

Climate change, vegetative responses and disturbances

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The US National Assessment of the impacts of climate variability and change was a stakeholder-driven process that began with this short list of questions for each region and sector:

- What are the current environmental stresses and issues?
- How might climate variability and change exacerbate or ameliorate existing problems?
- What adaptation options can build resilience to current stresses?
- What are the priority research and information needs?

In evaluating the impacts of climate change on natural and managed forests in the US many sources of information were drawn upon including published literature; data from long-term monitoring of climate, soils and vegetation; experiments in greenhouses, open-top chambers and in the field; and ecological modeling using several types of models. This information was used to help assess the impacts of climate variability and change on forest productivity, diversity, disturbances, and socioeconomic conditions.

The ecological models used in the assessment were:

Biogeochemical – VEMAP models (Tem, Century, Biome-BGC)

Biogeographical – VEMAP model (MAPSS)

Dynamic Global Vegetation Models (MC1)

Statistical

Individual Species (Iverson et al., Bartlein and Shafer)

Taxa (Currie)

Forest Economic Model (FASOM)

Forest Productivity and C Storage

For forest productivity, the model results suggest greater C storage in US forests during the coming decades, but that under the hotter and drier Canadian Climate Model scenario, C storage declines in the southern US (see Figure 1)

[insert slide 7 from powerpoint - Net C storage 2025-2034 for 4 models]

Another finding from the models is that vegetation C is less responsive to climate change only than to the combination of climatic warming and additional rising atmospheric CO₂ levels. The models also found that vegetation carbon storage response was sensitive to species shifts and fire, with fire leading to a decline in C storage under the Canadian scenario.

Major findings with regard to the effect of climate change on forest process include:

Productivity

Under elevated CO₂, forest productivity increases, subject to moisture and nutrient conditions.

Under warmer scenarios, drought and fire increase.

Under climate change only, productivity declines.

Carbon Storage

Modest warming could increase carbon storage.

Water Use

Runoff could increase in some areas of the US.

Biodiversity

With regard to climate change effects on forest biodiversity, the models suggest major species shifts in US forests (see Figure 2). Findings include the following.

[insert Figure showing shifts in dominant forest types - which one?]

Species Habitat Shifts

- Species favored by cool environments shift north.
- Aspen, sugar maple, fir, red pine, birch, and cedar decrease by at least 90%.

Geographic Distribution of Forests

- Western alpine, sub-alpine spruce/fir and aspen decline in area.
- Oak/hickory and oak/pine expand in the East.
- Ponderosa pine expands in the West.

Confounding Factors

- Land use changes, Air quality, Invasives, Species Dispersal

Disturbances

There is limited understanding of the interactions between forest disturbances and climate change, though this is an area of considerable concern. Currently, the disturbances that impact the largest amount of forest land are drought, exotic species, and insects and pathogens. Fire, hurricanes and tornadoes also impact significant amounts of land. There are both natural and human causes of disturbance, with some agents of disturbance having natural causes (ice storms, wind events, droughts, and hurricanes) while others are a combination of natural and human influences (introduced species, landslides, fire, and pathogens and insects).

Drought is a particularly widespread disturbance. Western forests have annual seasonal droughts, Central US forest typically experience late-summer droughts, and Eastern forests suffer from more random droughts. Rising air temperatures could exacerbate these conditions because even though precipitation is projected to increase in a warming climate, higher air temperatures increase evaporation, and this drying effect may outpace the greater precipitation in many areas.

Model results are mixed on this question. Under the Hadley scenario, vegetation carbon increases in response to warmer temperatures and greater precipitation. But under the hotter and drier Canadian climate model scenario, vegetation carbon decreases throughout the Central and Southern US (see Figure 3).

[insert Figure, 2 models projections for end of century change in veg C]

Especially with the added stresses of climate change, the importance of good forest management is central. Strategies for dealing with disturbance effects on forests under climate change include:

- Managing the System before the Disturbance

 - Altering Forest Structure (tree spacing)

 - Changing Species Composition

- Managing the Disturbance

 - Reduce the opportunity for the disturbance to occur

- Managing Recovery

 - To speed recovery – reduce environmental stress

- Monitoring for Adaptive Management

Measure the state of the forests and determine interactions between disturbances.

Socioeconomic Impacts

Recreation and forestry were the principal areas of socioeconomic impact examined in the National Assessment. With regard to recreation impacts, key findings include:

Outdoor recreation

- Impacts vary by type of recreation and location

Higher temperatures are likely to

- Shift summer activities northward

- Increase warm water fish production

- Decrease opportunities for cold water species

Influences on skiing

- Increased temperatures; snow melt, rain

- Water availability could increase

- Energy costs significant in snow-making

- Greatest impact in marginal areas

To evaluate the impacts of climate change on timber economics, the FASOM dynamic optimization model was utilized. This is a "smart farmer" model, meaning that it assumes that all known adaptations will be used to minimize impacts. Given this, the findings suggest that at the national scale there will be little impact because the system is adaptable. However, a more detailed look suggests that producer welfare declines while consumers benefit from increased inventories and reduced log prices.