

# Sprawl: A regional model for urban growth

North Atlantic Landscape Conservation Cooperative (LCC)

Science Seminar

Hadley, Massachusetts

Dec 14, 2017

Ethan Plunkett, Kevin McGarigal, Bradley Compton,  
William DeLuca, Joanna Grand, Liz Willey





1984





1990





1995





2000



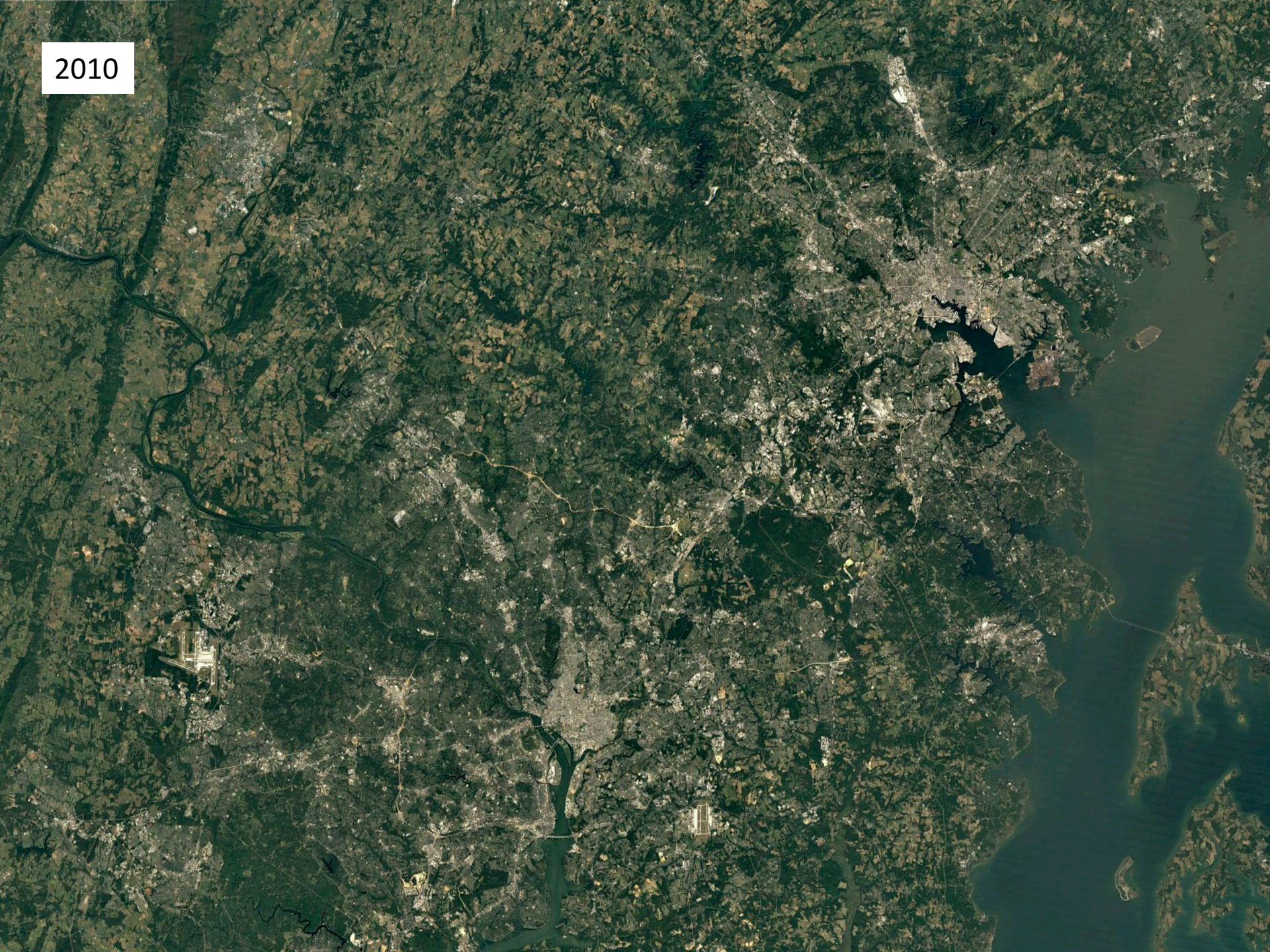


2005



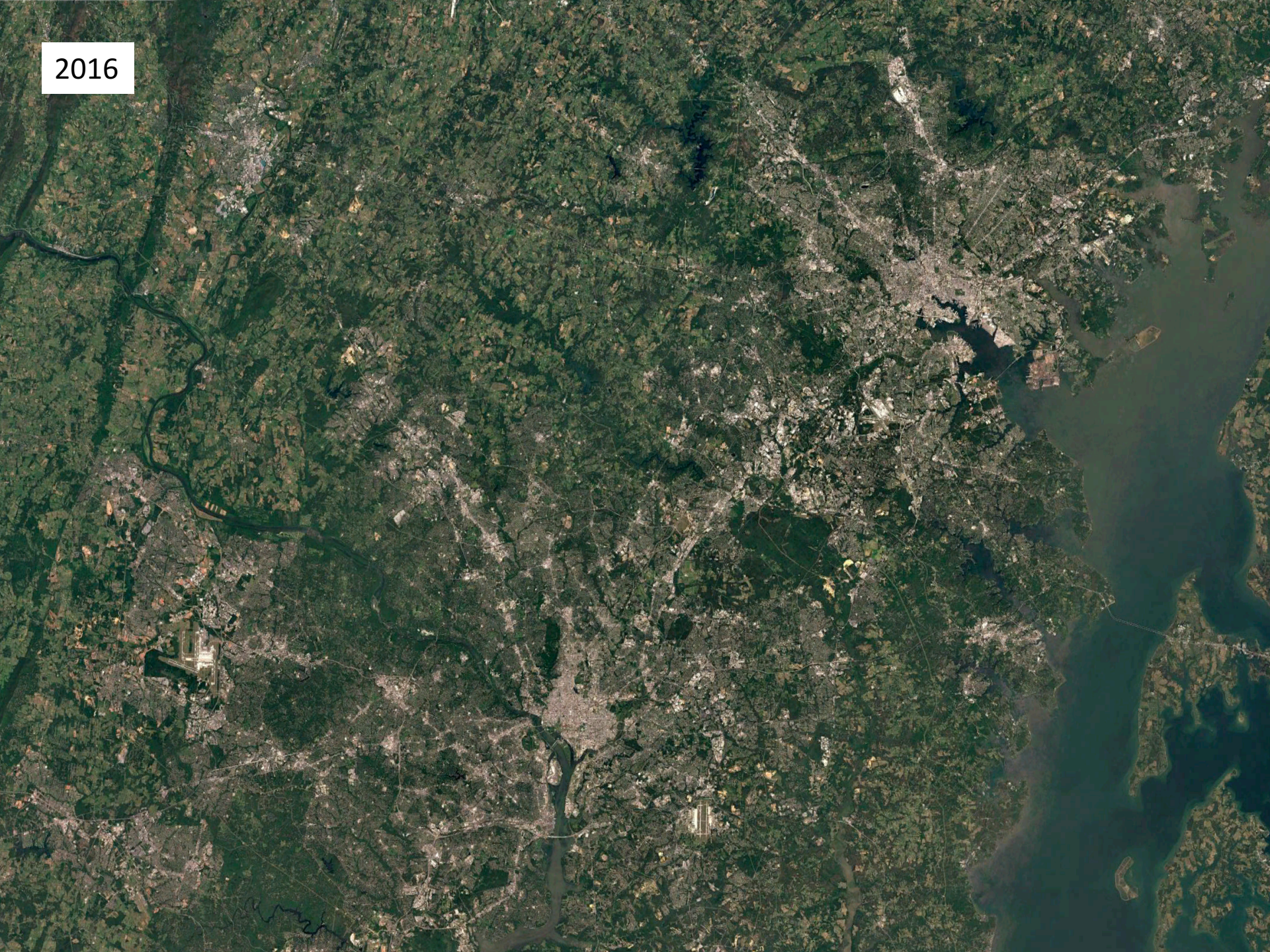


