

# Central Hardwoods Climate Change Response Framework Preliminary Vulnerability Assessment Results

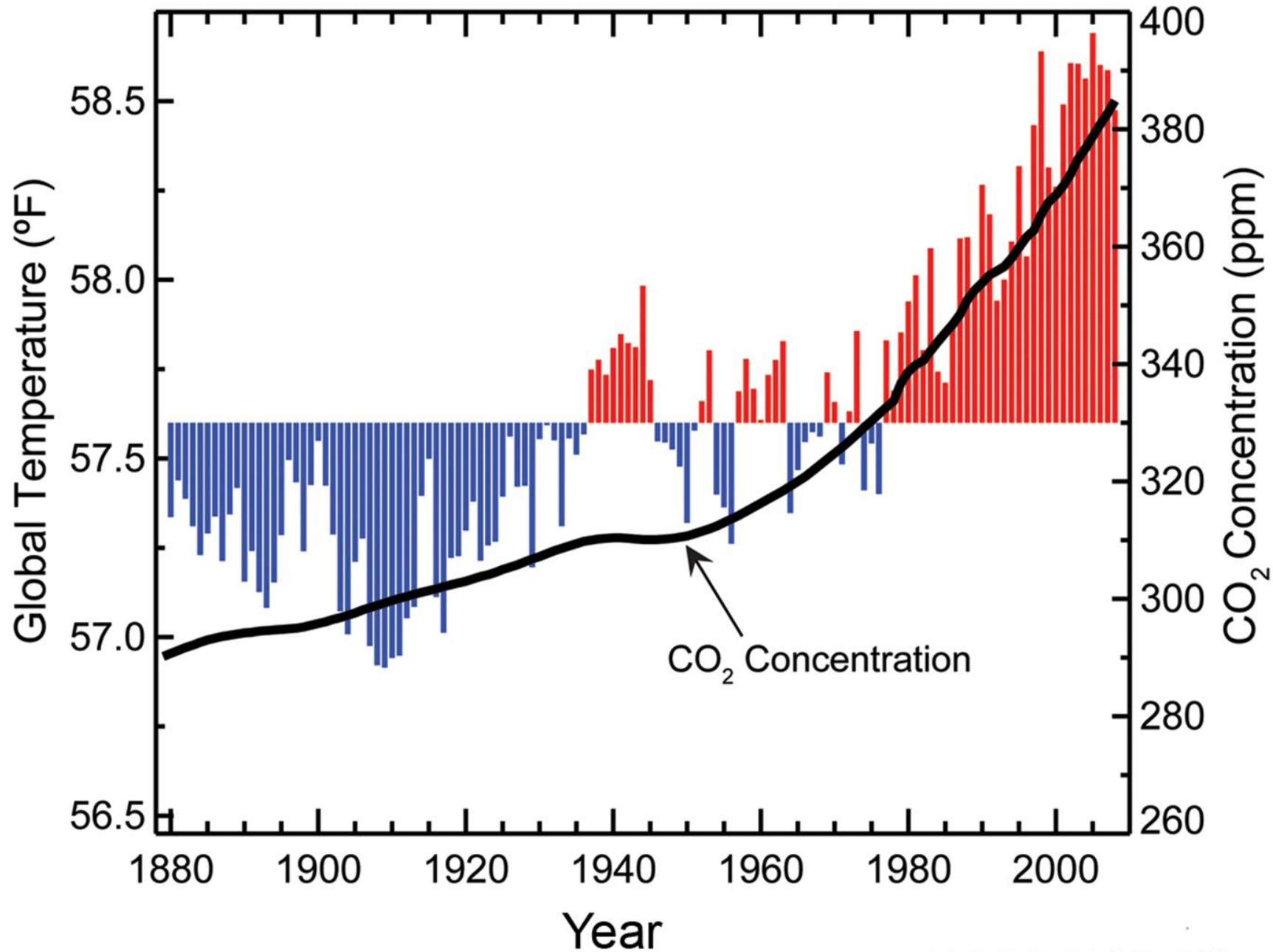
**Leslie Brandt**

Frank Thompson, Hong He, Louis Iverson, Anantha Prasad, Stephen Matthews, Matthew Peters, Patricia Butler, Stephen Handler, Maria Janowiak, Danielle Shannon, Chris Swanston, and others



[www.climateframework.org](http://www.climateframework.org)



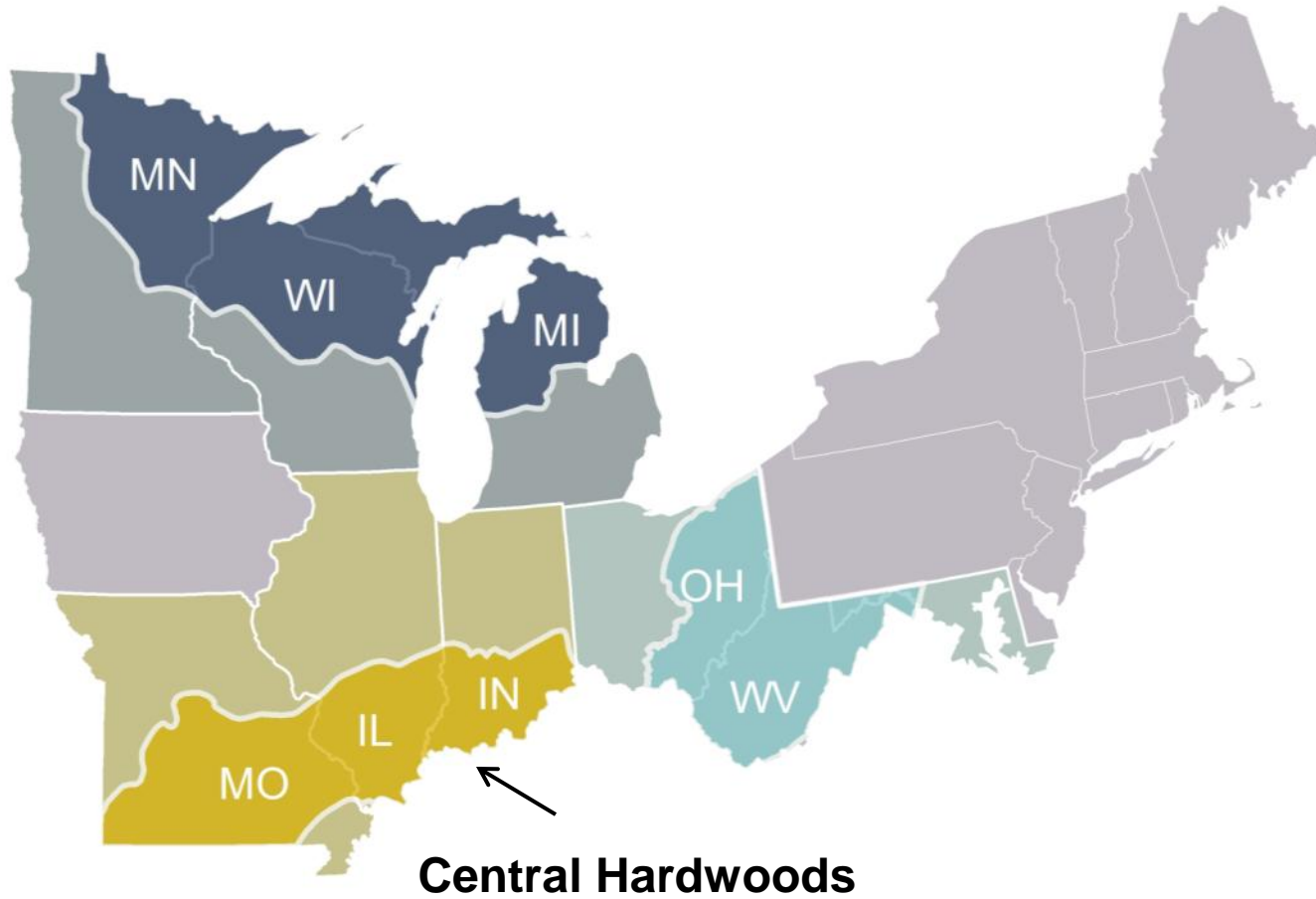


Where we have the greatest certainty about climate change



Where management decisions are made

# Climate Change Response Framework



Where we have the greatest certainty about climate change



Where management decisions are made

# Climate Change Response Framework

## Partnerships

A vertical flowchart with four steps: Partnerships, Vulnerability Assessment, Forest Adaptation Resources, and Adaptation Projects. Each step is in a rounded rectangular box, with arrows pointing down from one to the next. The boxes alternate in color between light blue and dark blue.

work with scientists, land managers  
federal, state, NGO, university,  
industry organizations

## Vulnerability Assessment

understand how climate change  
may affect forests in an ecoregion

## Forest Adaptation Resources

identify strategies, approaches, and  
tactics to adapt to climate change

## Adaptation Projects

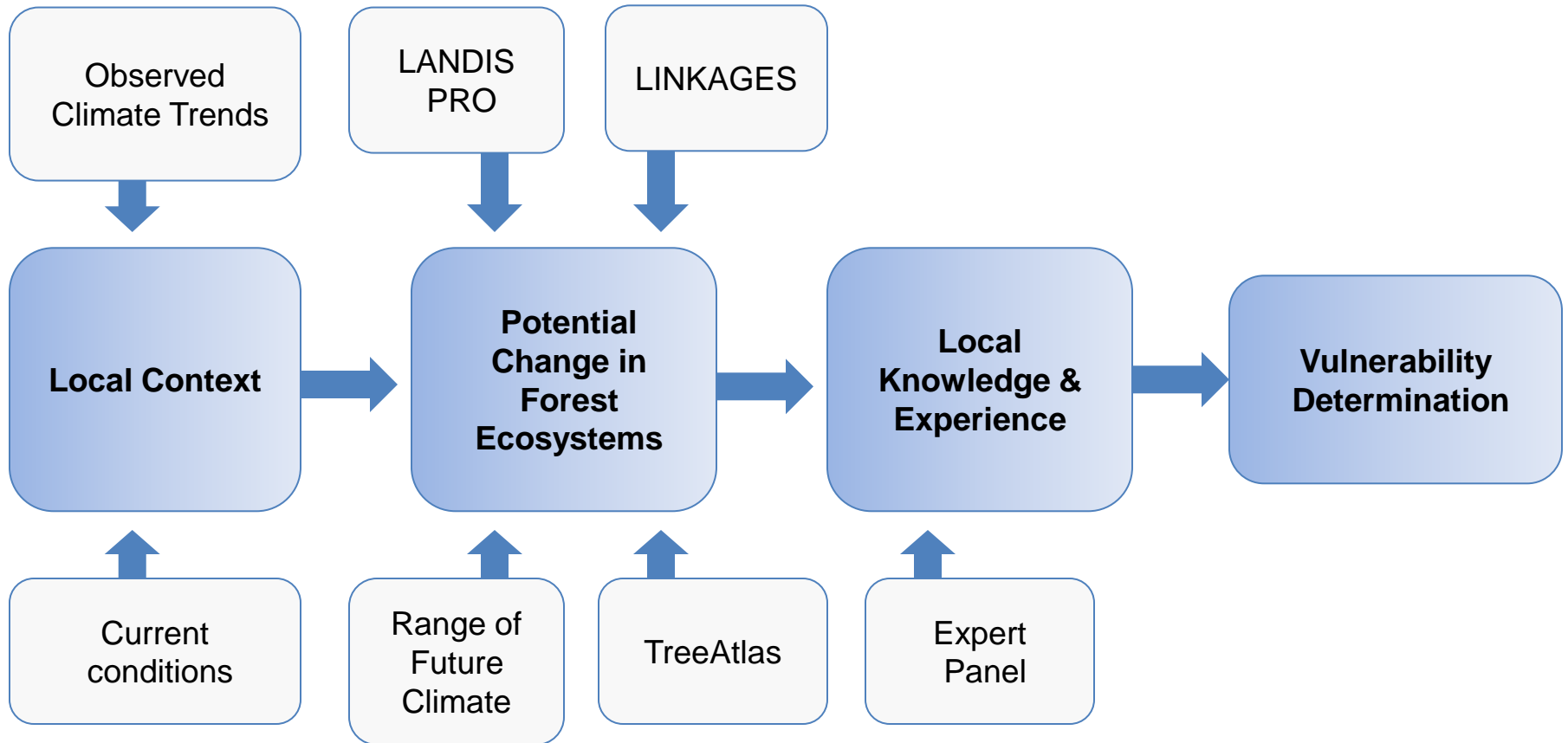
incorporate information  
into decision-making and on-the  
ground projects

# Climate Change Response Framework

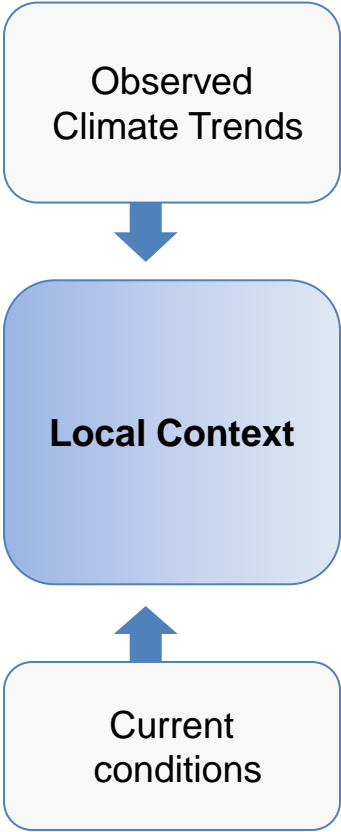


**Vulnerability  
Assessment**

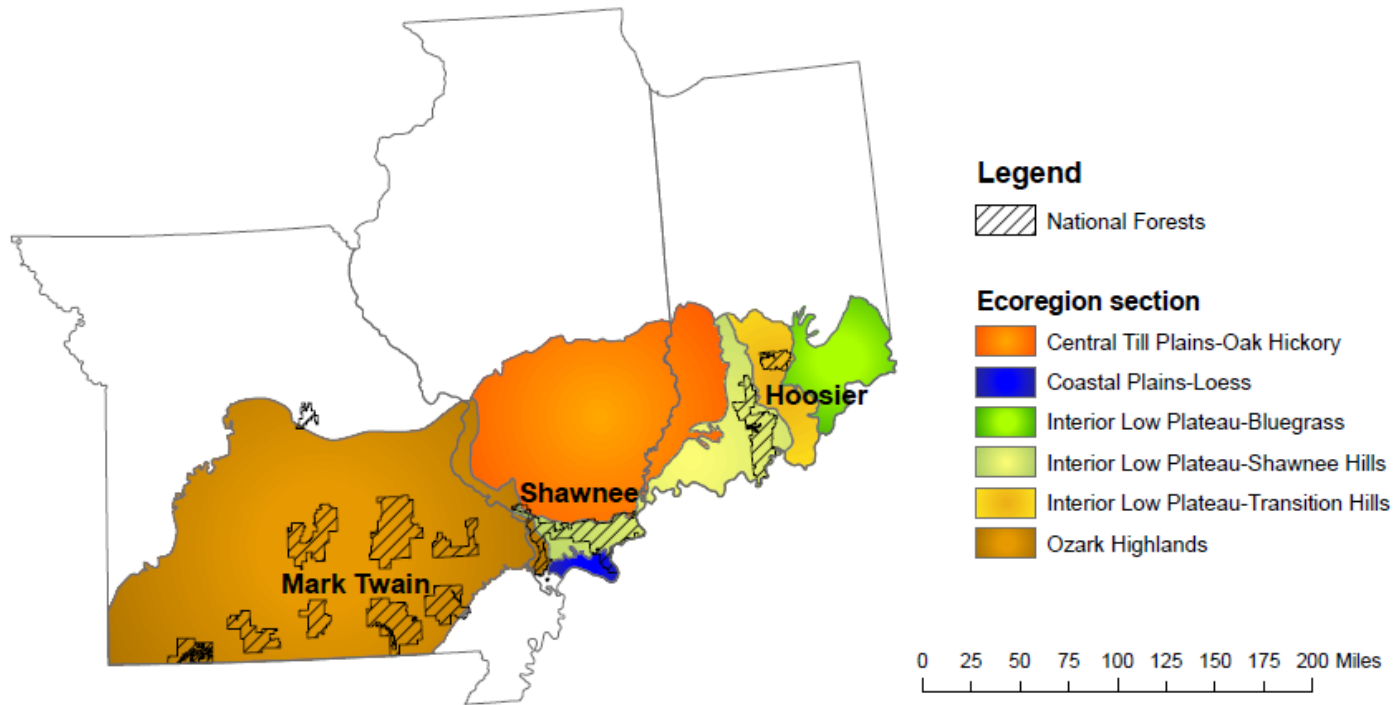
# Vulnerability Assessment Process



# Vulnerability Assessment Process



# Assessment Area



Ecological Subregions: Sections and Subsections of the Conterminous United States

Compiled at 1:500,000 to 1:1,000,000 scale in participation with Federal and State agencies and nongovernmental partners by David T. Cleland, Jerry A. Freeouf, James E. Keys, Jr.; Gregory J. Nowacki, Constance A. Carpenter, and W. Henry McNab.

