Forecasting Global Ecosystem Change Pressure

10th Annual Climate Prediction Applications Science Workshop, March 2012

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Construction Engineering Research Lab

Engineer Research and Development Center

Army Corps

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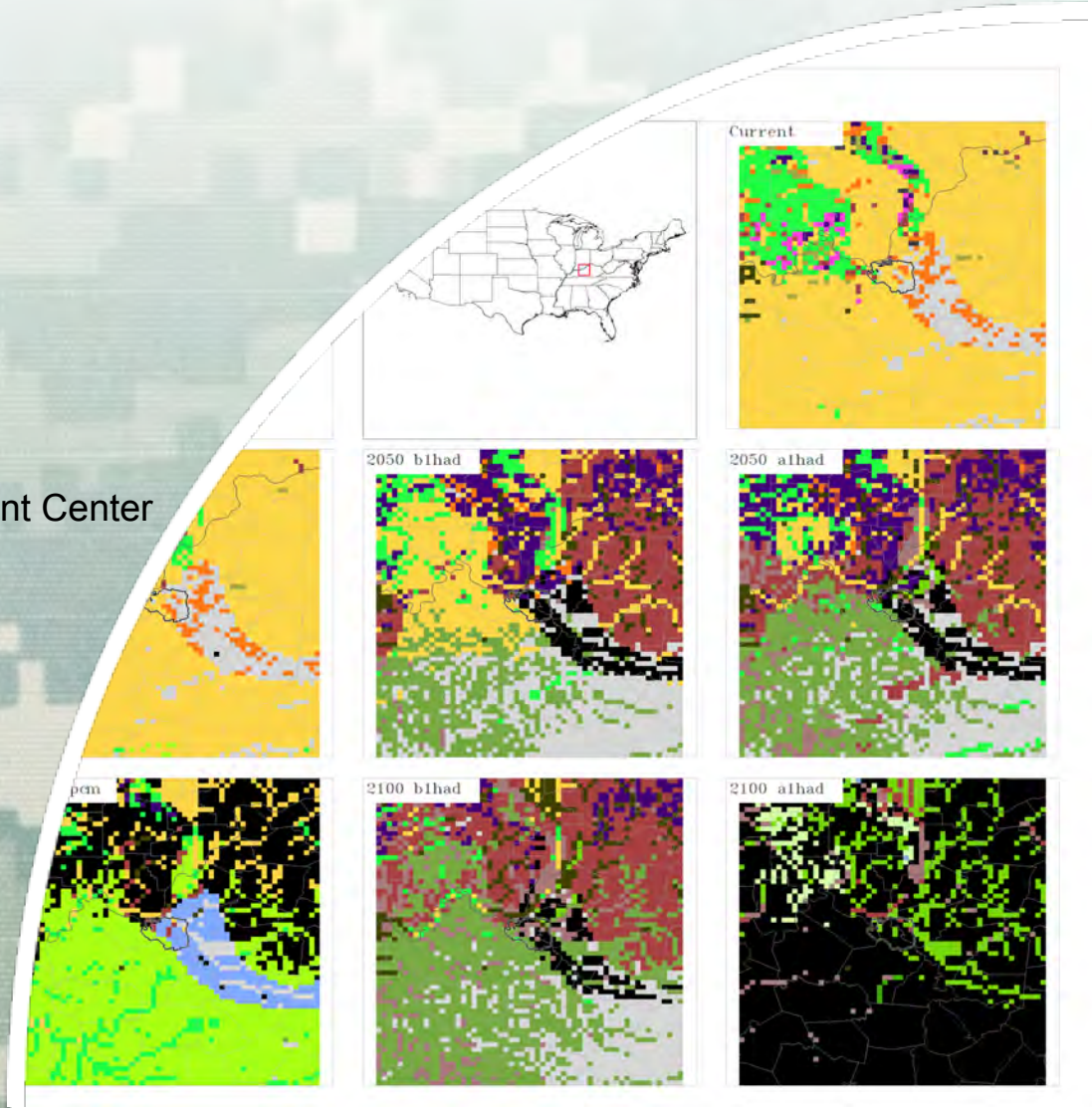
Forest Service



US Army Corps of Engineers

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Challenge

- Find a compelling way to communicate the consequences of forecasted climate change to the general population.*

* including military land managers ☺

Compelling Questions

How will climate change affect me, locally?

When I go outside my home in 20, 40, or 60 years, what will be different?

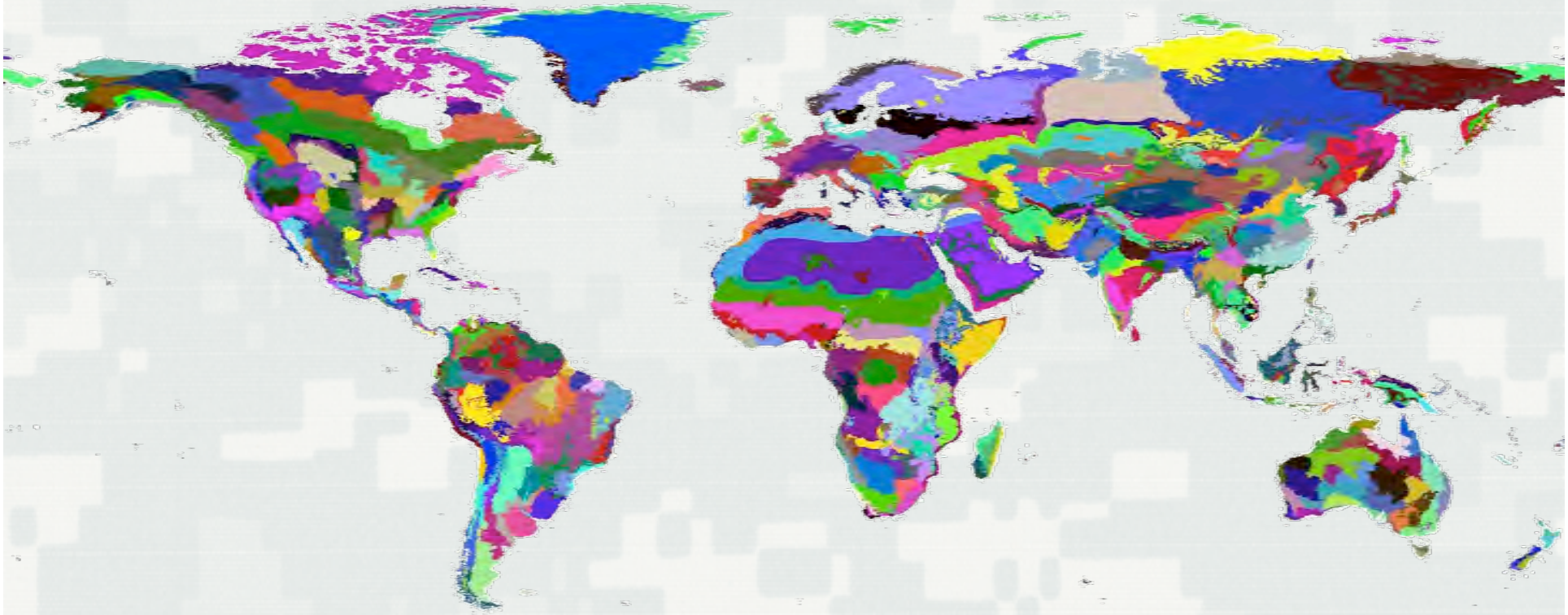
Specifically,
will the ecosystem around here be different?

Agenda

- Show you some results
  - ▶ World
  - ▶ US
  - ▶ Illinois
- Explain the process

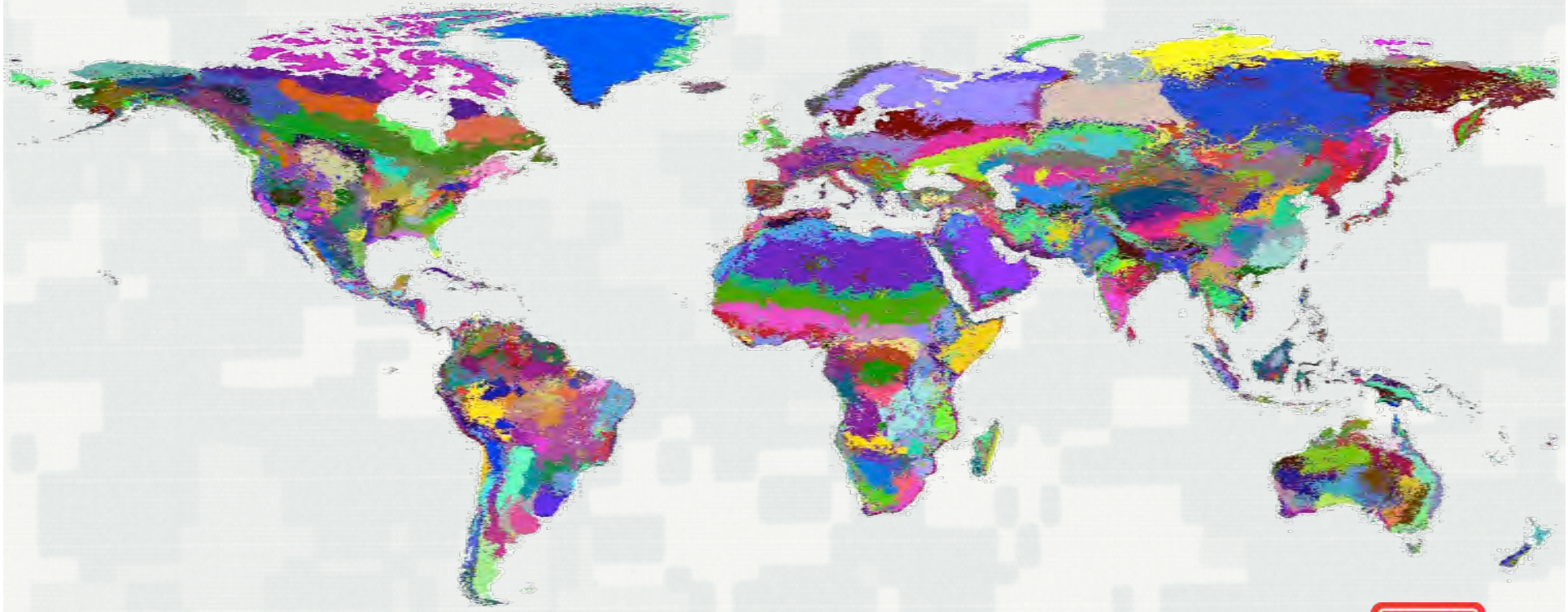
TNC Terrestrial Ecoregions

http://maps.tnc.org/gis_data.html

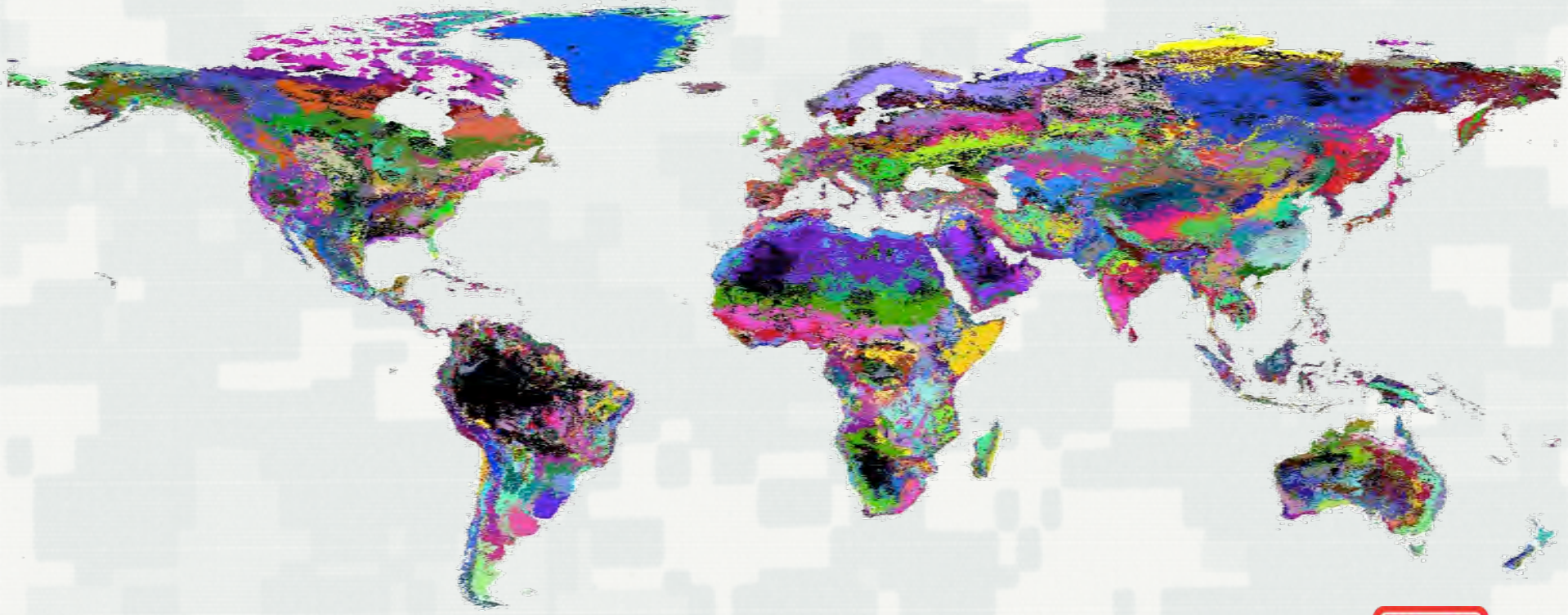


how might these shift?

