Climate Change, Vegetation Responses, and Disturbances

Linda Joyce

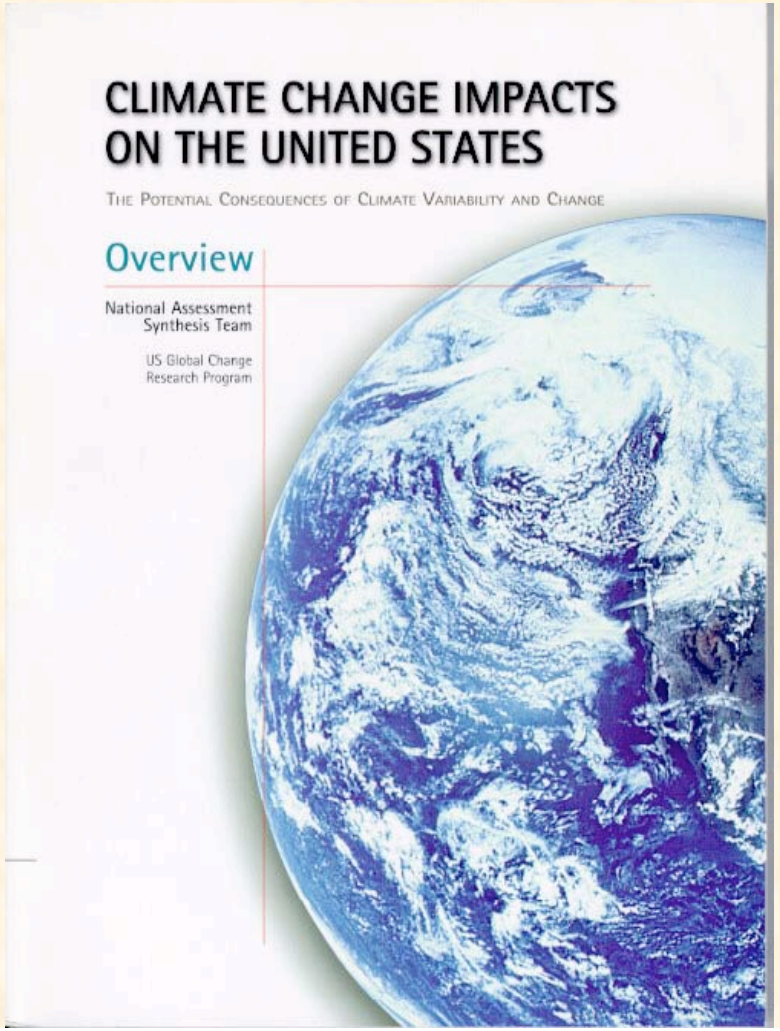
Member, National Assessment Synthesis Team

John Aber

Steve McNulty

Forest Sector Co-Chairs

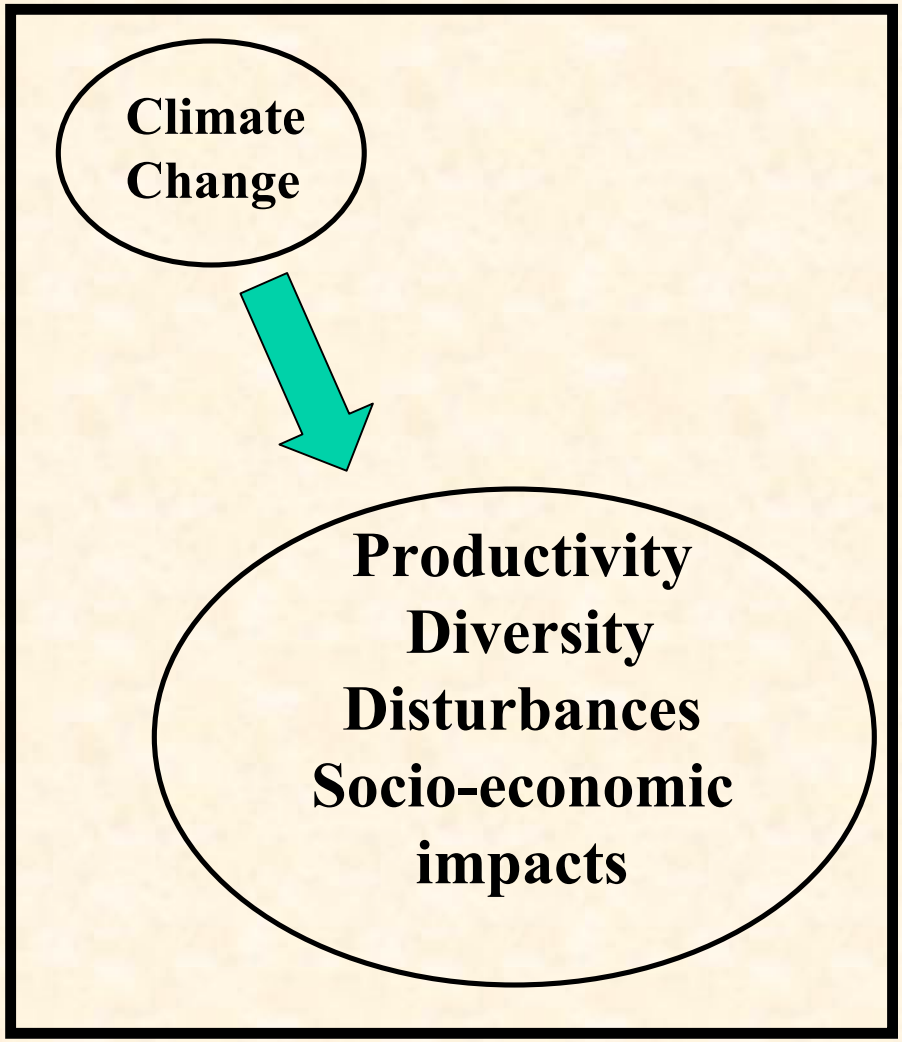
And many others



The Short List of Questions
National Assessment

- **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?**

Climate Change and U.S. Natural and Managed Forests



- Sources of Information
  - Published Literature
  - Long-term Monitoring
    - Climate, soils
    - Vegetation
  - Experimentation
    - Greenhouse
    - Field, open-top chambers
  - Ecological Modeling
    - Several types of models

