

Decisions and System Thinking

Jim Fox

November, 2012



UNC Asheville's NEMAC

National Environmental Modeling and Analysis Center

- **Applied Research** and technology development on integration of environmental and climate data sets
 - Data and GIS
 - Visualization
 - Decision Making
- **Decision Support tools** for Flood Mitigation, Emergency Response, Water Resource Issues, Vulnerability and Resilience
- **Collaboration** among government, academia and private enterprise
- **Economic Development** activities in the Western Carolina Region
- Active **Undergraduate Research**



Climate Literacy Education and Research (CLEaR) Grant



Eastern Forests Environmental Threat Assessment Center (EFETAC) Coop Agreement



Renaissance Computing Institute State of North Carolina

Local and State Government



Mountain Resource Commission

Companies



Others



Southeast Natural Resource Leaders Group



From Data to Decisions

A four-step business process

Integration of Data



GIS – Spatial
Images
Text
Data Feeds

Accurate and
Current

Creating Visualizations



Science
Multimedia
Delivery
Technologies

Dynamic and
Rapid Delivery

Telling the Story



Communications
Education
Narrative
Serious Games

Fits the
Audience and
Specific Need

Group Decision Making



Listening
Recording
Scenarios
Alternatives
Uncertainty

Supports the
Decision
Making Process

Overview

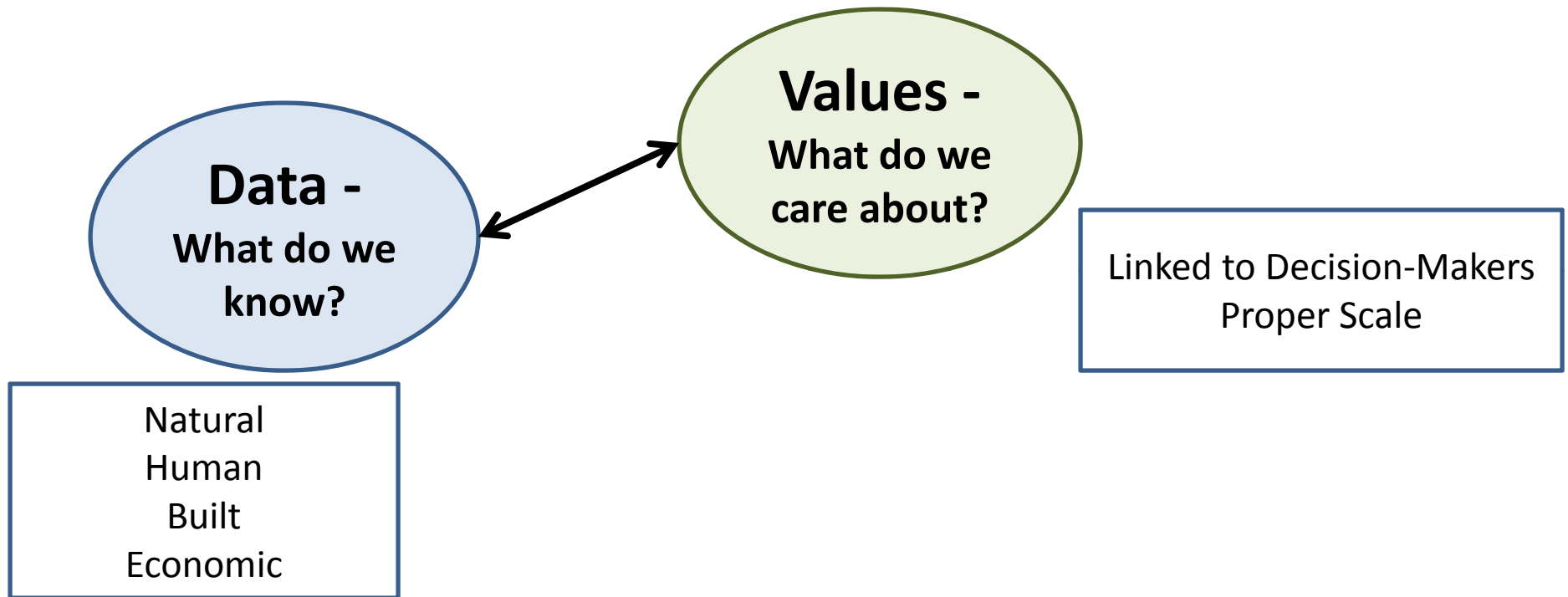
- Baseline changes in climate increases risk of severe weather impact
 - Drought -> fire from lightning
 - Long periods of rain -> big storm -> flood
 - Sea level rise -> storm surge -> flood
- Non-climate issues add to sensitivity
 - Pests killing trees
 - Population and demographic changes
 - Economic Issues
- Impact on decisions
 - Who accepts responsibility and assigns resources?