2010





2016



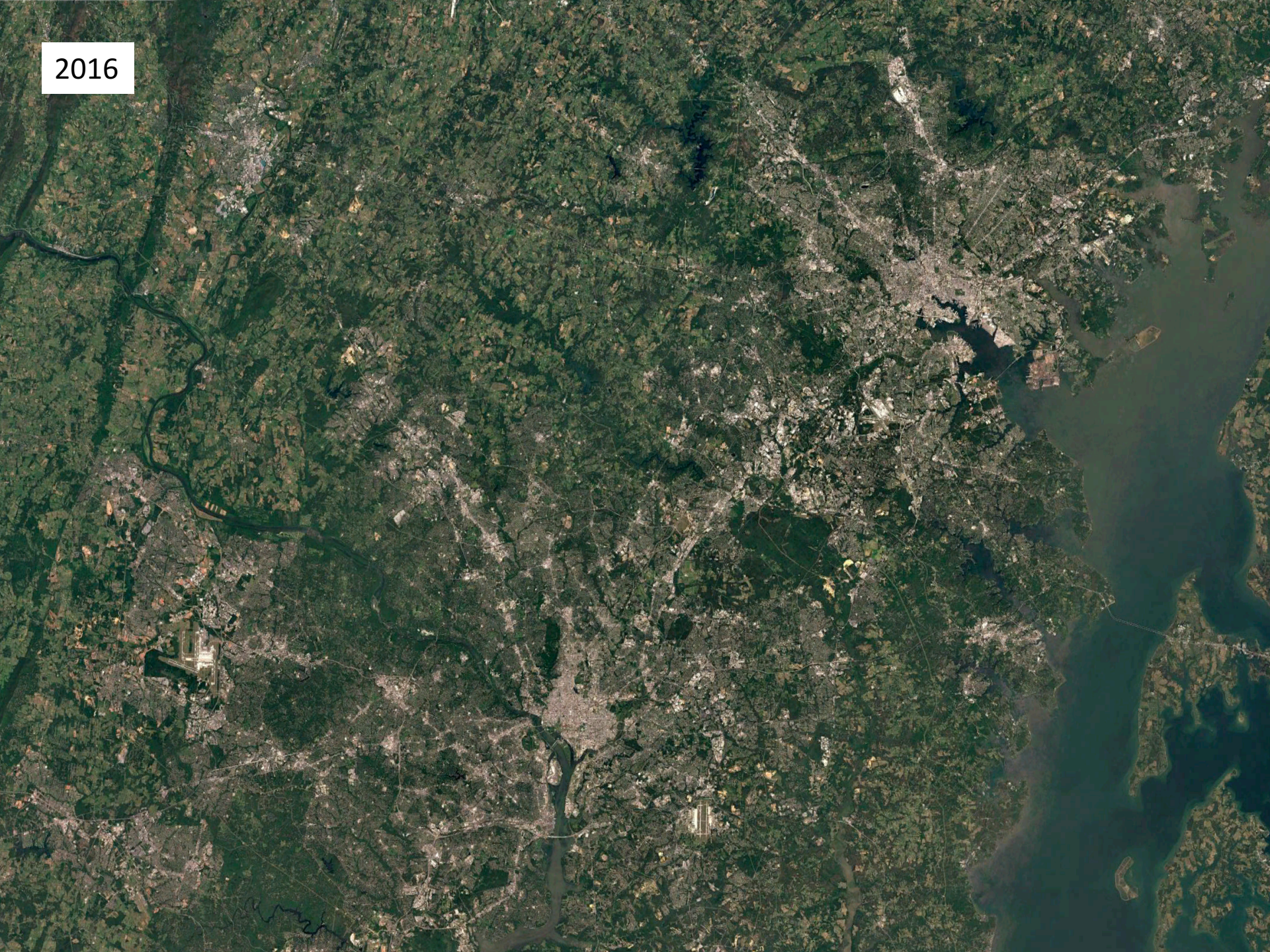


1984





2016

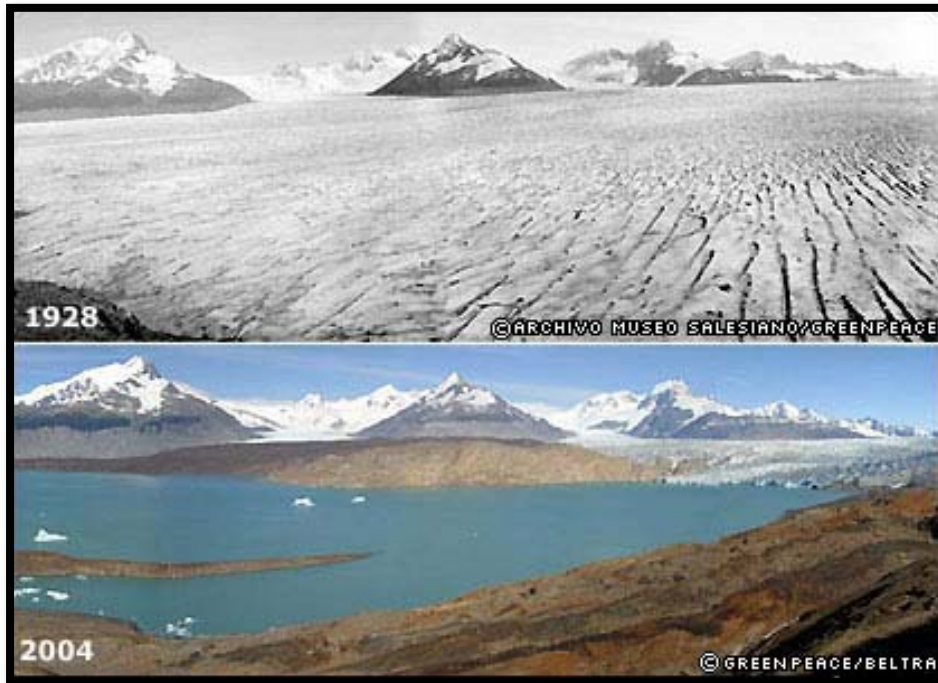




# Wildlife populations at risk

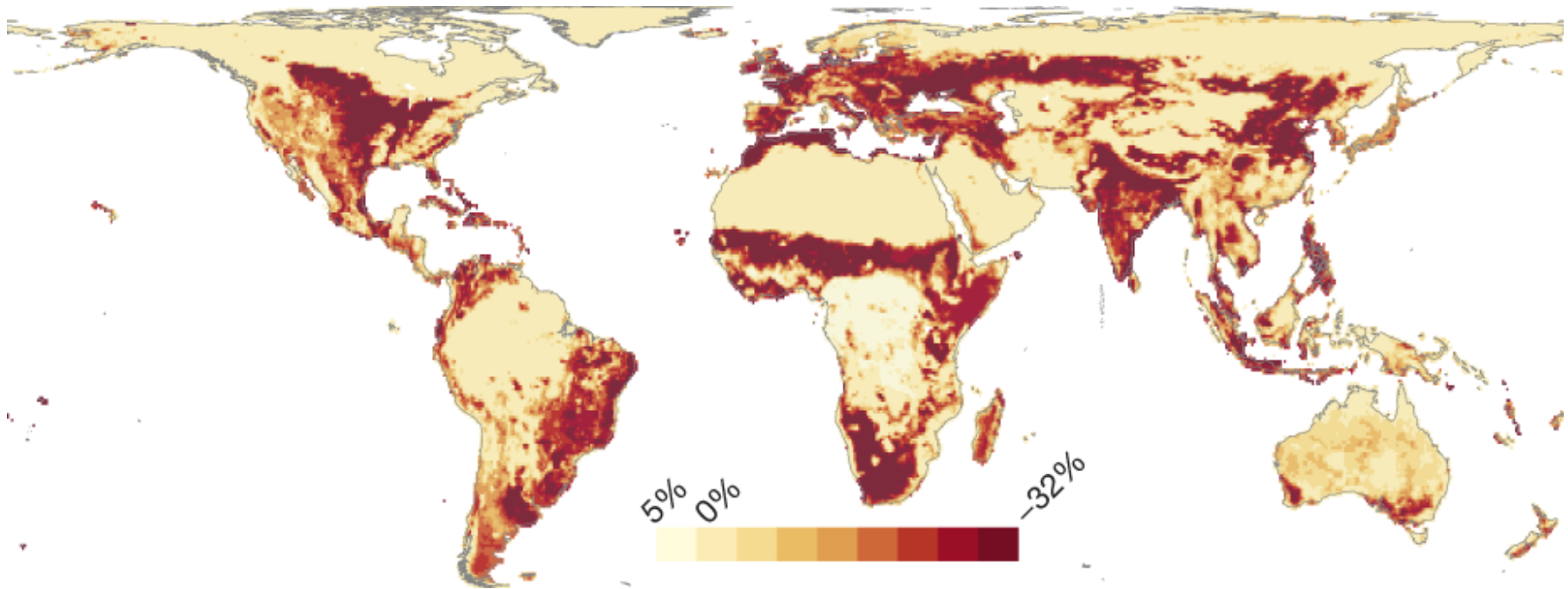
*“Current extinction rates are 1,000 times higher than natural background rates of extinction and future rates are likely to be 10,000 times higher.”*