Ecological Models

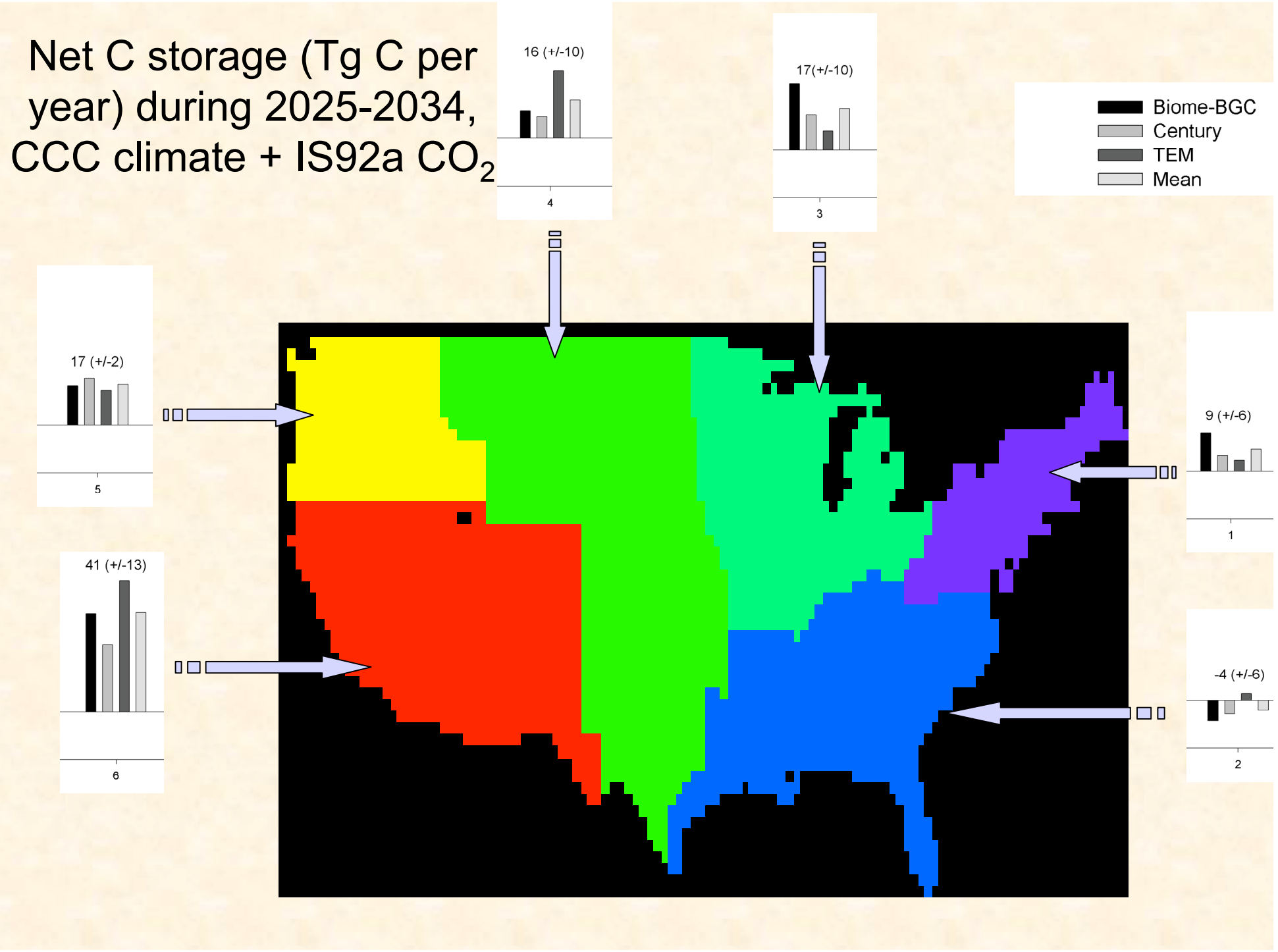
- **Biogeochemical – 'VEMAP' models**
  - Tem, Century, Biome-BGC
- **Biogeographical – 'VEMAP' model**
  - MAPSS
- **Dynamic Global Vegetation Models**
  - MC1
- **Statistical**
  - Individual Species -- Iverson et al, Bartlein and Shafer
  - Taxa, Currie
- **Forest Economic Model --** FASOM

Climate Change and Forest Productivity

Positive Responses of Vegetation Carbon Storage to Transient Climate and Elevated Carbon Dioxide

		Hadley	Canadian
Model	Simulations	2090-2099	2090-2099
TEM	**Climate-CO_2**	**28**	**33**
Century	**Climate-CO_2**	**14**	**13**
Biome-BGC	**Climate-CO_2**	**13**	**11**

Net C storage (Tg C per year) during 2025-2034, CCC climate + IS92a CO_2



Vegetation Carbon Storage
Less Responsive to Climate Only

		Hadley	Canadian
Model	Simulations	2090-2099	2090-2099
TEM	**Climate-CO_2** **Climate**	**28** **12**	**33** **-3**
Century	**Climate-CO_2** **Climate**	**14** **10**	**13** **8**
Biome-BGC	**Climate-CO_2** **Climate**	**13** **3**	**11** **-6**

Vegetation Carbon Storage Response Sensitive to Species Shifts and Fire

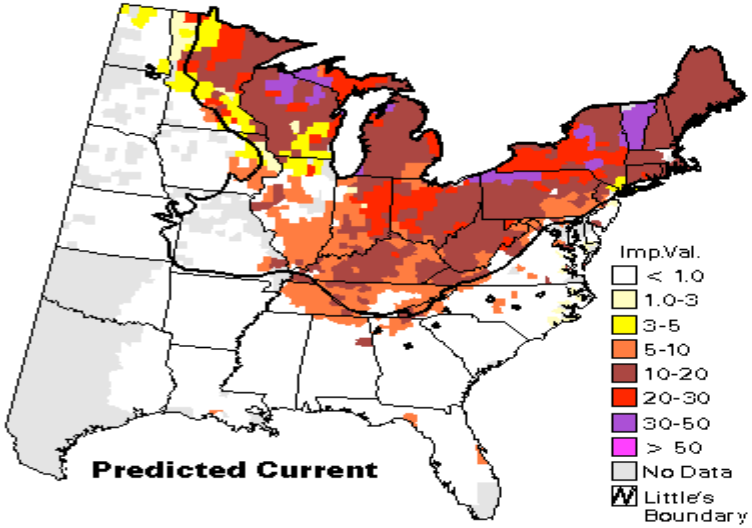
		Hadley	Canadian
Model	Simulations	2090-2099	2090-2099
TEM	**Climate-CO_2** **Climate**	**28** **12**	**33** **-3**
Century	**Climate-CO_2** **Climate**	**14** **10**	**13** **8**
Biome-BGC	**Climate-CO_2** **Climate**	**13** **3**	**11** **-6**
MC1	**Climate-CO_2 -Fire** **Climate-Fire**	**26** **18**	**-10** **-16**

