

Forecasting Global Ecosystem Change Pressure

10th Annual Climate Prediction Applications Science Workshop, March 2012

Dr. Jim Westervelt

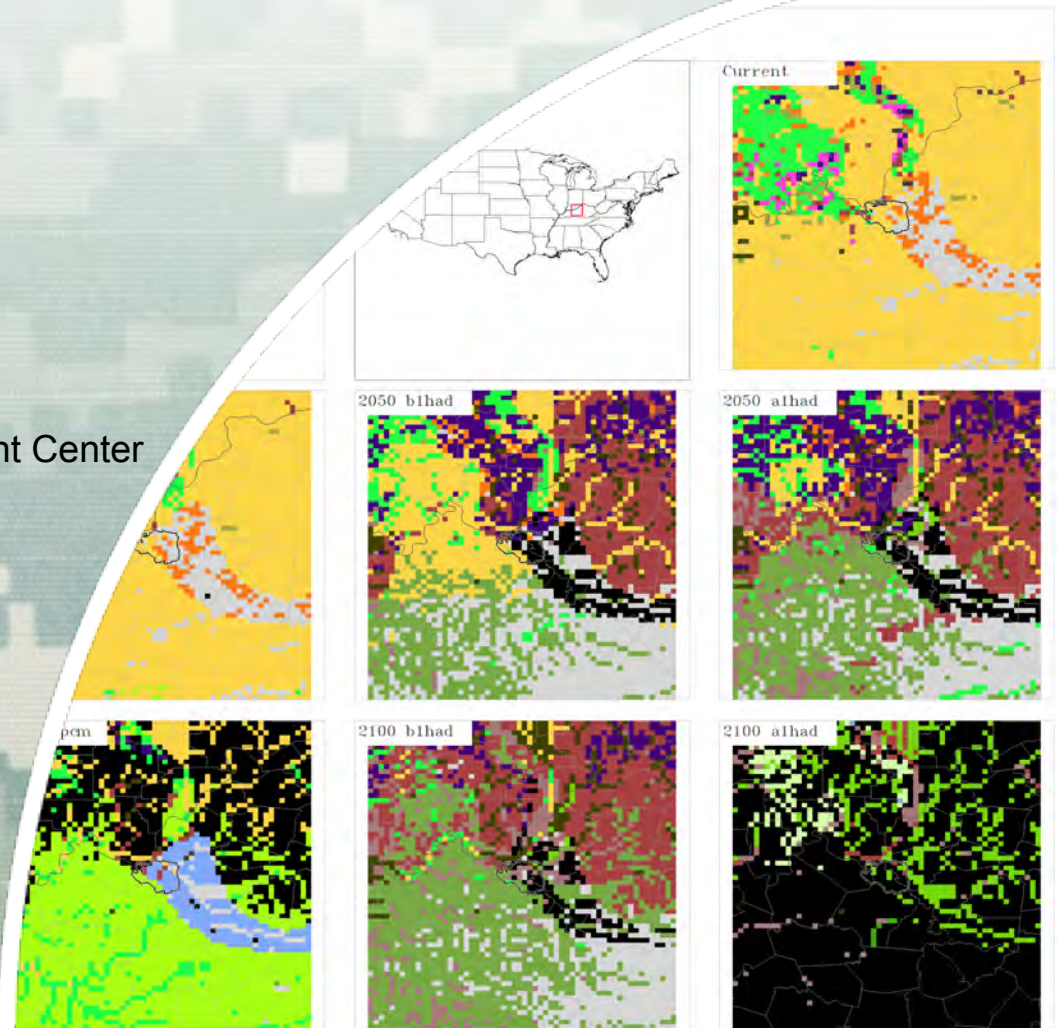
Construction Engineering Research Lab
Engineer Research and Development Center
Army Corps

Dr. William Hargrove

Eastern Forest Environmental Threat Assessment Center
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?



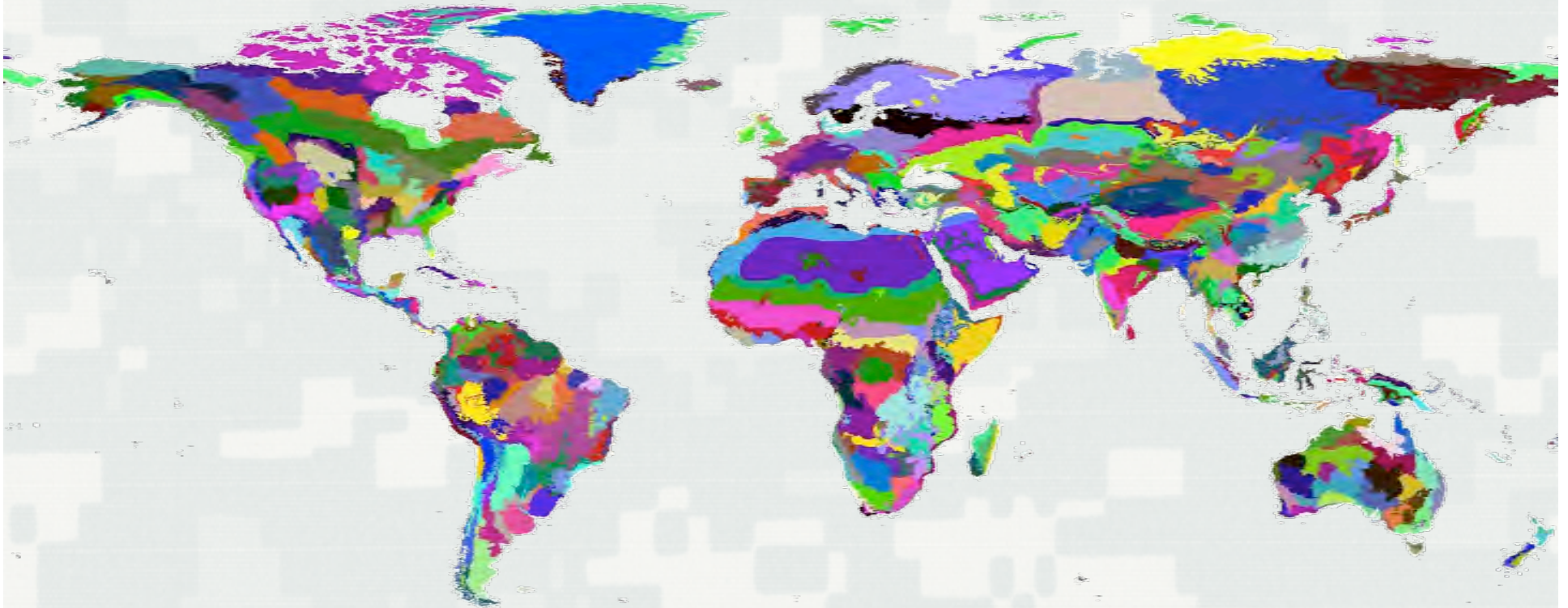
Agenda

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



TNC Terrestrial Ecoregions

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

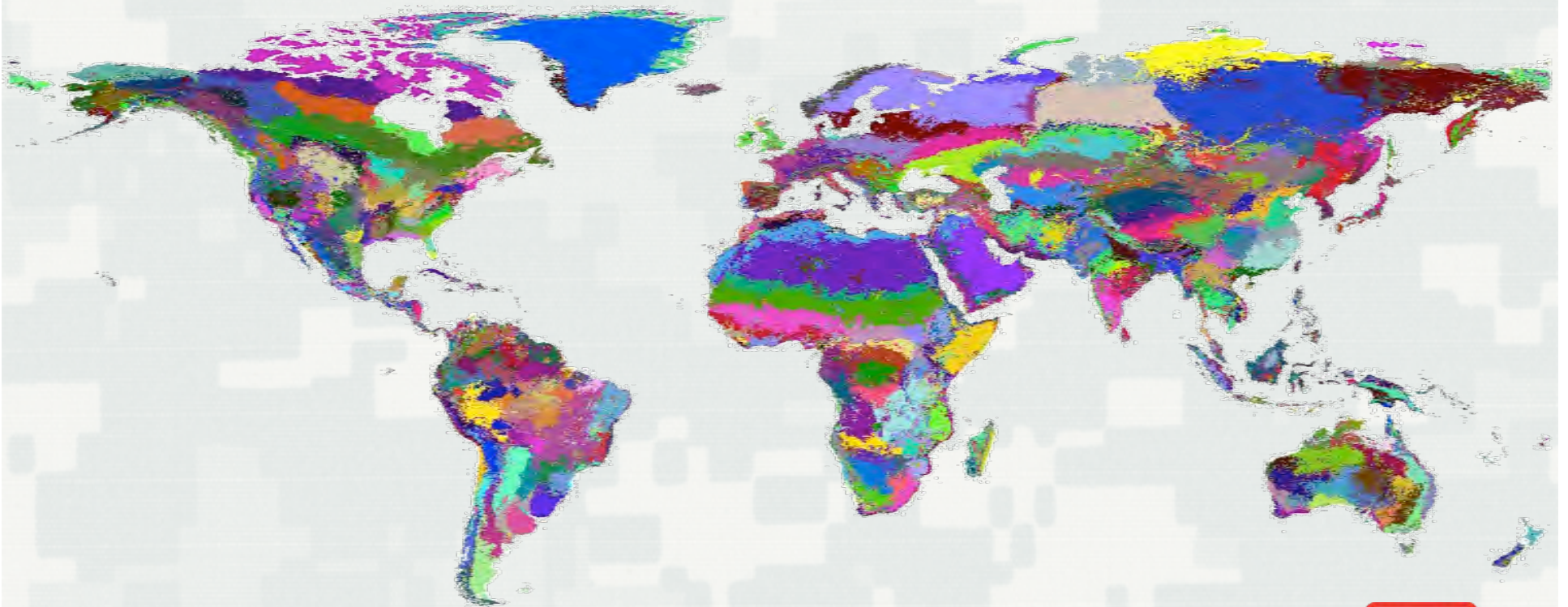


how might these shift?