De Vos et al., Cons. Bio. 2014





Net change in local richness caused by land use and related pressures by 2000.

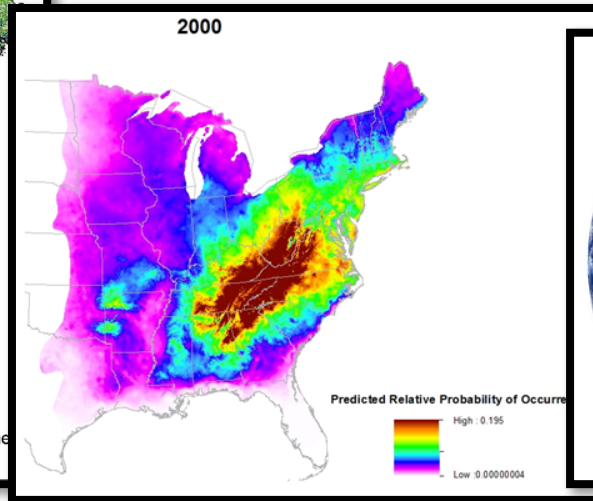
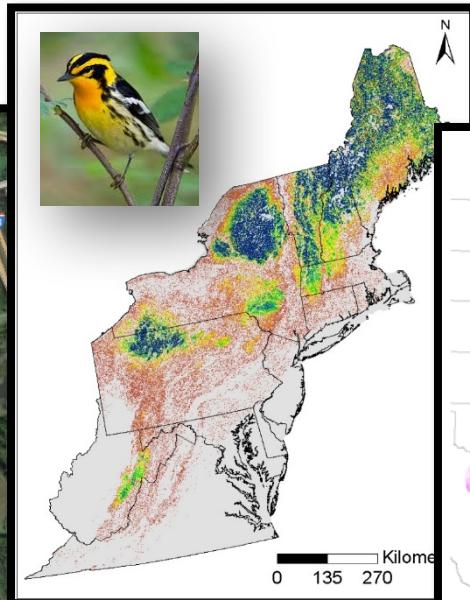
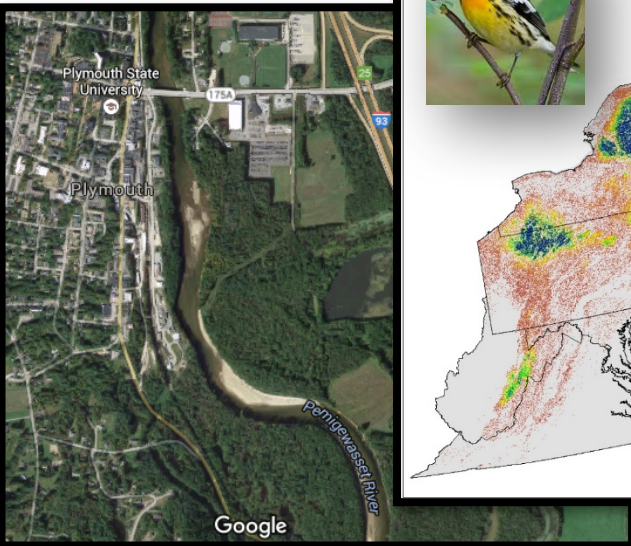




