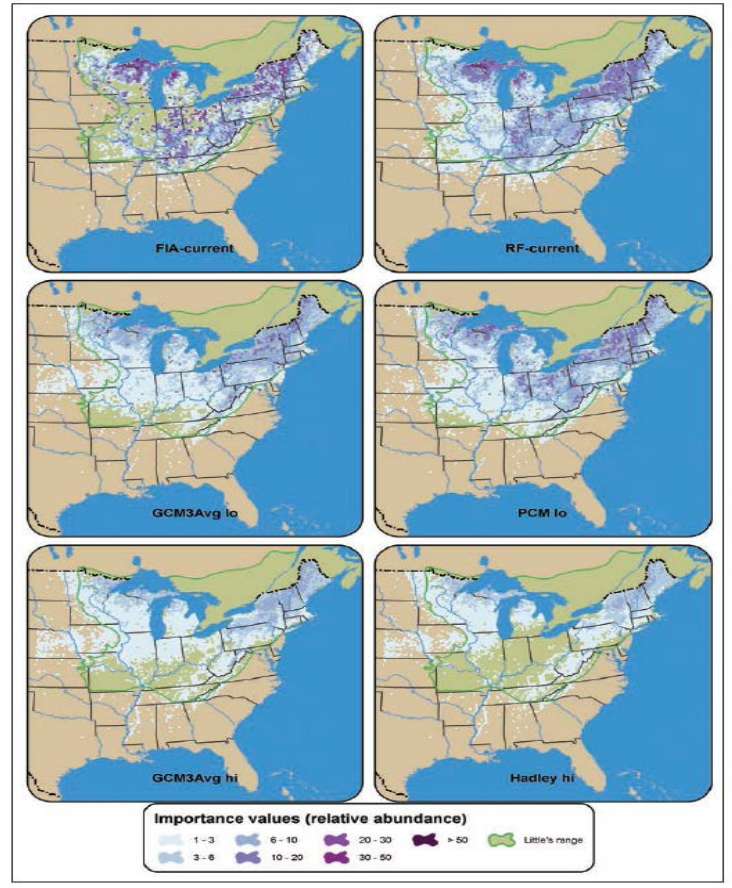
Combined effects, stress complexes

Direct Effects

- **Higher growth** where nutrients and soil moisture are available
- **Lower growth** in water-limited forests and where benefits are offset by disturbance
- **Higher mortality** in drier areas
- **Altered habitat** that will affect distribution of plant and animal species
- **Altered hydrologic, nutrient, and carbon cycling processes**

Distribution and abundance of tree species will change

- Changing conditions will substantially alter suitable habitat for many species
- Losers and winners
- Possible 400-800 km northward movement by 2100
- Pace of change may be faster than species can migrate



Species distribution models (Prasad and Iverson 1999)

Hydrologic and biogeochemical cycling will change

- Changing snow amount (lower) and snowmelt timing (earlier)
- Increased flooding, erosion, landslide potential
- Higher N in streams
- Increased C storage in Eastern forests
  - Potential increase may be offset by loss of forests, drought, other disturbance
- Decreased C storage in Western forests

Indirect effects and stress complexes will alter many forests

- **Indirect effects: altered disturbance regimes**

  Wildfire

  Insects and pathogens

  Invasive species

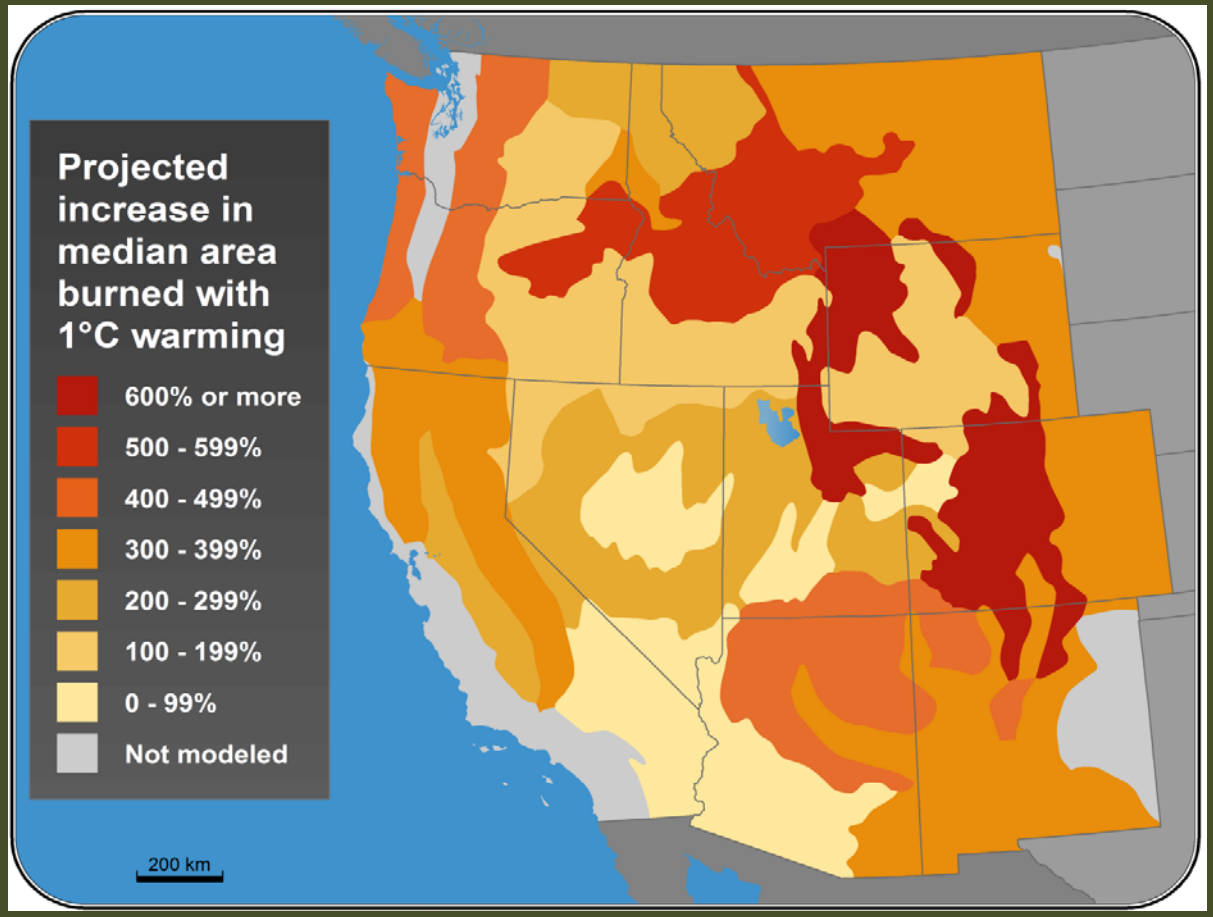
- **Stress complexes: combinations of stressors**