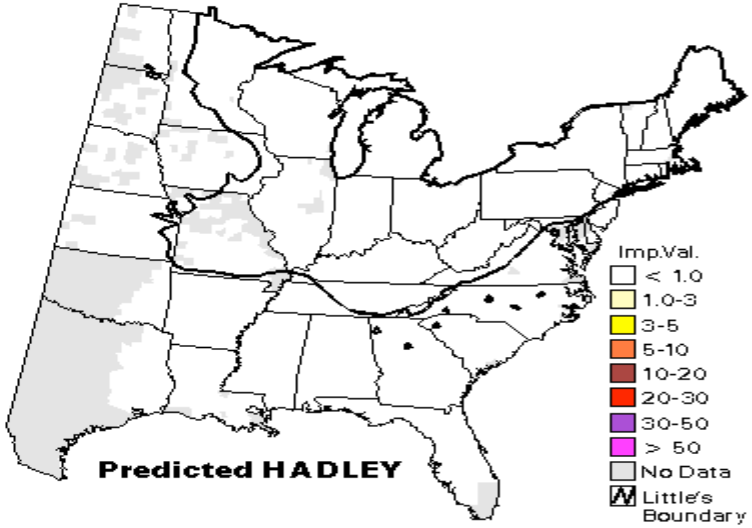
Climate Change and Forest Processes

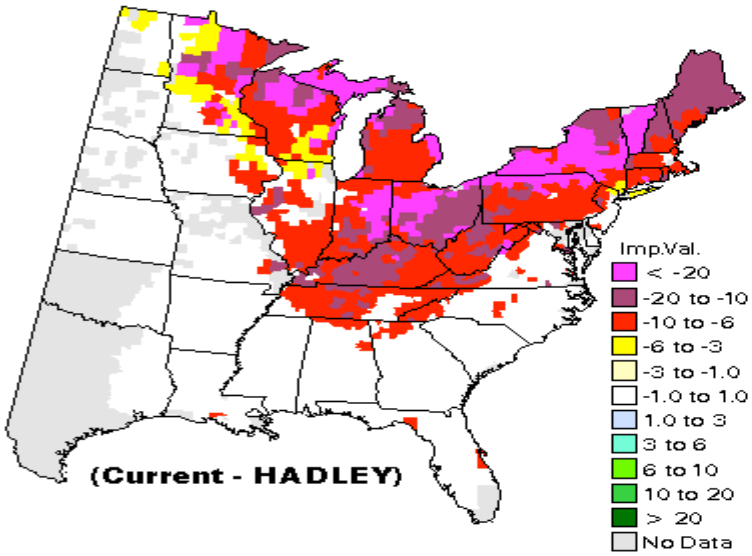
- **Productivity**
  - Under Elevated CO_2, forest productivity increases, subject to moisture and nutrient conditions
  - Under warmer scenarios, increased drought, fire
  - Under Climate Only changes, productivity declines
- **Carbon Storage**
  - Modest warming could increase carbon storage
- **Water Use**
  - Runoff could increase in areas of the US