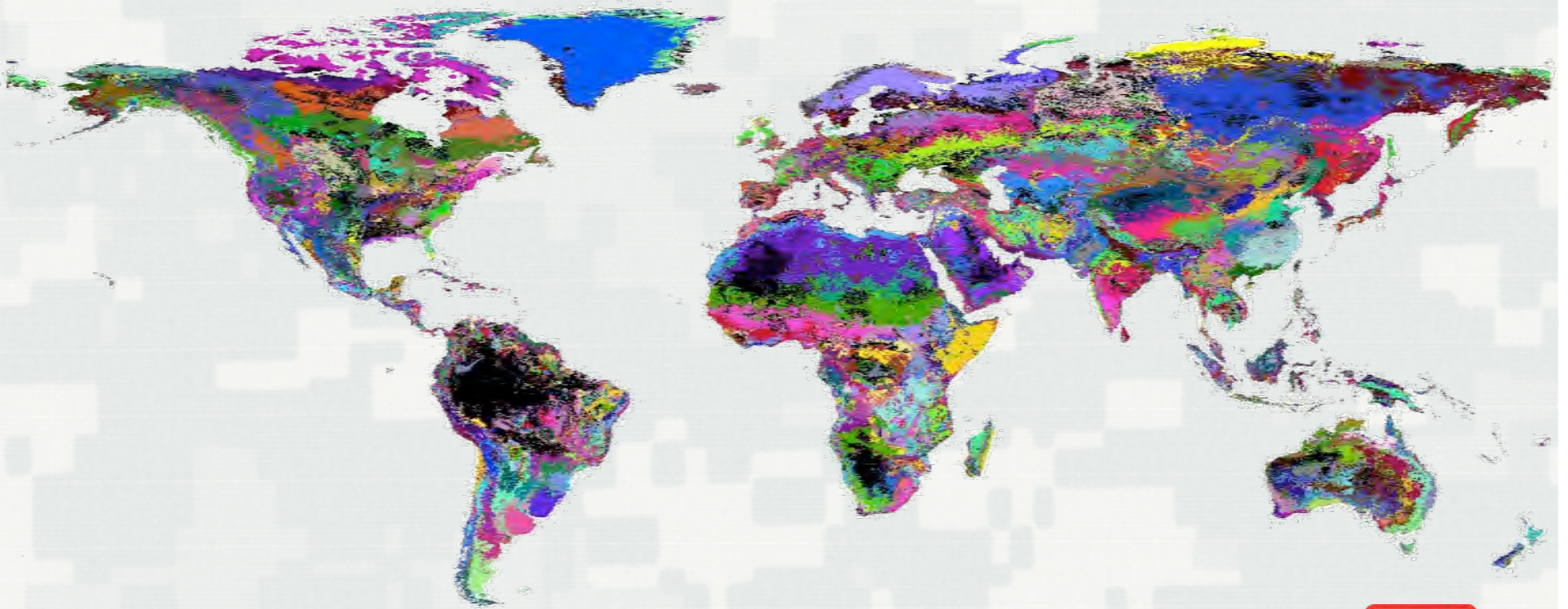


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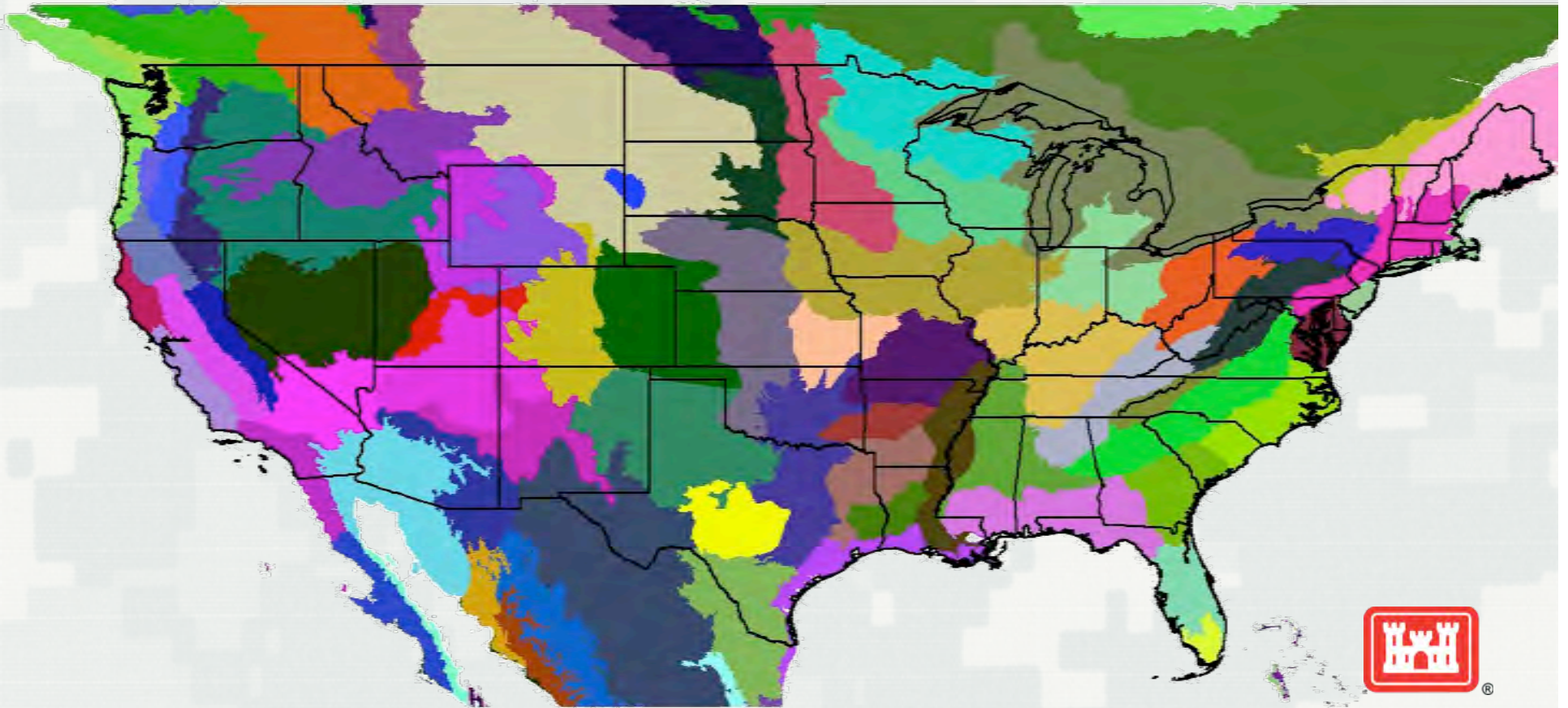
Current



