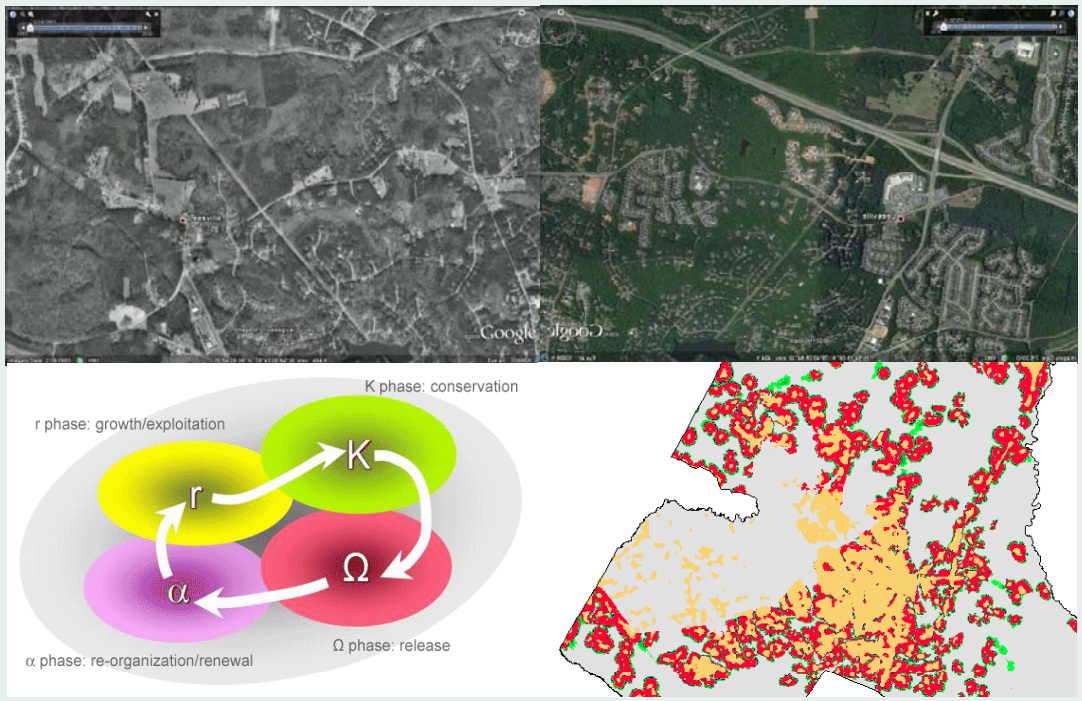
Barriers to Ecosystem Resiliency in the Face of Climate Change

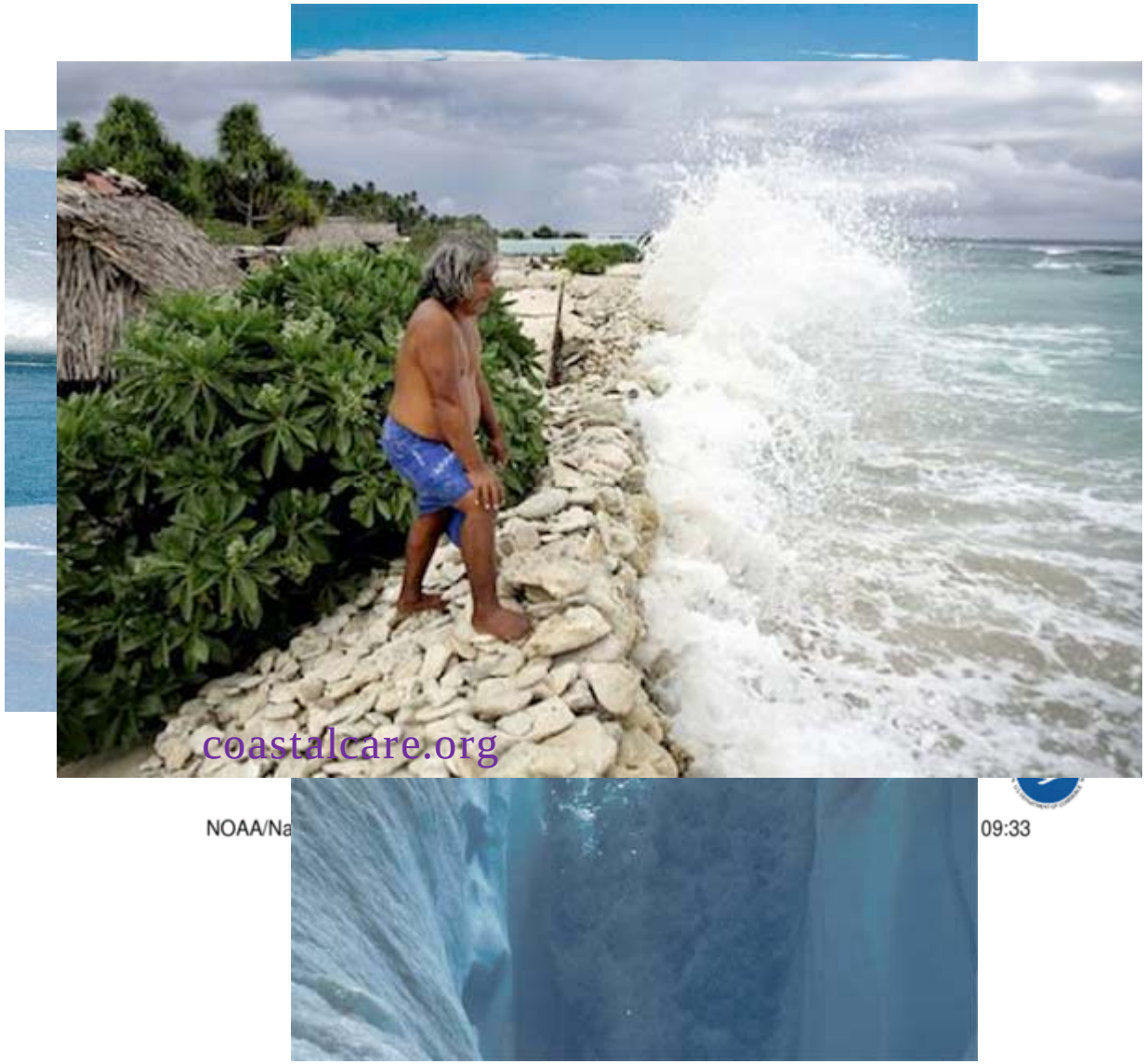


ADAM TERANDO

CLIMATE CHANGE IN THE CARIBBEAN 2011

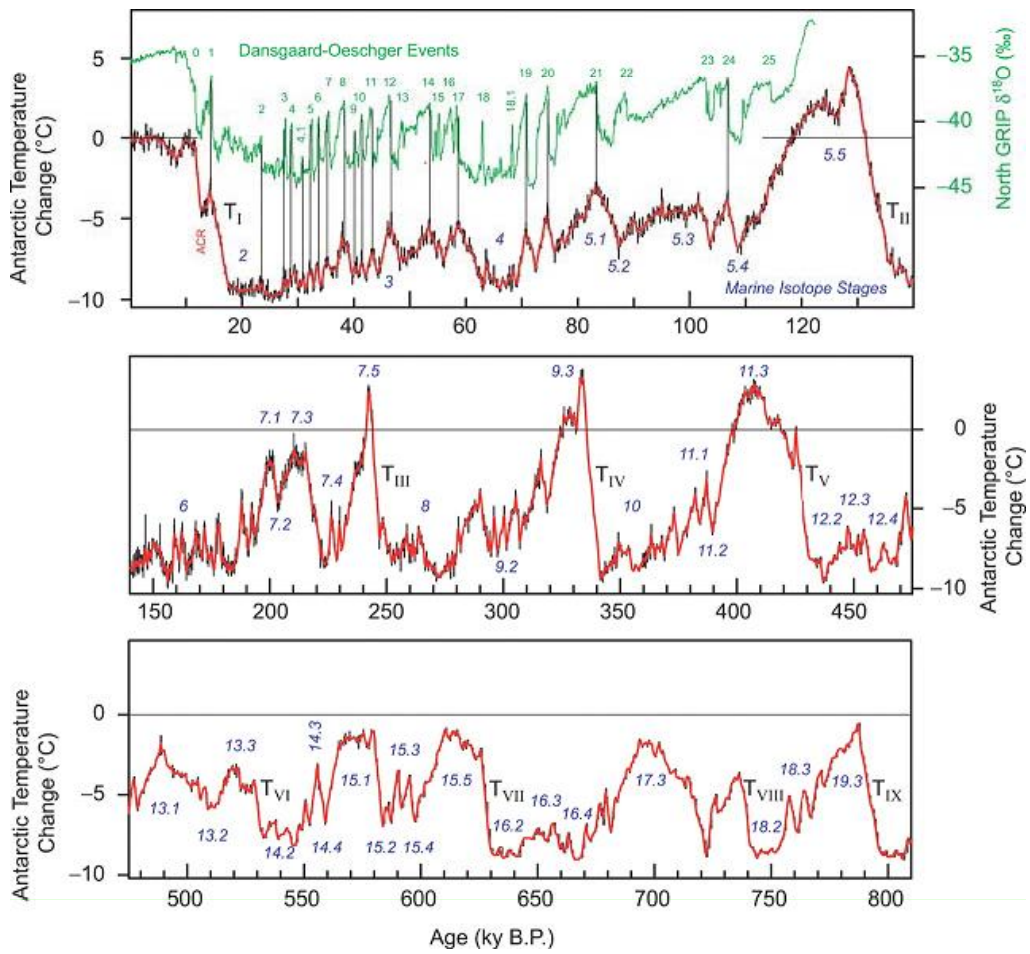
CLIMATE IS CHANGING

- Earth is getting warmer
- Ice is melting
- Sea level is rising



THEN AGAIN, IT'S ALWAYS BEEN CHANGING

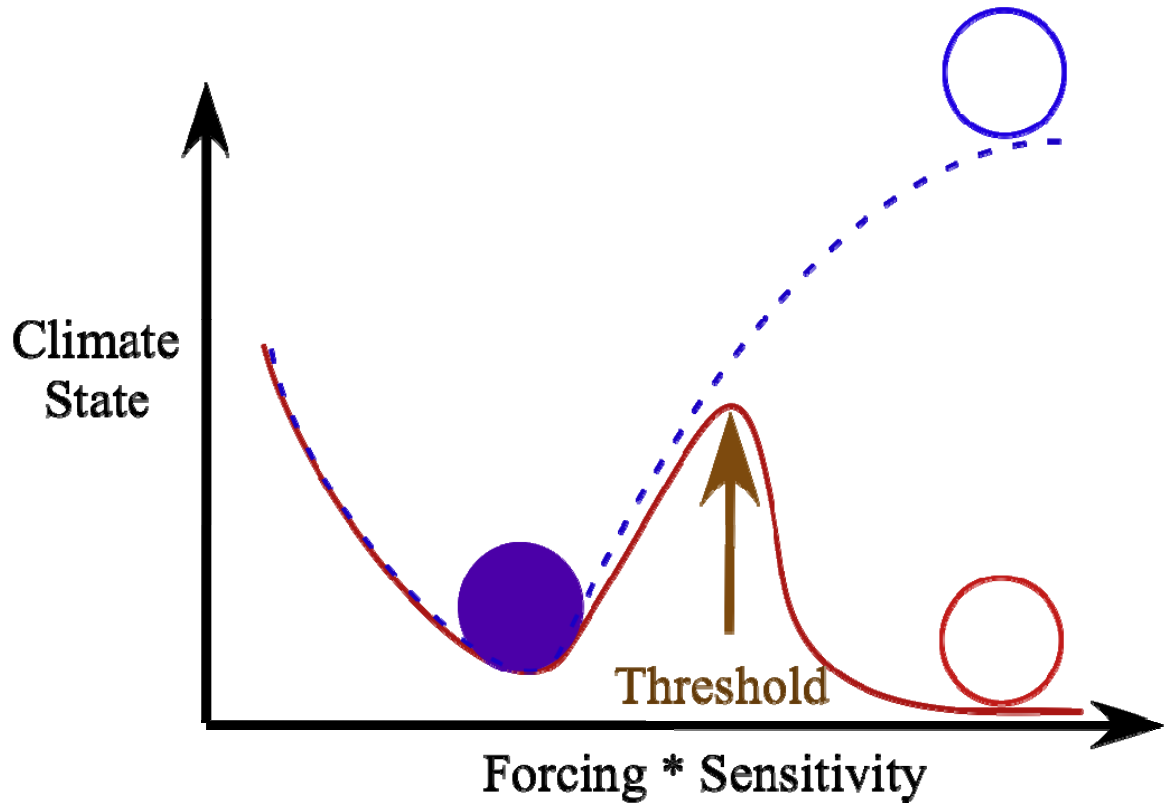
- Large swings in temperature before
- World's biological systems as a whole did not collapse
- Indicates *resilience* and large *adaptive capacity* in many systems



