Climate Change Impacts on Forest Ecosystems

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Today's Presentation – Three Messages

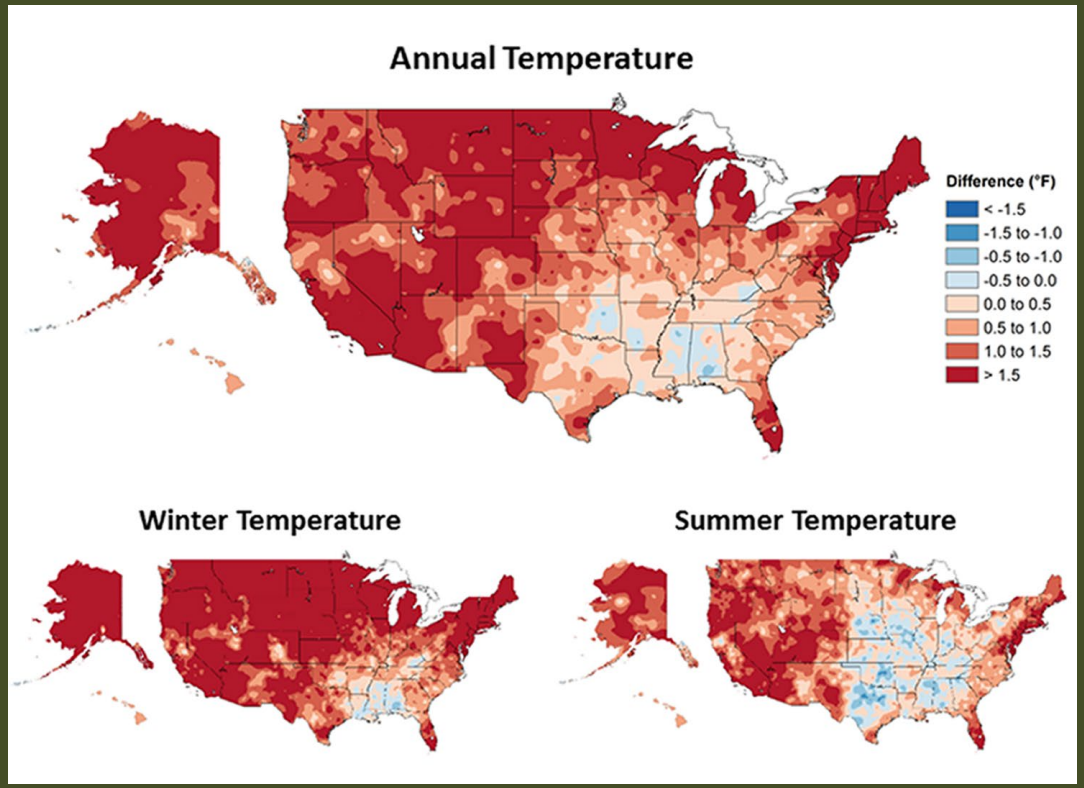
- Climate change effects are already evident in some forests. We are on the cusp of additional and potentially more severe effects, primarily facilitated by increased frequency and magnitude of extreme weather events (drought, heavy rainfall, heat waves) and associated disturbances (insect outbreaks, wildfire).

- Some climate change effects are slow and may take decades to be fully realized; other effects are rapid and observable now. Both can cause undesirable changes.

- Ecosystem services can be maintained in most locations by implementing risk assessments and climate-smart management. The long-term goal is to ensure that forests are resilient to current and future climate stressors.

Climate Change is Happening….

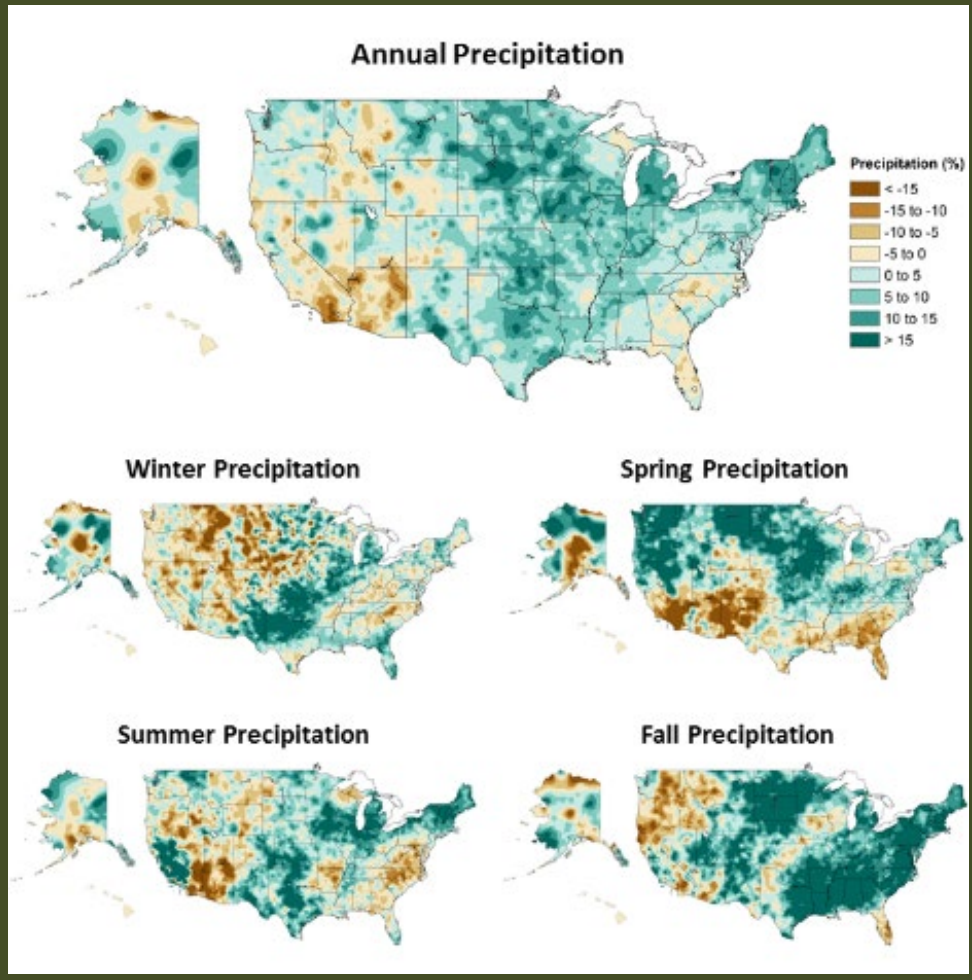
- Note variability across the U.S.
- Much of the warming occurring in the cold season and at night
- **Warming will continue in the future**