U.S. Department of Agricultural, Forest Service

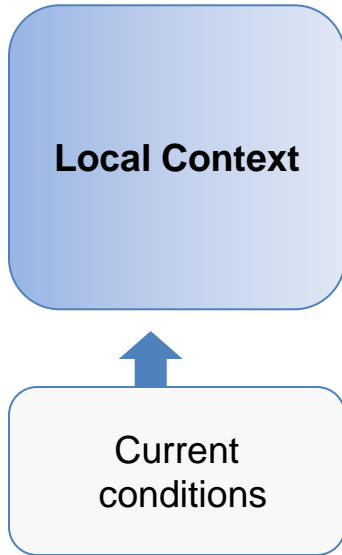
# Vulnerability Assessment Process

## Sources:

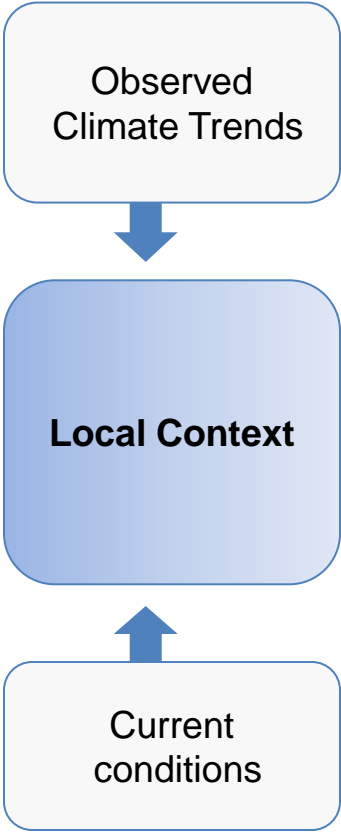
- **Existing assessments**
  - state forest assessments,
  - Ozark Highlands Assessment
  - Hoosier-Shawnee Ecological Assessment
- **Review of primary literature**
- **Expert opinion**

## Information:

- **Major forest community types and their drivers**
- **Major stressors (by community type)**
- **Socioeconomic and management trends**

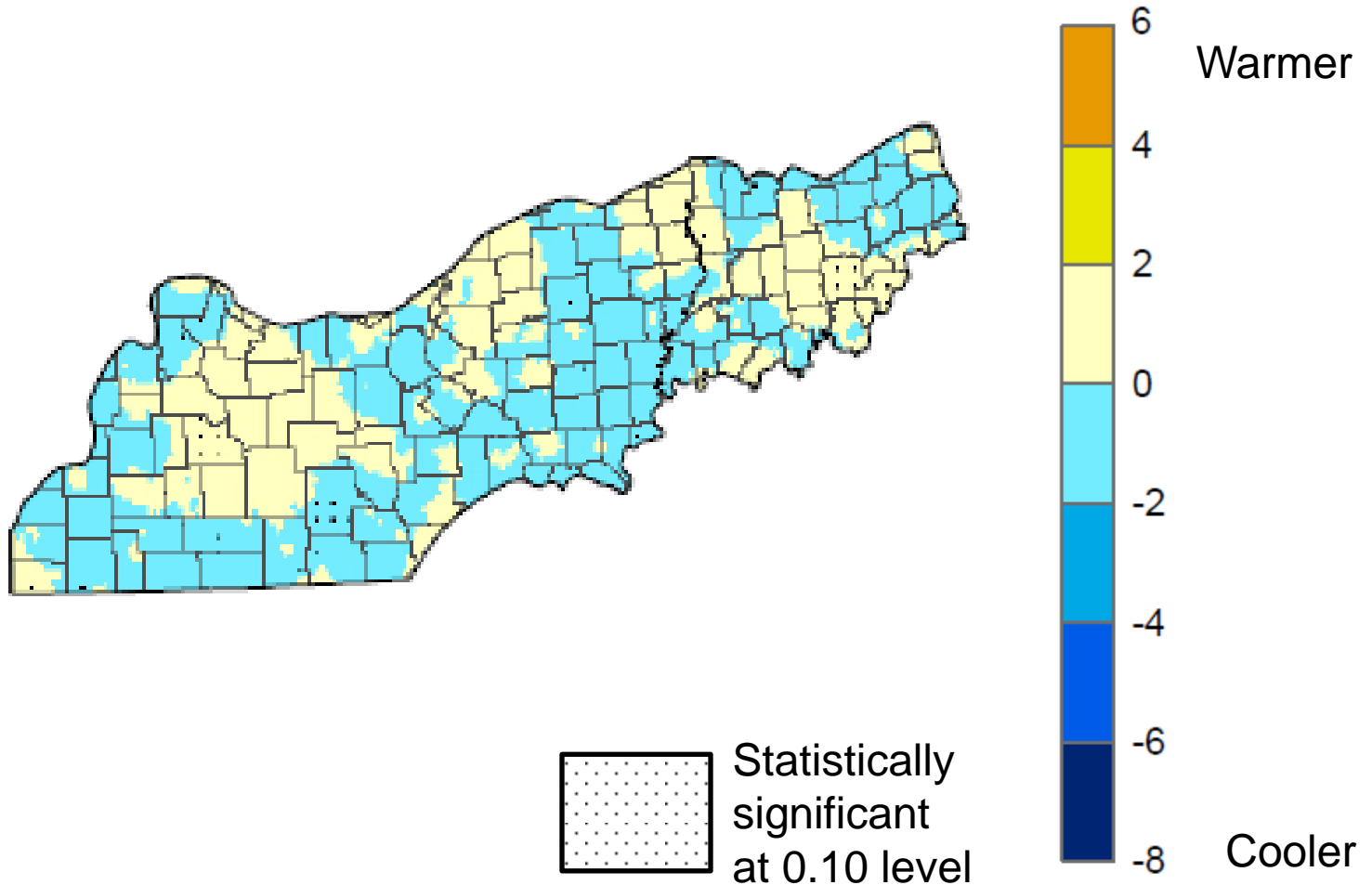


# Vulnerability Assessment Process



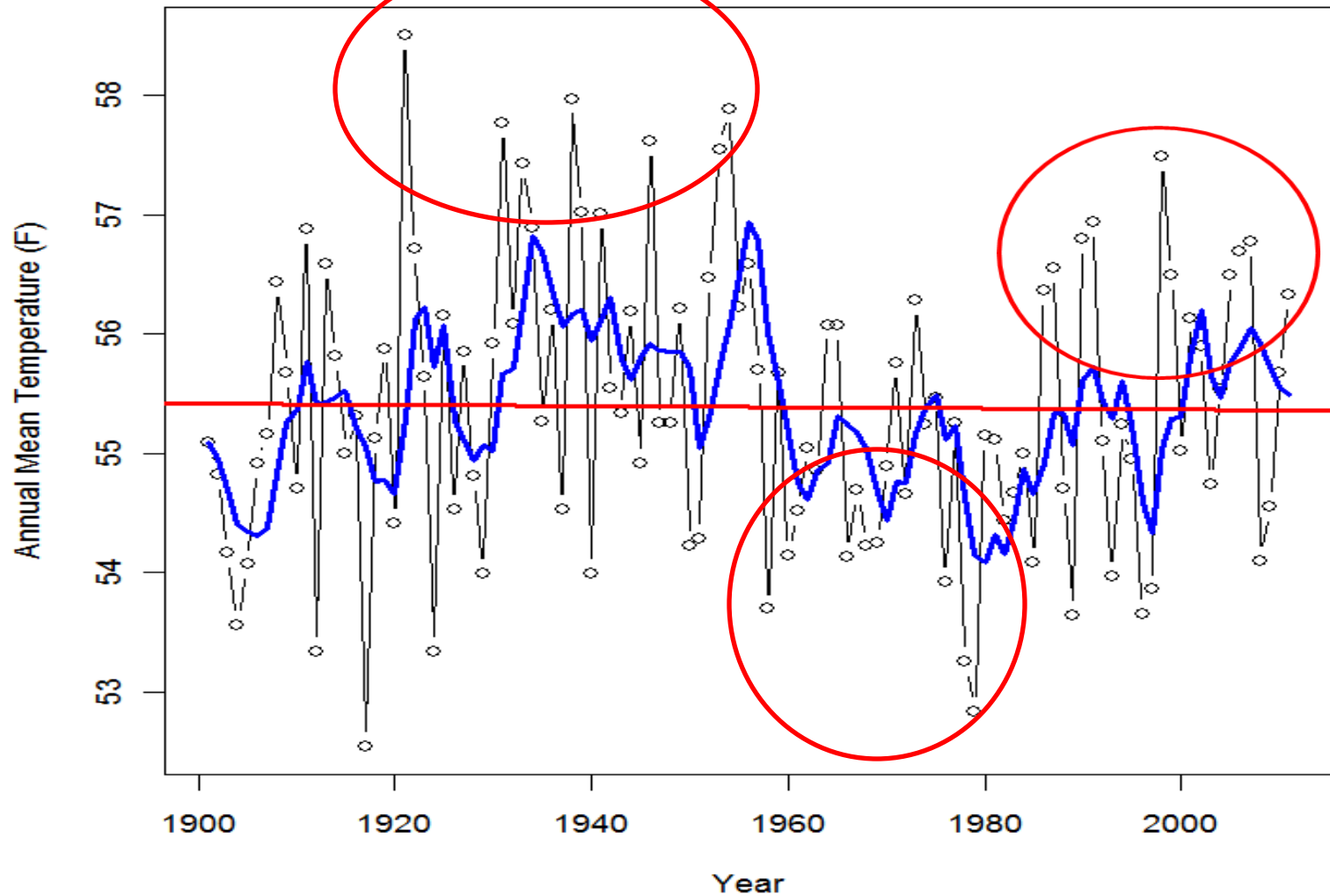
# Little Change in Mean Annual Temperatures

1901-2011  
Temperature  
Change ( F)