Jouzel et al. 2007

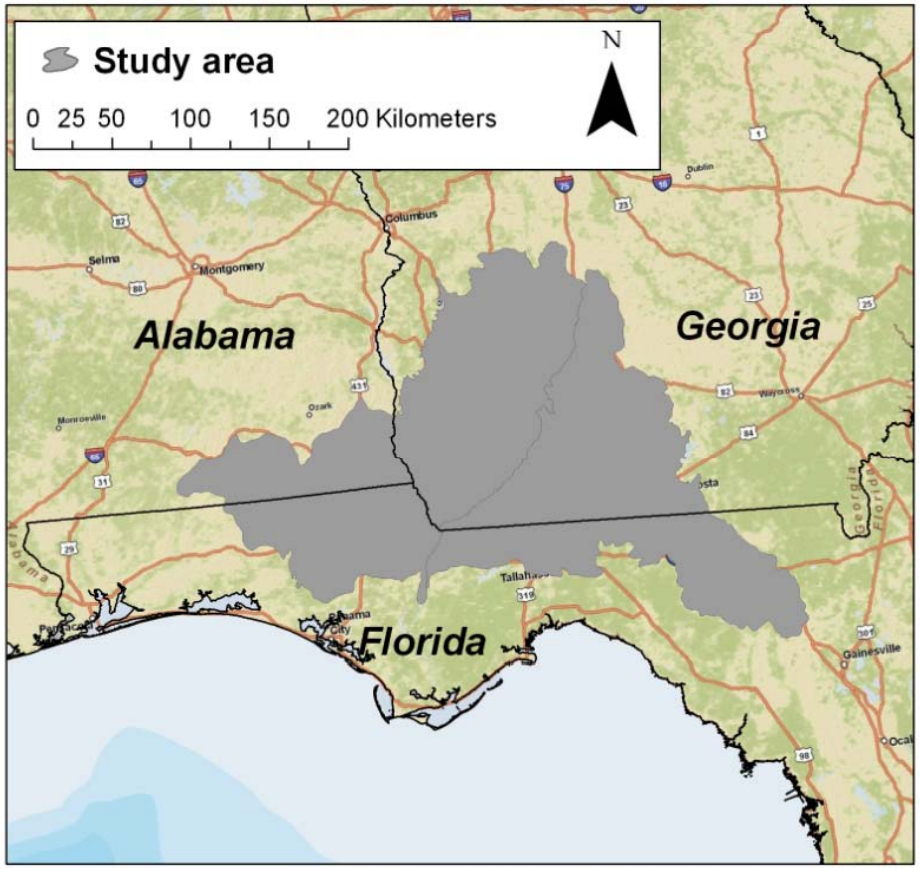
RESILIENCE REDUCES THE PROBABILITY OF ECOSYSTEM COLLAPSE

- A threshold (or "tipping point") response can occur when a negative feedback loop switches sign.
- Threshold response can occur abruptly (i.e., faster than the forcing) and show hysteresis.



Keller 2011

SYSTEM RESILIENCE TO CLIMATE CHANGE



Example: Climate effects on longleaf pine in the Gulf Coastal Plain

LONGLEAF PINE ECOSYSTEM

- A Southeastern endemic with high plant species diversity
- Notable for open canopy, savanna-like systems
- *Fire is a frequent and necessary disturbance*
- Results in accumulation of resources , frequent renewal and high biodiversity
- Critically Endangered (98% range-wide loss)

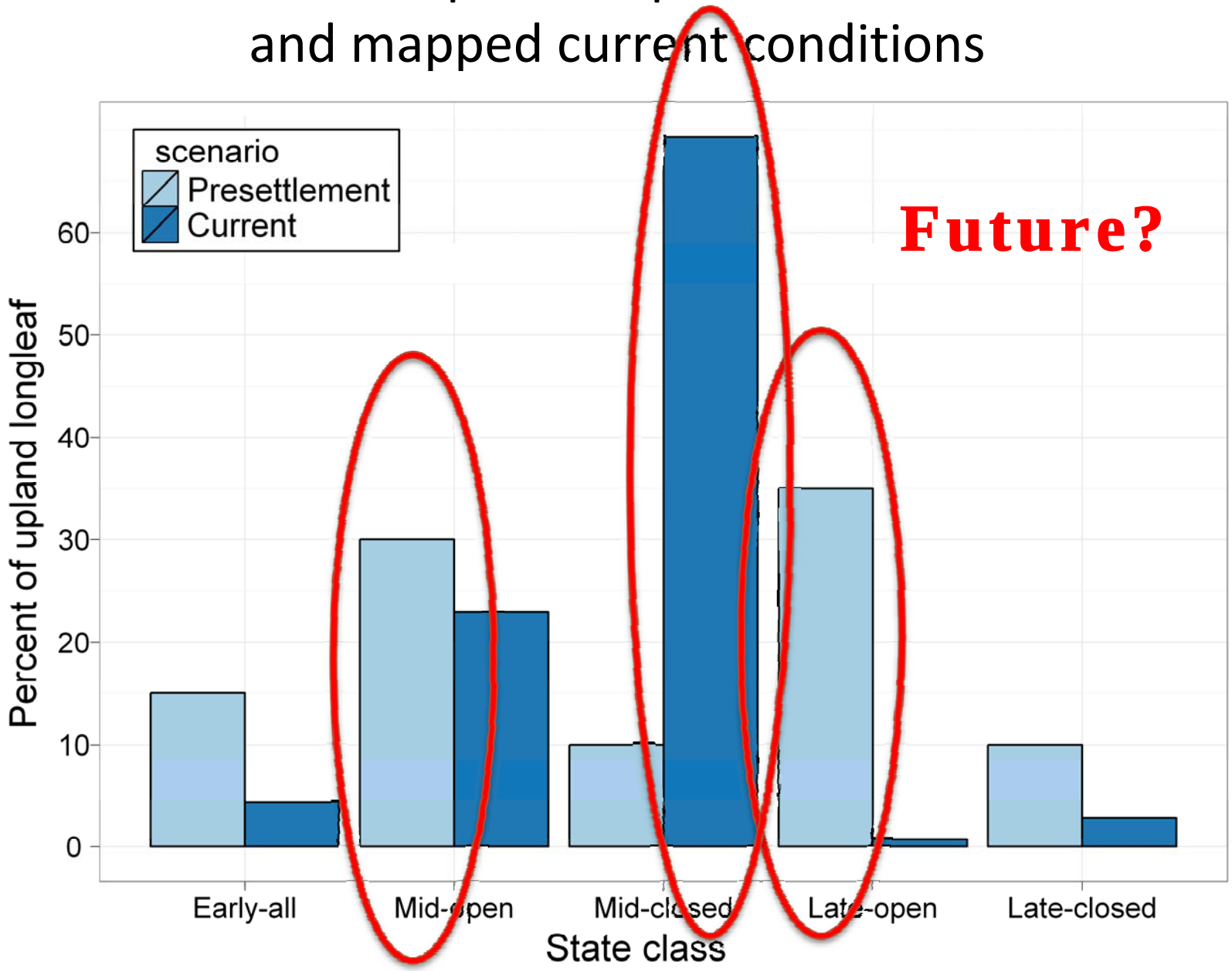
Photographer : John McGuire

RESEARCH QUESTIONS

1. How will climate change likely affect the annual area burned by wildfires over the next century?

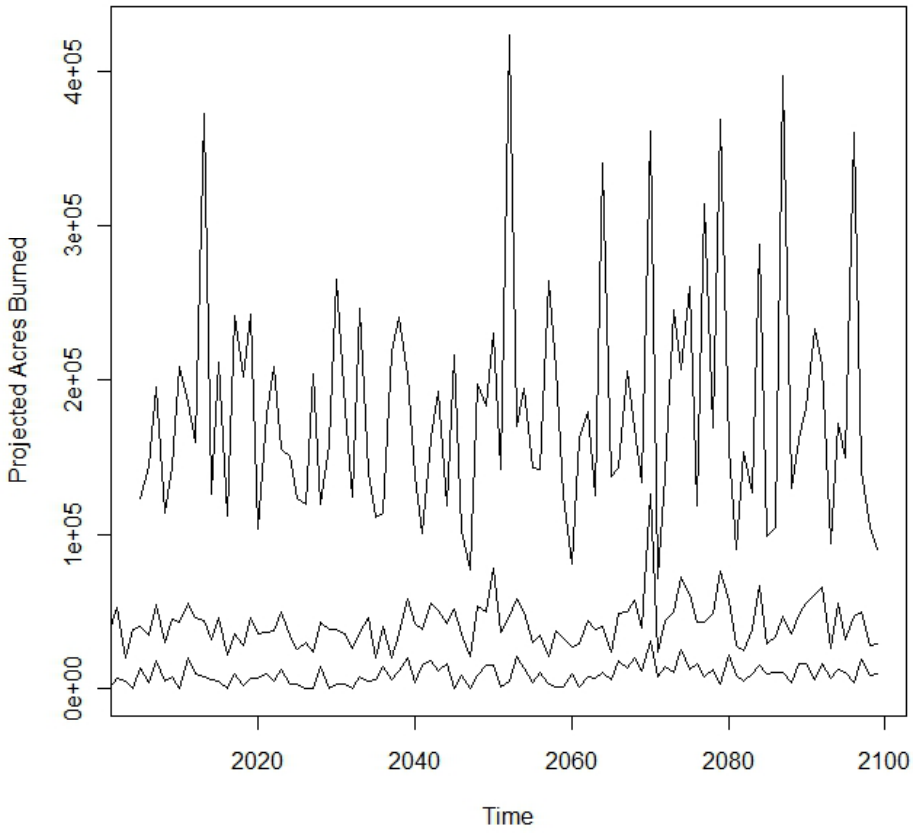
2. How will wildfires affect vegetation dynamics over the next century?