# Complex conservation solutions

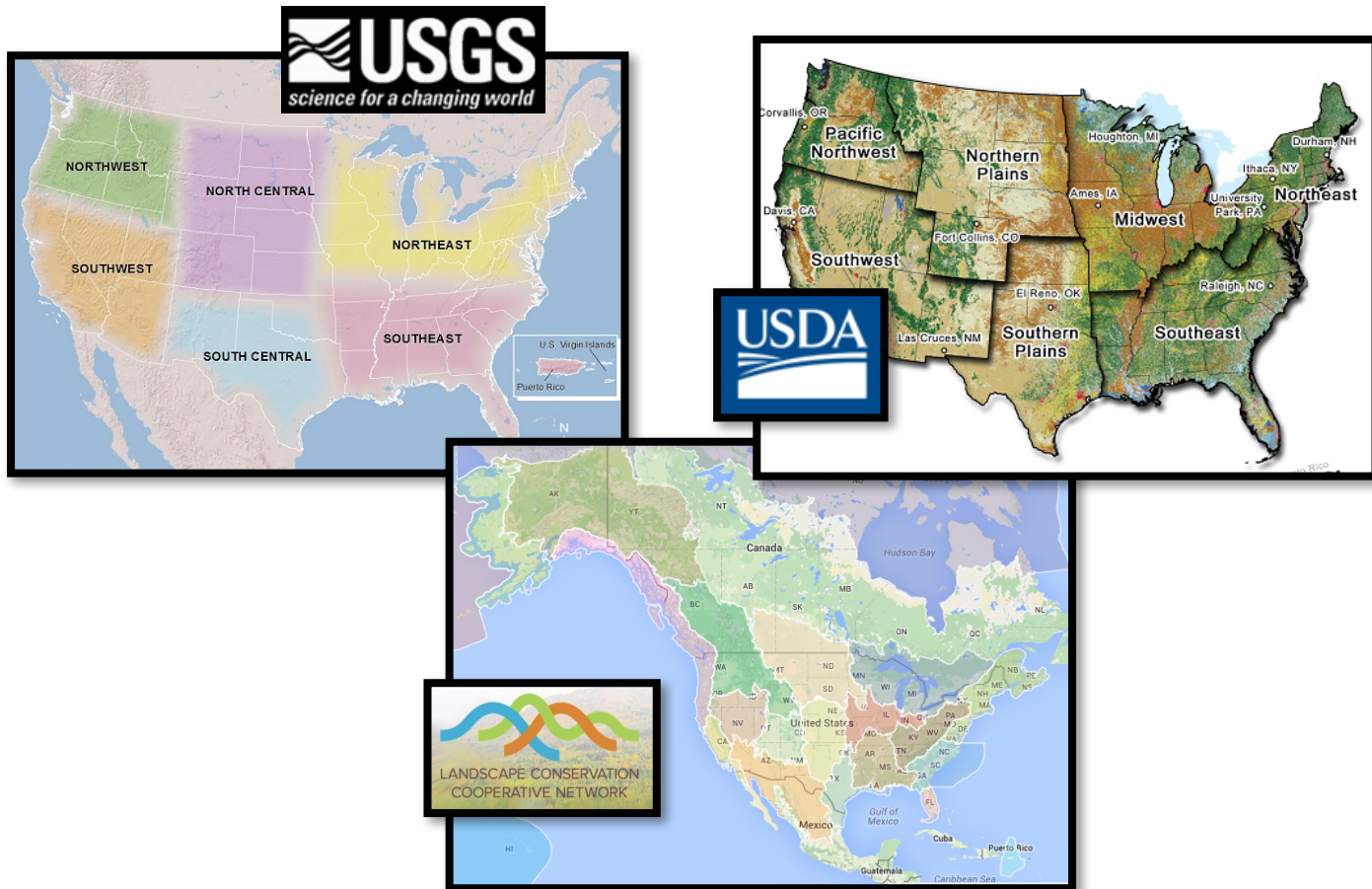
## Expand spatial boundaries

- Large-scale approaches
- Multi-scale approaches



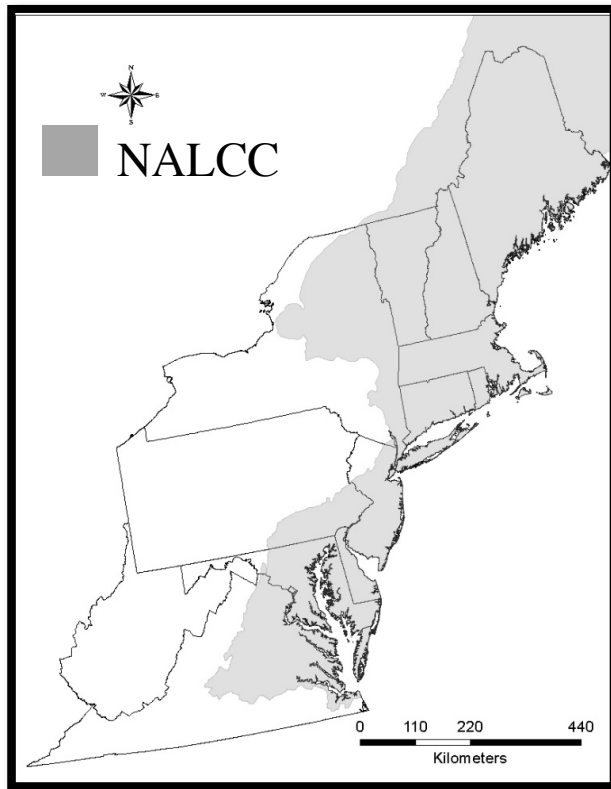


# Complex conservation solutions





# North Atlantic Landscape Conservation Cooperative



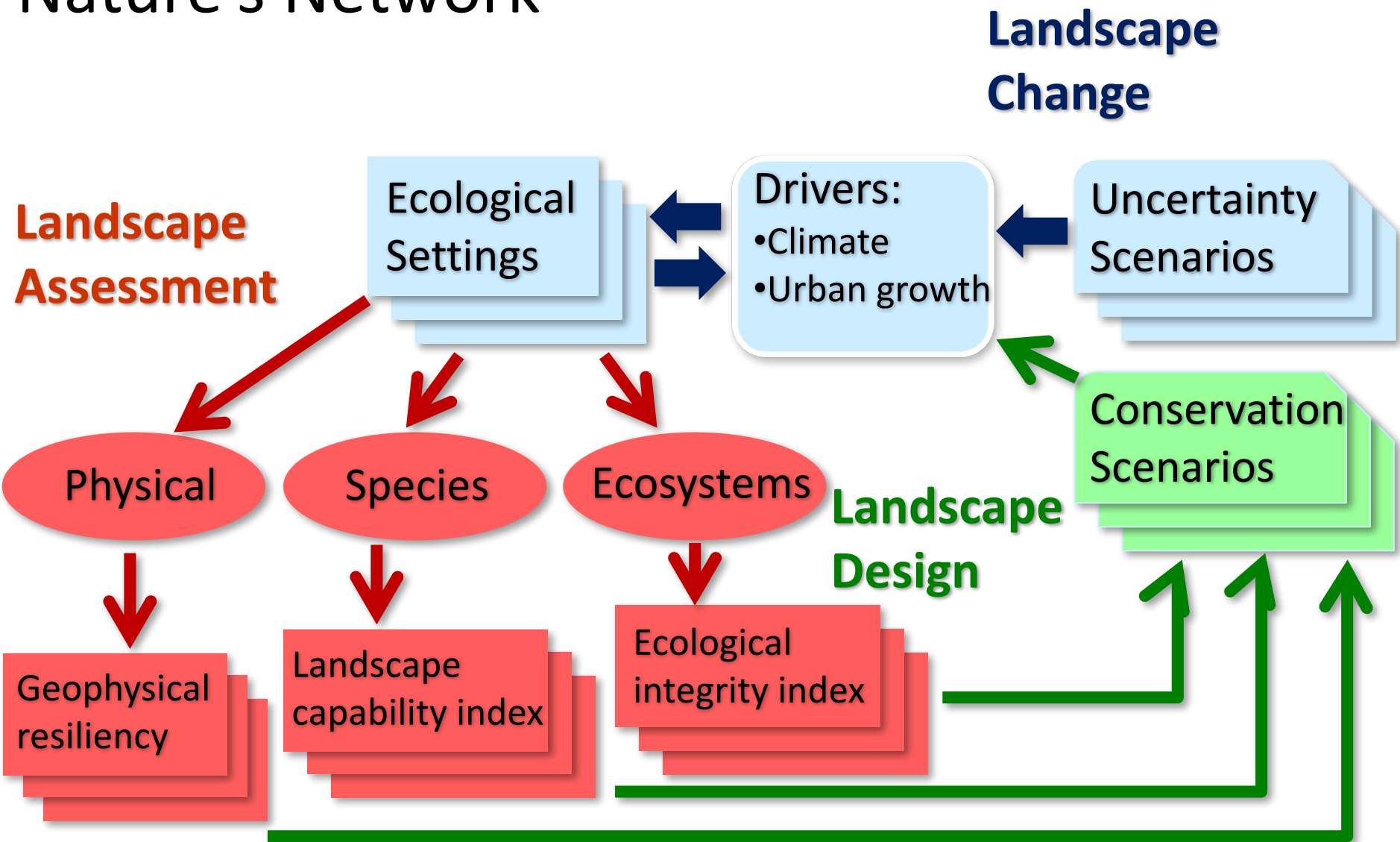
## Designing Sustainable Landscapes Project

- **Assess the capability of current and potential future landscapes in the Northeast to provide integral ecosystems and suitable habitat for a suite of representative species, and provide guidance for strategic habitat conservation**



# Designing Sustainable Landscapes

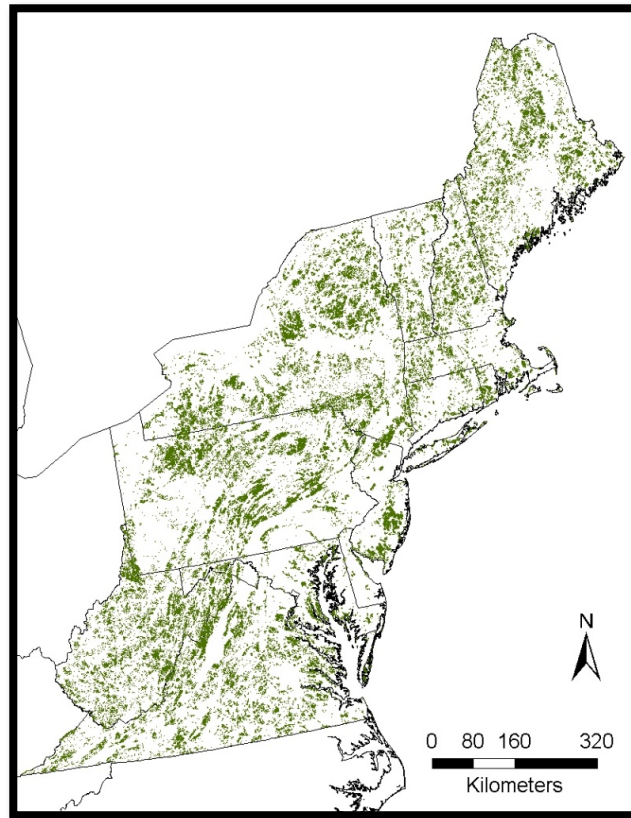
## Nature's Network





# Landscape Conservation Design

## Network of Core Areas and Connectors for the Northeast Region





**Nature's Network**  
Lands and waters sustaining wildlife and people

LEARN MORE ACCESS DATA

Nature's Network is a collaborative effort facilitated by the North Atlantic Landscape Conservation Cooperative that brings together partners from 13 states, the U.S. Fish and Wildlife Service, nongovernmental organizations, and universities to identify the best opportunities for conserving and connecting intact habitats and ecosystems and supporting imperiled species to help ensure the future of fish and wildlife across the Northeast region.