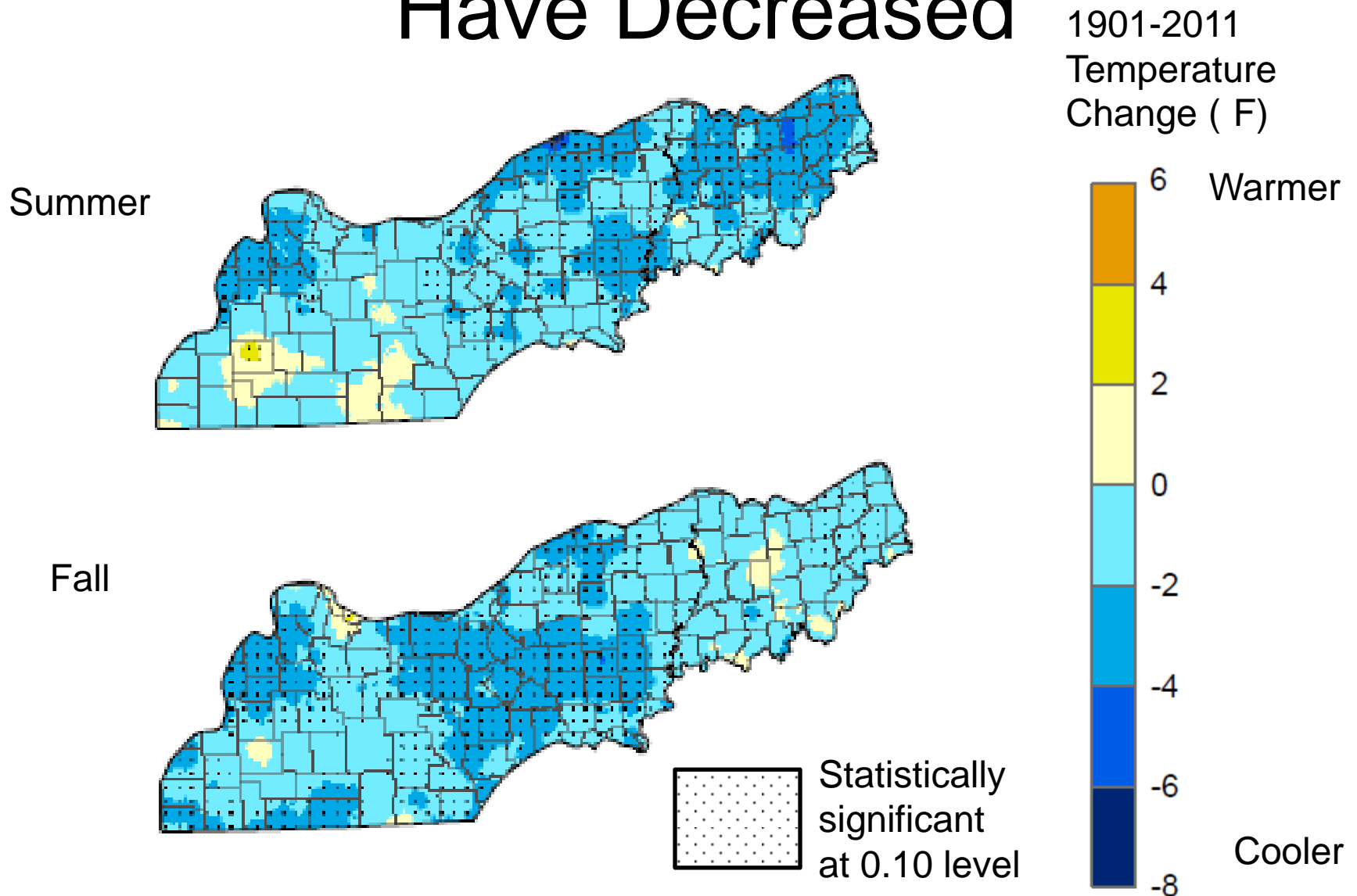


# Regional Trends

Change Rate = 0 F/yr, p-value = 0.90828, r-squared = NA

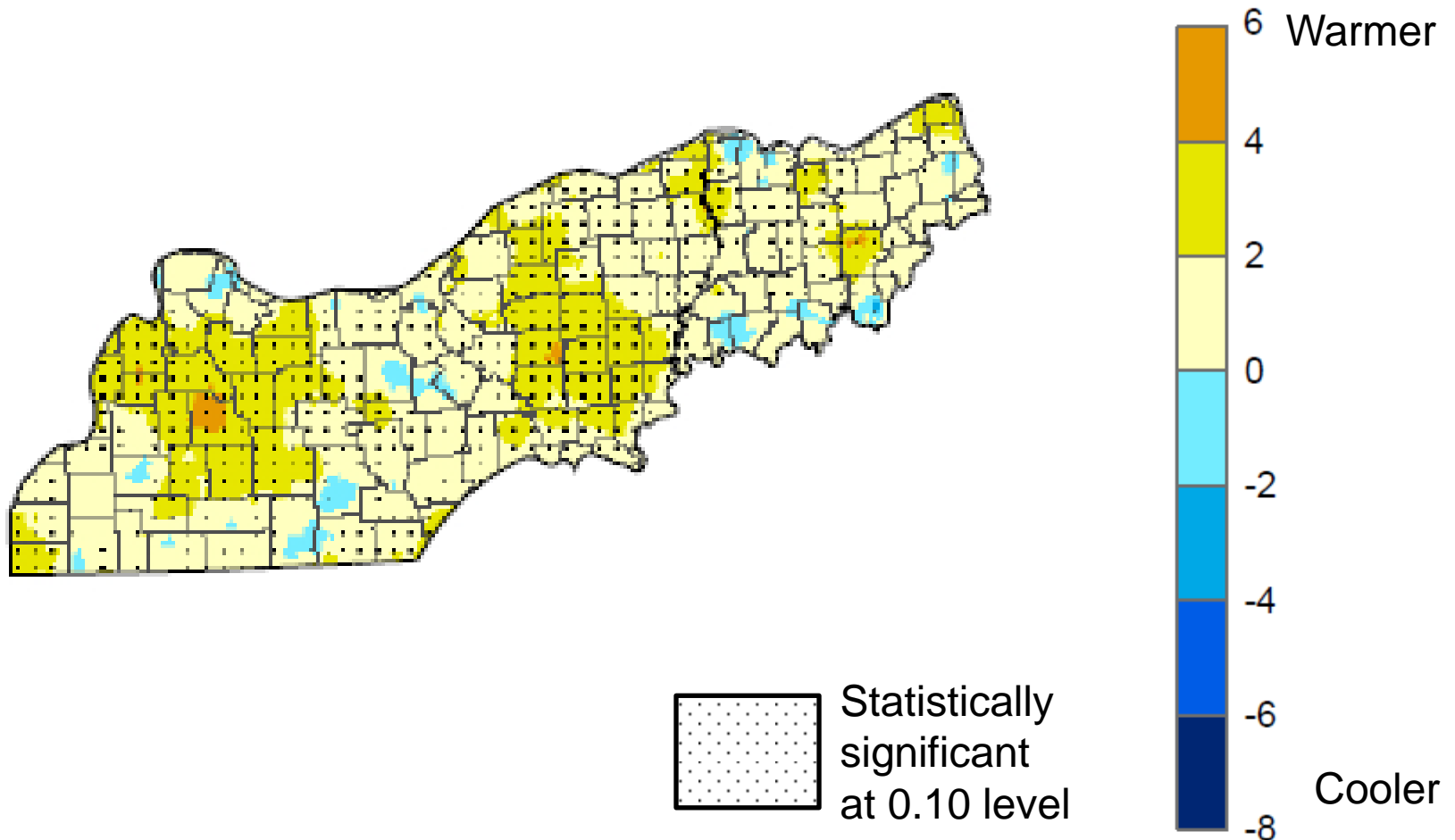


# Summer and Fall Highs Have Decreased



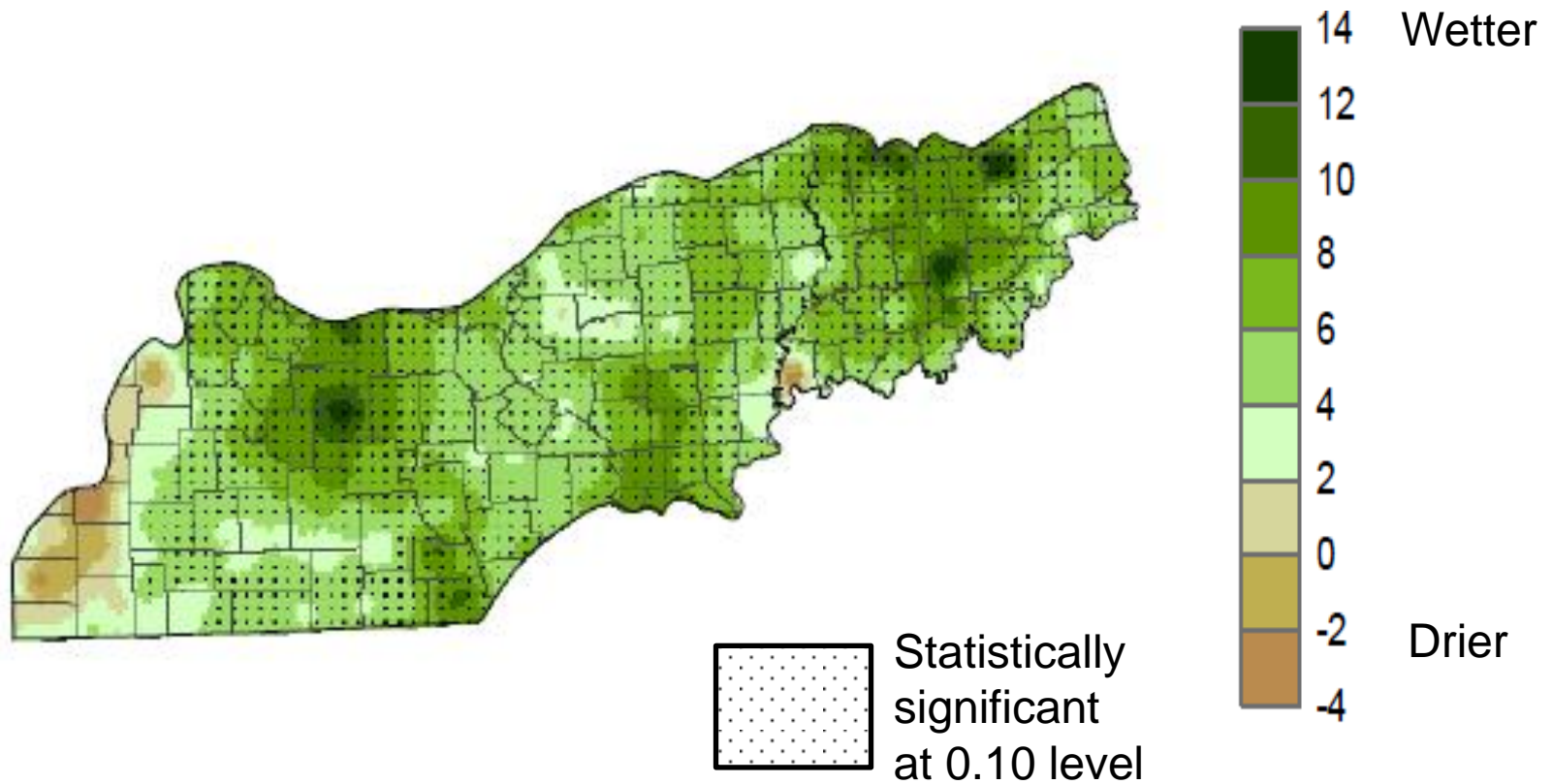
# Summer Lows Have Increased

1901-2011  
Temperature  
Change ( F )



# Precipitation Has Increased

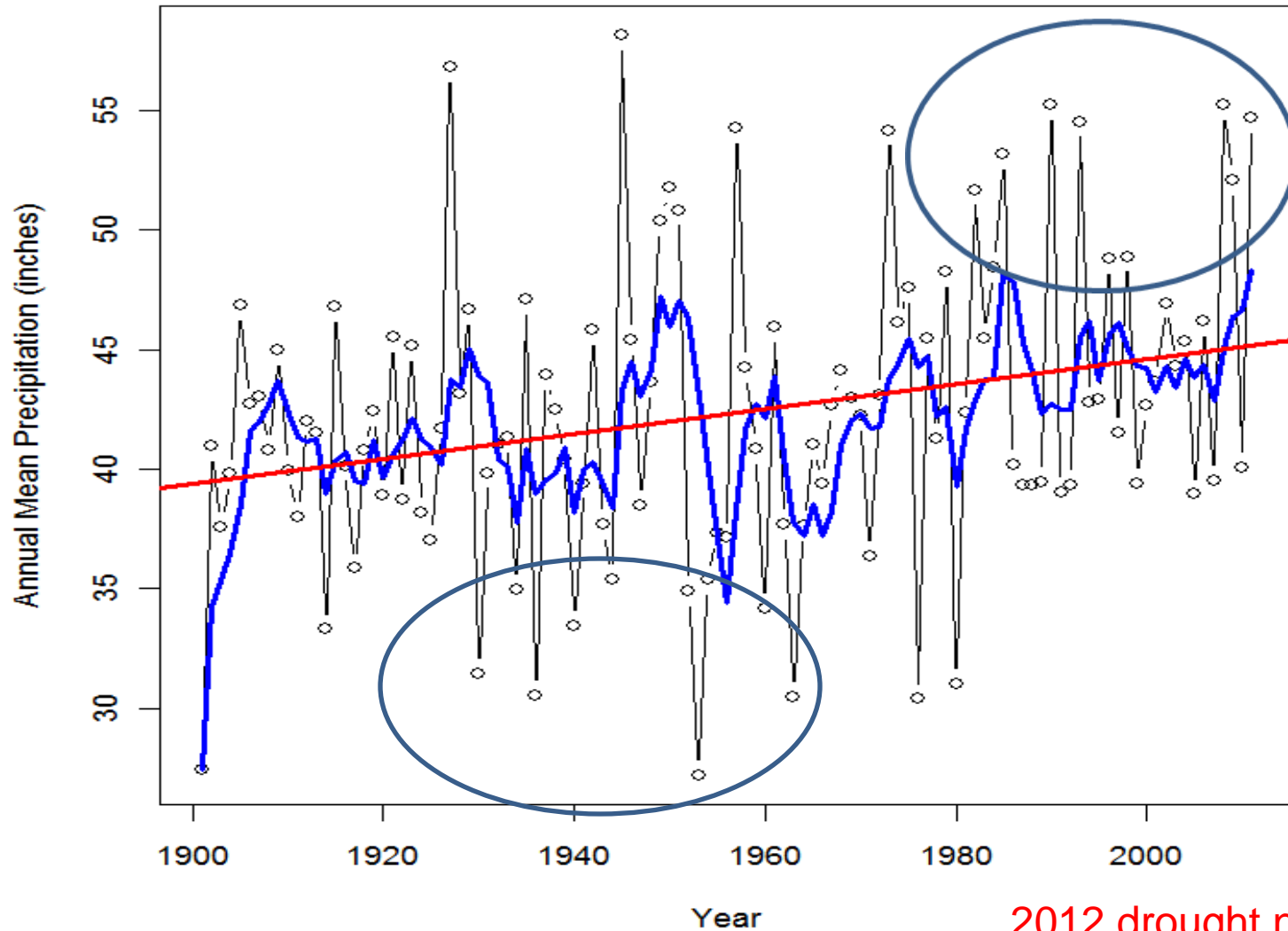
1901 - 2011  
Change in annual  
Precipitation (in)



Average annual : 42.3 inches

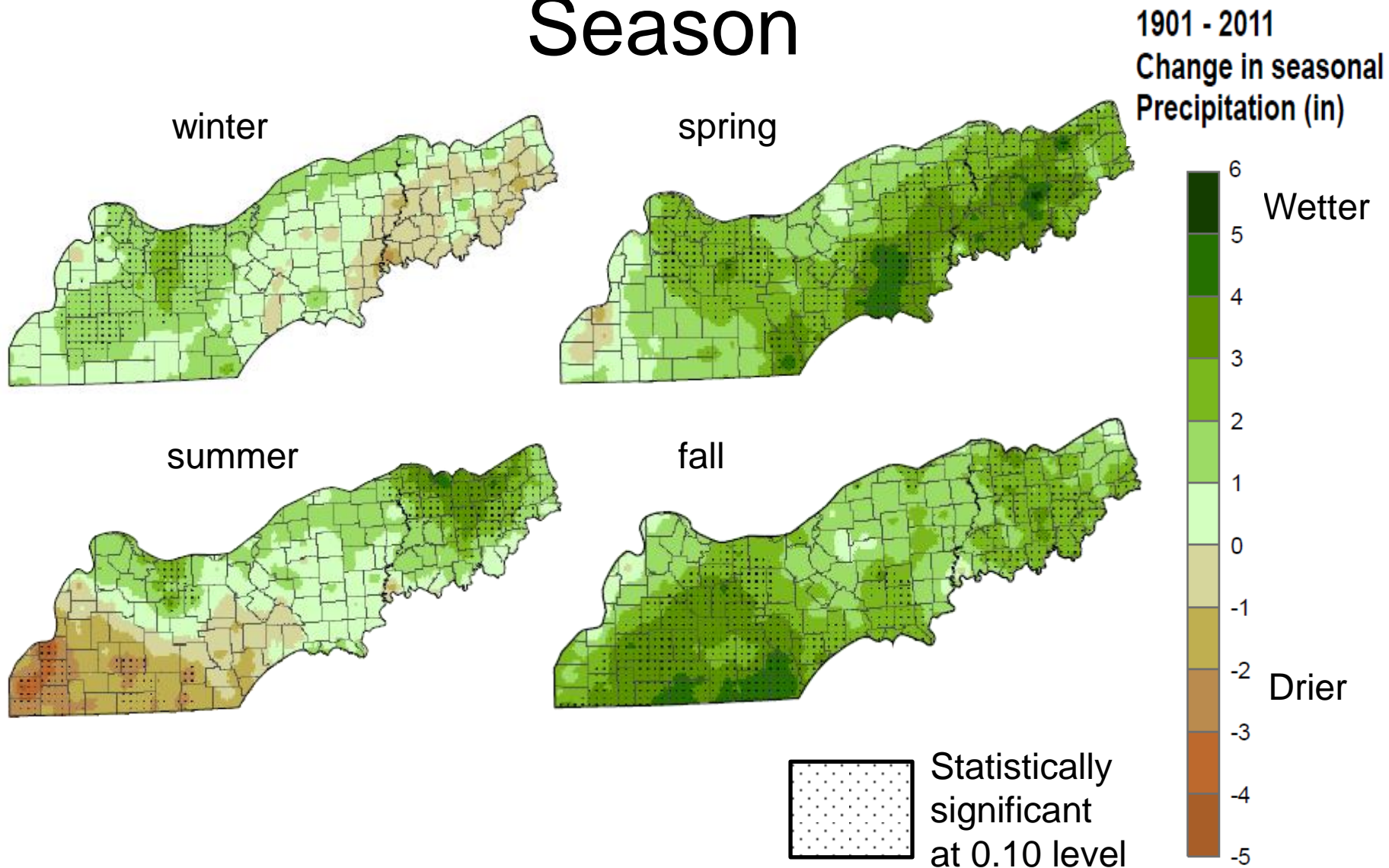
# Regional Trends

Change Rate = 0.052 inches/yr, p-value = 0.005, r-squared = NA

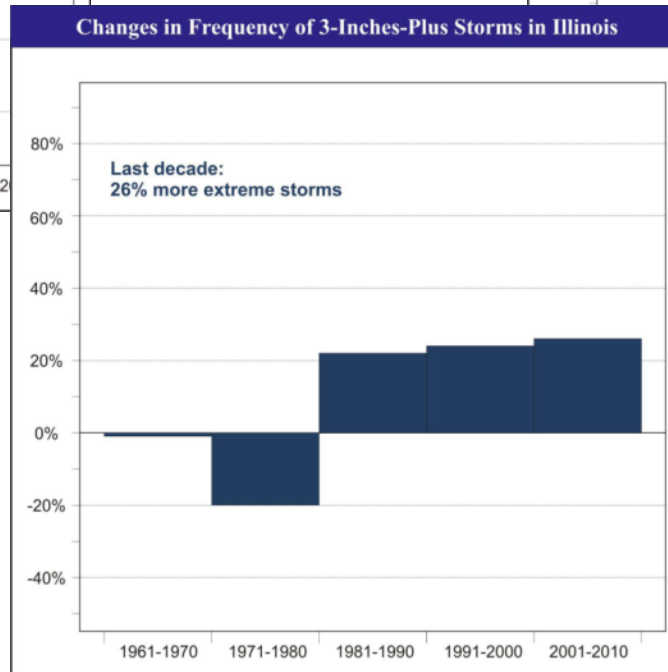
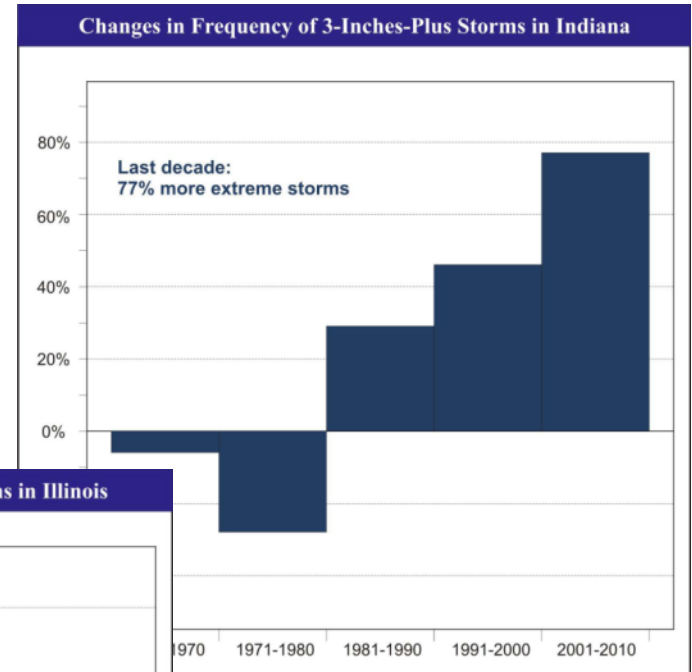
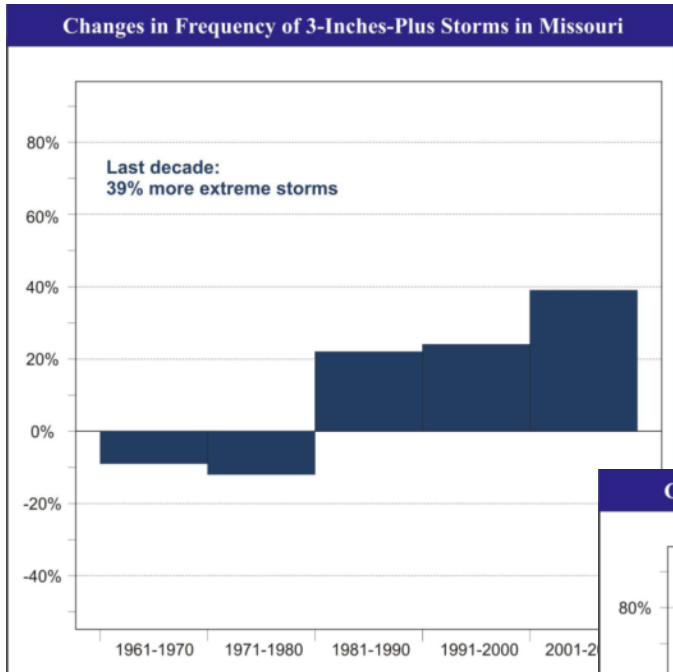


2012 drought not included!

