

Improving Resilience of Forest Ecosystems and Society to Climate Change and Extreme Events

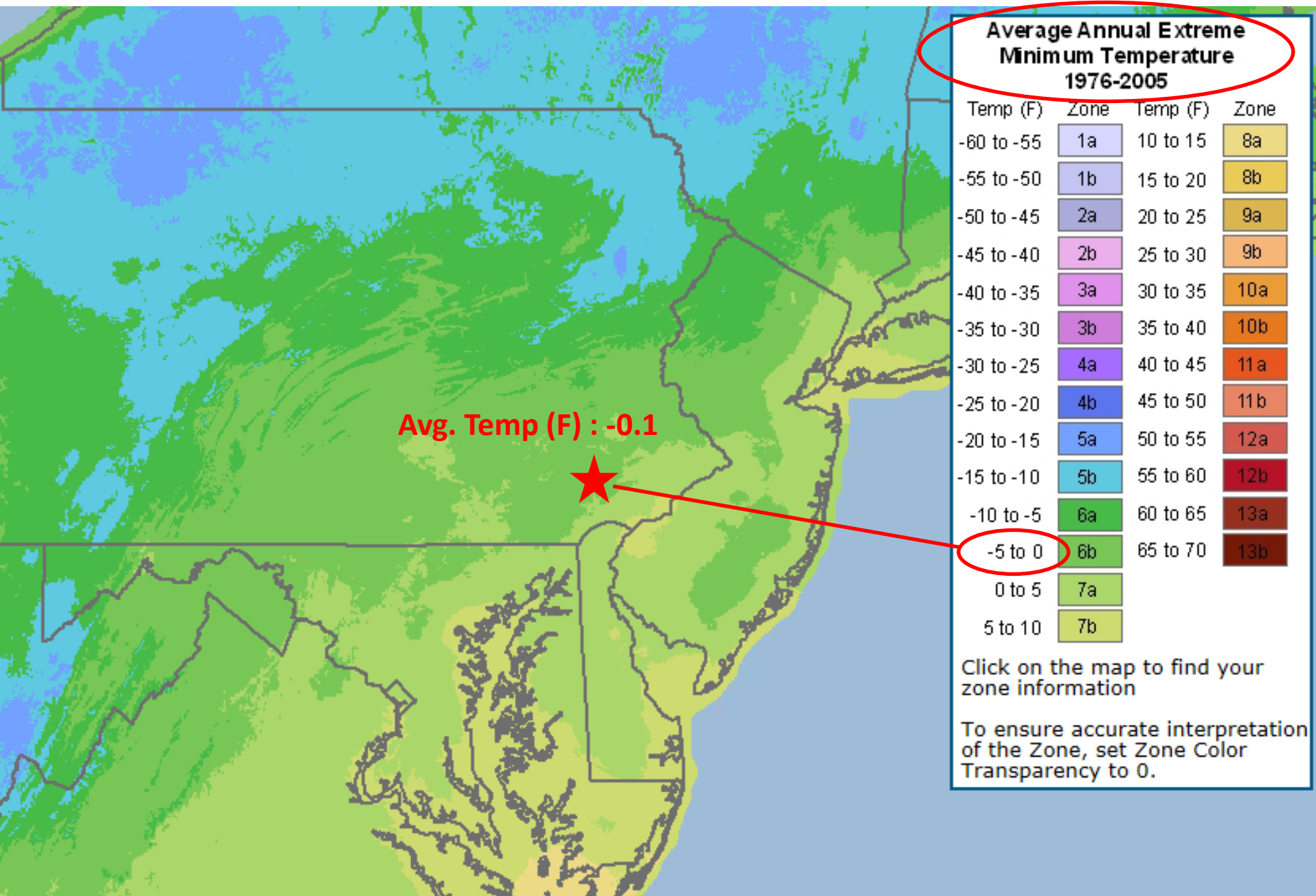


Richard Birdsey
U.S. Forest Service

Main Points

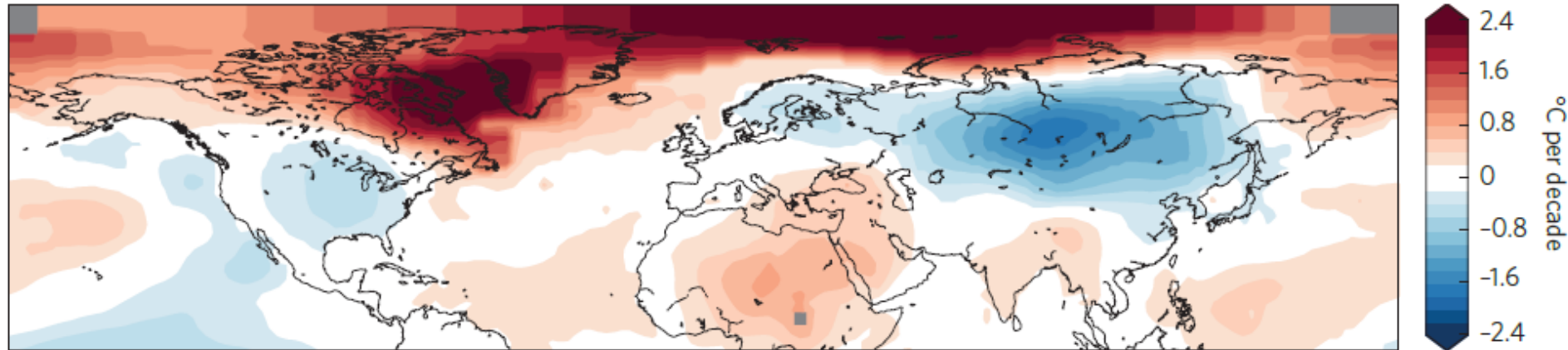
- Increase awareness of extreme events, their frequency, and their impacts.
- Is there a link between incidence and impacts of extreme events and climate change?
- How can we improve our ability to respond to extreme events and to understand their long-term impacts on forests?

USDA Plant Hardiness Zone Map



Winter Temperature Trends from 1990 to 2013

DJF surface temperature trends (1990–2013)



nature
geoscience

REVIEW ARTICLE

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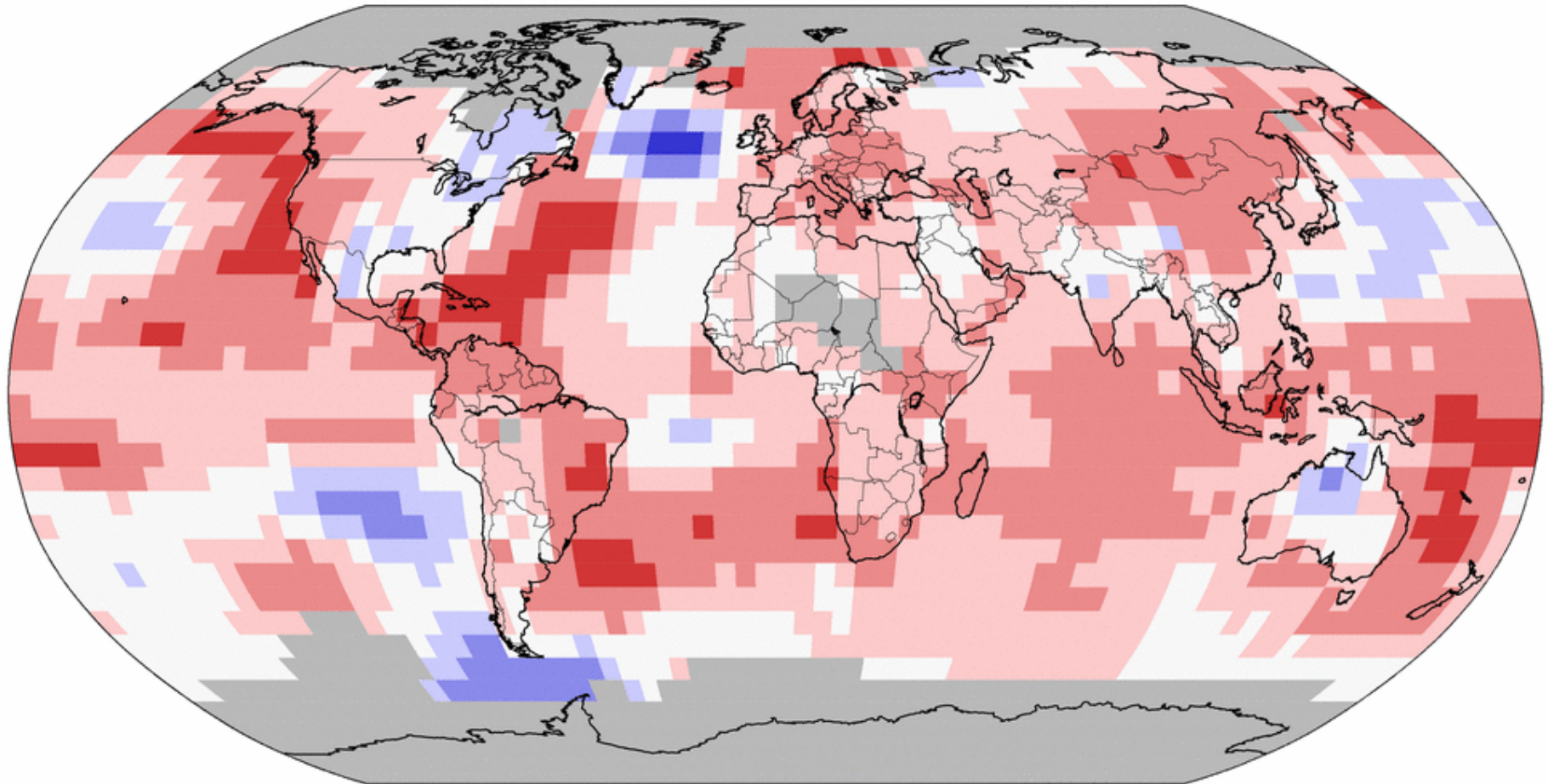
Recent Arctic amplification and extreme mid-latitude weather

Judah Cohen^{1*}, James A. Screen², Jason C. Furtado¹, Mathew Barlow^{3,4}, David Whittleston⁵,
Dim Coumou⁶, Jennifer Francis⁷, Klaus Dethloff⁸, Dara Entekhabi⁵, James Overland⁹ and Justin Jones¹