Decision Making Building Blocks

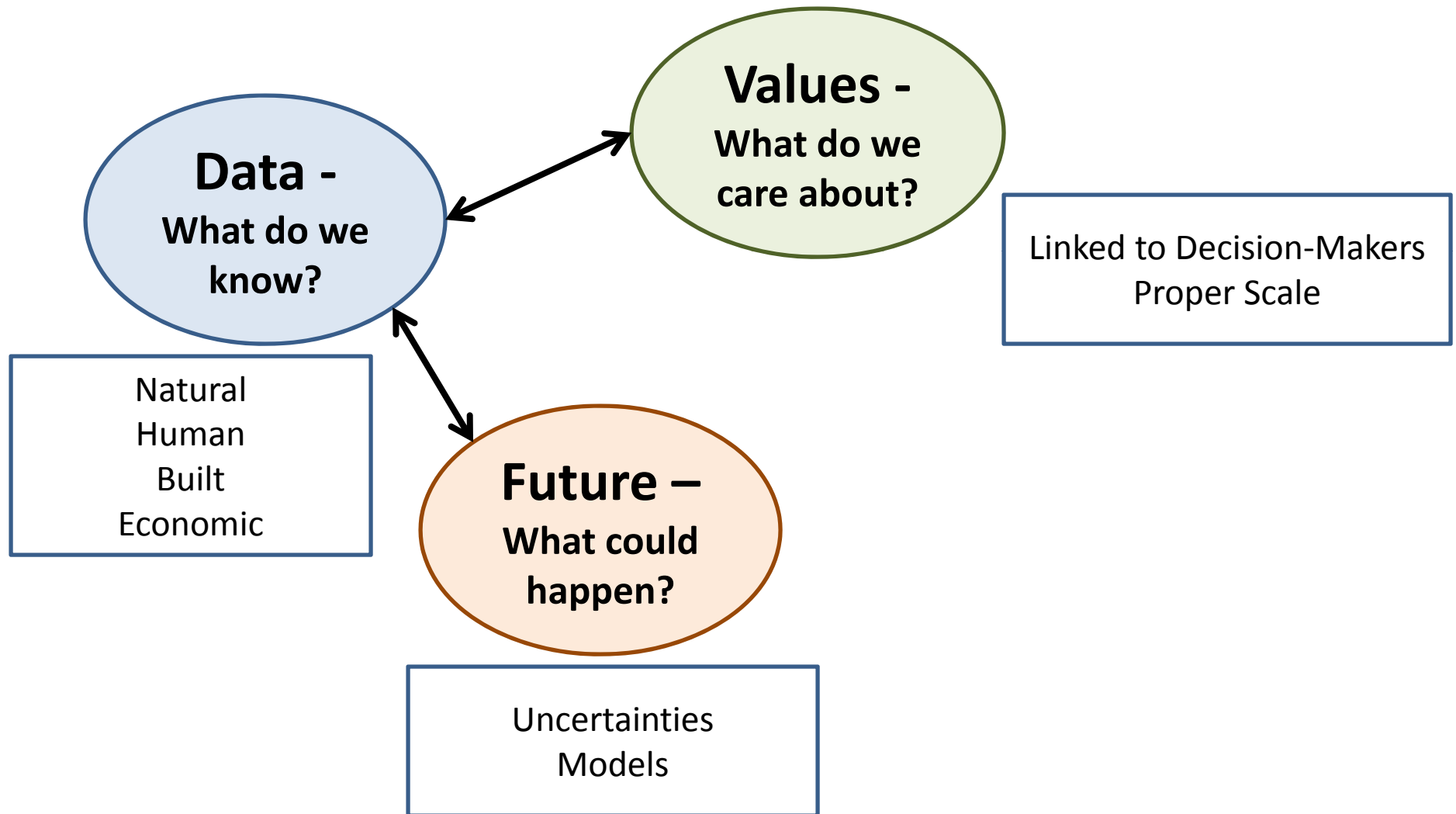
**Data -
What do we
know?**

Natural
Human
Built
Economic

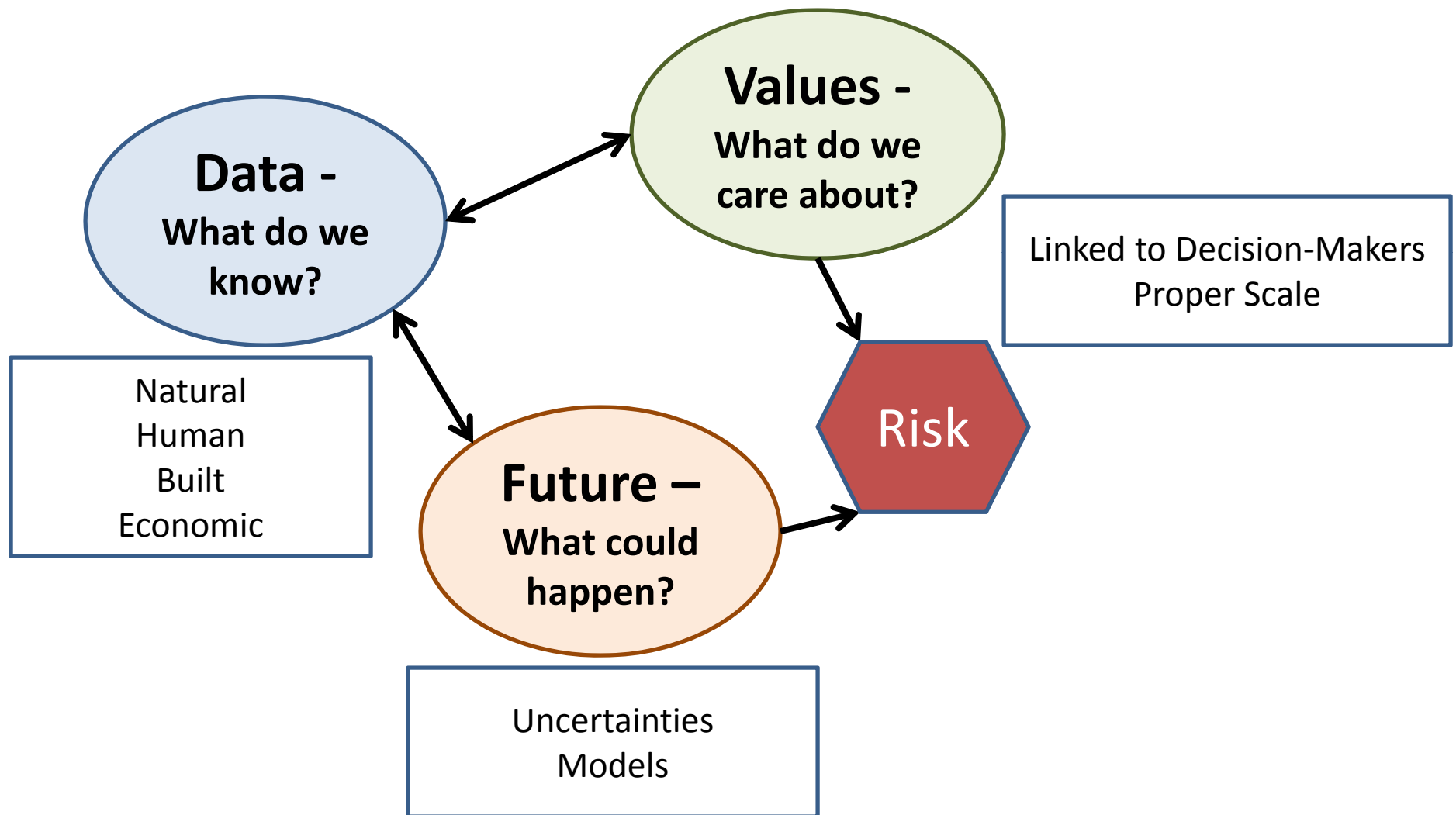
Decision Making Building Blocks



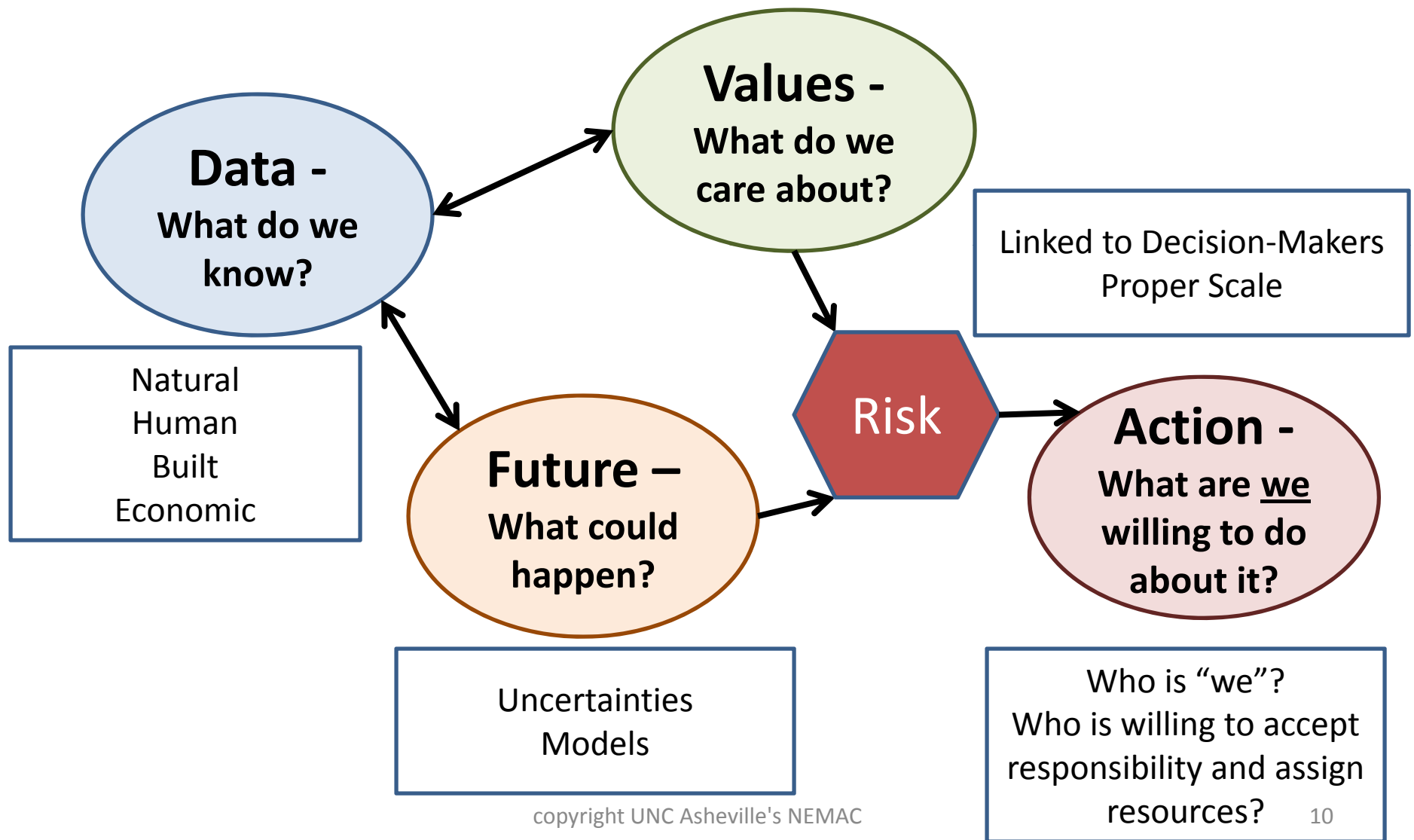
Decision Making Building Blocks



Decision Making Building Blocks



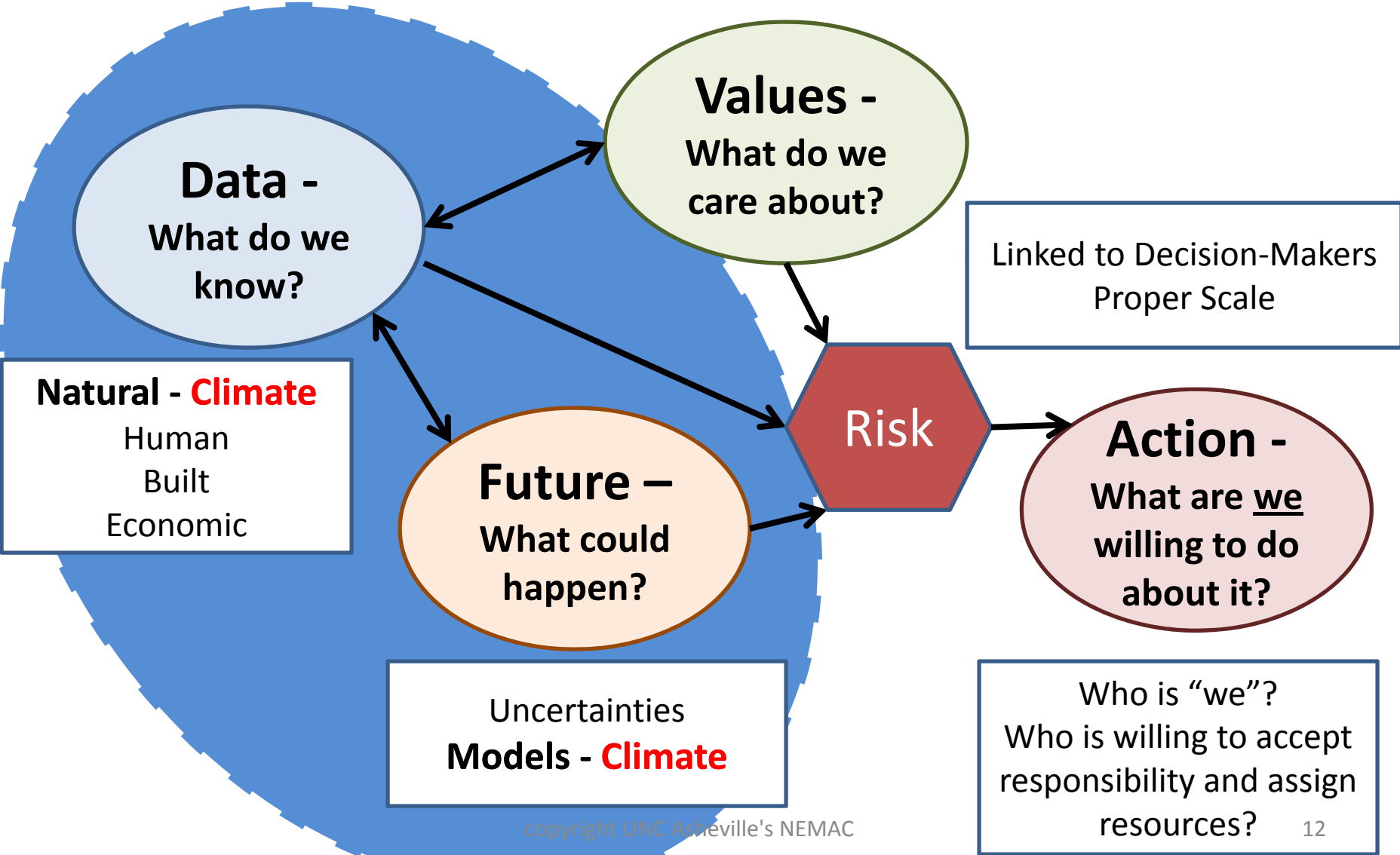
Decision Making Building Blocks

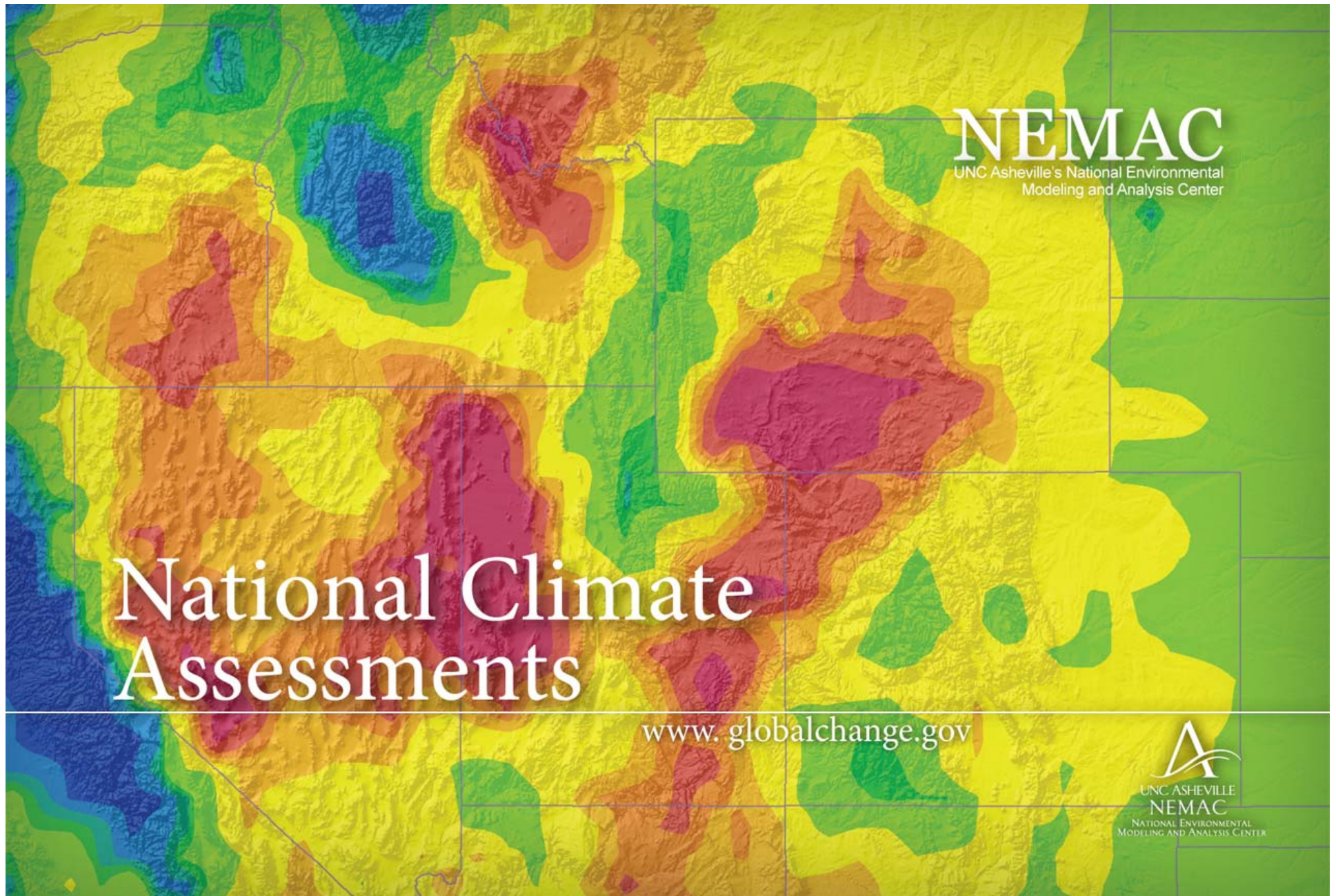


Scales of responsibility

1. Personal
2. Neighborhood/County
3. Regional – connected by a shared service
4. National
5. Global

Climate and Climate Change Data and Models



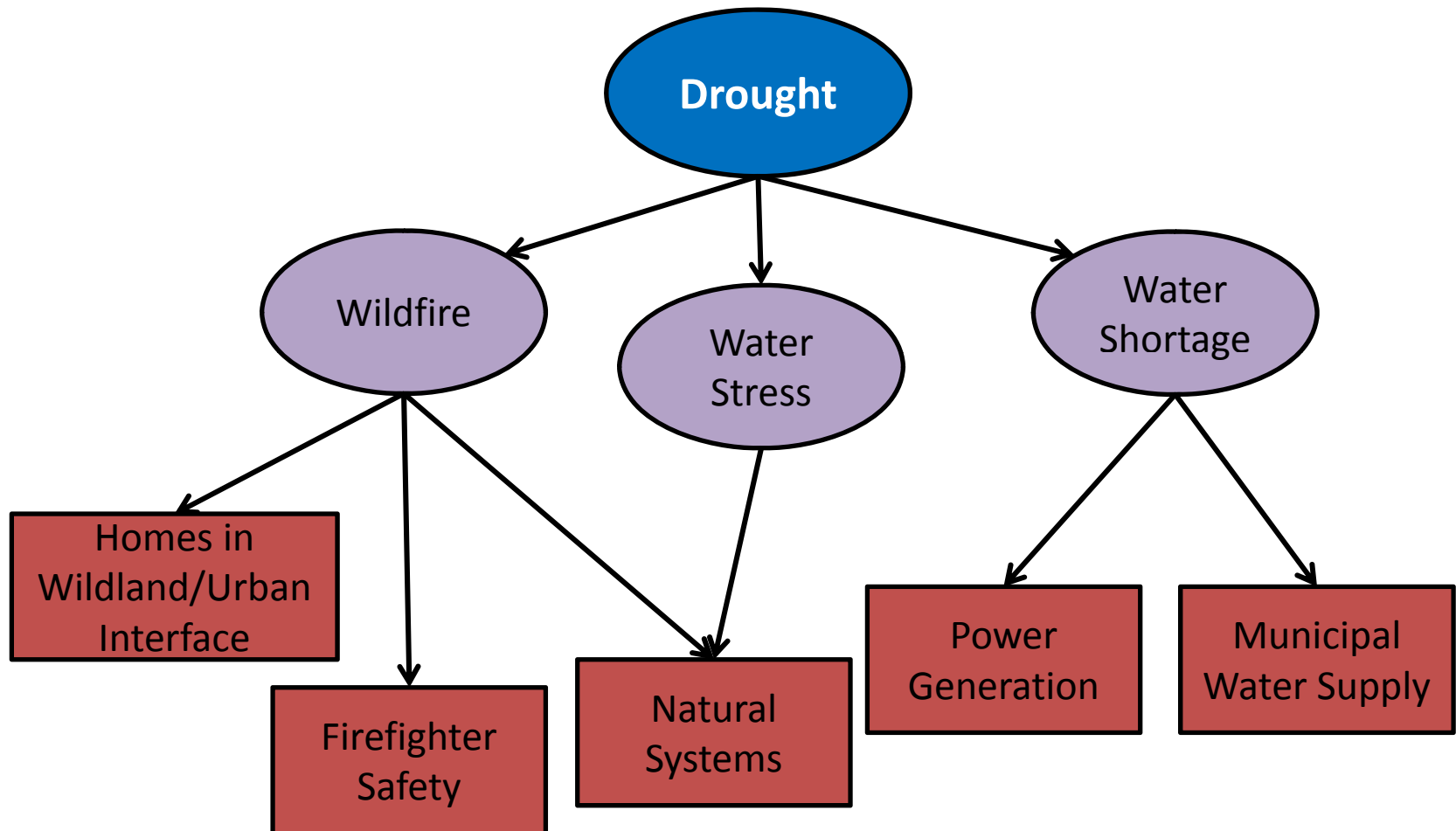


Decision Portals, GIS Viewers, Drafted Map Suites, Facilitation in support of the NCA

National Climate Assessment

- **Decision:** Integrated solutions that consider factors including economic development, transportation, agriculture, etc.
- **Scale:** National
- **Use of Climate Data:** National and Regional climate impacts on key issues and sectors

Climate Assessment Conceptual Model of Linked Relationships



Assessments **lead to** decisions: focus on resources and values lets end customer understand why climate matters



NEMAC
UNC Asheville's National Environmental
Modeling and Analysis Center

ForWarn

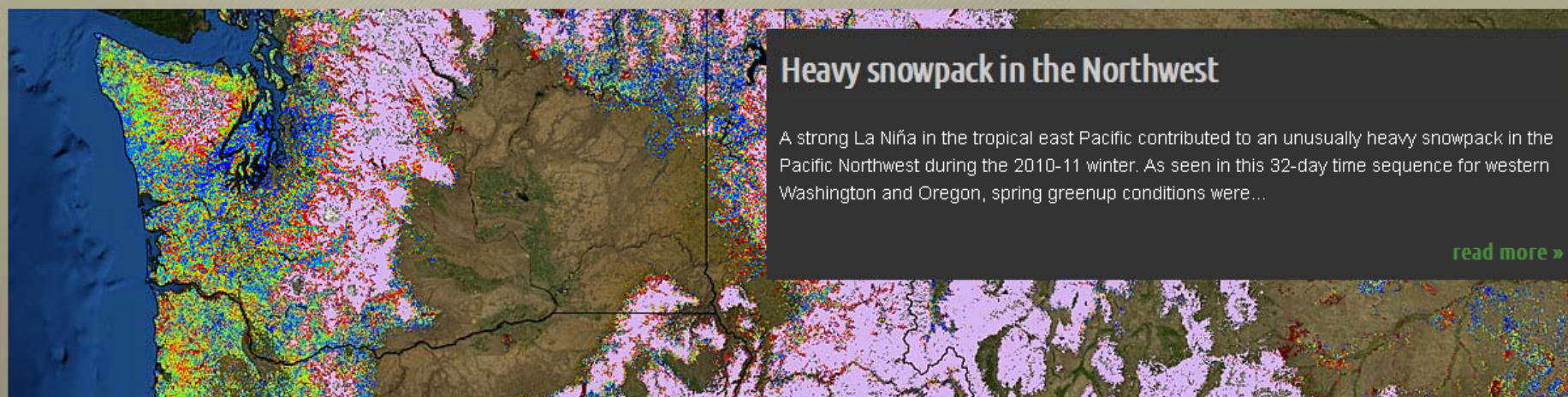
www.forwarn.forestthreats.org



National scale, updated every eight days, change detection system

ForWarn

Satellite-Based Change Recognition and Tracking


[Home](#)
[Overview](#)
[News](#)
[Highlights](#)
[Data](#)
[Support](#)


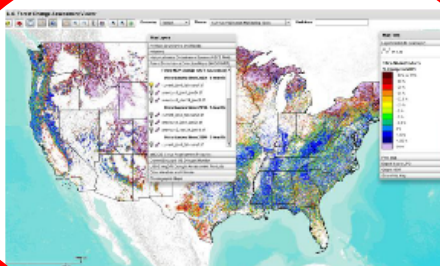
Heavy snowpack in the Northwest

A strong La Niña in the tropical east Pacific contributed to an unusually heavy snowpack in the Pacific Northwest during the 2010-11 winter. As seen in this 32-day time sequence for western Washington and Oregon, spring greenup conditions were...

[read more »](#)

What is ForWarn?

ForWarn is a satellite-based forest disturbance monitoring system for the conterminous United States. It delivers new forest change products every eight days and provides tools for attributing abnormalities to insects, disease, wildfire, storms, human development or unusual weather. Archived data provide disturbance tracking across all lands since 2000. Interactive maps are accessible via the [Forest Change Assessment Viewer](#). Read more about ForWarn [here](#).



Recent News

[Official ForWarn News Release Now Available](#)

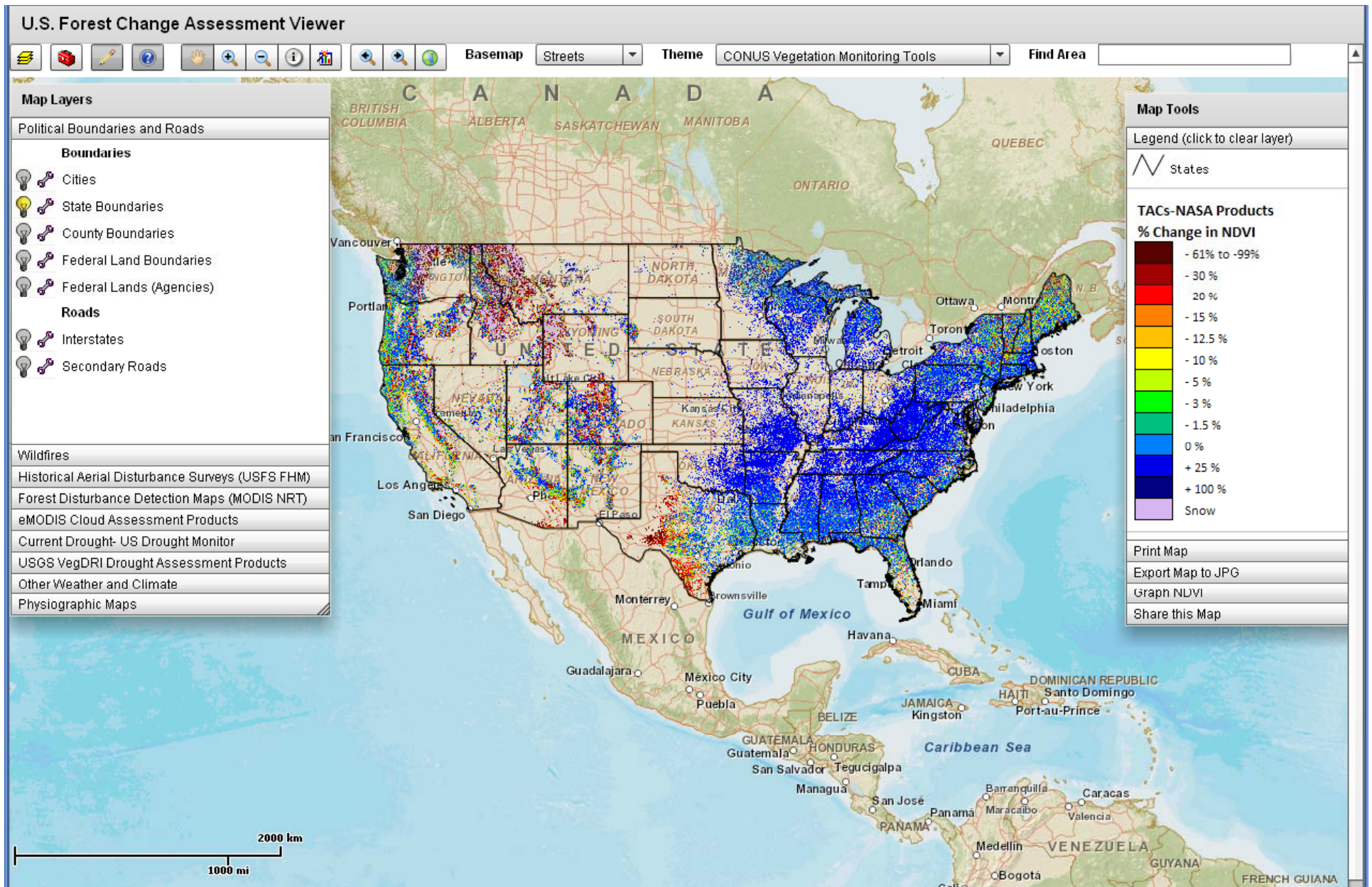
03/21/2012 - 09:25 The official news release from the USDA Forest Service and NASA announcing *ForWarn* is now available for download!