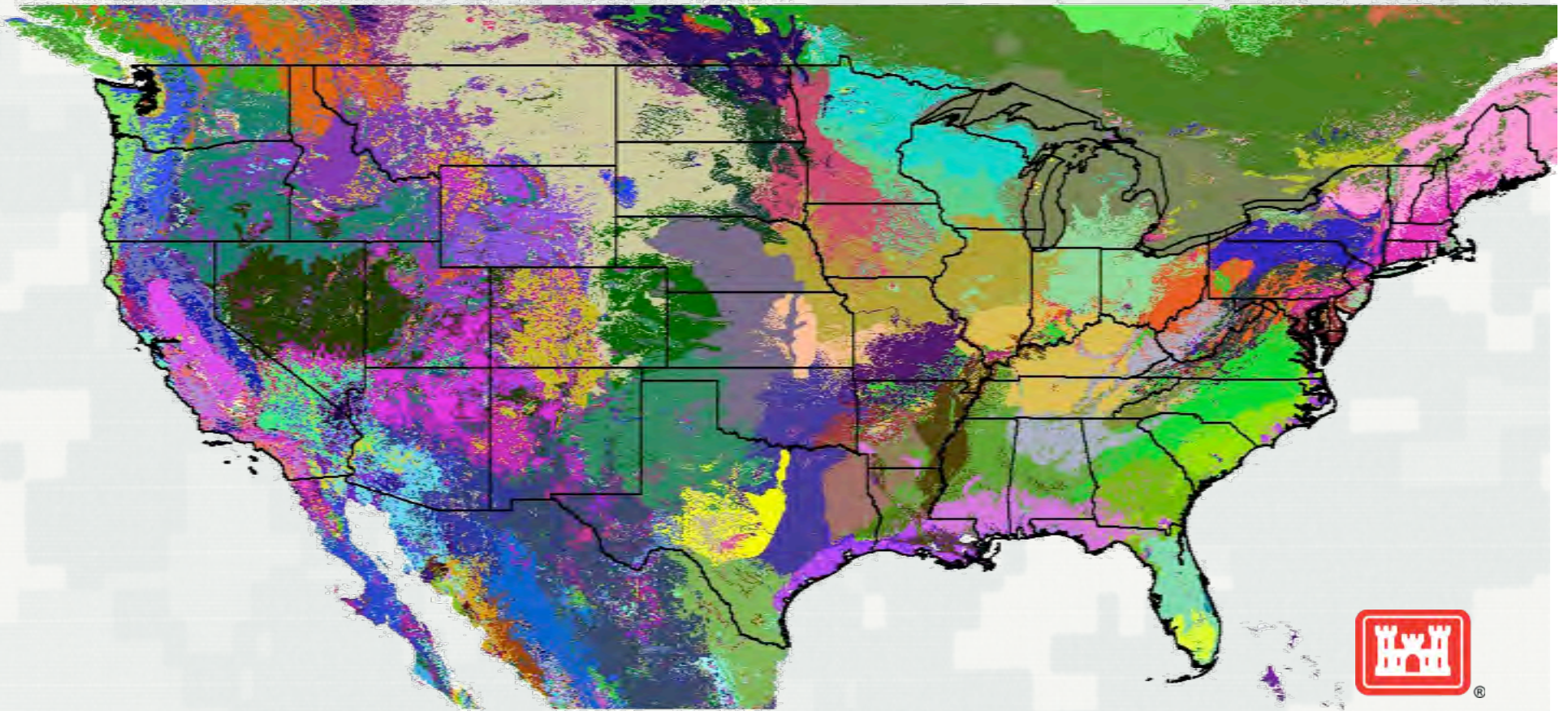
2050 Model, Hadley Scenario:A1



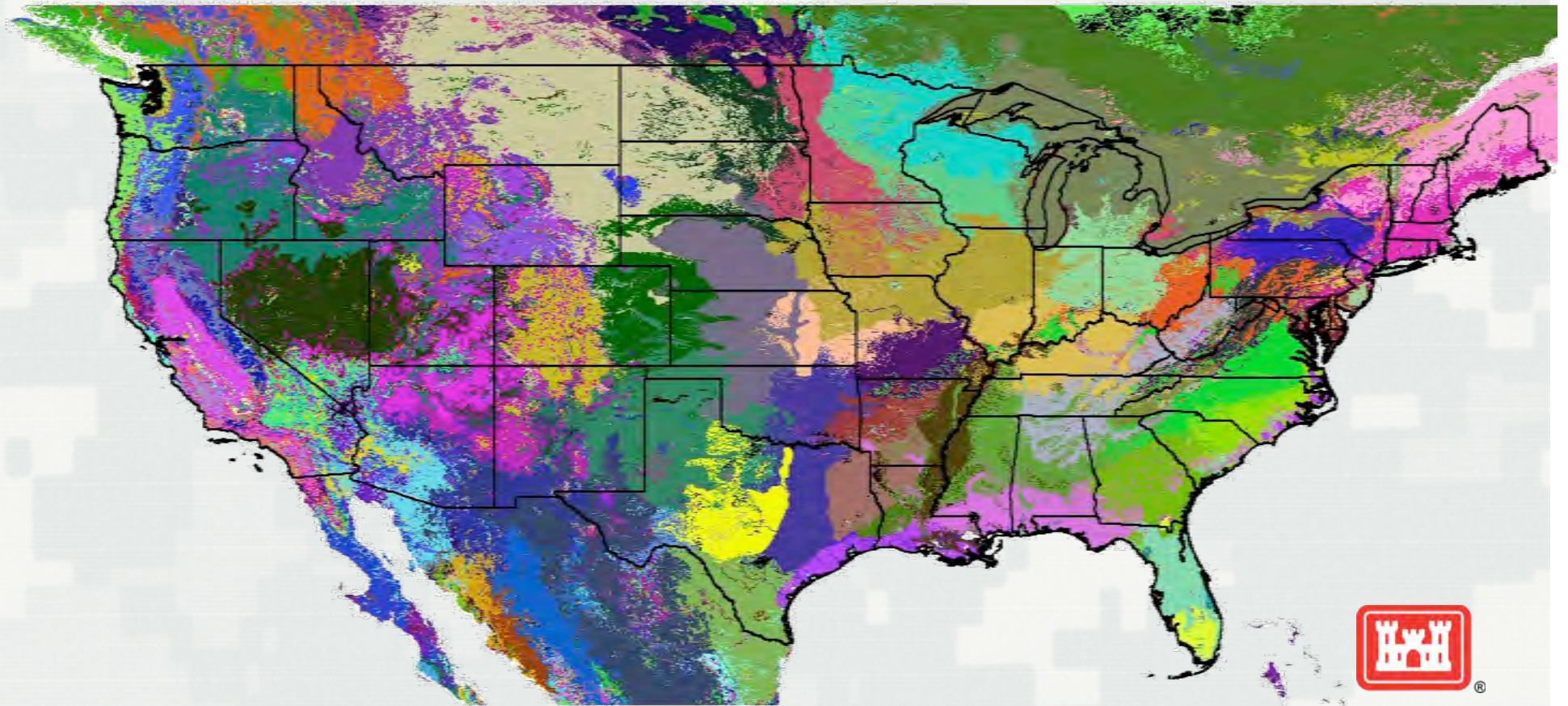
Zooming into the lower 48



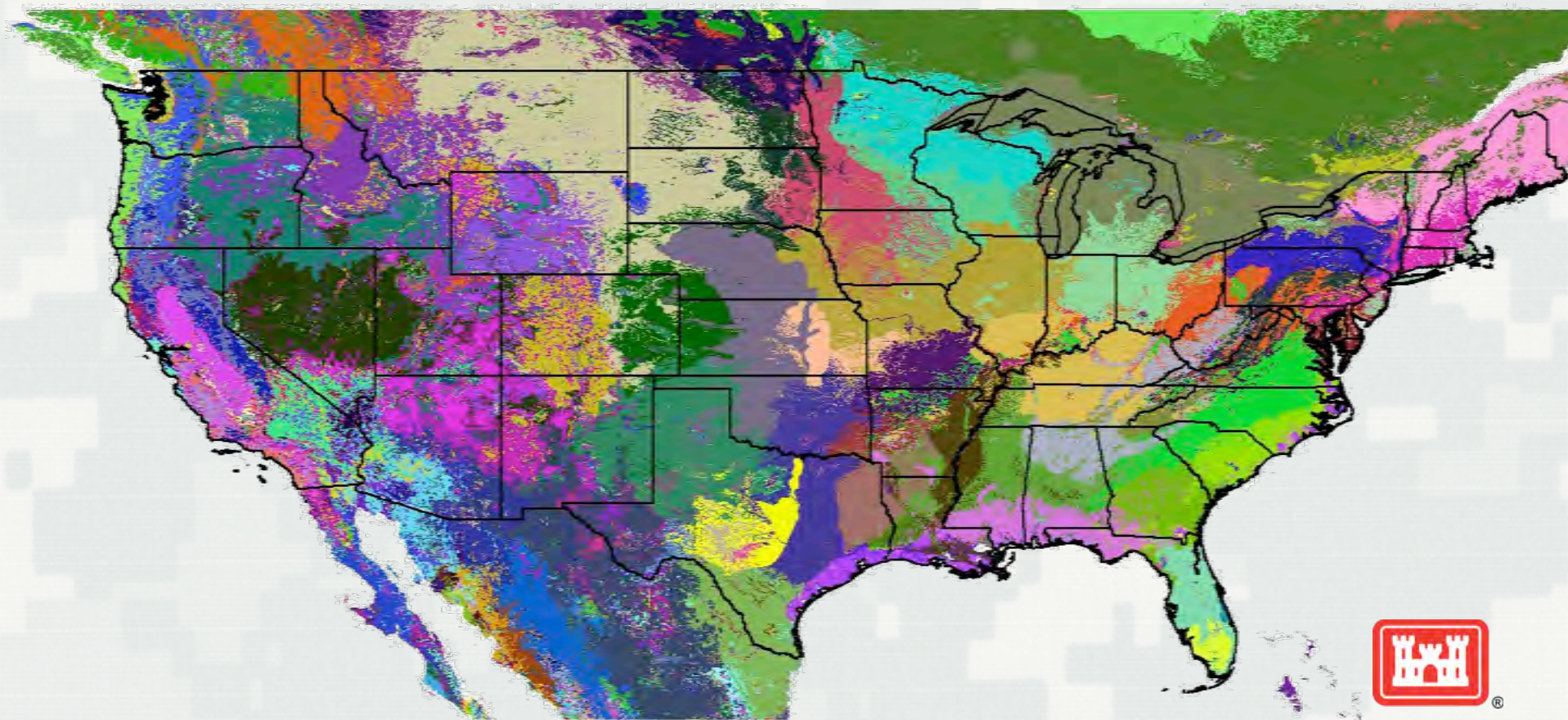
Current TNC* Ecosystems



2050 Model, PCM Scenario:B1

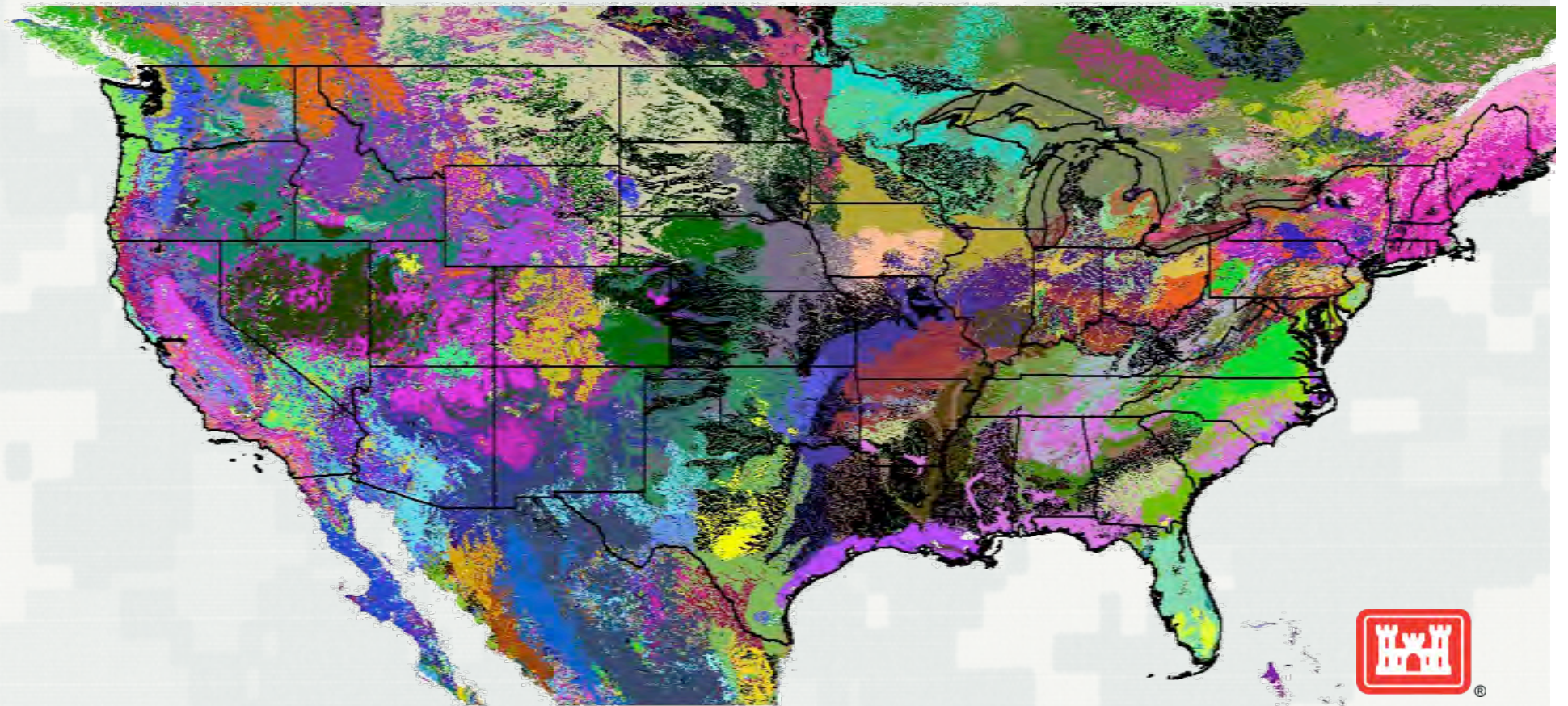


Current

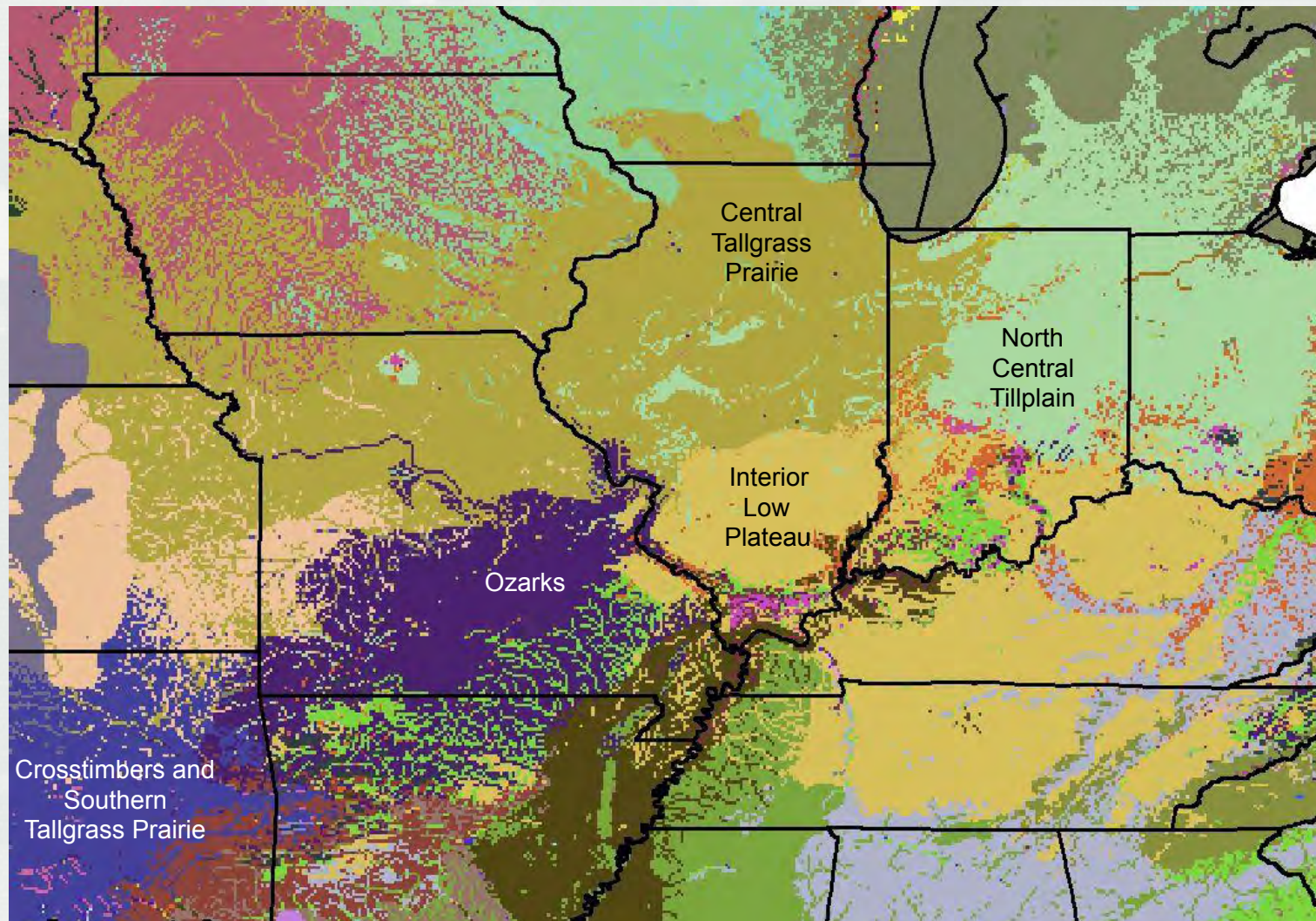


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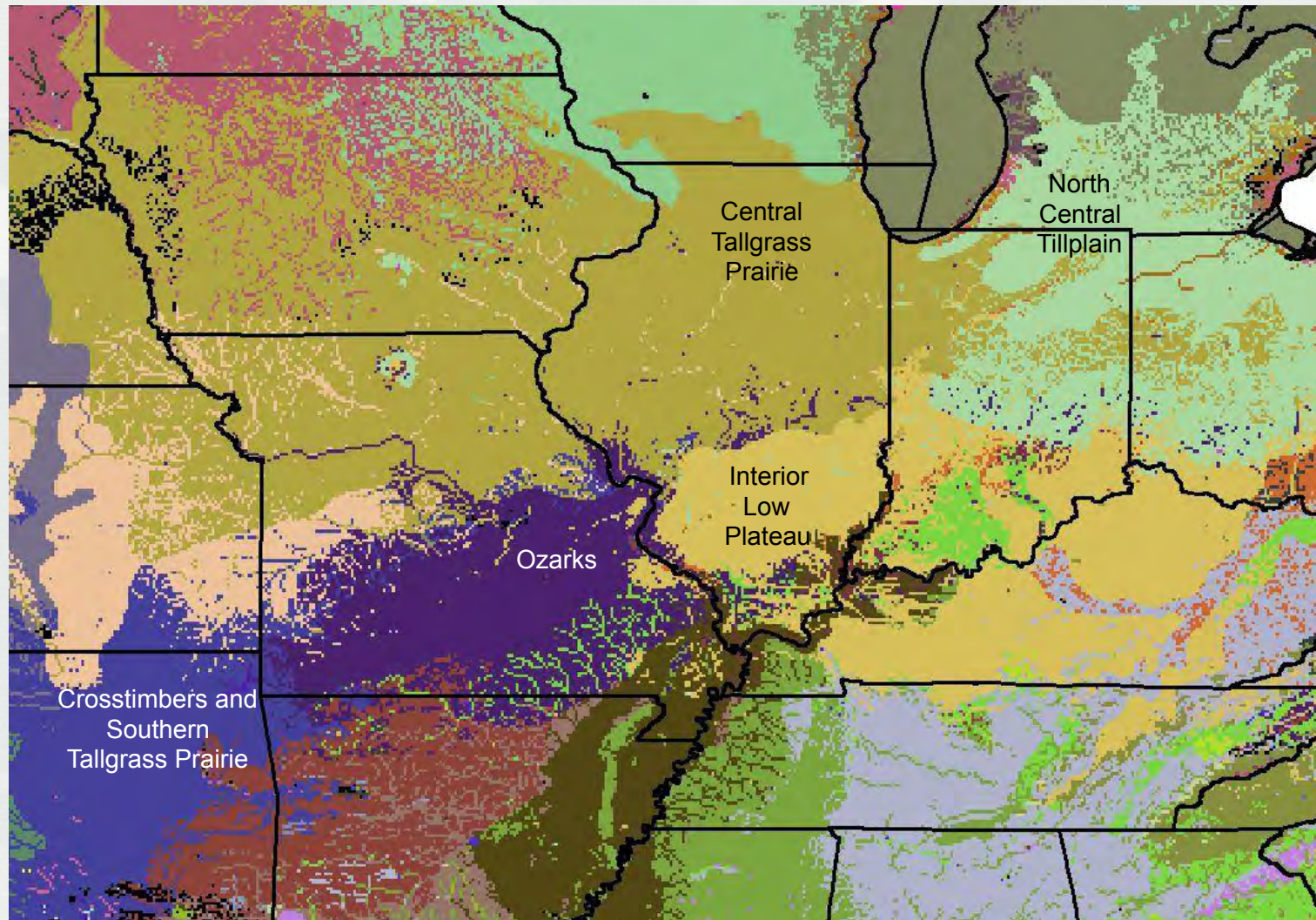
2050 Model, Hadley Scenario:A1