Land & Ocean Temperature Percentiles Jan 2015

NOAA's National Climatic Data Center

Data Source: GHCN-M version 3.2.2 & ERSST version 3b



**Record
Coldest**



**Much
Cooler than
Average**



**Cooler than
Average**



**Near
Average**



**Warmer than
Average**



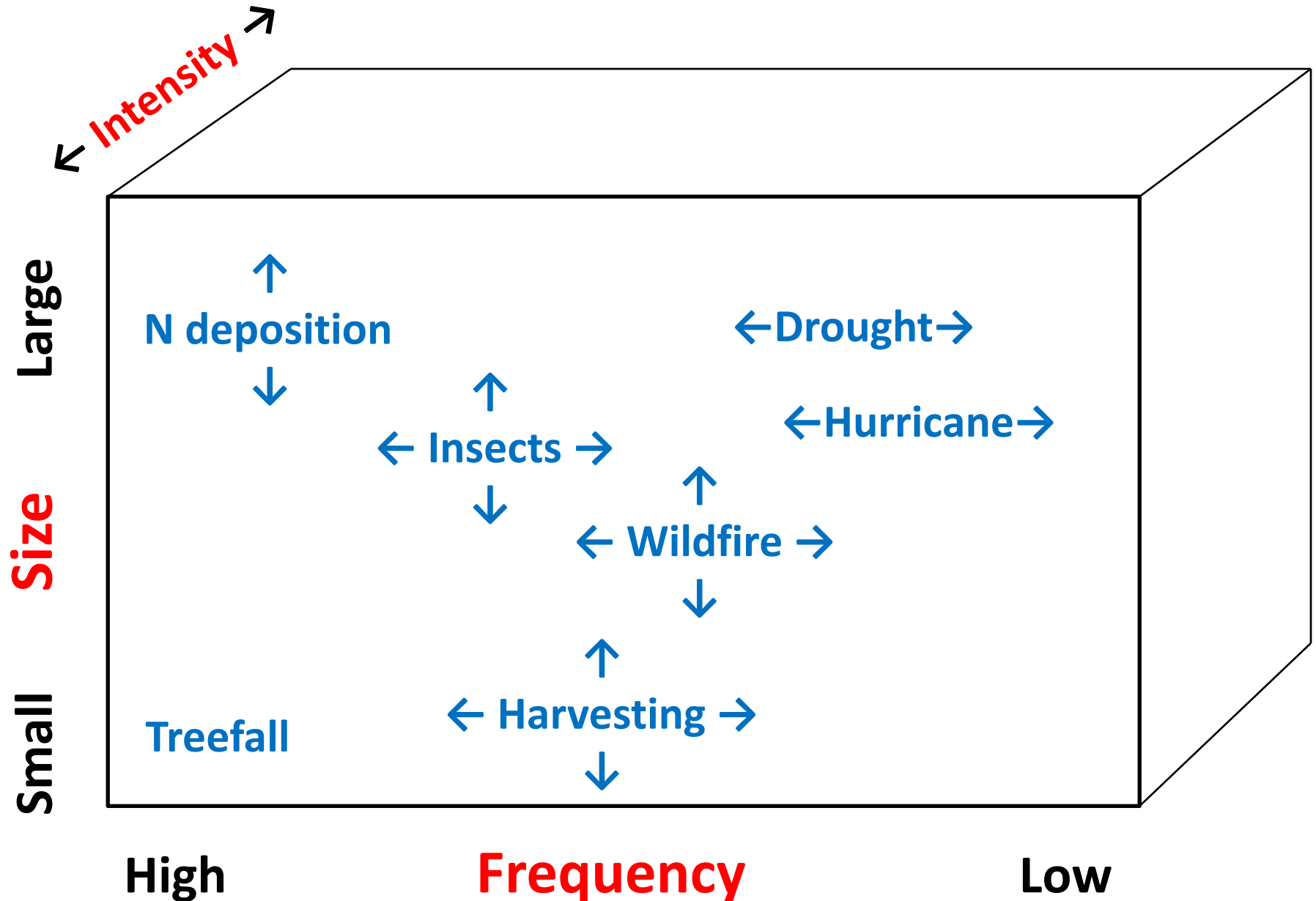
**Much
Warmer than
Average**



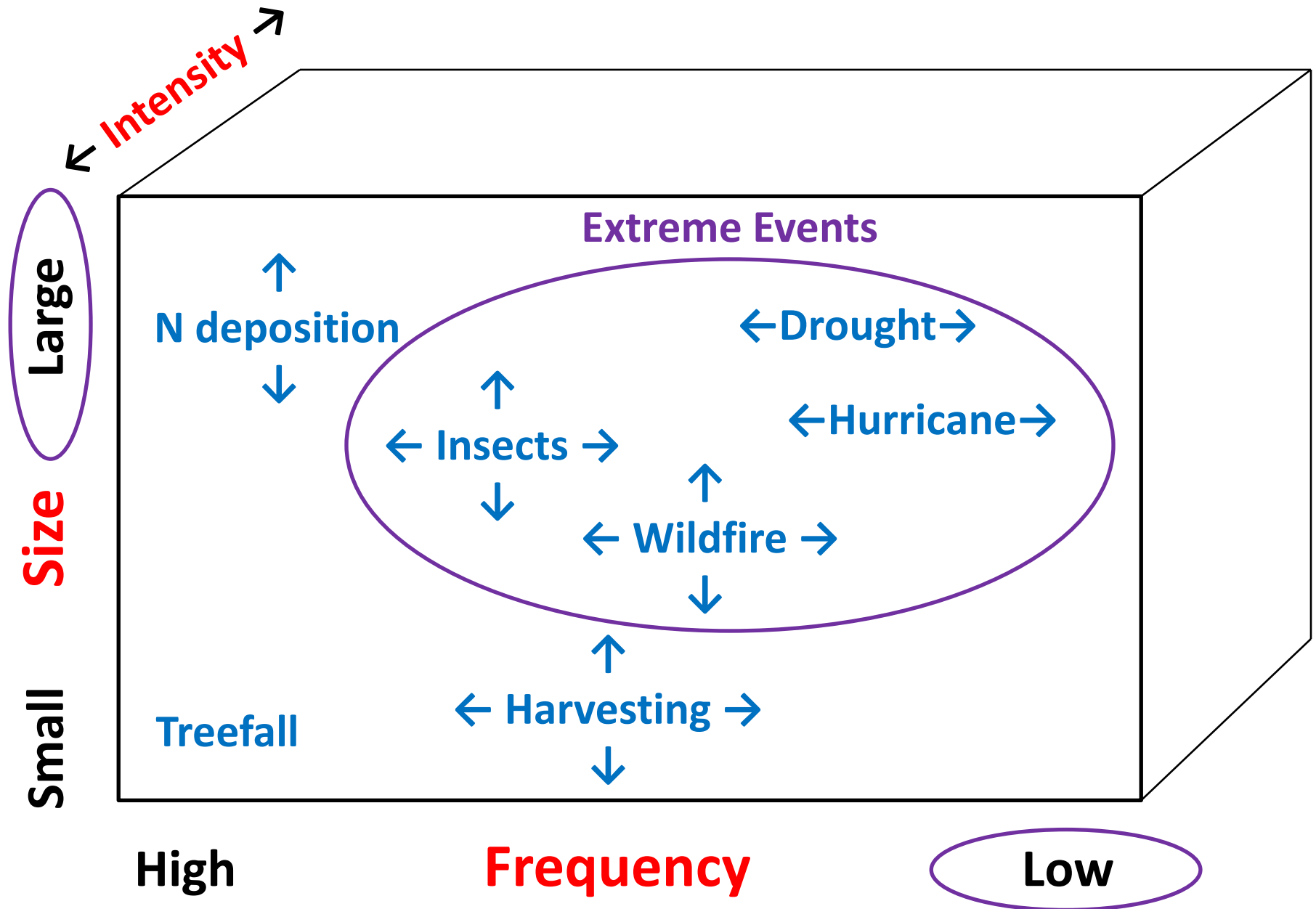
**Record
Warmest**



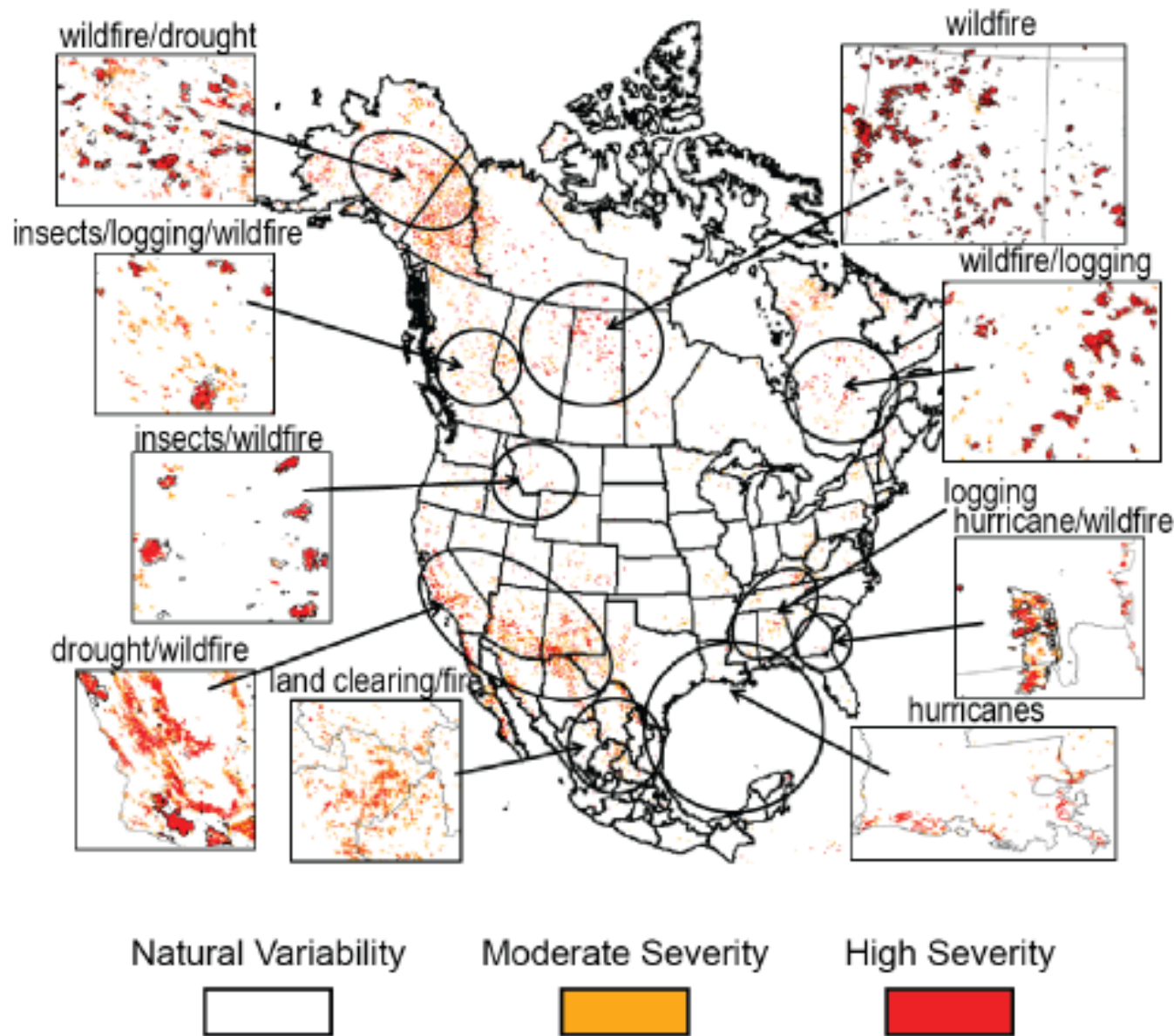
What is a disturbance?