Estimated pre-European settlement and mapped current conditions

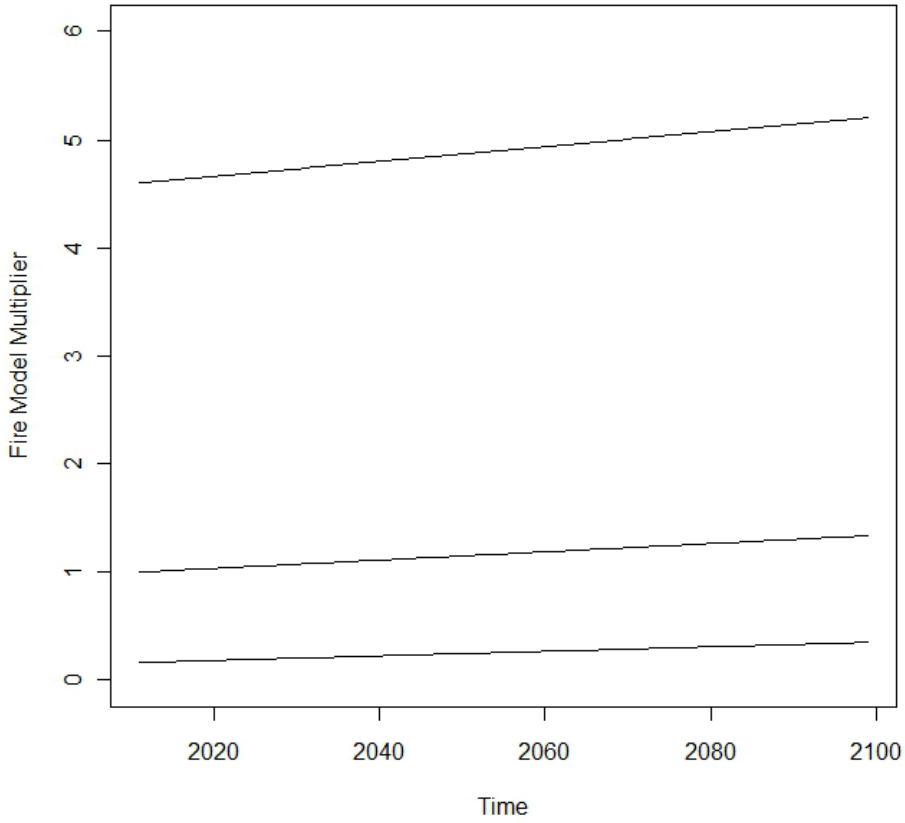


RESULTS: WILDFIRE PROBABILISTIC PROJECTIONS

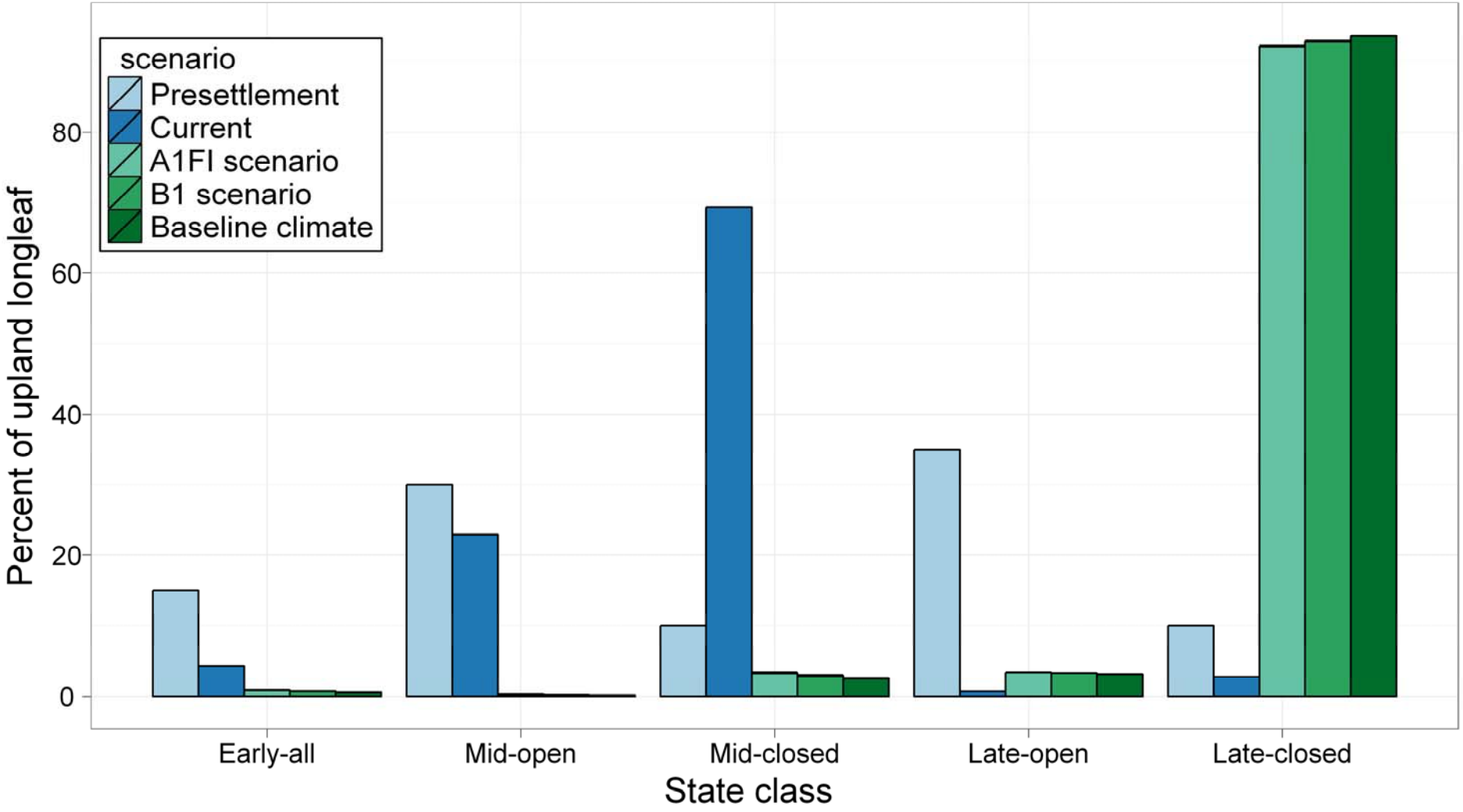
Annual area burned



Wildfire probability multiplier



RESULTS: LANDSCAPE COMPOSITION AT 2100



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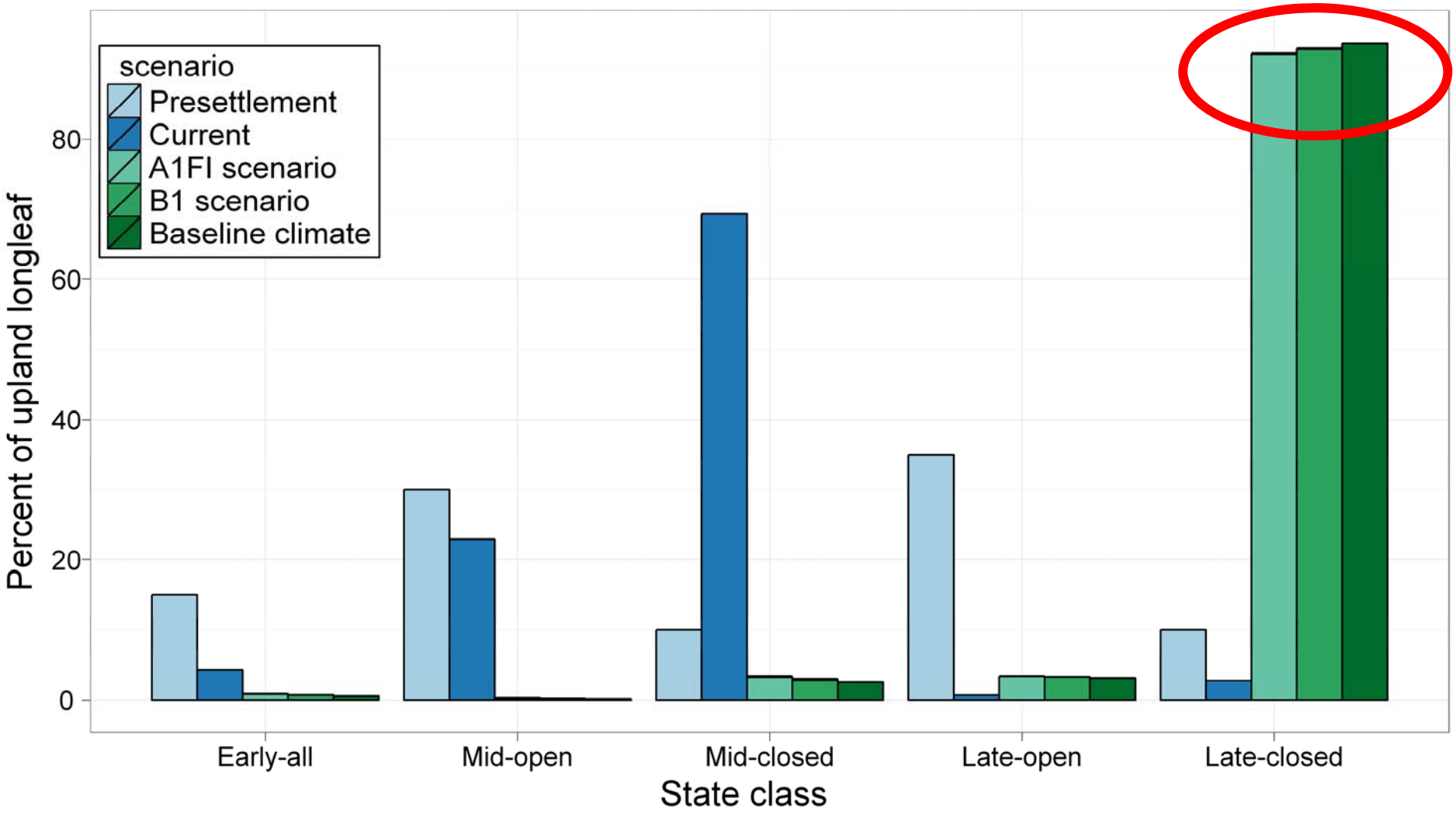
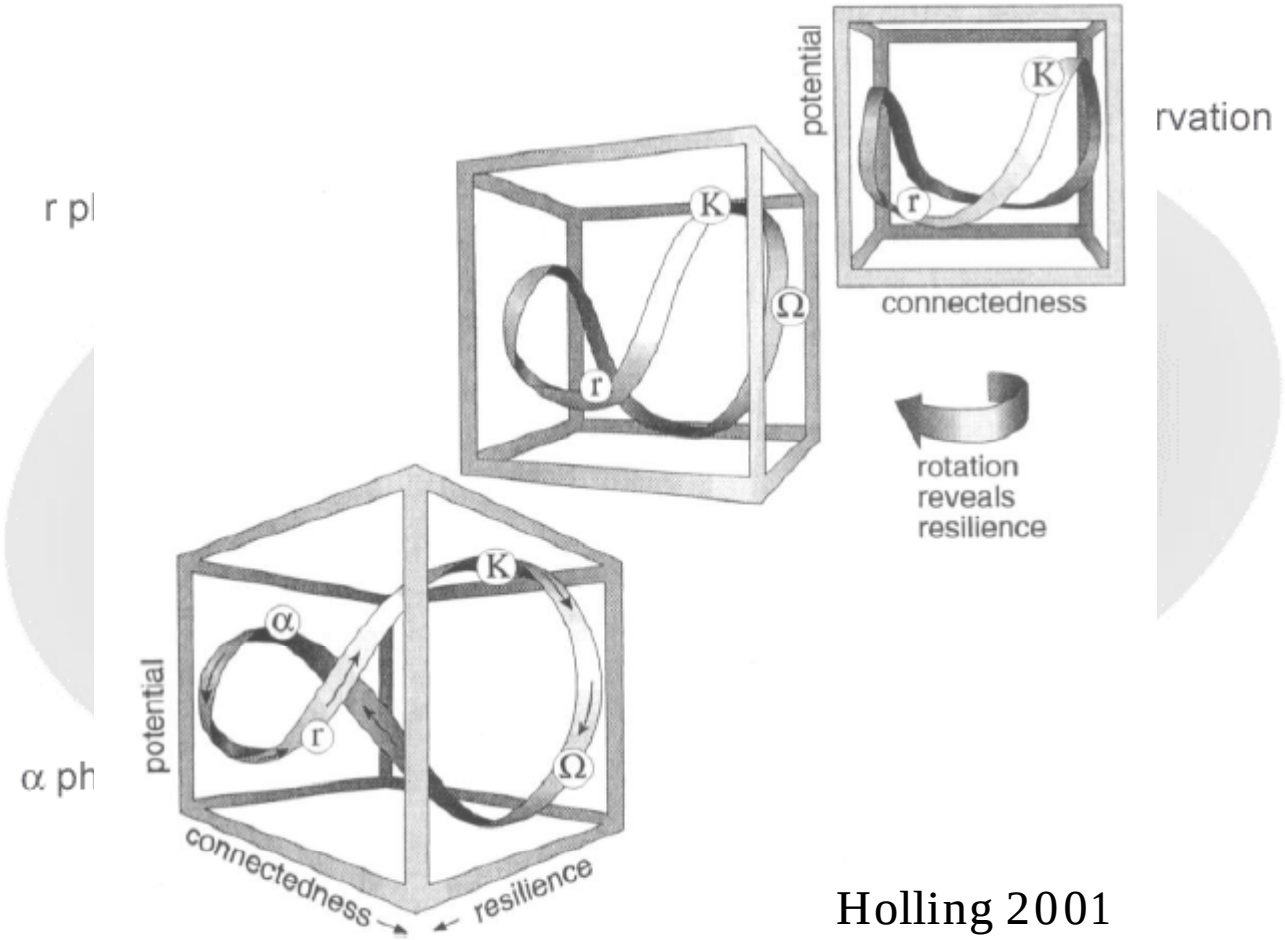