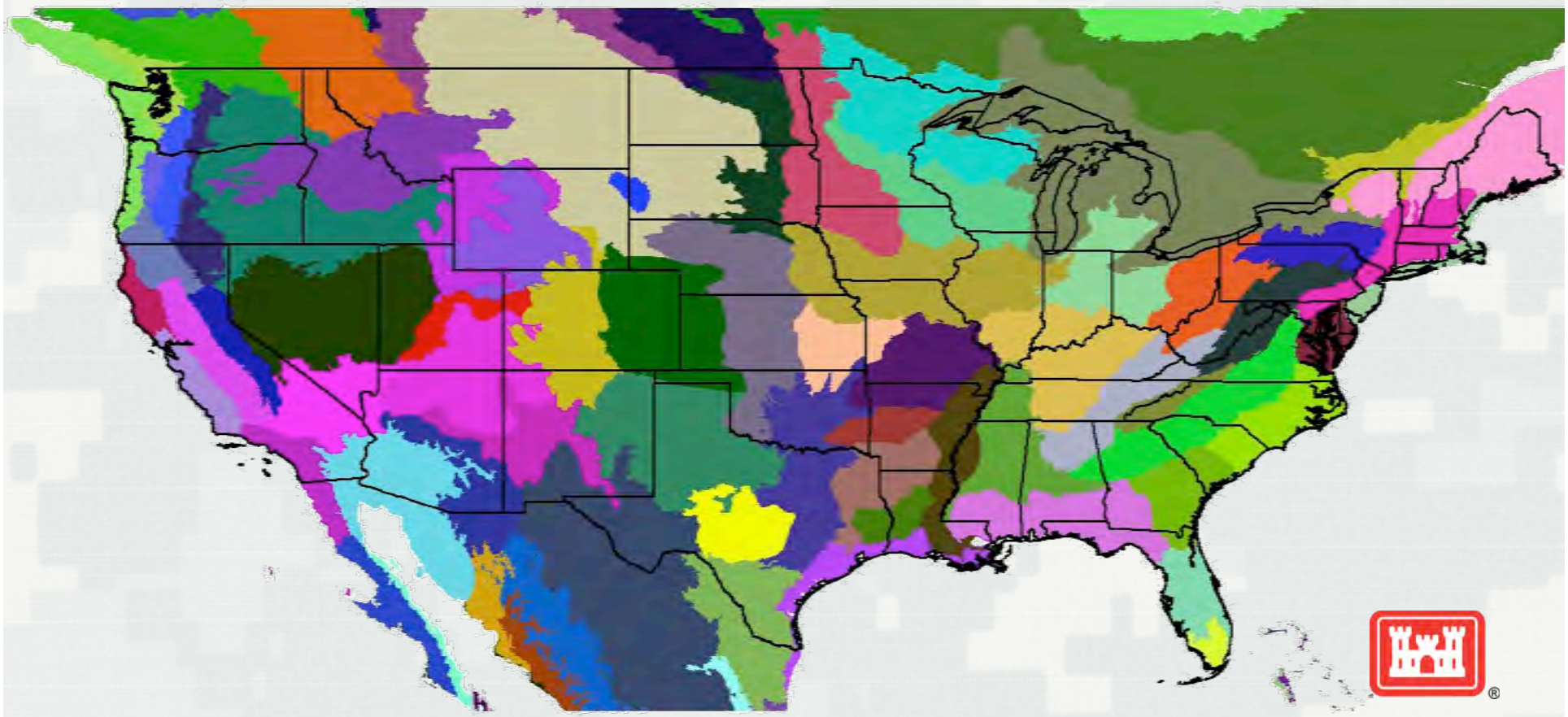
Current



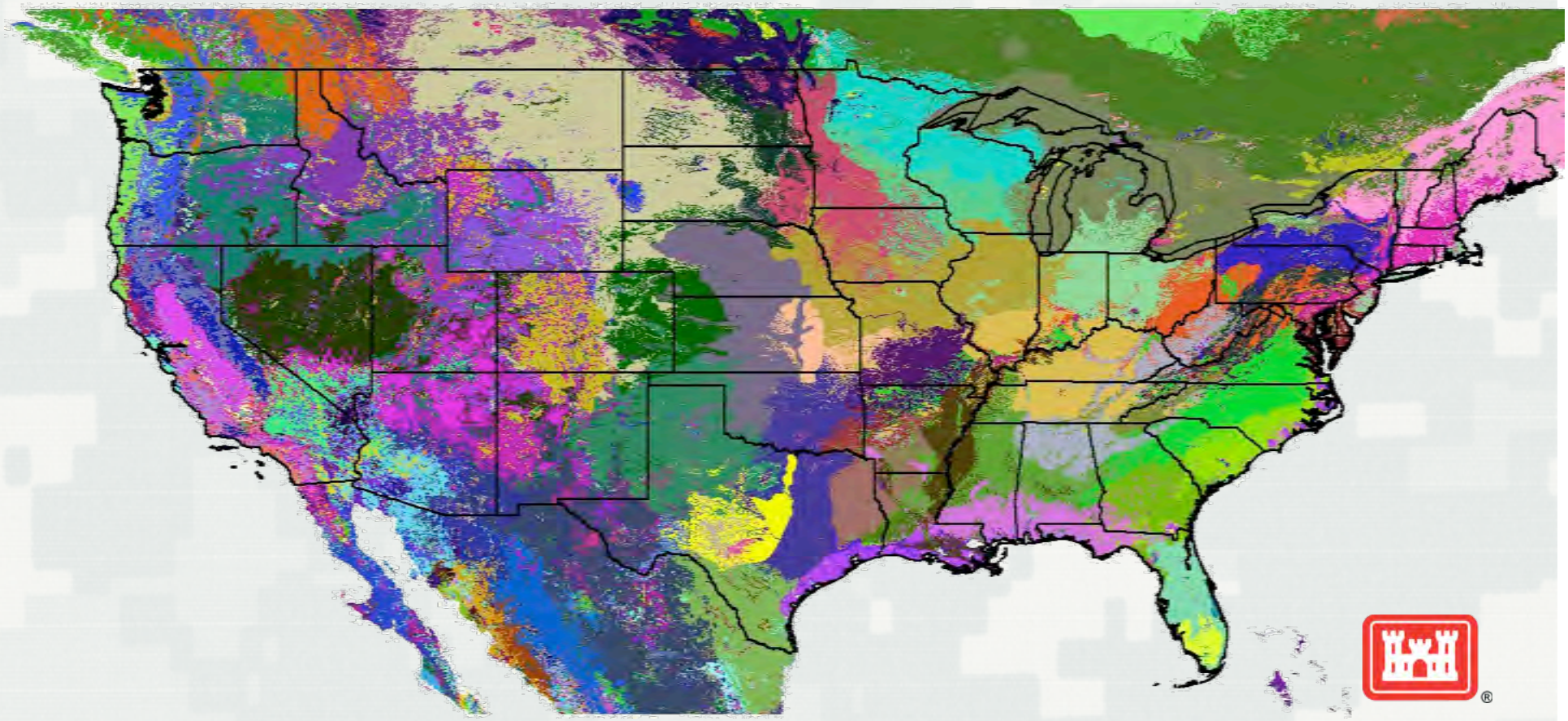
2050 Model, Hadley Scenario:A1



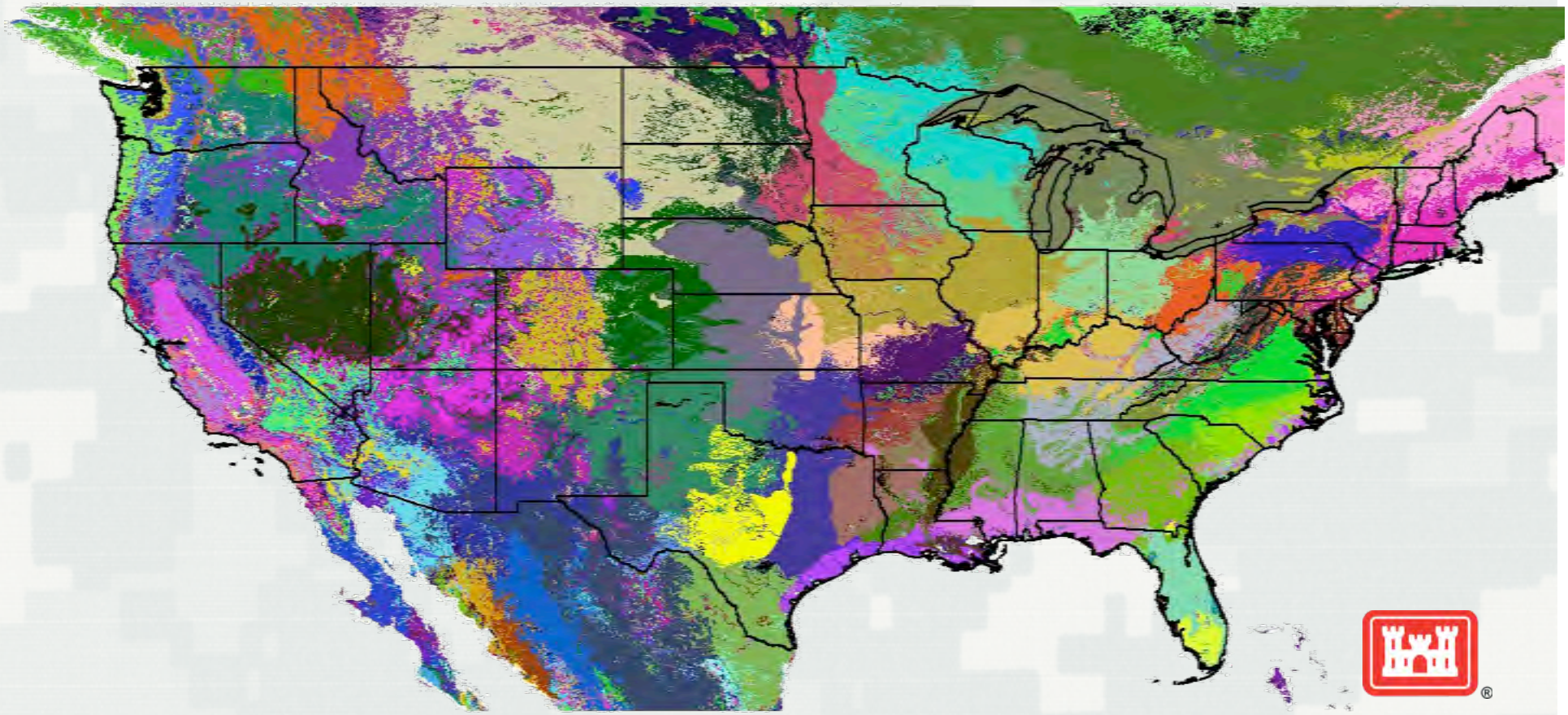
Zooming into the lower 48



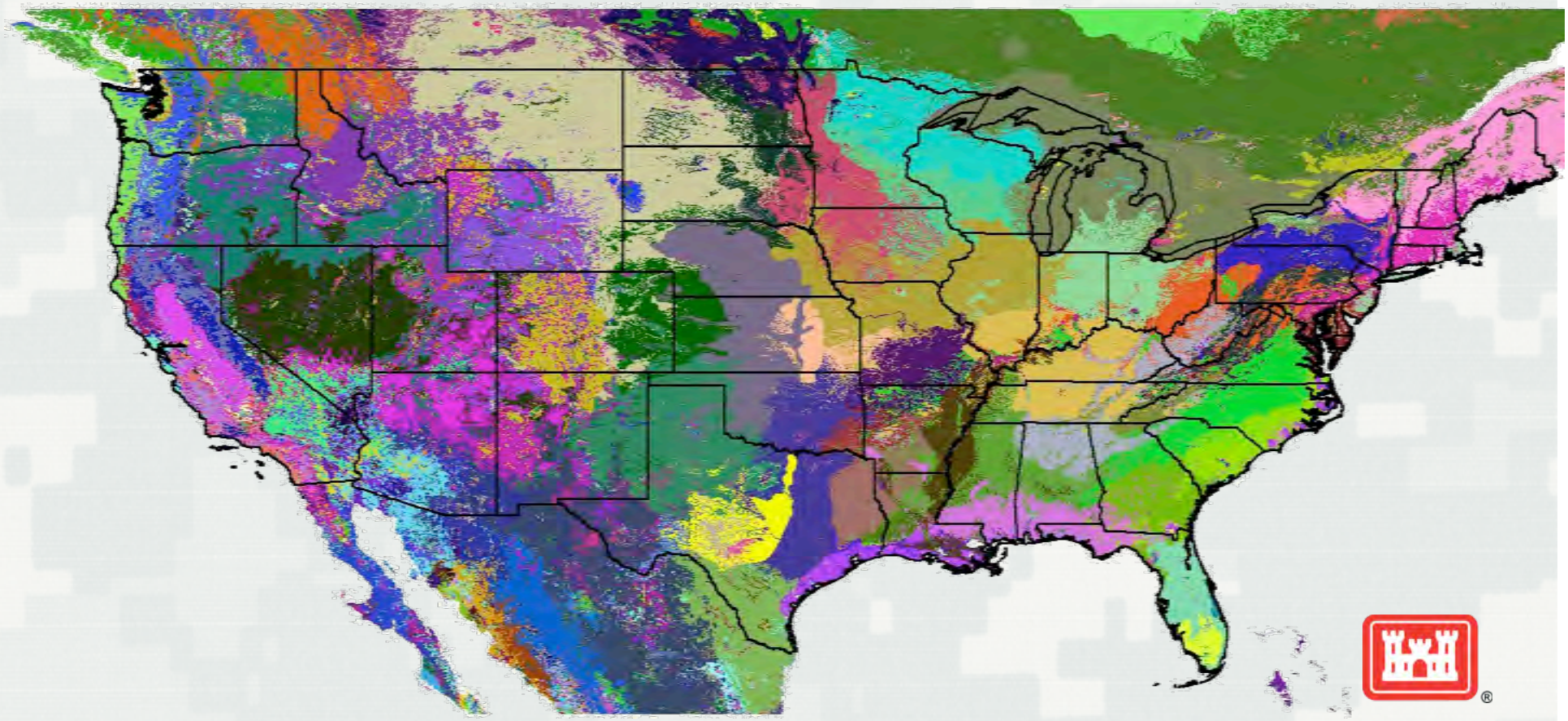
Current TNC* Ecosystems



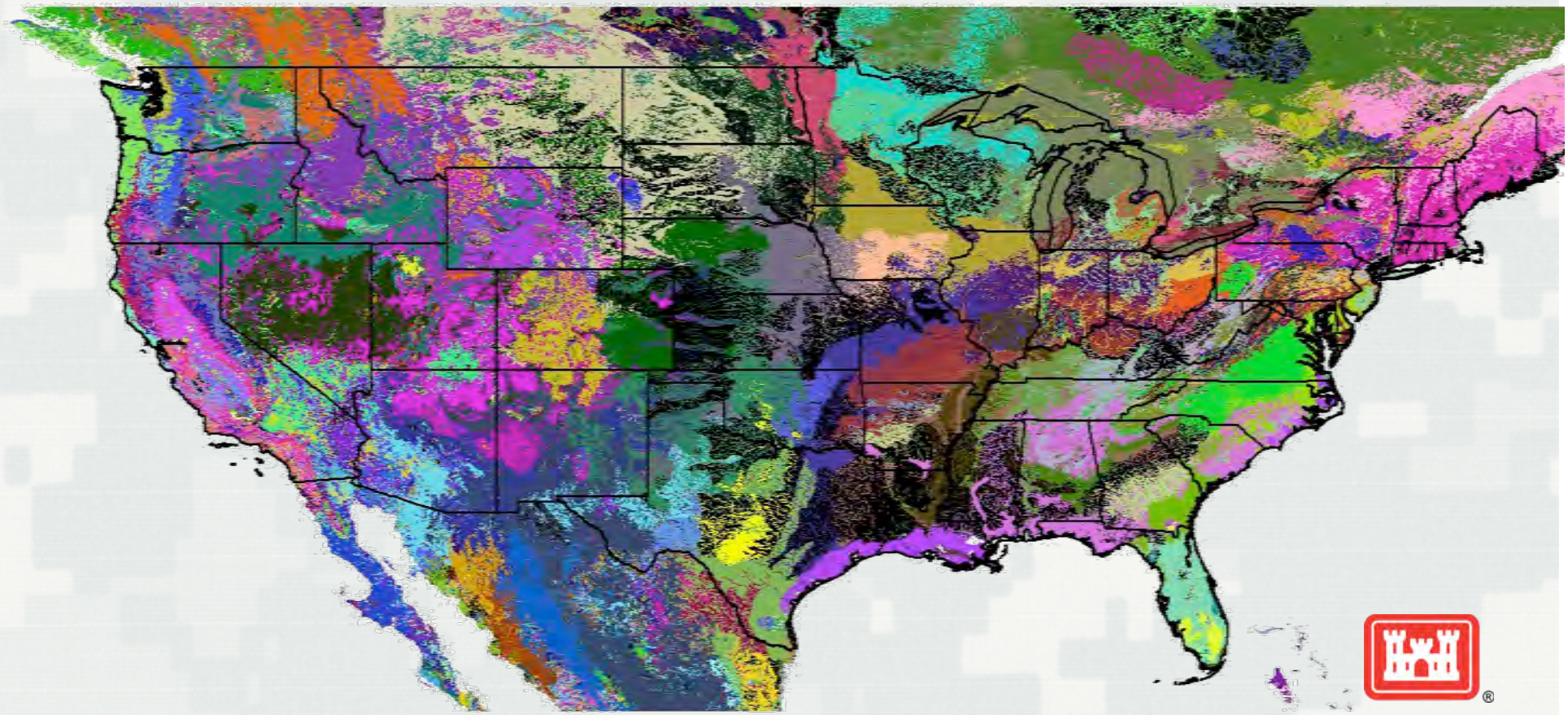