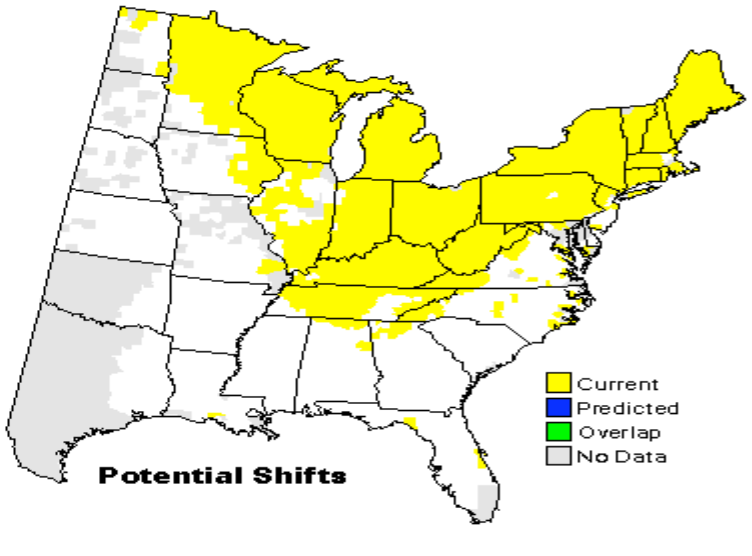
Climate Change and Biodiversity

Acer saccharum

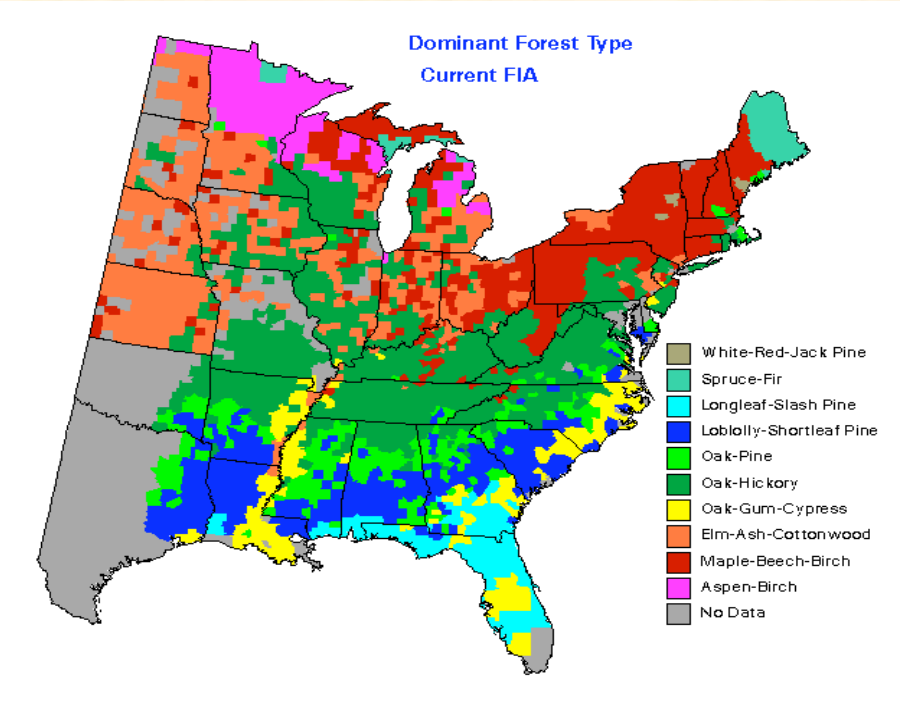


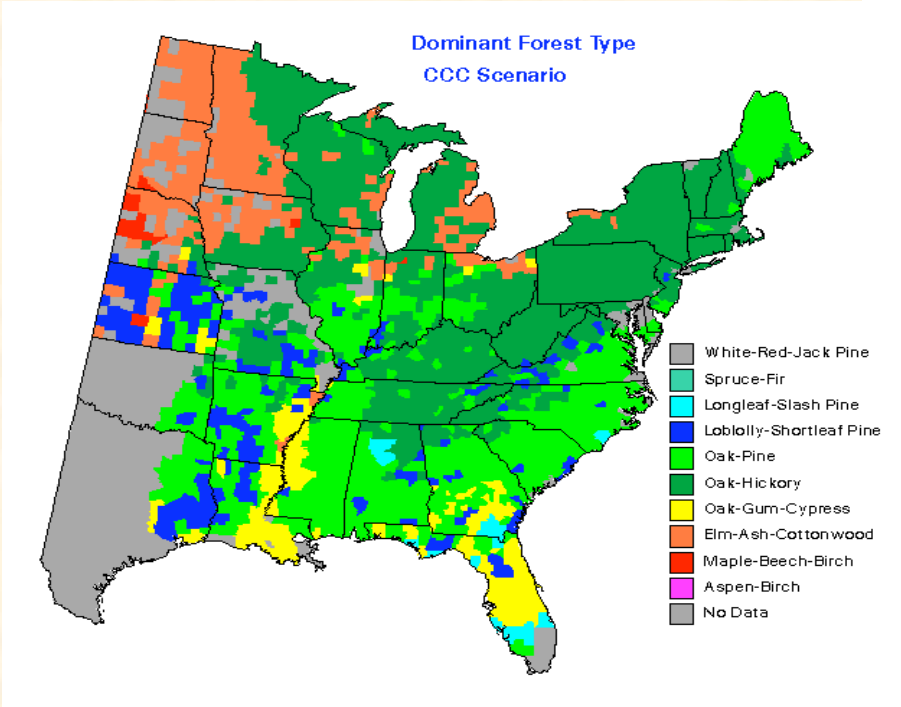




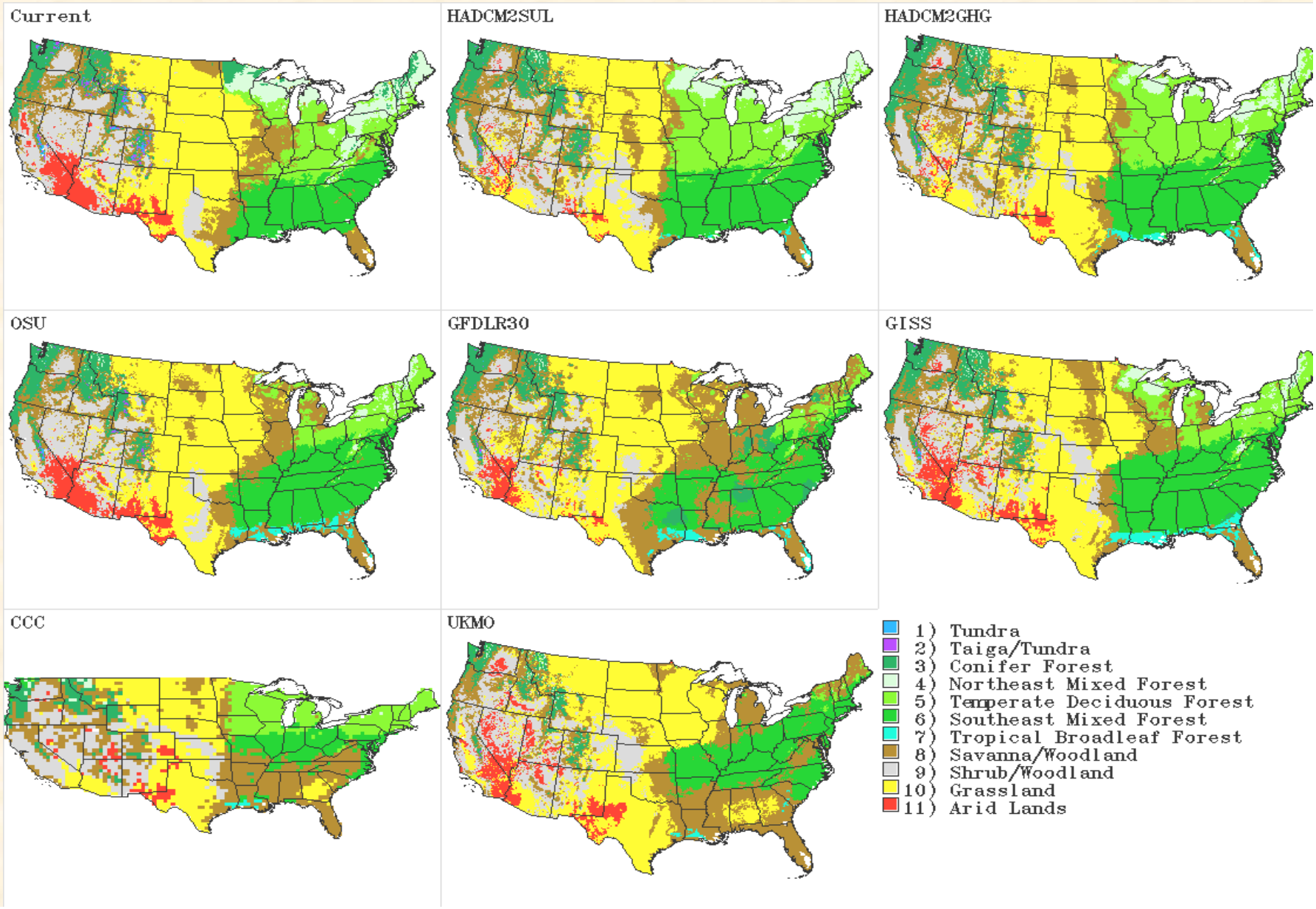


Climate Change and Distribution of Forest Types





Changes in Forest Distribution