Observed changes in annual, winter, and summer temperature (°F), 1901 to present

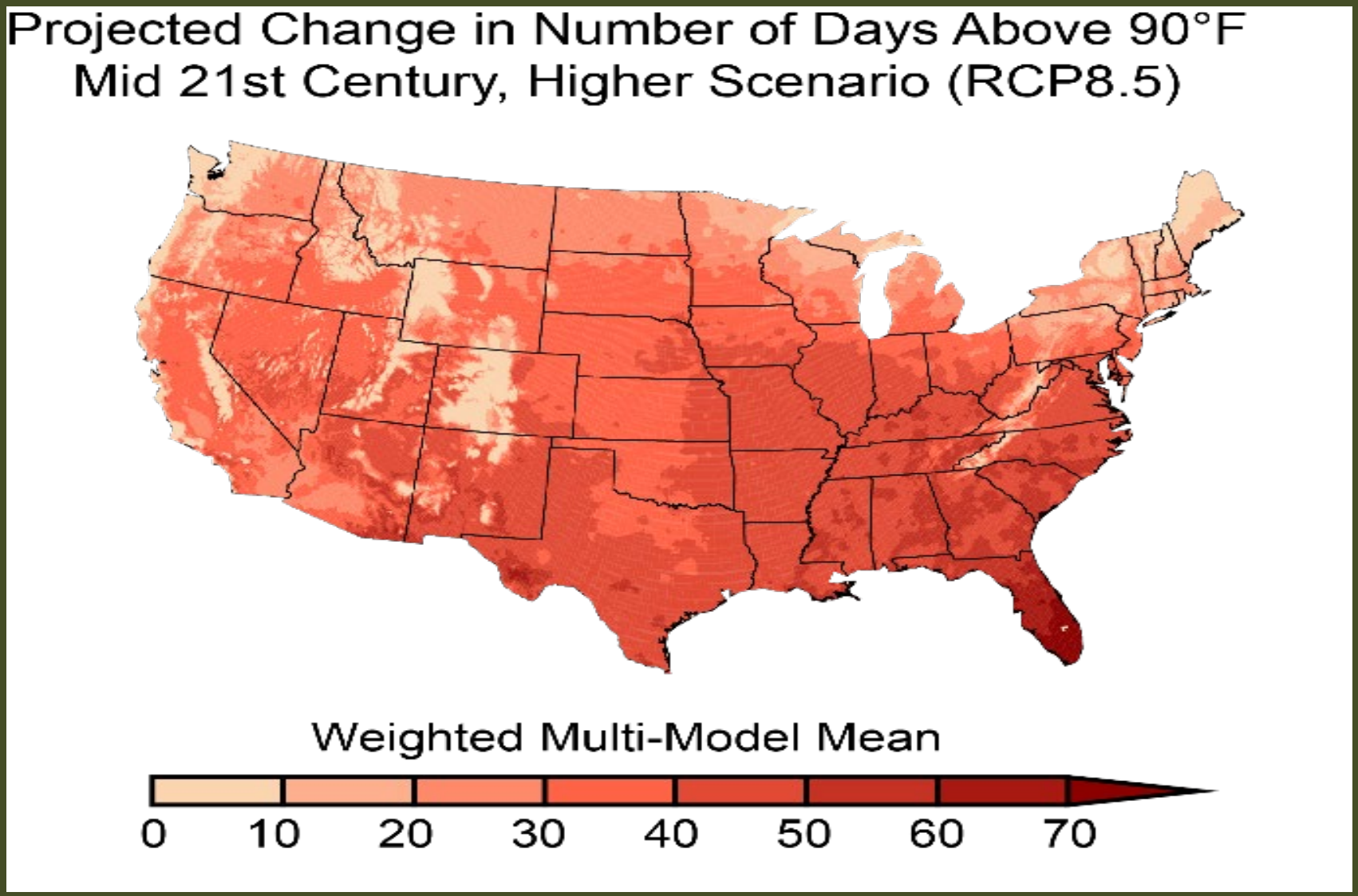
Climate Change is Happening….