2050 Model, PCM Scenario:B1



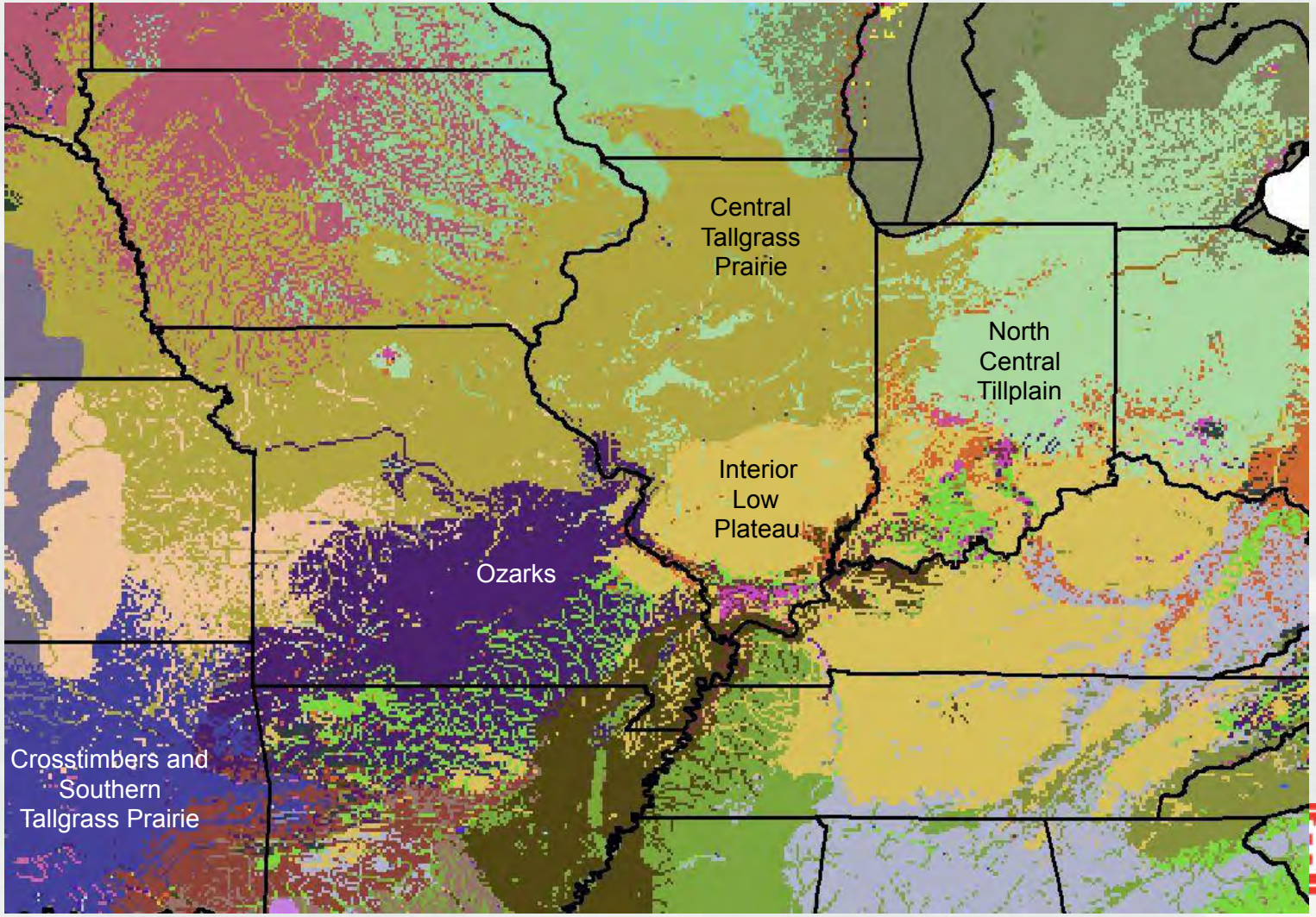
Current



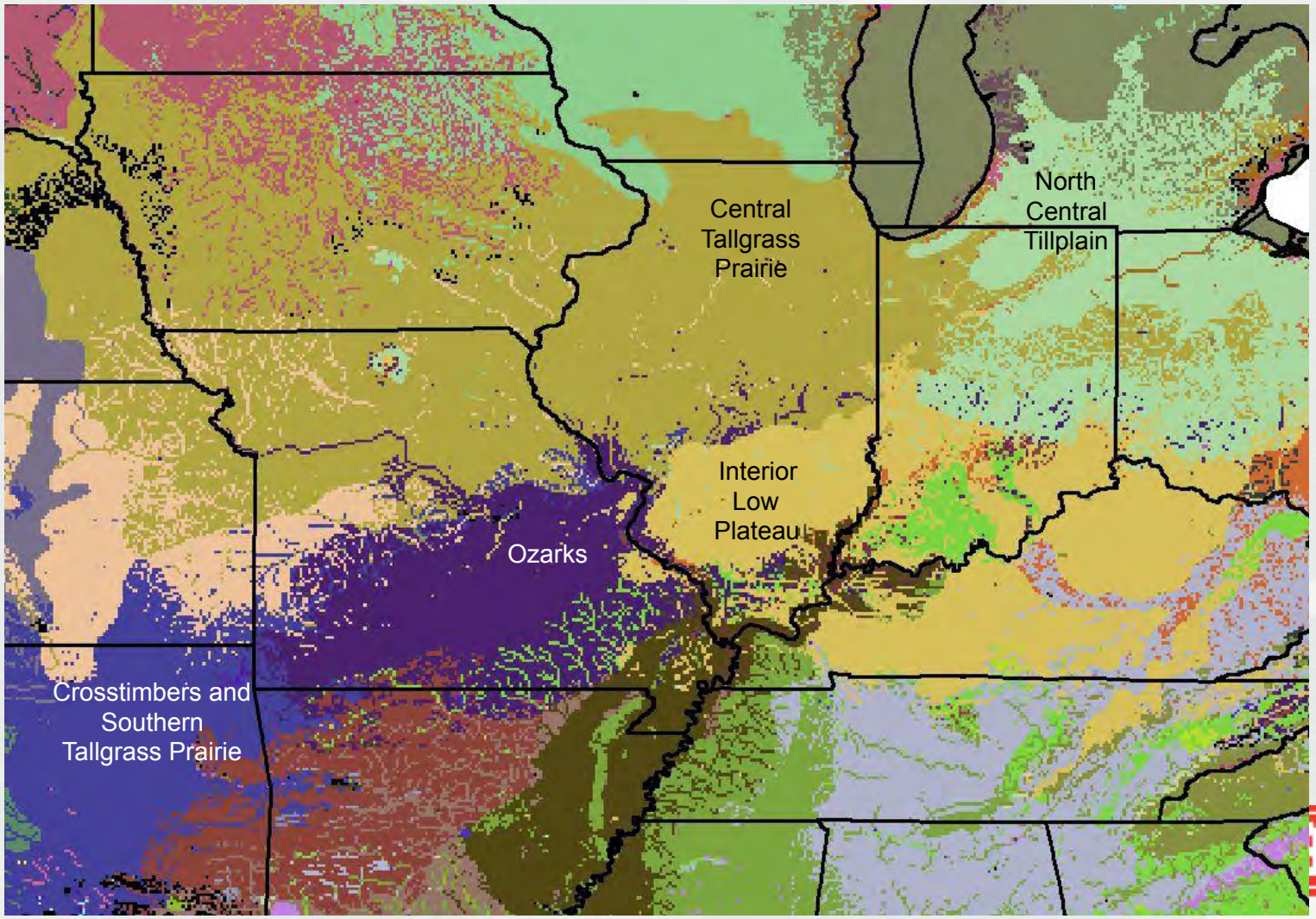
2050 Model, Hadley Scenario:A1



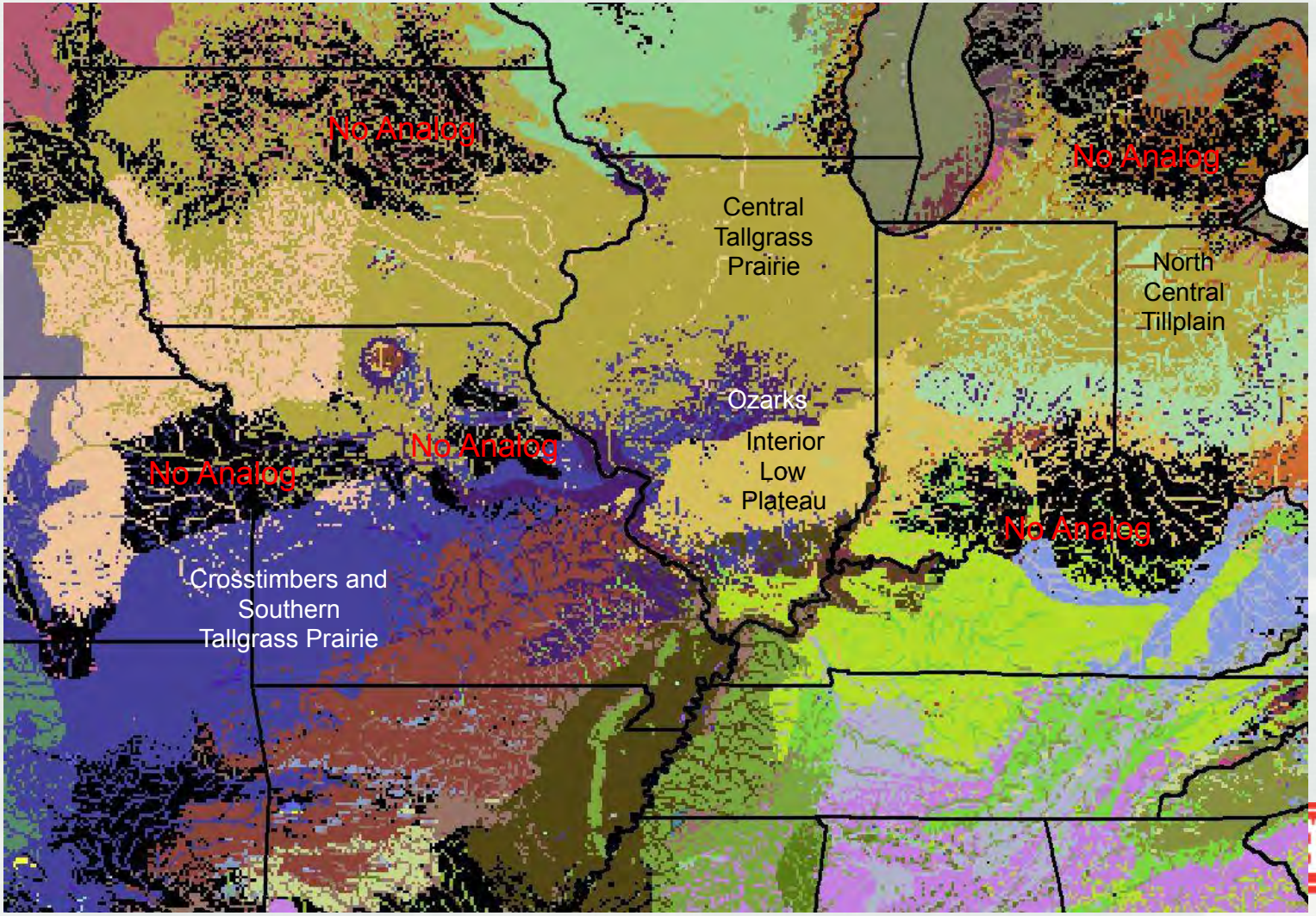
Illinois TNC – Current



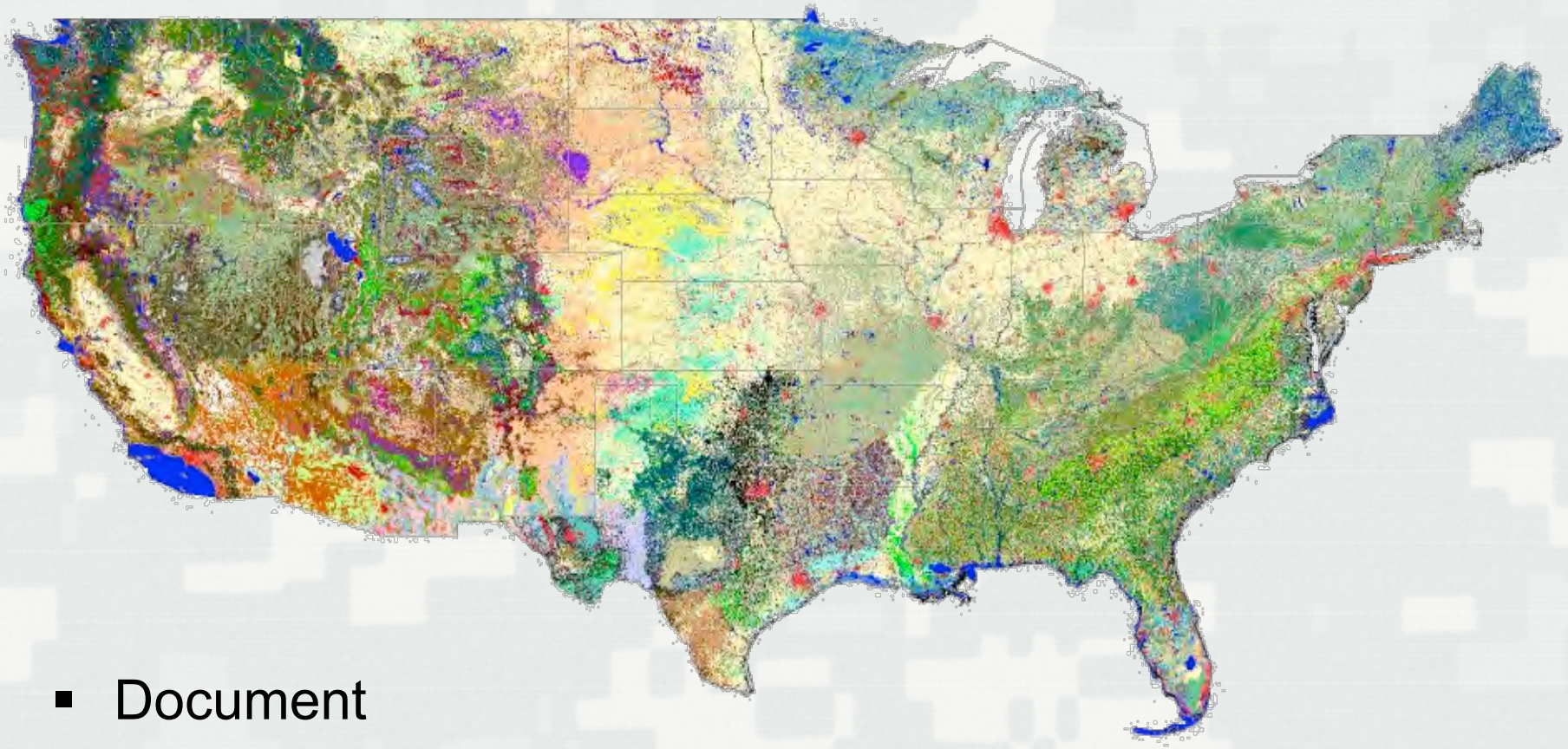