Terrestrial Habitat Imperiled Species Aquatic Habitat Connectivity Nature's Network Conservation Design

- Habitat needs for more than 3,000 species of animals and plants, including those identified as Species of Greatest Conservation Need (SGCN) in Wildlife Action Plans revised by states in 2015, and 30 species representing hundreds more with similar sensitivities, lifecycles, and habitat requirements.
- Important areas for the conservation of several hundred common and rare aquatic and terrestrial ecosystem types, and habitat connections needed for species to the landscape.
- Connected networks of intact and diverse terrestrial, wetland, and coastal systems that provide habitat for wildlife and benefits for people, such as access to intact forests and sources of clean water.
- Connected networks of intact and diverse rivers and river systems that provide habitat for resident and anadromous fish — as well as other organisms — and benefits to people, such as recreation and clean water.

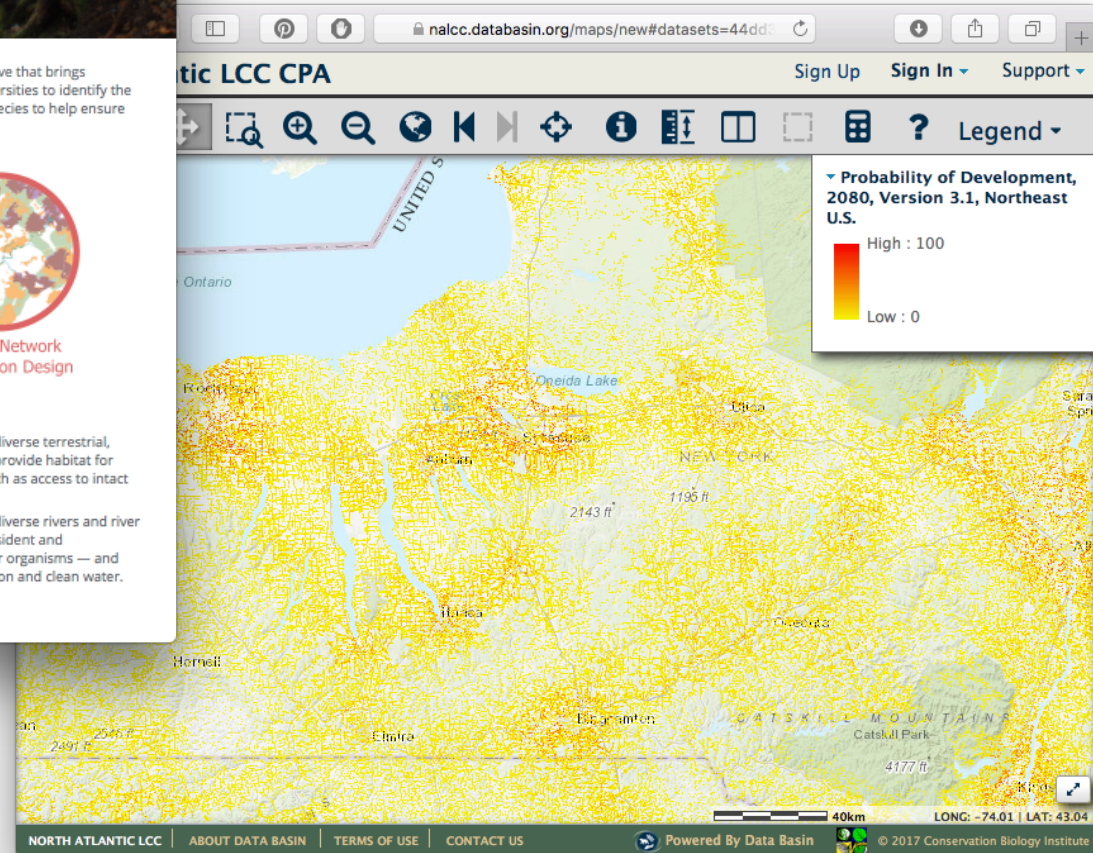
Display a menu

<http://naturesnetwork.org>

Links to probability of development

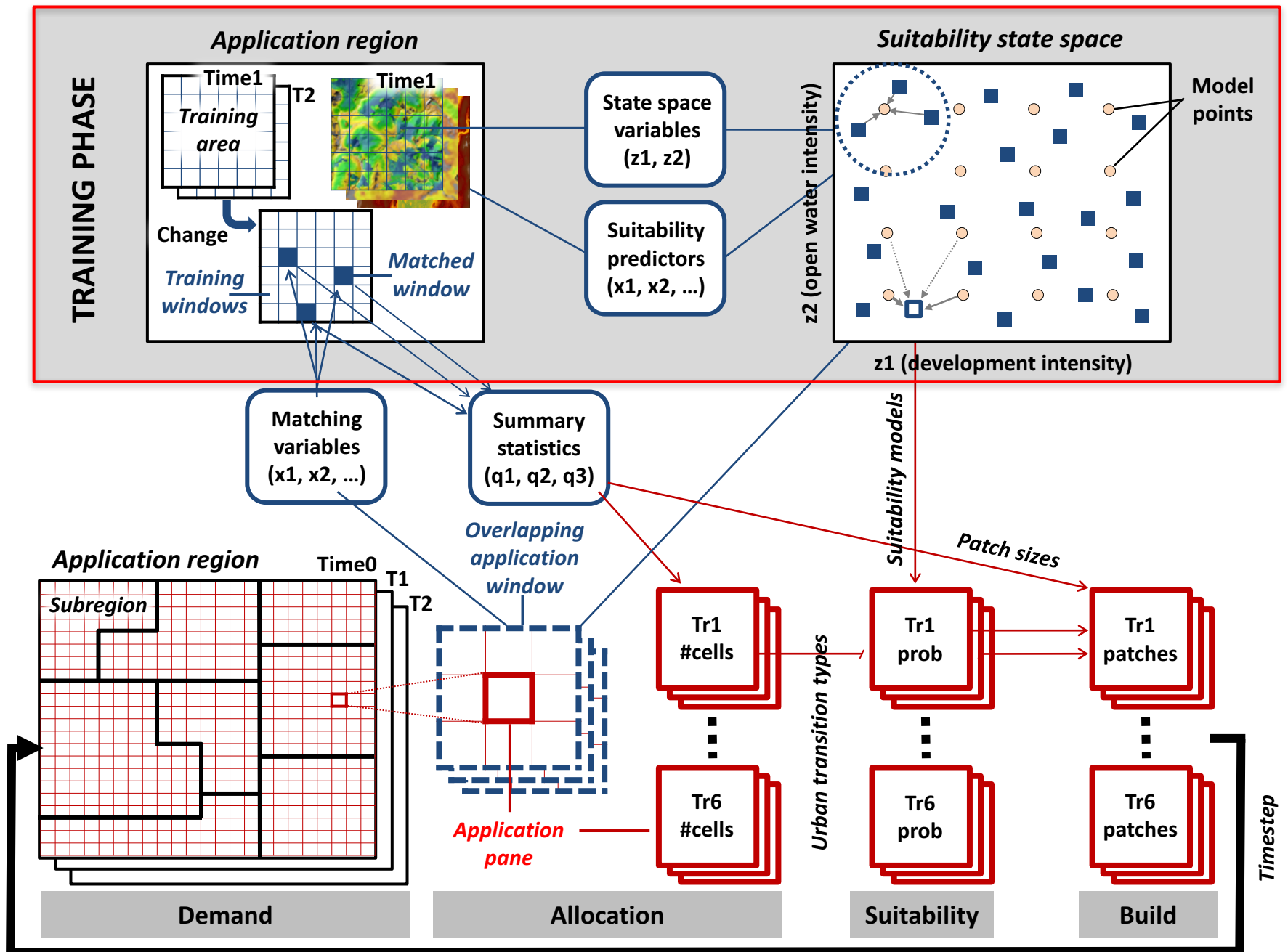
2030 - <https://nalcc.databasin.org/datasets/57ce011b074049d09b86c7213f4b0558>