- Note variability across the U.S.
- Overall amounts and larger individual events
- ***Future* — more offseason precipitation**
- **Drier Southwest and summers**



Annual and seasonal changes in precipitation (%), 1901 to present

Extremes more likely…"hot droughts"

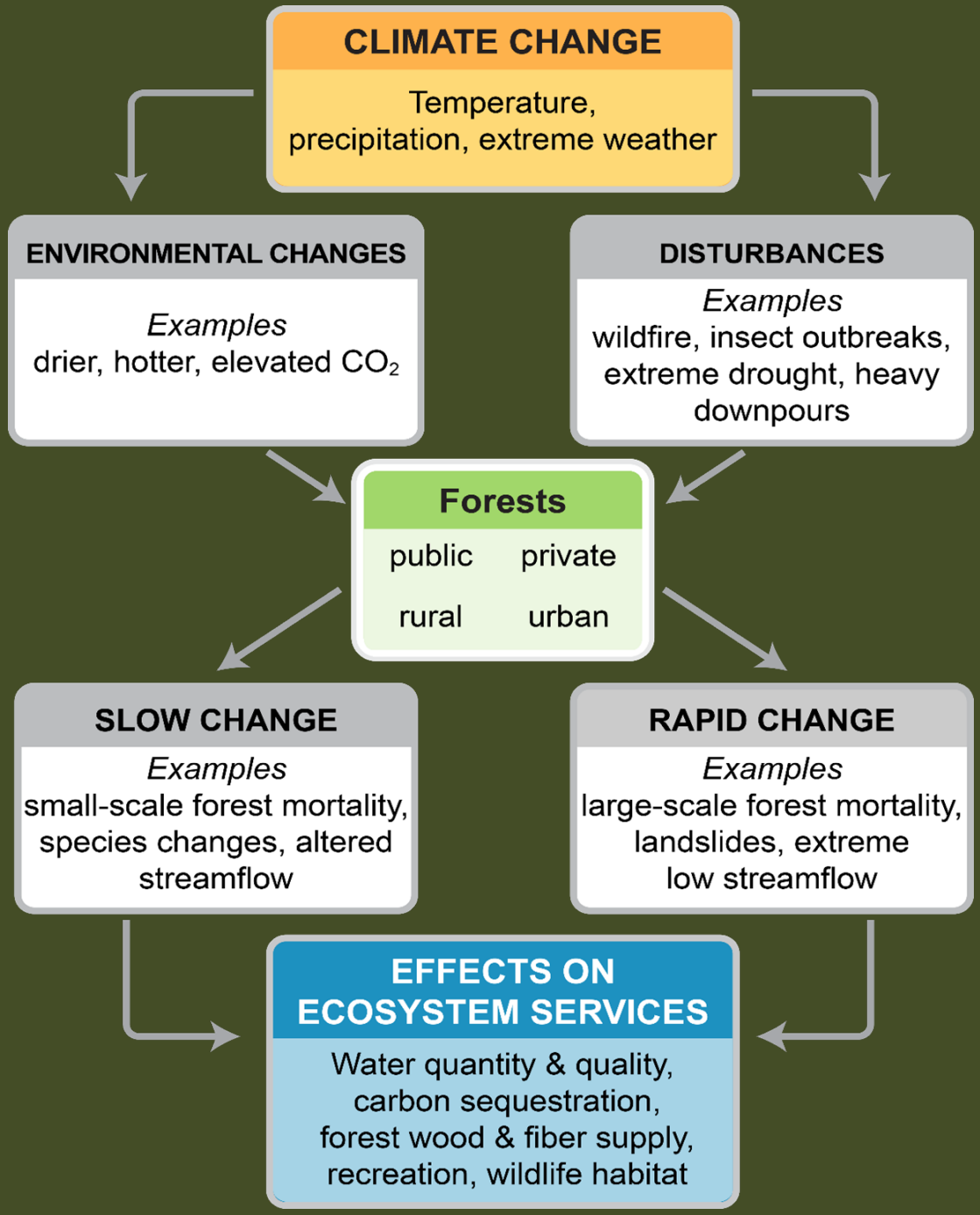


Forests and Climate Change

- Forests are distributed across the spectrum of rural to urban environments, on public and private land, and cover 33% of land in the U.S.

- The ability of trees to adapt to and survive changing climatic conditions ensures long-term persistence of forest ecosystems – adaptive capacity not unlimited.

Effects on US Forests



Rapid Change

- High temperatures and drought-caused beetle outbreaks have killed trees throughout the western U.S.