  Warming **+** drought + fire exclusion **+** insects **+** air pollution

Projected wildfire area burned

Statistical model output:

Changes compared to 1950-2003

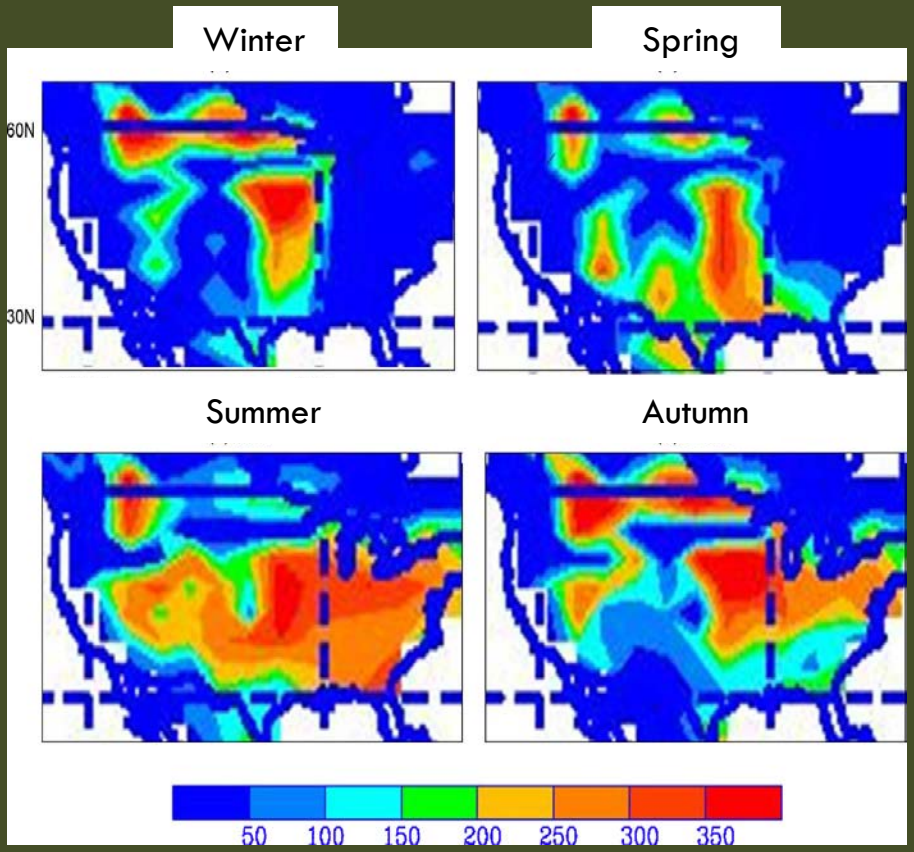


Data from J. Littell

Projected wildfire potential

Projected Keetch-Byram drought index, based on temperature and precipitation changes for the end of the 21st century

Orange-red colors indicate areas with highest fire potential



Data from Liu et al. (2010)

Insect outbreaks are widespread

Mountain pine beetle and other insects are expanding, including at high elevations