Illinois TNC – PCM A1 2050



Illinois TNC – PCM A1 2100

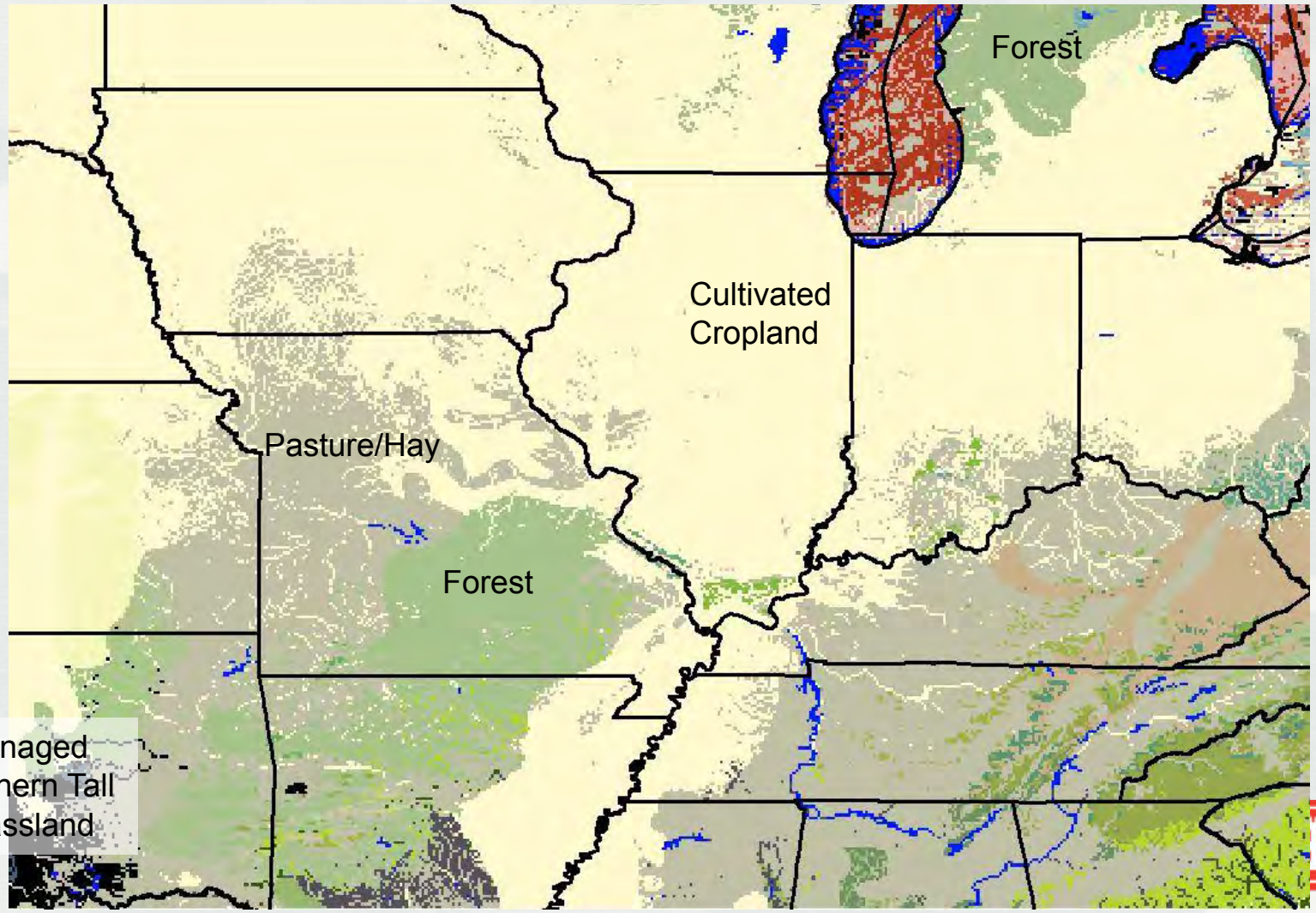


United States GAP Ecosystem

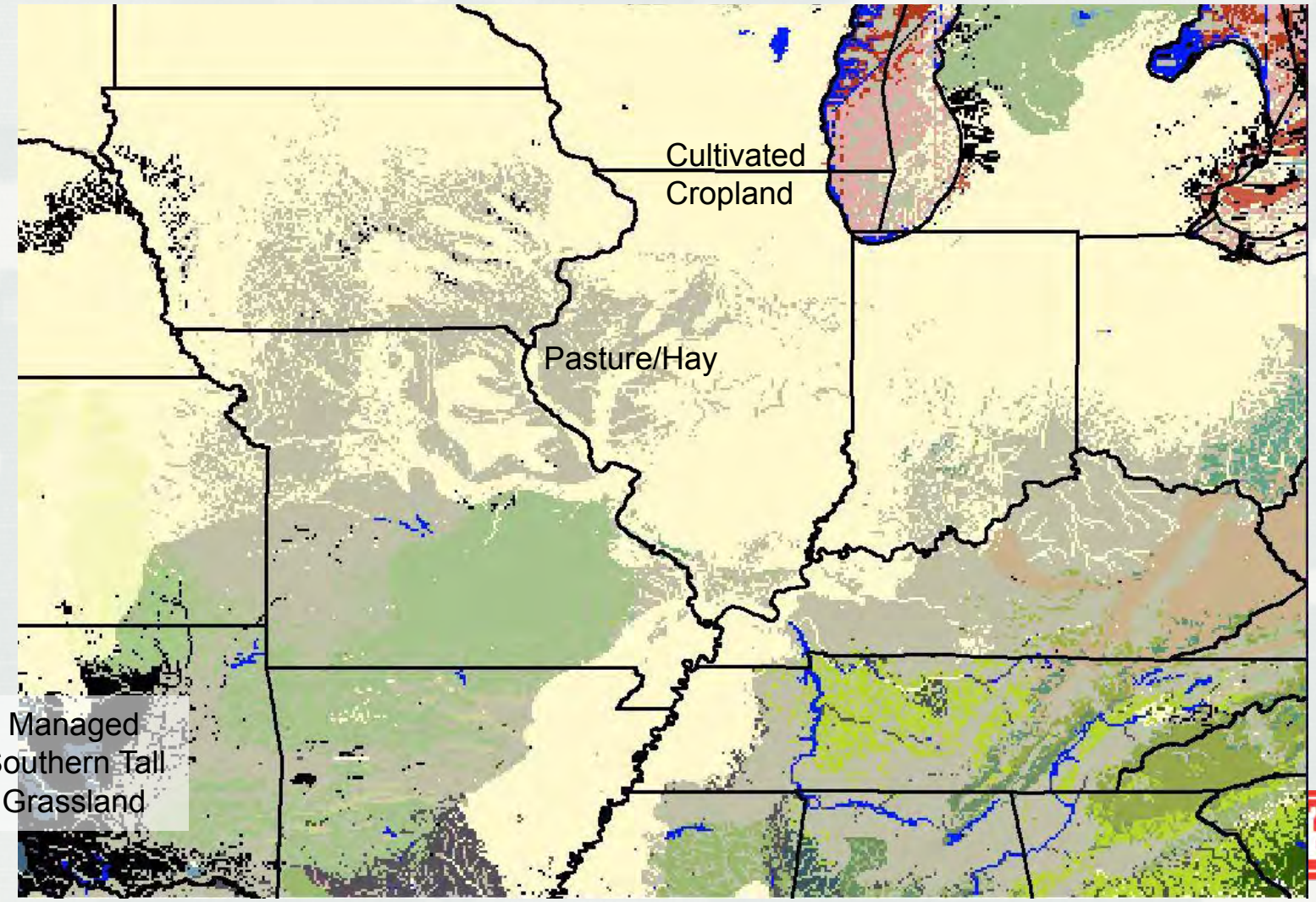


- Document
  - http://pubs.usgs.gov/pp/1768/pp1768.pdf
- Map viewer and download
  - http://www.gap.uidaho.edu/landcoverviewer.html