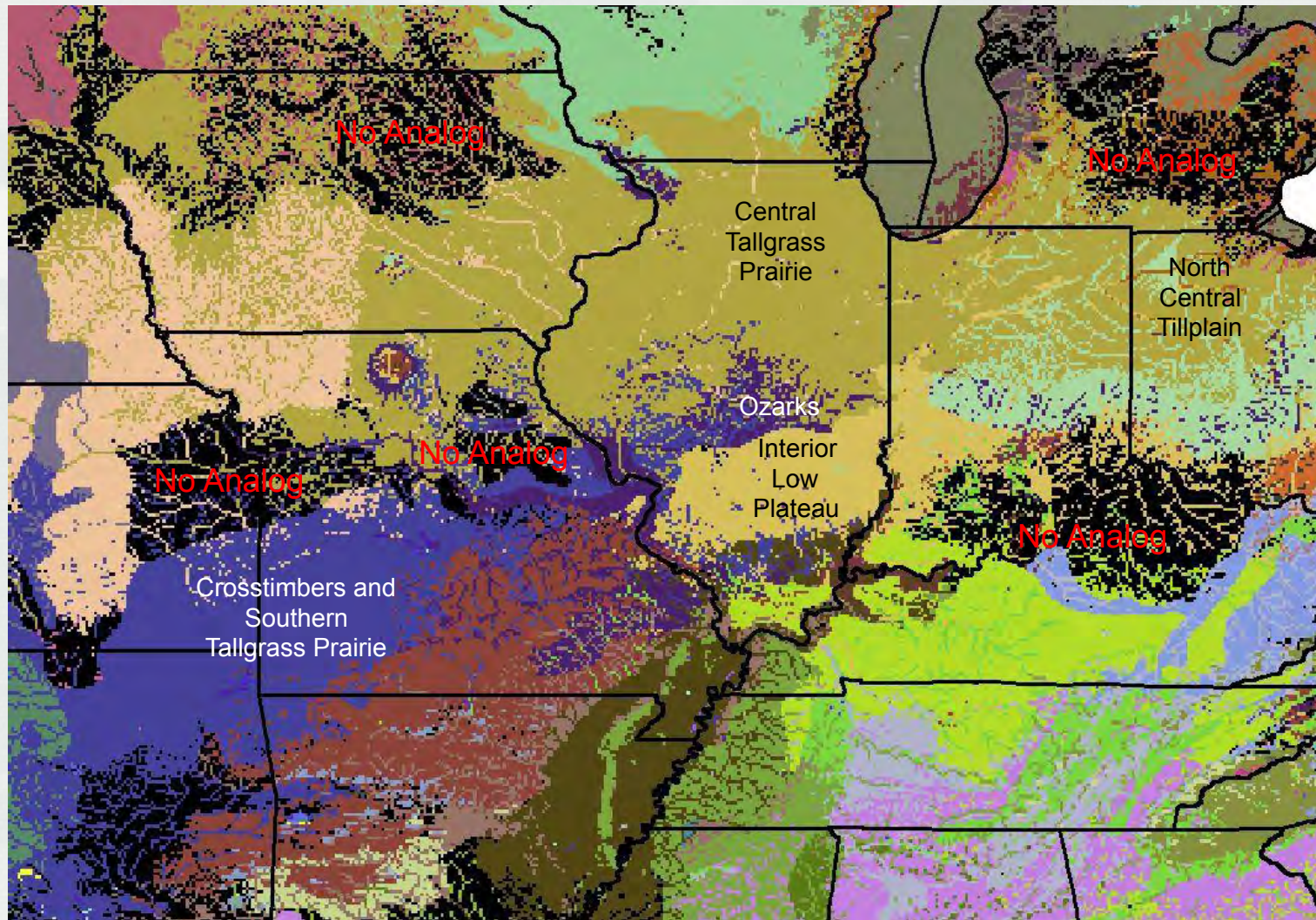
Illinois TNC – Current



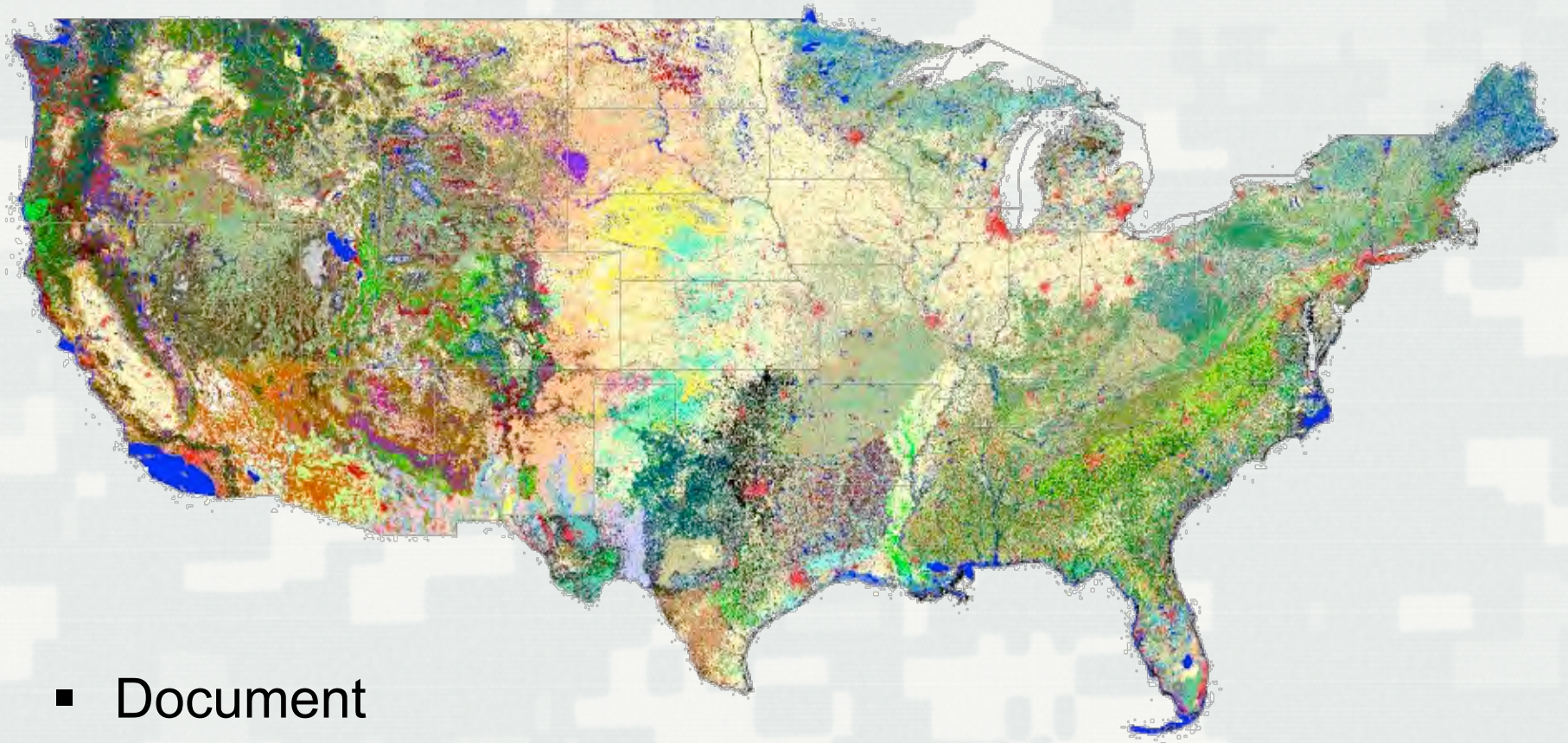
Illinois TNC – PCM A1 2050



Illinois TNC – PCM A1 2100



United States GAP Ecosystem

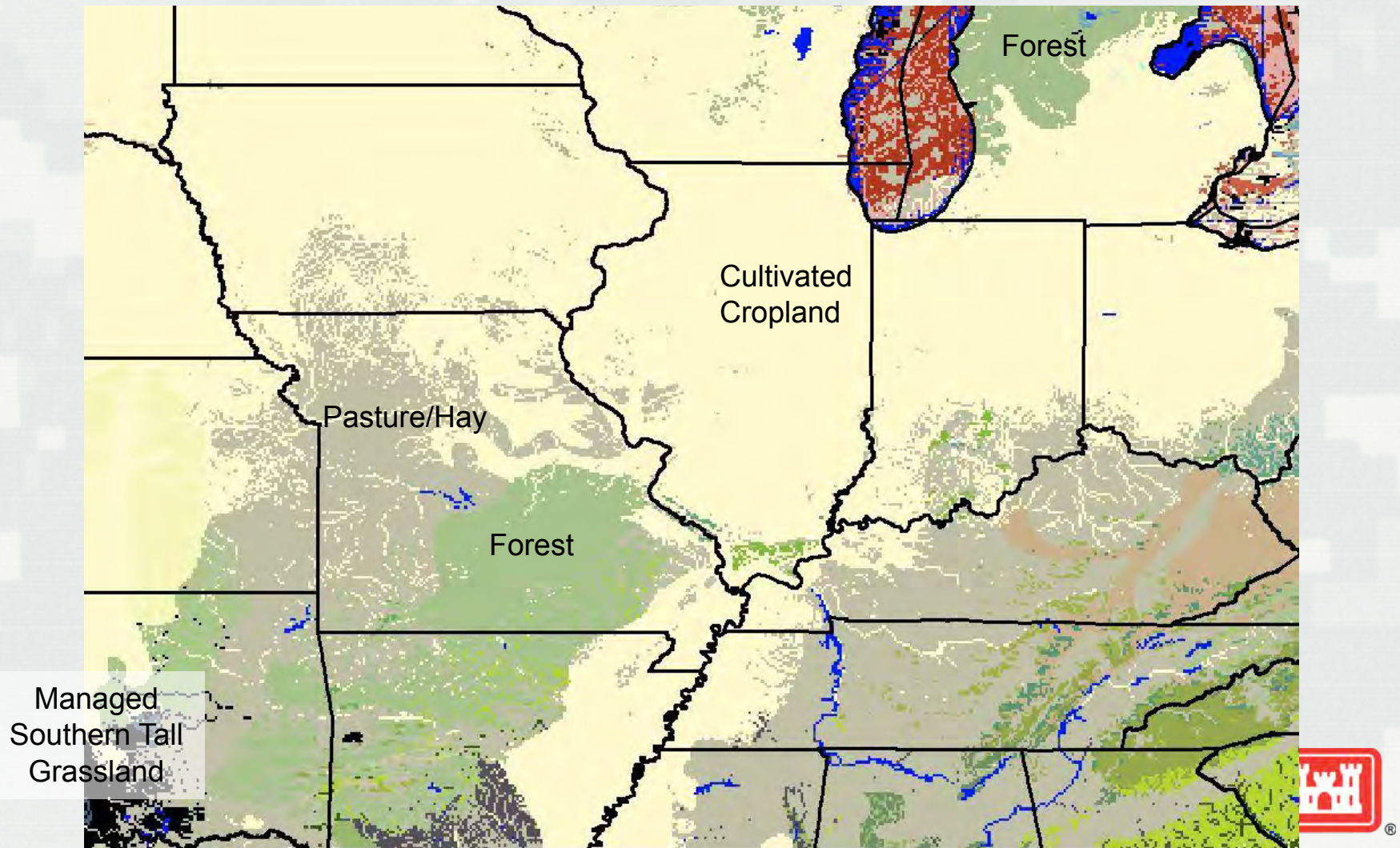


- Document
 - ▶ <http://pubs.usgs.gov/pp/1768/pp1768.pdf>
- Map viewer and download
 - ▶ <http://www.gap.uidaho.edu/landcoverviewer.html>

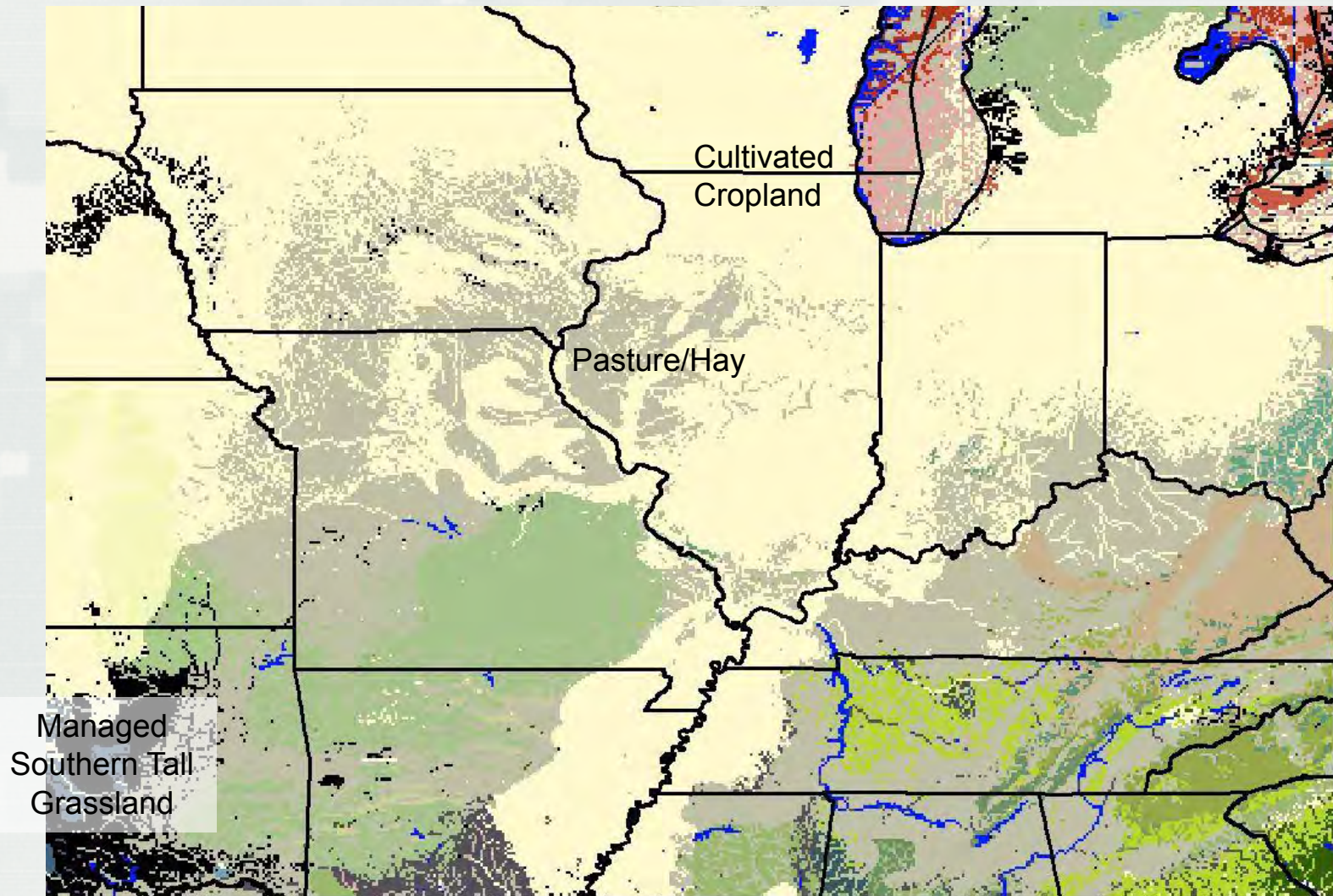


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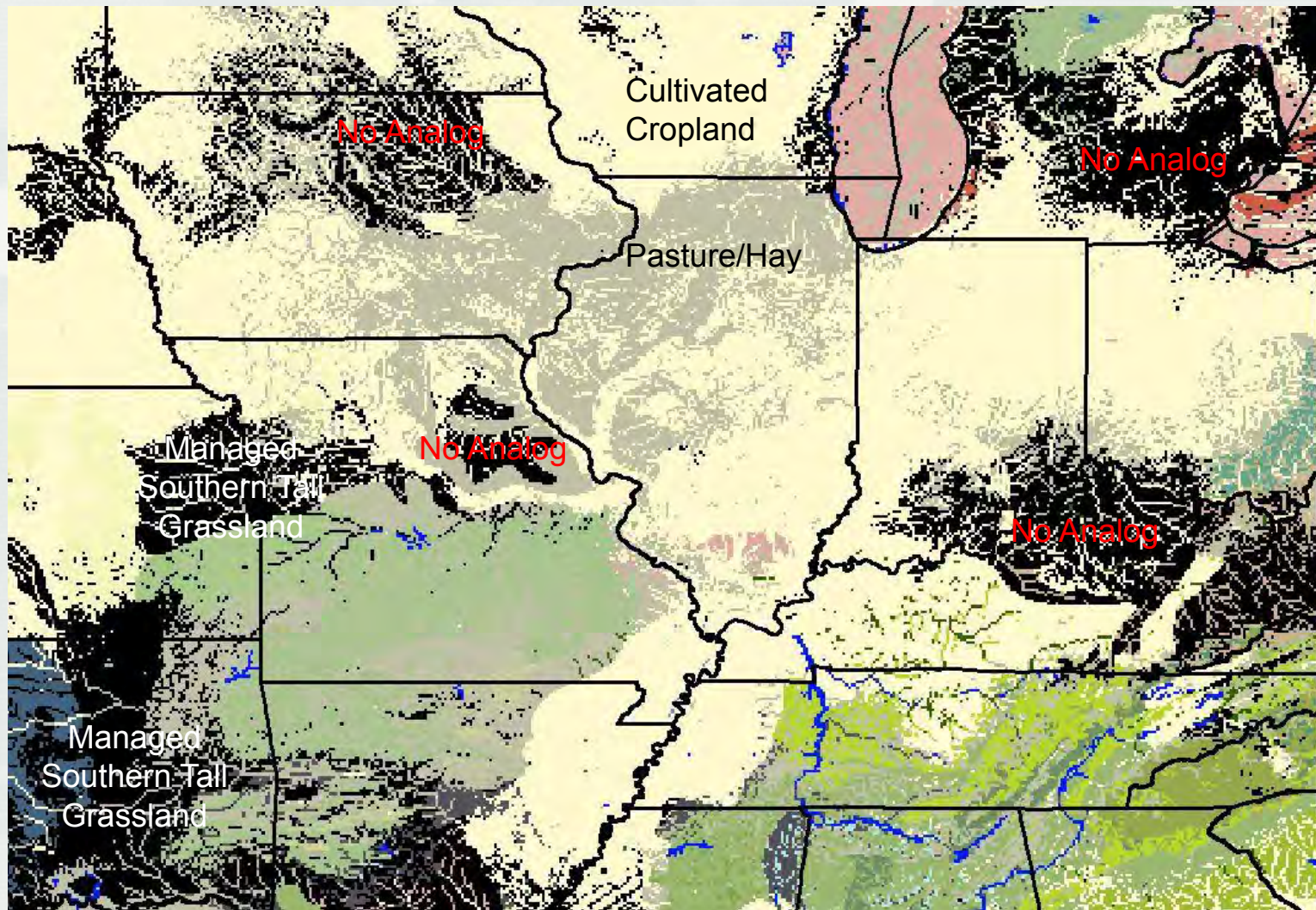
Illinois GAP – Current