[USDA FS AND NASA JOINT PRESS RELEASE 03 15 12.DOC](#)

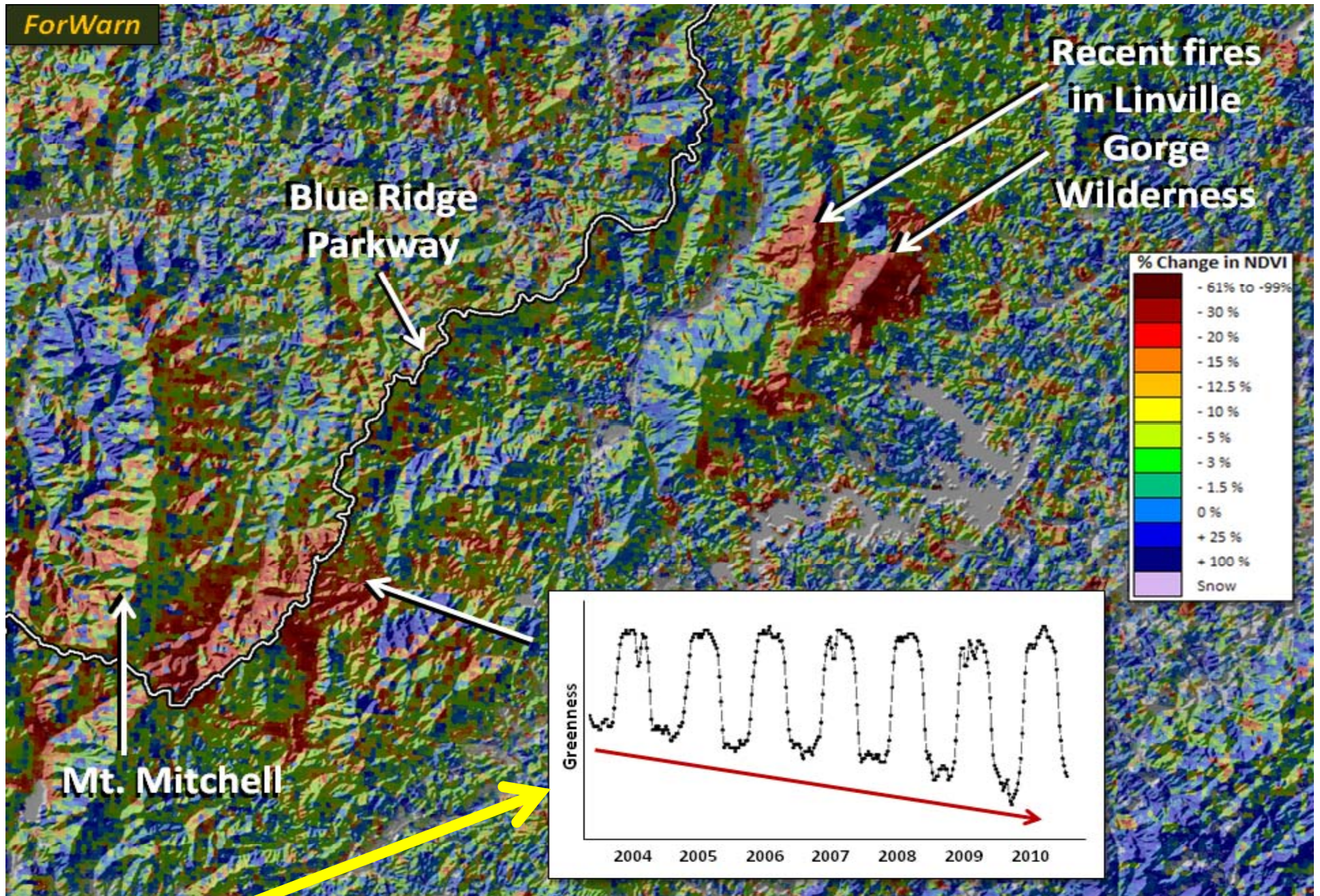
[Introducing the Pest Proximity Database](#)

02/17/2012 - 10:40 The new Pest Proximity Database, now built into the Forest Change Assessment Viewer, helps determine which insects and disease agents are most likely to have been responsible for new forest...

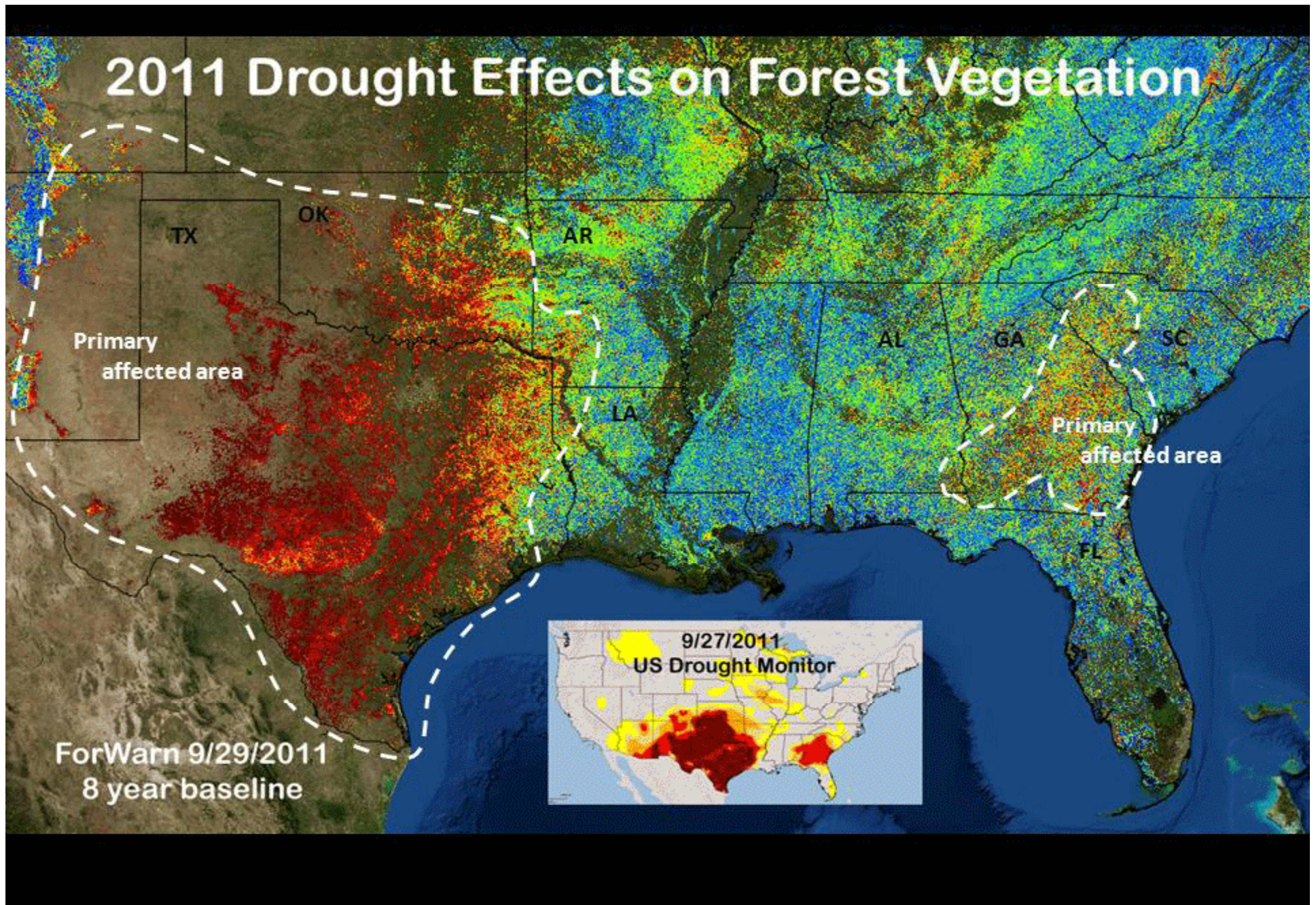
[more news »](#)



ESRI Web Viewer, Powered by FLEX and ArcGIS Server 10

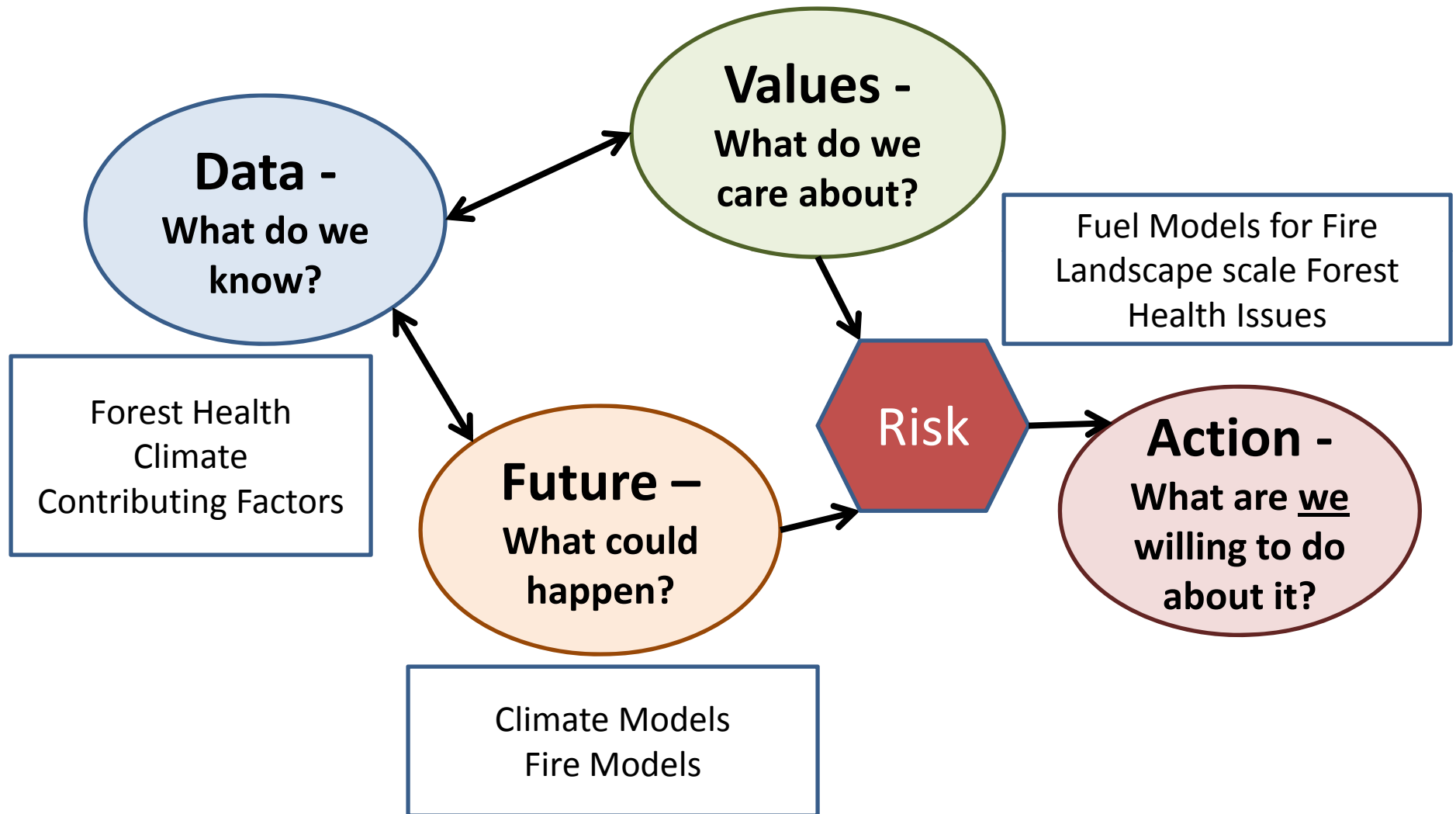


Multigraph tool (imbedded in GIS Viewer) allows users to see in the temporal dimension