300 million trees in Texas (2011)
100 million trees in California (2015)

Rapid Change

- Mountain pine beetles have caused tree mortality across 50 million acres in the U.S. and Canada

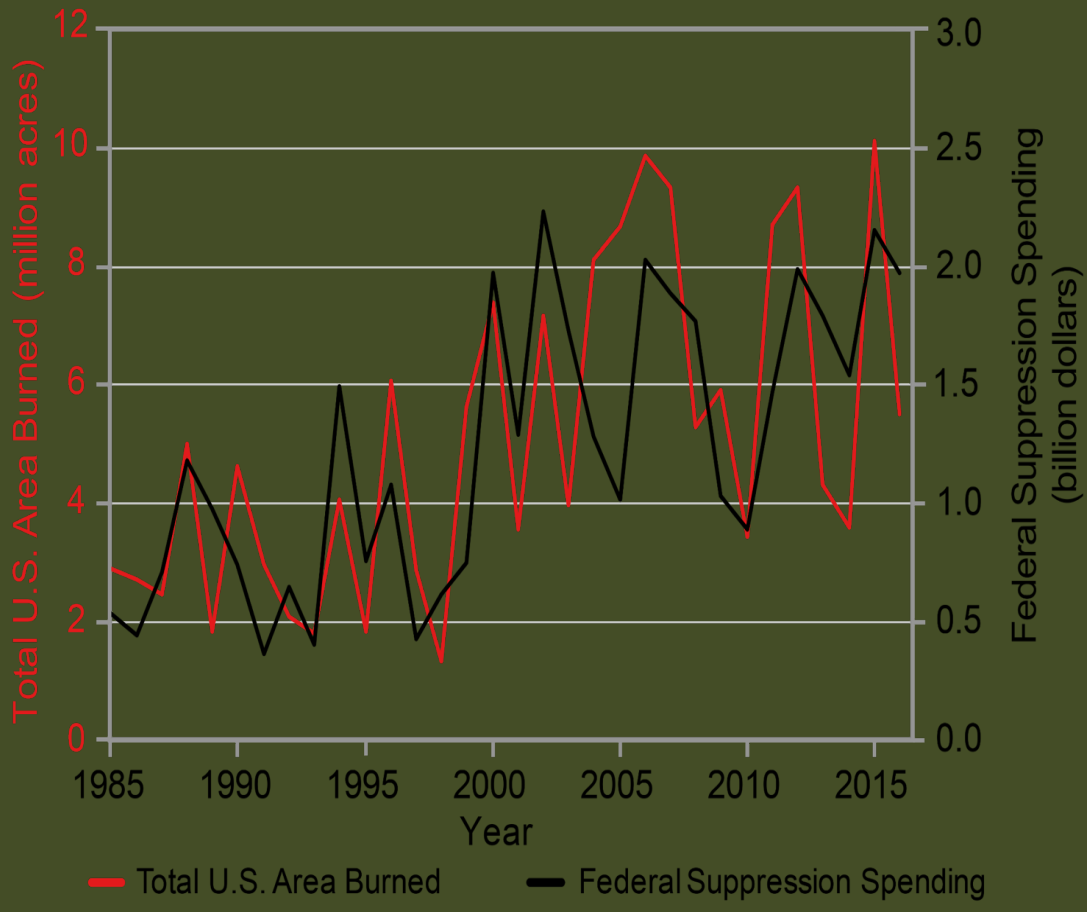
The range of **mountain pine beetle is expanding** with warming; new breeding populations are now found in parts of the western Plains and in jack pine forests in Alberta.

Mountain pine beetle populations are also expanding in **high-elevation forests** of the western U.S., affecting lodgepole pine, whitebark pine, and other species.

Southern pine beetles have expanded into forests of the northeastern U.S.