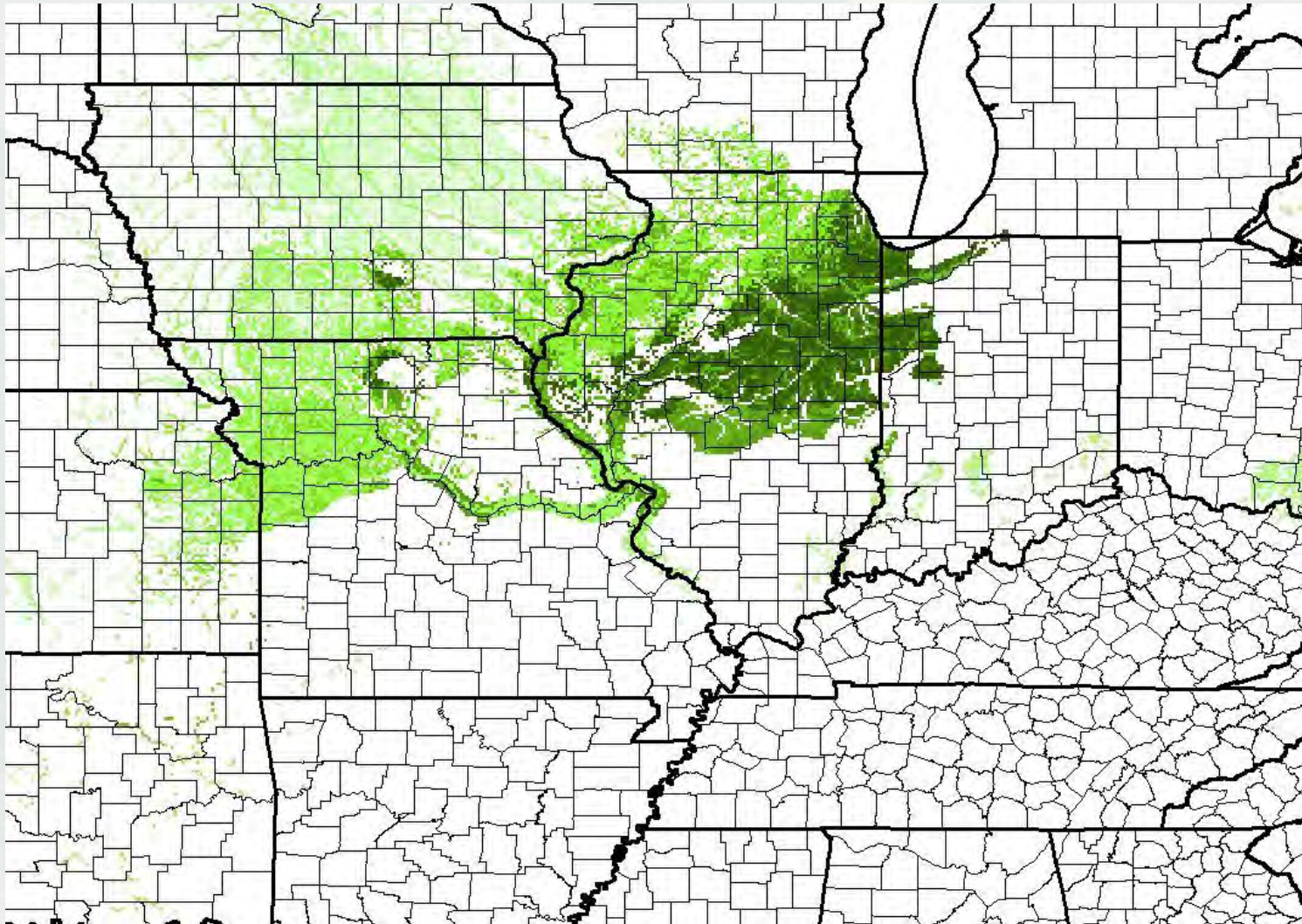
Illinois GAP – PCM A1 2050



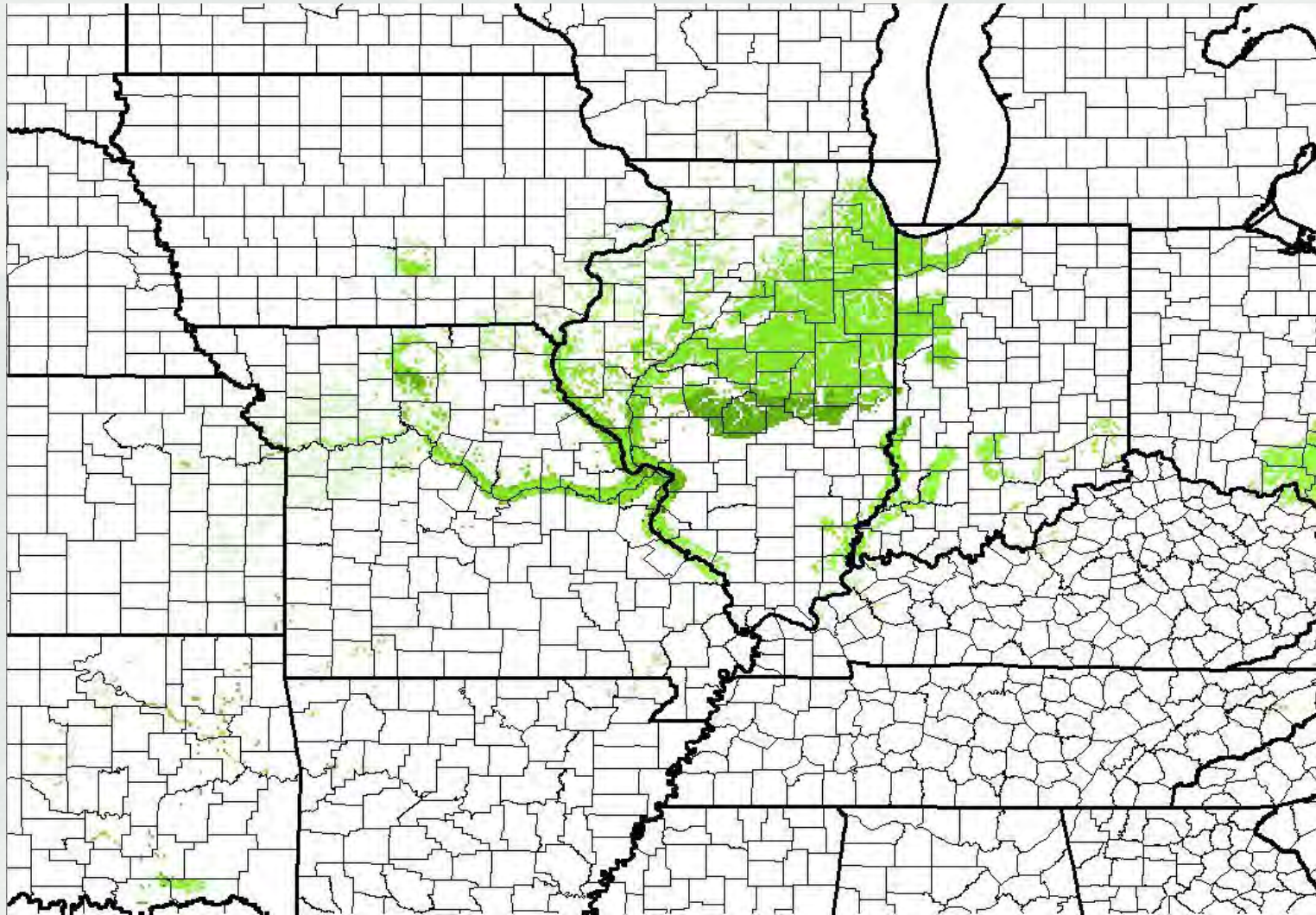
Illinois GAP – PCM A1 2100



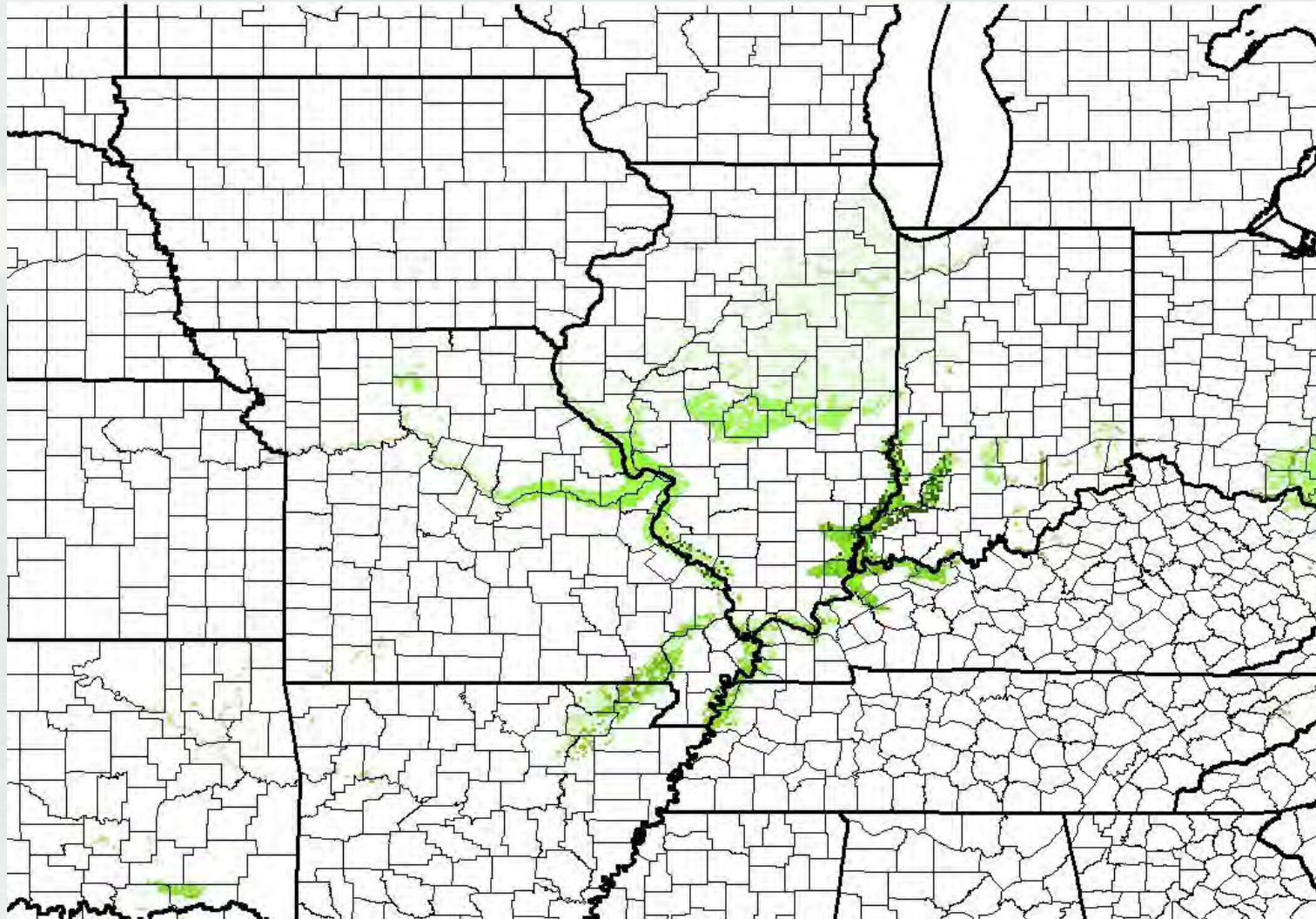
East-Cent III – Similar – Current



East-Cent III – HAD B1 2050



East-Cent III – 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>

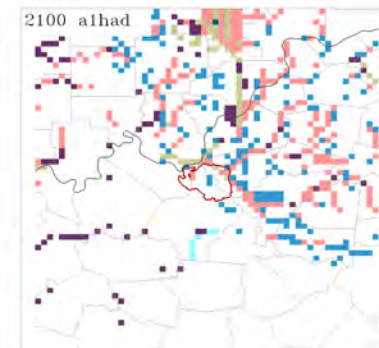
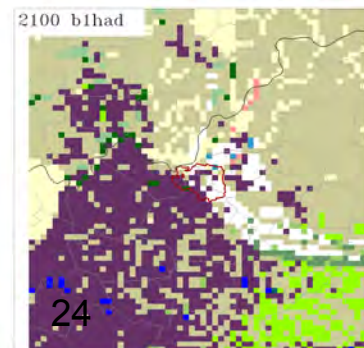
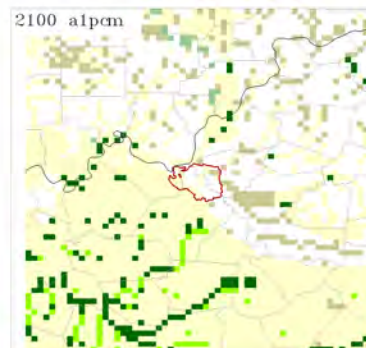
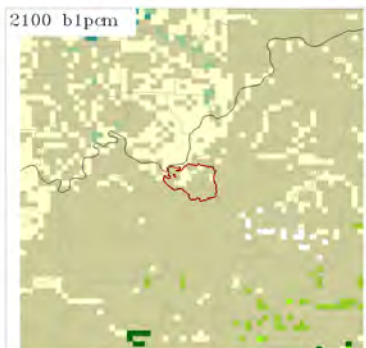
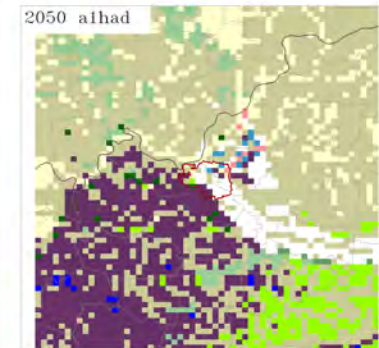
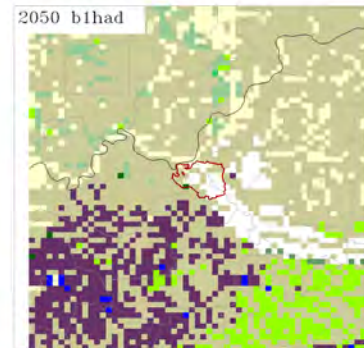
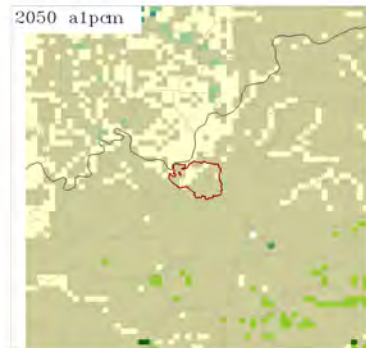
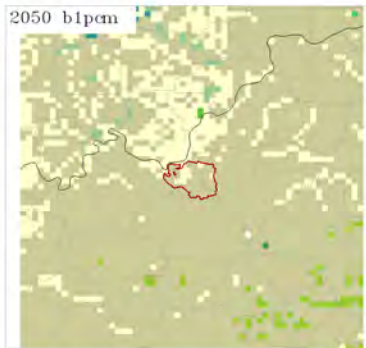
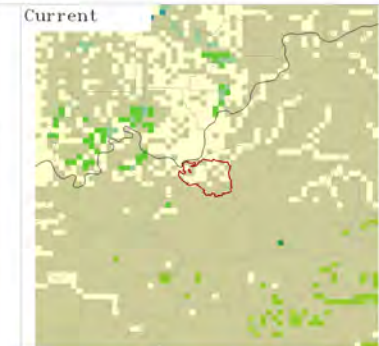


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Sample GAP – Fort Knox

Fort Knox

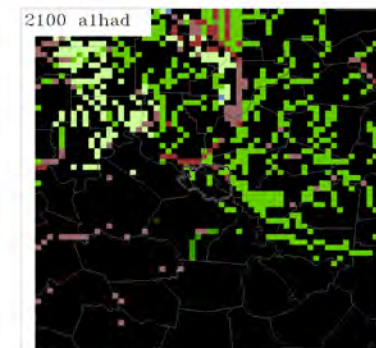
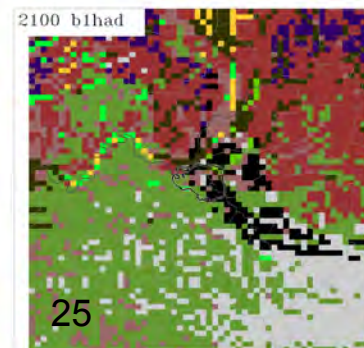
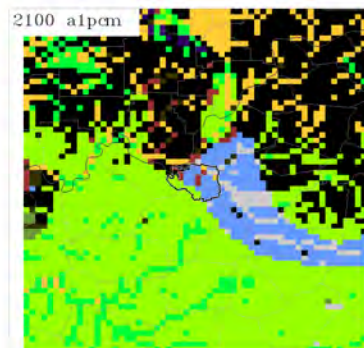
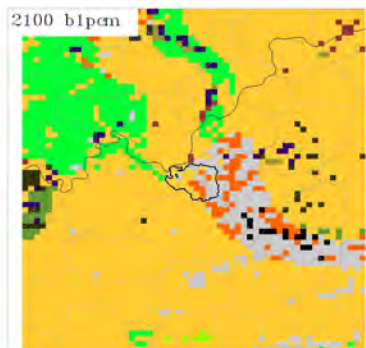
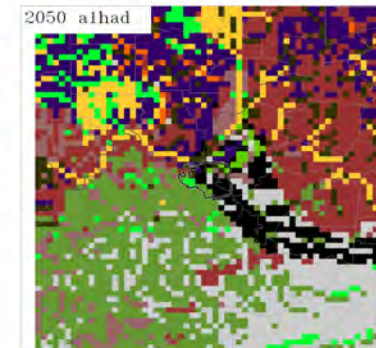
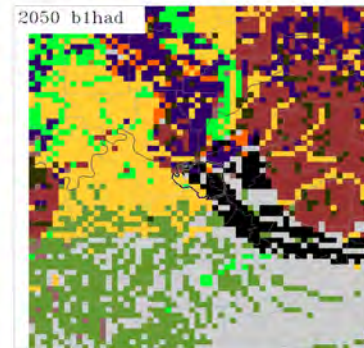
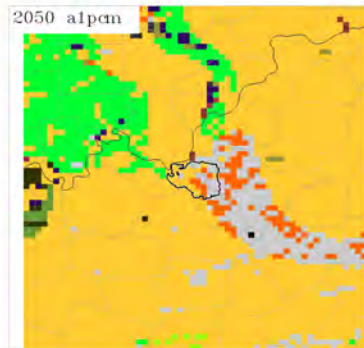
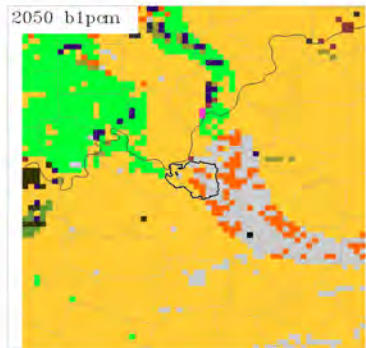
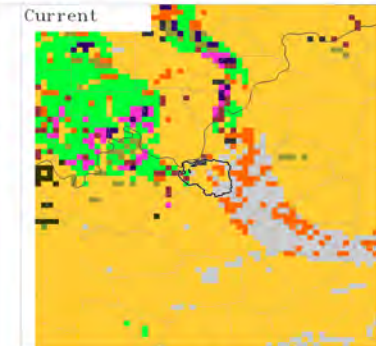
- 4115) Ozark-Ouachita Dry-Mesic Oak Forest
- 4116) Southern Interior Low Plateau Dry-Mesic Oak Forest
- 4126) Allegheny-Cumberland Dry Oak Forest and Woodland – Hardwood
- 4302) Southern Piedmont Dry Oak-(Pine) Forest – Hardwood Modifier
- 4328) Ozark-Ouachita Shortleaf Pine-Oak Forest and Woodland
- 4330) Central Appalachian Oak and Pine Forest
- 4332) West Gulf Coastal Plain Pine-Hardwood Forest
- 4334) Southern Ridge and Valley Dry Calcareous Forest
- 4401) Southern and Central Appalachian Cove Forest
- 4402) South-Central Interior Mesophytic Forest