RESILIENT SYSTEMS CAN BE DESCRIBED AS PART OF THE ADAPTIVE CYCLE



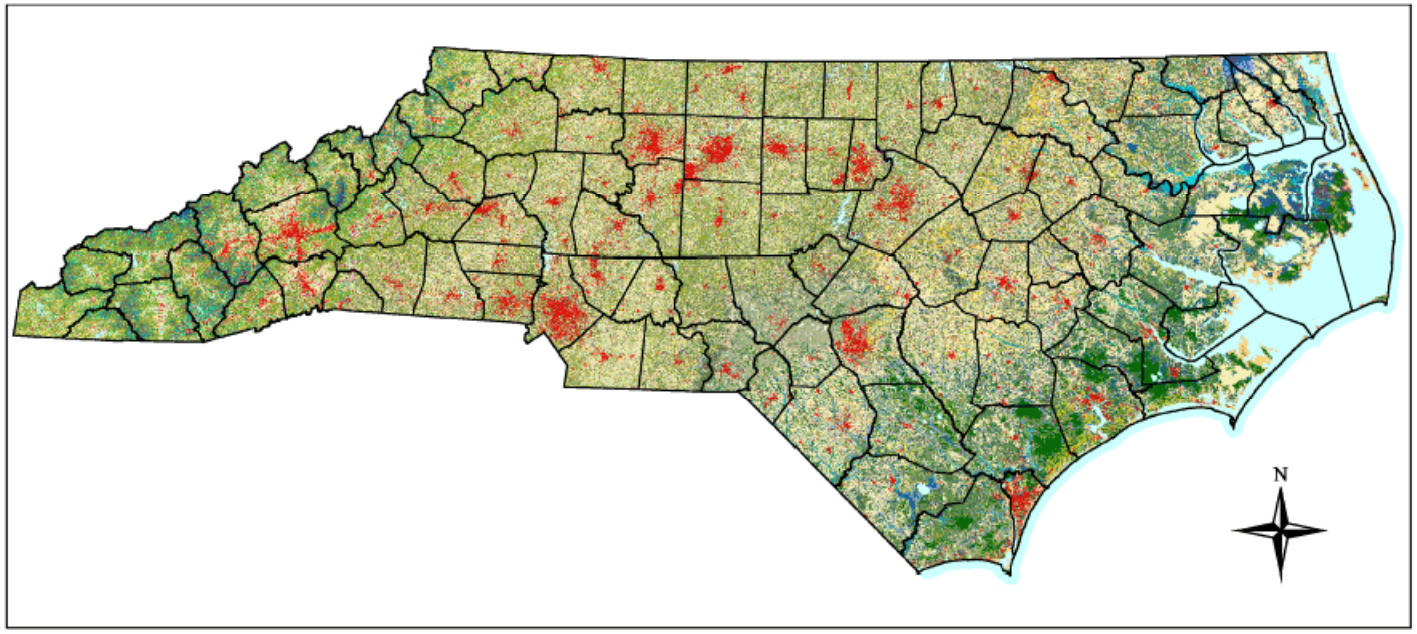
Holling 2001

Resalliance.org

HOW CAN THIS CYCLE BE INTERRUPTED?

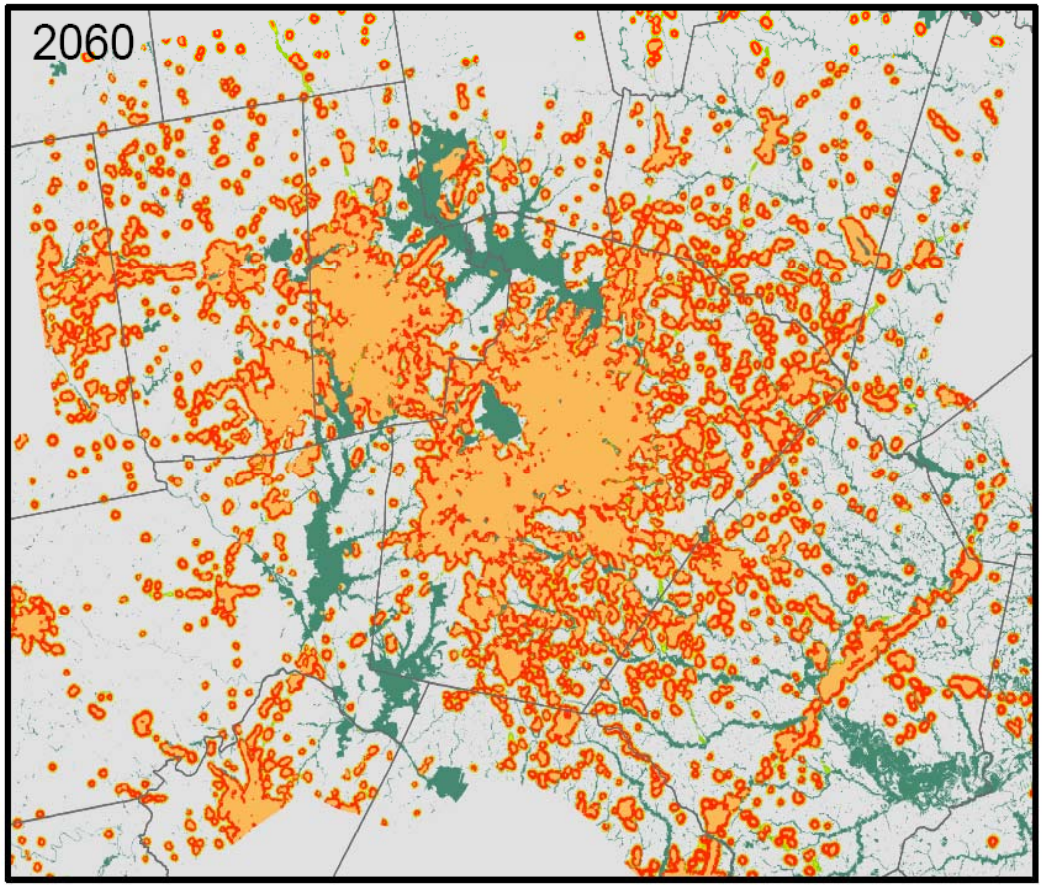
- Direct reduction of system extent
- Disruption of conservation and renewal dynamics
- Reduction in biodiversity, future potential
- Urbanization can impact all of these processes

URBANIZATION AND URBAN SPRAWL



- Low density development but large spatial extent
- Can we target areas for conservation that promote resilience?
- Need information on areas that are likely to become urbanized in the future

SIMULATING FUTURE URBAN PATTERNS

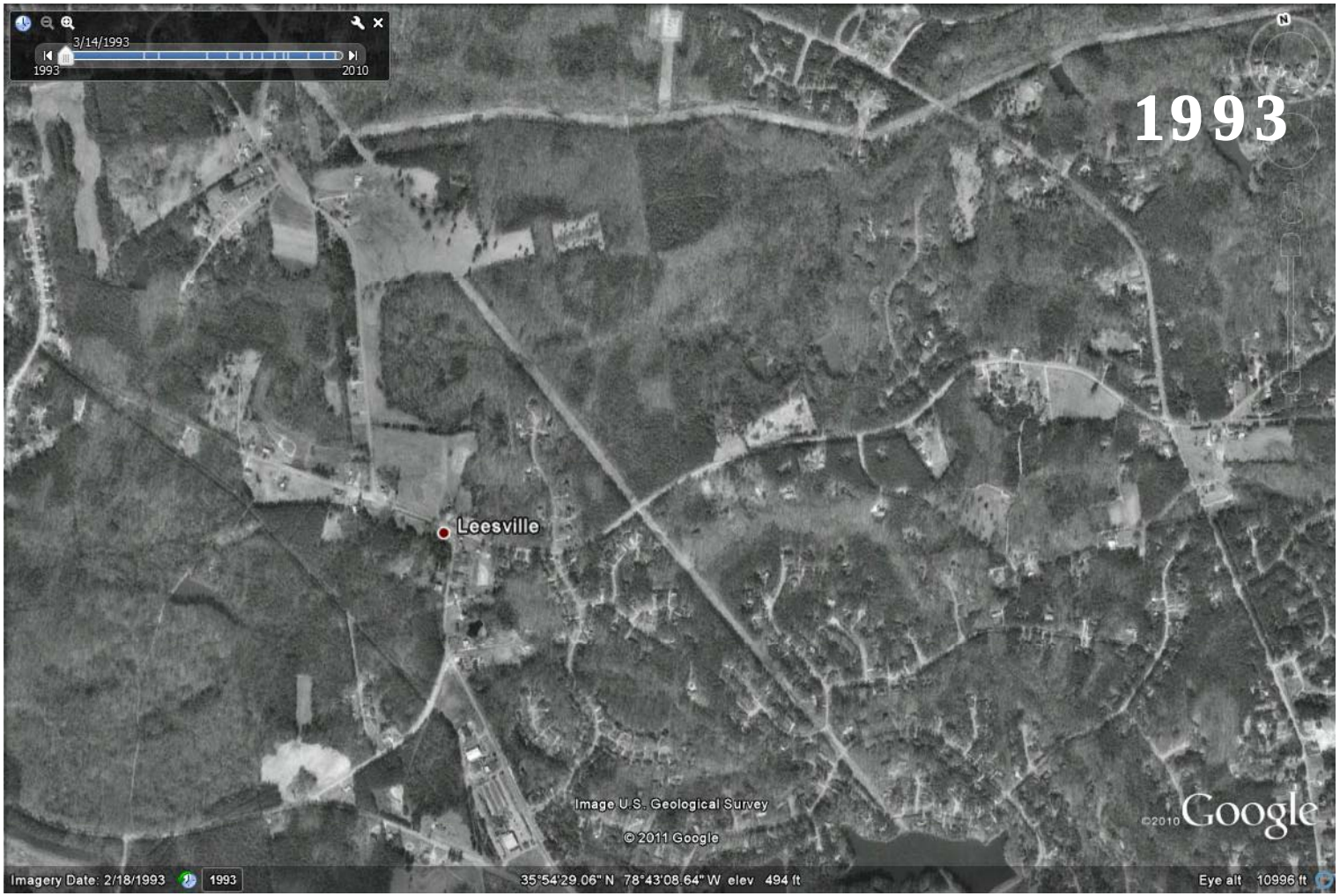


Using the USGS SLEUTH model to inform robust decision-making

SLEUTH URBAN MODEL

- Cellular Automata Model
- Use historic rates of urbanization (from imagery) to calibrate model
- Simulate urban growth based on physical and social constraints and proximity to existing urban and transportation
- Monte Carlo-based simulation allows for probabilistic projections

WHAT TYPE OF GROWTH ARE WE SIMULATING?