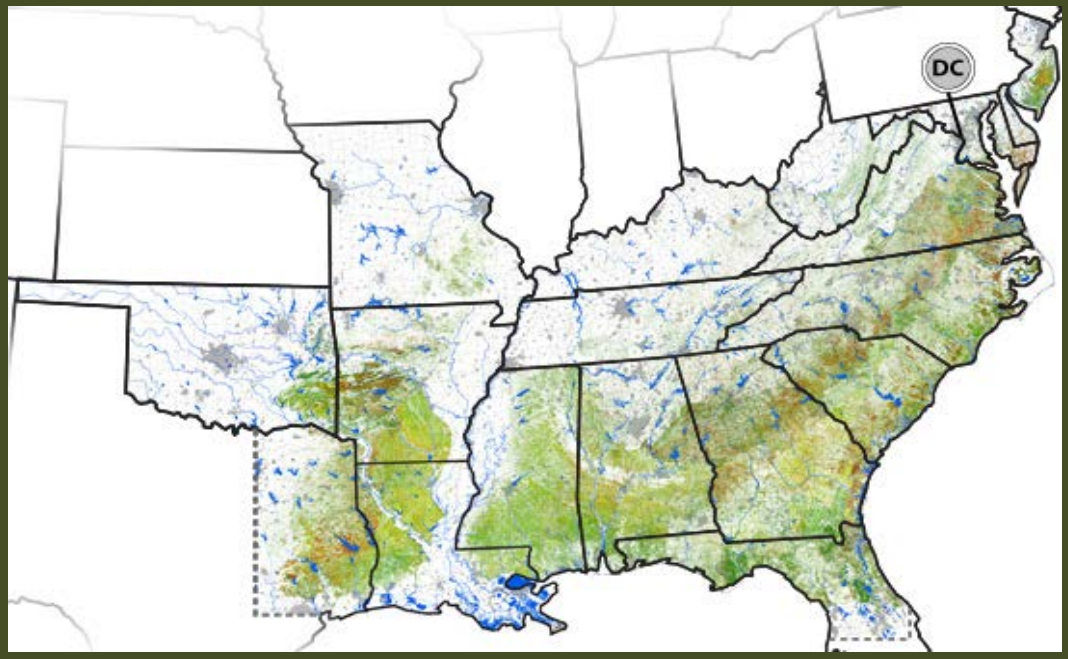
This will probably continue as the climate warms

Insect outbreaks are widespread

Southern pine beetle hazard map

Hazard will increase as the climate continues to warm

<u>Hazard rating</u>
White = none
Green = low
Yellow = moderate
Orange = high



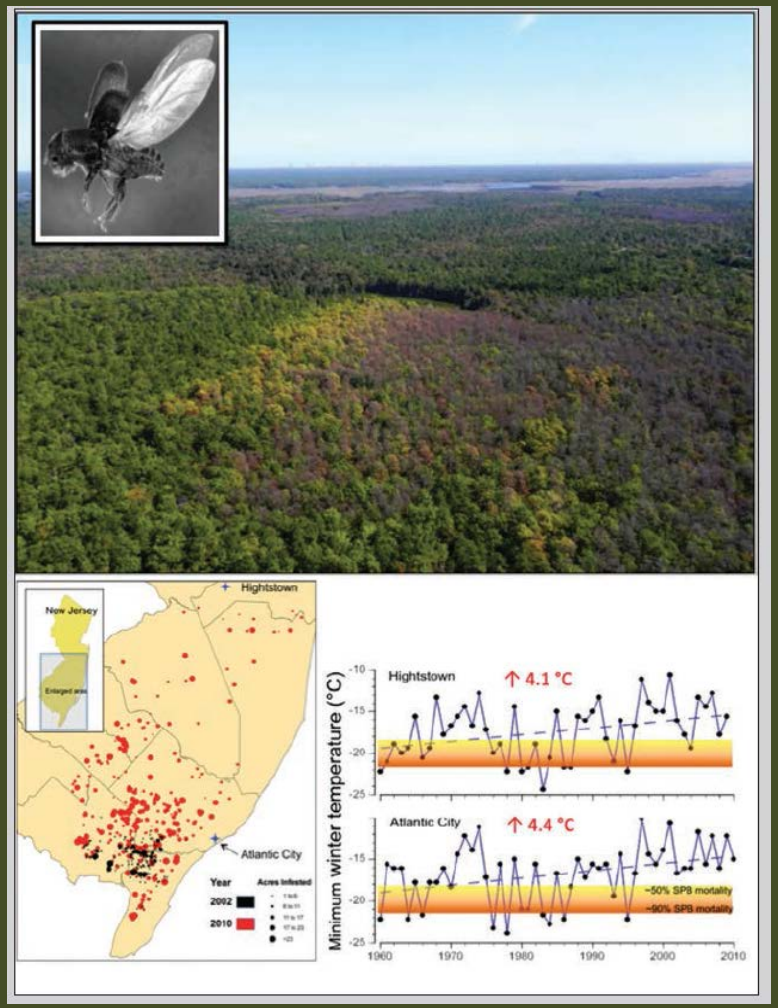
Data from US Forest Service Forest Health Protection

Insect outbreaks are widespread

Southern pine beetle has reached the New Jersey pinelands

Winter temperature is no longer low enough to kill beetles

This outbreak is changing the ecology of forests in the region



Aerial photo by Bob Williams, Land Dimensions
Close-up photo by Erich Vallery, US Forest Service