2080 - <https://nalcc.databasin.org/datasets/44dd387b0aa143b78bc51472bc9bfcf8>





# Urban Growth Model - Overview

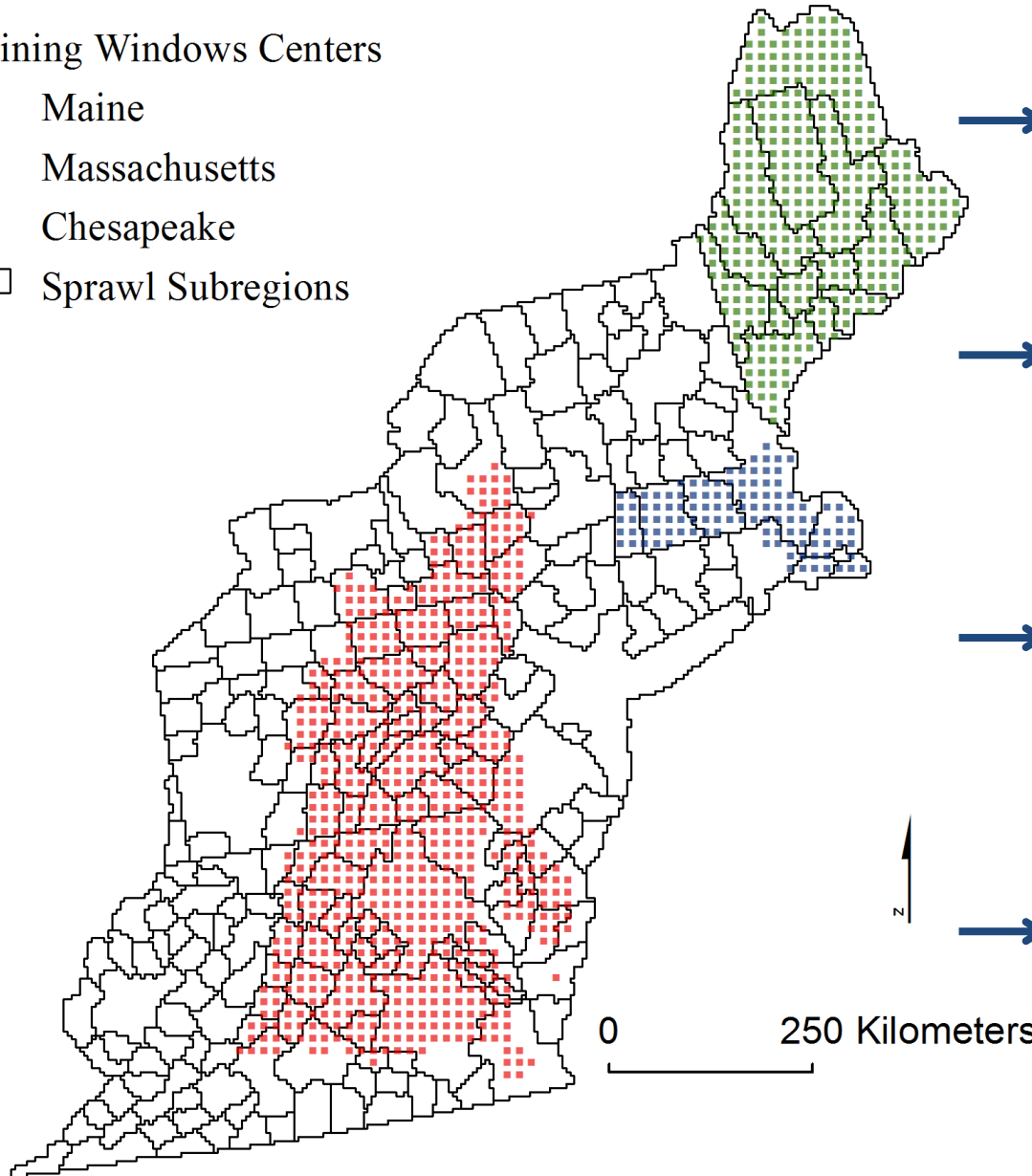




# Urban Growth Model – Training

## Training Windows Centers

- Maine
- Massachusetts
- Chesapeake
- ⊕ Sprawl Subregions



## Summary statistics

Amount of growth  
Patch sizes  
Transition Distribution

## Matching variables

Intensity of Water, Development,  
and Roads (12,800 m);  
and Road Density

## State space variables

Development intensity (12,800 m)  
Open water intensity (12,800 m)

## Suitability predictors

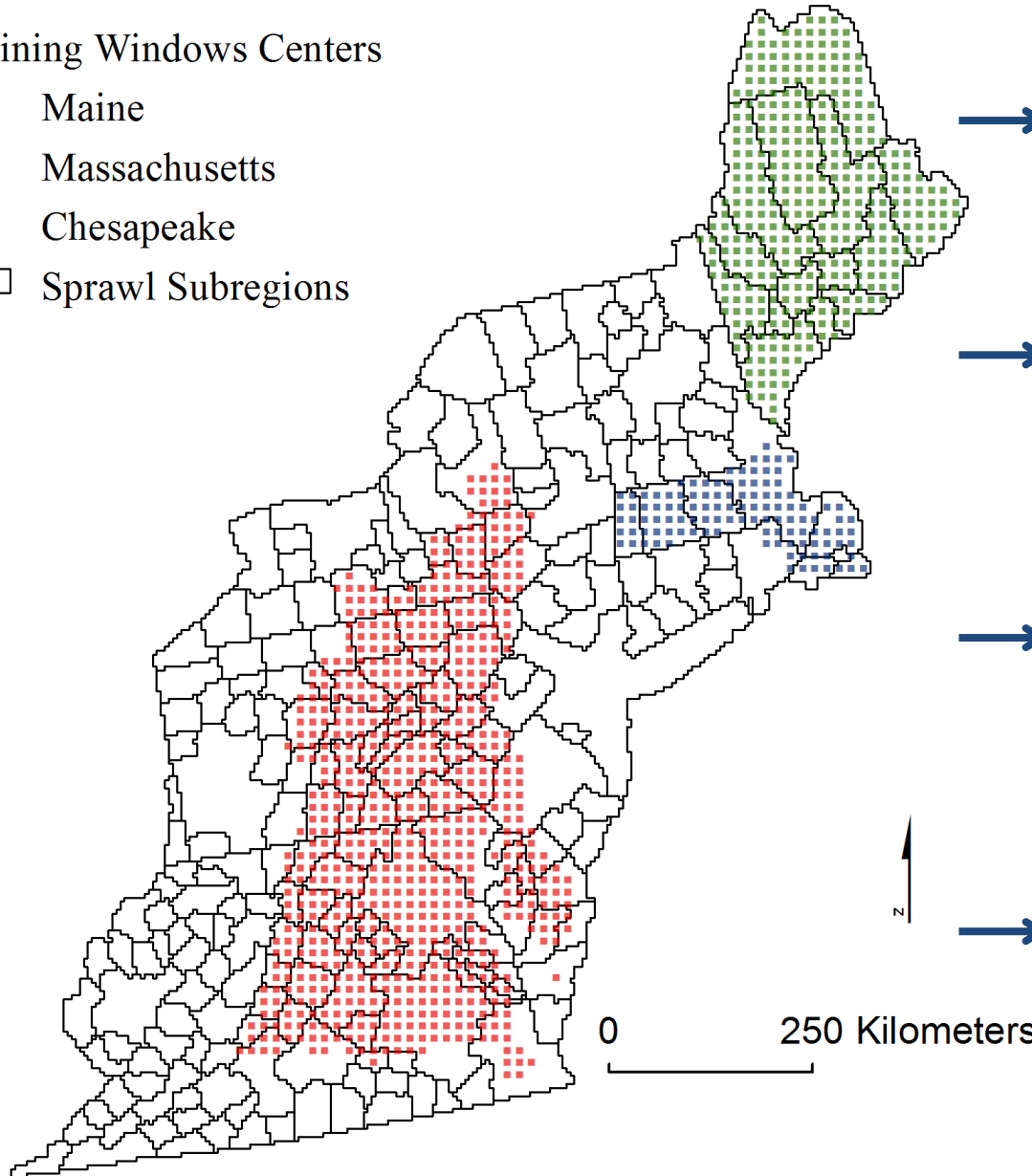
Water (100, 800, 3200 m)  
Big Roads (800 m)  
All Roads (3,200 m)  
Development (400, 3,200 m)  
Slope, Distance to roads