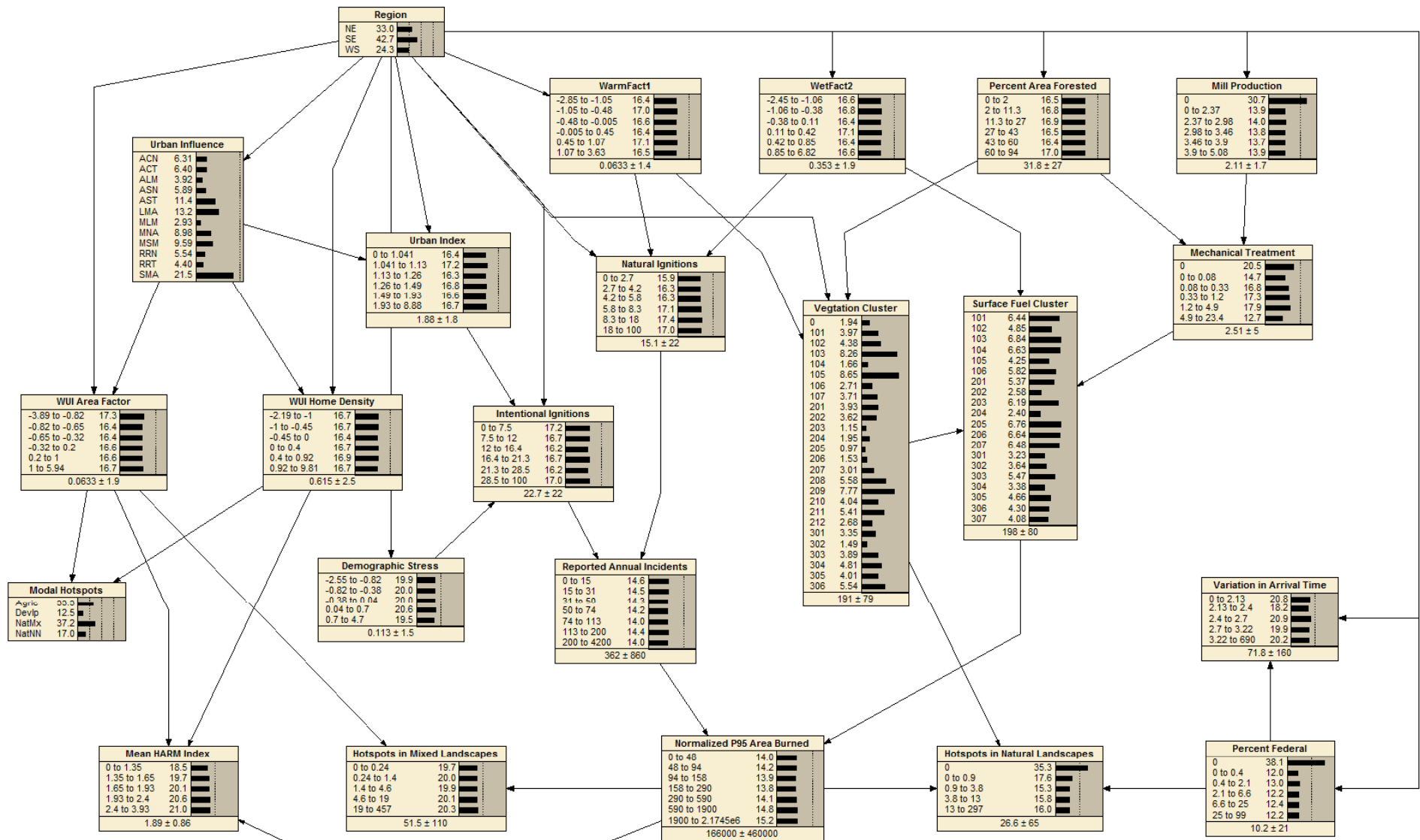


Storytelling on the web to support the GIS Viewer





ForWarn Decisions



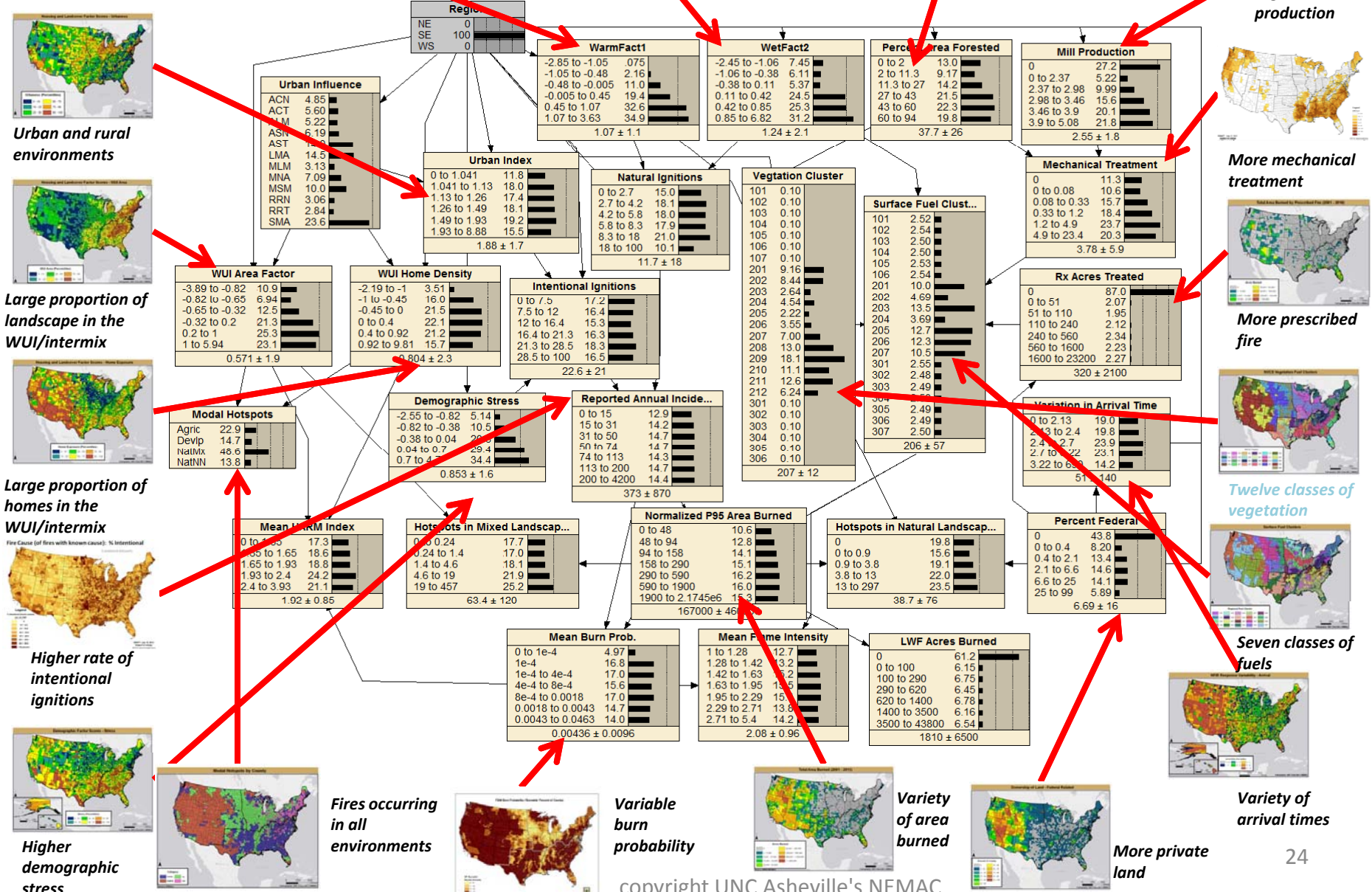
A Quantitative Model – BBN for Wildfire



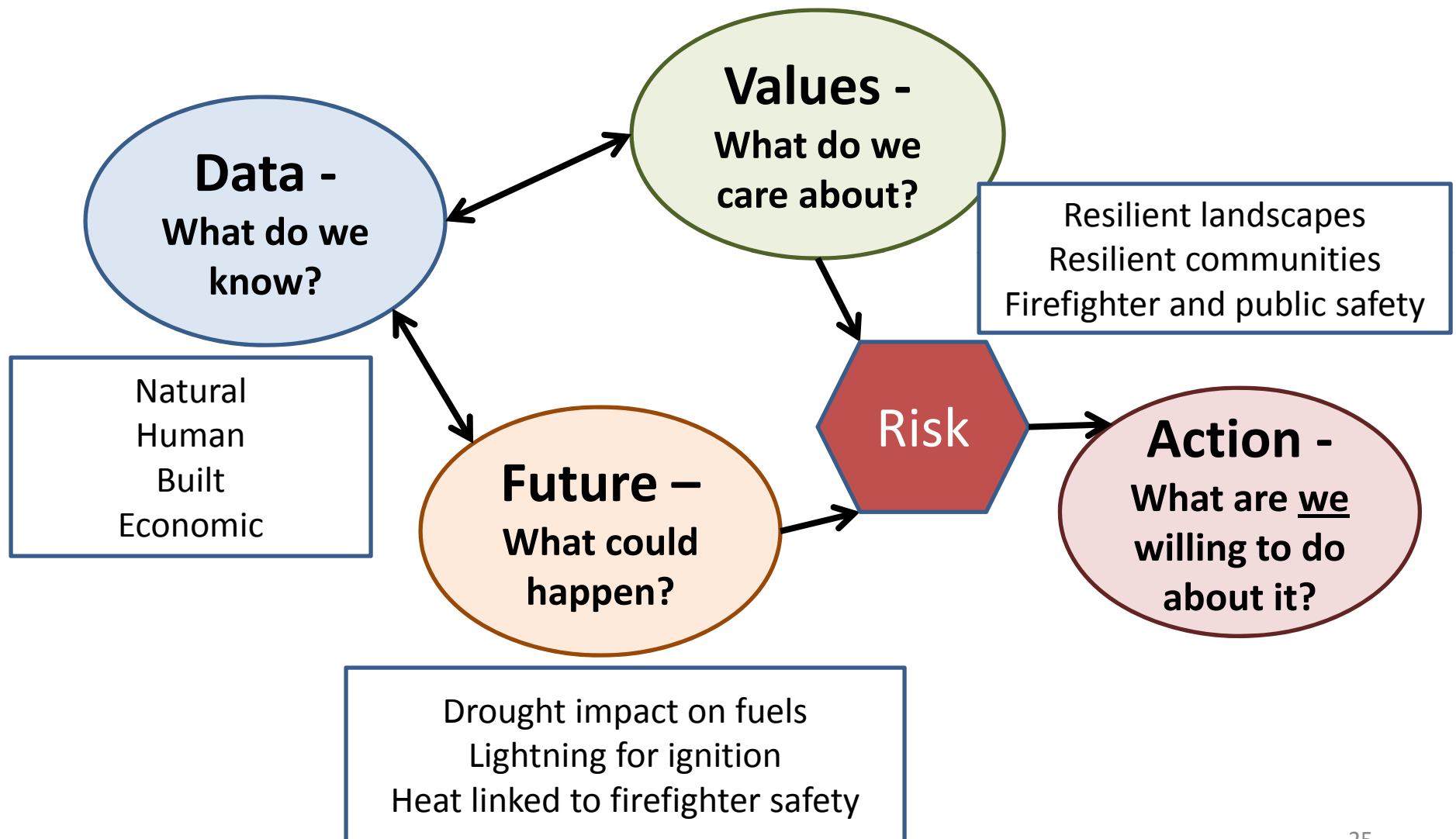
Crosswalk of Data to Nodes

<p>Urban Influence</p>	<p>Urban Influence based on population and location</p>	<p>Factor score, States= e.g. Small metropolitan area, Large metropolitan area. ???</p>		<ul style="list-style-type: none"> ERS typology codes
<p>Urban Index</p>	<p>Average urbanness value calculated from Edwards and Hargrove product.</p>	<p>Index</p>		
<p>Natural Ignitions</p>	<p>Percent of known fires that were caused by natural ignitions.</p>	<p>Percentages, 6 bins (Low to High)</p>		
<p>Vegetation Cluster</p>	<p>Existing vegetation cluster based on LANDFIRE NVCS class information.</p>	<p>Classes; NE= 100s; SE= 200s; W= 300s</p>		<ul style="list-style-type: none"> LANDFIRE NVCS

What makes the Southeast unique?



National Fire Plan









A scenic view of a mountain range with a lake in the valley, overlaid with text. The foreground shows dense evergreen trees and some yellowing foliage. The middle ground features a large blue lake nestled in a valley between green mountains. The background shows more distant, hazy mountain ranges under a blue sky with scattered white clouds.

North Carolina Mountain Resources Commission
Vitality Index
www.wncvitalityindex.org

County Decision Makers needed some help – we provided an online tool with 160 metrics

Home

-  **Overview**
-  **Natural**
-  **Human**
-  **Built**
-  **Economic**
-  **Download PDF**

The Western North Carolina Vitality Index reports on the 27 counties of Western North Carolina through the perspectives of the region's natural, social, built, and economic environments. Designed to assist local governments, interest groups, and the public in furtherance of the Mountain Resources Commission's overall mission to "take care of our natural resources to enhance and sustain quality of life and ensure the long term health of our region and our people," this resource allows the information necessary to:

- Protect our region's abundant and unique natural resources,
- Promote development and land use planning that accommodates sustainable growth,
- Preserve the heritage and culture that defines our communities while strengthening public health, and
- Improve the region's local economic activity and expand its influence.

This index is sorted into four categories.



The Natural Environment – From the pristine streams and rivers to the towering Blue Ridge Mountains, this analysis of Western North Carolina's natural resources reports on the vitality and sustainability of our topography and geology, the state of our weather and climate, water quality, and air quality.



The Human Environment – With generations of experience honed down to an efficient craft, local music, art, heritage, and spiritual values are important elements that reflect all Western North Carolinians. This study observes the region through a lens focused on our population, human health, education, and culture.

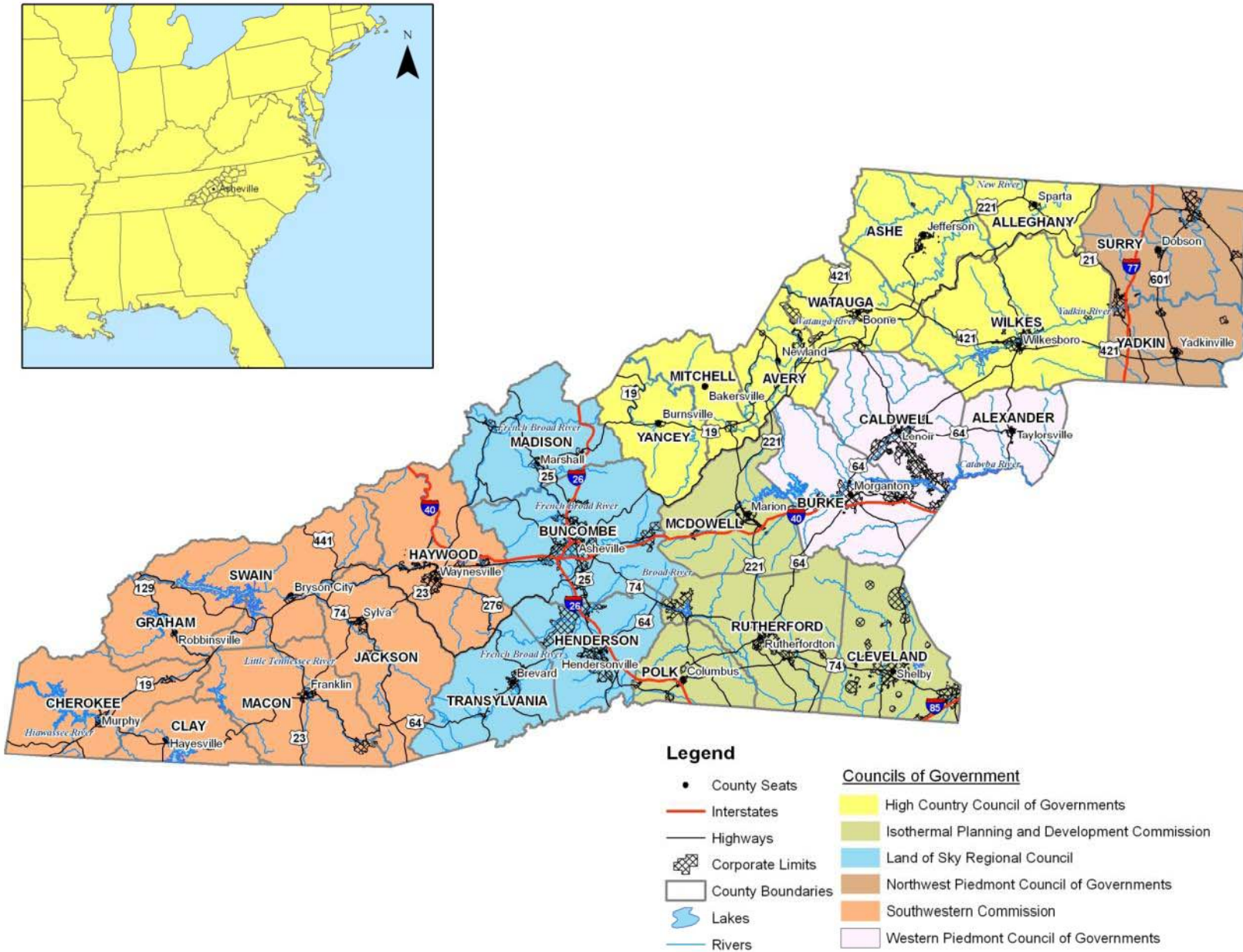


The Built Environment – Looking at the region's status on land use, housing, transportation, water supply, energy, and natural stressors, hazards, and risks, this analysis covers the places we work, shop, play, travel, and live. Through careful planning, these uses can be balanced to minimize their environmental impacts in order to ensure a lasting and productive community.



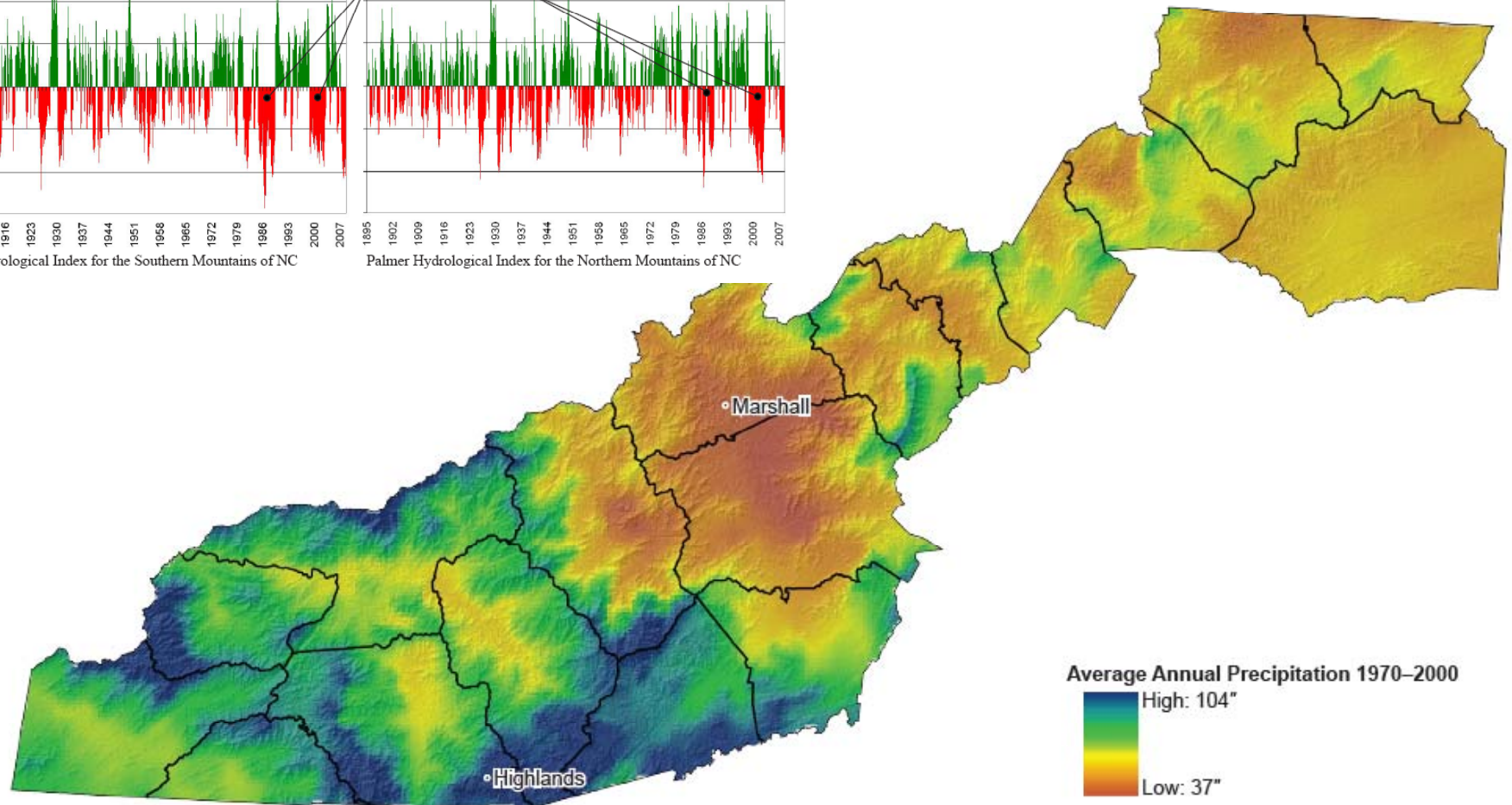
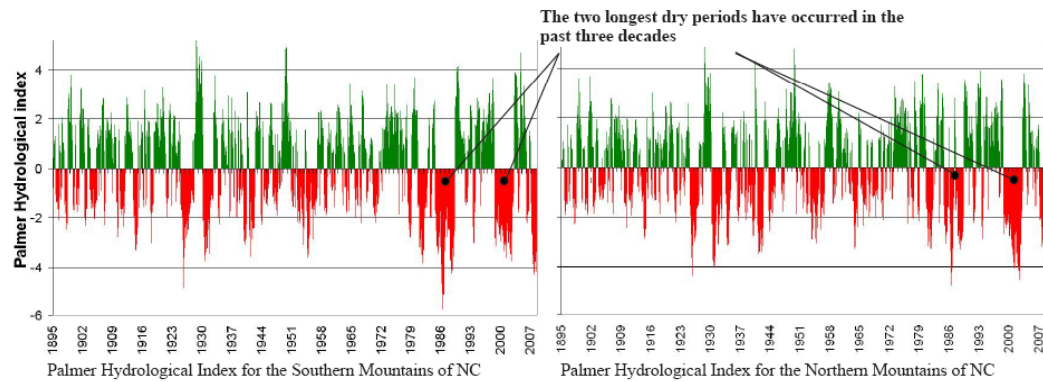
The Economic Environment – A look at the region's standing on income and poverty, employment, agriculture, forestry, and tourism is essential to promoting a locally sustainable and resilient economy.





Decision makers at county and regional scale

Precipitation Patterns Climate Change

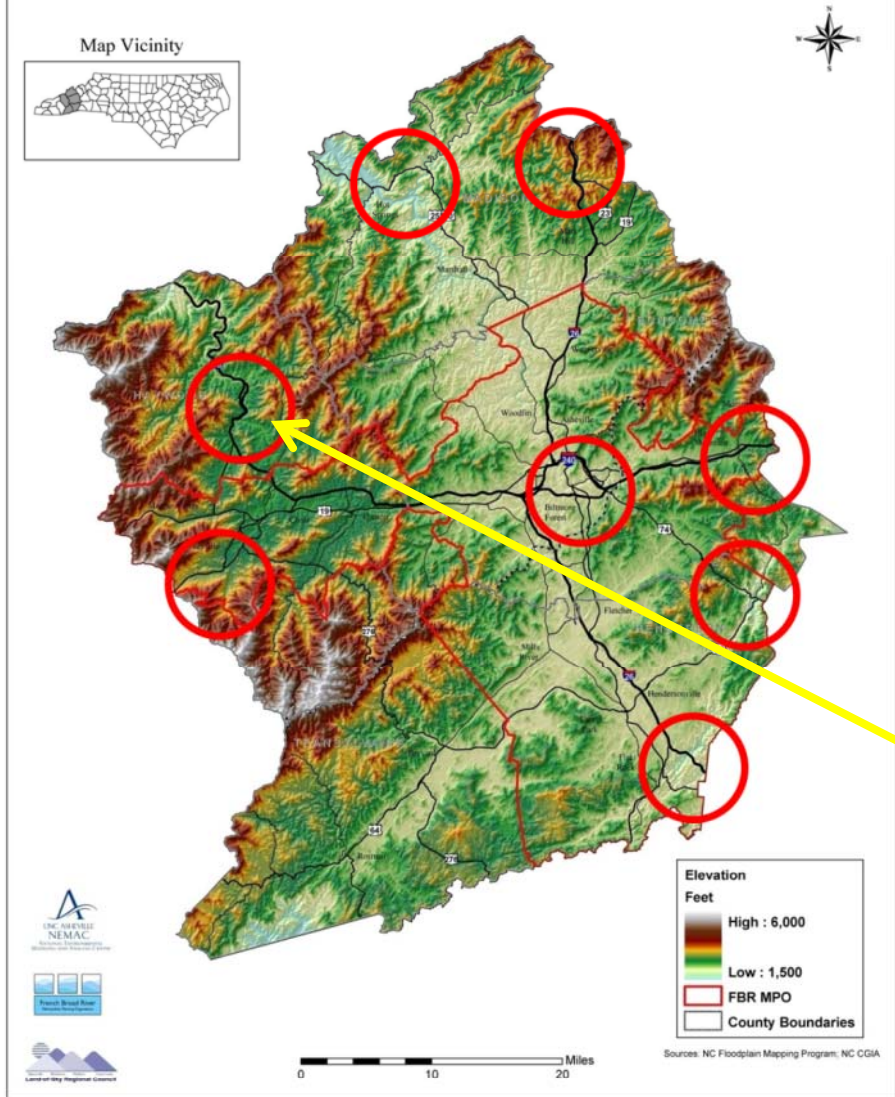


Average precipitation has remained constant over the past century.