# Precipitation Changes Vary by Season



# Heavy Precipitation Events Have Increased



# Other Observed Climate-Related Changes

Earlier snowmelt and decreasing snow depth in the area



Increase in number of days with frozen soil



*Decreased* frequency of extreme and exceptional droughts

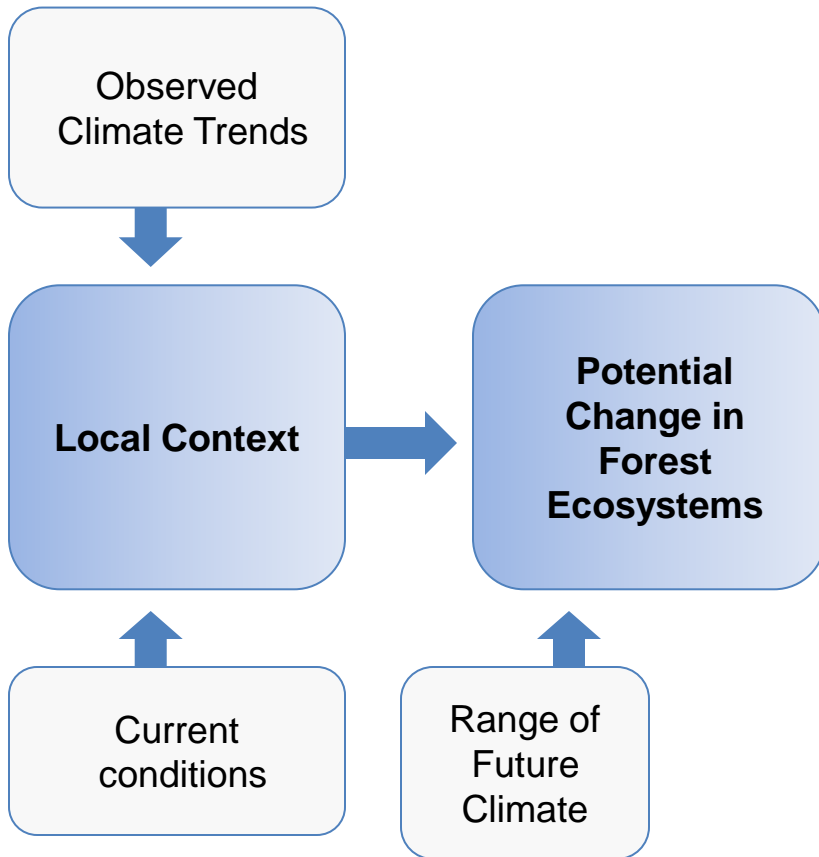


More tornadoes occurring as clustered outbreak sequences

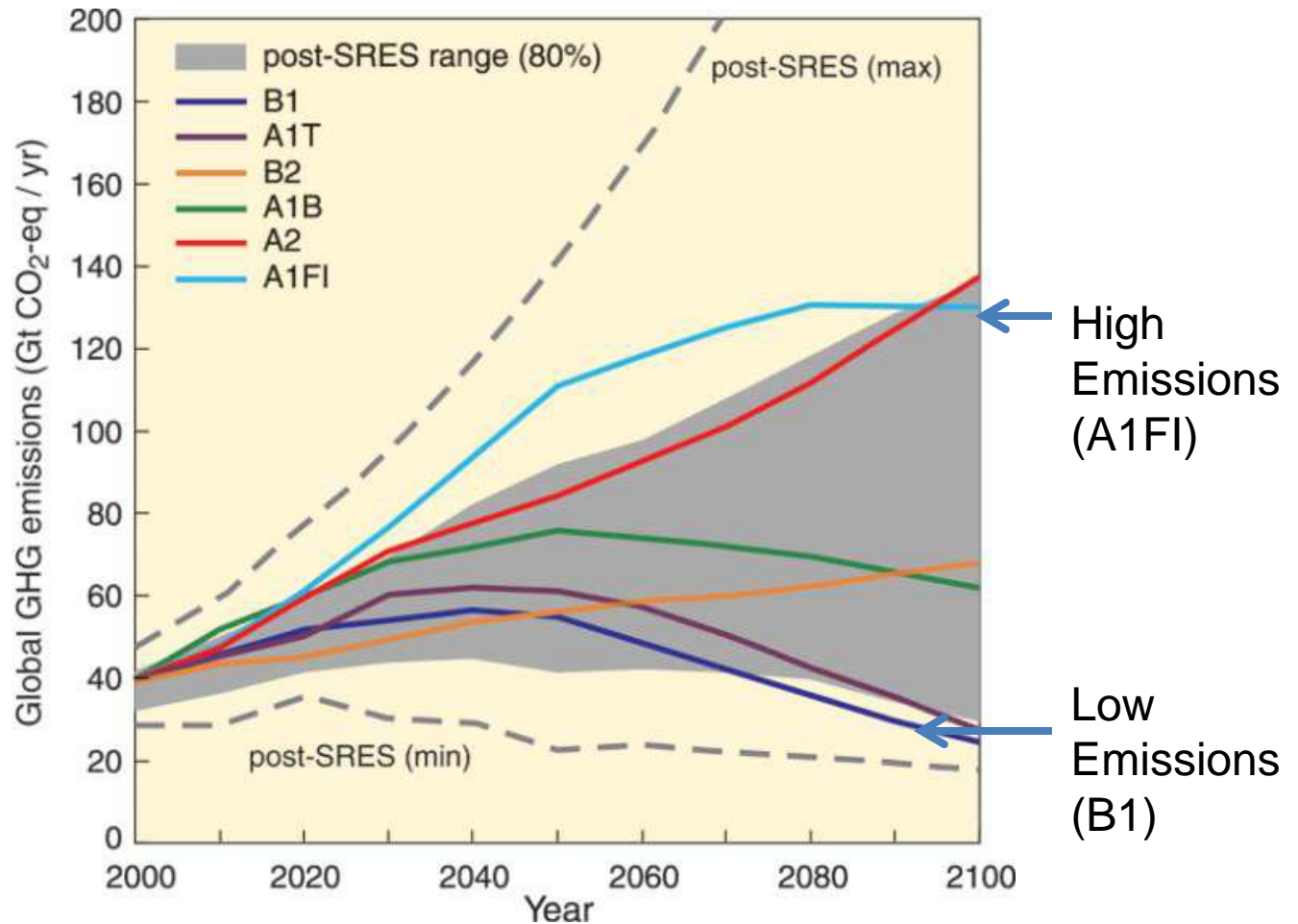


Sources: Diffenbaugh et al. 2008, Dyer and Mote 2006, Kunkel et al. 2008, Mishra et al. 2010,

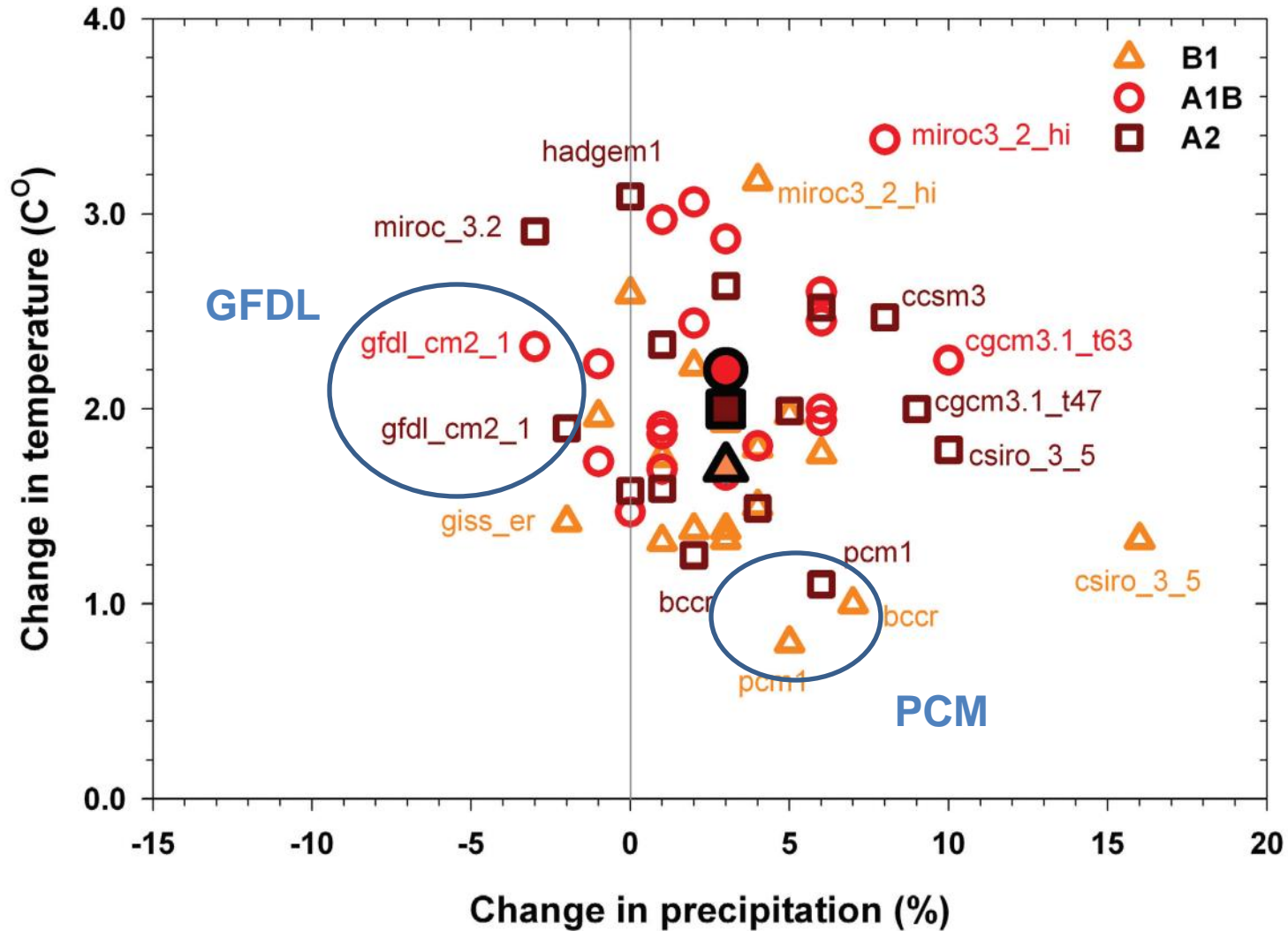
# Vulnerability Assessment Process



# Emission Scenarios

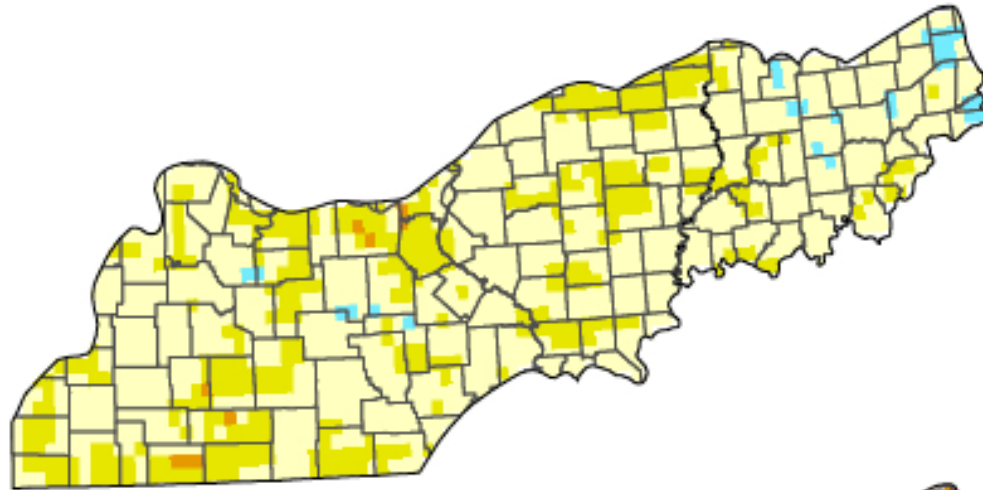


# Climate Models

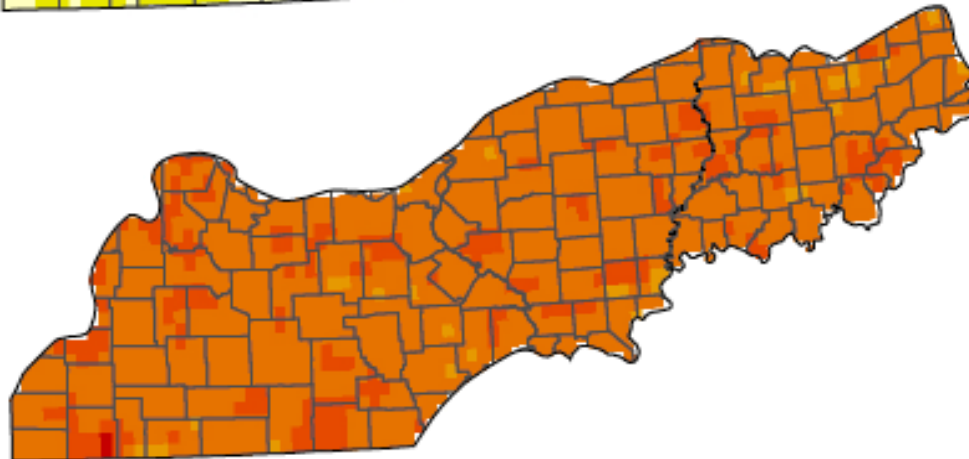


# Mean Annual Temperatures Will Almost Certainly Get Warmer

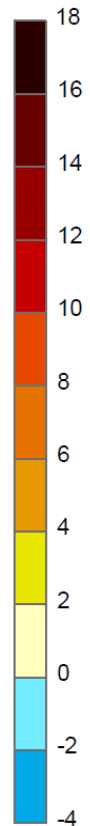
Low Emissions



High Emissions



2070 - 2099  
departure  
from baseline  
(°F)