USDA FOREST SERVICE US DEPARTMENT OF AGRICULTURE

Changing Forests...Enduring Values

Invasive plant species will increase

Many invasives are more competitive at higher temperatures

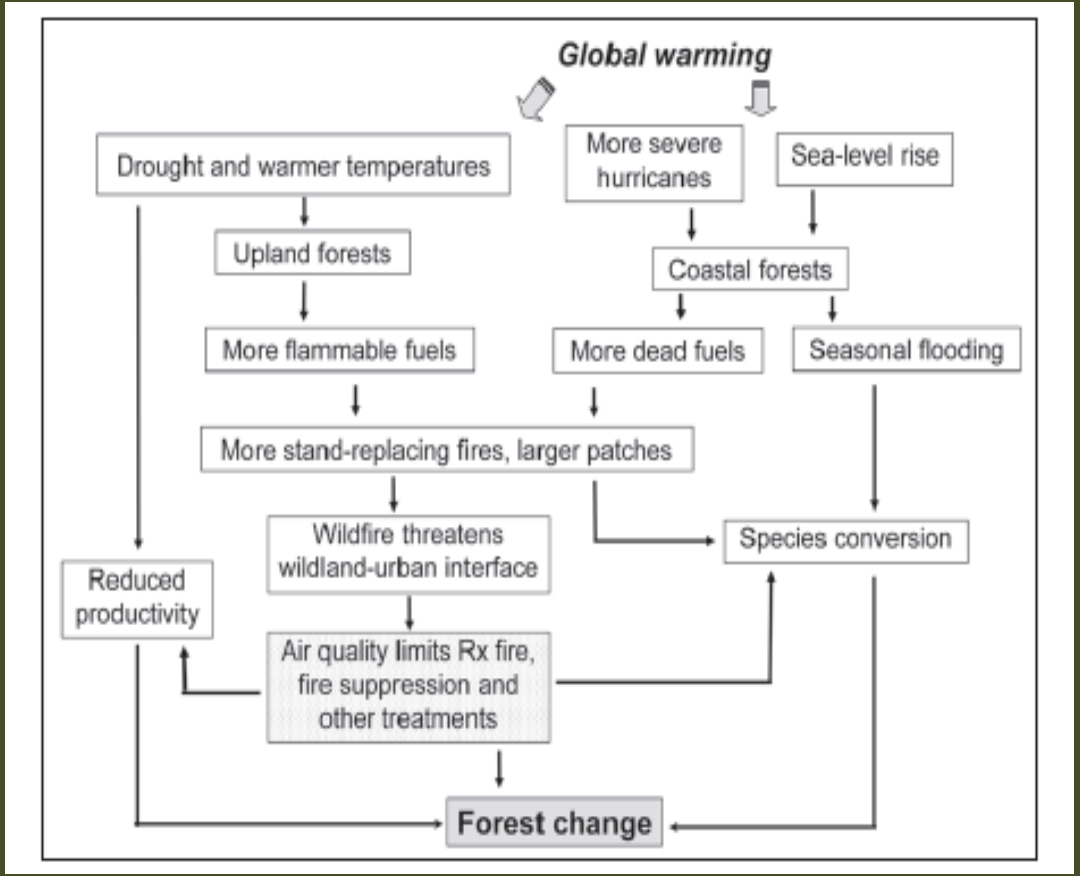
Cogongrass (right) is increasing in the southeastern U.S.

Photo by James Meeker, US Forest Service

Stress complexes will be affected by a warmer climate

Interactions of multiple stressors will accelerate with higher temperature and more droughts

Stress complexes for upland and coastal forests in the southern U.S. (right)



From Don McKenzie

Climate change effects and management responses will differ across rural to urban environments

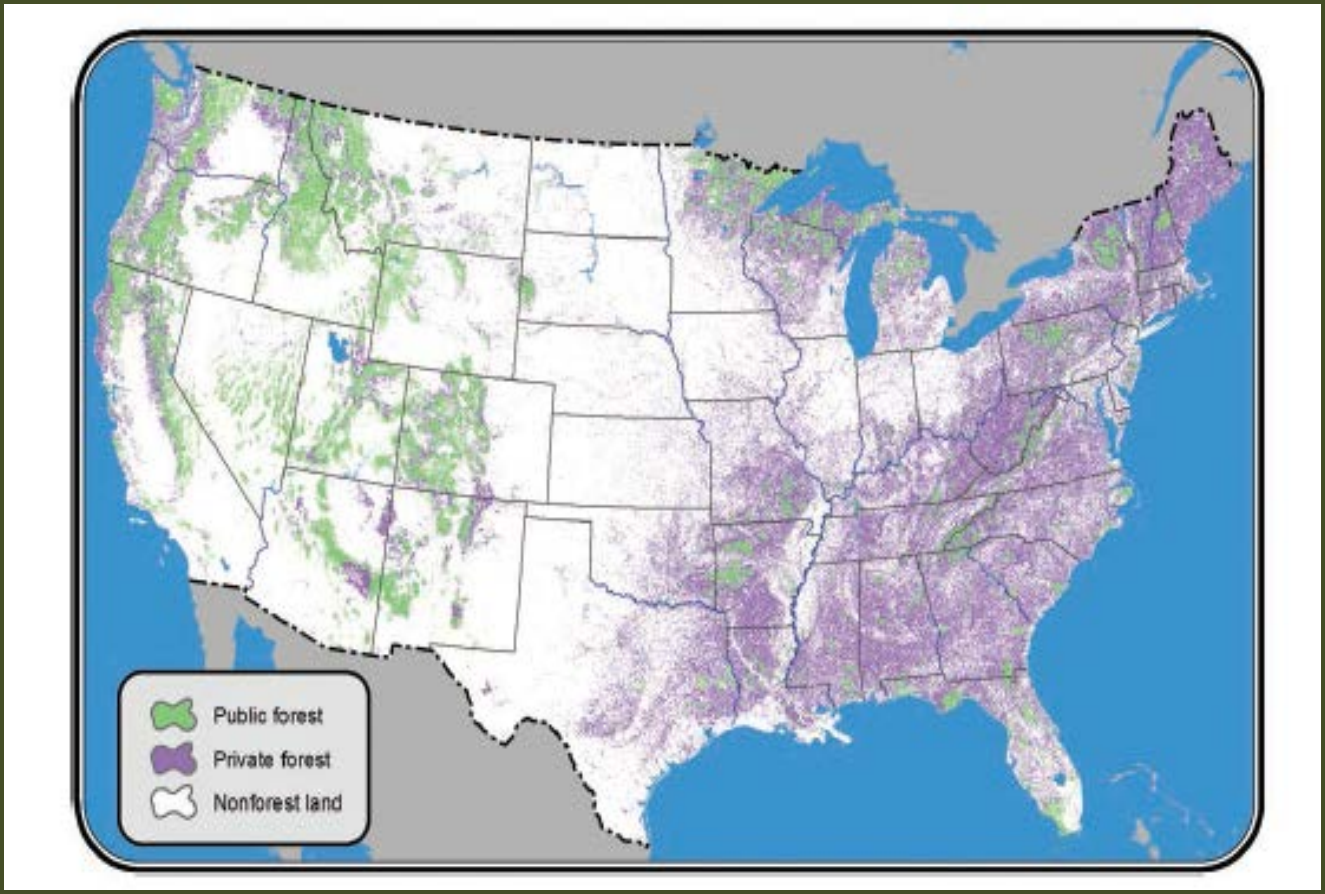
RURAL	WILDLAND-URBAN	URBAN
Land-use change	Fire risk	Tree health
Rural economy	Home values & safety	Comfort & energy use
Incentives	Firewise	Intensive treatments