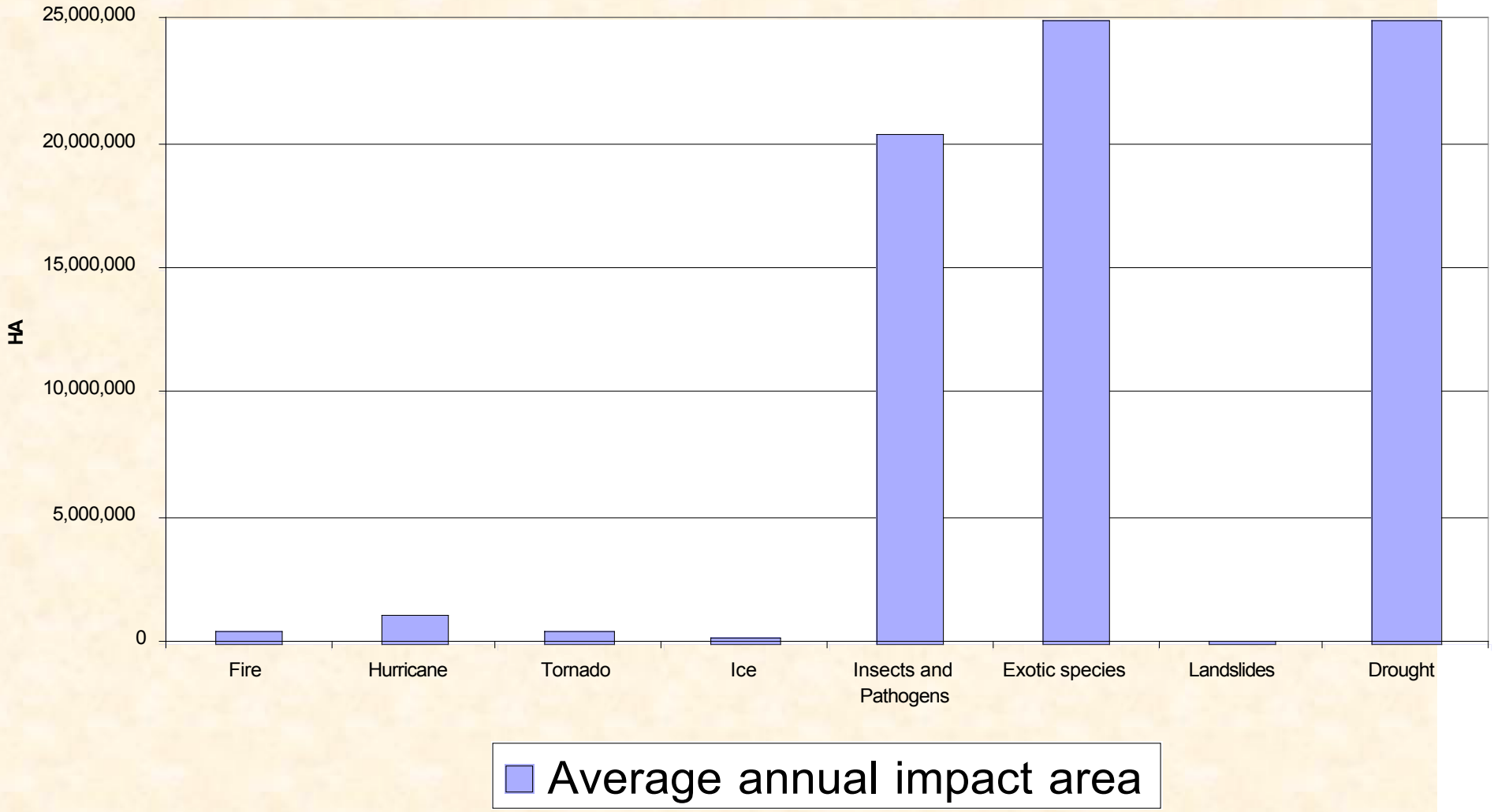


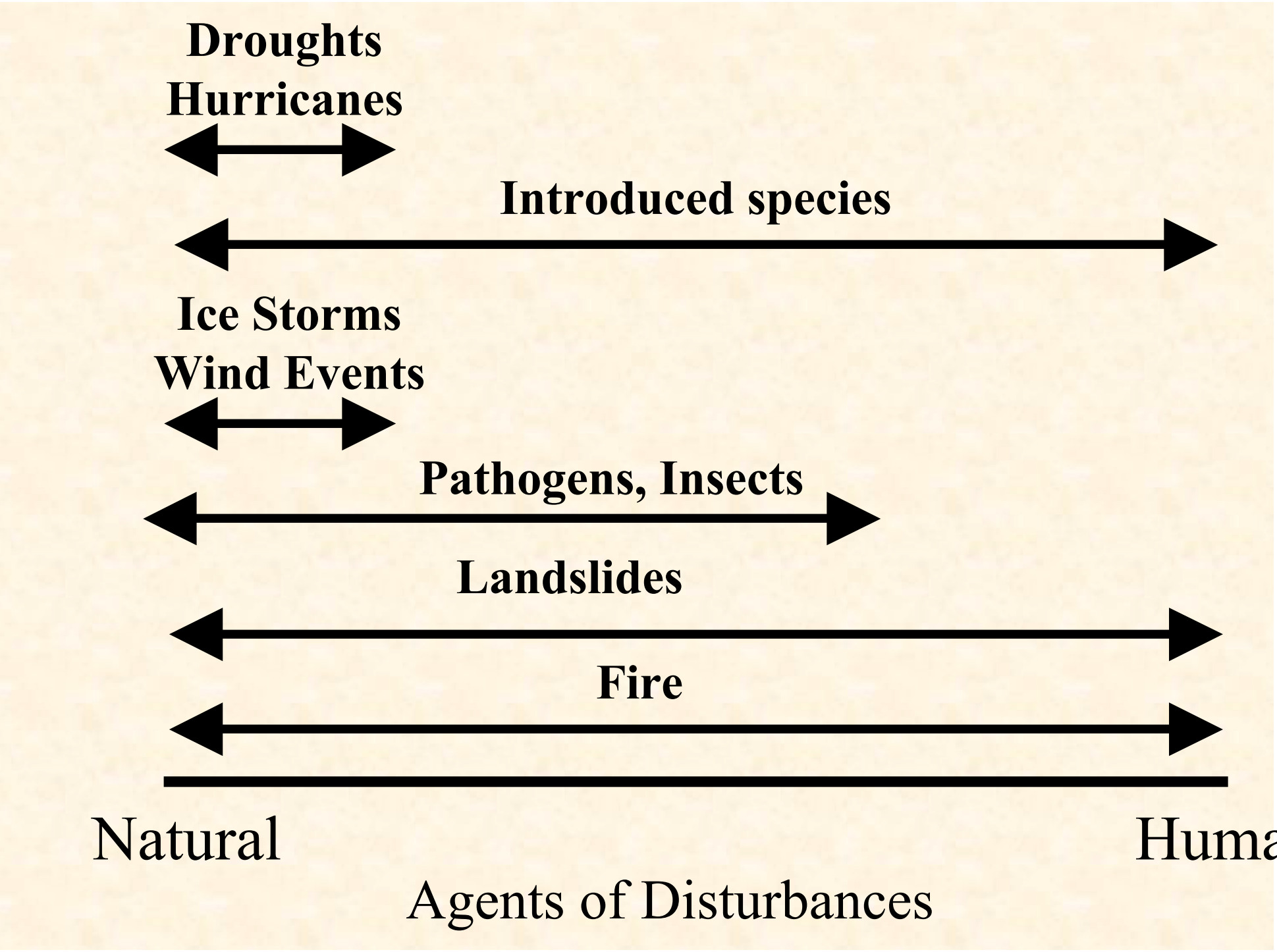
Climate Change and Forest Biodiversity

- 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, subalpine 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 Disperal

Climate Change and Disturbances

Relative Areal Extent of Current Disturbances in the U.S.