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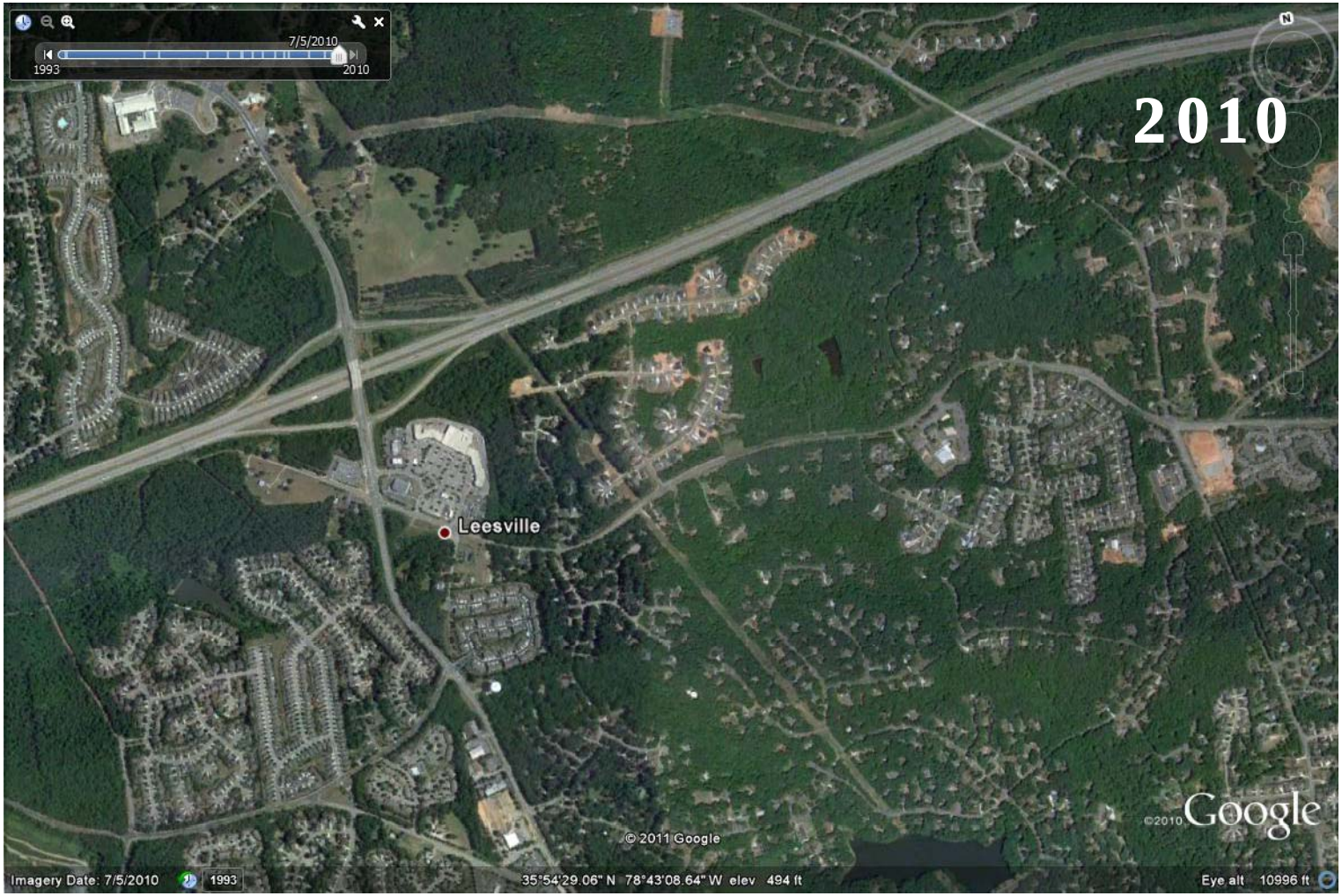

DEFINING URBAN AREAS

USE SATELLITE AND ROADS DATA

Create Road Density Layers as proxy for Suburban Growth – SLEUTH is simulating spread of road density and therefore urbanization

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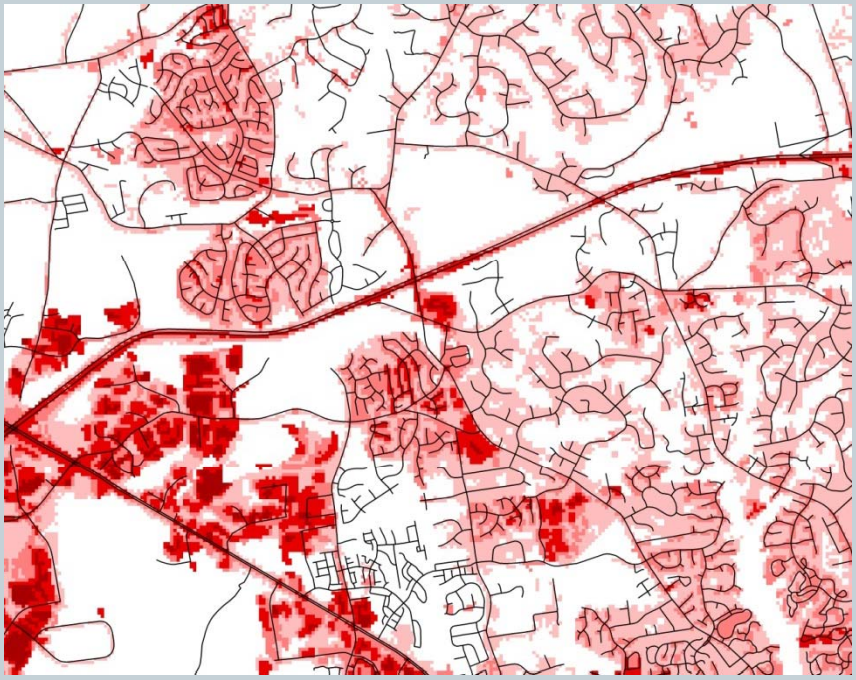
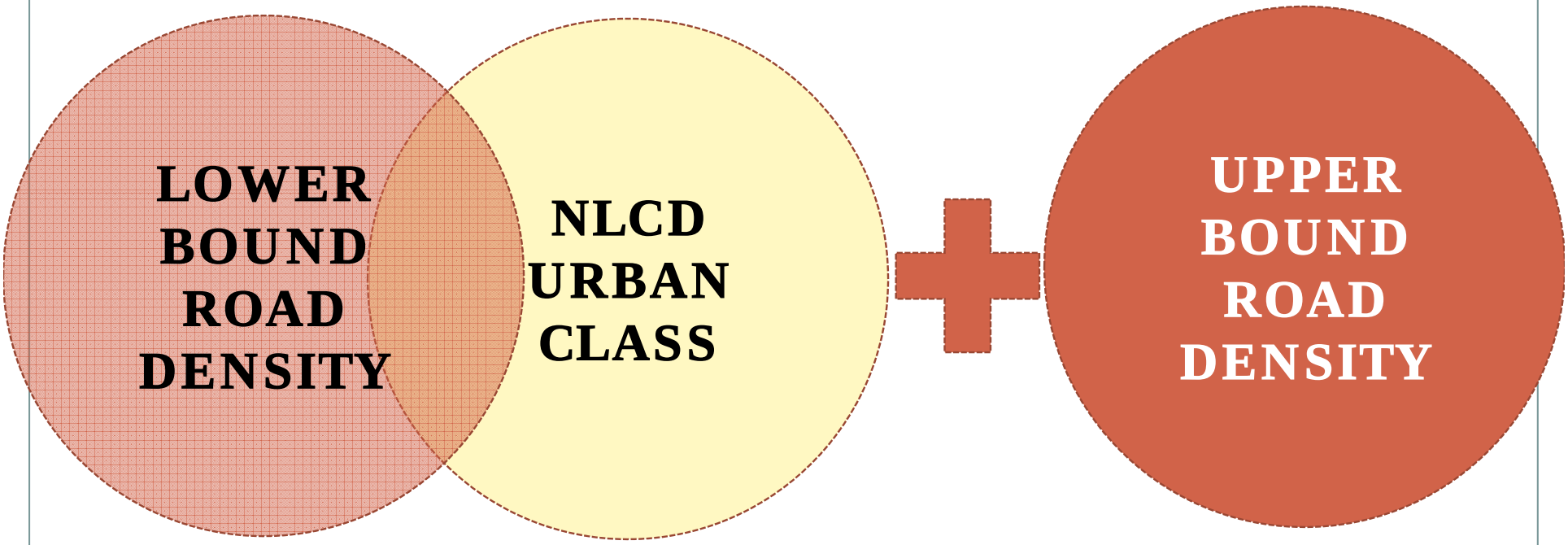
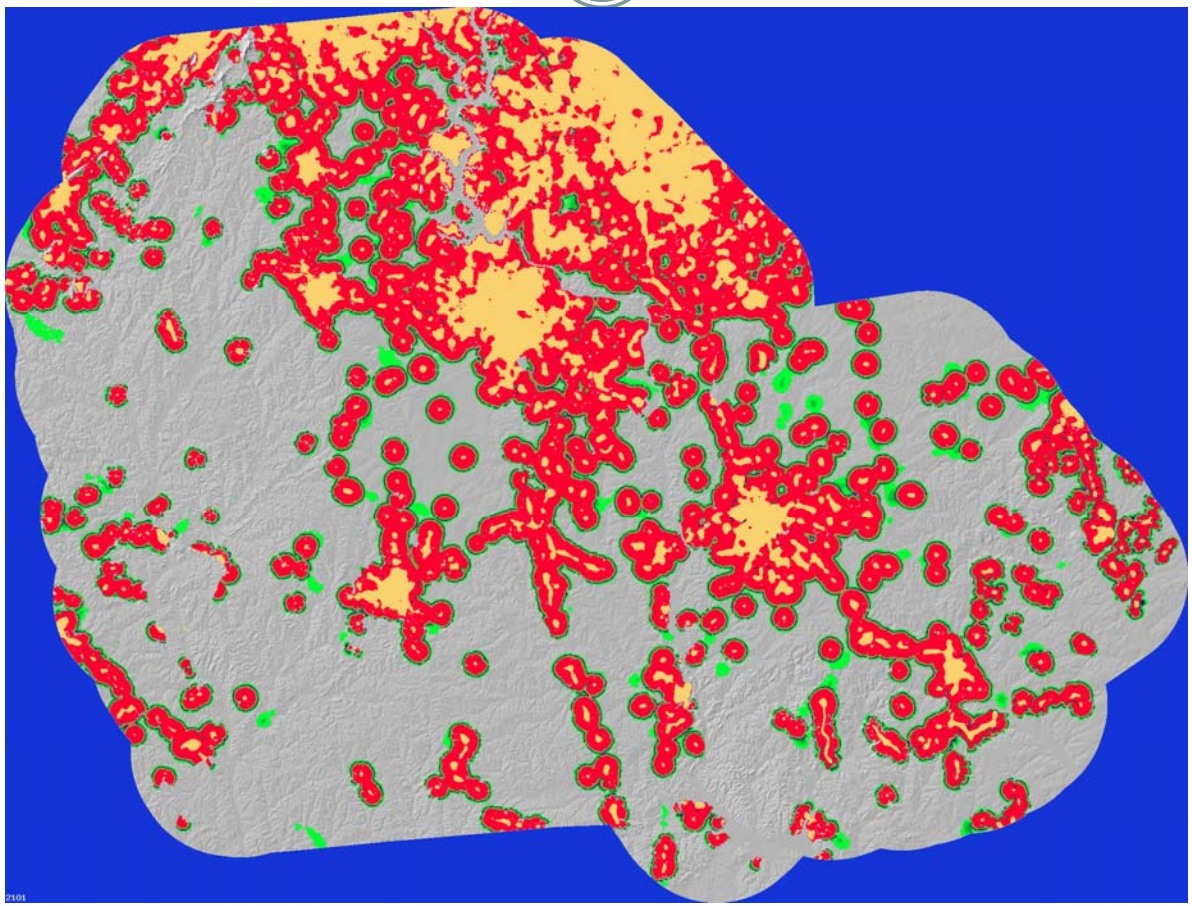