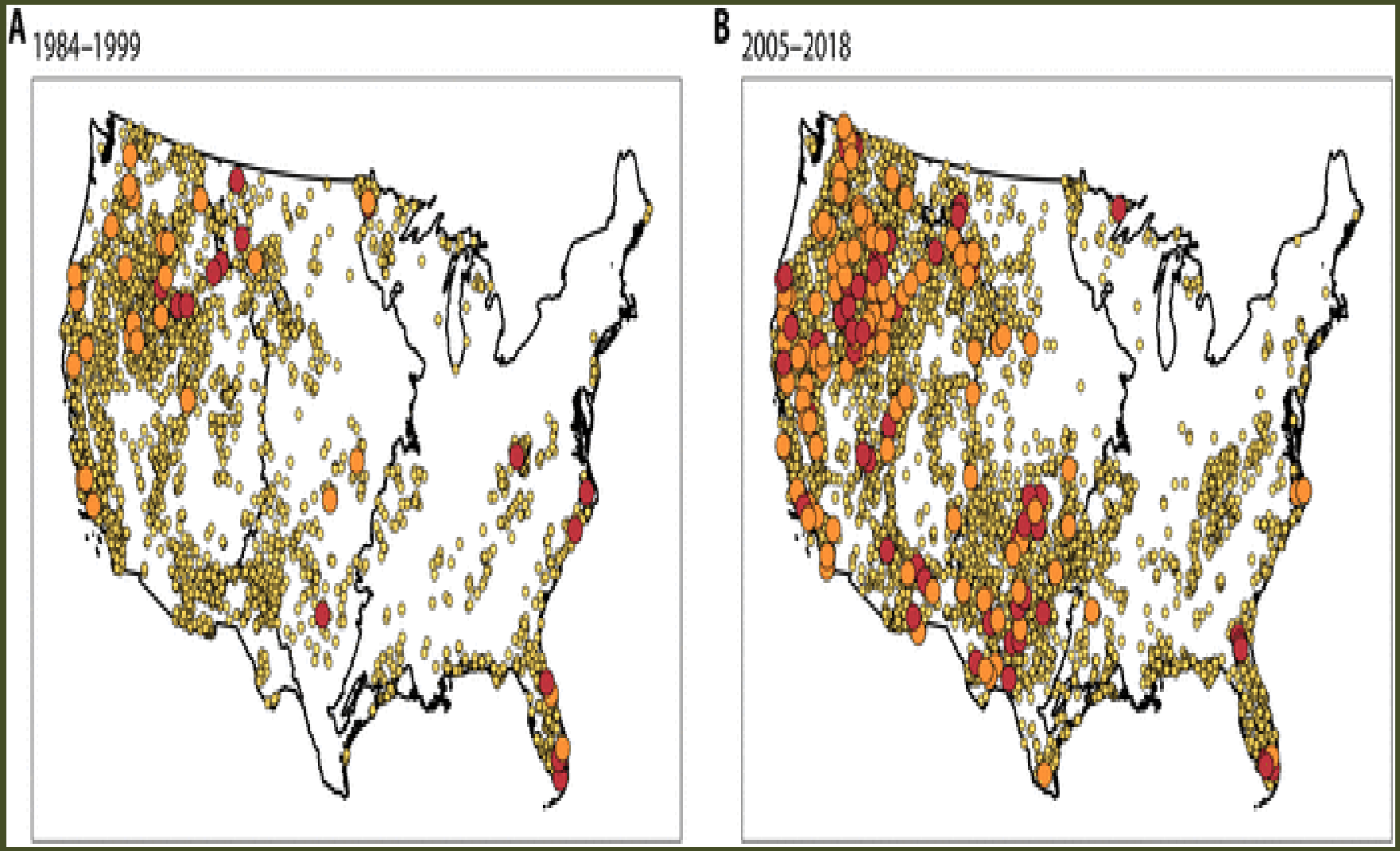
Rapid Change

- Since 2000, annual area burned by wildfire was >5 million acres in 15 years (7 years with >9 million acres)
- Annual fire suppression costs ranged from $800 million to $3.1 billion during this time



Rapid Changes

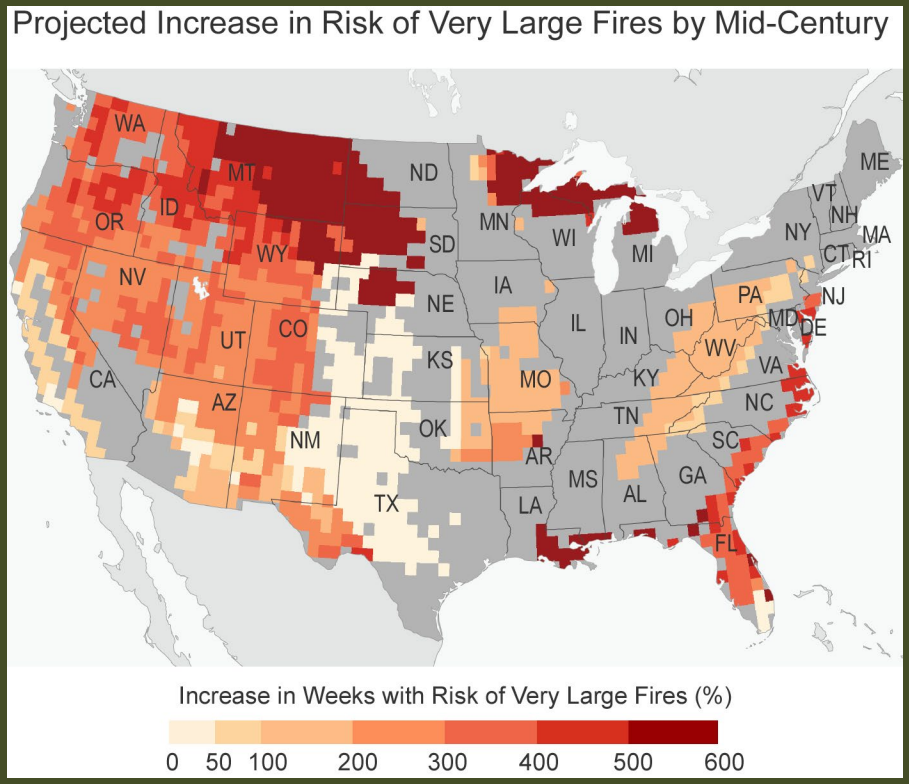
- Fire risk and fire season length have increased in the western U.S. due to higher temperatures and more frequent droughts
- Larger and more intense wildfires are occurring in some locations, increasing risk to people, homes, infrastructure, and firefighters