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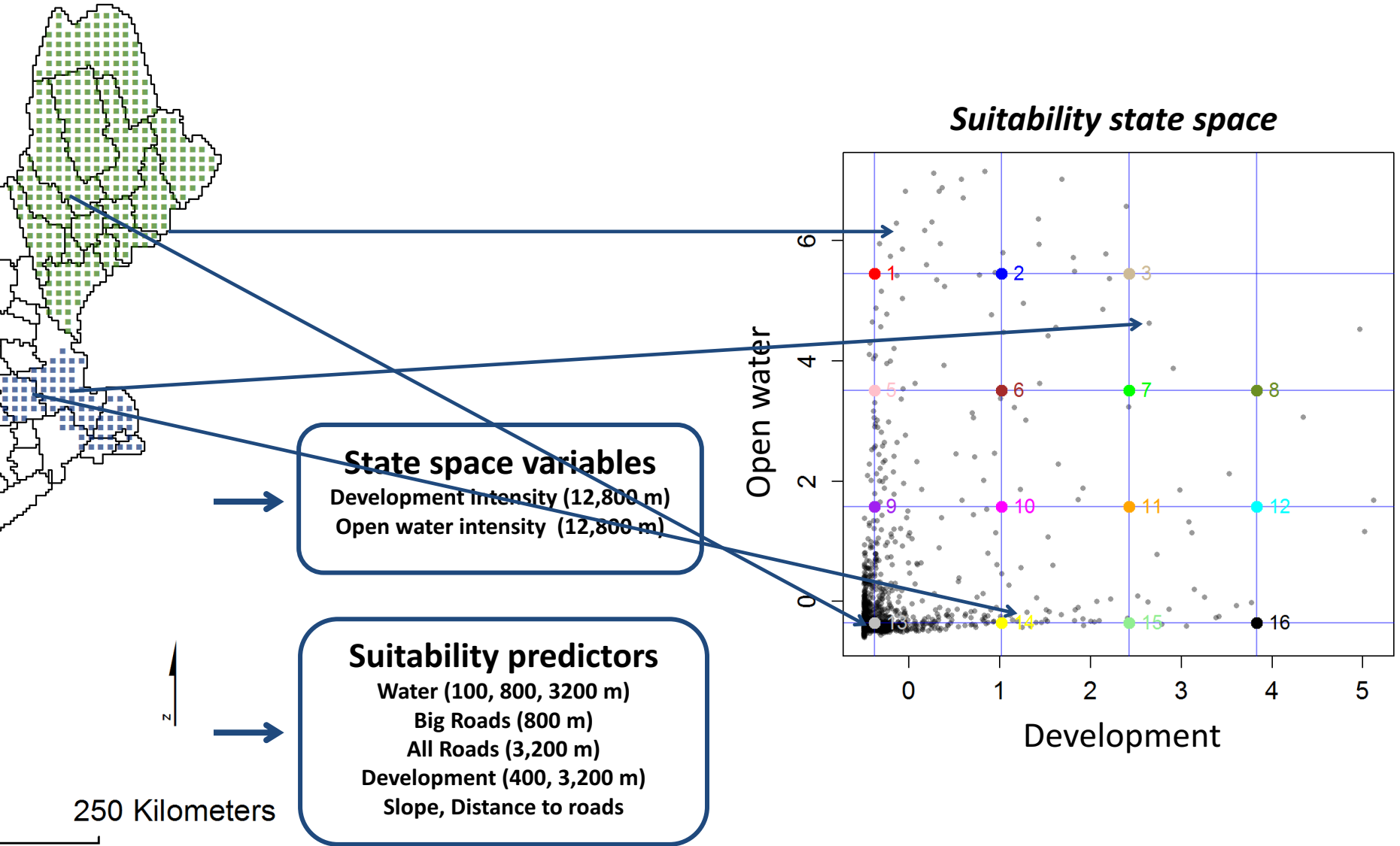
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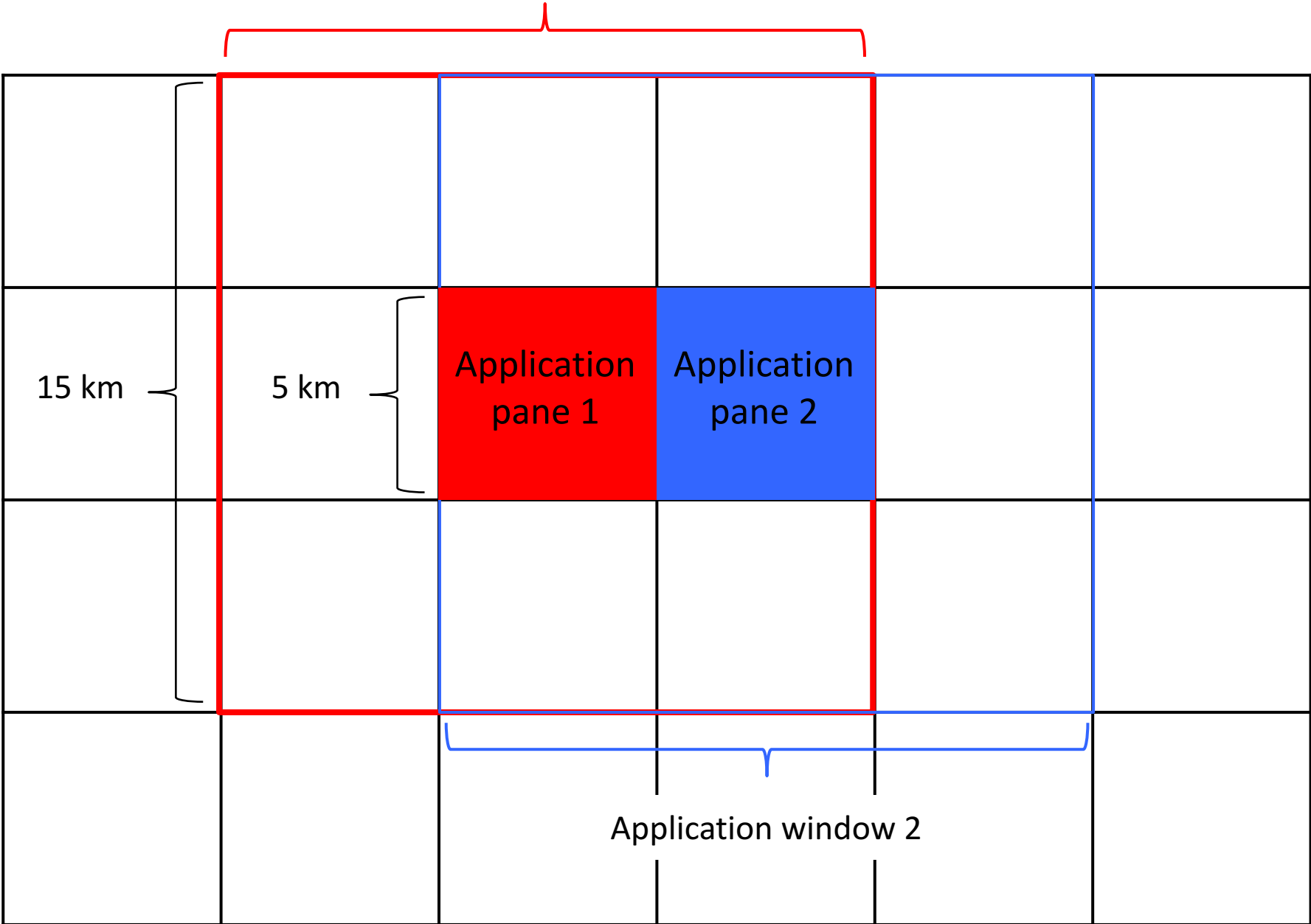
# Urban Growth Model – Training