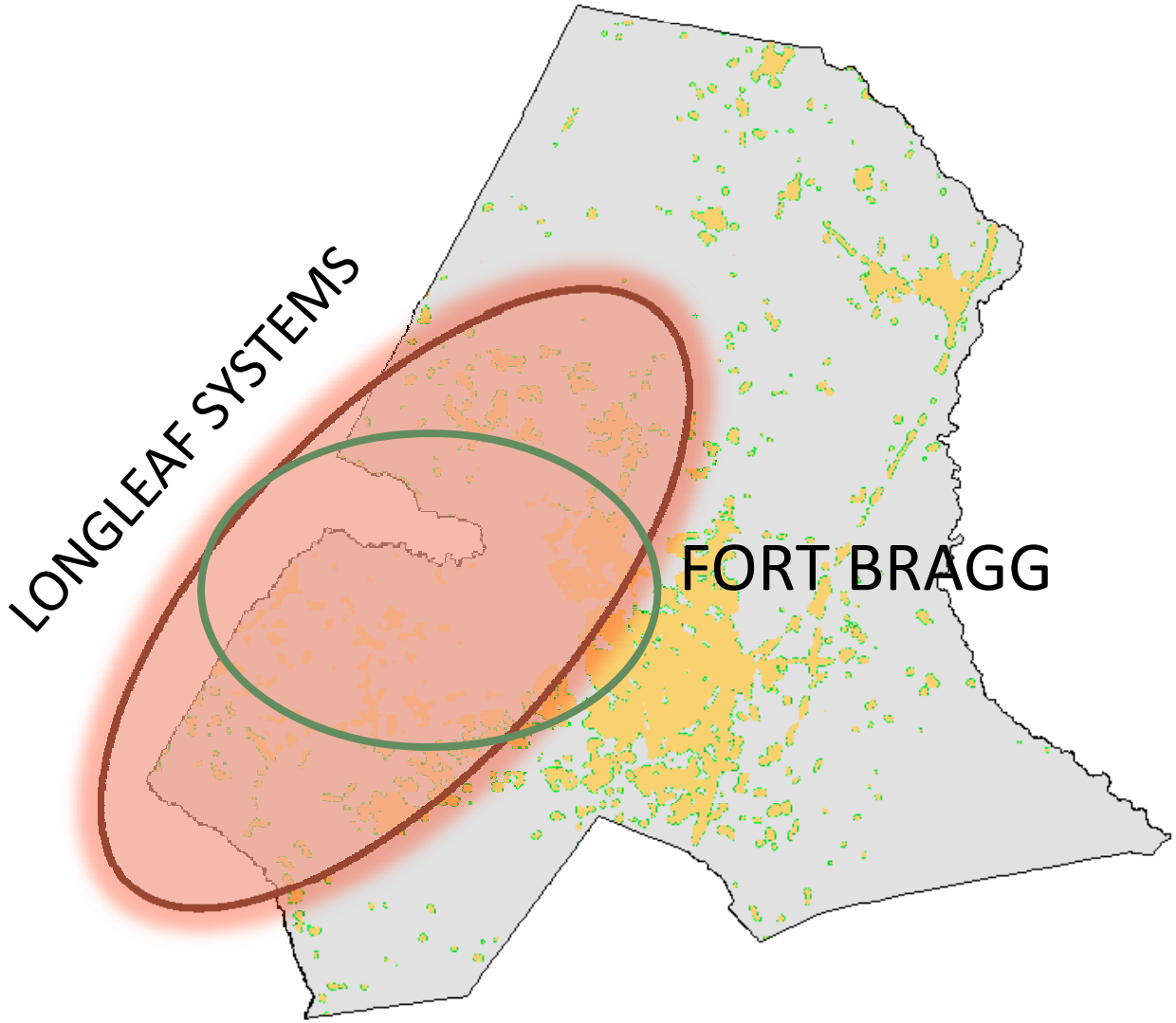
HOW WE DEFINE URBAN AREAS



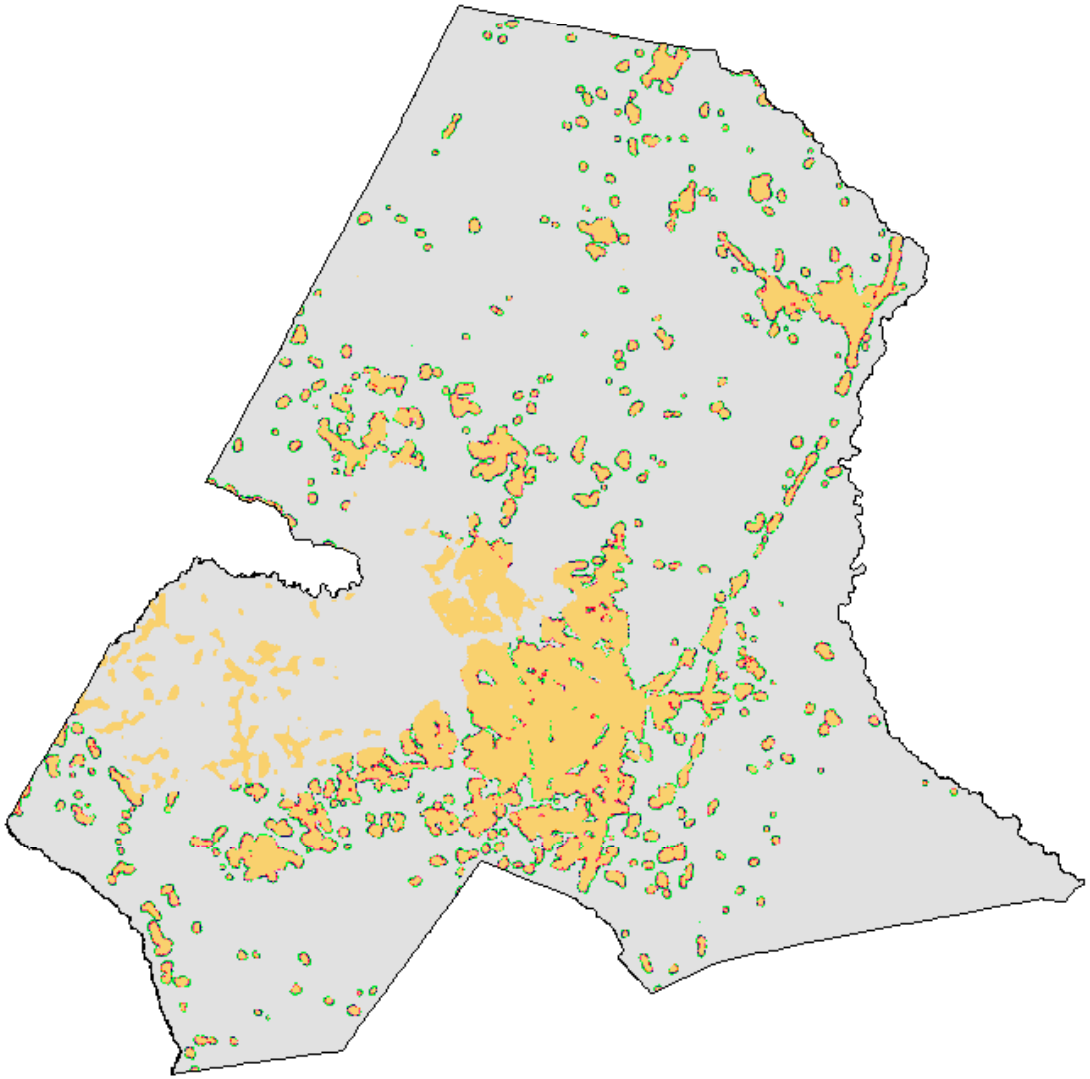
PROBABILITIES TO CAPTURE UNCERTAINTY



2010



2020



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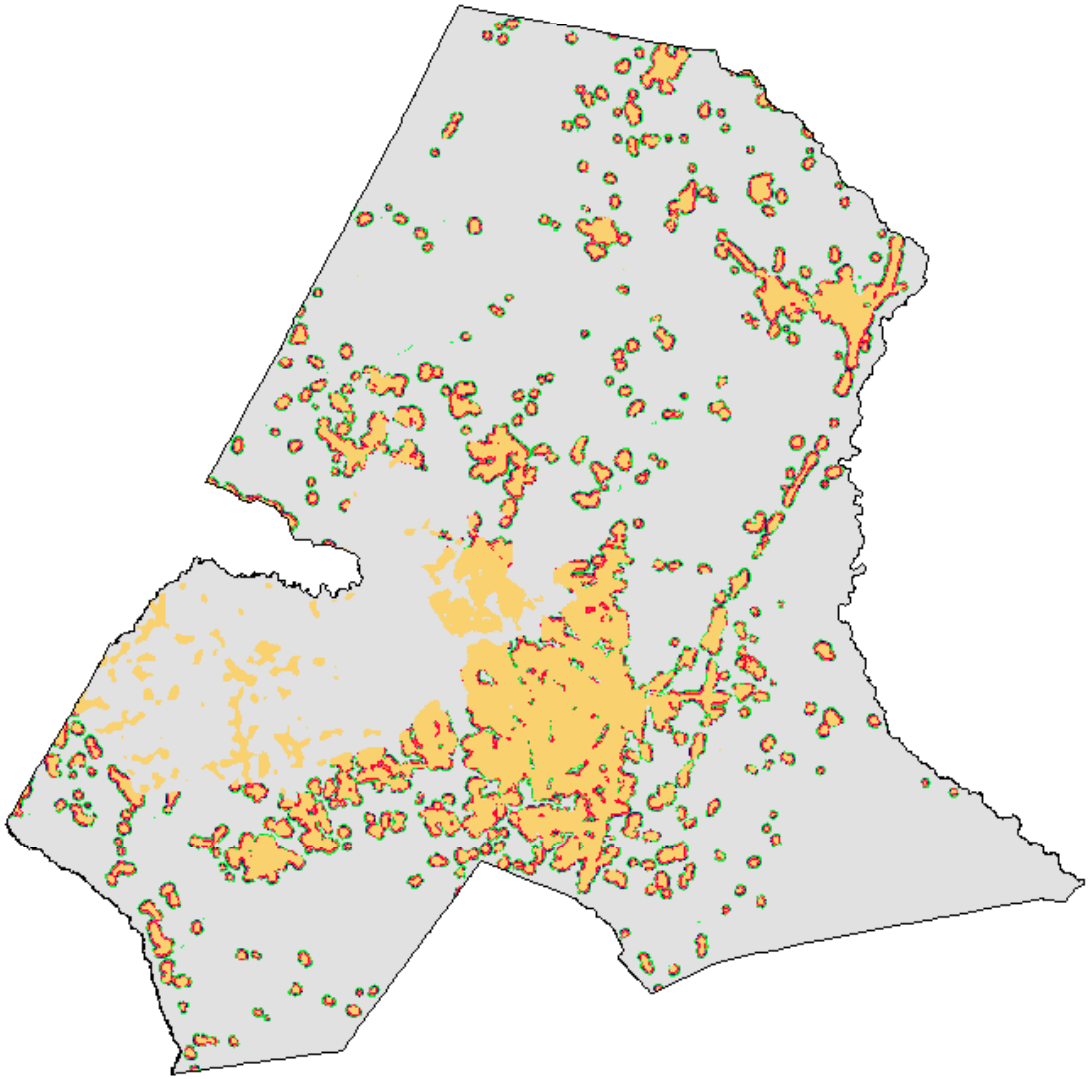