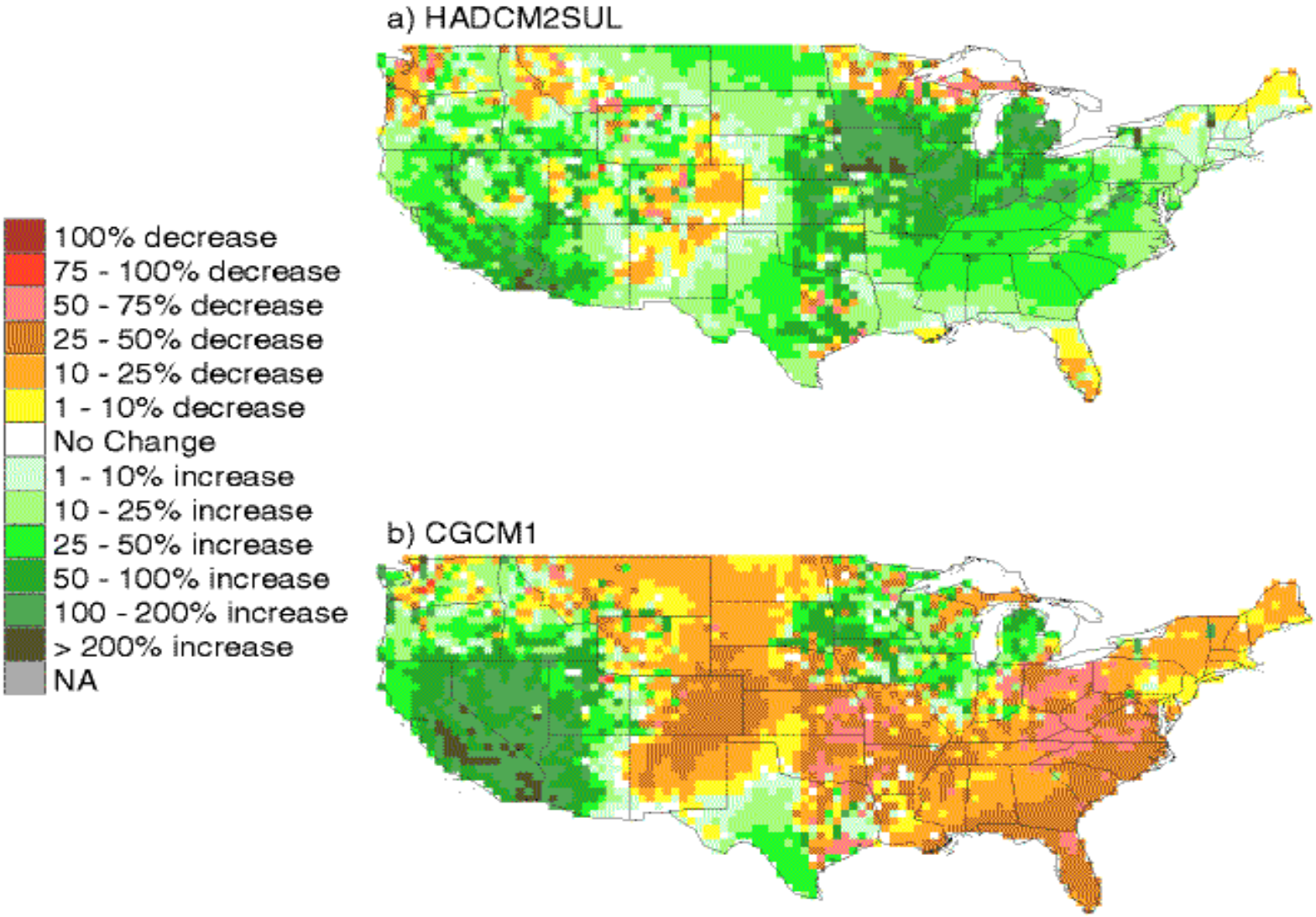



Droughts
Hurricanes
Introduced species
Ice Storms
Wind Events
Pathogens, Insects
Landslides
Fire
Natural
Human
Agents of Disturbances

Droughts and Forests

- Western Forests
  - Annual Seasonal Droughts
- Central US
  - Late-summer droughts
- Eastern Forests
  - Random Droughts

Percent Change Veg. Carbon 2090-2099

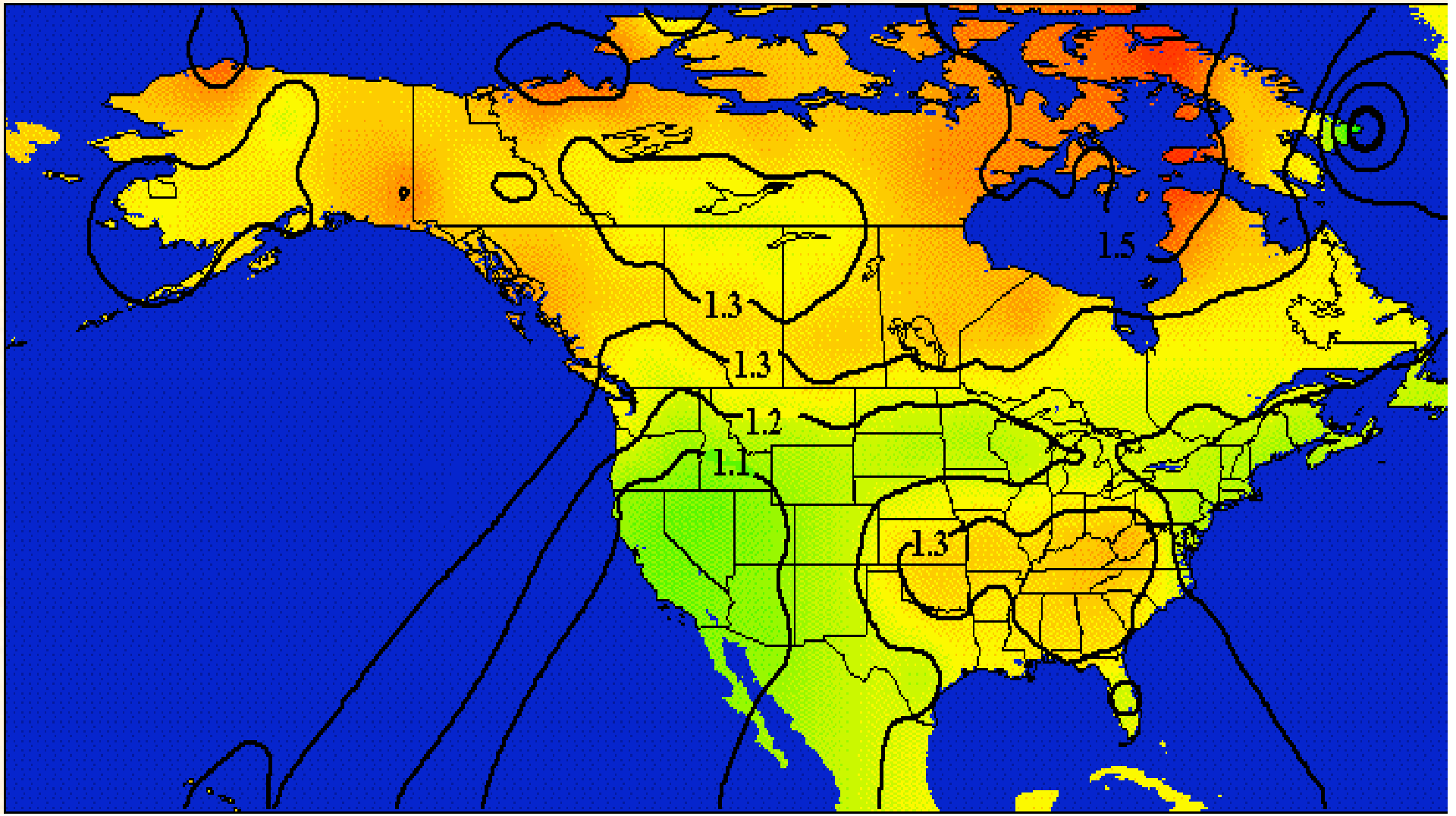


Fire Regime Components and Their Ecological Impacts

- Frequency influences selection pressure
- Size determines landscape patchiness
- Intensity influences amount of energy released
- Seasonality determines post-fire successional pathway of ecosystems
- Fire type influences the mosiac of post-fire plant communities
- Severity direct impacts on soils and underground plant parts

The ratio of the mean Seasonal Severity Rating (SSR) for 2060/present day (1985-94) using the Canadian GCM.

* The SSR is a rough indicator of area burned.
* Ratios > 1.0 mean an increase in SSR.