These maps show the spatial distribution of fires in the United States in 1984–1999 and 2005–2018. Small yellow dots represent small fires, large orange dots represent fires considered large by 1984–1999 standards, and large red dots represent fires considered large by 2005–2018 standards. Credit: Iglesias et al., 2022, https://doi.org/10.1126/sciadv.abc0020, CC BY-NC 4.0

Rapid Change

Fire risk and annual area burned could increase greatly by 2050, depending on geographic area, ecosystem, and local climate



Barbero et al. 2015

Rapid Change

- In the Southeast, by 2060, median annual area burned by lightning-ignited wildfire is projected to increase by 34%

- Extensive wildfires in the Southeast in recent years, including near urban areas, may corroborate these projections

Rapid Change

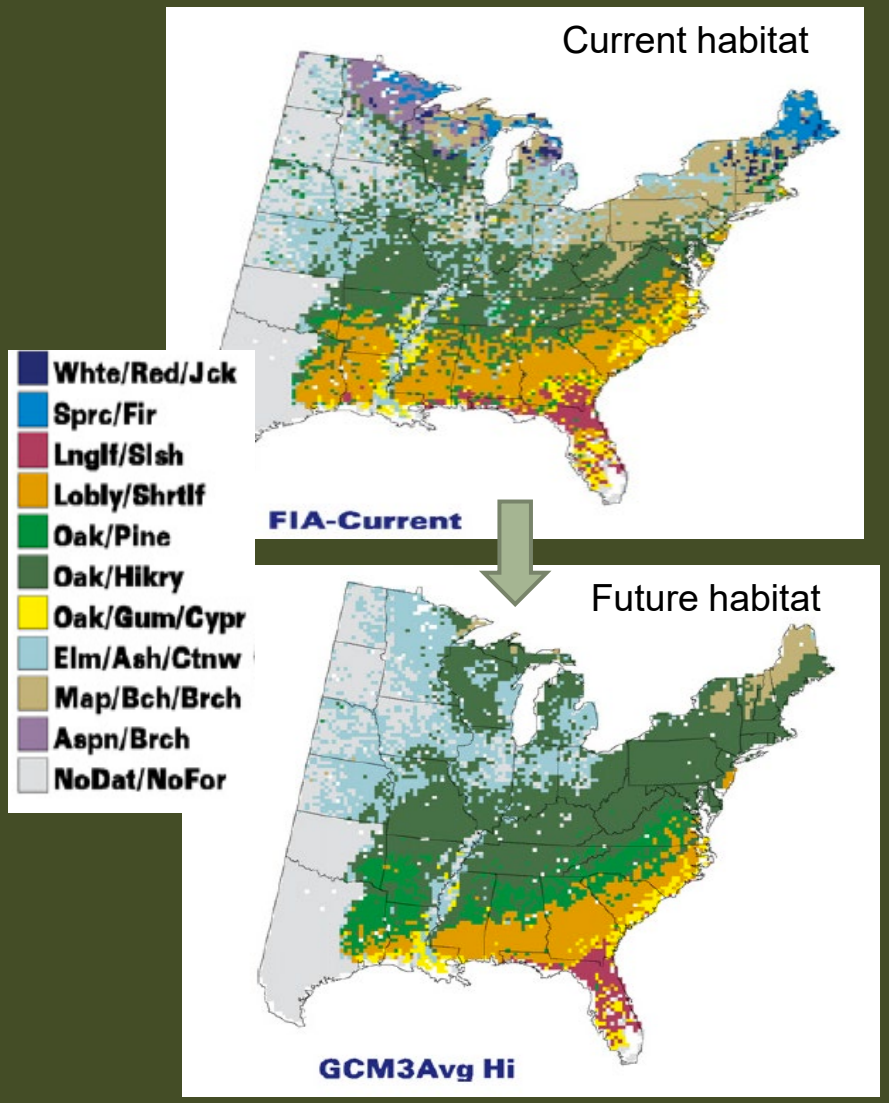
Declining mountain snowpack in the West, heavy rainfall, and summer droughts are increasing the risk of winter flooding, low summer streamflow, and reduced water quality

Slow change

- The effects of climate change on tree mortality and health can be obscured by slow response times of long-lived trees
- Climate-related stresses on trees facilitate higher risk for tree mortality that can go unrecognized for years