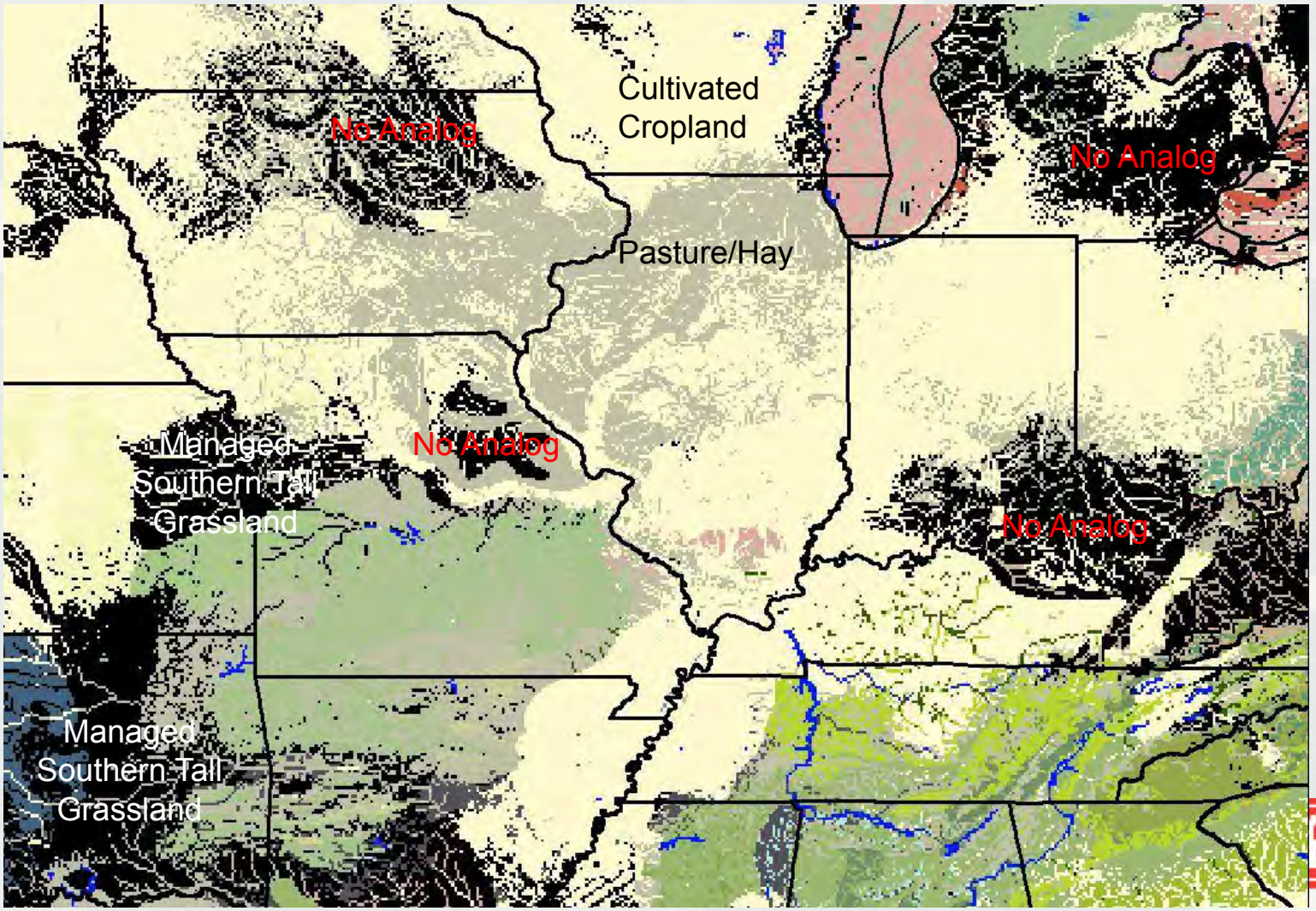
Illinois GAP – Current



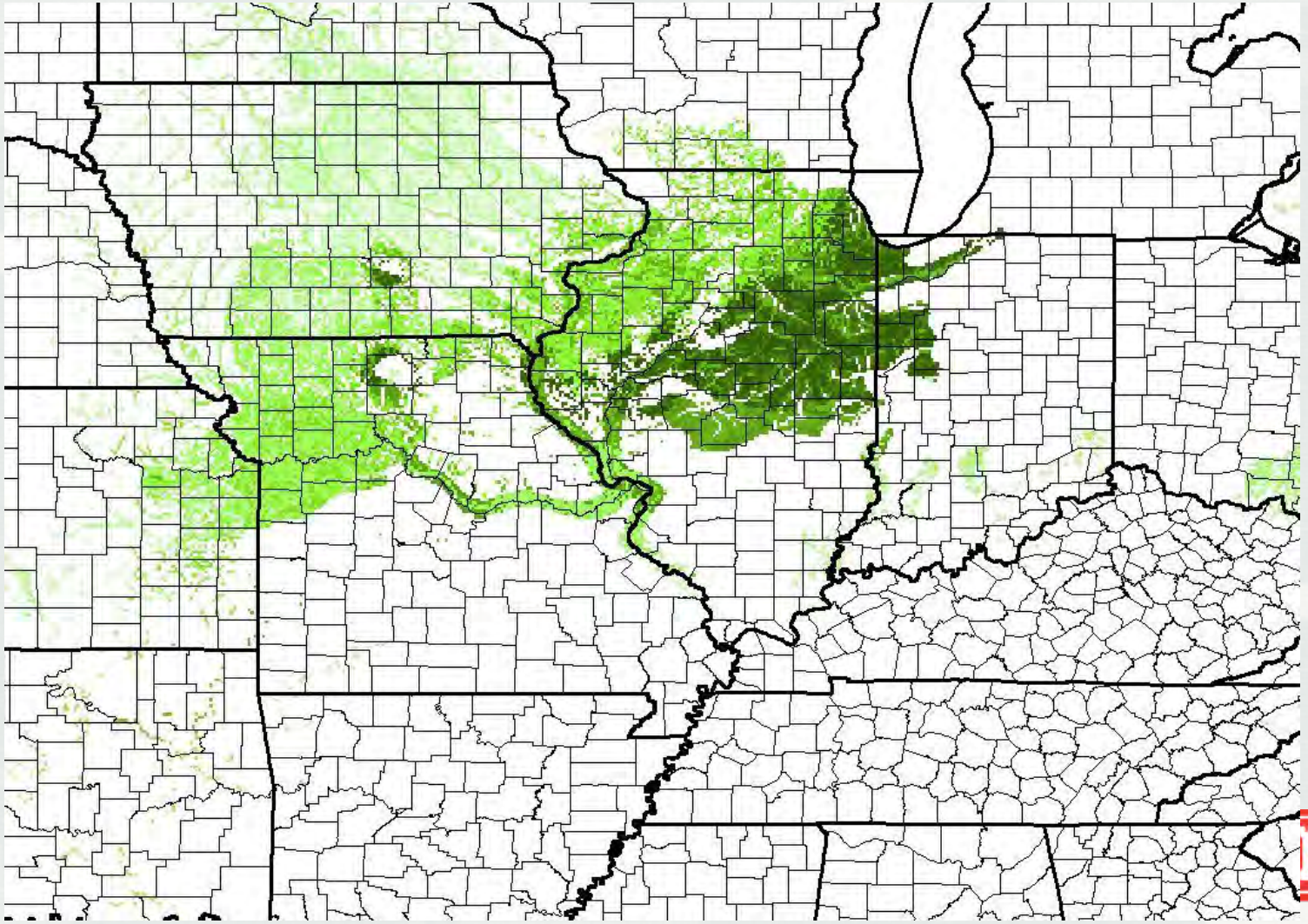
Illinois GAP – PCM A1 2050



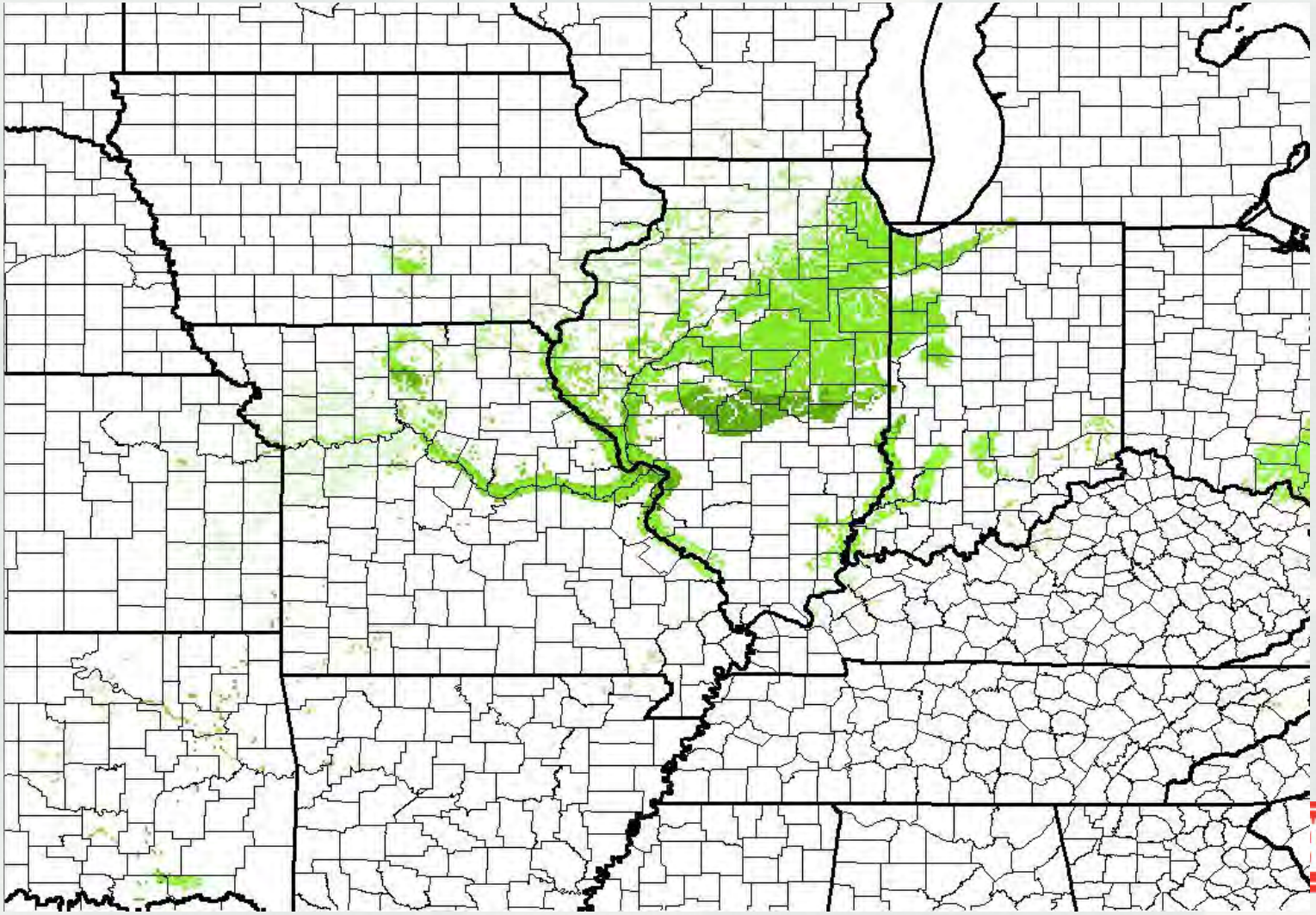
Illinois GAP – PCM A1 2100



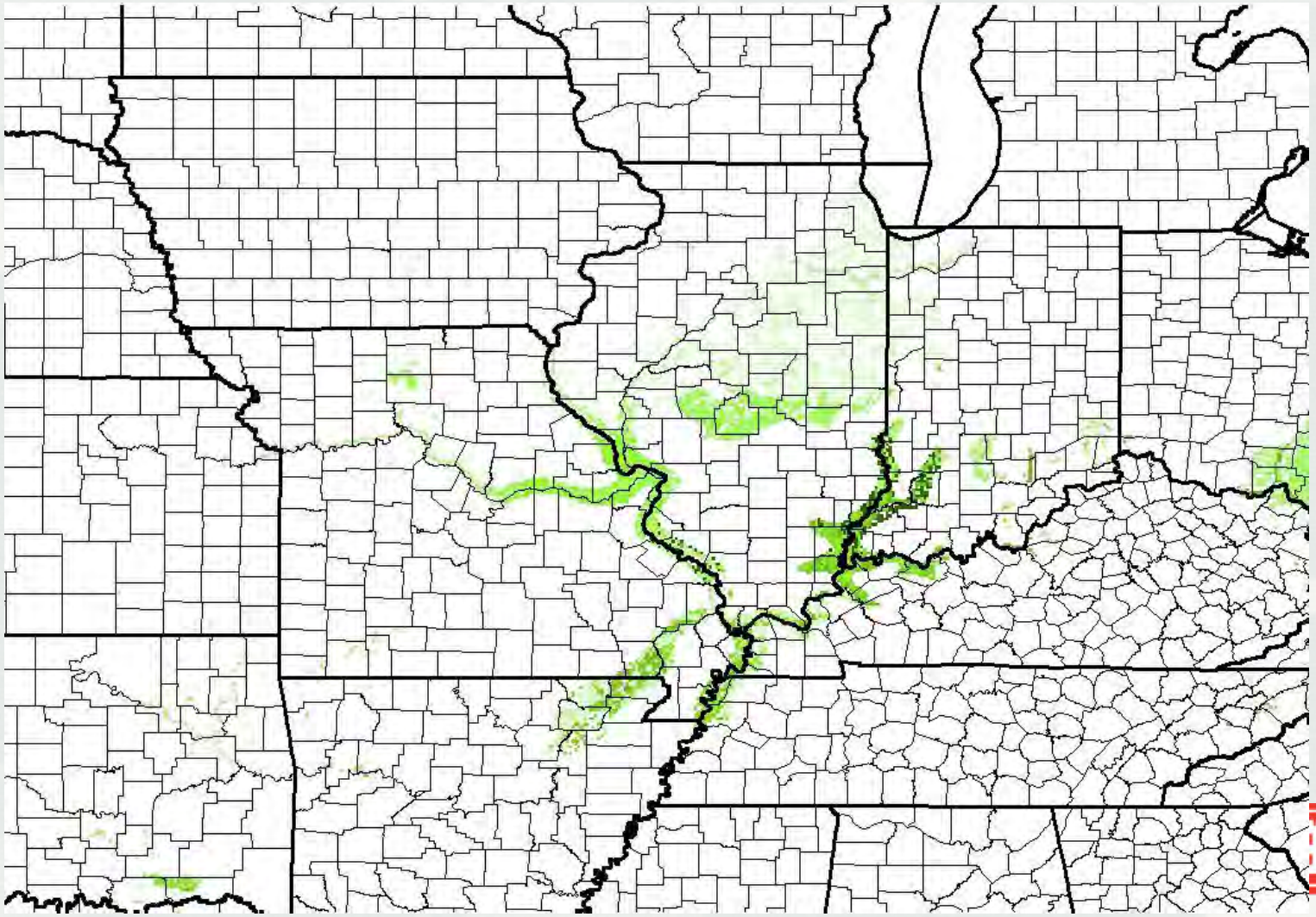
East-Cent III – Similar – Current



East-Cent III – HAD B1 2050



East-Cent Ill – HAD B1 2100

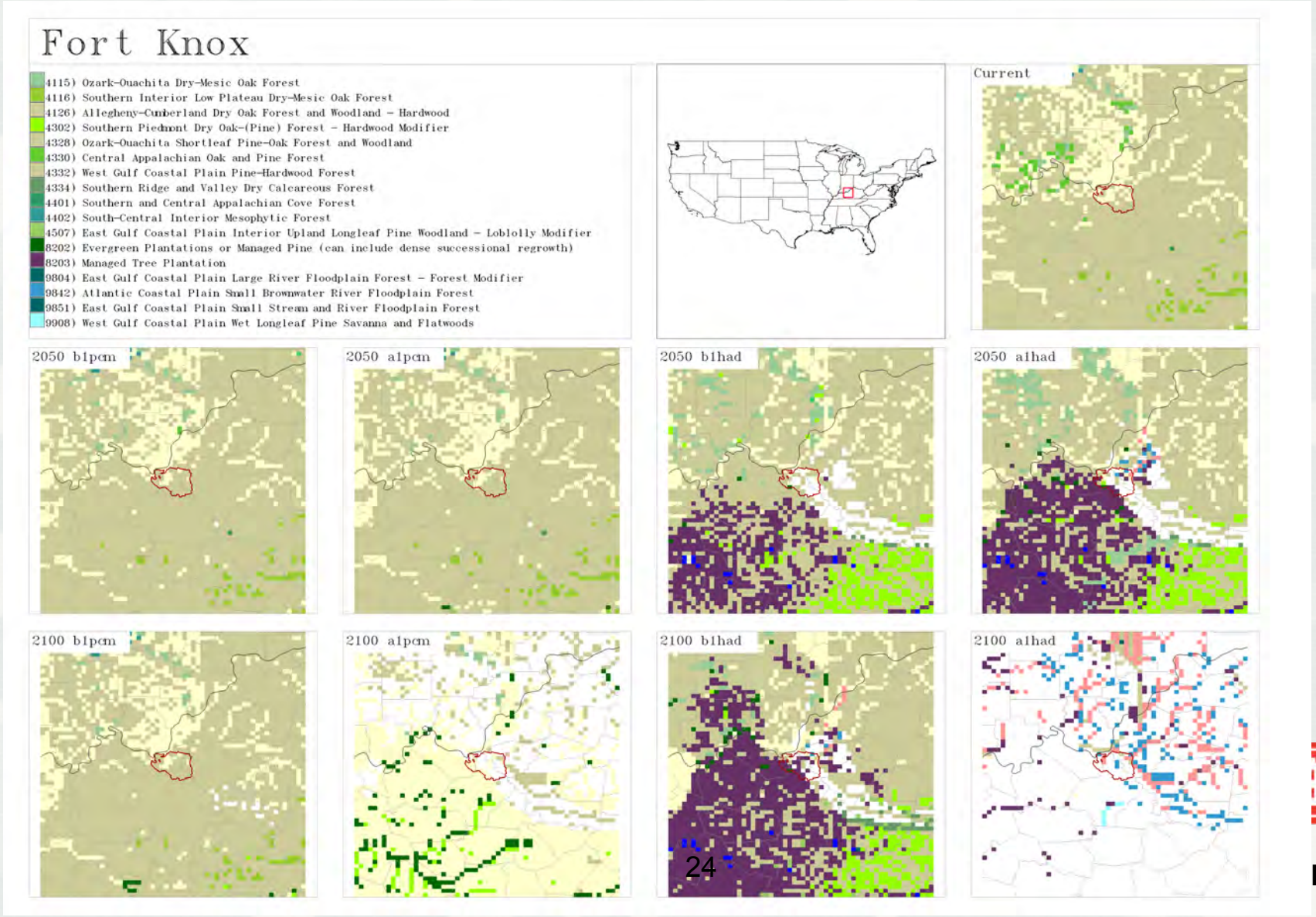


Results for Military Installations

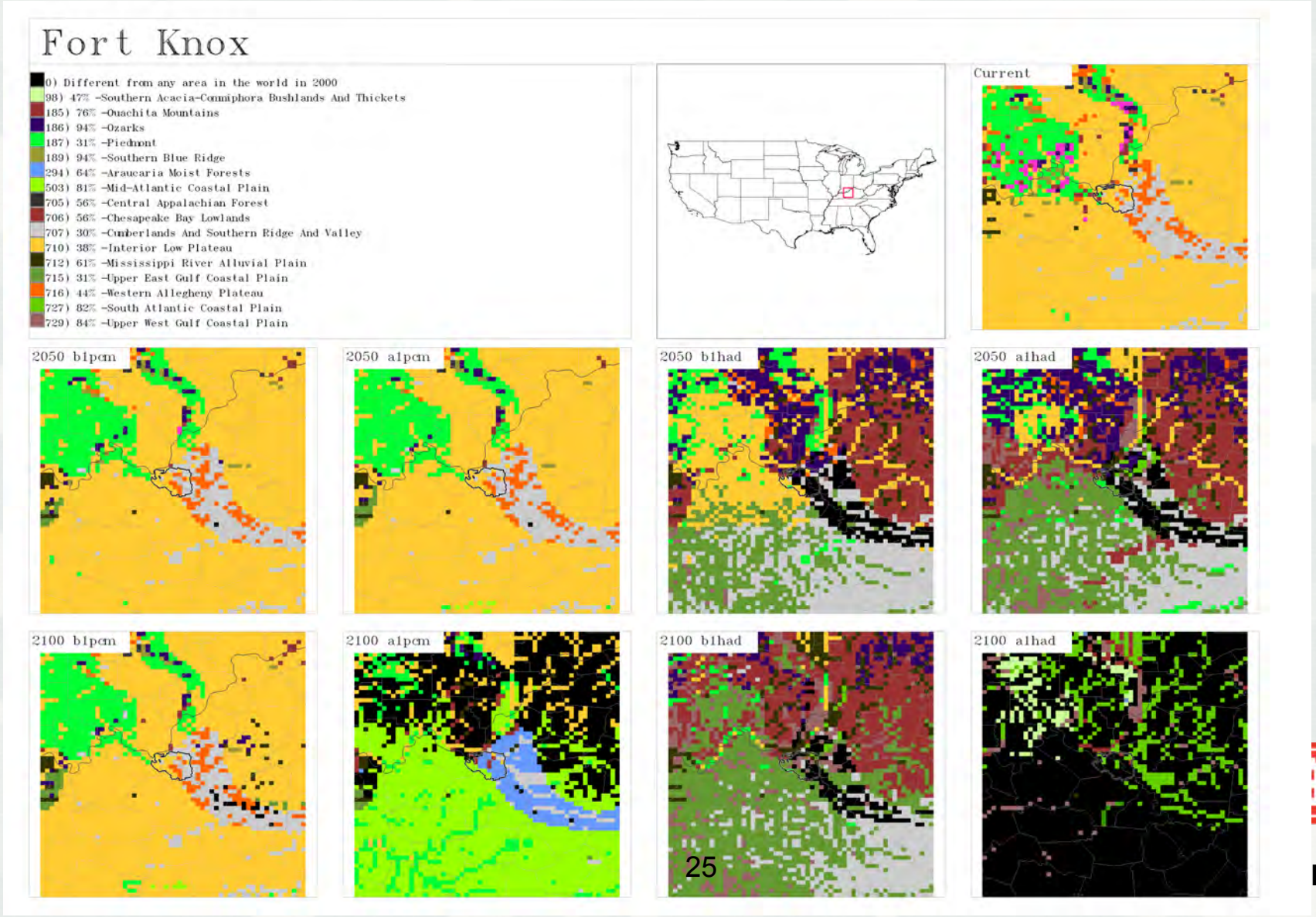
- All Navy, Marines, Air Force, and Army
- Two Models
  - ►Hadley and PCM
- Two Scenarios
  - ►A1 and B1
- Three time periods
  - ►2000, 2050, and 2080

- http://earth.cecer.army.mil

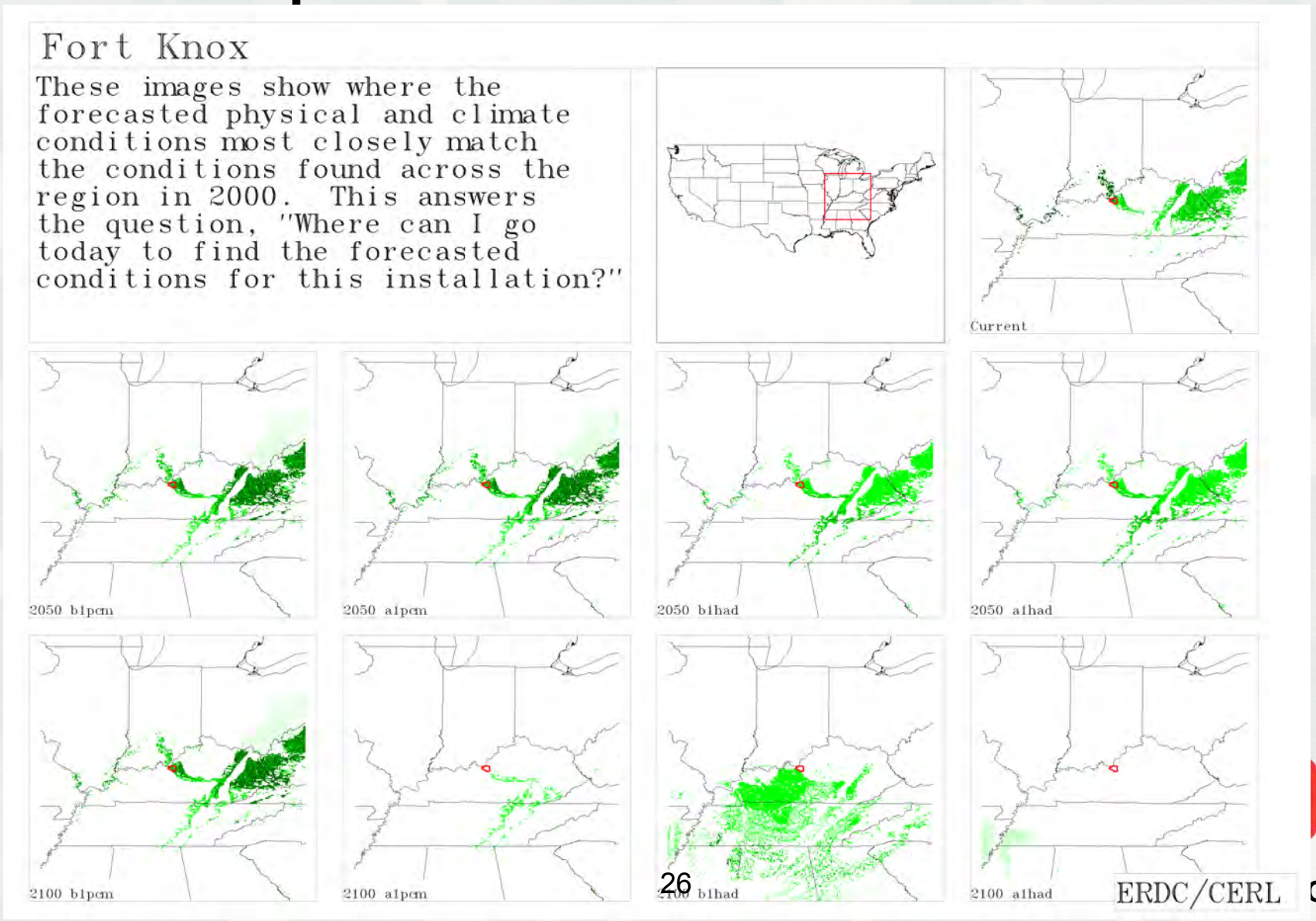
Sample GAP – Fort Knox



Sample TNC – Fort Knox



Sample Similar – Fort Knox



ERDC/CERL

Approach

- Identify a set of ecosystem drivers
- Develop global maps of those drivers
  - For current and future conditions
- Conduct a cluster analysis
  - To group related areas
- Correlate clusters with current ecosystems
- Forecast future ecosystem conditions

Ecosystem drivers

1. Precipitation during the locally hottest quarter
2. Precipitation during the locally coldest quarter
3. Precipitation during the locally driest quarter
4. Precipitation during the locally wettest quarter
5. Ratio of precipitation to potential evapotranspiration
6. Temperature during the coldest locally quarter
7. Temperature during the hottest locally quarter
8. Sum of monthly Temp avg where Temp avg >= 5 deg C