Regionally specific products aided by storytelling turns a map into a tool

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Concept of Pinch Points

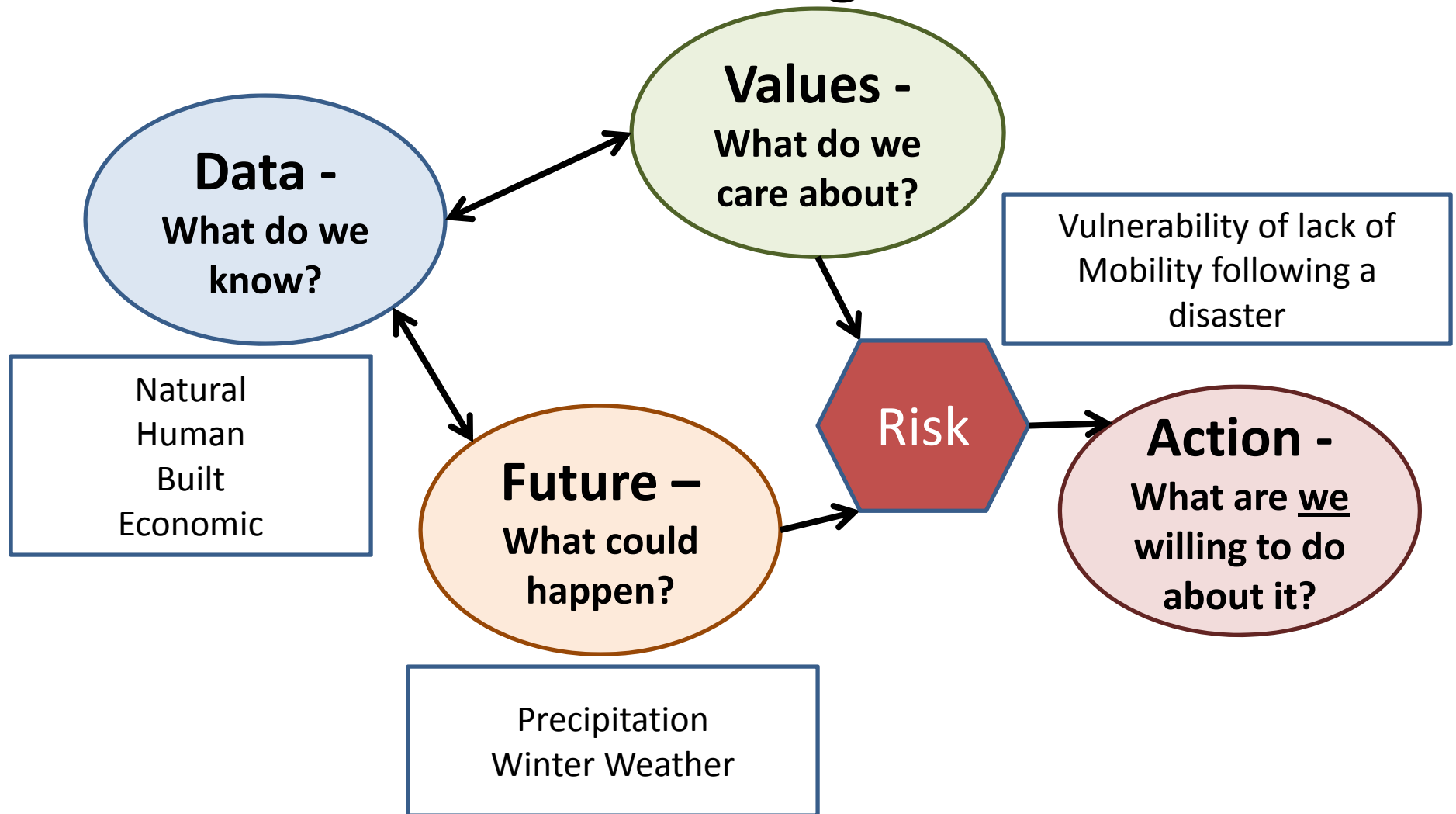


I-40 Landslide in 2010

- **Vulnerability** is related to mobility in the transportation sector
- Pinch points that disrupt a service
- Climate Change chapter for a Regional Transportation Plan



Western North Carolina Transportation Planning





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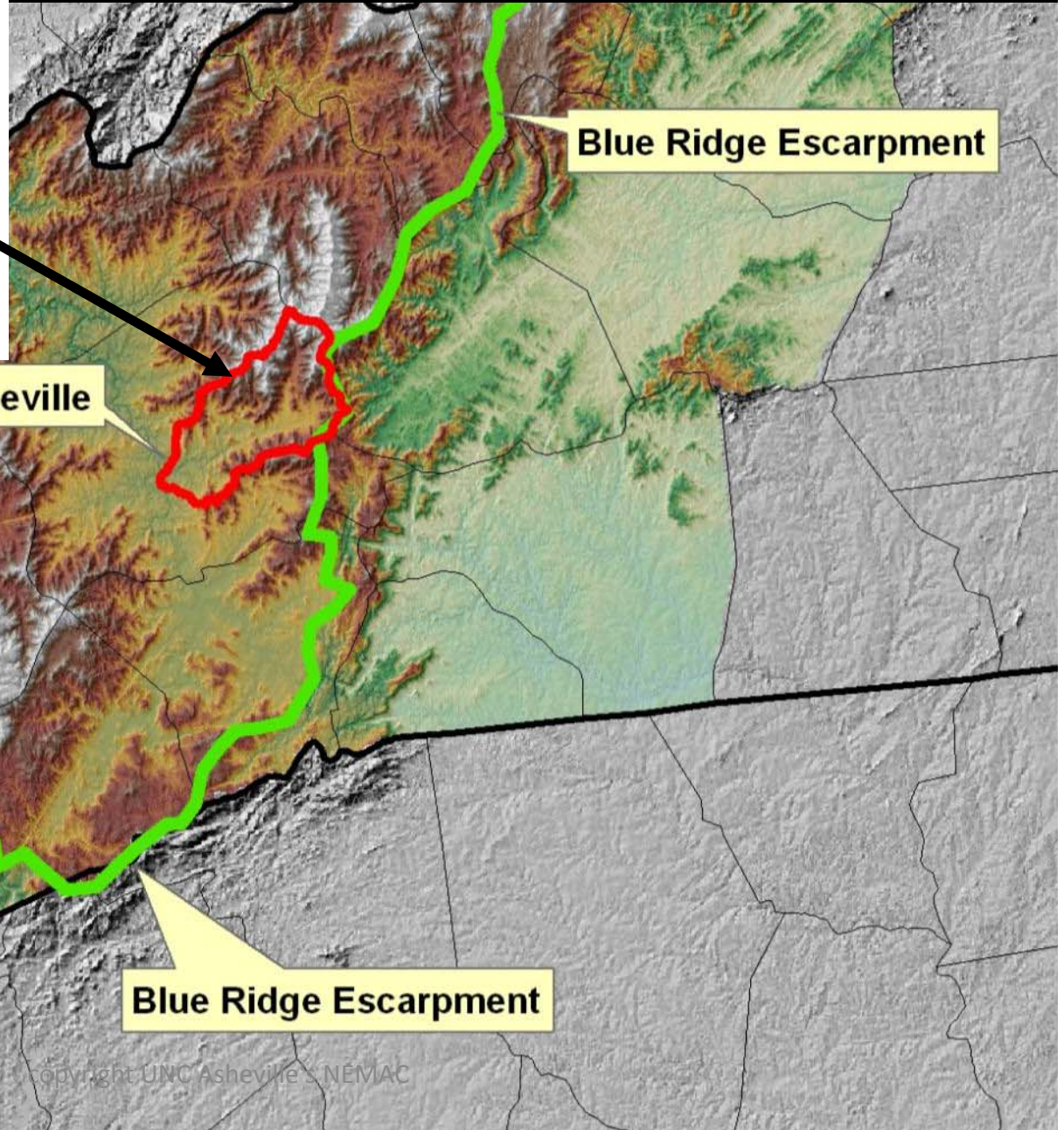
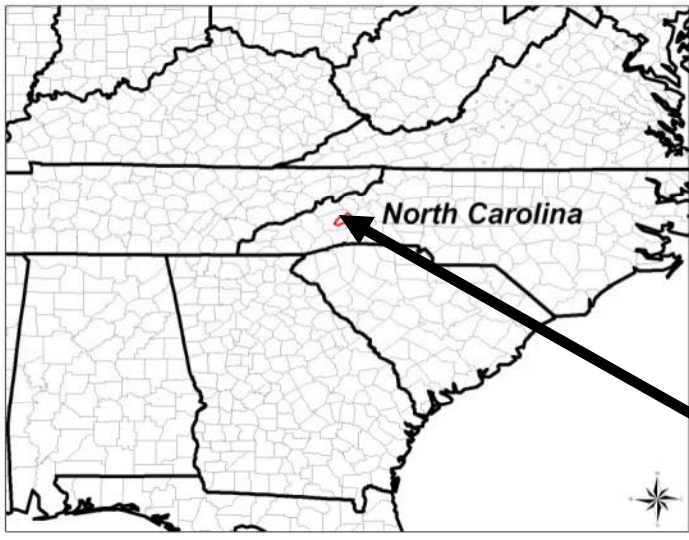
Swannanoa Flood Risk Management Project

www.swannanoafloods.org

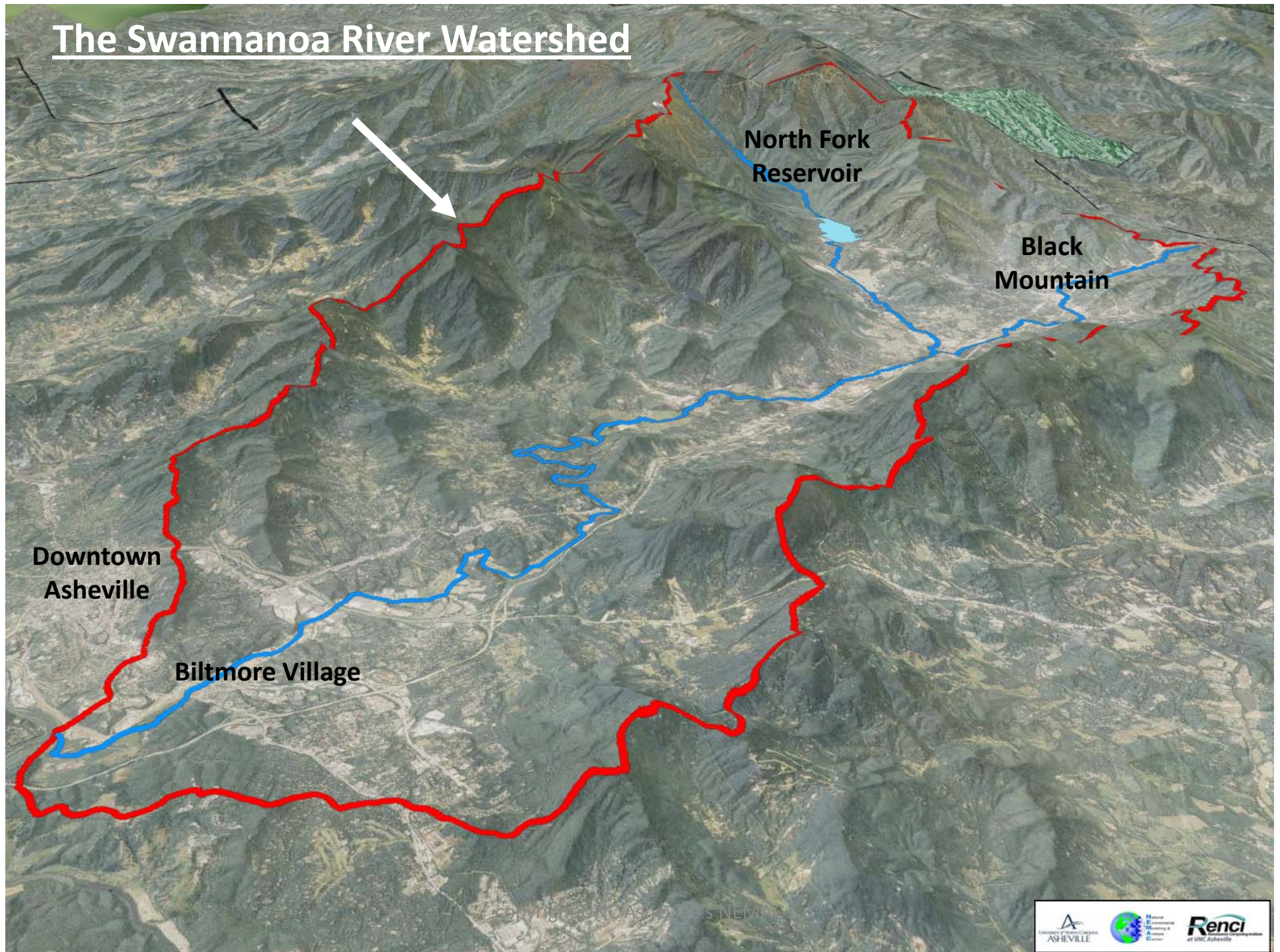


3D Visualization adds another dimension to public understanding – integrated ArcGlobe

Swannanoa Watershed



The Swannanoa River Watershed



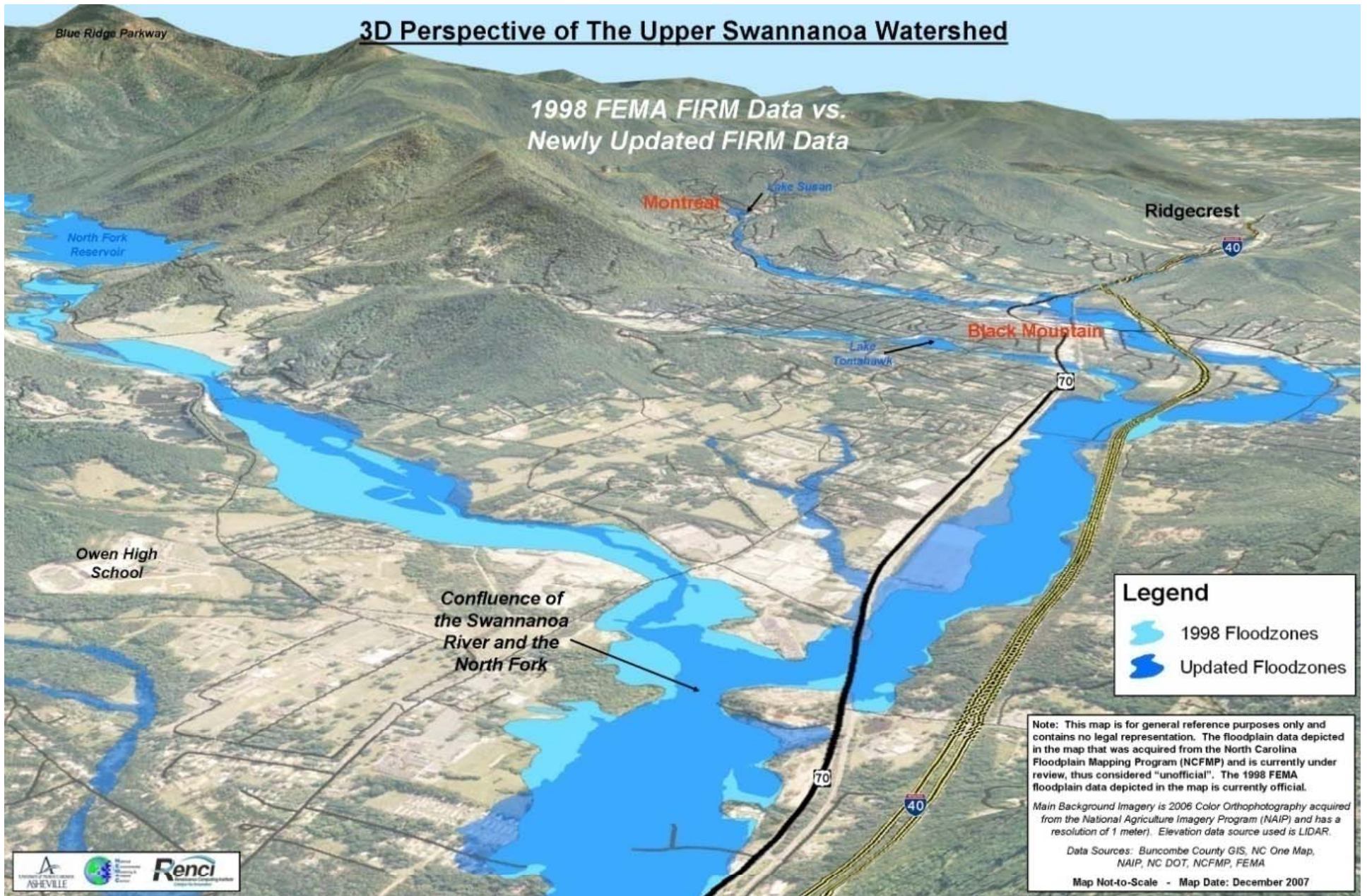
copyright © UNC Asheville's NEMO

Main Village Center Flooded



photo courtesy of John Cram

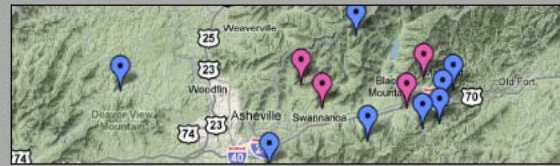




Watershed mapped and displayed in full three dimensions



Map
News



Click the image above to access the Buncombe County Automated Flood Warning System.