- 4507) East Gulf Coastal Plain Interior Upland Longleaf Pine Woodland – Loblolly Modifier
- 8202) Evergreen Plantations or Managed Pine (can include dense successional regrowth)
- 8203) Managed Tree Plantation
- 9804) East Gulf Coastal Plain Large River Floodplain Forest – Forest Modifier
- 9842) Atlantic Coastal Plain Small Brownwater River Floodplain Forest
- 9851) East Gulf Coastal Plain Small Stream and River Floodplain Forest
- 9908) West Gulf Coastal Plain Wet Longleaf Pine Savanna and Flatwoods



Sample TNC – Fort Knox

Fort Knox

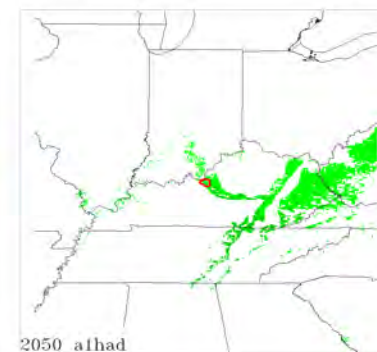
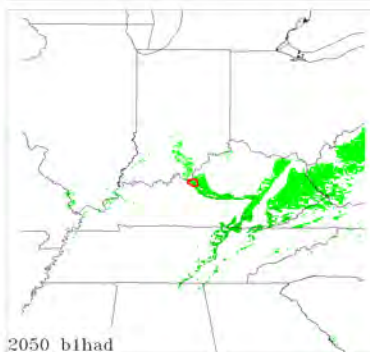
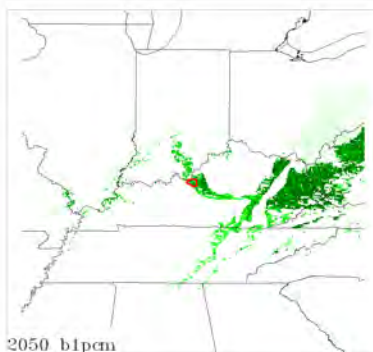
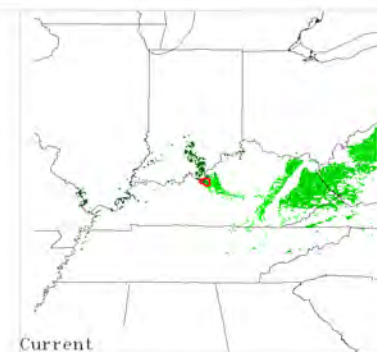
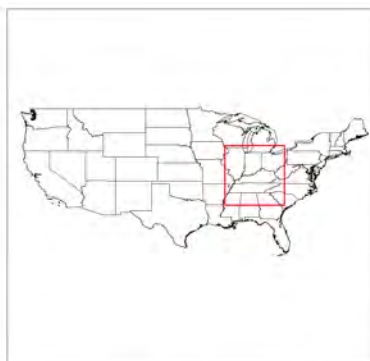
- 0) Different from any area in the world in 2000
- 98) 47% -Southern Acacia-Commiphora Bushlands And Thickets
- 185) 76% -Ouachita Mountains
- 186) 94% -Ozarks
- 187) 31% -Piedmont
- 189) 94% -Southern Blue Ridge
- 294) 64% -Araucaria Moist Forests
- 503) 81% -Mid-Atlantic Coastal Plain
- 705) 56% -Central Appalachian Forest
- 706) 56% -Chesapeake Bay Lowlands
- 707) 30% -Cumberlands And Southern Ridge And Valley
- 710) 38% -Interior Low Plateau
- 712) 61% -Mississippi River Alluvial Plain
- 715) 31% -Upper East Gulf Coastal Plain
- 716) 44% -Western Allegheny Plateau
- 727) 82% -South Atlantic Coastal Plain
- 729) 84% -Upper West Gulf Coastal Plain



Sample Similar – Fort Knox

Fort Knox

These images show where the forecasted physical and climate conditions most closely match the conditions found across the region in 2000. This answers the question, "Where can I go today to find the forecasted conditions for this installation?"