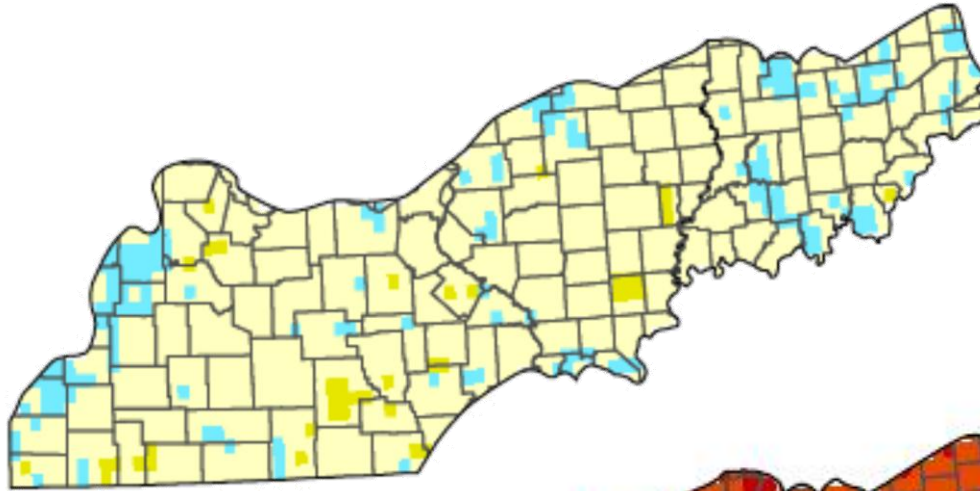


warmer

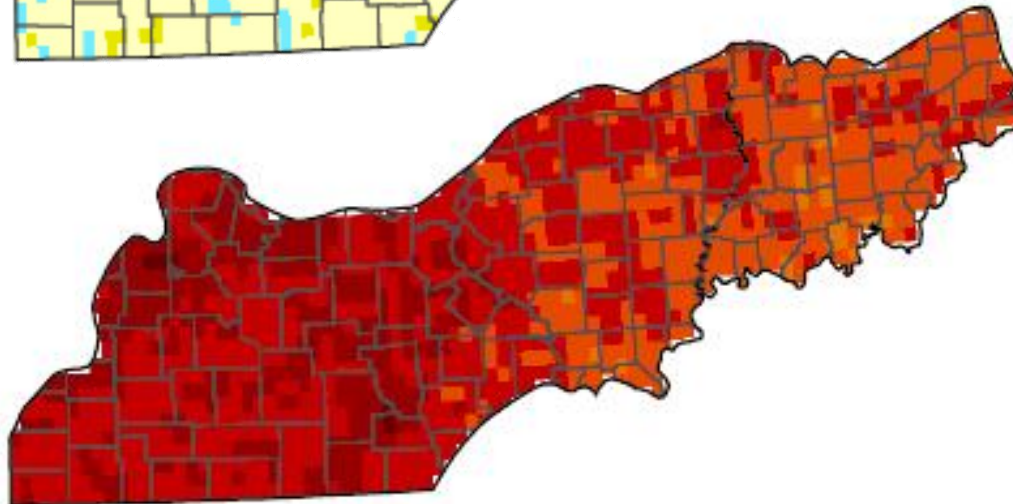
cooler

# Large Discrepancy in Summer High Temperatures

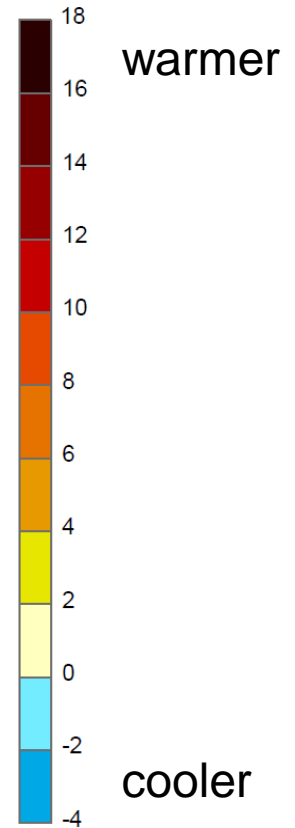
Low Emissions



High Emissions

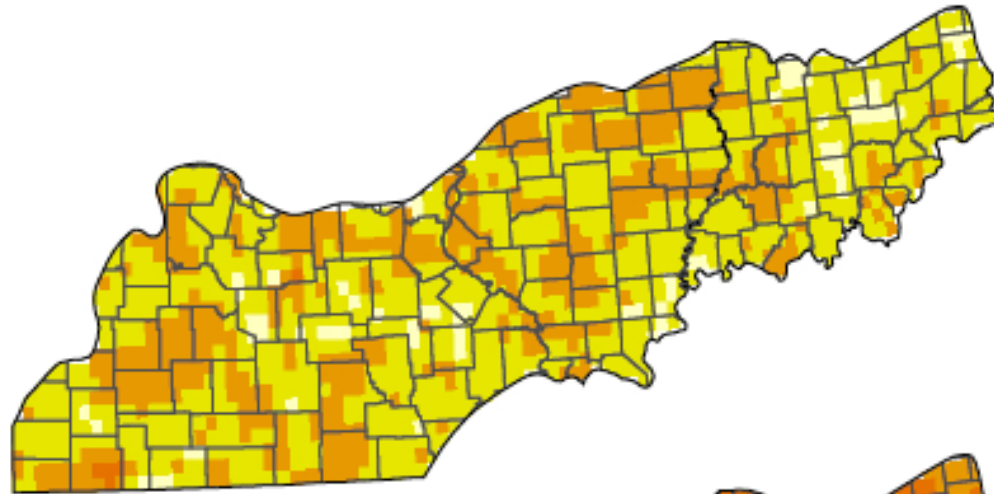


2070 - 2099  
departure  
from baseline  
(°F)

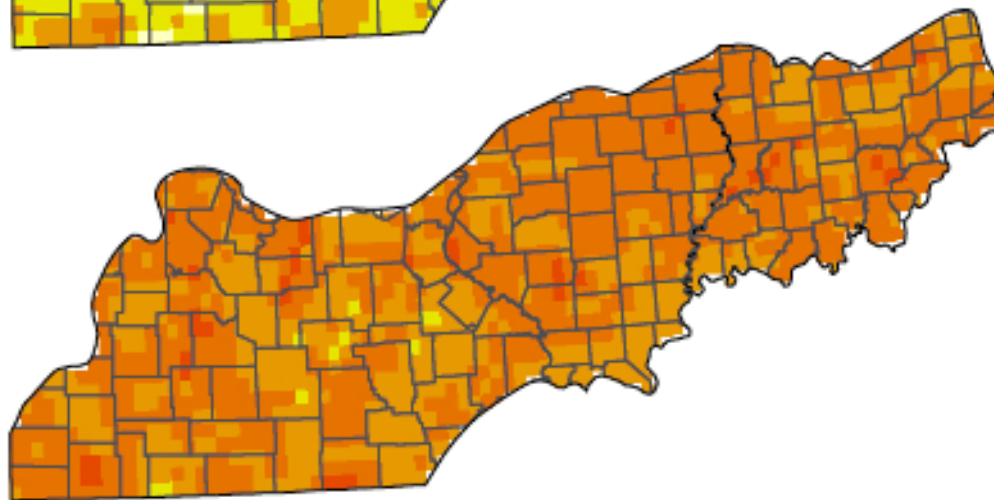


# More Agreement in Winter Low Temperatures

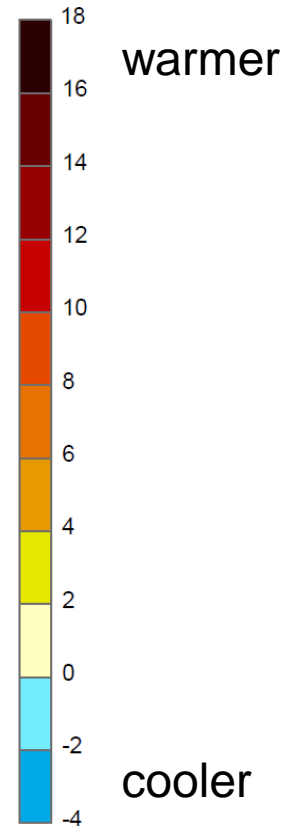
Low Emissions



High Emissions



2070 - 2099  
departure  
from baseline  
(°F)



# Winters and Springs May Get Wetter

Low Emissions

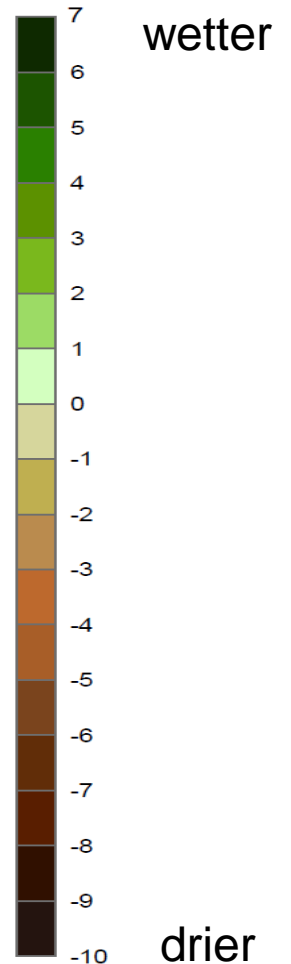
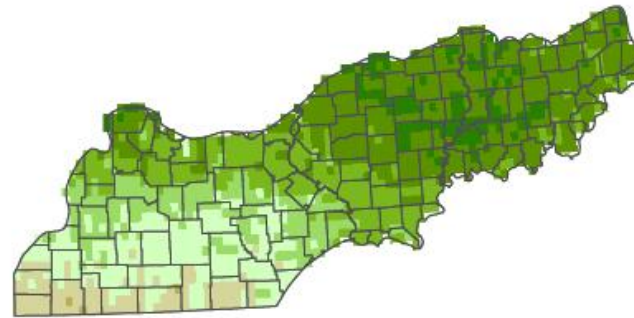
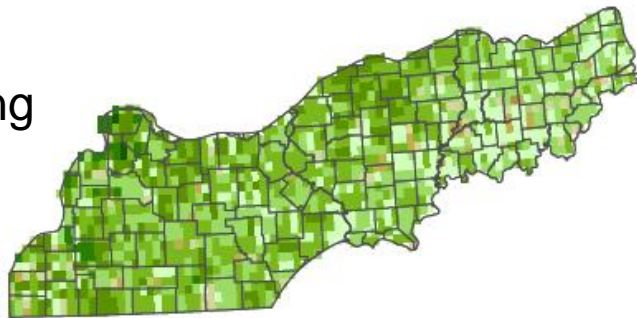
High Emissions

2070 - 2099  
departure  
from baseline  
(inches)

Winter



Spring



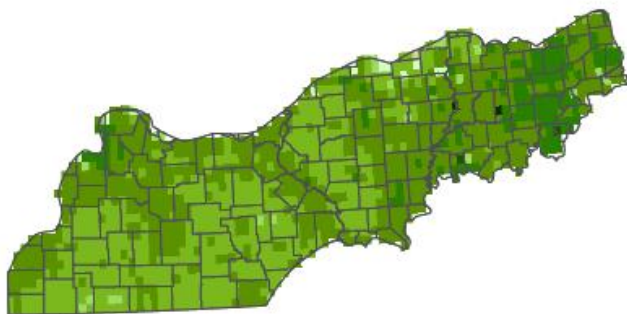
# Summers or Falls May Be Drier

Low Emissions

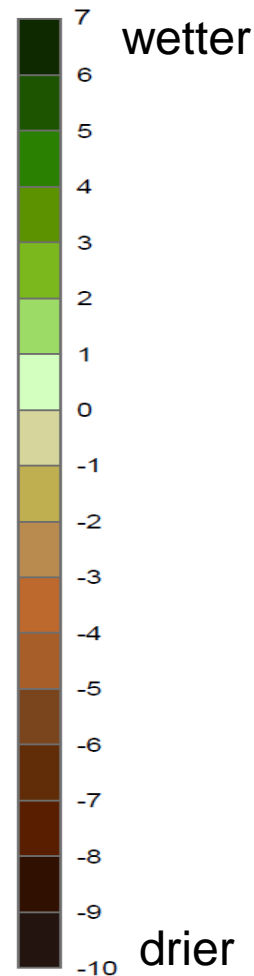
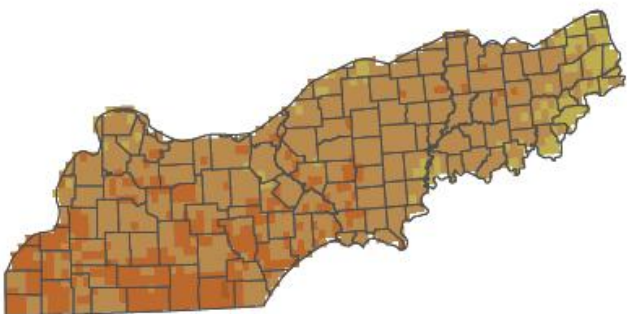
High Emissions

2070 - 2099  
departure  
from baseline  
(inches)