9. Integer number of consecutive months where Temp avg >= 5 deg C

CC-Based

Collected by Chris Zganjar at TNC from WORLDCLIM (http://www.worldclim.org)

10. Available water holding capacity of soil
11. Bulk density of soil
12. Carbon content of soil
13. Nitrogen content of soil
14. Compound topographic index (relative wetness)
15. Solar interception
16. Day/night diurnal temperature difference

Constant

Develop global maps of drivers

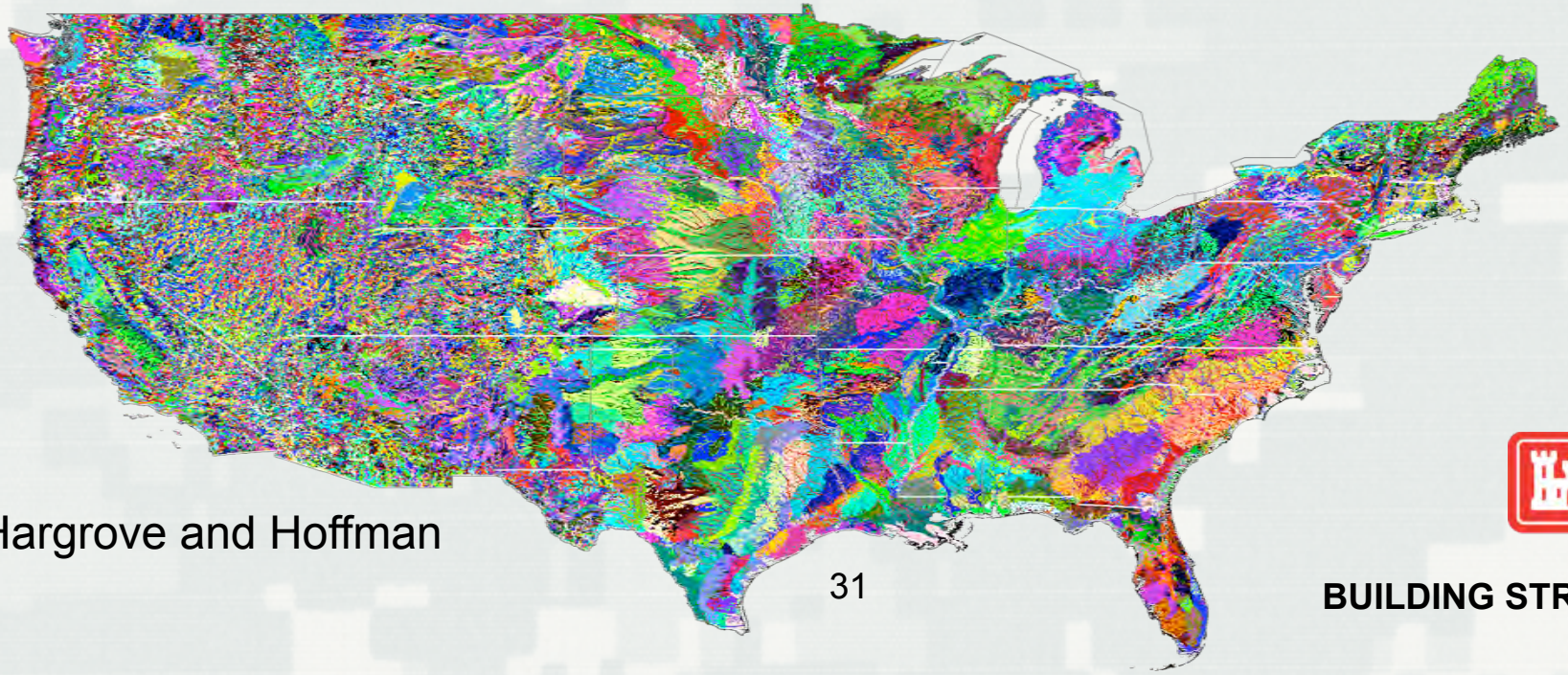
- Choose general circulation models (GCM)
  - ► Hadley and PCM (high and low)
- Choose climate scenarios
  - ► A1 (higher CO_2) and B1(lower CO_2)
- Choose time
  - ► Current, 2050, 2080 (based on 30-yr averages)
- Collect maps (for current and 8 futures)

Scenarios

- A1 scenarios characterized by:
  - Rapid economic growth.
  - A global population that reaches 9 billion in 2050 and then gradually declines.
  - The quick spread of new and efficient technologies.
  - A convergent world.
- B1 scenarios are characterized by:
  - Rapid economic growth as in A1
  - Rapid changes towards a service and information economy.
  - Population as in A1.
  - Reductions in material intensity and the introduction of clean and resource efficient technologies.
  - An emphasis on global solutions to economic, social and environmental stability.

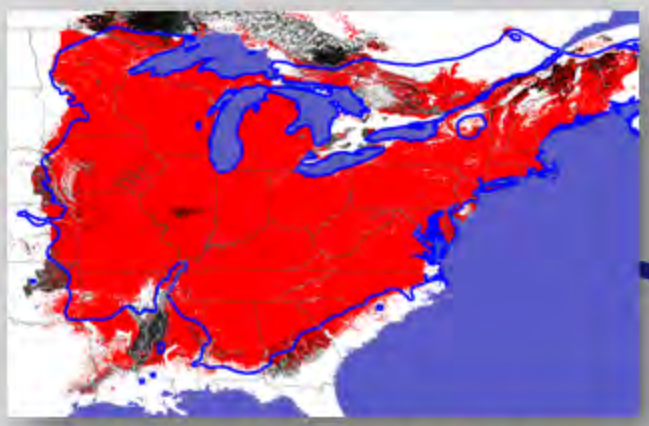
Cluster Analysis

- Convert all maps to standard-deviation form
- Run cluster analysis (30,000 clusters) Grouping all 9 sets across the world!!