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 CO₂) and B1(lower CO₂)
- Choose time
 - ▶ Current, 2050, 2080 (based on 30-yr averages)
- Collect maps (for current and 8 futures)



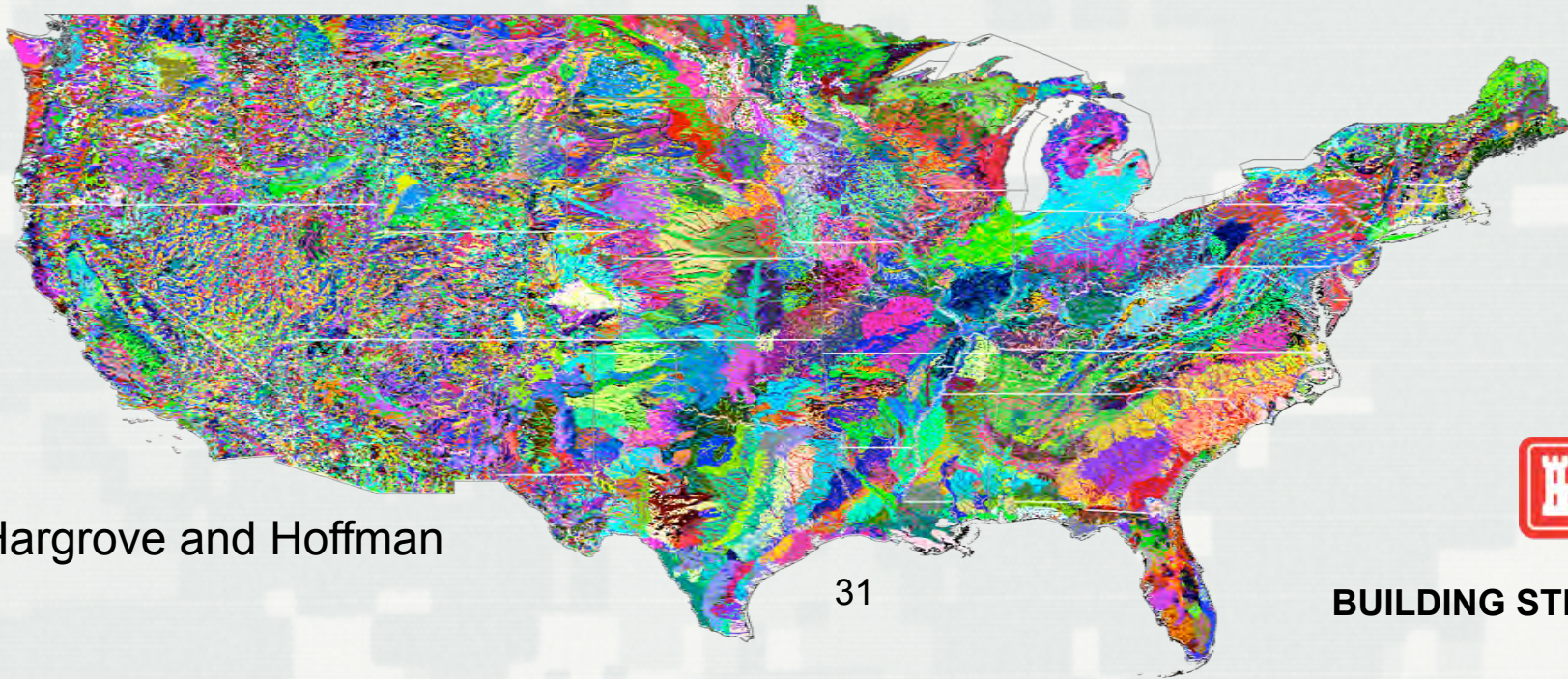
Scenarios

- 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

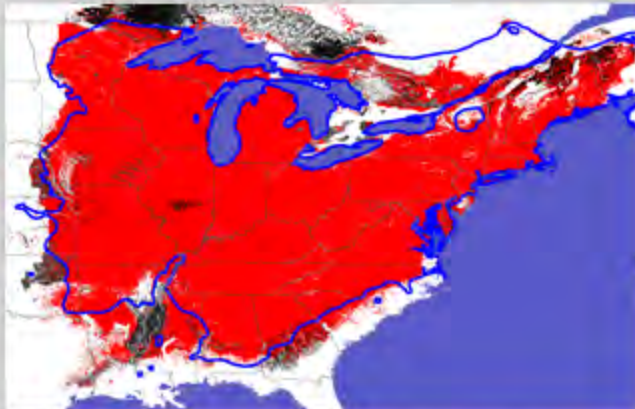
- Convert all maps to standard-deviation form
- Run cluster analysis (30,000 clusters) Grouping all 9 sets across the world!!



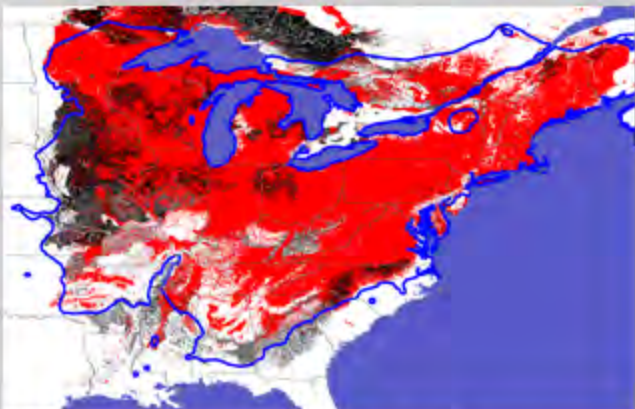
Hargrove and Hoffman



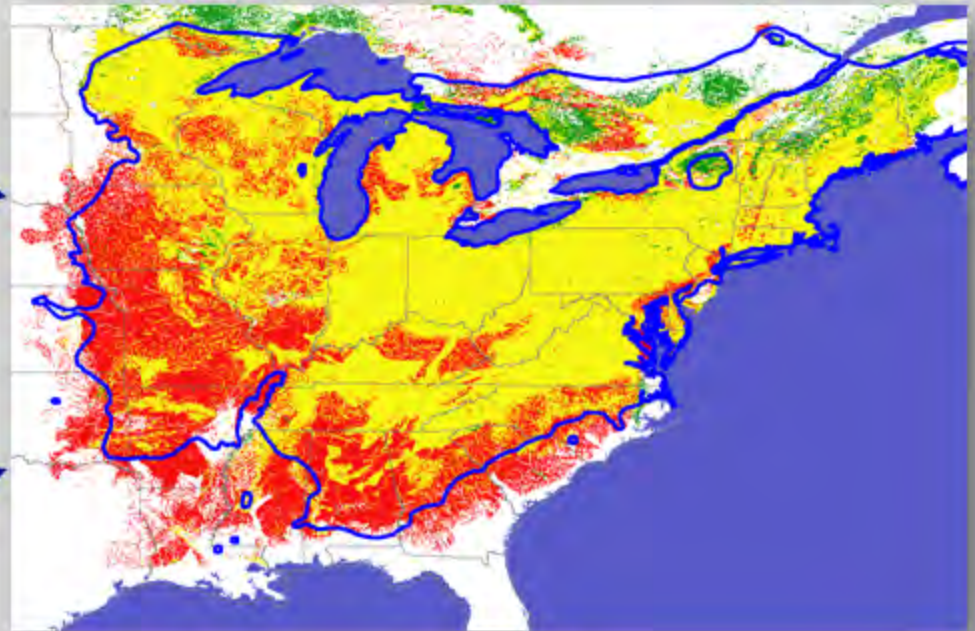
Northern red oak (*Quercus rubra*)