What can we do about climate change in forest ecosystems?

- Slow it down = Mitigate (manage carbon)
- Buy some time = Adapt (prepare systems and species)

Land ownership patterns will affect management responses

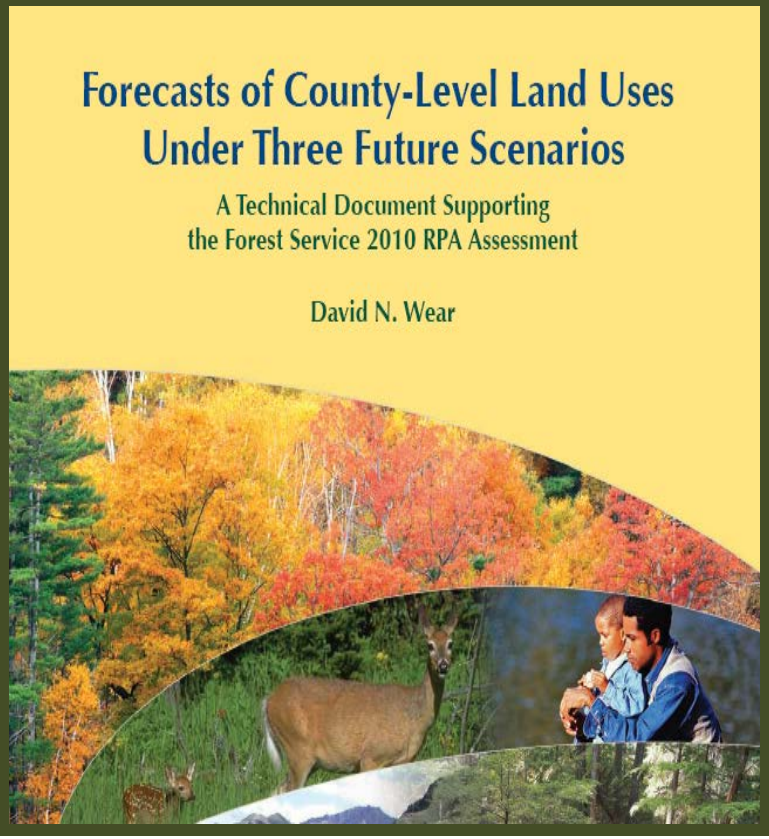
Public forest lands dominate much of the western U.S., whereas private lands dominate in the East