Background and Timeline

September 2004

- Hurricanes Frances and Ivan
- Severe flooding in the Swannanoa Watershed
- Extreme property and infrastructure damage a
- City of Asheville makes emergency repairs to p

2005

- North Carolina Legislature passes 2005 Hurric

2006

- City of Asheville forms the Flood Damage Redu
- City of Asheville installs Swannanoa Flood War

2007

- Floodplain management recommendations deli
- City of Asheville adopts new Flood Operations
- Burnette Reservoir

2008

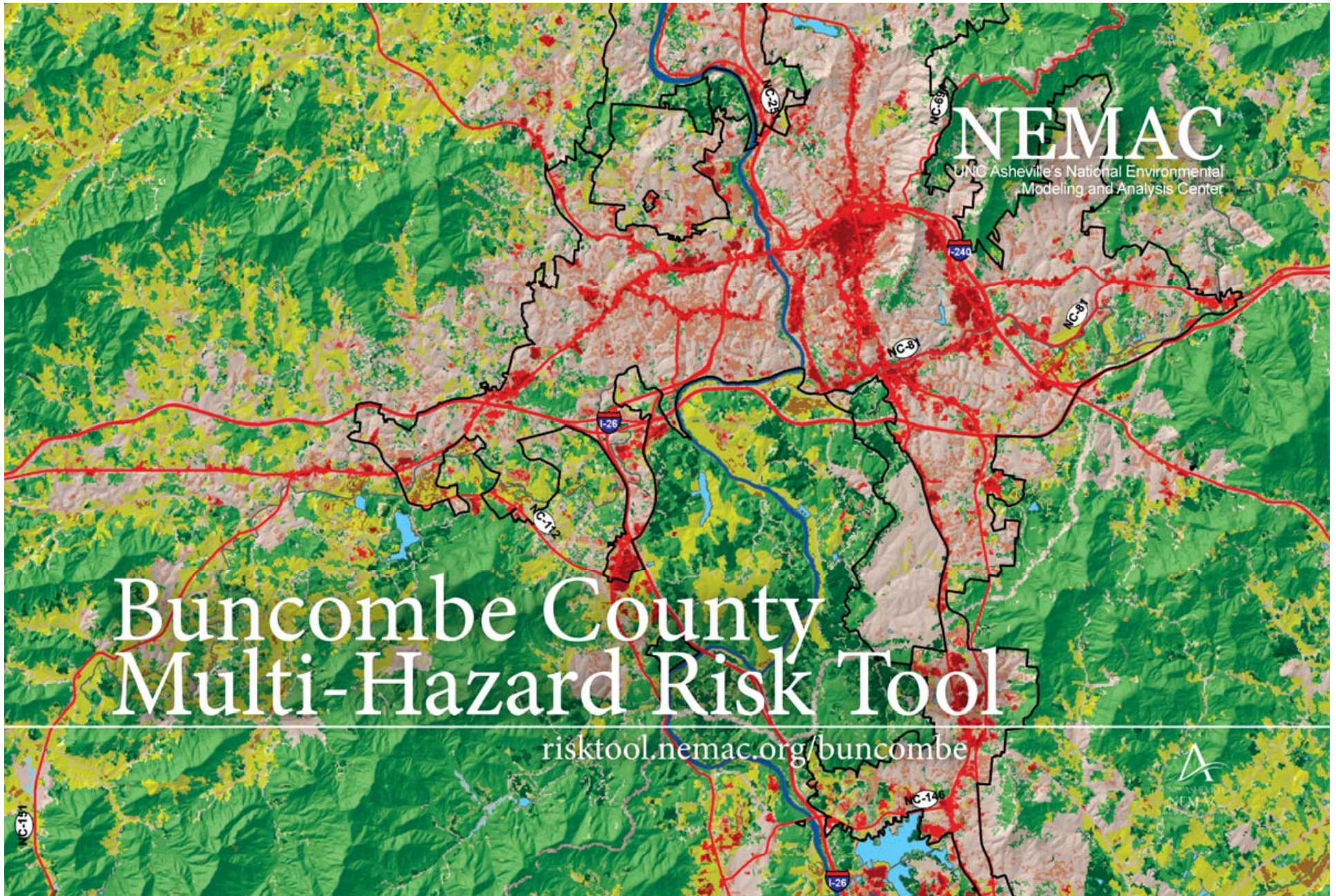
- U.S. Army Corps of Engineers completes Biltmo

Assessing Projects using Evaluation Criteria

	Flood Mitigation	Economic Feasibility	Environmental Impact	Ease of Implementation
PROJECTS	Objectives	Objectives	Objectives	Objectives
Lake Craig	Positive	Positive	Positive	Negative
Bee Tree Res.	Positive	Positive	Positive	Positive
Grove Stone	Positive	Positive	Positive	Negative
Lake Tomahawk	Positive	Positive	Positive	Positive
Railroad Bridge	Positive	Positive	Positive	Negative
Biltmore Av Brg	Positive	Positive	Positive	Positive
Black Mtn Trestl	Positive	Positive	Positive	Negative
Owen Park	Positive	Positive	Positive	Positive
Thompson St.	Negative	Negative	Positive	Negative
Lake Susan	Positive	Positive	Positive	Negative

Positive Neutral Negative

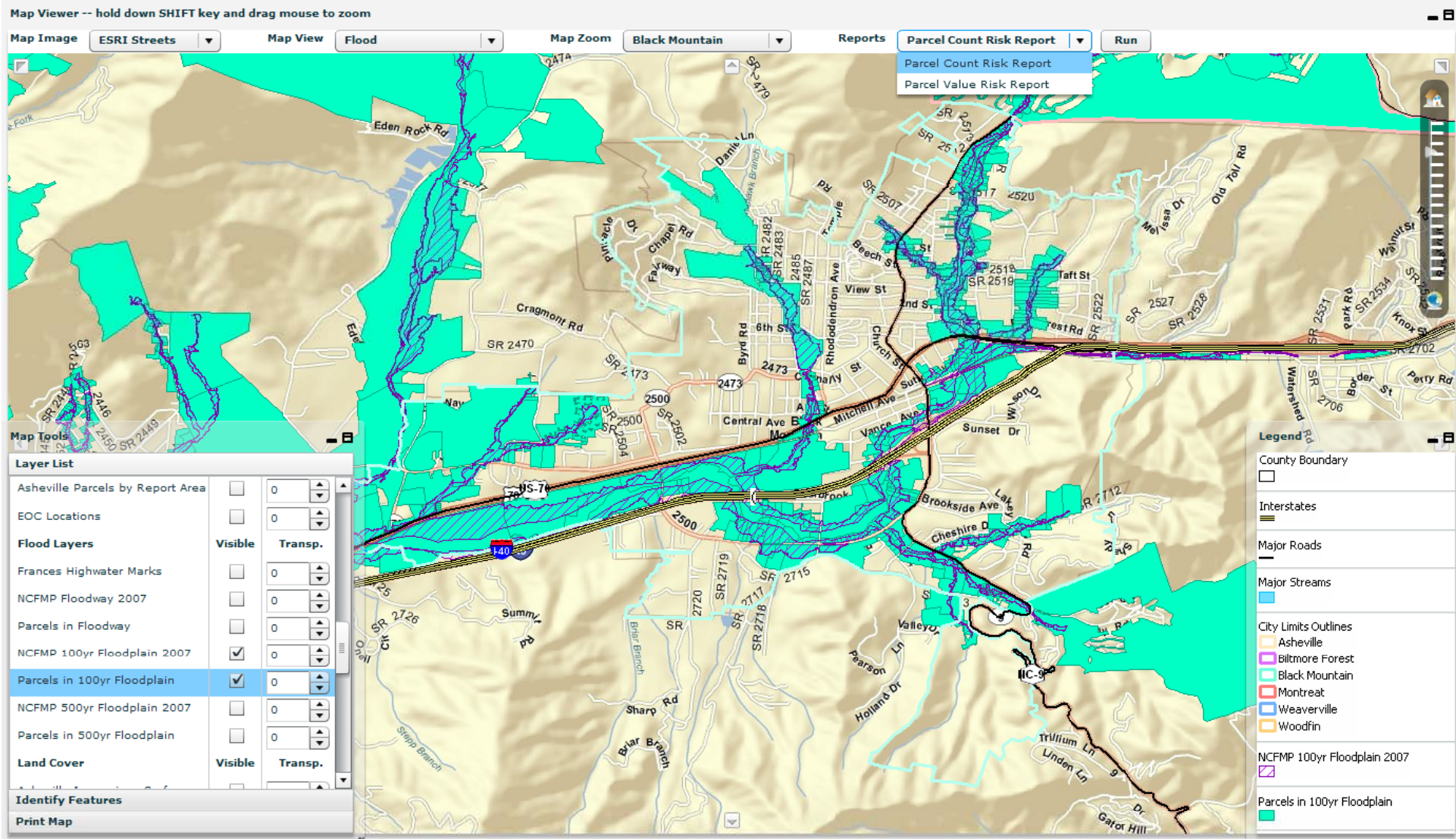
Companion website to allow full interaction with data and recommendations



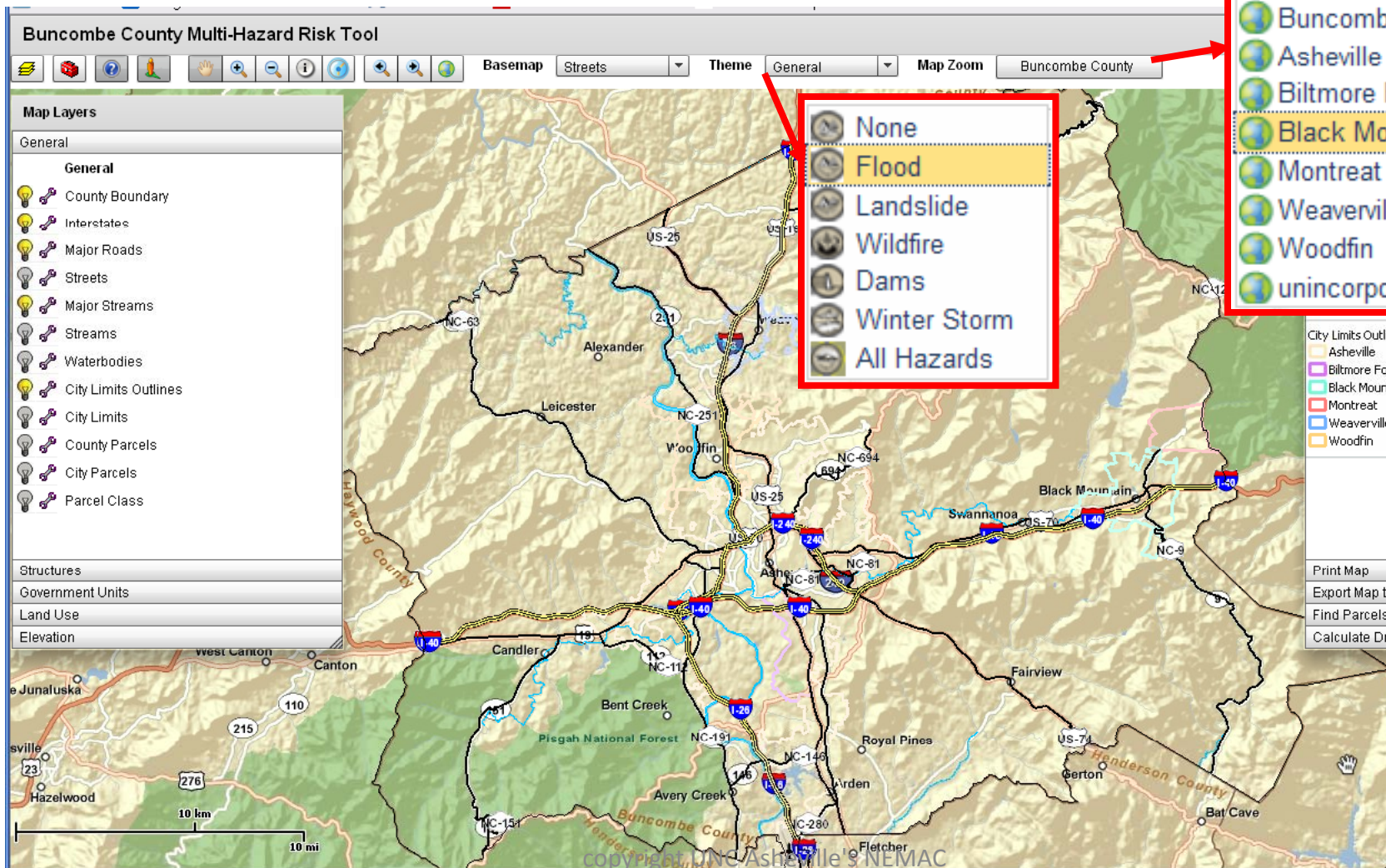
Emergency Managers needed an integrated decision tool for FEMA reporting

Multi-Hazard Risk Tool

- **Purpose of study:** Tool for Emergency Managers that integrates
- **Decision:** How to plan for multiple risks including flooding, wildfire, landslides, winter storms, dam failure, etc.
- **Scale:** Buncombe County
- **Use of Climate Data:** Drought, flooding, precipitation, winter storm occurrence



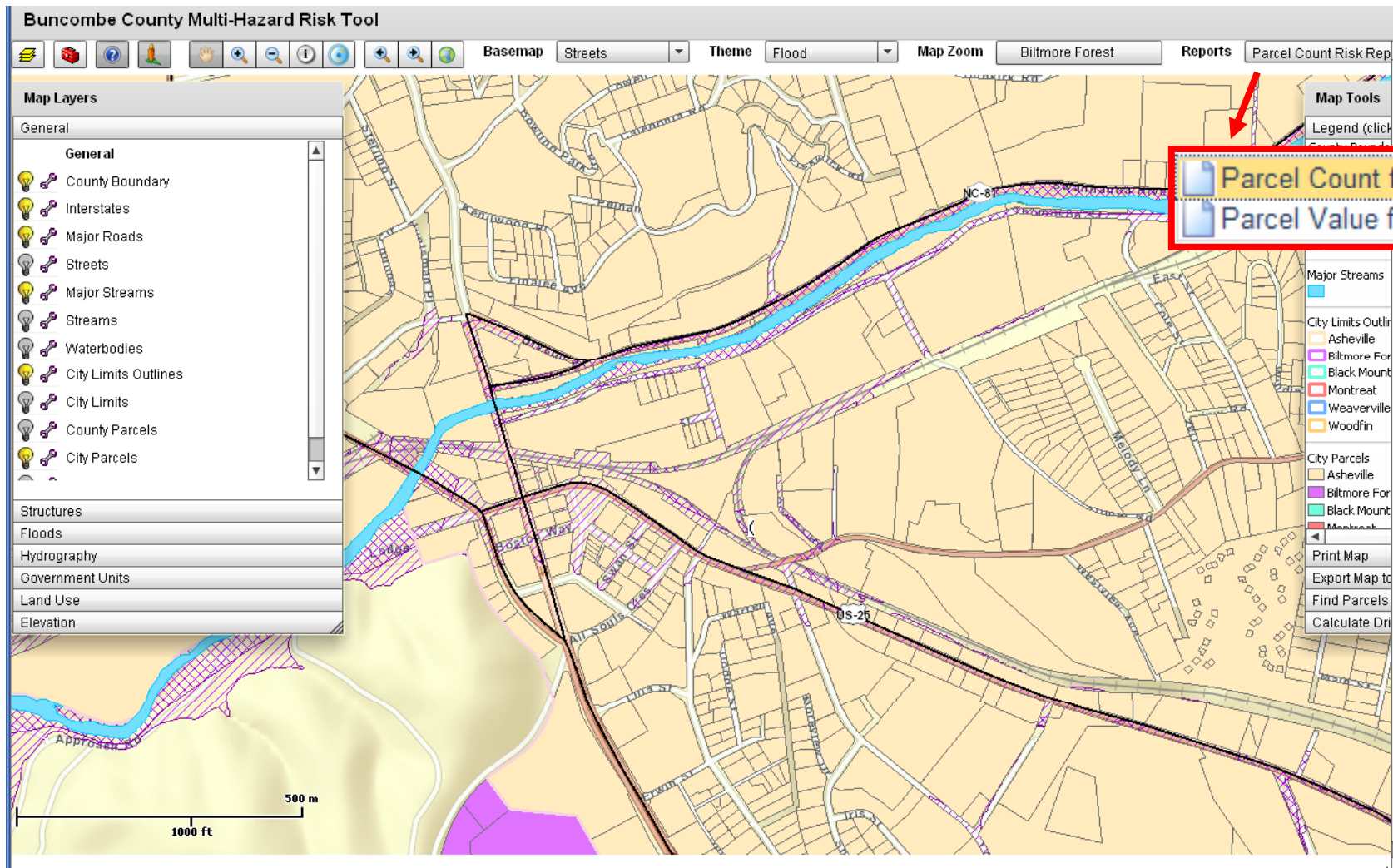
Tool tied to individual parcels – integration with City of Asheville and Buncombe County GIS Databases



- Buncombe County
- Asheville
- Biltmore Forest
- Black Mountain
- Montreat
- Weaverville
- Woodfin
- unincorporated area

- None
- Flood
- Landslide
- Wildfire
- Dams
- Winter Storm
- All Hazards

- City Limits Outline
 - Asheville
 - Biltmore Forest
 - Black Mountain
 - Montreat
 - Weaverville
 - Woodfin
- Print Map
- Export Map to PDF
- Find Parcels
- Calculate Drive Time



Tool tied to individual parcels – integration with City of Asheville and Buncombe County GIS Databases

Summary reports available by area and hazard

Parcel Count for Floods for Black Mountain [Export to MS Excel](#)

DRAFT - Do not use numbers for any official capacity.