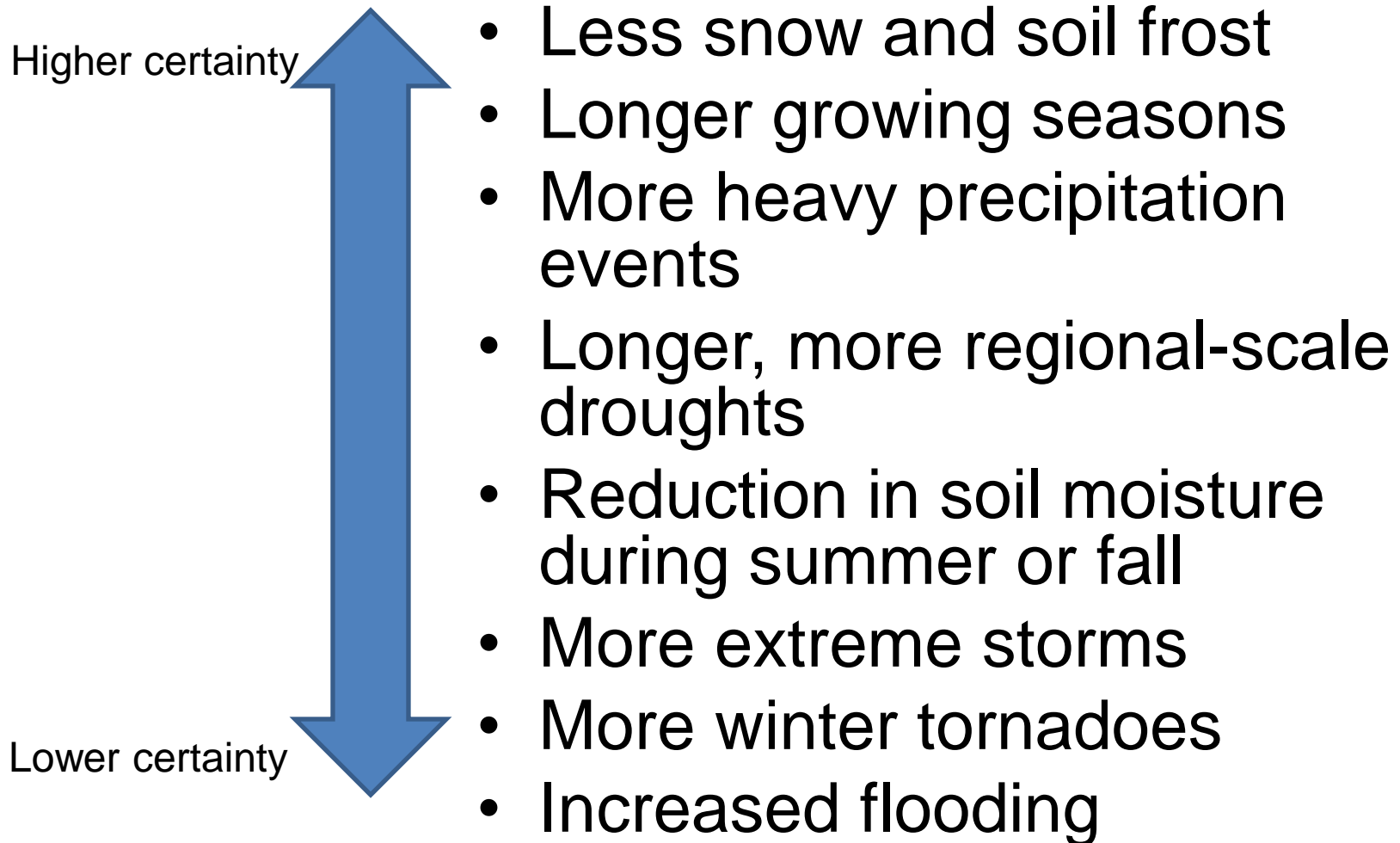
Summer



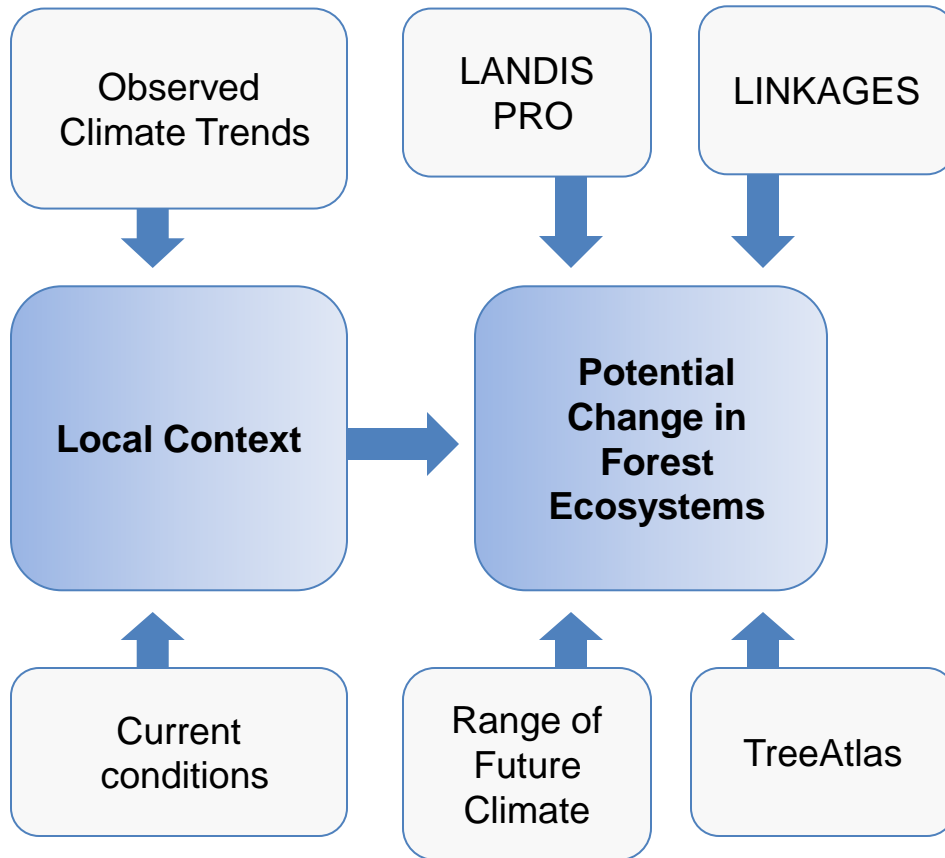
Fall



# Other Projected Climate Changes



# Vulnerability Assessment Process

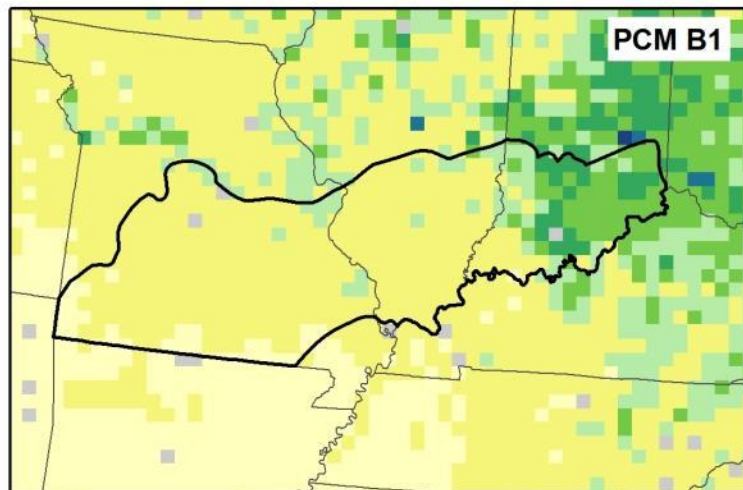
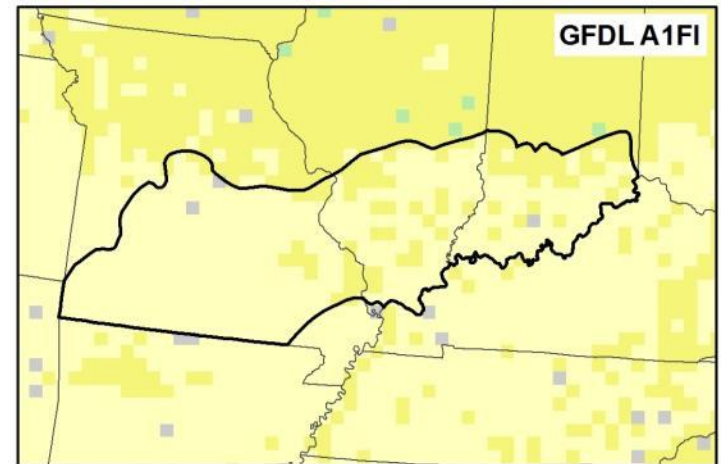
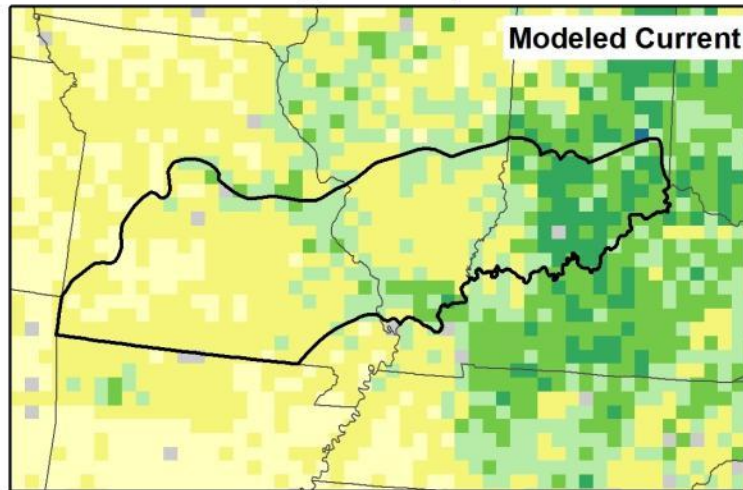


# Tree Atlas

- Iverson et al., US Forest Service Northern Research Station
- Large-scale statistical model based on FIA data
- 20 km resolution
- 134 tree species assessed across the eastern US

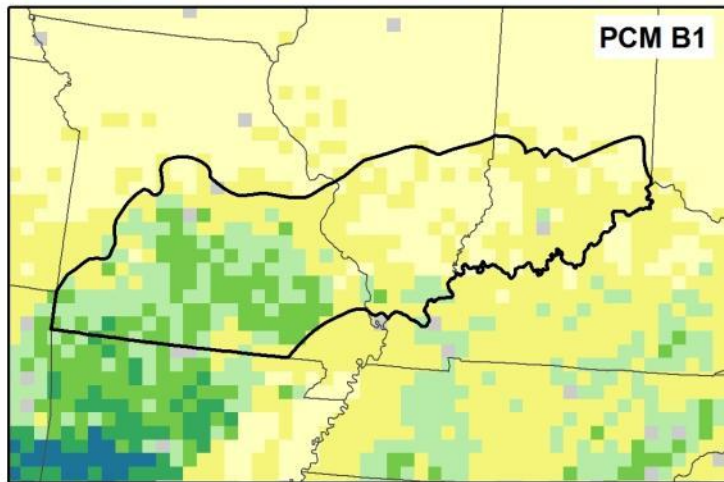
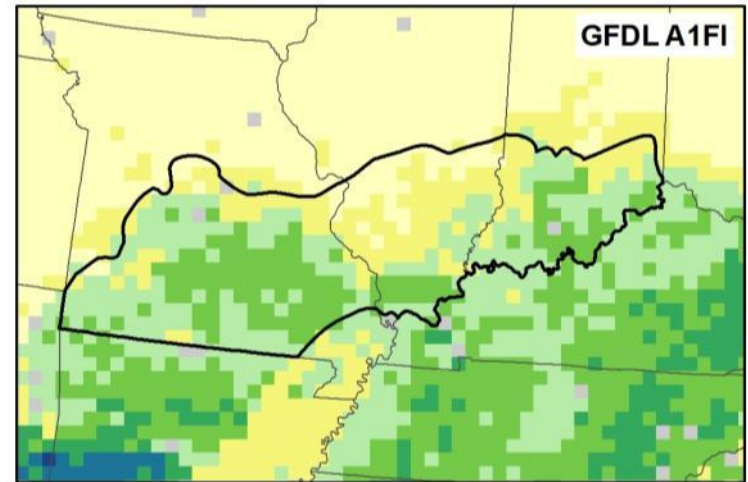
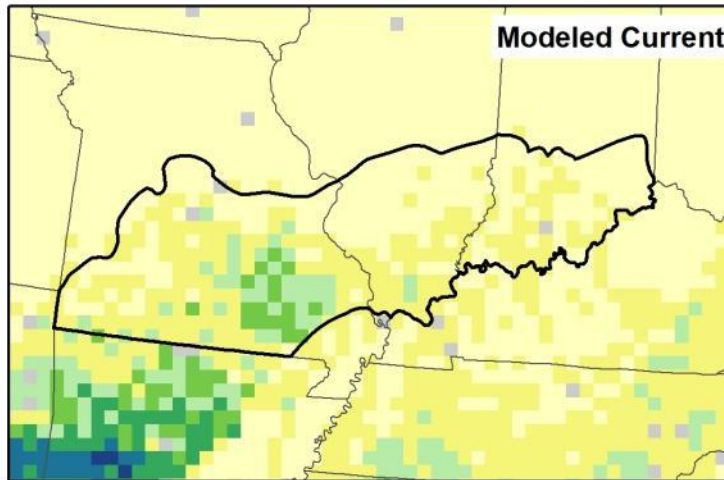
# Decline in Sugar Maple Habitat Suitability

## Sugar Maple



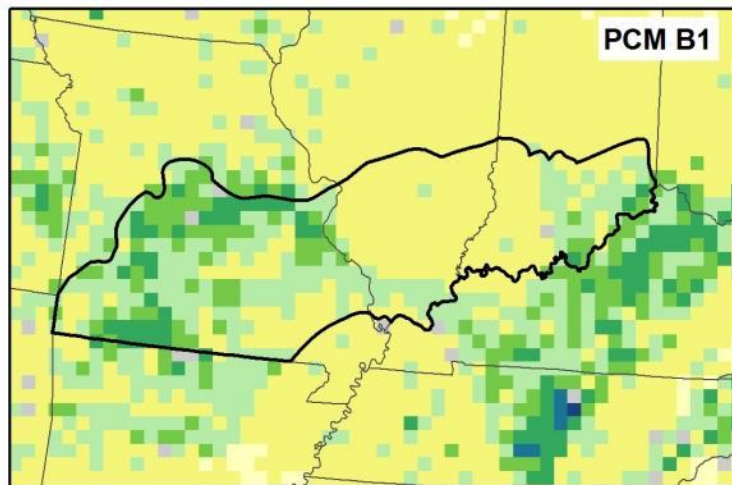
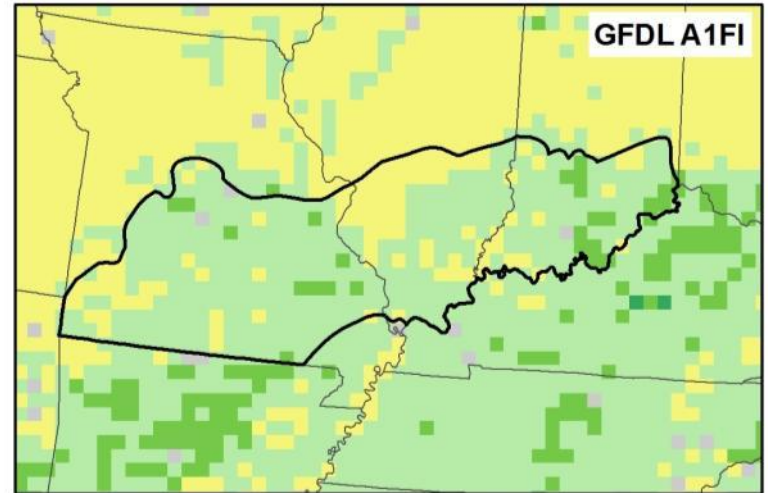
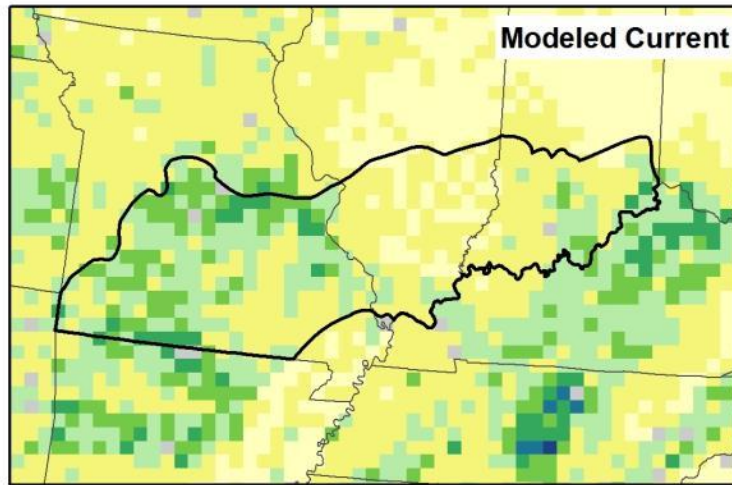
# Increase in Shortleaf Pine Habitat Suitability

## Shortleaf Pine



# Habitat May Remain Suitable for Eastern Redcedar

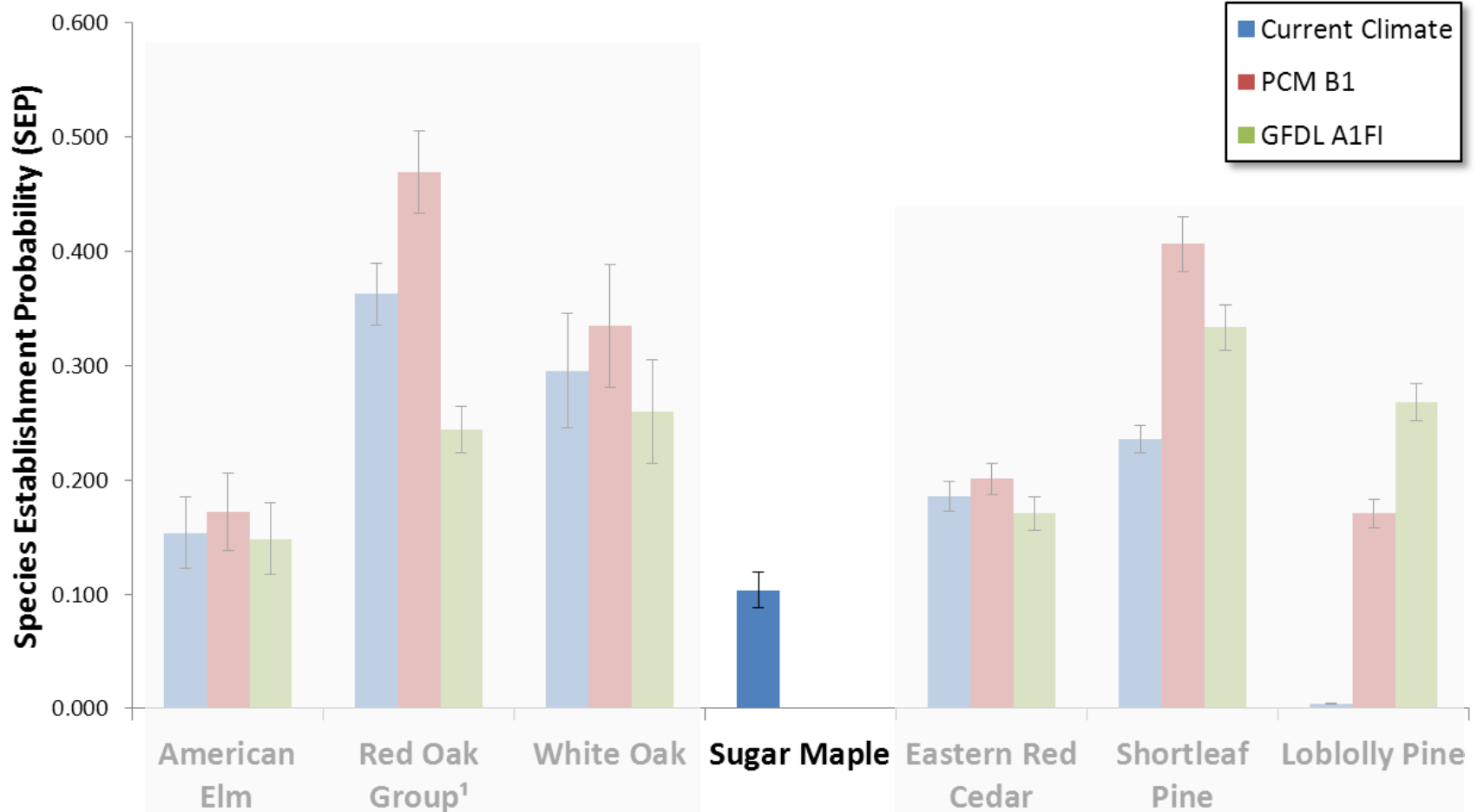
## Eastern Redcedar



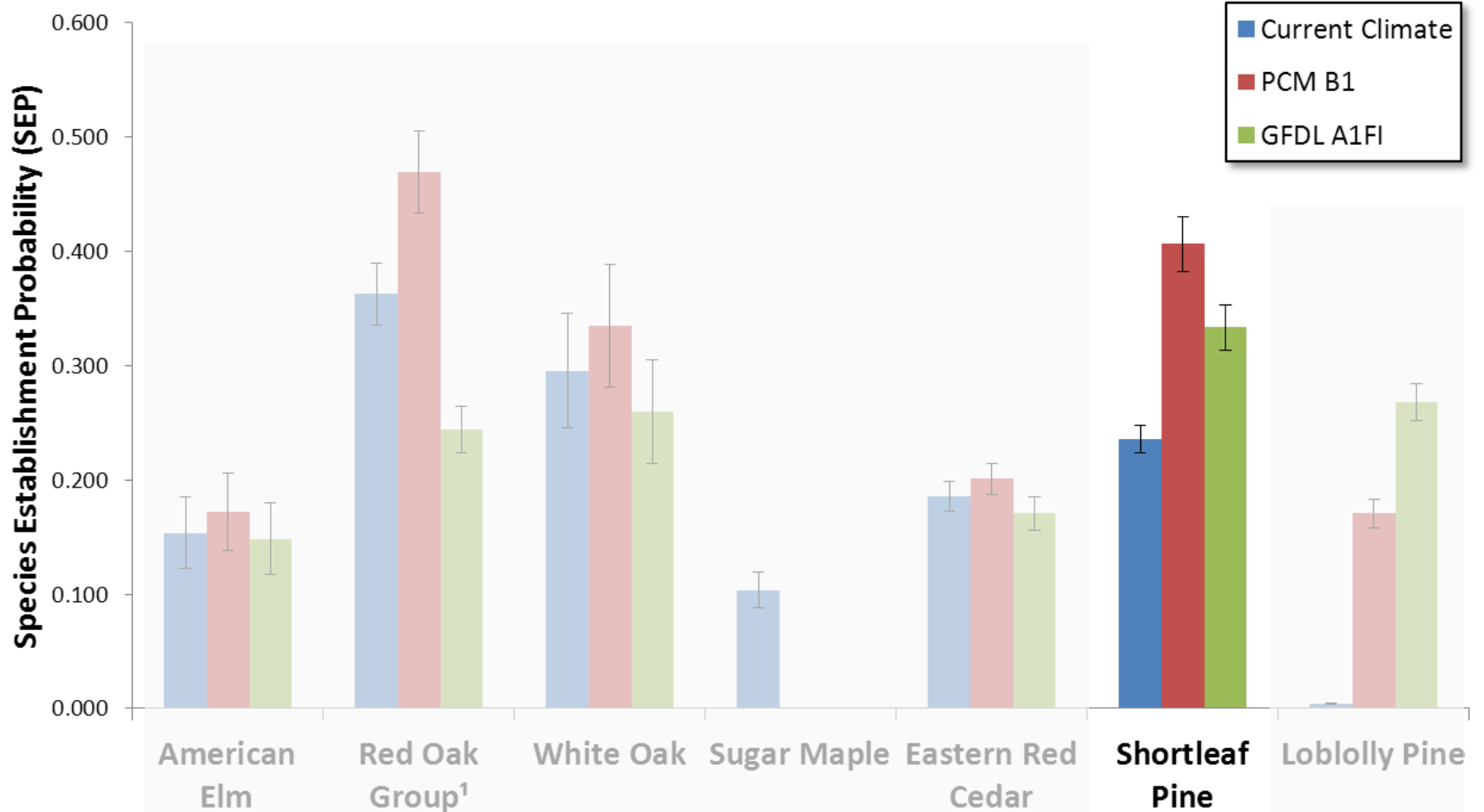
# LINKAGES

- Thompson, He, et al.
- Dynamic “gap” model
- 1/12 ha plots, averaged by ecological subsection
- 7 species groups
- Nutrient dynamics simulated