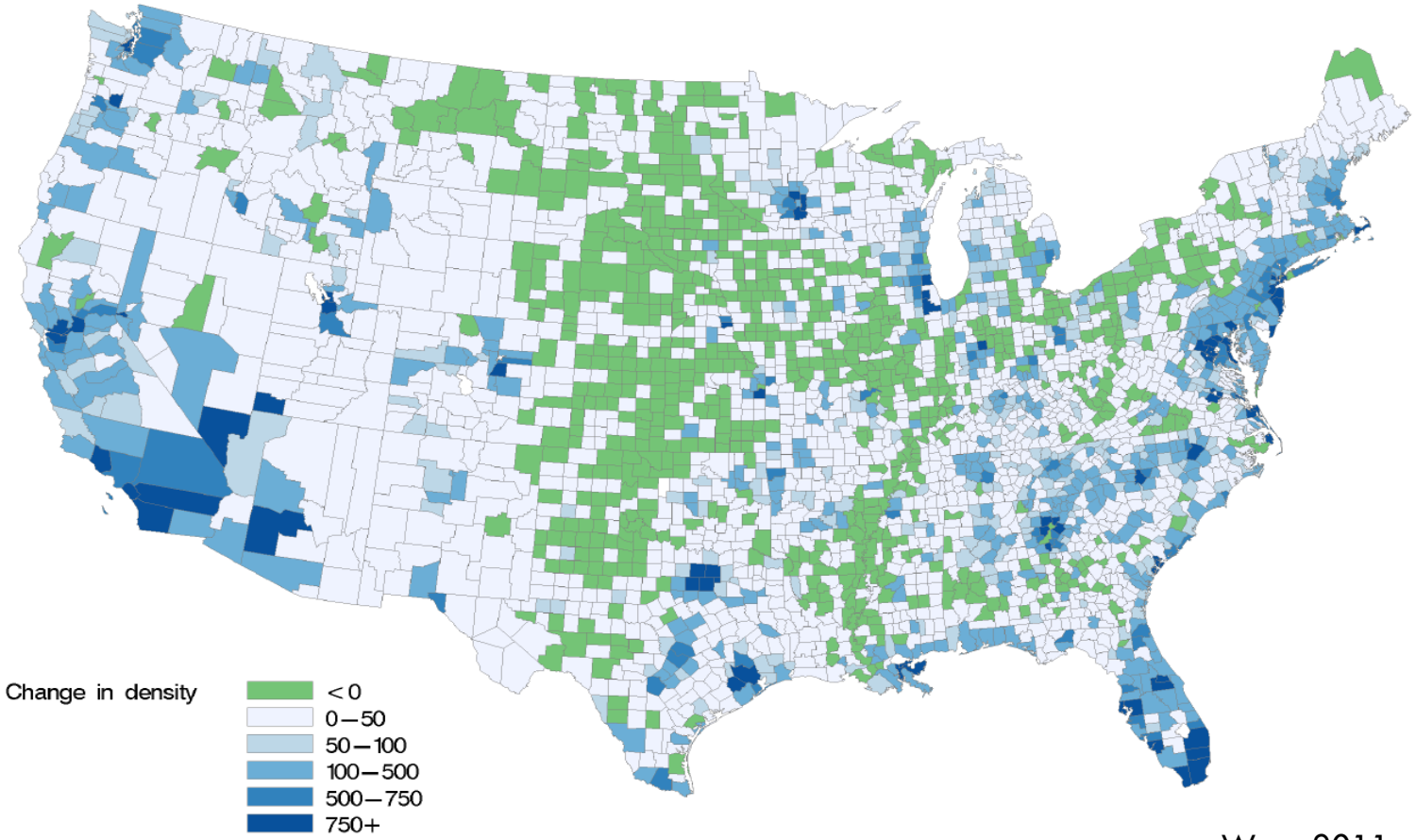
From Wear and Joyce (2012)

Human Impacts

- Broad scale – *decisions about land use*
  - Forest vs. alternative
  - Managed vs. unmanaged