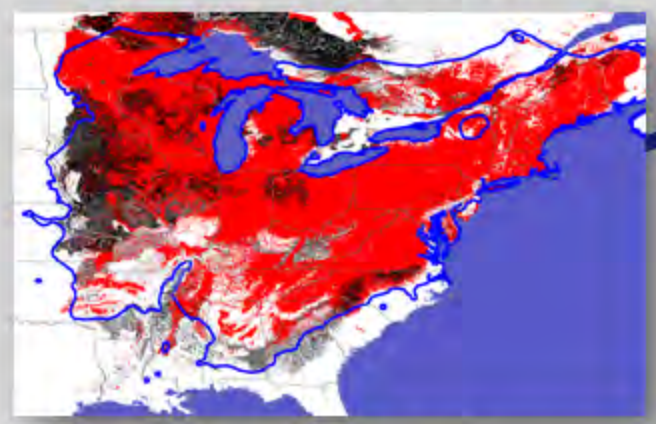


Hargrove and Hoffman

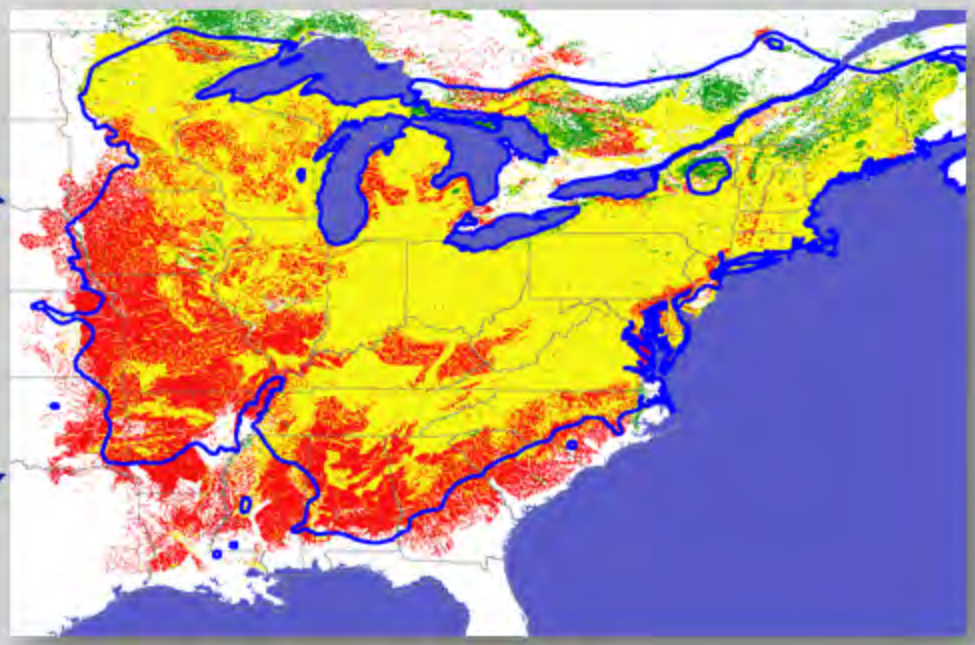
Northern red oak (*Quercus rubra*)



Current prediction



Hadley B1, 2050



New habitat in 2050

Habitat overlap, current and 2050

Current habitat gone in 2050

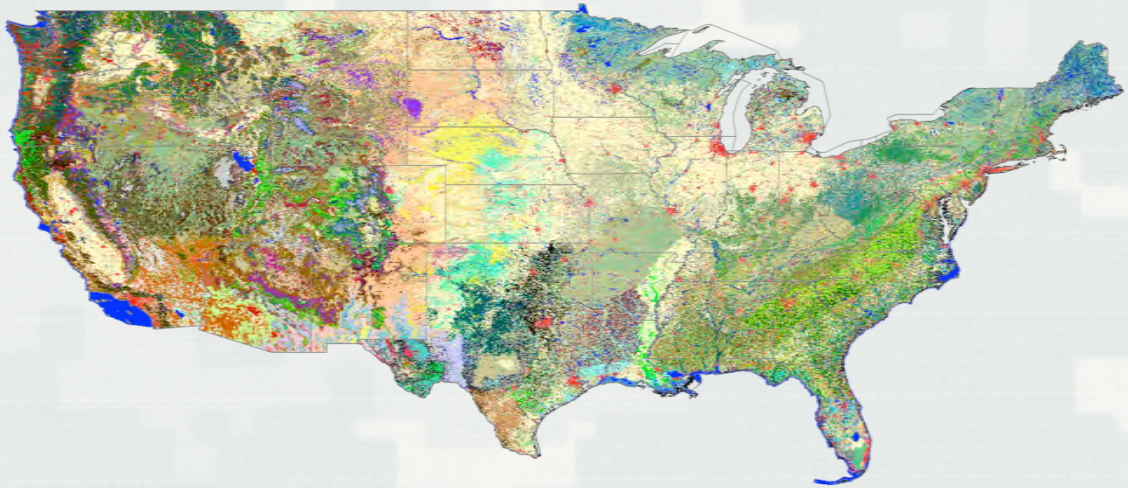
http://www.geobabble.org/~hnw/global/treeranges4/climate_change/index.html

Results

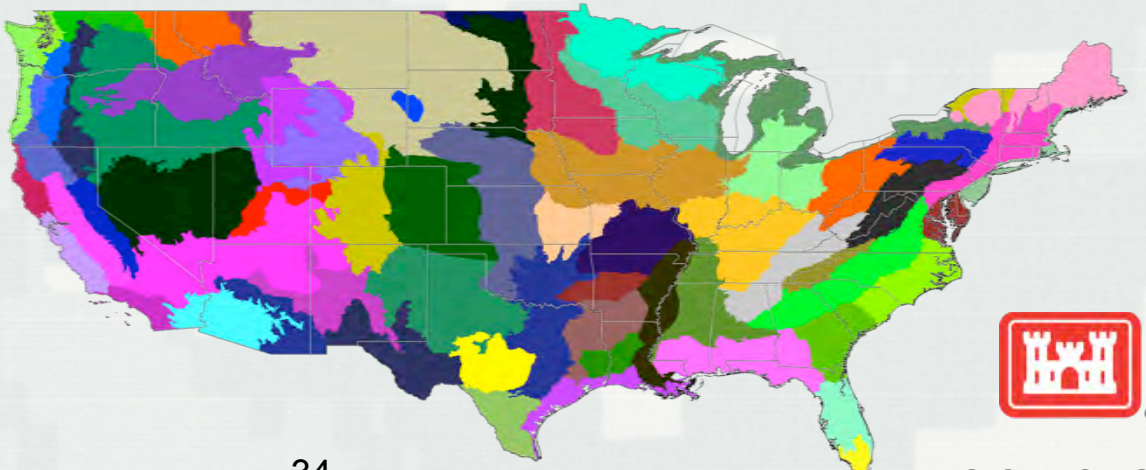
- Correlation with GAP and TNC
- Application of correlation to future
- Sample look at Illinois
- Results for all military installations

Correlate Clusters with Ecosystems

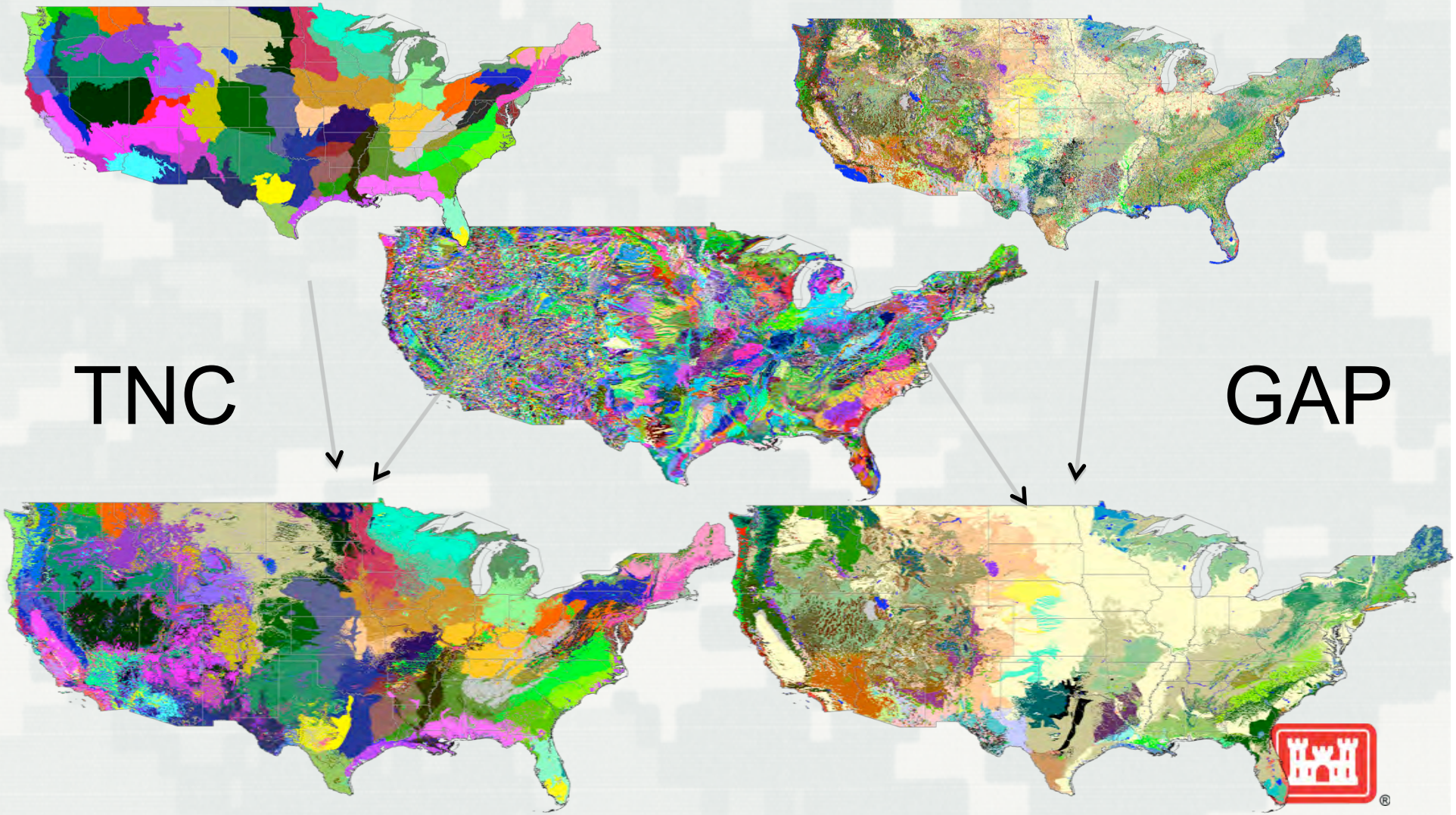
- Choose ecosystem map
  - GAP
    - US
    - 533 types



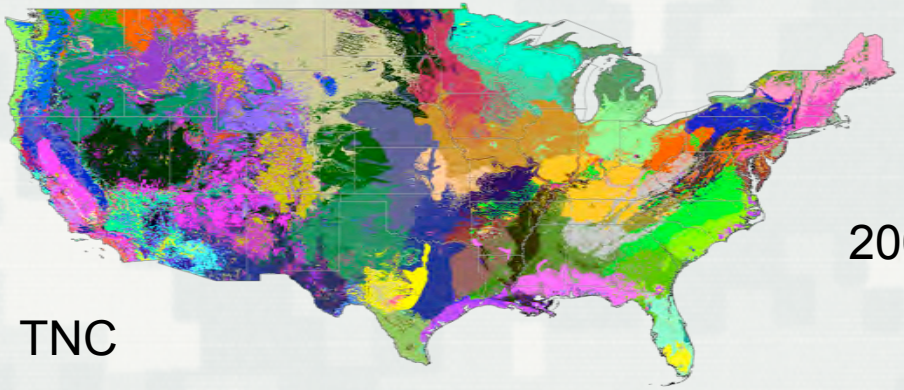
  - TNC
    - Global
    - 814 types



Correlate Clusters with Ecosystems

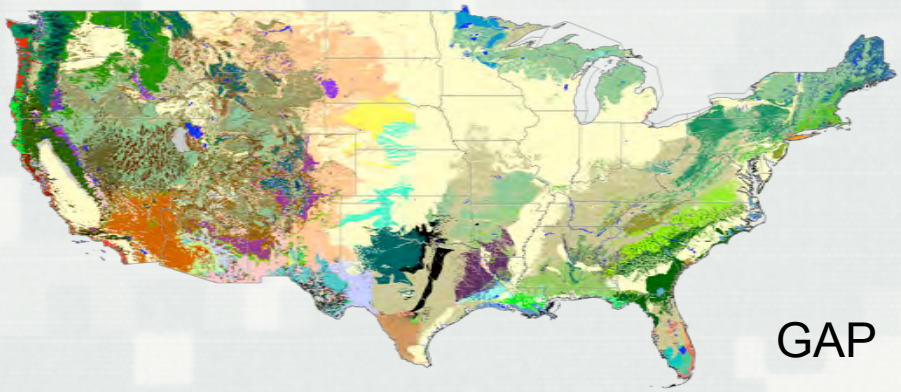


PCM model – B1 scenario (low-low)