What is a disturbance?



Forest Ecosystem Disturbances

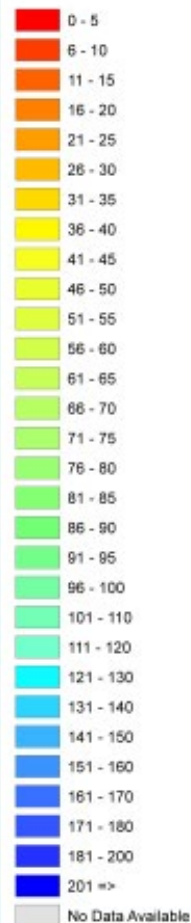


Is logging an extreme event?

How about deforestation?

Stand Age of Forested Areas for Canada and the United States

Stand Age of Forest in Years:



Almost all forests are recovering from a past disturbance...

Age = "time since disturbance"

Age Structure and Disturbance Legacy of North American Forests.
 Pan, Y. (1); Chen, J.M. (2); Birdsey, R. (1); McCullough, K. (1); He, L. (2); Deng, F. (2).
Biogeosciences, 8: 713-732, 2011.

1. Climate, Fire and Carbon Cycle Sciences, Northern Research Station, US Forest Service
 2. Department of Geography, University of Toronto

Most forests of the world are recovering from a past disturbance. It is well known that forest disturbances profoundly affect carbon stocks and fluxes in forest ecosystems, and it has been a great challenge to assess disturbance impacts on estimates of forest carbon budgets. Non-quantification or loss of CO₂ by forests after disturbance follows a predictable pattern with forest "recruits". Forest age, which is related to time since disturbance, is a useful surrogate variable for analyses of the impact of disturbance on forest carbon.

In this study, we compiled the first continental forest age map of North America by combining forest inventory data, historical fire data, optical satellite data and the dataset from M&G's Land Ecosystem Disturbance Adaptive Processing System (LEDA) project. A comparison map of the standardized deviation for age estimates was developed for quantifying uncertainty.

We discuss the significance of the disturbance legacy from the past, as represented by current forest age structure in different regions of the US and Canada. By analyzing the causes of disturbance from land management and natural fire scenarios and at various scales, we also show how such information can be used with inventory data for analyzing carbon management opportunities. By combining geographic information about forest age with estimated C dynamics by forest type, it is possible to conduct a complete and powerful analysis of the net CO₂ uptake by forests, and the potential for increasing (or decreasing) this rate as a result of direct human intervention in the disturbance regime.

Finally, we describe how the forest age data can be used in large-scale carbon modeling, both for land-based biogeochemical models and atmosphere-based transport models, in order to improve the spatial accuracy of carbon cycle simulations.

The Canada data is based upon 2004.
 The U.S. data is based upon 2006.

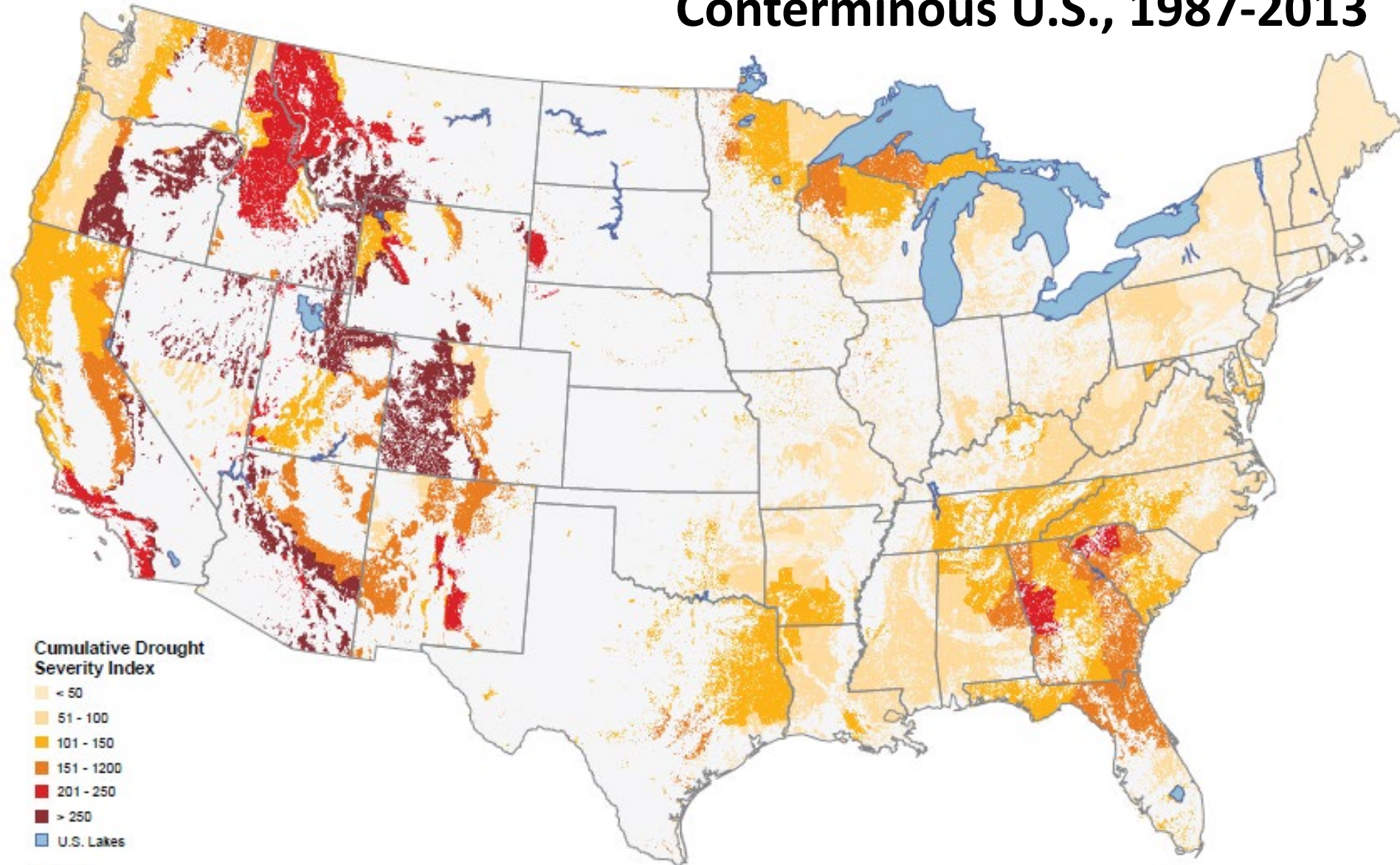
1 Kilometer Resolution
 Last revision 7/05/2011



33%

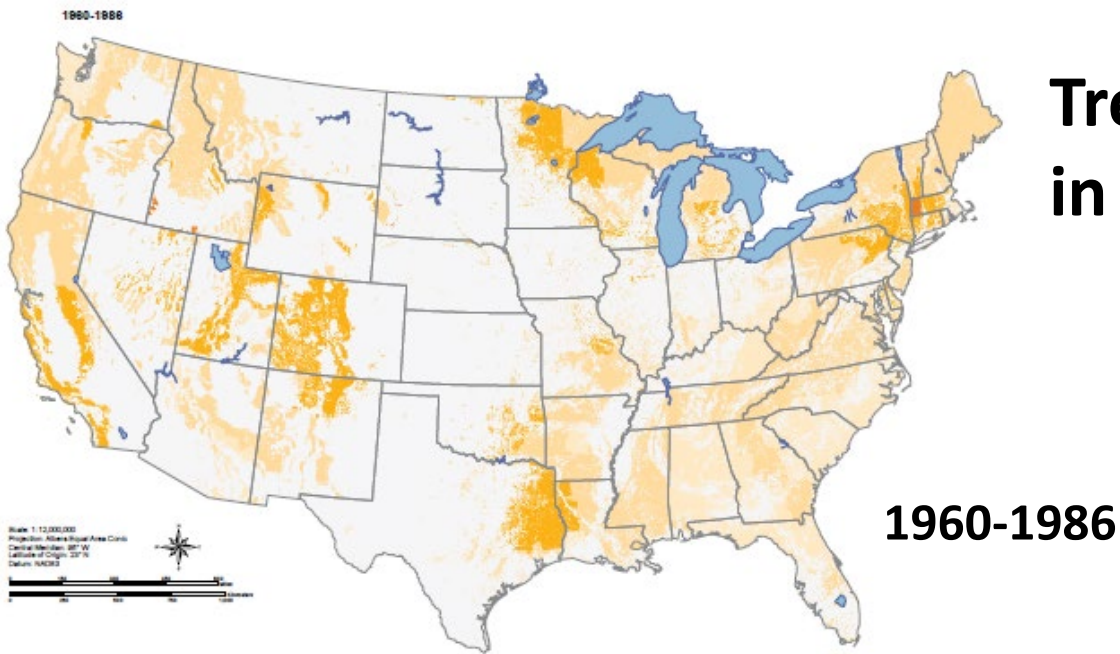
Drought Severity in the Conterminous U.S., 1987-2013