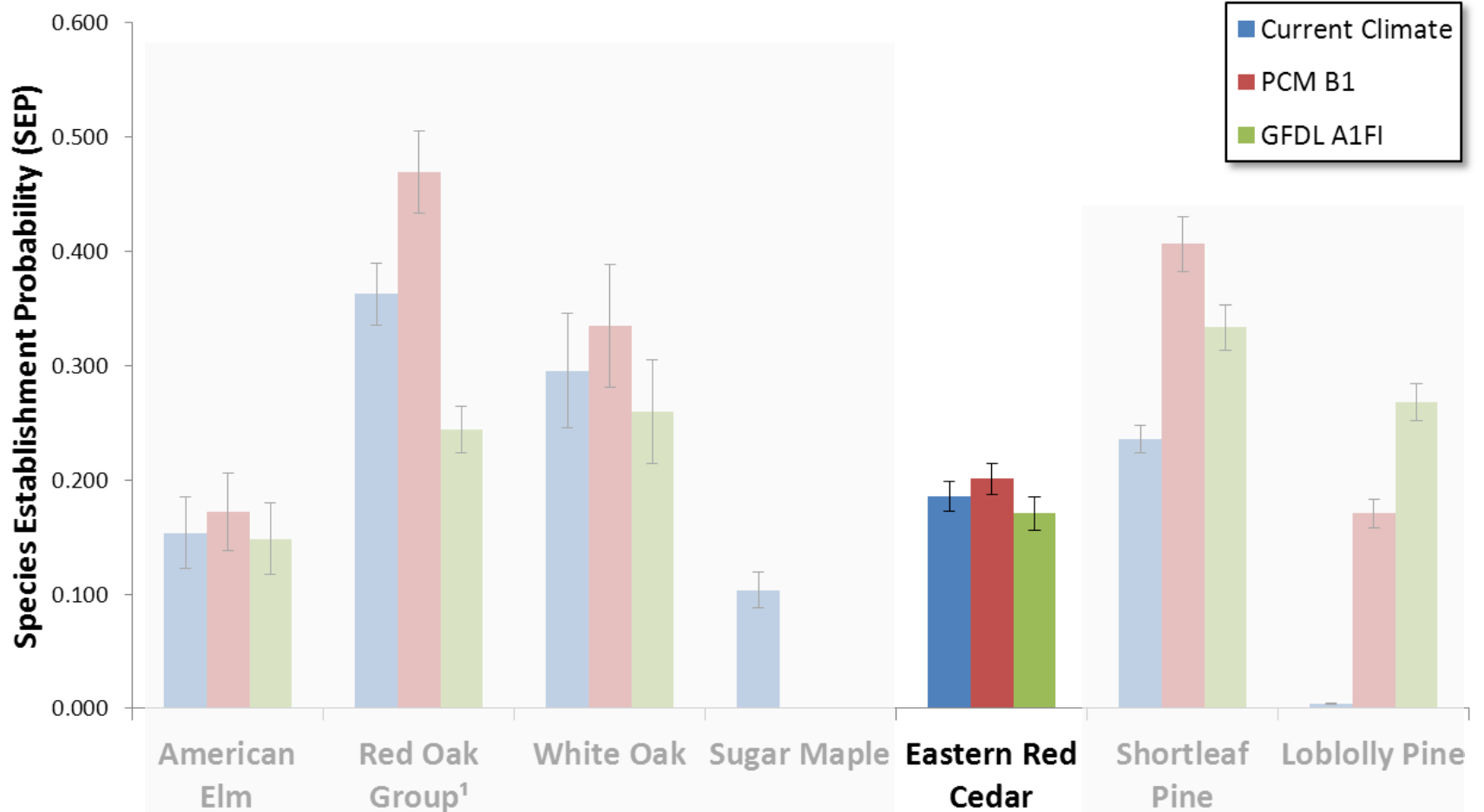
## LINKAGES: Species Establishment Probability (SEP)<sup>2</sup> Average Over Landscape



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# LANDIS PRO

- He, Thompson, et al.
- Spatially dynamic model
- 90 m grid
- 7 species groups
- Migration simulated

LANDIS Pro: Percent Change from 2000 (on Forested Acres)							
		Current Climate		PCM B1		GFDL A1FI	
Species name	Year	Basal Area	Trees/Acre	Basal Area	Trees/Acre	Basal Area	Trees/Acre
Ulmus Group <sup>1</sup>	2040	132.25	-66.99	128.98	-66.20	134.98	-65.86
	2070	150.26	-81.43	141.30	-80.89	161.08	-79.55
	2090	137.18	-87.00	127.16	-86.45	152.53	-85.18
Red Oak Group <sup>2</sup>	2040	53.58	-14.88	57.61	0.13	47.01	-55.22
	2070	86.45	-16.36	93.28	5.62	72.69	-56.98
	2090	88.00	-7.59	99.80	24.42	68.27	-54.47
White Oak Group <sup>3</sup>	2040	5.11	-45.87	4.62	-41.10	5.64	-44.49
	2070	13.08	-54.53	10.27	-50.41	15.47	-50.10
	2090	13.53	-58.05	9.72	-53.35	18.05	-49.61
Acer Group <sup>4</sup>	2040	88.19	-65.78	76.78	-75.06	78.69	-74.82
	2070	129.64	-70.54	94.40	-87.00	100.43	-86.57
	2090	154.65	-65.11	94.95	-91.40	102.73	-91.01
Eastern Redcedar	2040	182.89	147.41	178.25	139.42	169.51	114.12
	2070	450.58	180.45	411.50	143.40	433.05	159.66
	2090	649.69	158.29	575.35	114.48	629.70	136.14
Shortleaf Pine	2040	11.06	141.19	34.68	276.85	34.20	276.94
	2070	90.25	223.40	150.51	439.58	176.85	486.67
	2090	135.96	256.39	220.51	499.58	267.79	574.97

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# Other Forest Impacts

Increased probability of wildfire by end of century



Greater susceptibility to non-native species invasions



Carbon dioxide fertilization

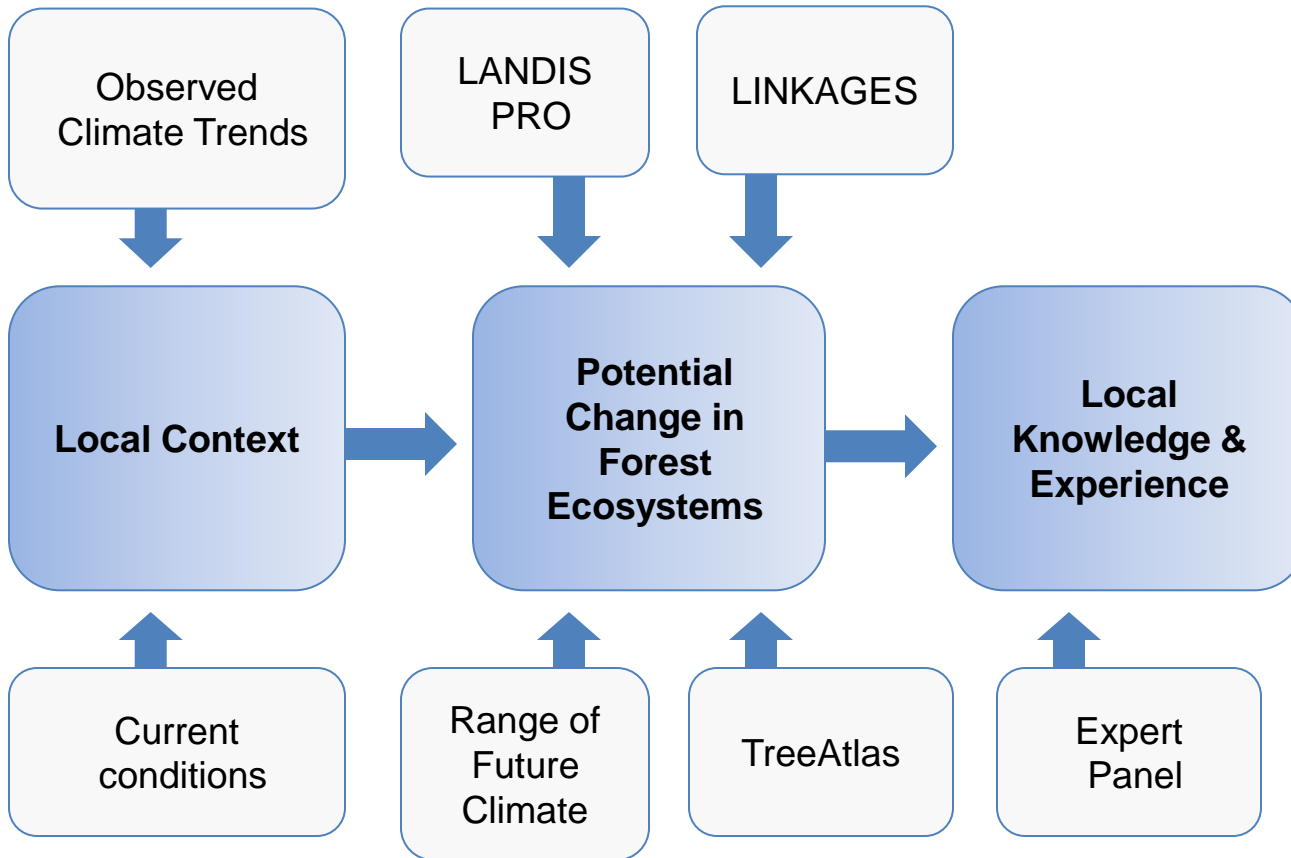


More pest and disease outbreaks



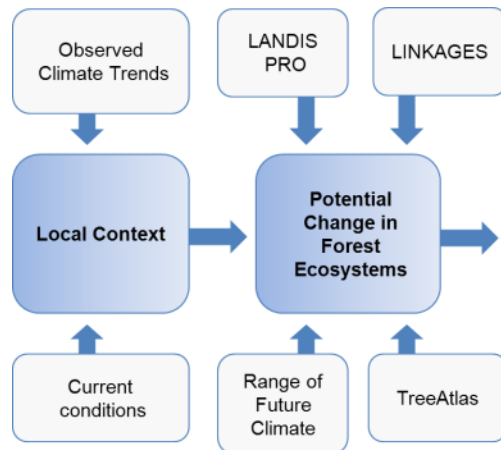
Sources: Moritz et al. 2012, Dukes et al. 2009, Lenihan et al. 2008

# Vulnerability Assessment Process

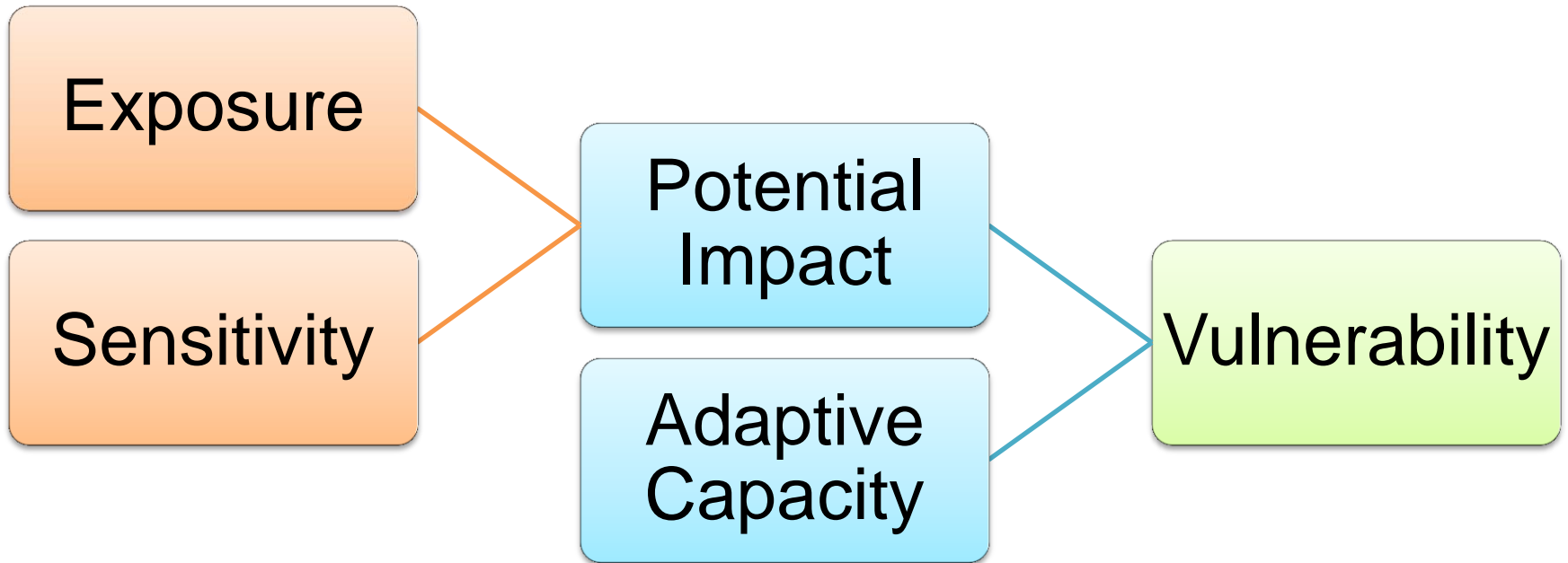


# Expert Panel

- 20 scientists, managers
- Range of institutions, geography, area of expertise (forest ecology, management, climate change, modeling)
- Given information:

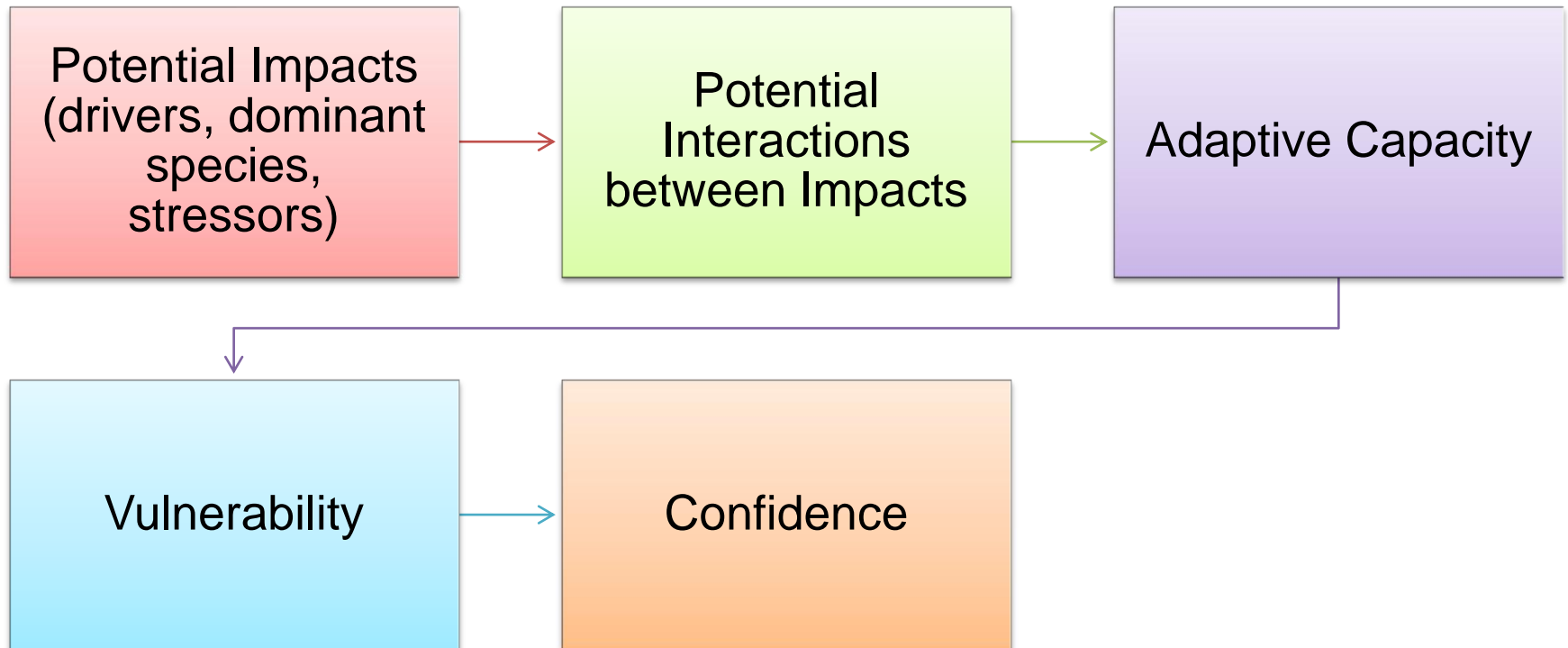


# Vulnerability



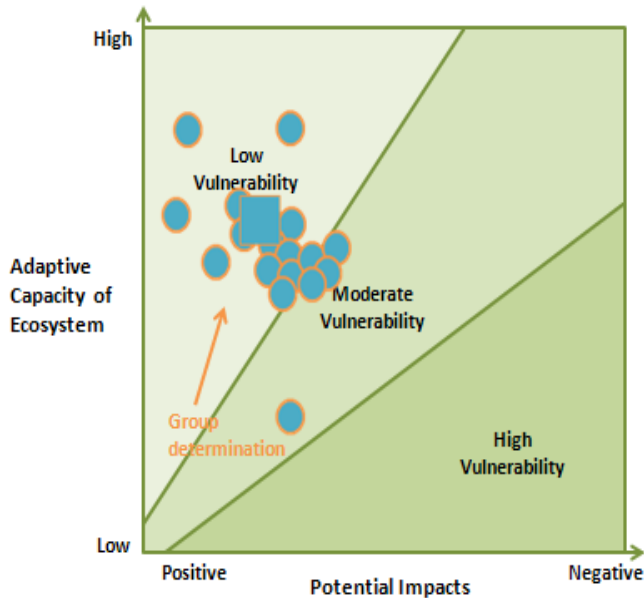
# Vulnerability Determination Process

For each community type:

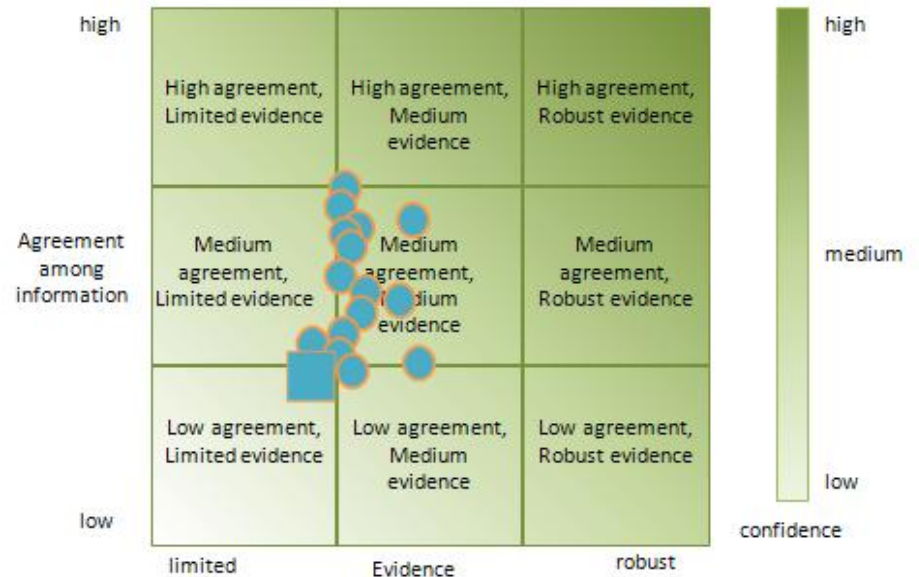


# Group Determination

## Vulnerability



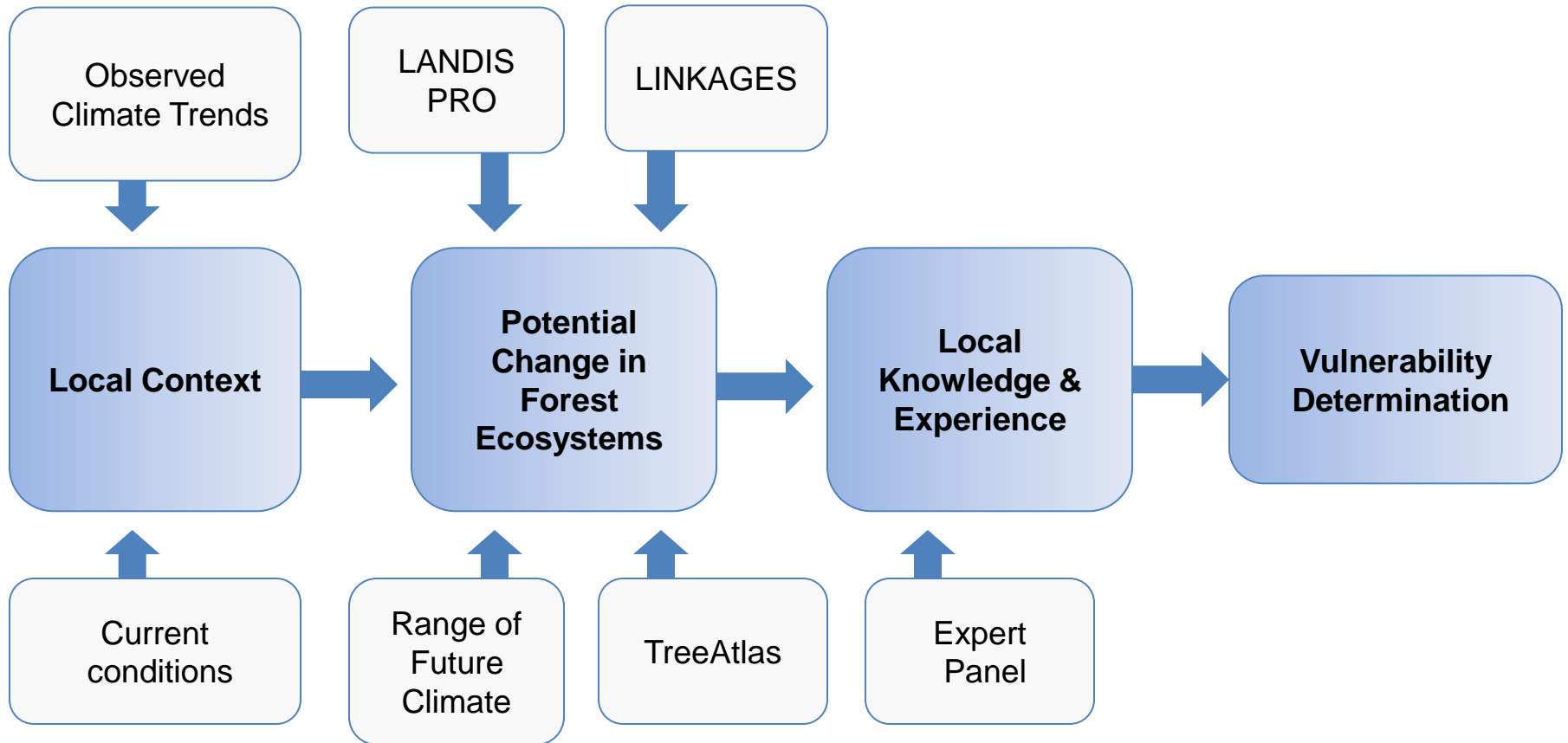
## Confidence



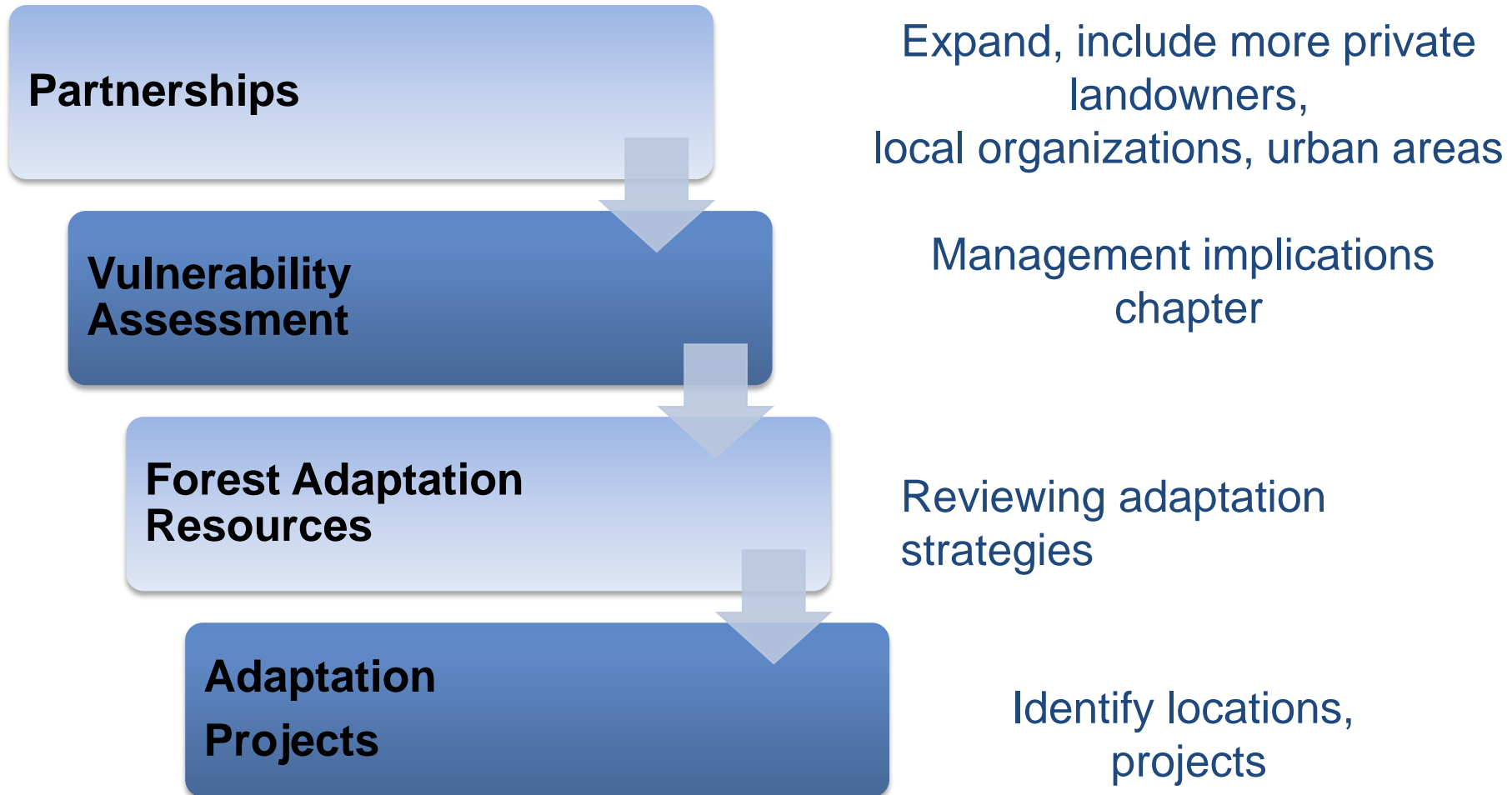
# Communities Assessed

Community Type	Potential Impacts	Adaptive Capacity	Vulnerability	Confidence
Barrens	Moderate	High	Low	Medium-high agreement; Medium evidence
Closed Woodland	Positive	High	Low	Medium agreement; Limited evidence
Open Woodland	Positive	High	Low	Medium agreement: Medium to Limited evidence
Dry-Mesic Upland Forest	Moderate	High	Low-Moderate	Medium to high agreement; Medium evidence
Flatwoods	Slightly Positive	Moderate	Low-Moderate	Medium agreement.; Limited to medium evidence
Glade	Slightly Positive	Moderate	Low-Moderate	Medium to high agreement; Medium evidence
Mesic Bottomland Forest	Moderate	Moderate	Moderate	Medium agreement; Medium to limited evidence
Wet Bottomland Forest	Slightly Negative	Moderate	Moderate- High	Medium agreement; Medium to limited evidence
Mesic Upland Forest	Negative	Low	High	Medium-high agreement; medium evidence

# Vulnerability Assessment Process



# Next Steps



```
graph TD; A[Define goal] --> B[Assess vulnerabilities]; B --> C[Evaluate objectives]; C --> D[Identify adaptation strategies]; D --> E[Monitor effectiveness]; E --> A;
```

Define goal

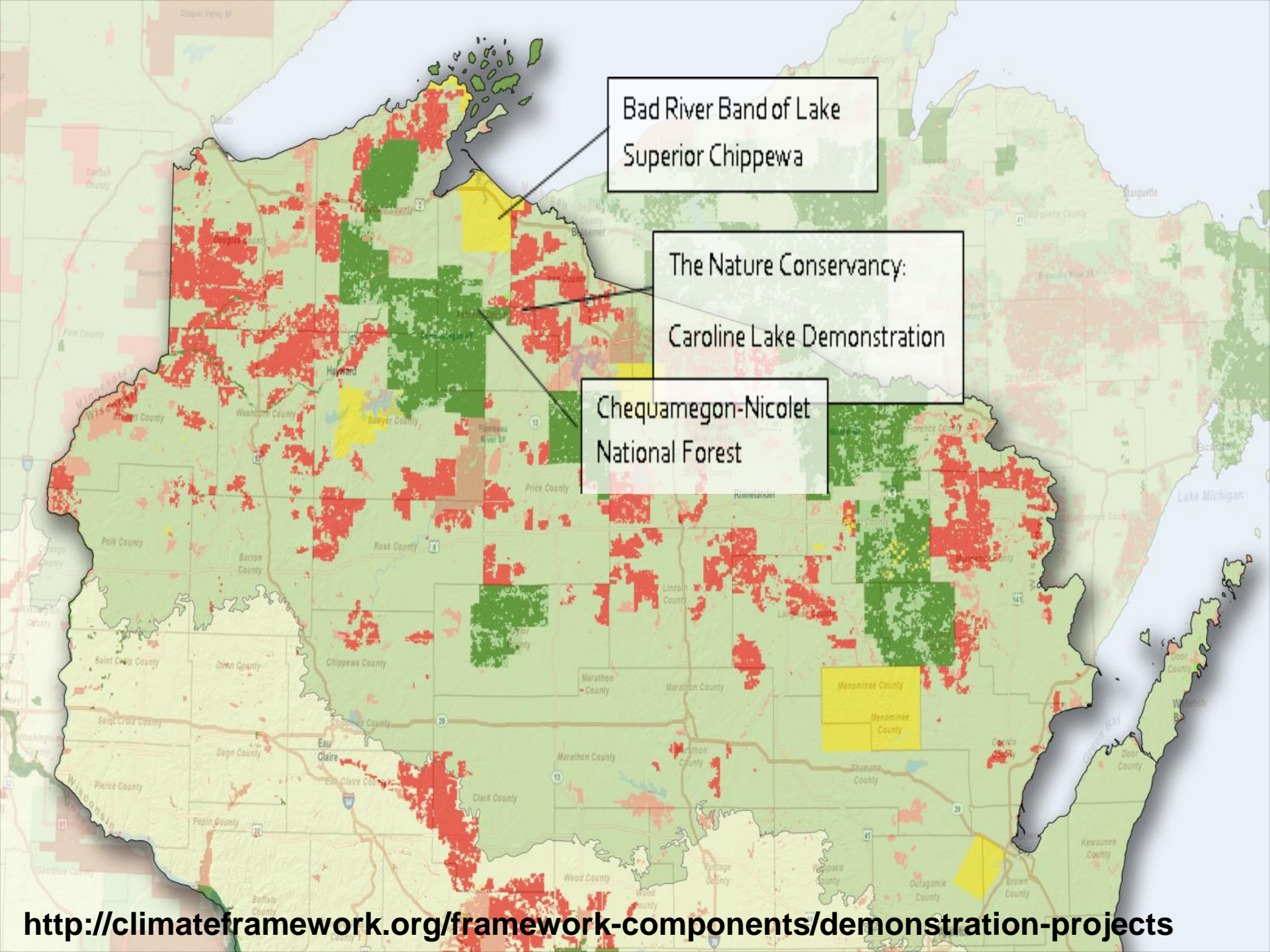
Assess  
vulnerabilities

Evaluate  
objectives

Identify  
adaptation  
strategies

Monitor  
effectiveness





Bad River Band of Lake Superior Chippewa

The Nature Conservancy:  
Caroline Lake Demonstration

Chequamegon-Nicolet National Forest



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*Bibliography available on request*