Human Population Change



Changes in major land uses

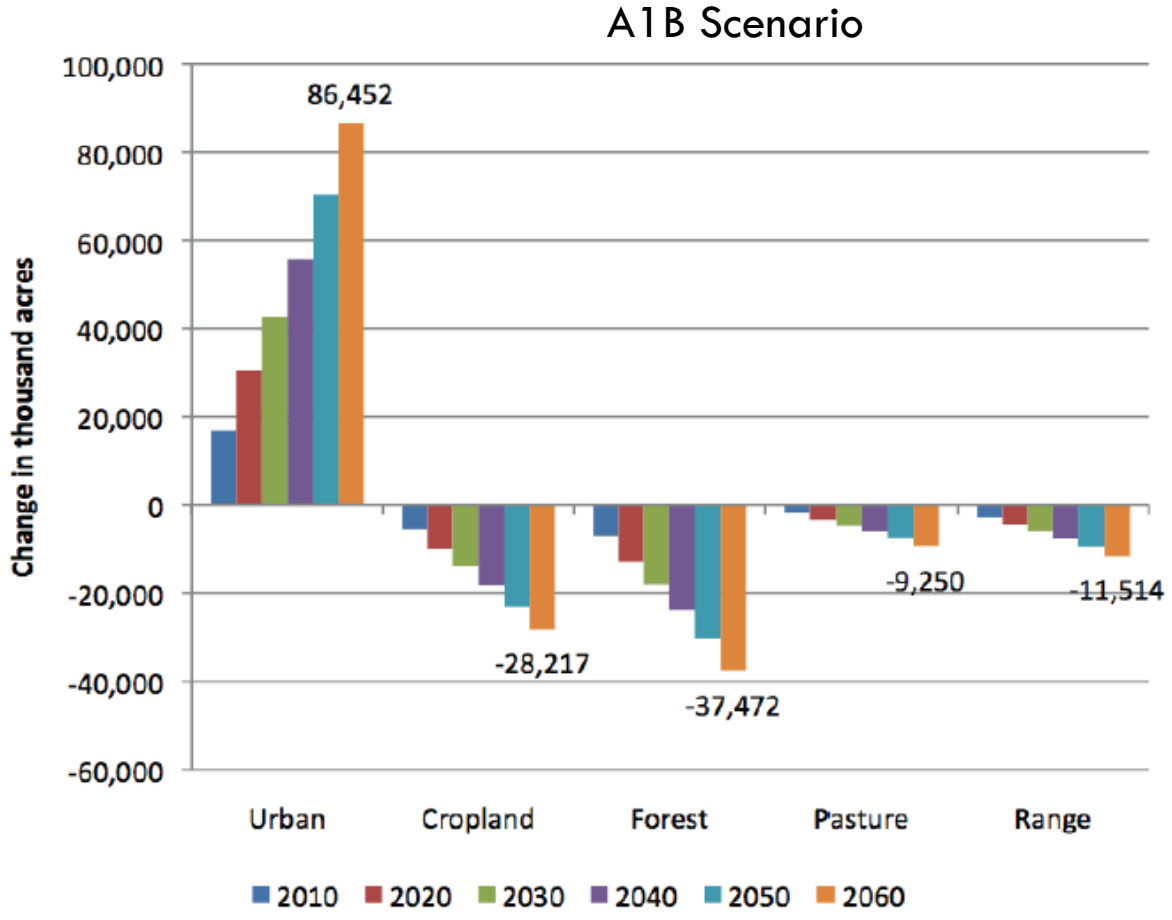
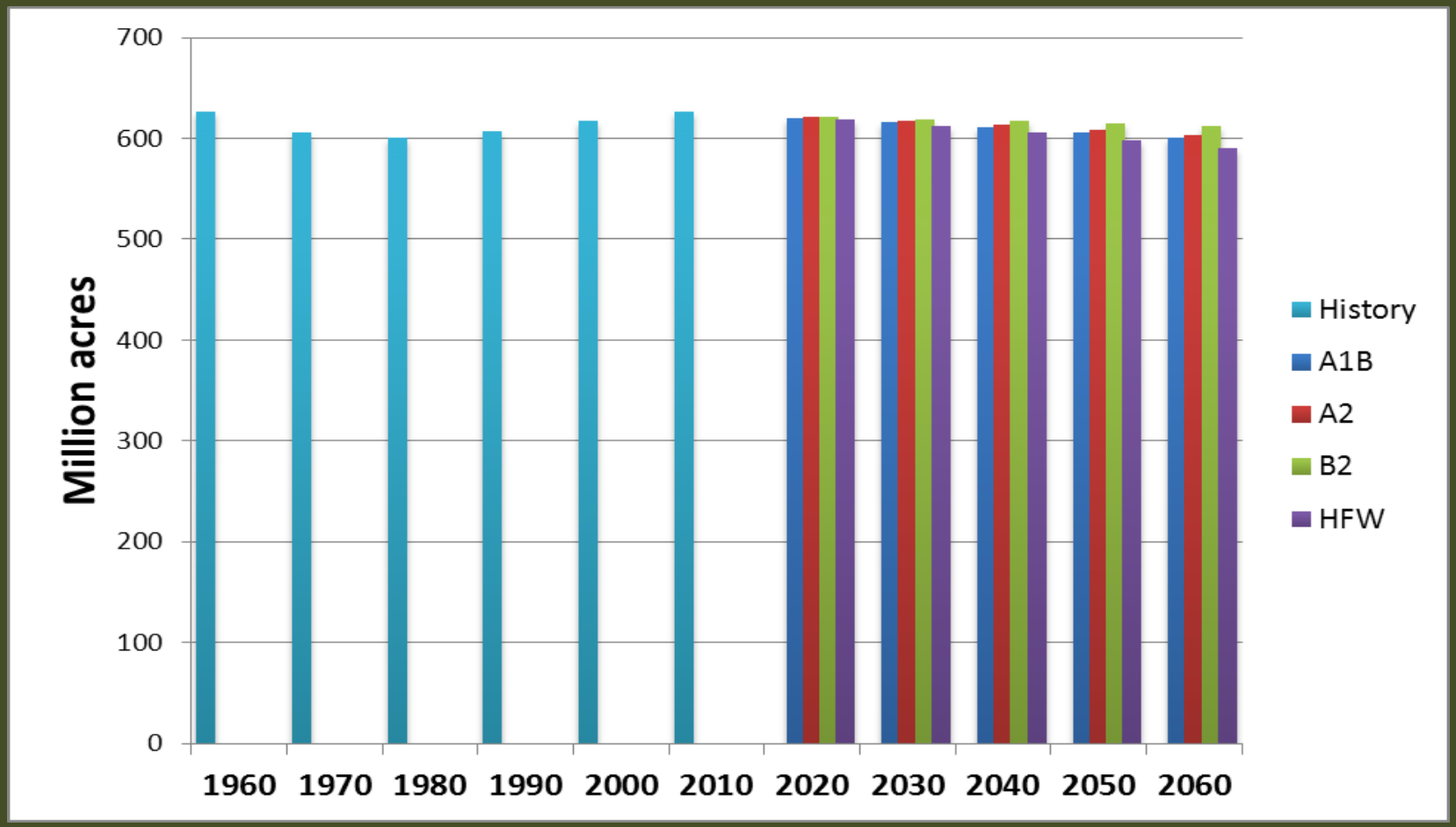