Parcels in Floodway		Parcels in 100 Year Floodplain		Parcels in 500 Year Floodplain		Information
Agricultural	Parcels	% Total Parcels	Acres	% Total Acres		
Occupied	0	0.00	0.00	0.00		
Vacant	0	0.00	0.00	0.00		
Total	0	0.00	0.00	0.00		
Commercial	Parcels	% Total Parcels	Acres	% Total Acres		
Occupied	28	0.61	215.24			
Vacant	12	0.26	57.54			
Total	40	0.87	272.78			
Industrial	Parcels	% Total Parcels	Acres	% Total Acres		
Occupied	4	0.09	78.34			
Vacant	0	0.00	0.00			
Total	4	0.09	78.34			
Residential	Parcels	% Total Parcels	Acres	% Total Acres		
Occupied	75	1.63	106.40			
Vacant	25	0.54	46.42			
Total	100	2.17	152.82			
Other	Parcels	% Total Parcels	Acres	% Total Acres		
Occupied	18	0.39	283.01			
Vacant	6	0.13	9.25			
Total	24	0.52	292.26			
Total	Parcels	% Total Parcels	Acres	% Total Acres		
Occupied	125	2.71	682.98			
Vacant	43	0.93	113.21			
Total	168	3.65	796.19			

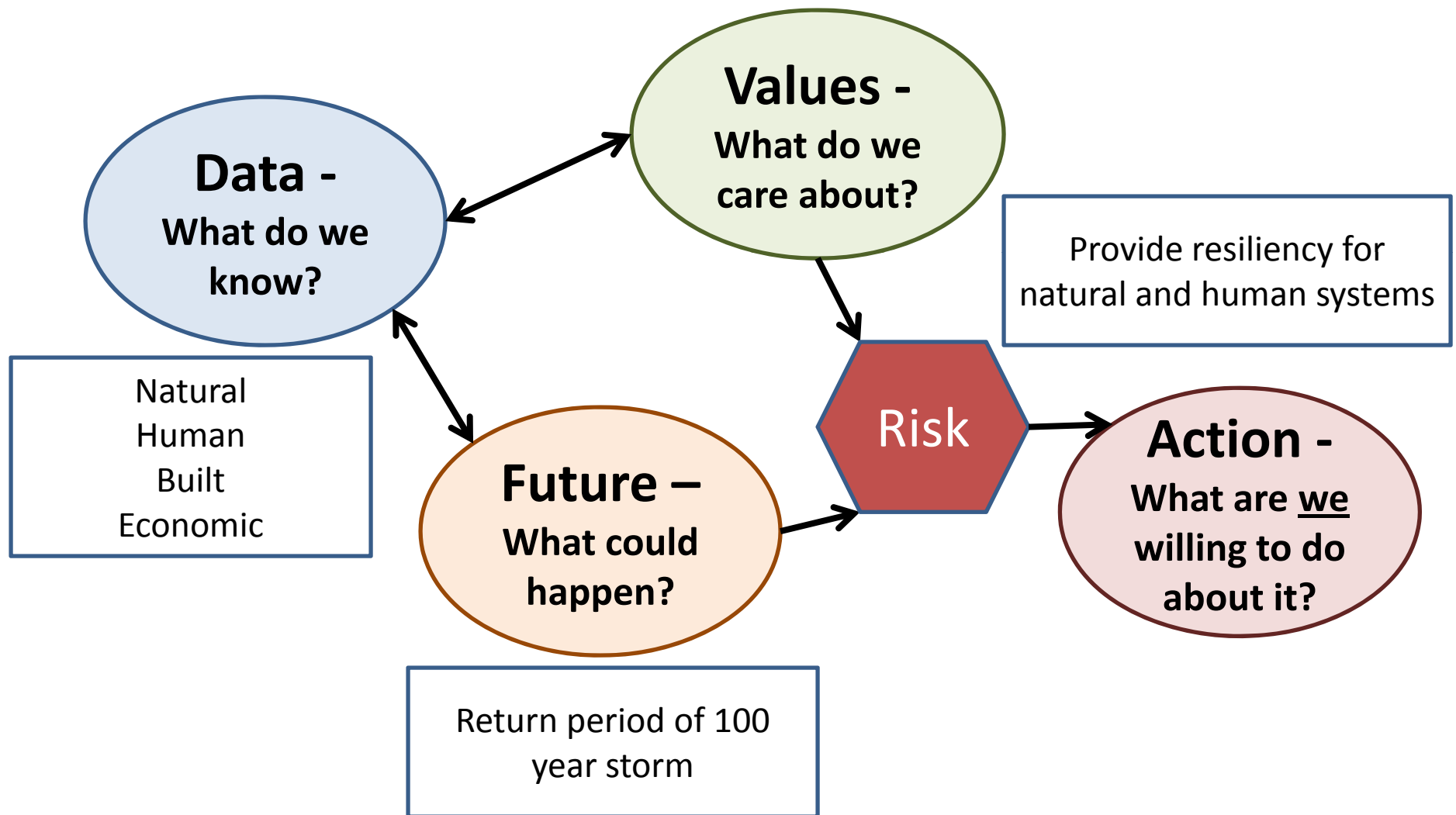
Parcel Value for Floods for Black Mountain [Export to MS Excel](#)

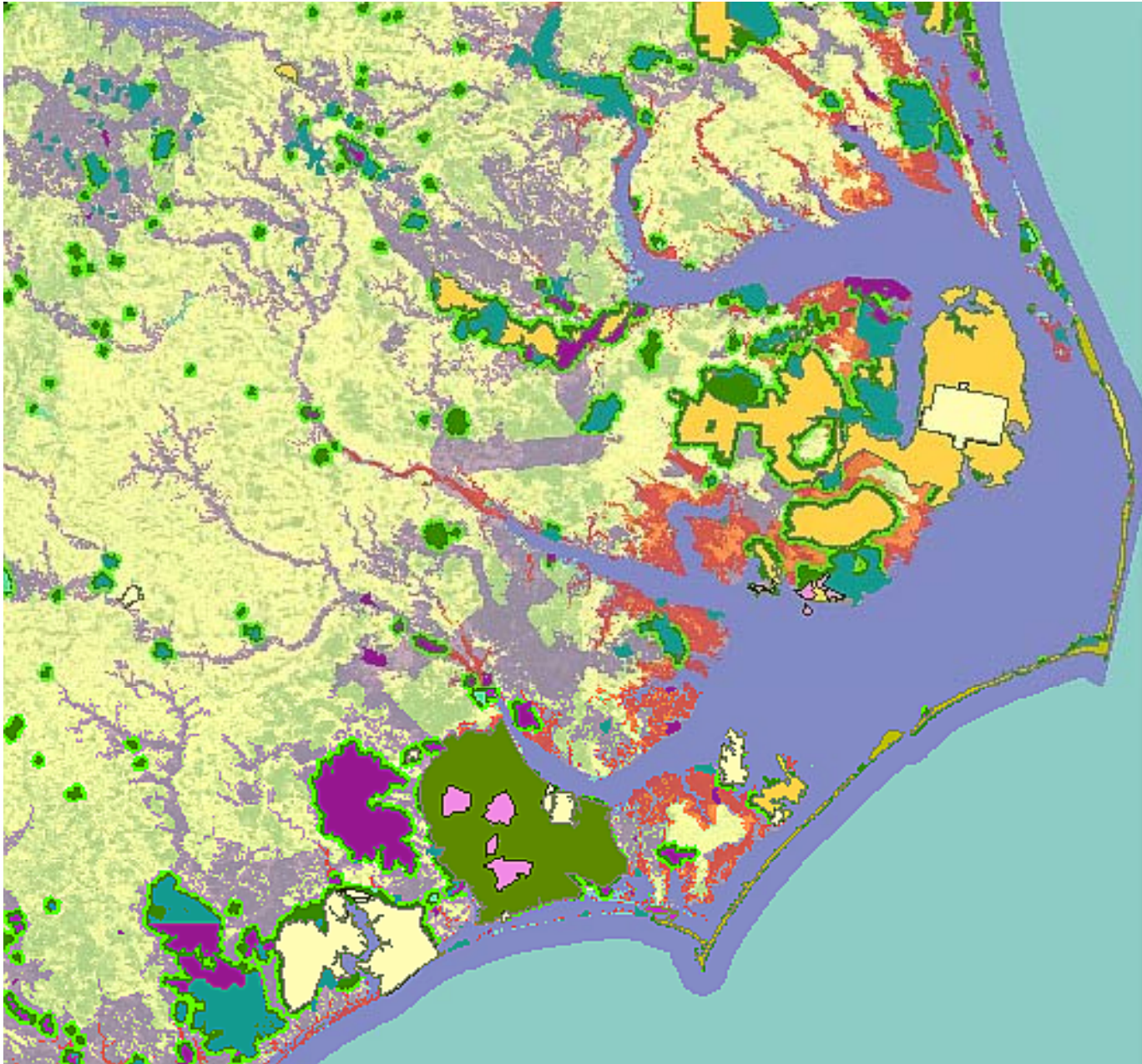
Value Multiplier:

DRAFT - Do not use numbers for any official capacity. Adjusted Market Value equals Total Market Value times 1.25.

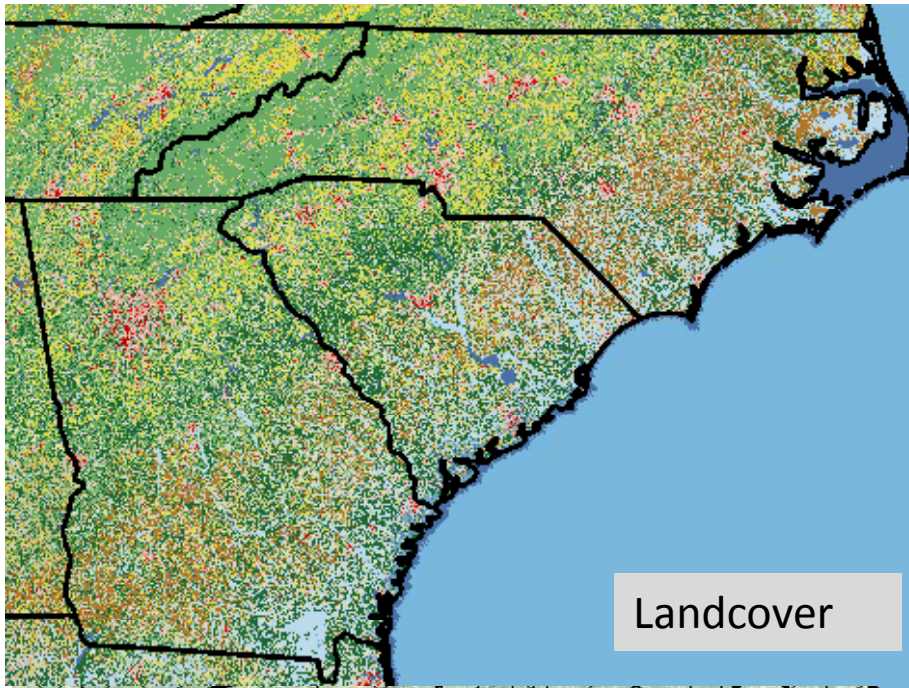
Parcels in Floodway		Parcels in 100 Year Floodplain		Parcels in 500 Year Floodplain		Information
Agricultural	Adjusted Market Value	Total Market Value	Land Value	Building Value	Improved Value	
Occupied	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Vacant	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Total	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Commercial	Adjusted Market Value	Total Market Value	Land Value	Building Value	Improved Value	
Occupied	\$50,718,500.00	\$40,574,800.00	\$9,581,300.00	\$30,686,000.00	\$307,500.00	
Vacant	\$1,424,000.00	\$1,139,200.00	\$1,139,200.00	\$0.00	\$0.00	
Total	\$52,142,500.00	\$41,714,000.00	\$10,720,500.00	\$30,686,000.00	\$307,500.00	
Industrial	Adjusted Market Value	Total Market Value	Land Value	Building Value	Improved Value	
Occupied	\$4,017,000.00	\$3,213,600.00	\$1,182,200.00	\$2,011,500.00	\$19,900.00	
Vacant	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	
Total	\$4,017,000.00	\$3,213,600.00	\$1,182,200.00	\$2,011,500.00	\$19,900.00	
Residential	Adjusted Market Value	Total Market Value	Land Value	Building Value	Improved Value	
Occupied	\$11,794,250.00	\$9,435,400.00	\$2,649,500.00	\$6,742,100.00	\$43,800.00	
Vacant	\$1,807,750.00	\$1,446,200.00	\$1,446,200.00	\$0.00	\$0.00	
Total	\$13,602,000.00	\$10,881,600.00	\$4,095,700.00	\$6,742,100.00	\$43,800.00	
Other	Adjusted Market Value	Total Market Value	Land Value	Building Value	Improved Value	
Occupied	\$63,645,500.00	\$50,916,400.00	\$6,536,800.00	\$43,191,100.00	\$1,188,500.00	
Vacant	\$254,500.00	\$203,600.00	\$196,900.00	\$0.00	\$6,700.00	
Total	\$63,900,000.00	\$51,120,000.00	\$6,733,700.00	\$43,191,100.00	\$1,195,200.00	
Total	Adjusted Market Value	Total Market Value	Land Value	Building Value	Improved Value	
Occupied	\$130,175,250.00	\$104,140,200.00	\$19,949,800.00	\$82,630,700.00	\$1,559,700.00	
Vacant	\$3,486,250.00	\$2,789,000.00	\$2,782,300.00	\$0.00	\$6,700.00	
Total	\$133,661,500.00	\$106,929,200.00	\$22,732,100.00	\$82,630,700.00	\$1,566,400.00	

Swannanoa Watershed

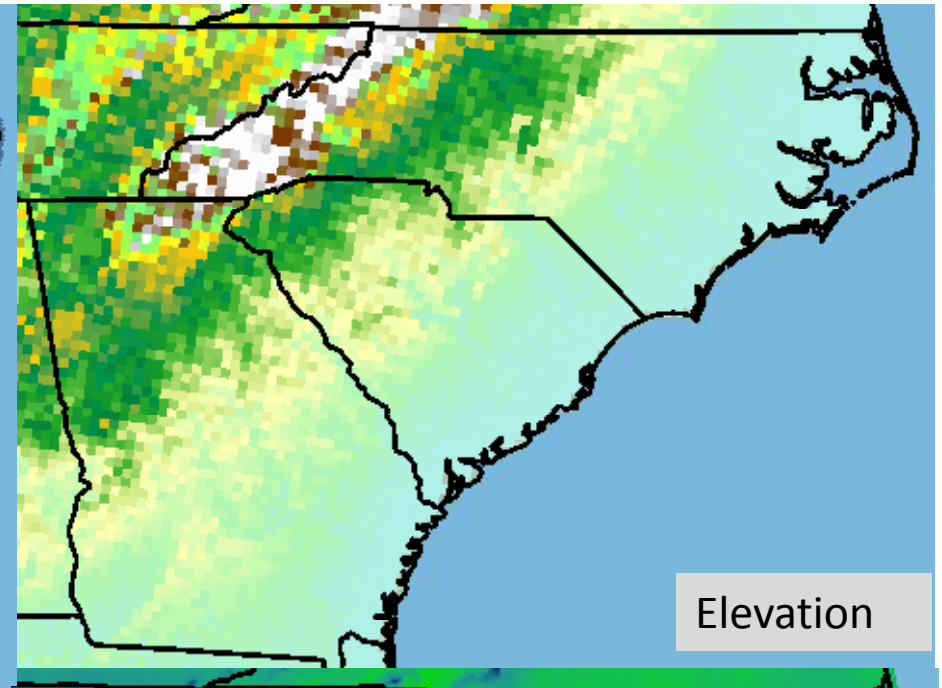




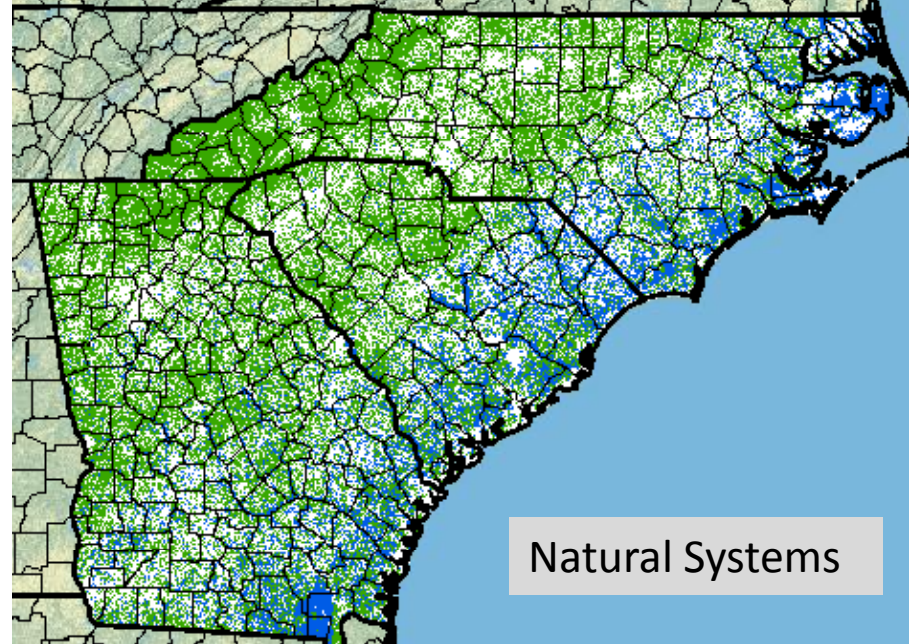
Sea Level Rise Impacts across all Sectors for Federal, State and County Decision Makers ⁴⁵