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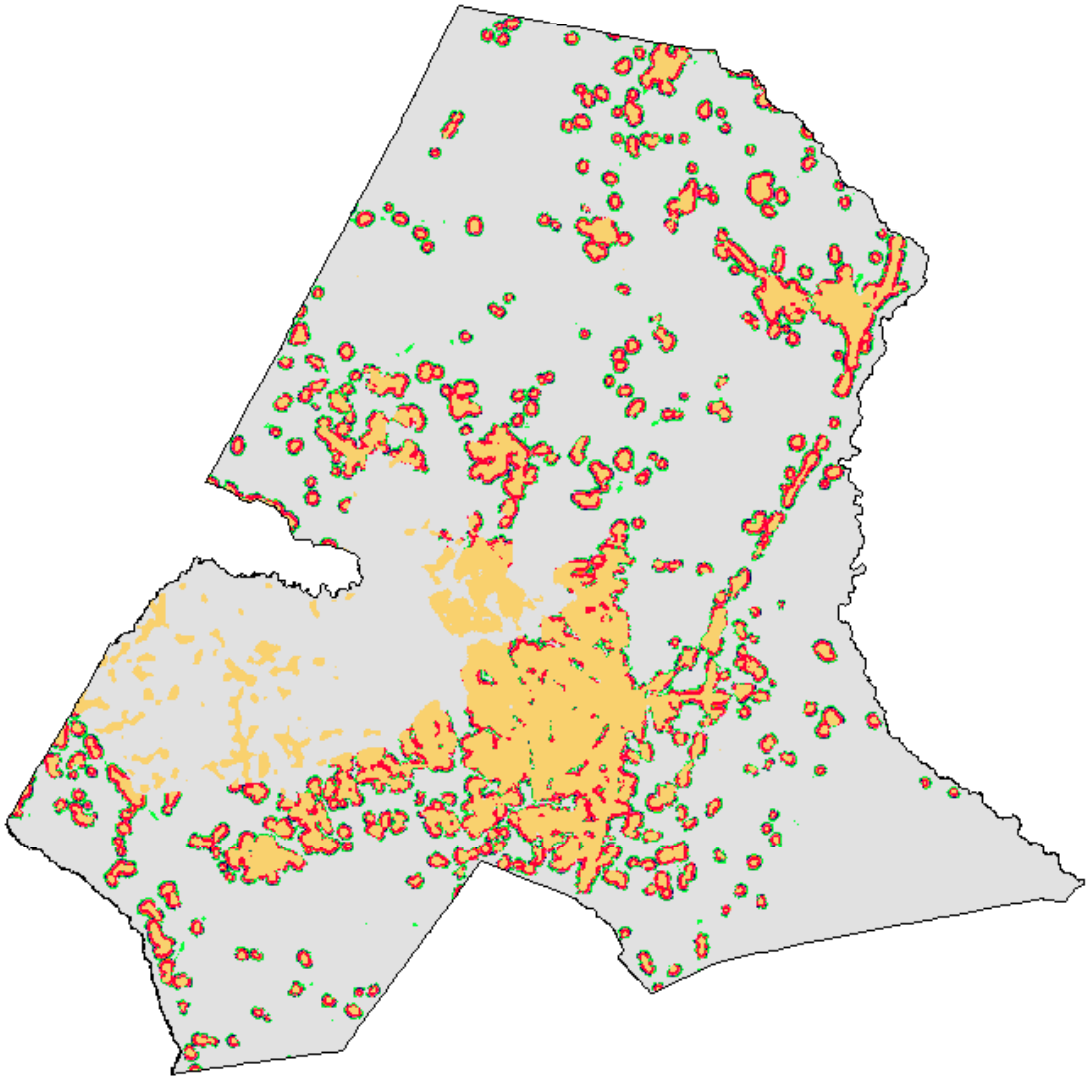

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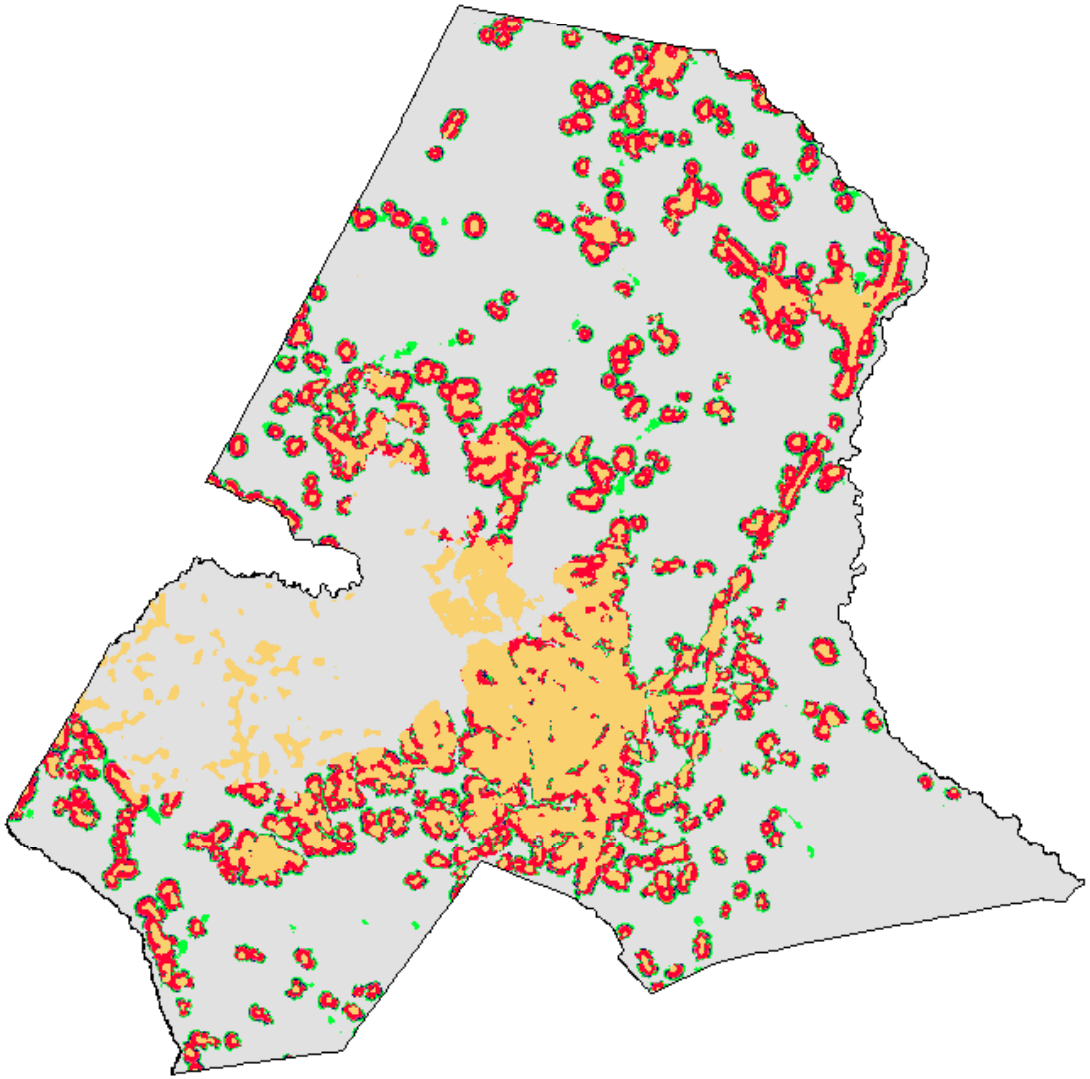

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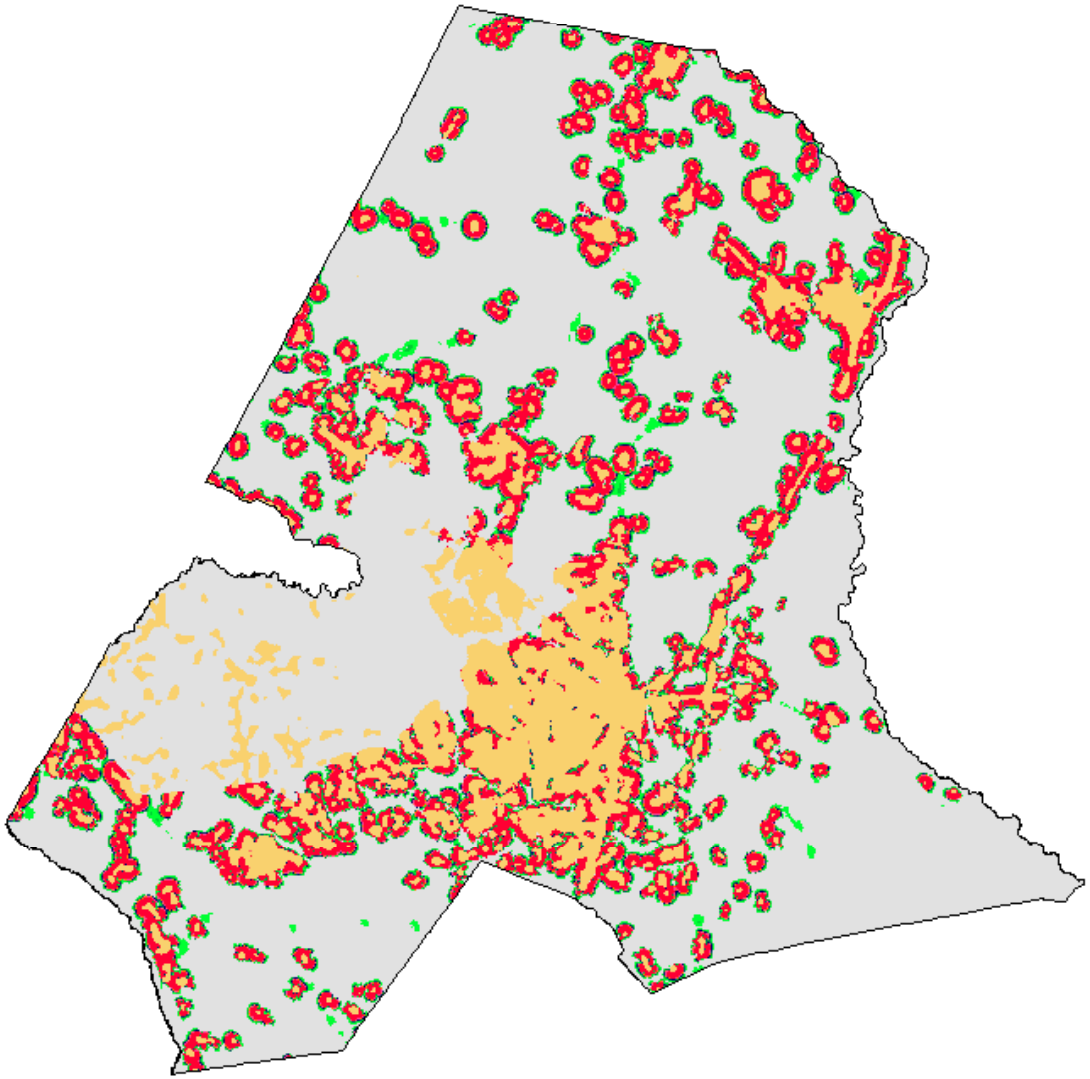