Slow Change

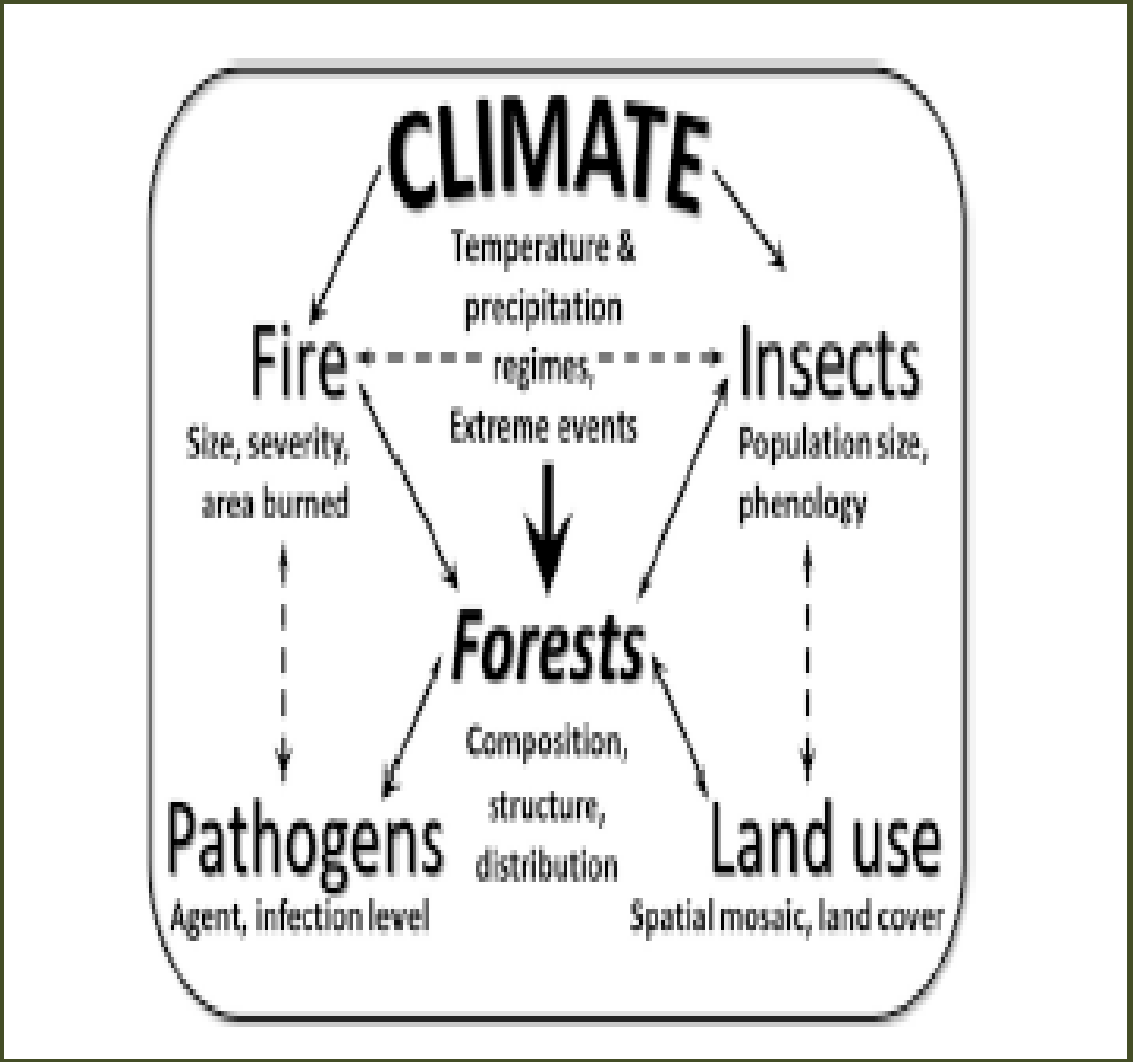
- In some locations, the rate of climate change may be outpacing the capacity of trees to adjust, potentially reducing forest health and altering forest composition
- Altered forest composition has altered streamflow and increased drought vulnerability in some regions



Iverson et al. 2008

“Stress complexes”

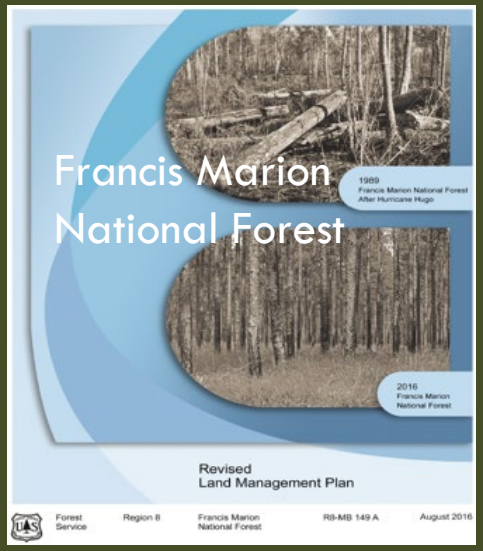
Drought, insect outbreaks, disease, and wildland fire often create stress complexes that influence disturbance regimes and **compound effects on ecosystem services**.



Adaptation = Building resilience

- Many current forest management practices are already "climate smart" and may need only fine tuning

- Progress is being made on incorporating climate change into agency planning and on-the-ground projects

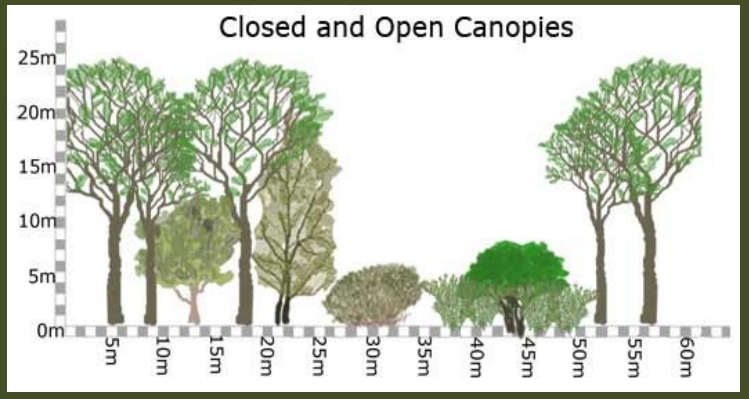


Building resilience: Wildfires

- Accelerate the pace and scale of fuel treatments: thinning + surface fuel reduction
- Maintain fuel treatment programs in perpetuity
- Implement strategically across large landscapes