1987-2013

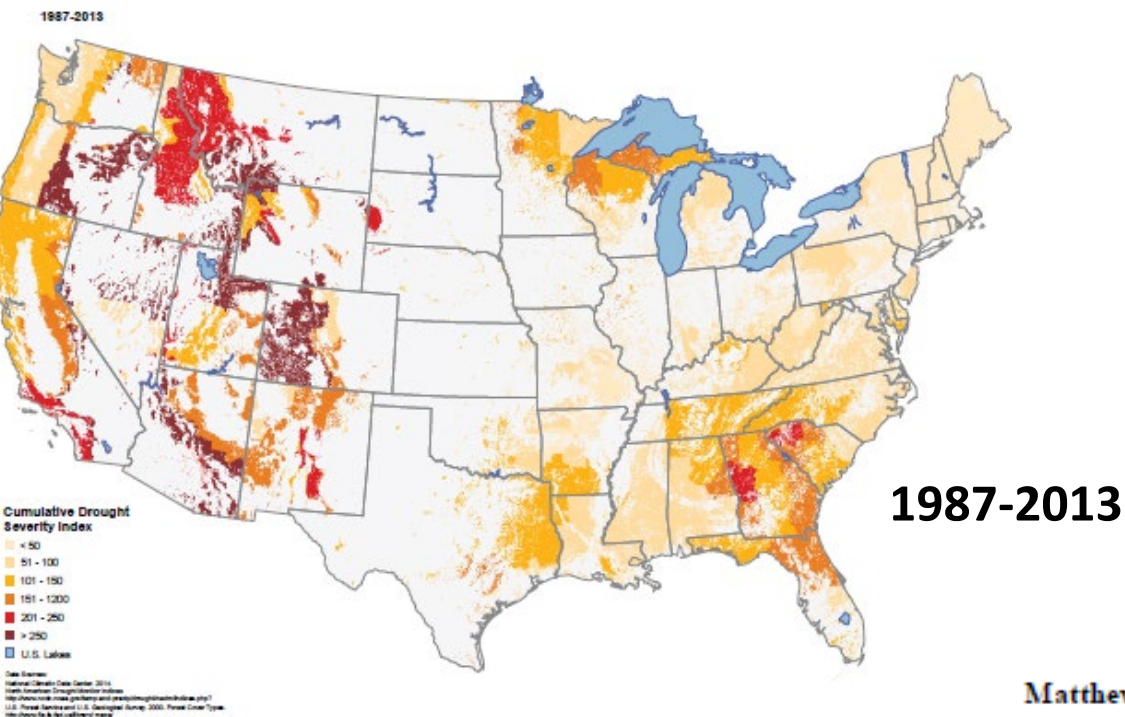


Data Sources:
National Climatic Data Center 2014.
North American Drought Monitor Indices
<http://www.ncdc.noaa.gov/temp-and-precip/droughtshedn/indices.php?>
U.S. Forest Service and U.S. Geological Survey 2000. Forest Cover Types.
<http://www.fs.fed.us/library/maps/>

Matthew P. Peters, Louis R. Iverson, and Stephen N. Matthews

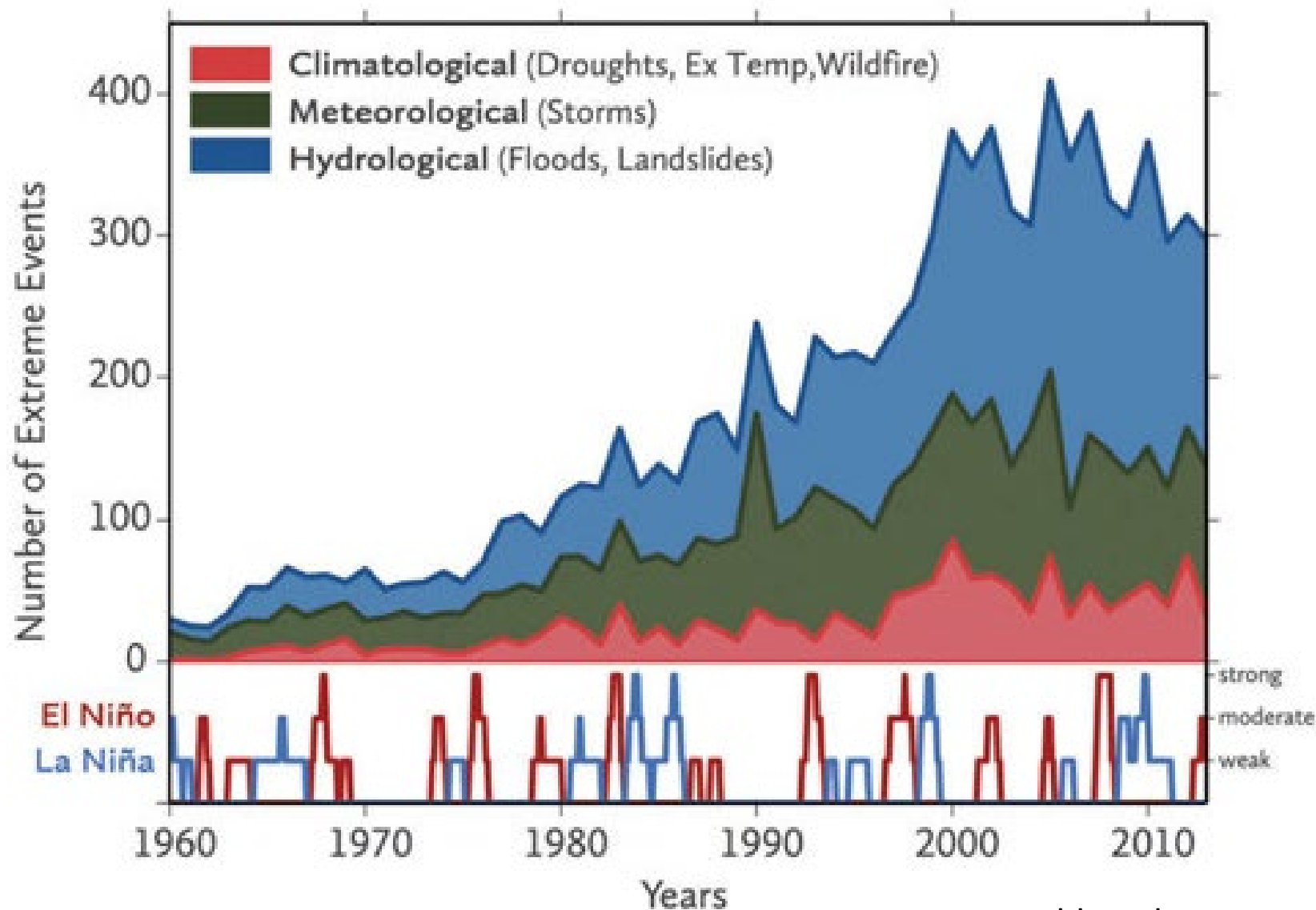


Trends in Drought Severity in the Conterminous U.S.



Matthew P. Peters, Louis R. Iverson, and Stephen N. Matthews

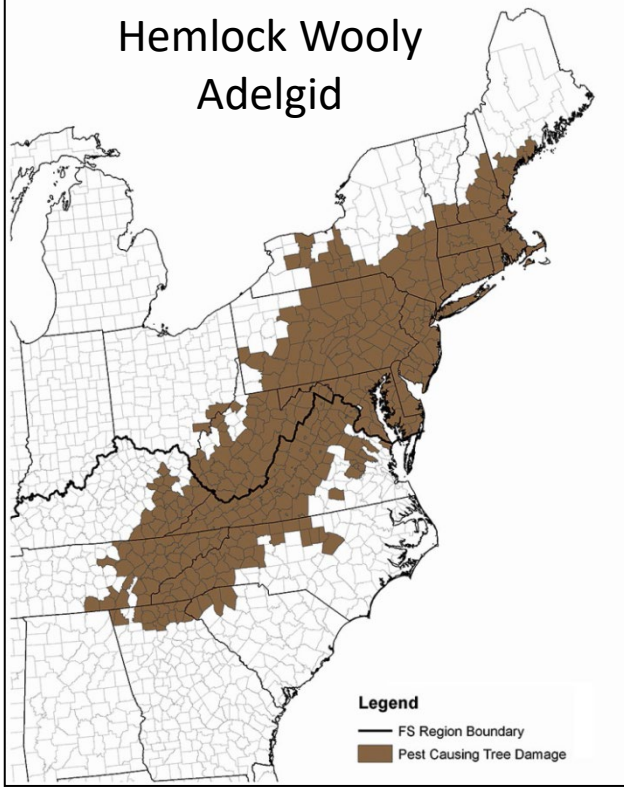
Number of Climate-related Disasters from 1960-2013 (Global)