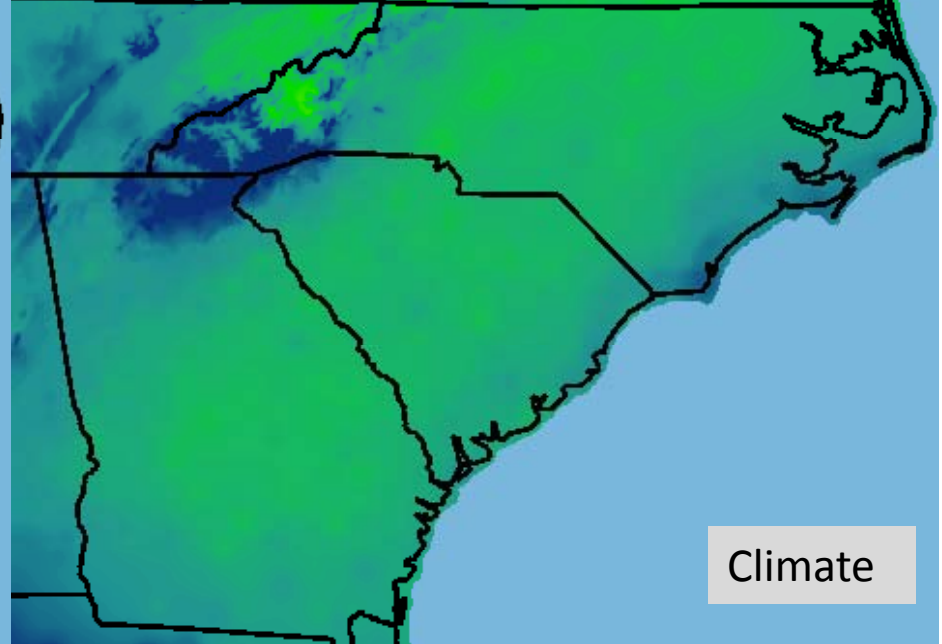
Landcover



Elevation



Natural Systems

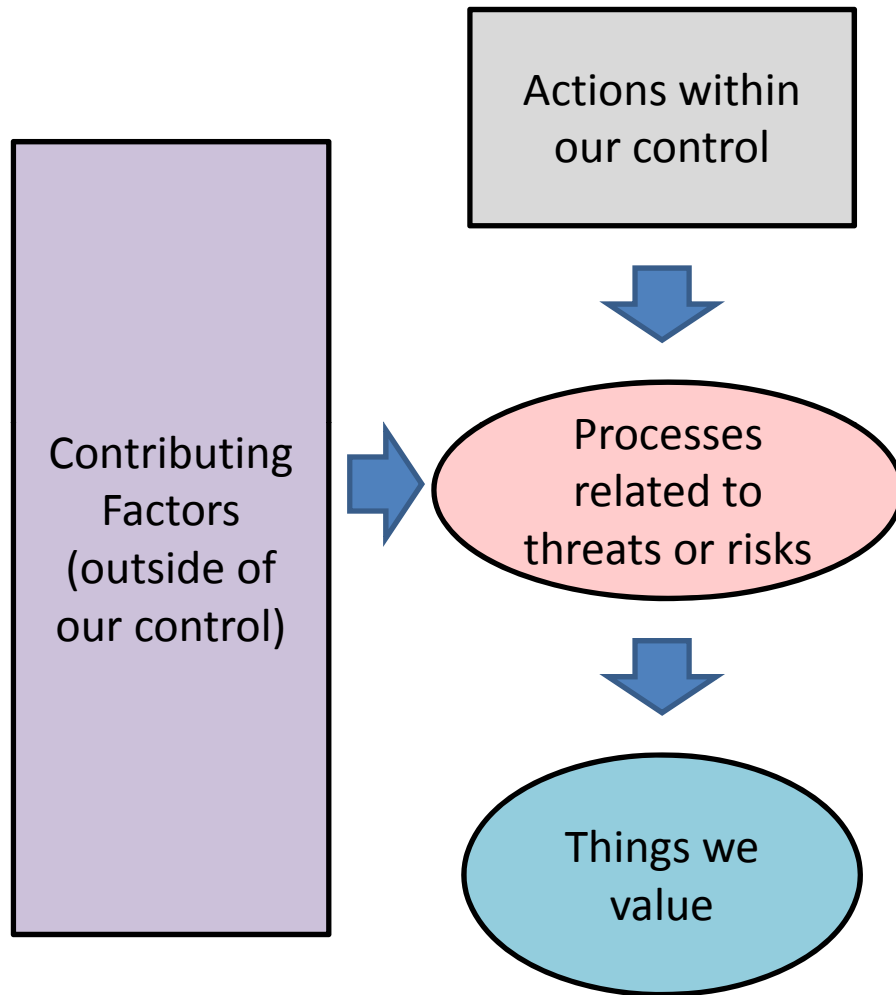


Climate

During the first phase of the study, regional differences were discussed and evaluated

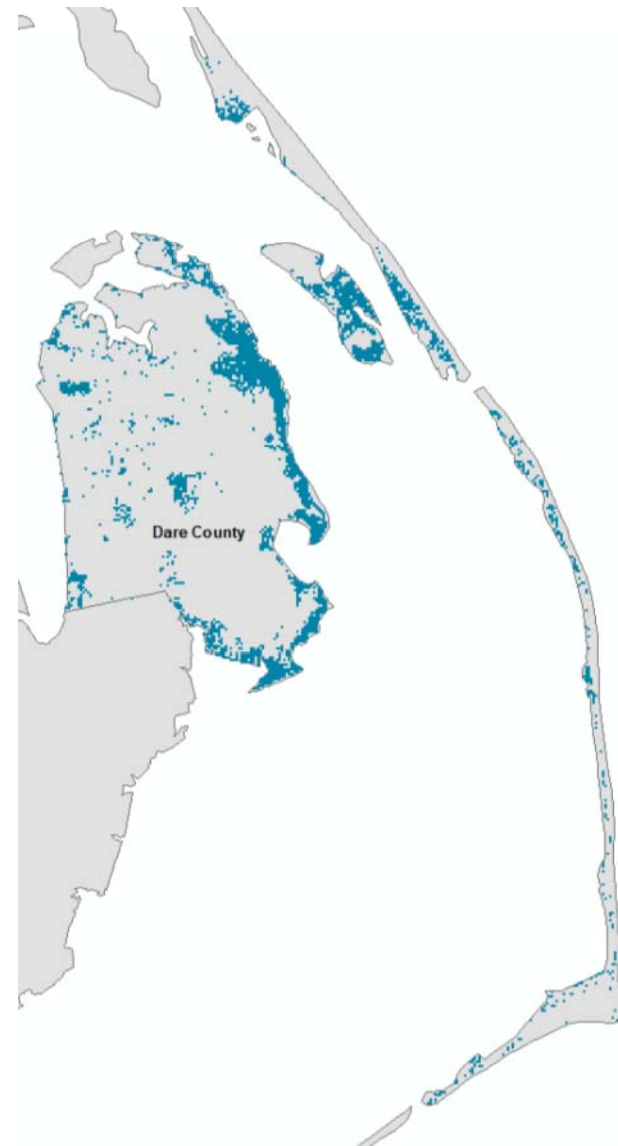
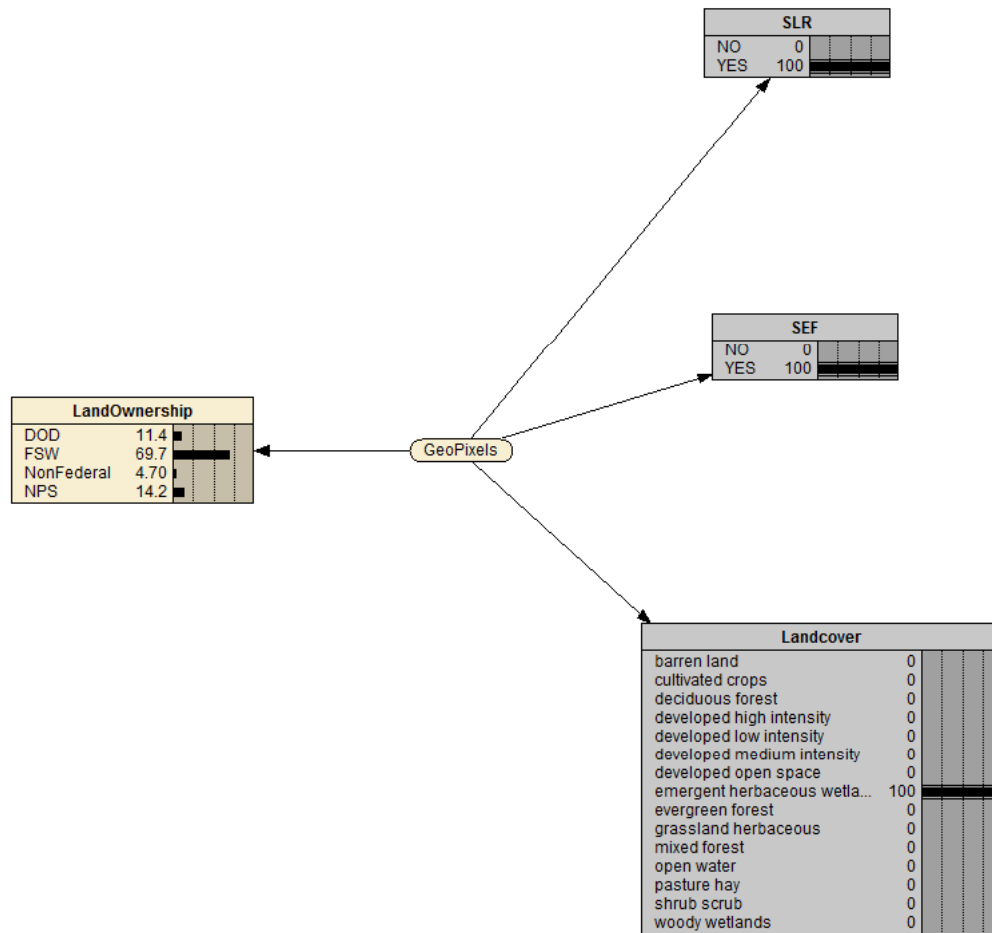


Maps are important, but facilitation leads to decision making in group settings



Decision framework used to integrate GIS data with Belief Nets (decision tools)

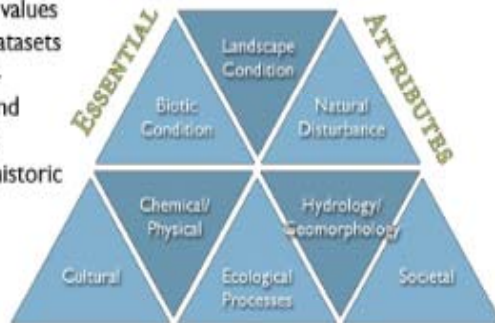
Dare County, NC- SLR, SEF, Emergent Wetlands



A belief net with the resulting map (NEMAC published the approach in ArcUser)

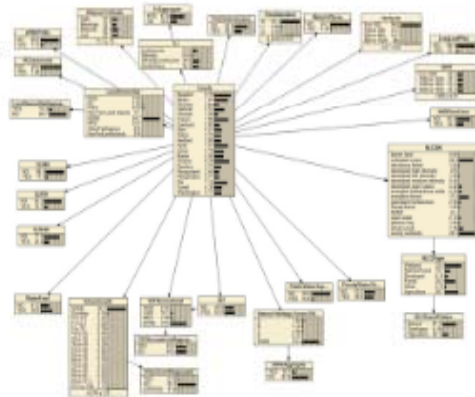
Essential Attributes and Data

Data were collected from each essential attribute to represent the values of each SENRLG agency. Datasets selected for the Albemarle-Pamlico region included Land cover, habitat, longleaf pine, environmental justice and historic places, to name a few.



Belief Network

SENRLG used a belief network to apply probabilistic map algebra to the essential attribute data. Each node of the network represented criteria, which were queried then used to determine areas in the Albemarle-Pamlico region that fit that criteria. These criteria were used to create "stories."



Stories

The SENRLG "stories" described different themes and indicated which areas in the AP met the criteria.

Criteria for Natural Story

Distance to Roads: HIGH
Ownership: NON-FEDERAL
NLCD: NATURAL
NDVI: HIGH



+

Criteria for Drinking Water Story

Environmental Justice: YES
First Order Streams: YES
Priority Watersheds: YES
SEF: YES
Public Water Supply: YES



+

Criteria for Biotic Habitat Story

Waterfowl: YES
SN Heritage Areas: YES
SEF: YES
NLCD: NATURAL



+

Criteria for Tourism Story

SEF Recreation: YES
National Register of Historic Places: YES



+

Sea Level Rise

40cm



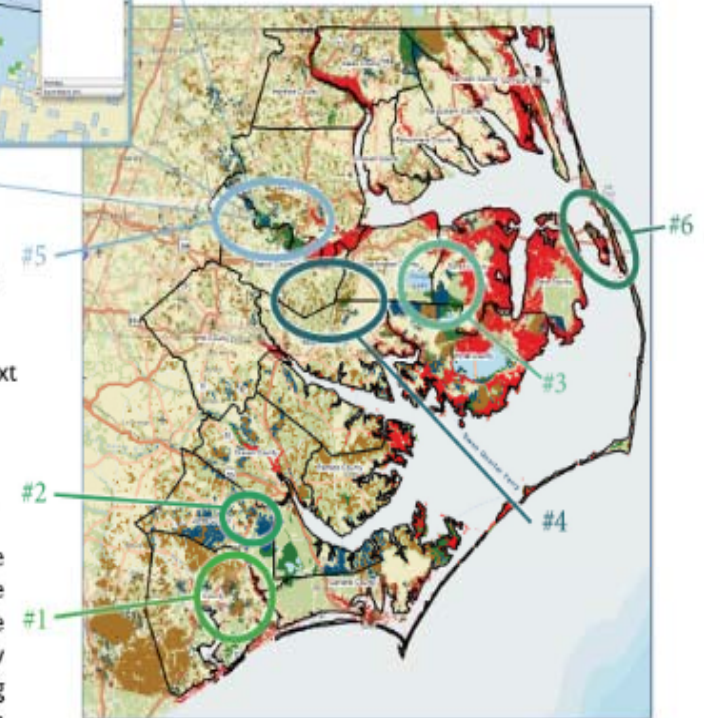
2. for r in range[rows]
3. cols ← number of columns in P
4. for c in range[cols]
5. if r, c_j within ϵ
6. then add r, c_j to P



The "Identify" tool links the Catalog of Federal Domestic Assistance (CFDA) programs to the focus areas, which provide information about potential funding opportunities for the next phase of the project.

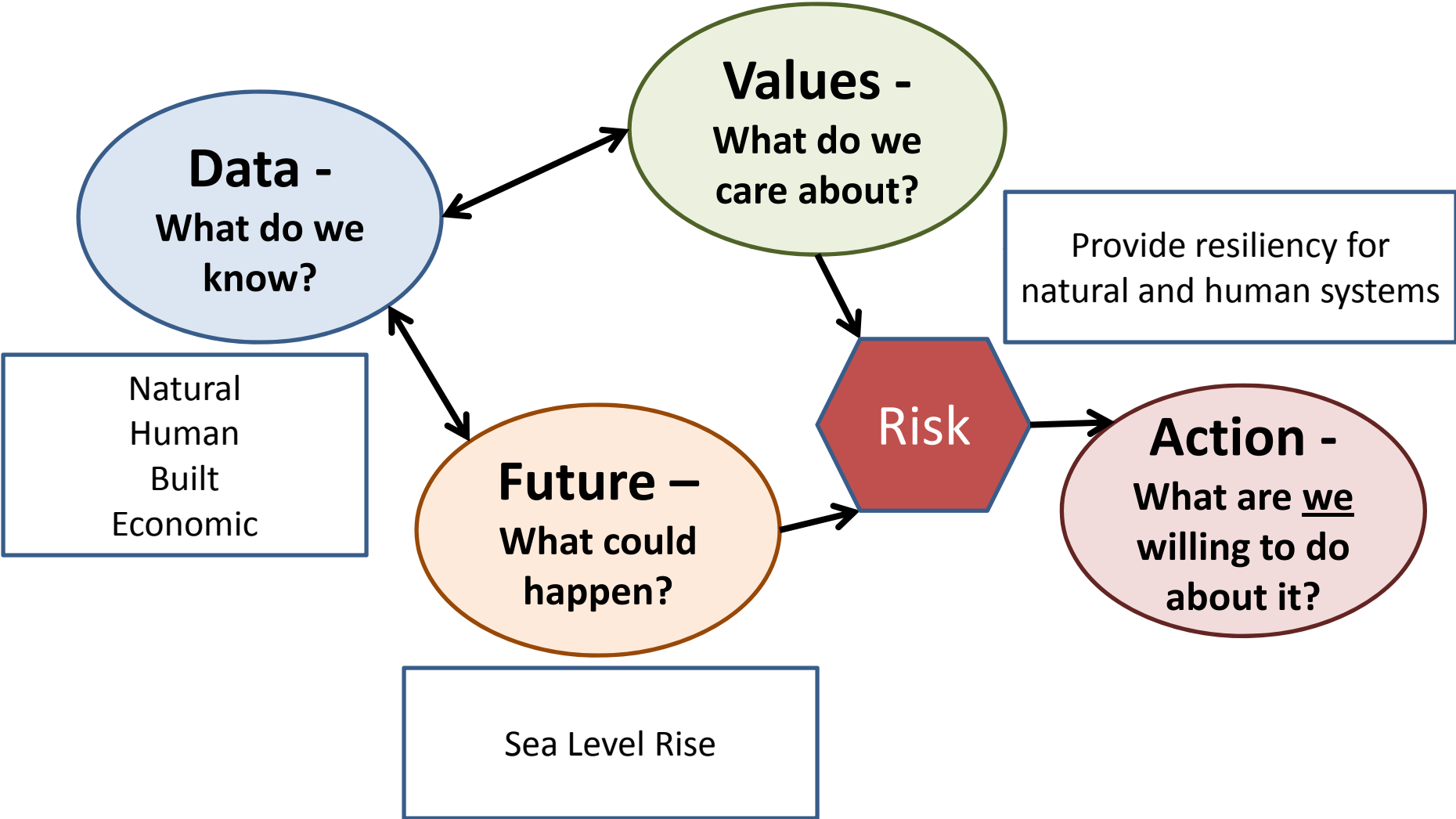
Focus Areas

The final focus areas were selected based on criteria for the SENRLG "stories." These three regions are located in Onslow and Jones County (1,2), along the Roanoke River (3,4,5), and in Dare County (6).



Albemarle Pamlico - Link from Values, to Analysis, to Visualizations and then to Decision Making

Albemarle Pamlico Sea Level Rise



Key Metrics for Decision Support Tools

- “An online data viewer (by itself) is **NOT** a decision support tool”
- **Data** must be accurate, current and scaled for the decision
- **Visualizations** make data meaningful and locally relevant
- **Storytelling** by group facilitators is critical for policy makers to understand uncertainty and follow a decision making process
- **Group Decision Making** is a continuing, iterative process that needs to be actively supported with appropriate technologies and toolsets
- Collaboration is key – the three sectors of **government, academia and industry** must work together to meet this challenge