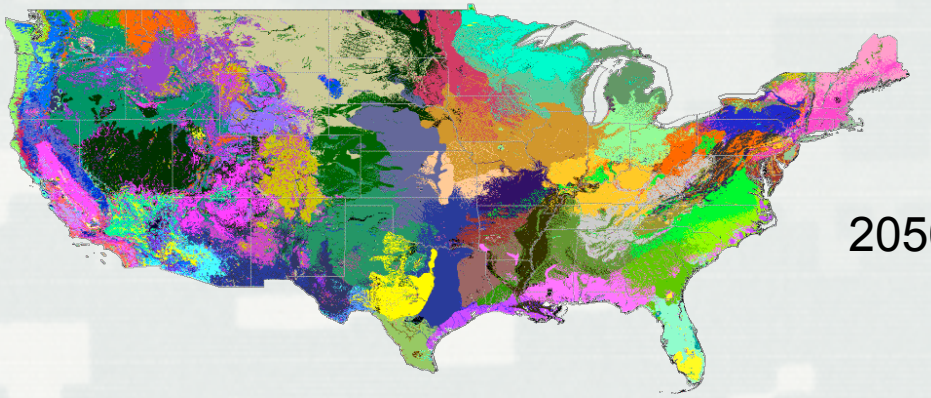


TNC

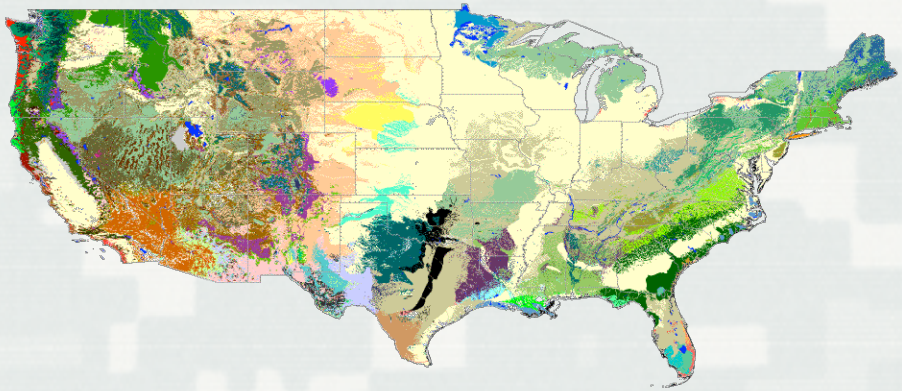
2000

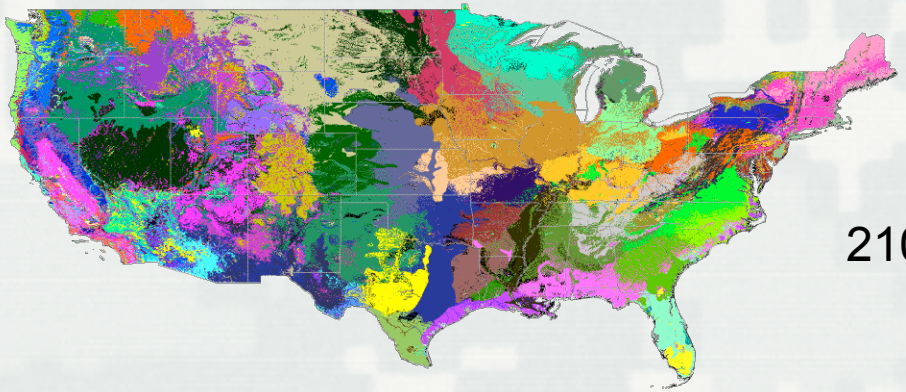


GAP



2050





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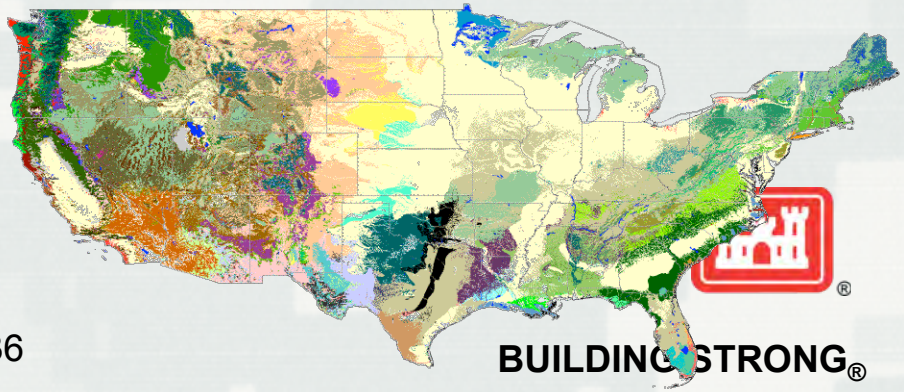
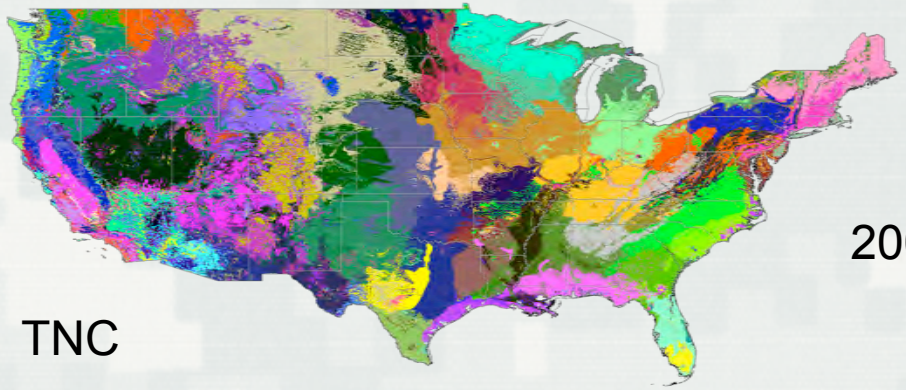
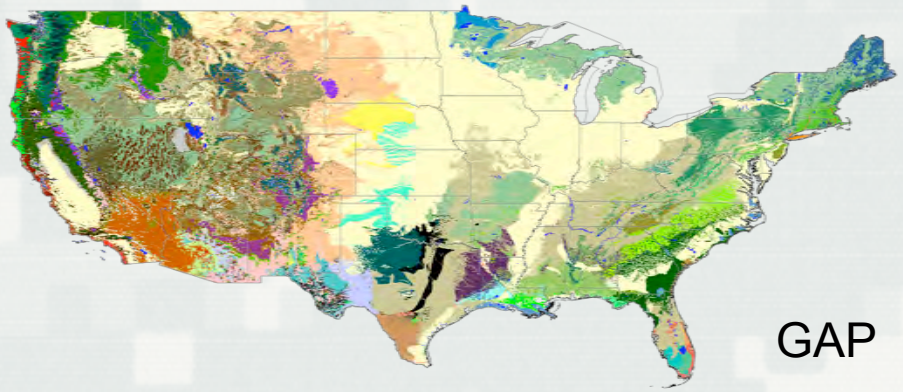


Hadley model – A1 scenario (high-high)

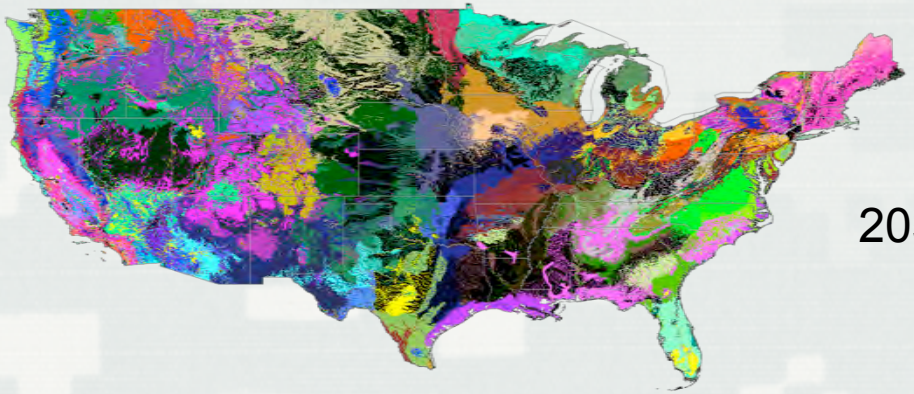


TNC

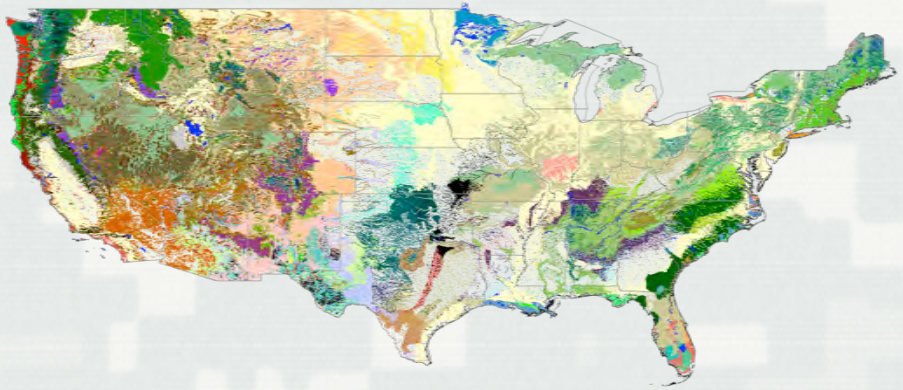
2000

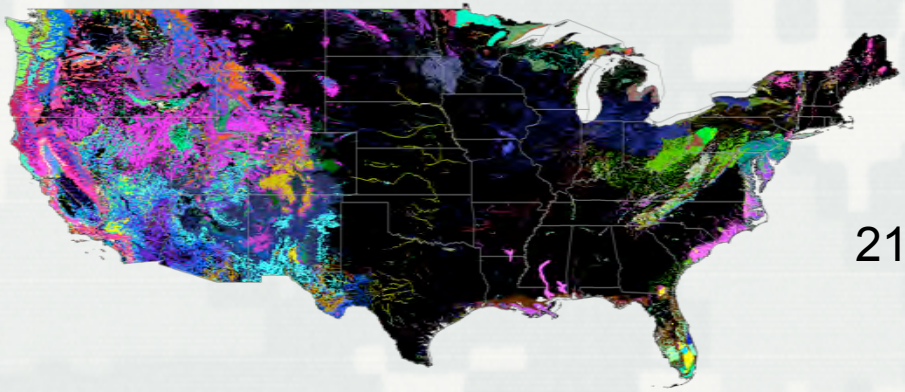


GAP



2050





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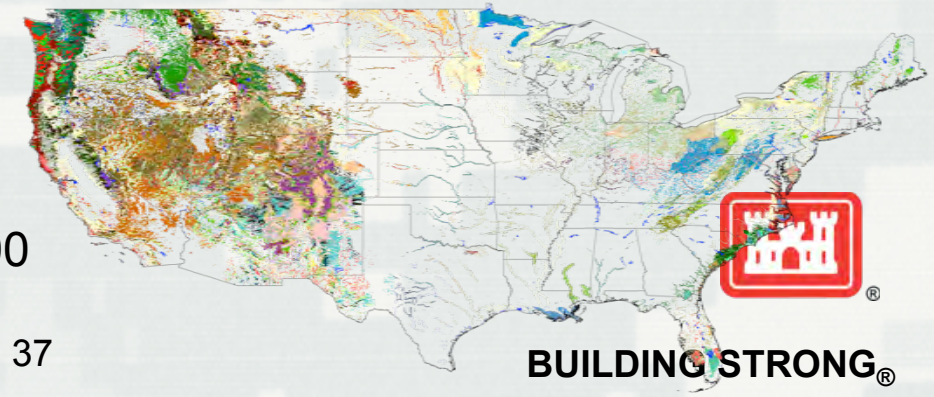

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Discussion

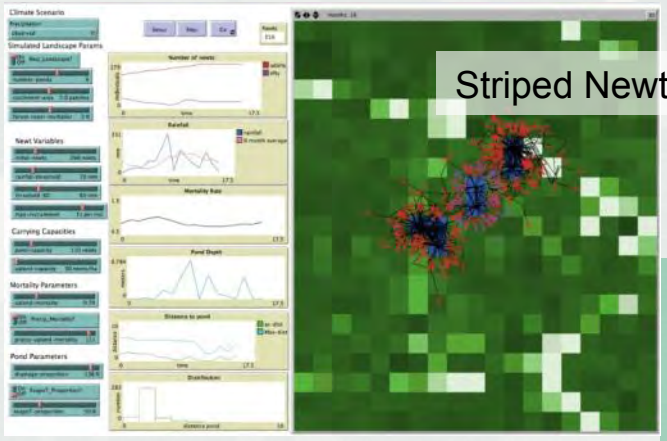
- We have a process for turning GCM forecasts into potential future ecosystem maps.
- Ready to apply to the next round.

Next?

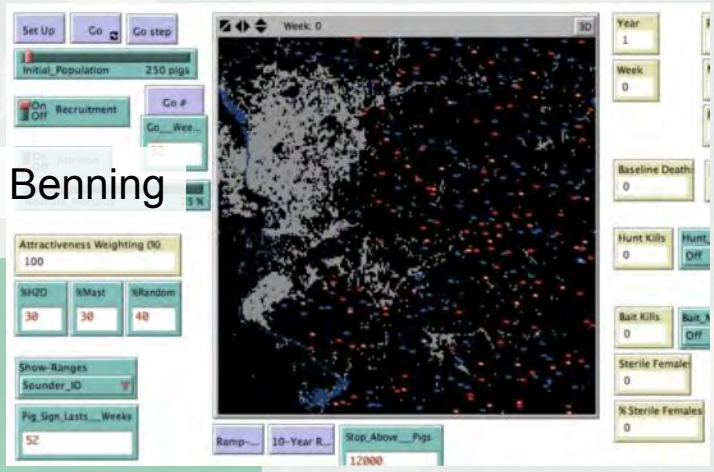
Two parts:

- Forecasted conditions currently support what ecosystems? ✔
- How and when will current ecosystems shift in response?
  - Resilience
  - Persistence
  - Seed distribution rates
  - ??

Some Ecological Sim Models

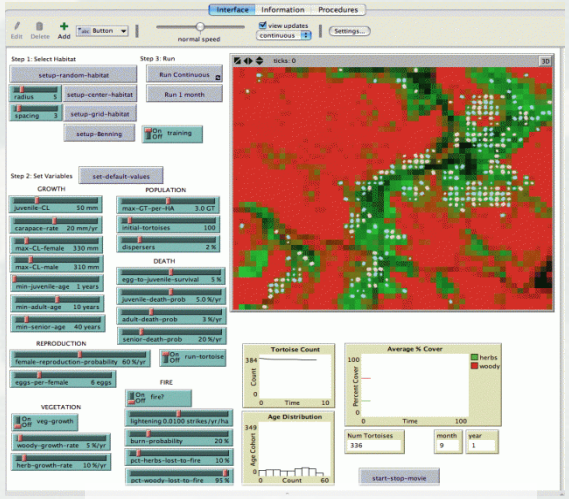


Striped Newt, Ft. Stewart

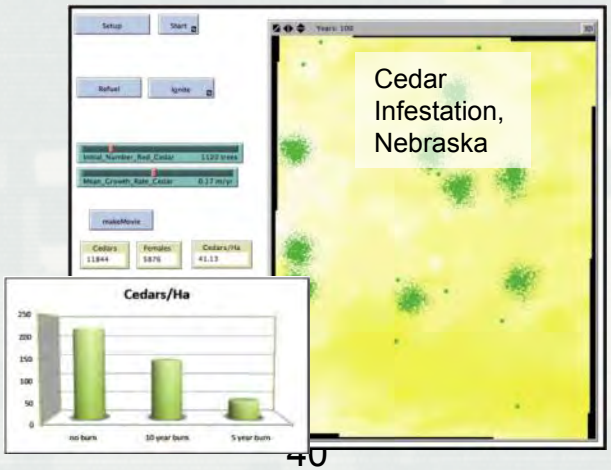


Feral Hogs, Fort Benning

- Quick
- Spatial
- Agent-based



Gopher Tortoise, Ft. Benning



Cedar Infestation, Nebraska

Fire Ants and Cave Crickets, Ft Hood

Questions??

- Sample Forest Service forecasts of movement of optimal tree habitat:
  - http://www.geobabble.org/~hnw/global/treeranges2/climate_change/index.html

- ERDC-CERL forecasts of ecosystem shifts around military installations:
  - ► http://earth.cecer.army.mil