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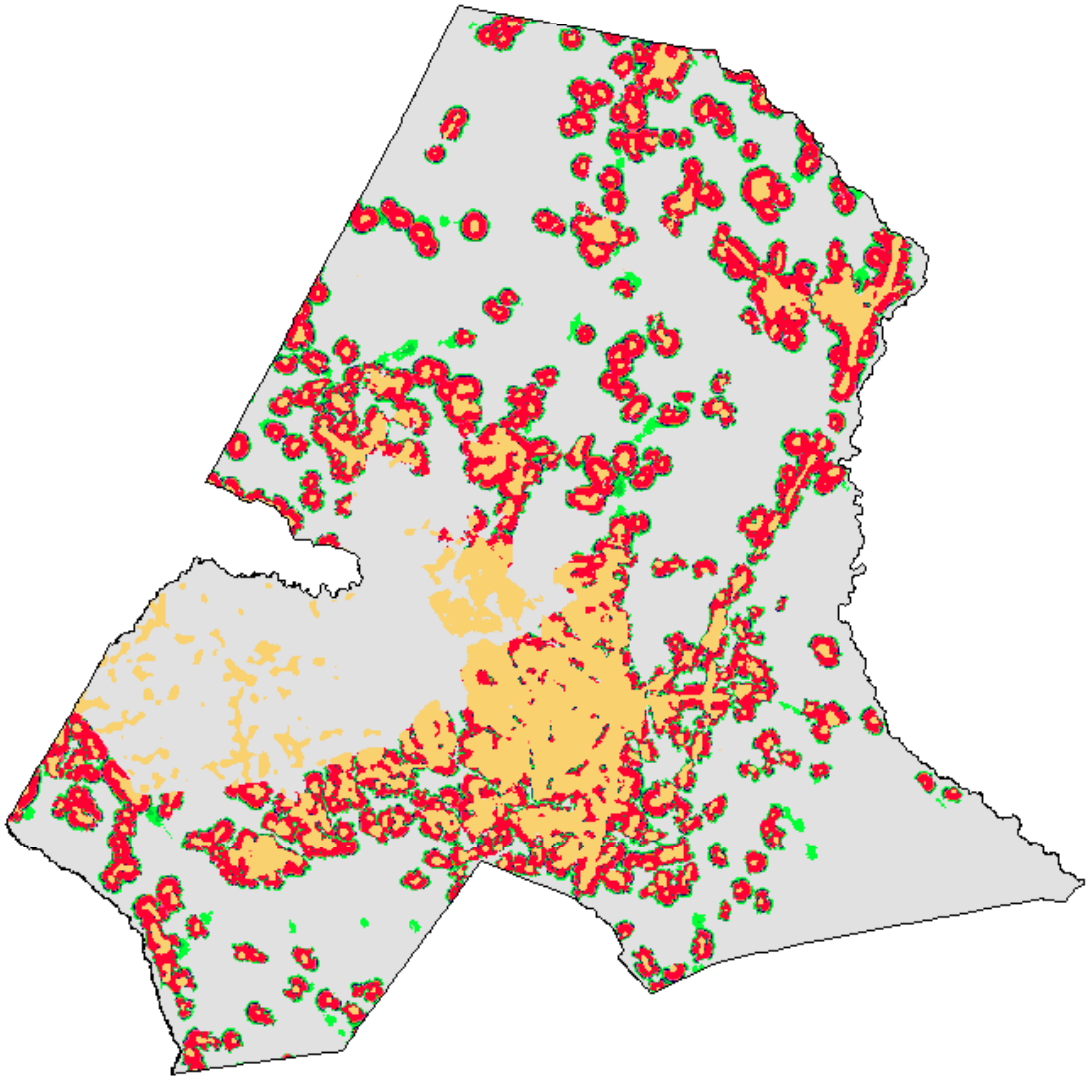
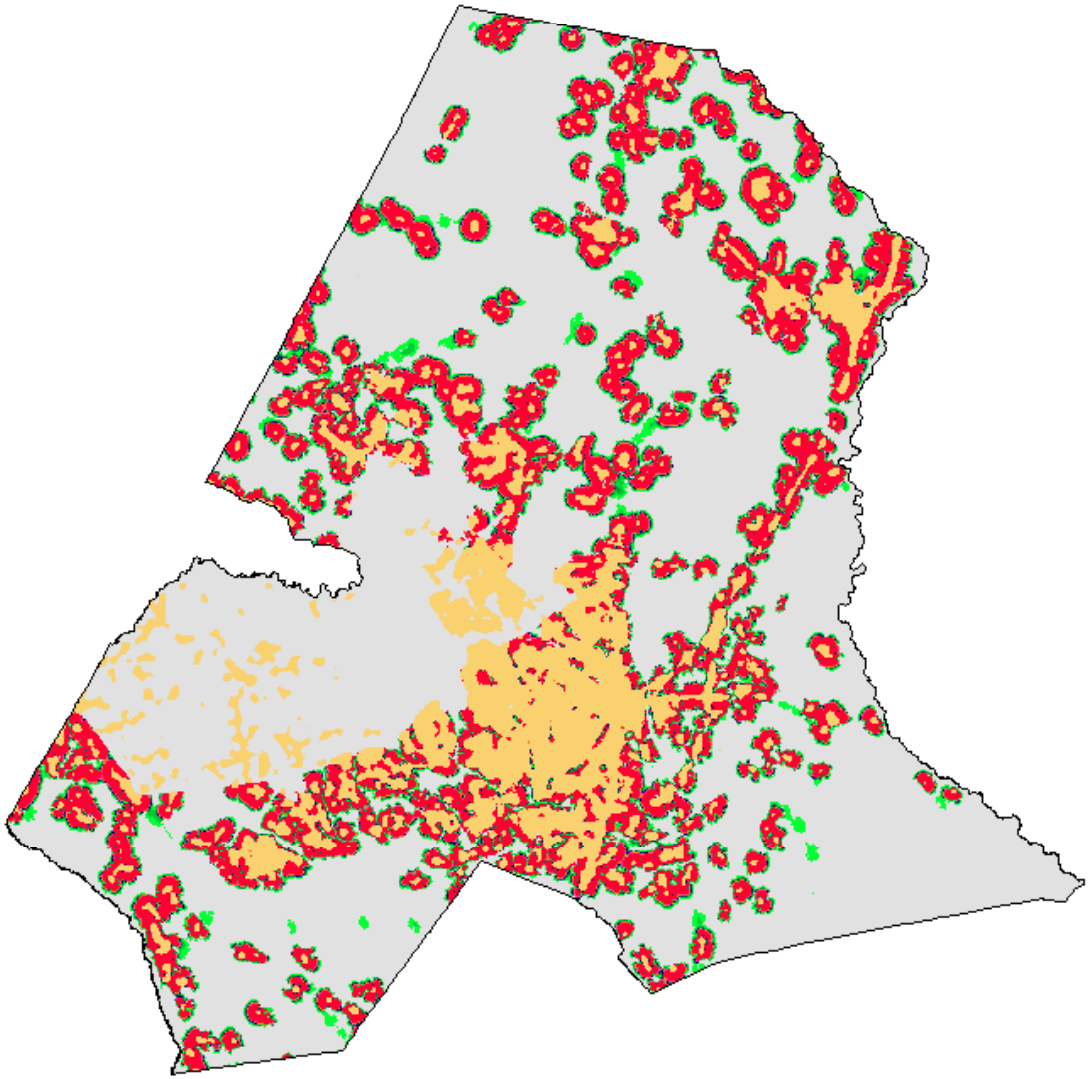
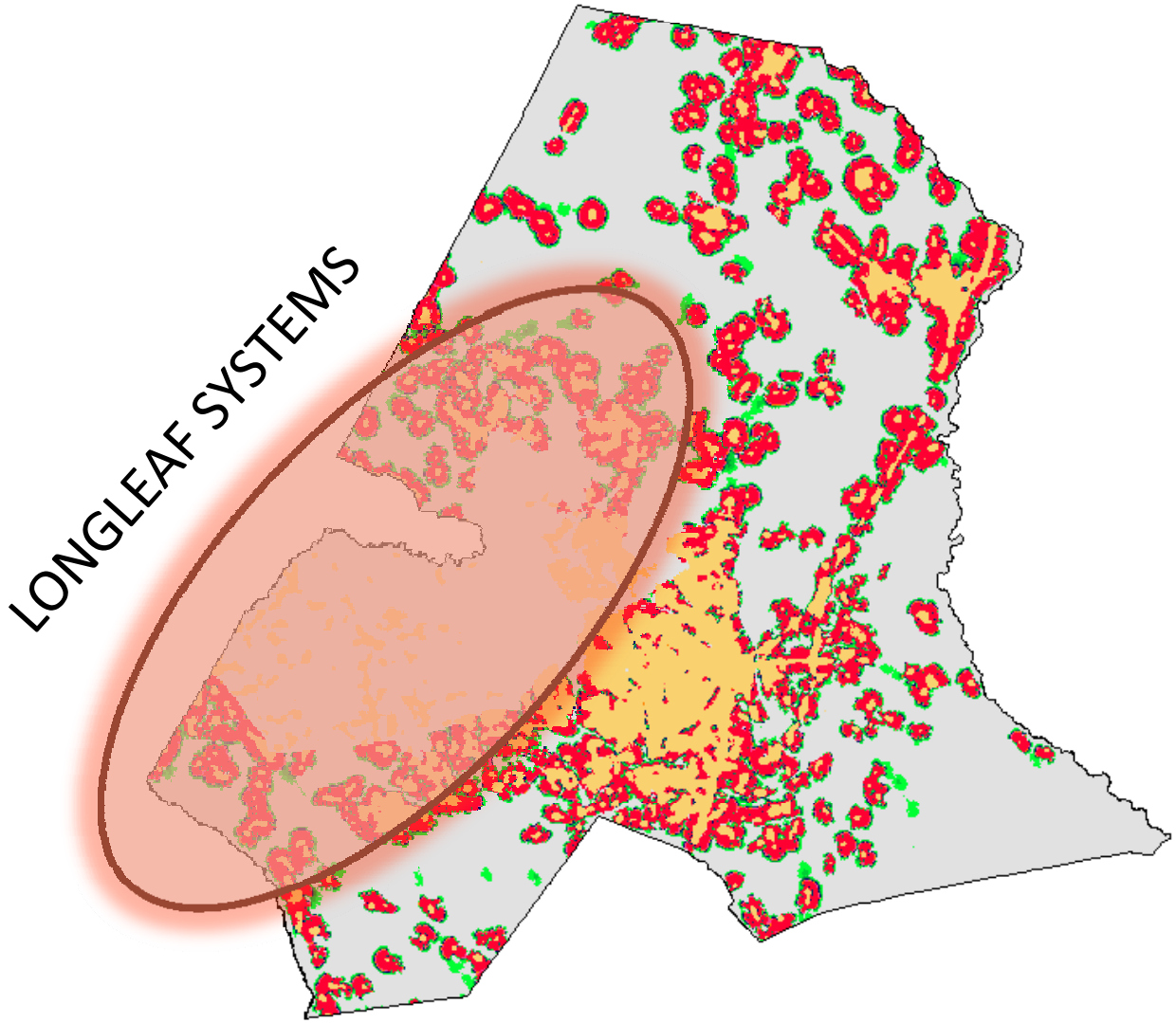


2090



2100



CONCLUDING THOUGHTS

- Resilience to climate change is present in many ecosystems, challenge is identifying and promoting them
- Human actions can reduce adaptive capacity and resilience by short-circuiting the ability of ecosystems to adapt and respond to climate change
- Simulating future human landscape patterns can help inform stakeholders about worst-case scenarios and foster more robust decisions

Thanks!

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Collaborators

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Klaus Keller
Biodiversity and Spatial Information Center
USGS Southeast Regional Assessment Project