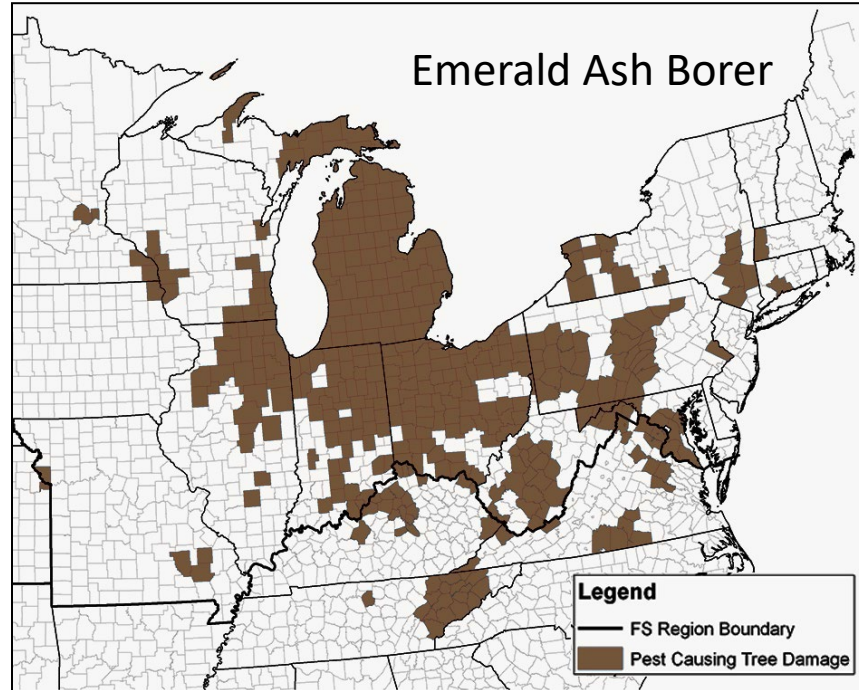
From World Bank Report

Some Insect Threats to NJ Forests

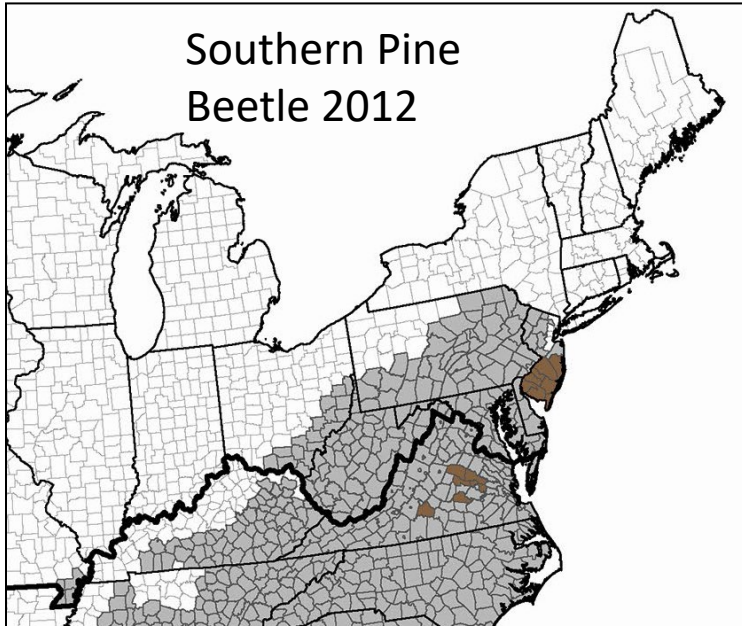
Hemlock Woolly Adelgid



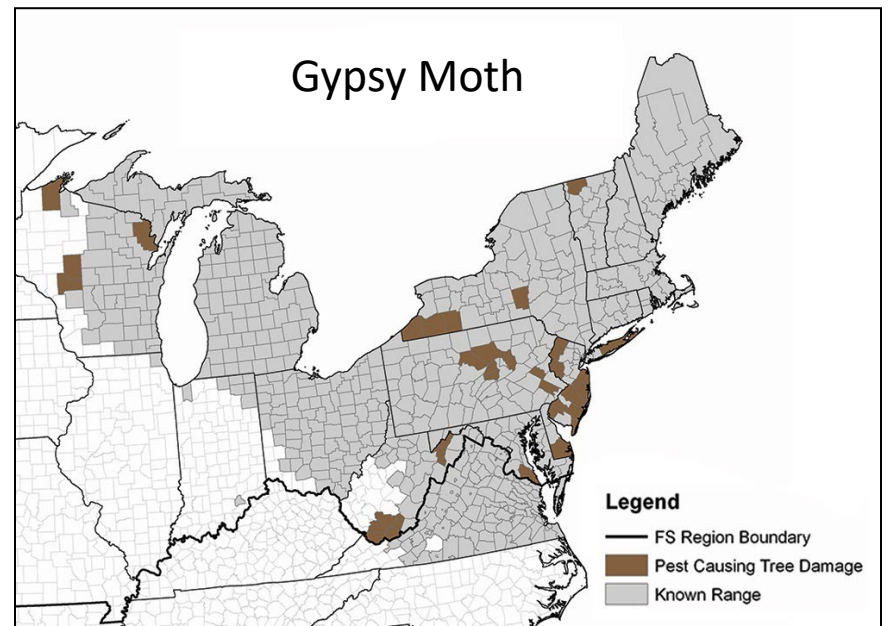
Emerald Ash Borer



Southern Pine Beetle 2012



Gypsy Moth

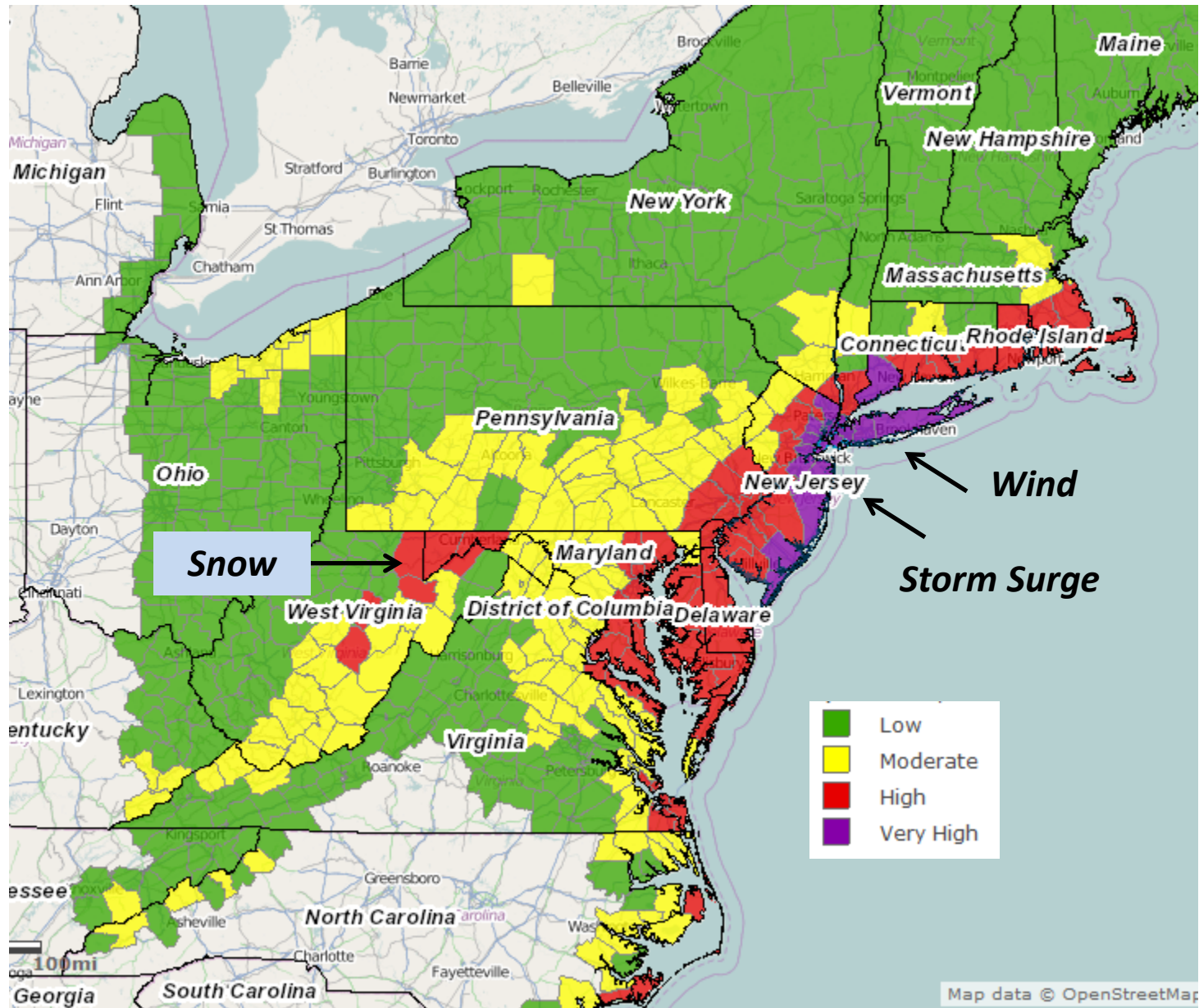


Wildfire in New Jersey – Always a Threat



Impacts on ecosystems

Hurricane Sandy Impact Analysis – from FEMA

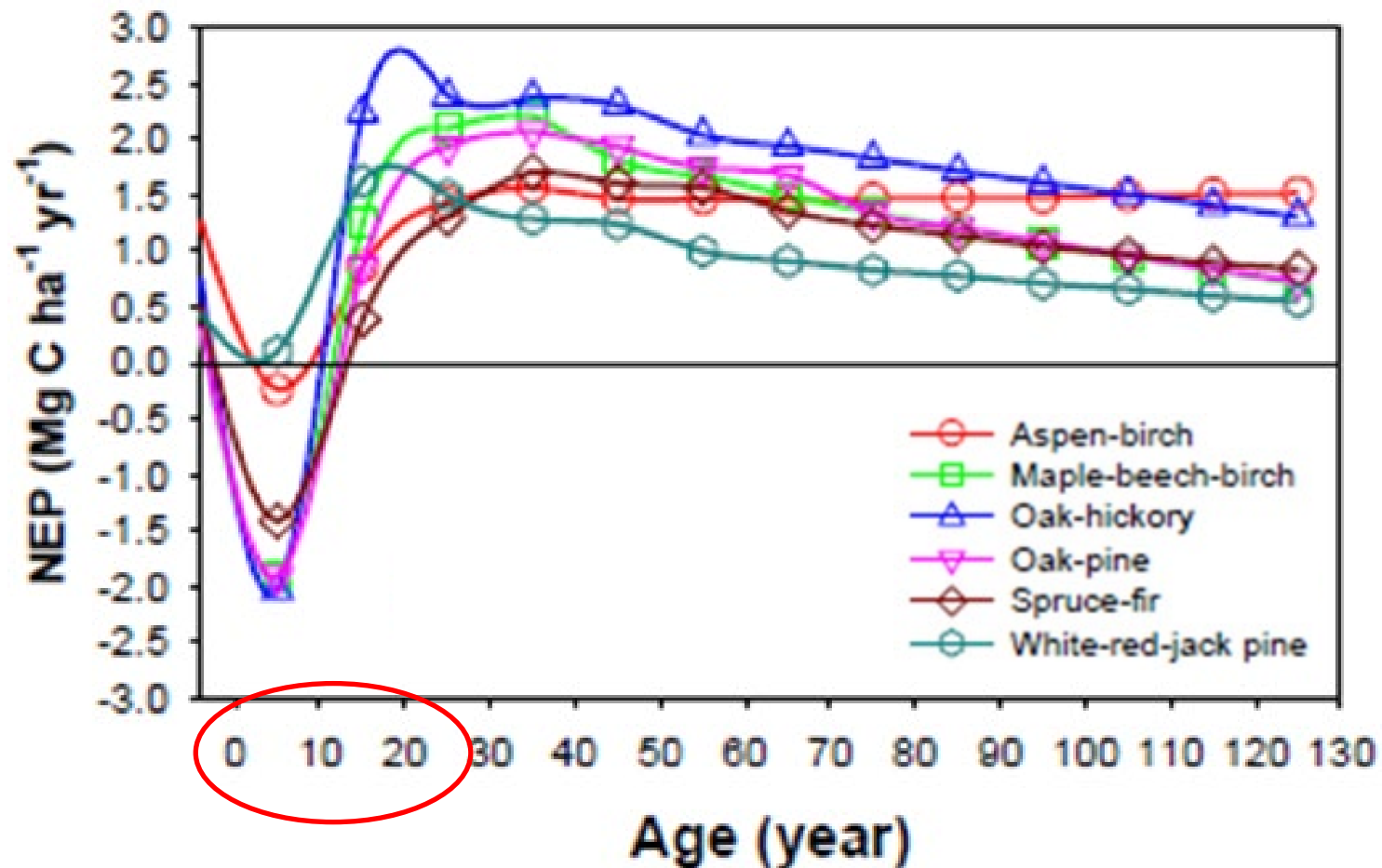


Description of tree damage severity classes

Adapted from the Saffir-Simpson hurricane wind scale.