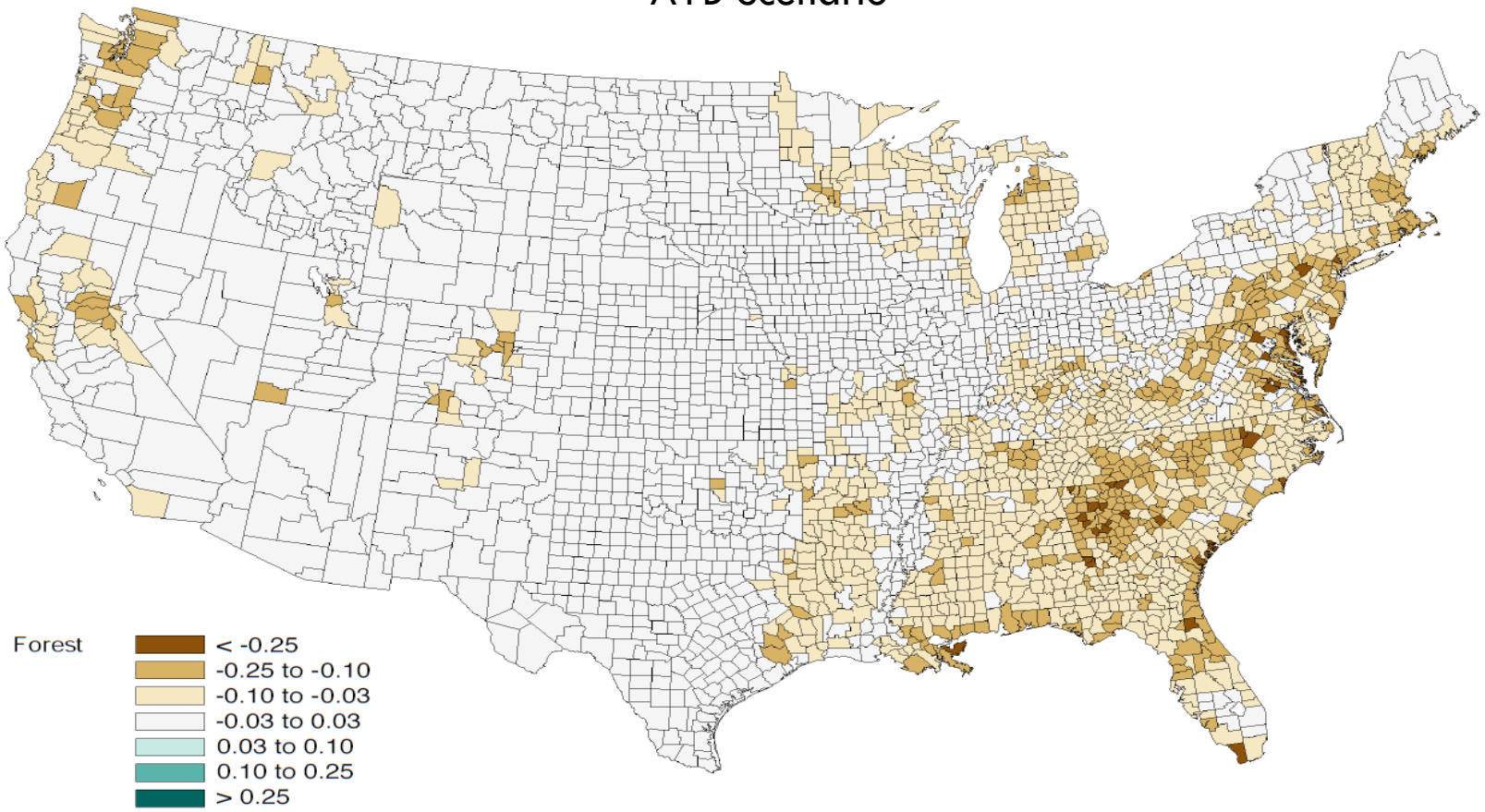
Figure 11—Forecasted change in the areas of major nonfederal land uses, A1B Scenario, 2010-2060, compared to 1997.

Wear 2011

Total Forest Land in Conterminous U.S.



Changes in Forest Land Use



Proportional change in forest land use

Figure 14—Forecasted change in proportion of county that is in forest use, A1B Scenario, 1997-2060.

Wear 2011

Conclusions — disturbances

- Increased wildfire will have major ecological, social, and economic effects by the mid-21st century.
- Bark beetles and other insects will have major effects in some forests.
- Invasive plants and some pathogens will increase, but with uncertain long-term outcomes.

Conclusions — processes

- Hydrology and biogeochemical cycling will differ by forest ecosystem, interacting with altered disturbance and decreased snowpack.
- Species will move up in elevation and north, but with high variability; models disagree on spatial and temporal patterns.
- Carbon storage will decrease in the western U.S. and may increase in the East.

Conclusions – land use change

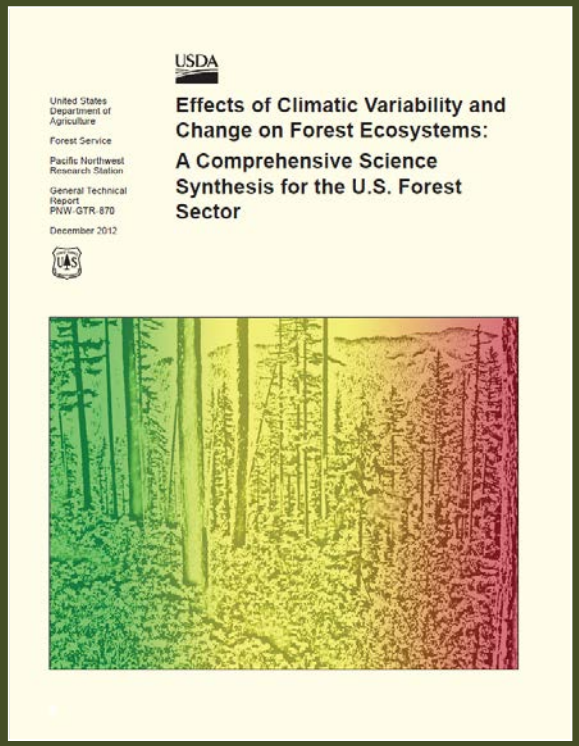
- Population growth and other factors are likely to put pressure on forest land uses and may result in a loss of forests.
- Projected losses will be concentrated in the eastern U.S., coinciding with where the majority of private forest ownership is located.

Conclusions – forest management

- Managing forests to help mitigate and adapt to climate change will be critical.
- Land owners and managers have always had to deal with external stressors – what's different is the pace and magnitude of climate change.
- Private land owners will play a crucial role!

For more information

See the publication



Contact the authors

Jim Vose
USFS Southern Res. Stn.
jvose@fs.fed.us

Dave Peterson
USFS Pacific Northwest Res. Stn.
peterson@fs.fed.us