Other Fire-influencing Factors

Ignition agents

- May increase from increased cloud-to-ground lightning discharges with warming

Length of the fire season

- Longer growing seasons may imply longer fire season

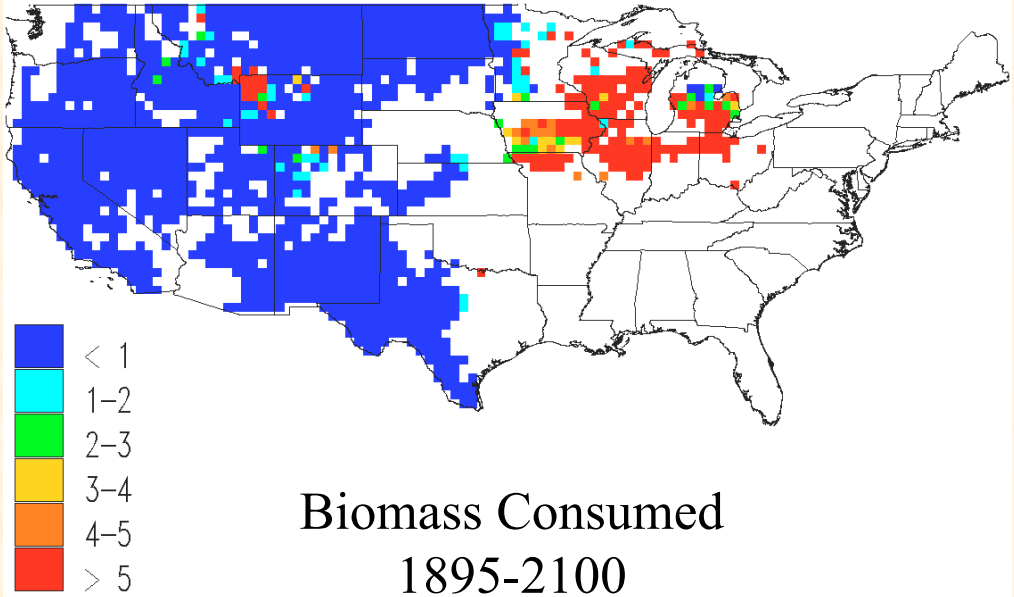
Vegetation characteristics

- Changes in ecosystem type, biomass

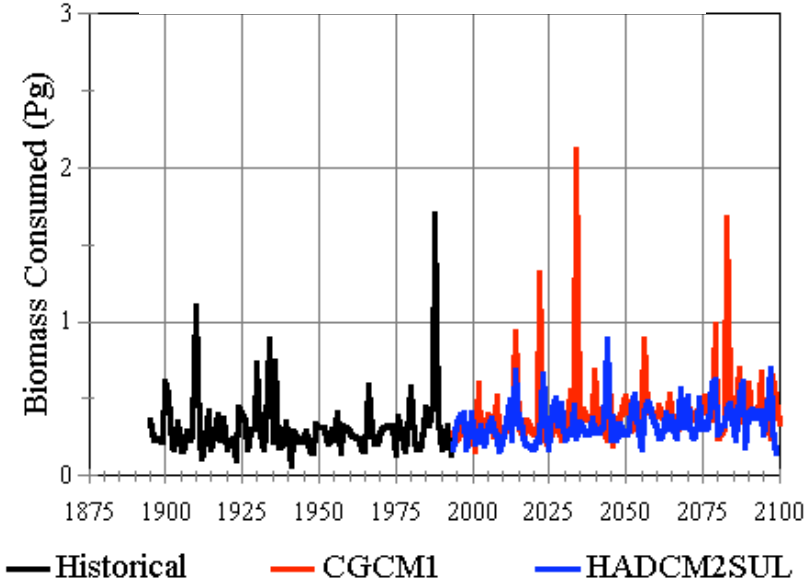
Human activities

- Fire management policies
- Landscape fragmentation

Biomass Consumed, 1988



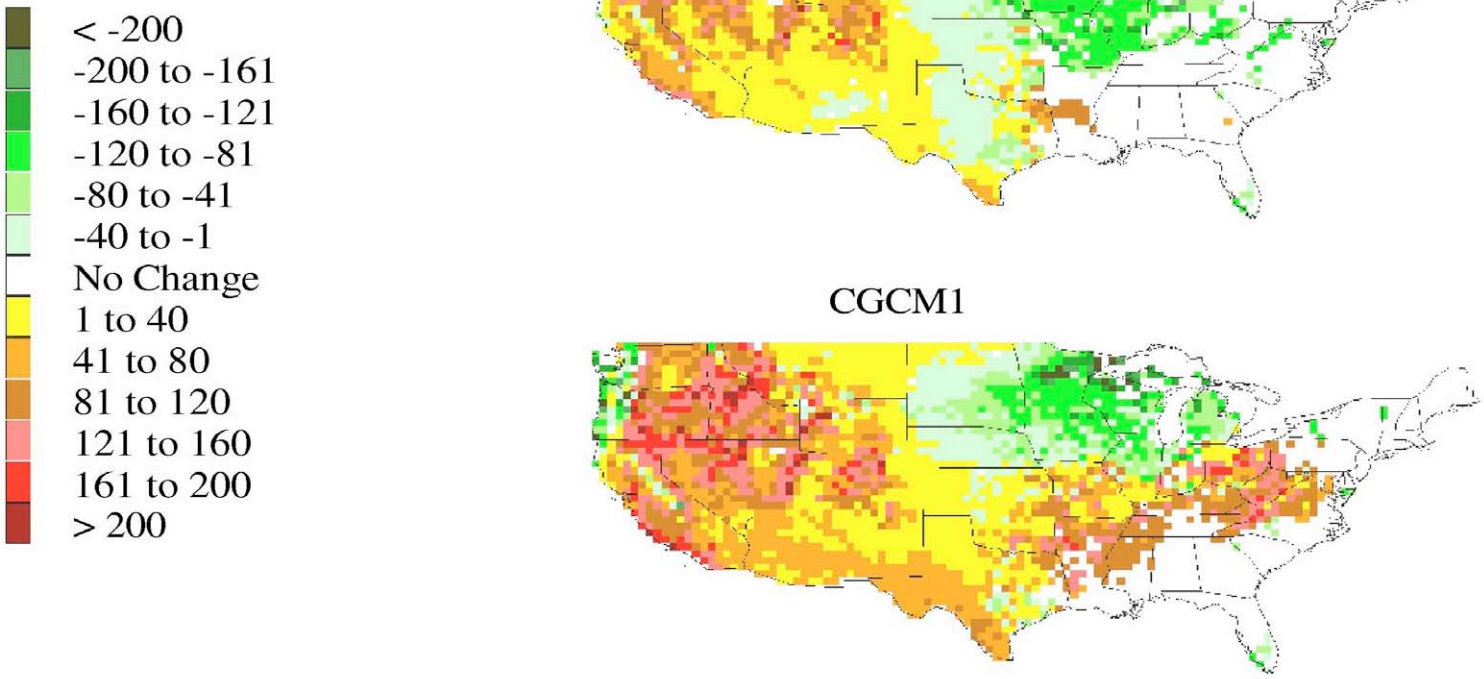
Biomass Consumed 1895-2100



Simulated Change in Average Annual Biomass Consumed by Fire
Future Century Compared to Past Century, g/m2

HADCM2SUL

CGCM1



Introduced Species and Global Change

- Insects – 360 non-indigenous insects in US forests
- Snails – Cause native tree snails extinctions
- Birds – Disperses introduced plants
- Reptiles– Brown tree snake, 10 of 12 native birds gone
- Plants – Introduced tree species; alter ecosystem dynamics
- Pathogens – More than 20 introduced plant pathogens in US forests
- Mammals – Examples include the wild boar