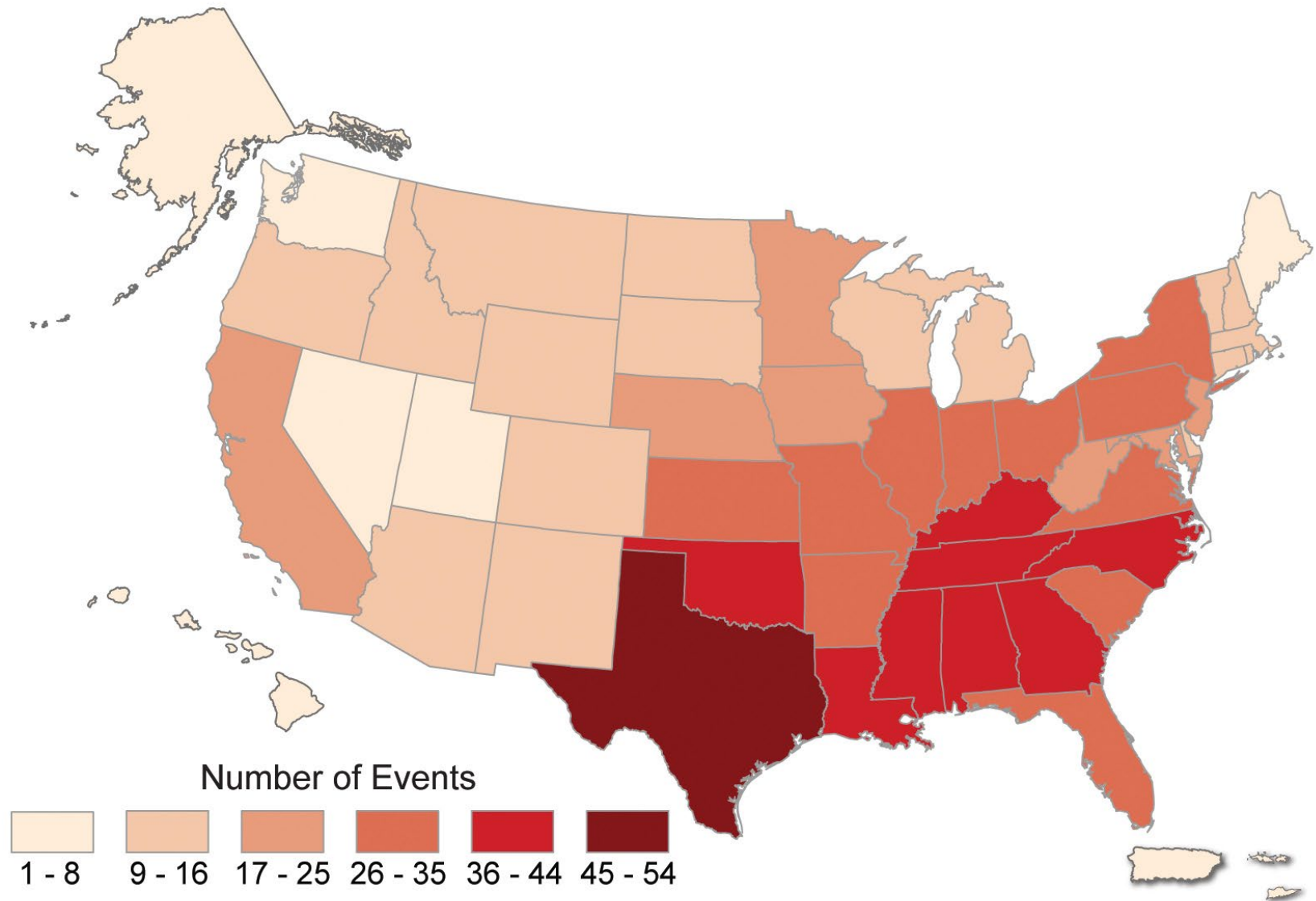
<i>Severity of impact</i>	<i>Description of typical tree damage</i>
Low	Large branches of trees will snap and shallow rooted trees may be toppled. Power lines may be downed and structures damaged.
Moderate	Many shallow rooted trees will be snapped or uprooted and block numerous roads. Widespread power outages due to fallen trees.
High	Many trees regardless of rooting condition will be snapped or uprooted and block numerous roads. Widespread power outages due to fallen trees.
Very High	Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks or longer.

Response of Net Ecosystem Production after disturbance is most dynamic for first few years, but effects last for decades



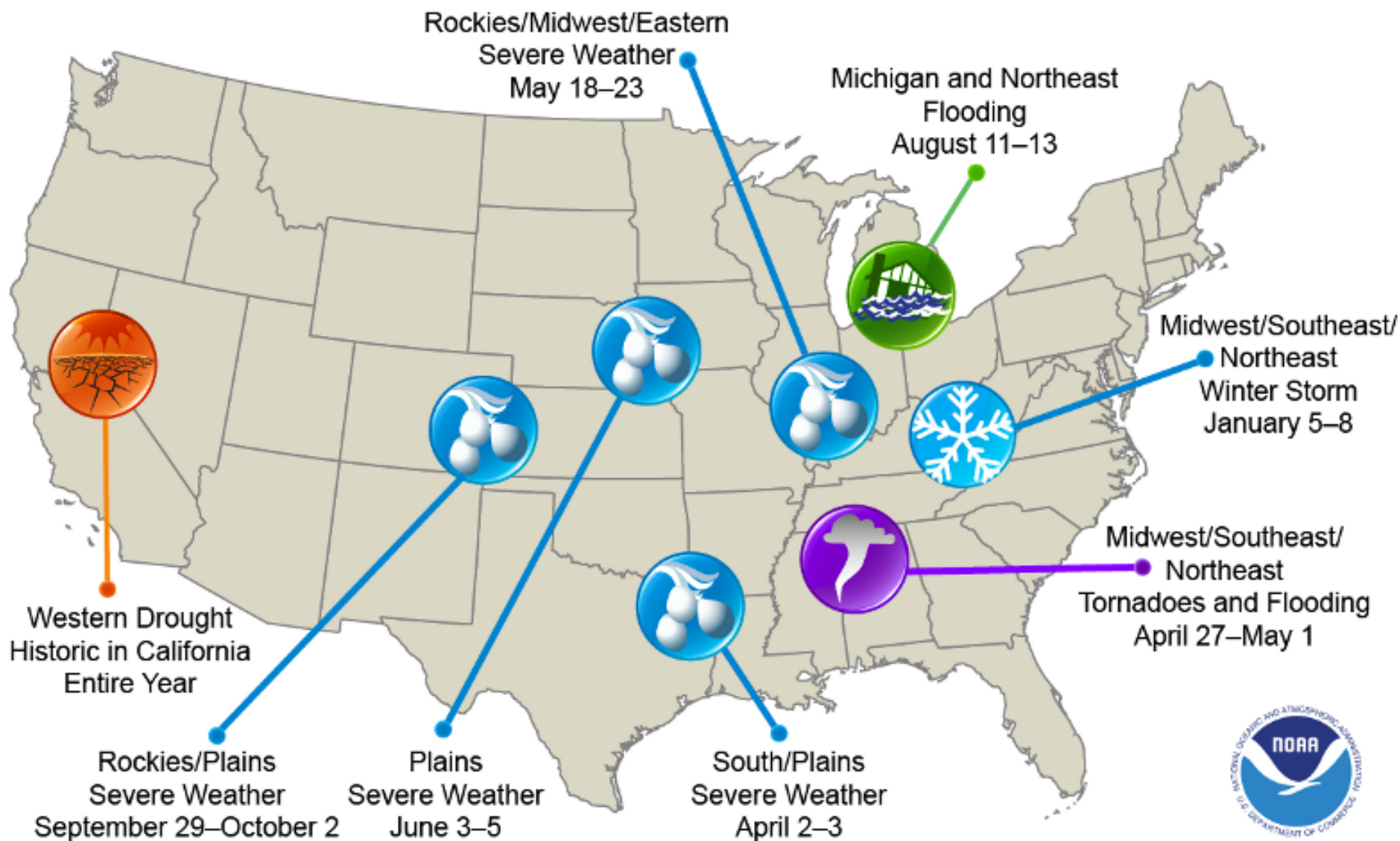
Impacts on society

Billion Dollar Weather/Climate Disasters 1980-2012



Melillo et al., 2014: Climate Change Impacts in the United States

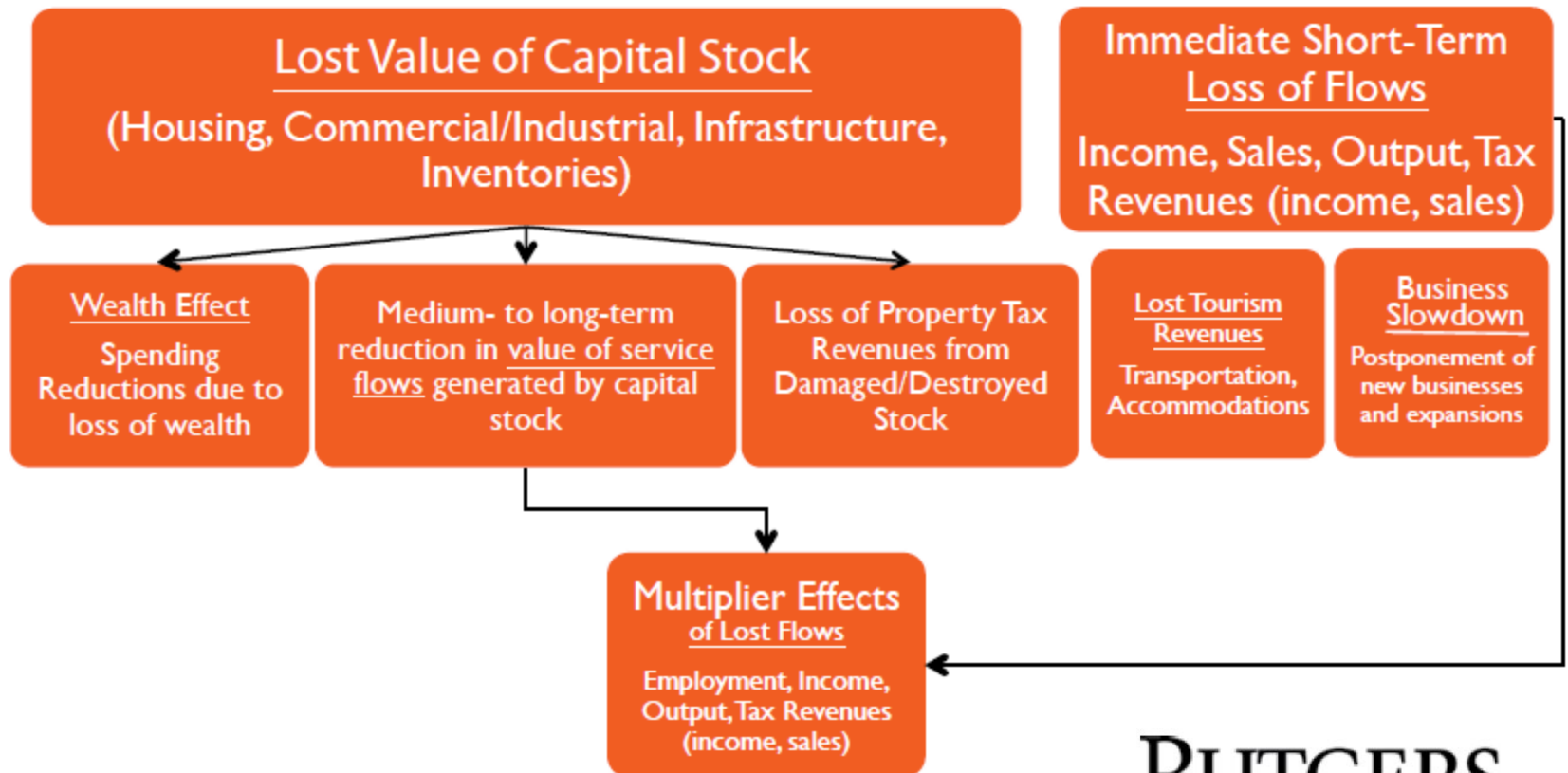
U.S. 2014 Billion-Dollar Weather and Climate Disasters