Building resilience: Forest health

- In response to increased temperature, drought, and insect outbreaks…
  - Manage stand densities to reduce competition for water
  - Increase age-class and structural diversity
  - Increase genetic diversity by planting outside historical seed zones

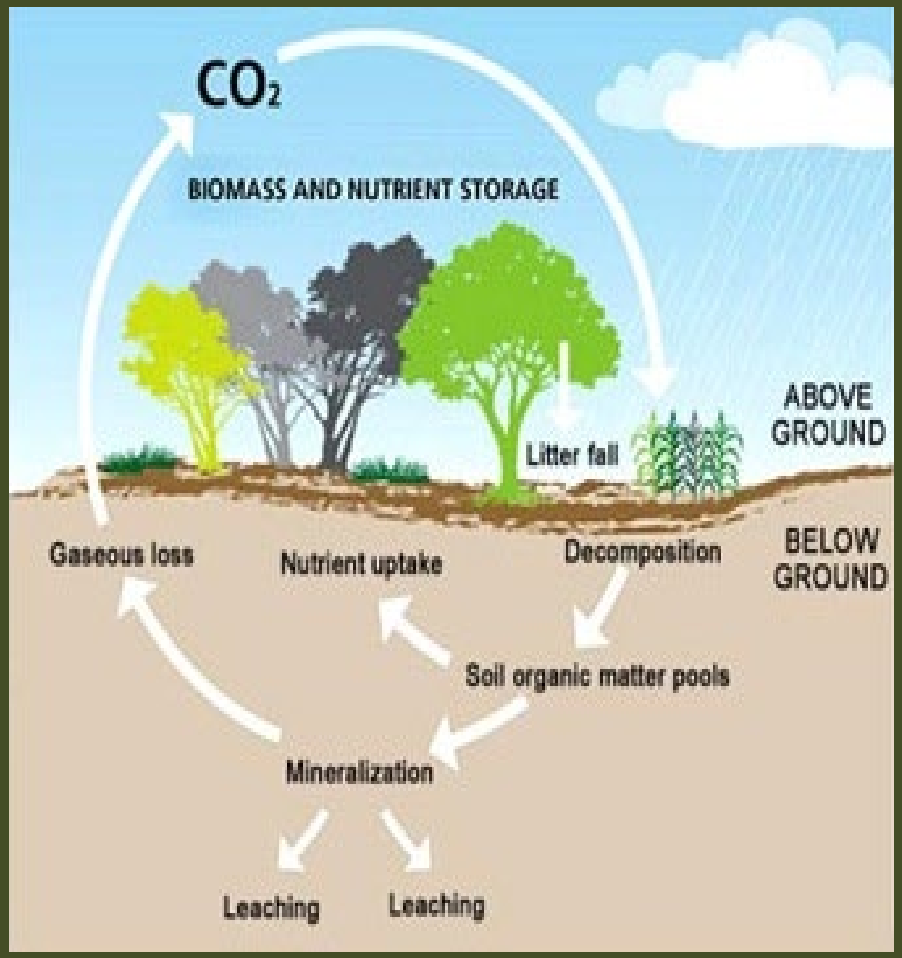


Building resilience: Water, infrastructure

- Develop sustainable road systems
- Up-size culverts to match projected streamflow
- Reintroduce beavers to retain water
- Use projected stream temperatures to set priorities for fish conservation

Forests play a critical role in removing CO_2 from the atmosphere

- Net CO_2 sequestration from forest land offsets 14% of CO_2 emissions in the U.S. (Domke et al. 2021)
- Forests are projected to continue to sequester C but at declining rates, affected by land use and aging forests
- Increasing frequency and extent of disturbances will make it difficult to retain carbon within some forests



Building resilience: Carbon sequestration

Retain forests on the landscape, keep them healthy

- Minimize extreme fire and insect mortality
- Increase drought resilience
- Protect soils (55% of C stored in soils)
- Recognize the value of ecosystem services to reduce forest loss to other land uses

Increase forests on the landscape

- Regeneration of understocked forest could increase C sequestration by 20% (Domke et al. 2021)

Some challenges and opportunities…

- Keeping forests as forests (regeneration after disturbances, slowing pace of land-use change)
- Managing for resilience and transitions (restoration is not enough)
- Managing forests for water supply as a primary ecosystem service
- Increasing the pace and scale of climate-smart management

Key Points Revisited….

Climate change effects are already evident in some forests. We are on the cusp of additional and potentially more severe effects, primarily facilitated by increased frequency and magnitude of extreme weather events (drought, heavy rainfall, heat waves) and associated disturbances (insect outbreaks, wildfire).

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