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

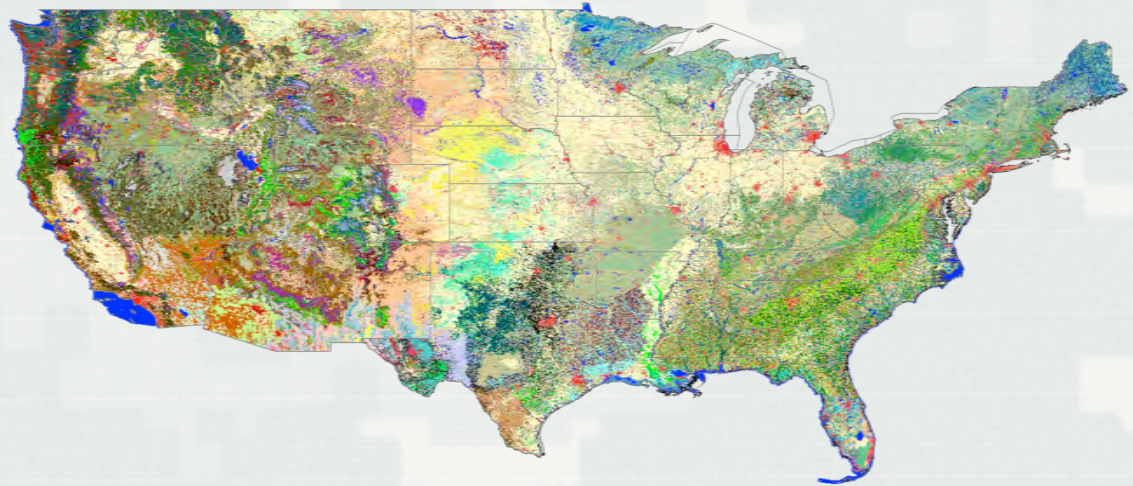


Correlate Clusters with Ecosystems

- Choose ecosystem map

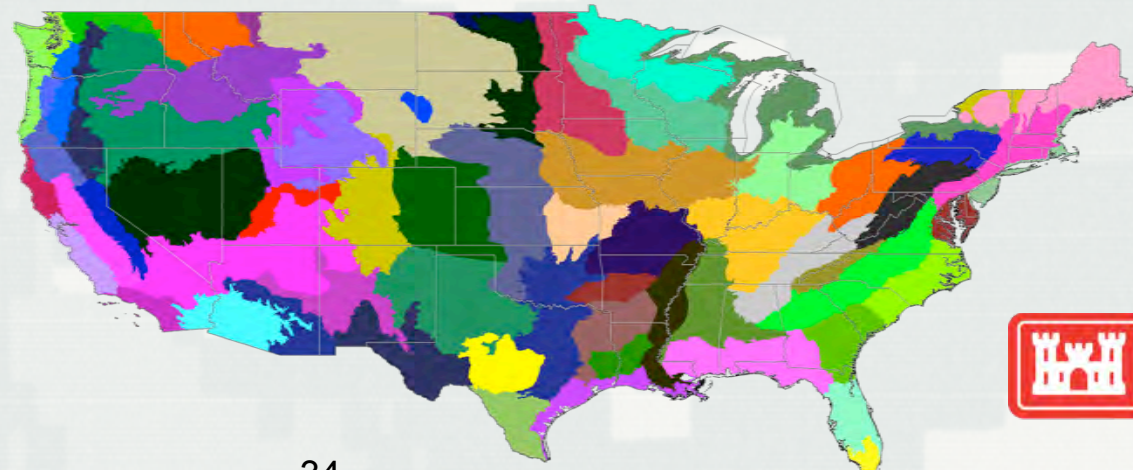
- ▶ GAP

- US
 - 533 types



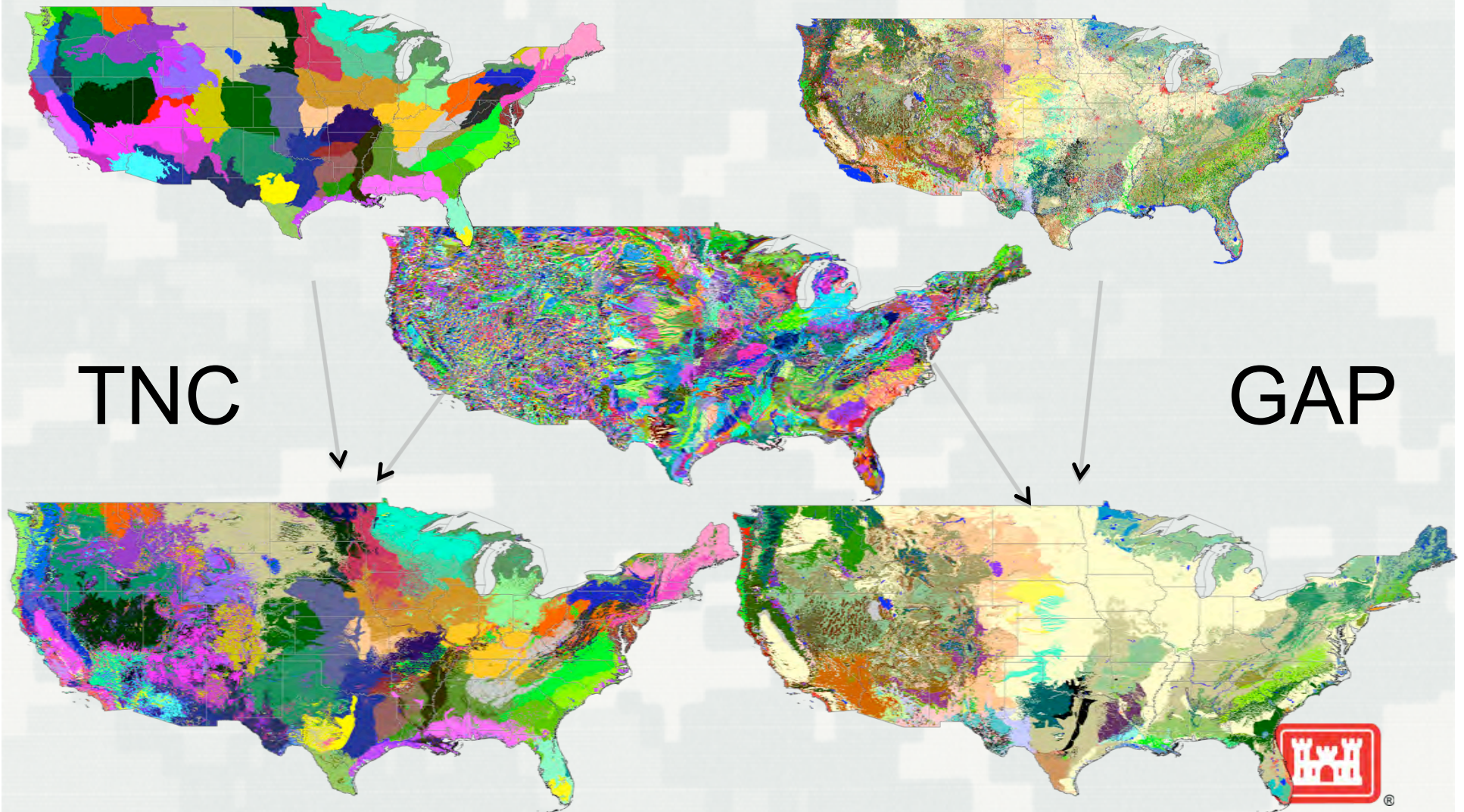
- ▶ TNC

- Global
 - 814 types

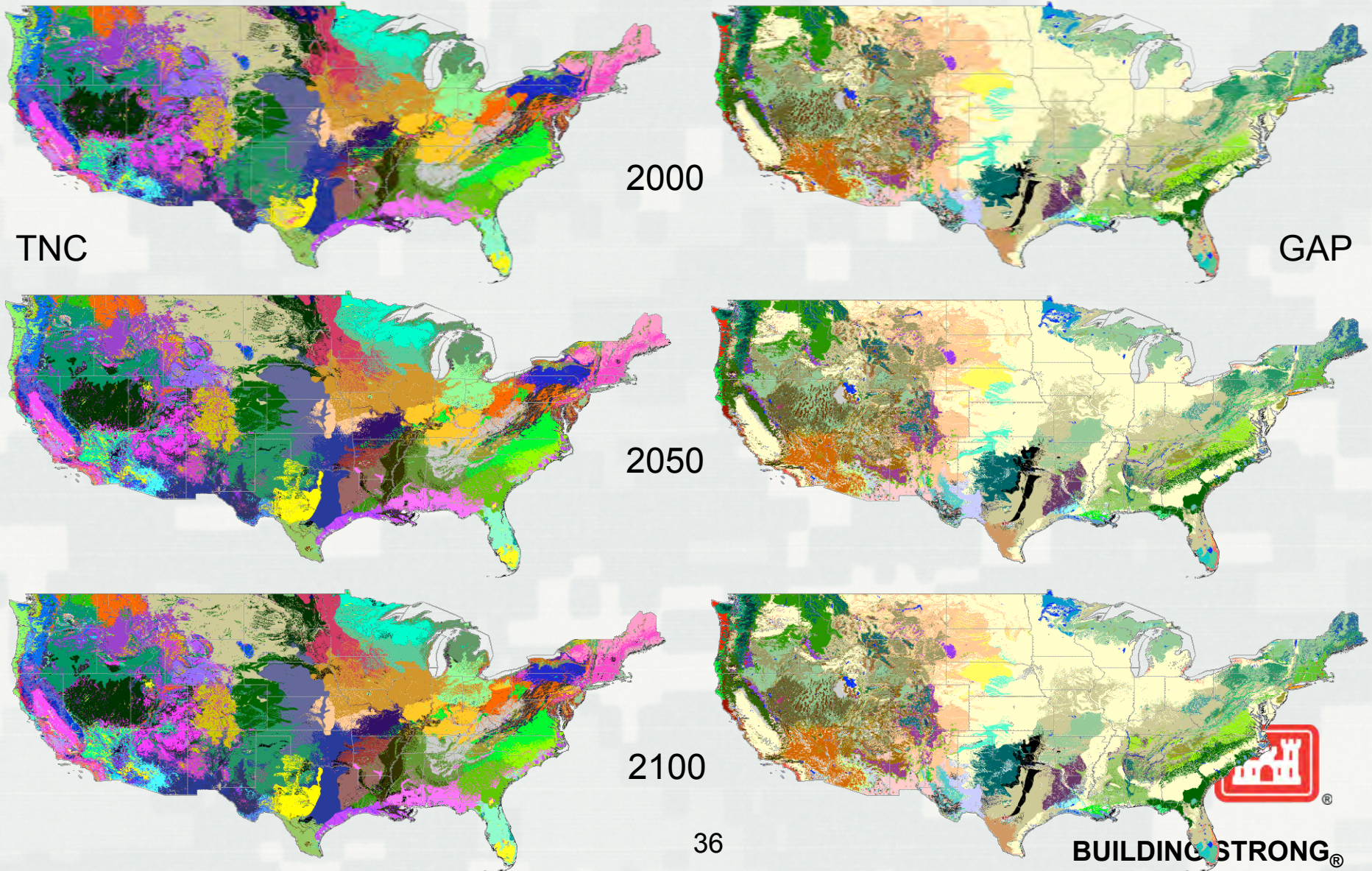


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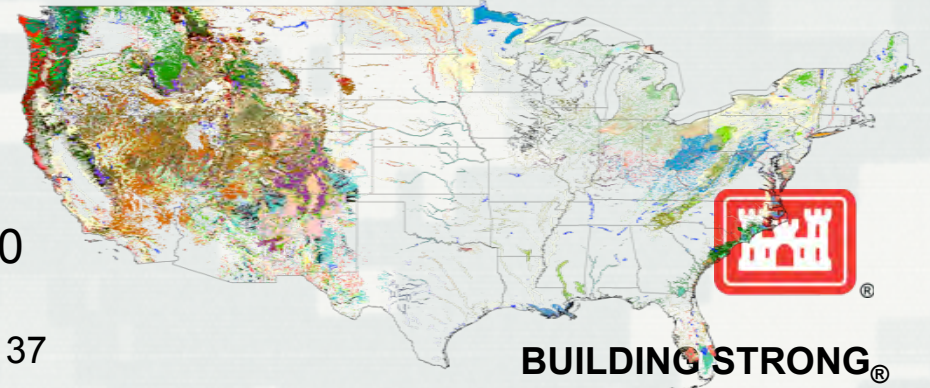
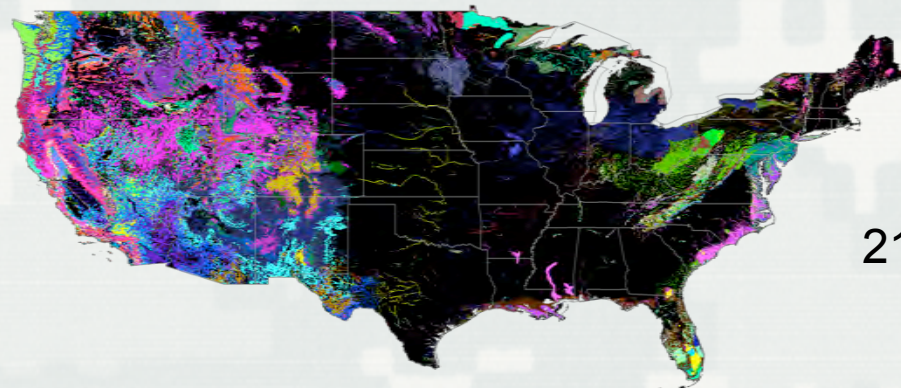
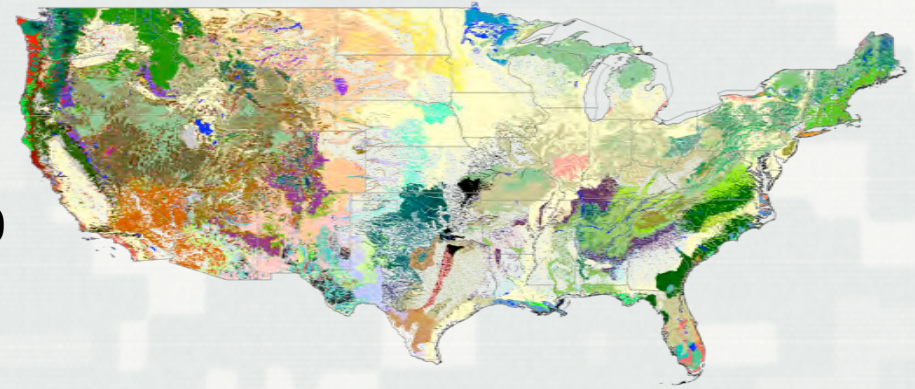
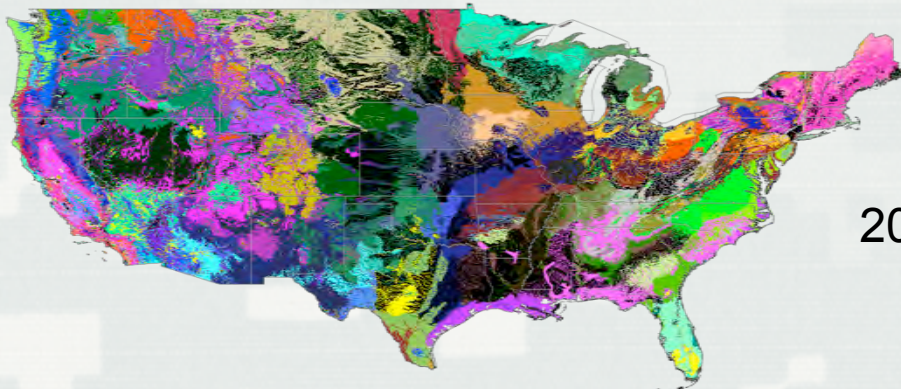
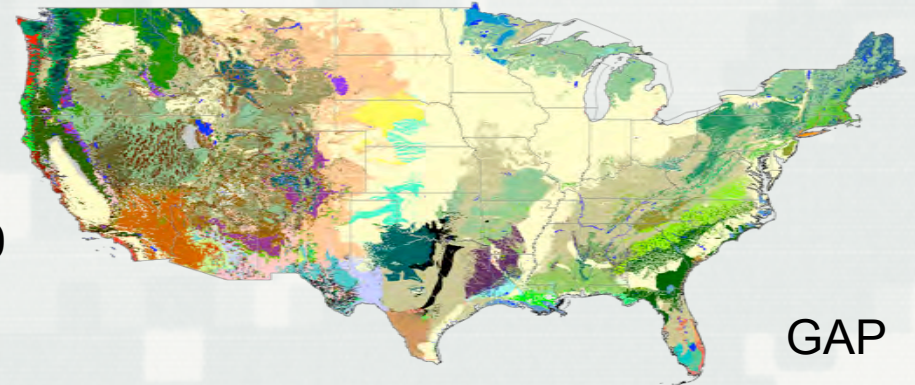
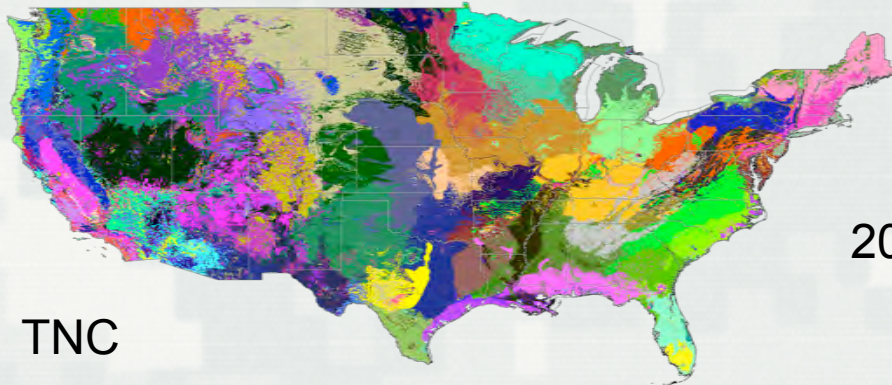
Correlate Clusters with Ecosystems



PCM model – B1 scenario (low-low)



Hadley model – A1 scenario (high-high)



Discussion

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



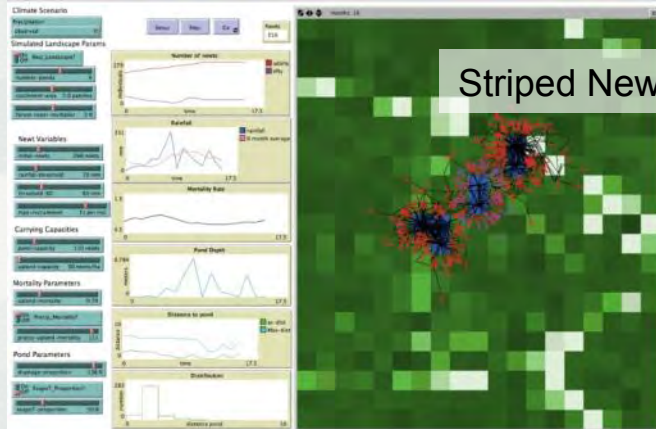
Next?

Two parts:

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

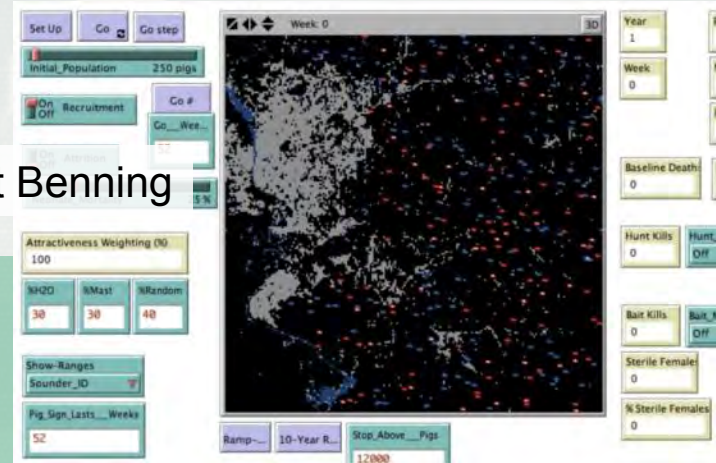


Some Ecological Sim Models

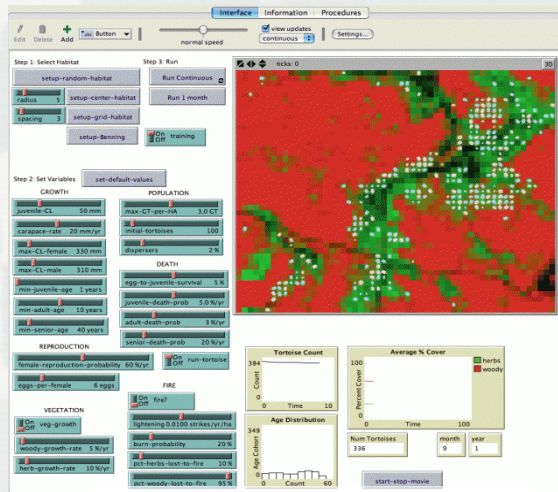


Striped Newt, Ft. Stewart

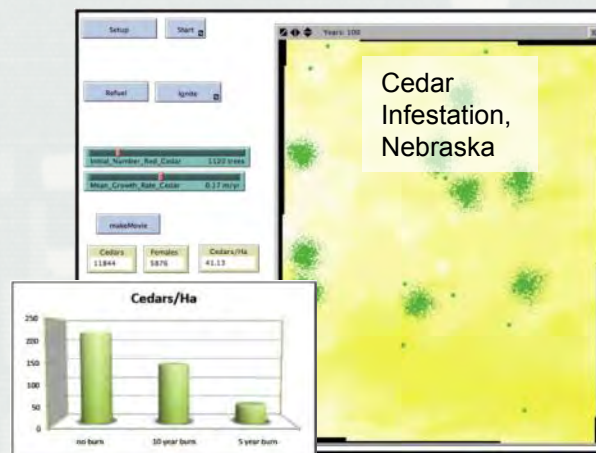
Feral Hogs, Fort Benning



- Quick
- Spatial
- Agent-based



Gopher Tortoise, Ft. Benning



Cedar Infestation, Nebraska



Fire Ants and Cave Crickets, Ft Hood



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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>