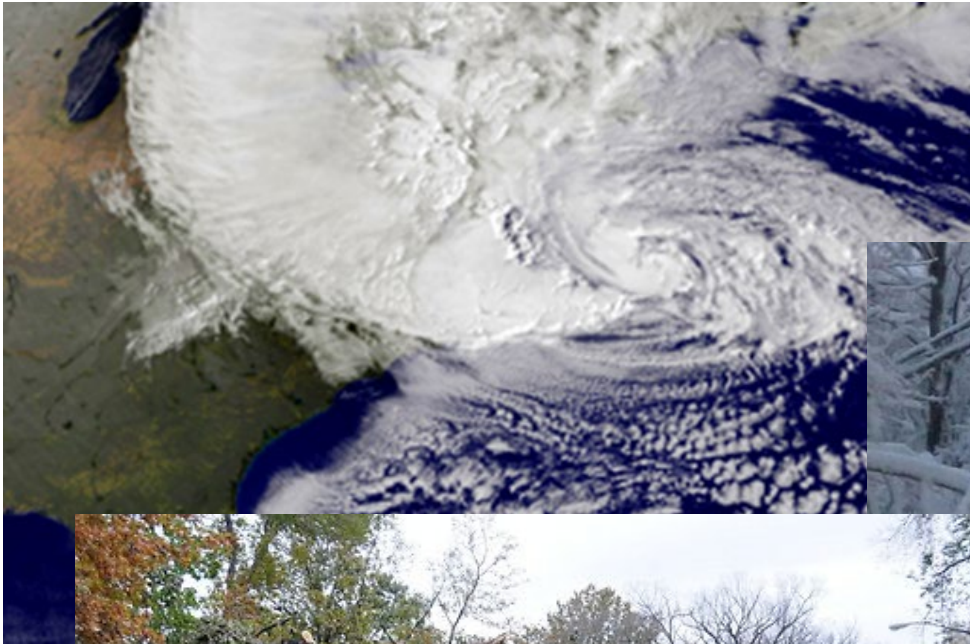
This map denotes the approximate location for each of the eight billion-dollar weather and climate disasters that impacted the United States during 2014.

Negative Impacts of Hurricane Sandy

Losses in Economic Activity



Responding to Extreme Events

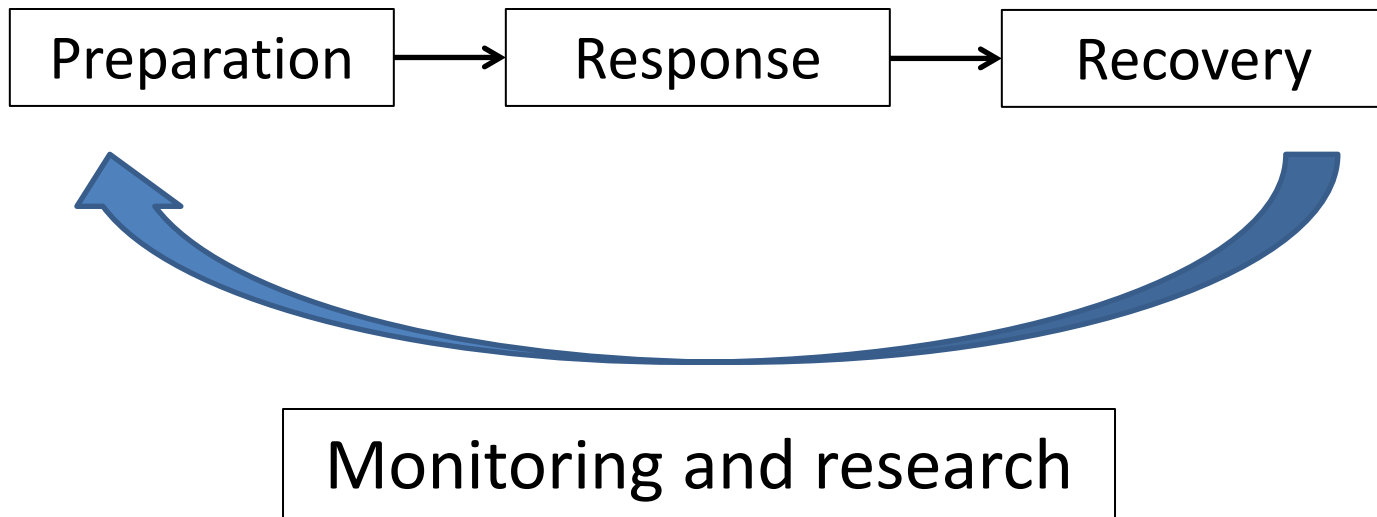


Activity phases for responding to extreme events



“Lives and Property”

Activity phases for responding to extreme events



Response to Extreme Events – Emphasis on Ecosystems

- Predictions of risks prior to catastrophic events
- Rapid damage assessment following an event
- Evaluation of near-term risk to soil, water, and other resources due to loss of tree cover
- Assessment of long-term impacts and recovery scenarios
- Recommendations for rural and urban habitat and community restoration

What is “restoration”?

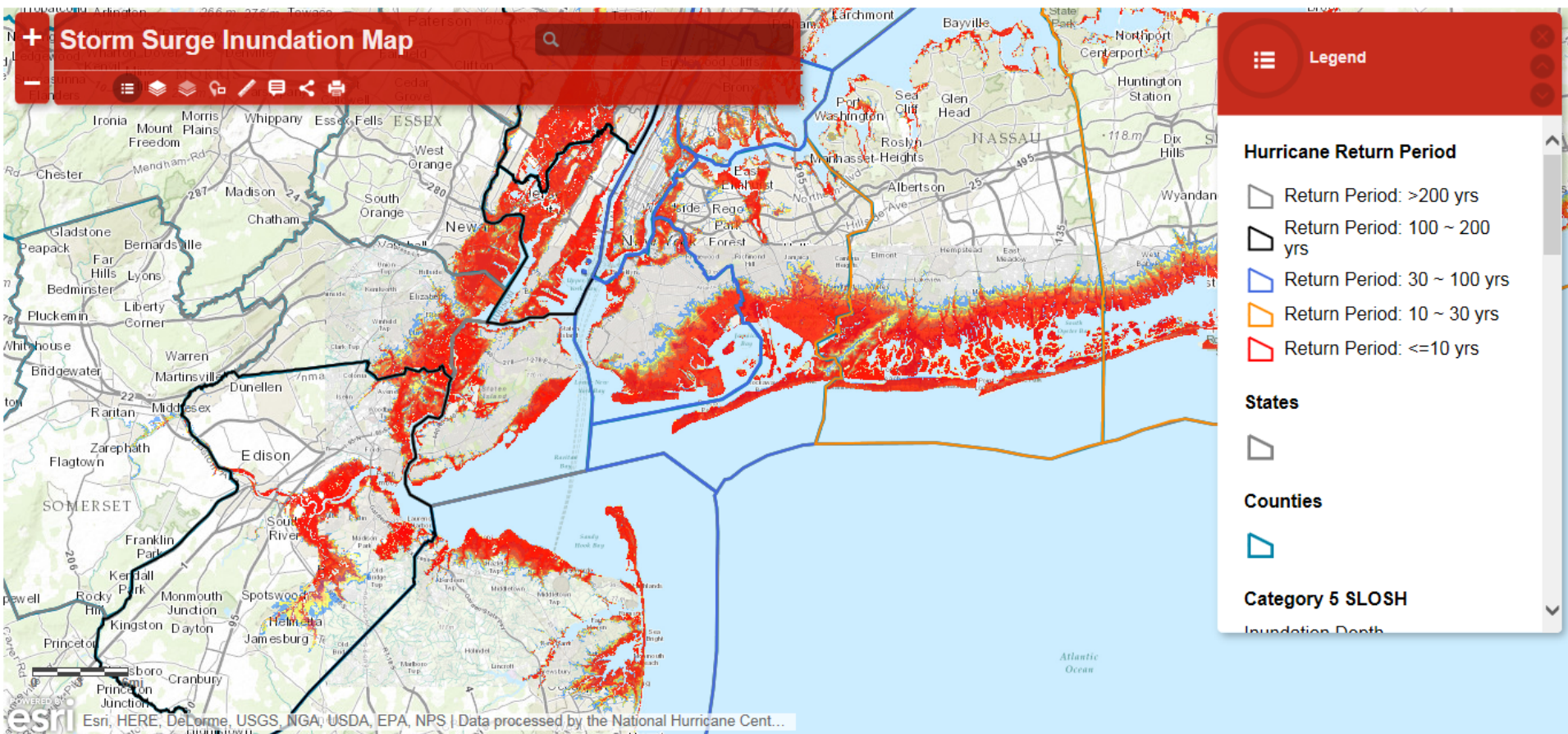
“By restoration, we mean re-establishing the functions and processes characteristic of healthier, more threat-resistant, and **more resilient ecosystems**, even if they are not exactly the same ecosystems that existed before.”