Climate Change and Disturbances
Limited Understanding

Basic information on the disturbance

Small scale wind events

Climatological conditions that initiate the disturbance

Genesis of ice storms is understood, but not ice formation

Impact of the disturbance

Ice storms, wind events, insects, diseases, introduced species

Interactions between disturbances; with climate, changing climate

Difficult to predict

Climate Change and Socio-economic Impacts

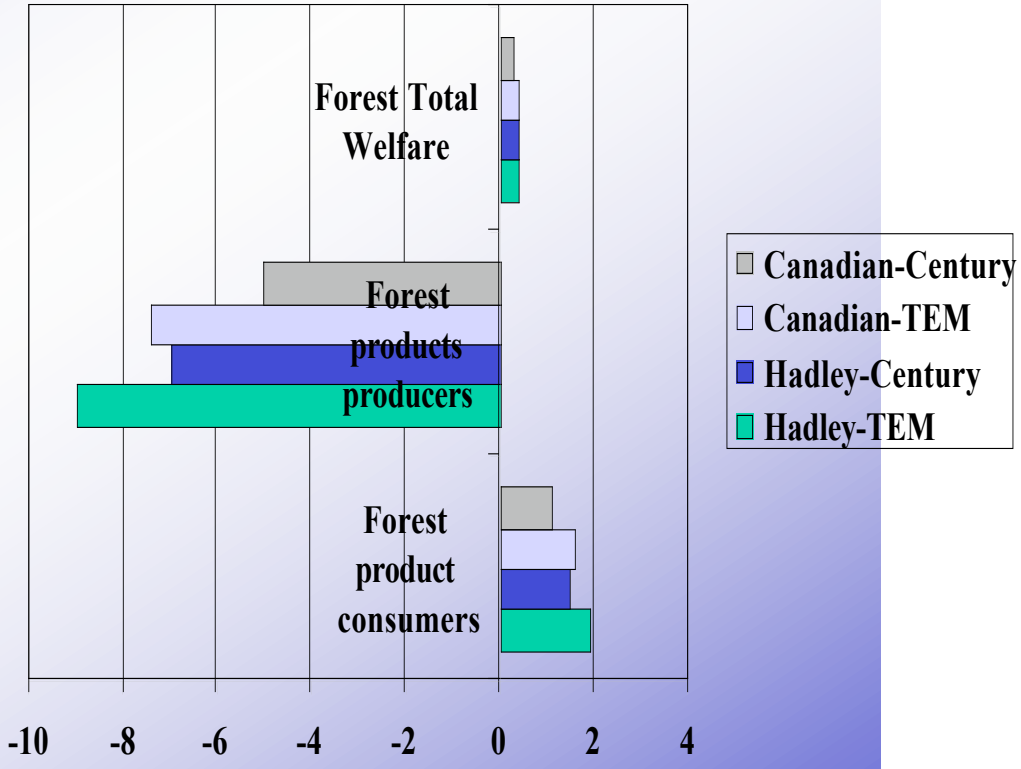
Recreation
Forestry

Climate Change and Recreation

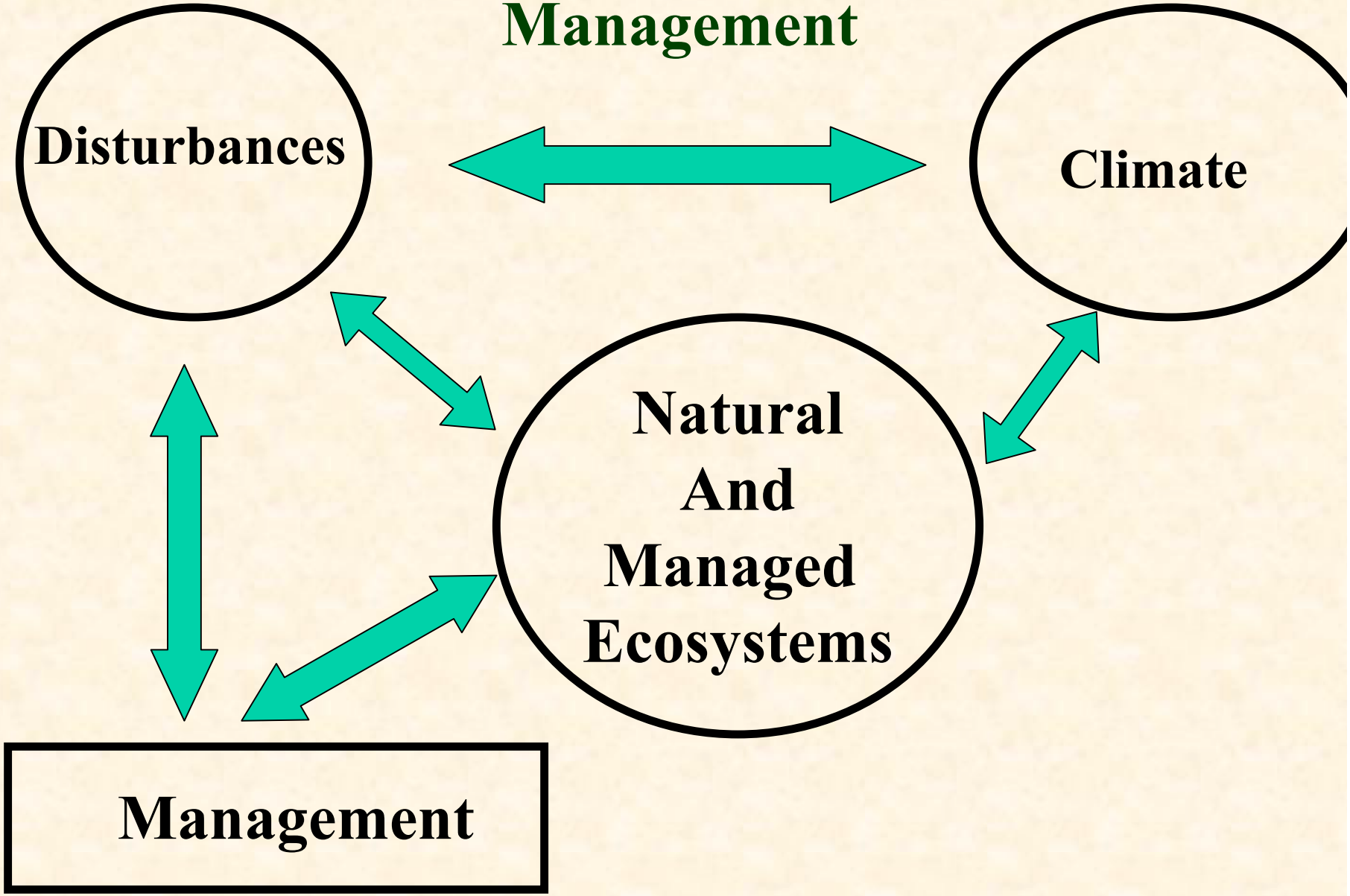
-Outdoor recreation
  -Impacts vary by type of recreation and location
-Higher temperatures are likely to
  -Shift summer activities northward
  -Increase warm water fish production
  -Decrease opportunities for cold water species
-Influences on skiing
  -Increased temperatures; snow melt, rain
  -Water availability could increase
  -Energy costs significant in snow-making
  -Greatest impact in marginal areas

Climate Change and Timber Economics

- Total Welfare Unchanged
  - Similar across scenarios
- Consumers Benefit
  - Increased inventories
  - Reductions in log prices
- Producer's welfare
  - Declines
- Land shifts between forestry and agriculture
- Non-climate factors (land use, international resource supply) will have greater impact



Dynamics of Ecosystems, Disturbances, Climate, and Management



Strategies for Dealing with Disturbance Effects on Forests under Climate Change

- 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