Tom Tidwell, Chief
U.S. Forest Service
February 26, 2015



Responses to extreme events: assessment tools

Storm Surge Inundation and Hurricane Strike Frequency Map (NOAA, FEMA, EPA)





New Jersey Forest Health Advisory



[Emerald ash borer](#)



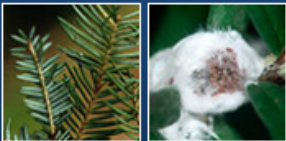
[Beech bark disease](#)



[Dutch elm disease](#)



[Oak decline](#)



[Hemlock woolly adelgid](#)



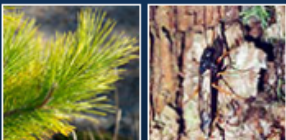
[Southern pine beetle](#)



[Maple decline](#)



[Heterobasidion \(annosus\) root disease](#)



[Sirex woodwasp](#)



[Engraver beetles \(Ips spp.\)](#)



[Asian longhorned beetle](#)

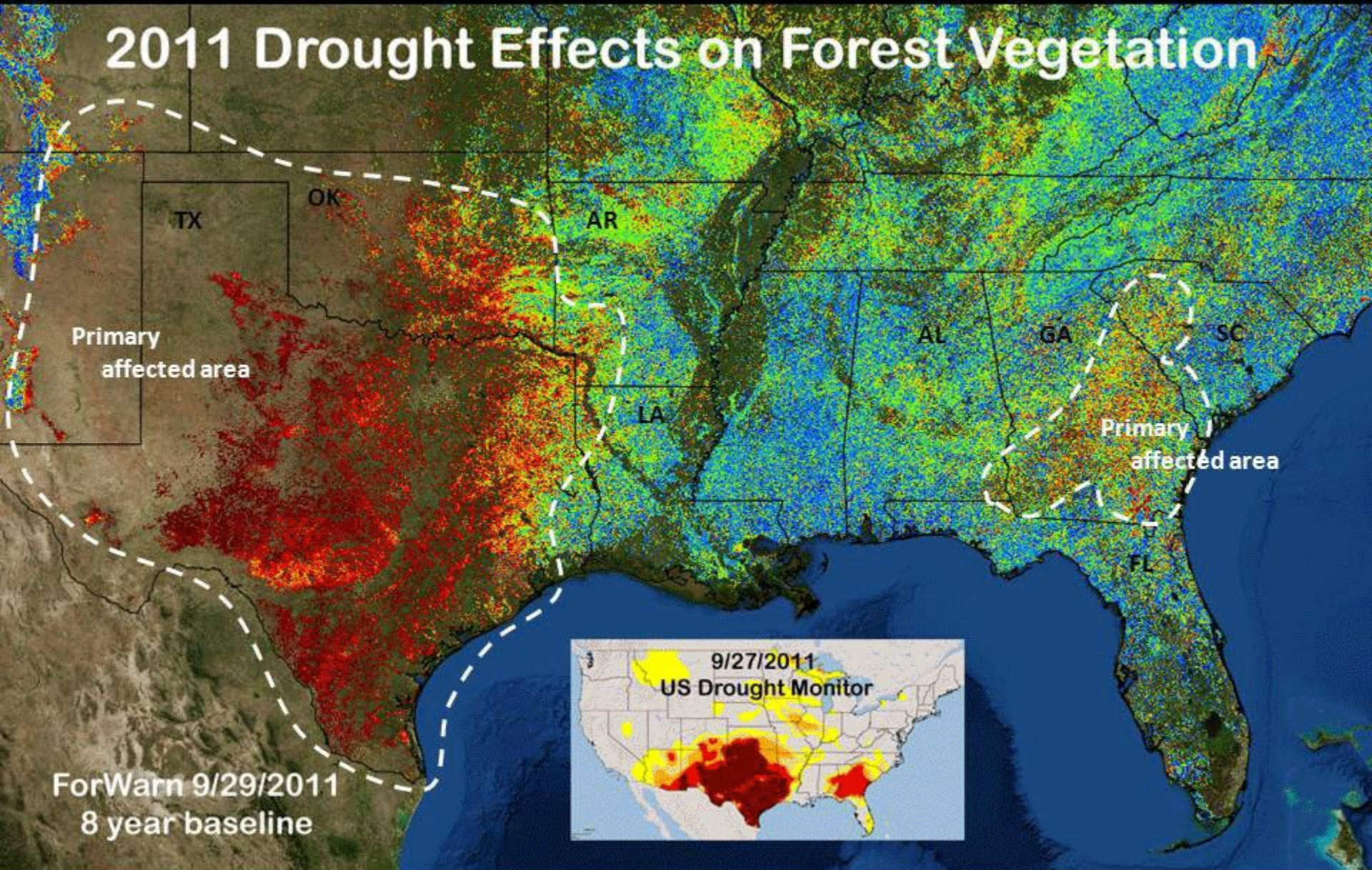
Within New Jersey 186,810 acres are susceptible to **high levels ($\geq 25\%$) of overall** tree mortality.

Modeled Impacts to Host Tree Species

Host Tree Species	Loss, % of Host	Loss, % of All Trees
Ash spp.	38%	3%
American Beech	30%	<1%
American Elm	26%	<1%

Example of satellite change detection from ForWarn

2011 Drought Effects on Forest Vegetation



Priority Agenda

Enhancing the Climate Resilience



of America's Natural Resources

COUNCIL ON CLIMATE PREPAREDNESS AND RESILIENCE

- Foster climate-resilient lands and waters
- Manage and enhance U.S. carbon sinks
- Enhance community preparedness and resilience by utilizing and sustaining natural resources
- Modernize Federal programs, investments, and delivery of services to build resilience and enhance sequestration of biological carbon

Guidelines from FAO for Forest Productivity, Biodiversity, Water, Fire, Pests, and more

EXTREME WEATHER EVENTS: recommended adaptation actions

CLIMATE CHANGE IMPACTS AND RISKS	MANAGEMENT ACTIONS	RESPONSIBILITY
Increased flood frequencies and intensities	Improve early-warning systems and the level of communication among local stakeholders	 
	Protect headwaters through watershed protection and management interventions	  
	Ensure unimpeded water flows by keeping rivers, creeks and streams free of debris and blockages	 
	Maintain natural vegetation in riparian zones and avoid the channelization of headwater streams	
	Design and build infrastructure with larger safety factors (e.g. forest roads with proper drainage and dams with higher storage capacity)	 
	Ensure the adequate maintenance of road networks, particularly in areas with steep slopes	 
	Avoid the use of heavy equipment on steep slopes and riparian areas	
	Avoid soil compaction to maintain infiltration rates and the water-storage capacity of the soil	

FAO
FORESTRY
PAPER
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Climate change guidelines
for forest managers





The **Center for Resilient Landscapes (CRL)** is a new center located on Rutgers' George H. Cook Campus. It is a collaborative research effort of [Rutgers University](#), the [USDA Forest Service Northern Research Station](#), and the [New Jersey Agricultural Experiment Station](#).

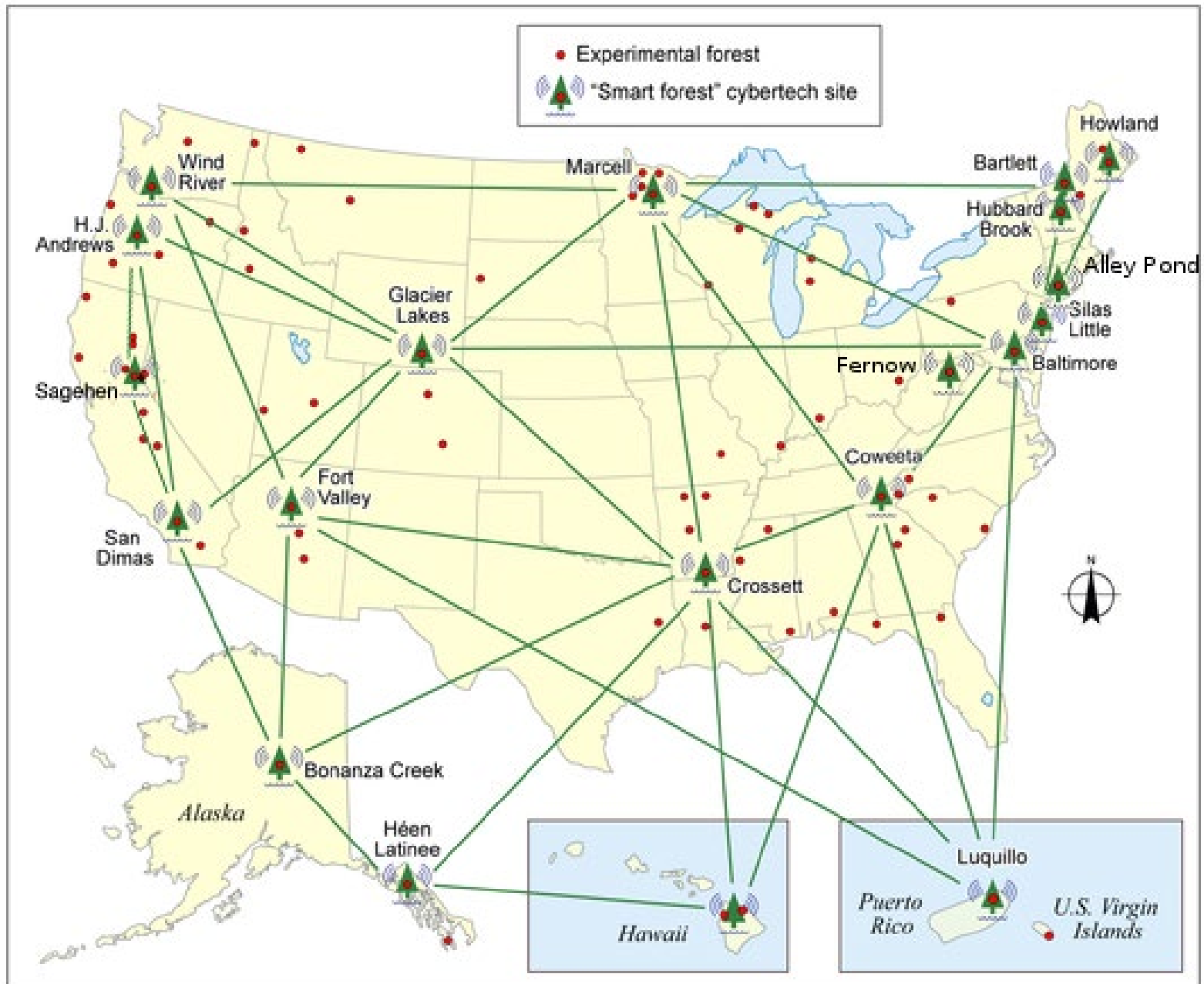
Initial research emphases of the CRL include:

- Understanding resilience within complex landscapes under conditions of global change, periodic disturbance, and urbanization.
- Evaluating strategies for increasing socio-ecological resilience.
- Designing scientifically informed tools to facilitate state and community responses to natural disturbances and extreme events.

Needs for Short- and Long-term Assessment of Impacts and Restoration

- Assessment of stakeholder needs
- Baseline database
- Event impact database
- Establish an early alert and activation protocol
- In-depth damage assessment
- Baseline recovery projections
- Community engagement in defining the restoration process

“Smart Forest” Network





Questions?

Thank You!!!