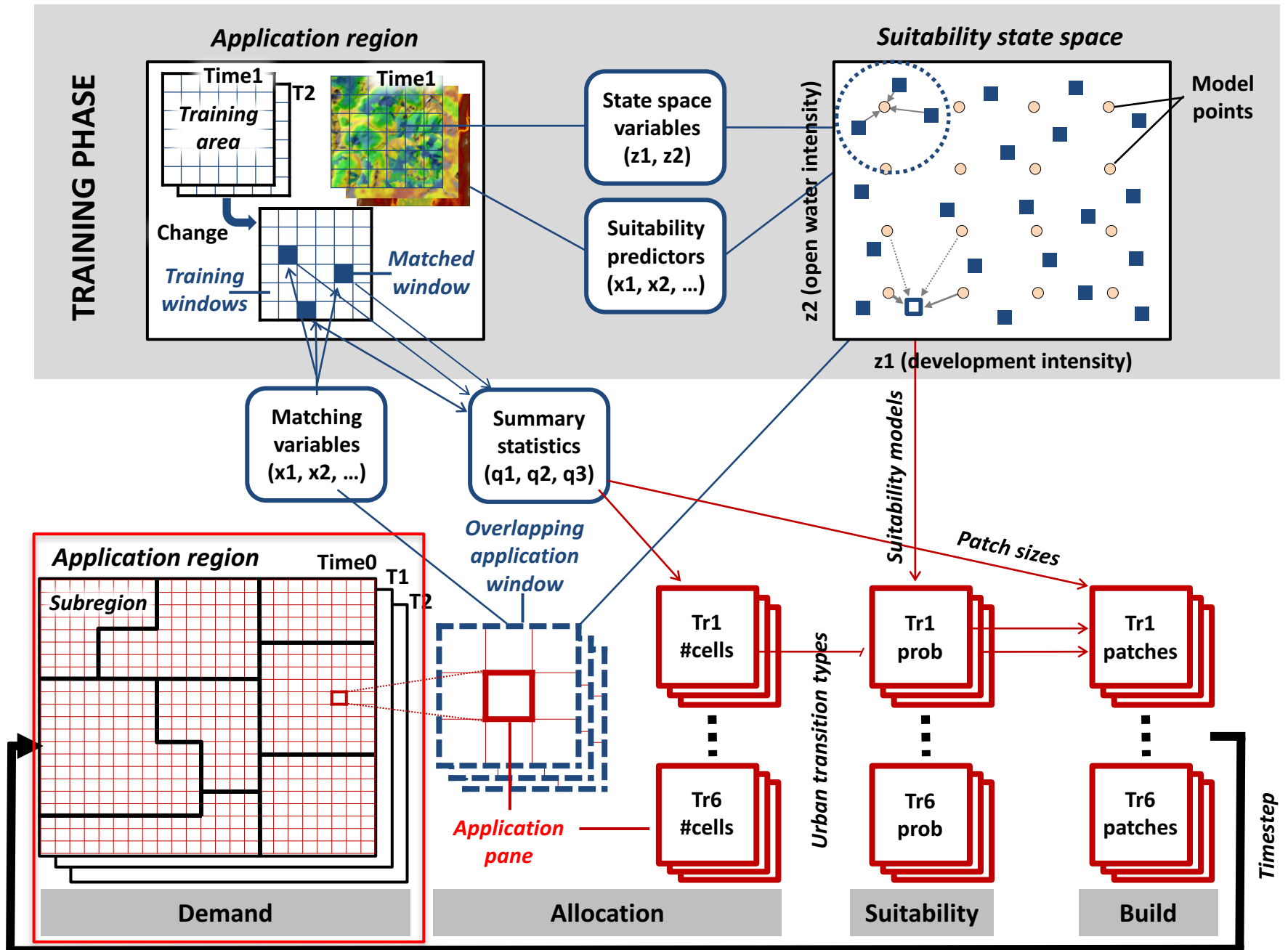
# Urban Growth Model – Application

Application window 1





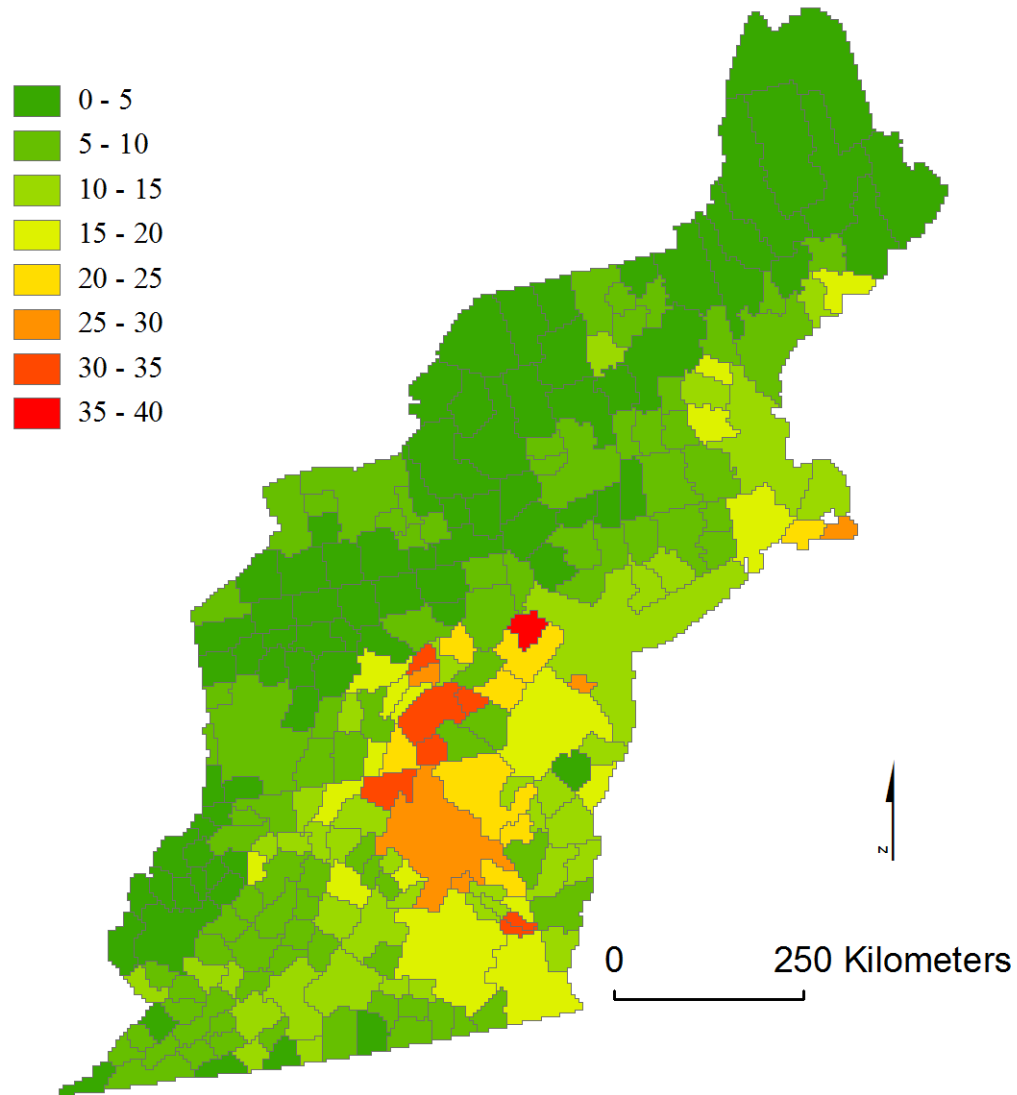
# Urban Growth Model - Overview





# Urban Growth Model - Demand

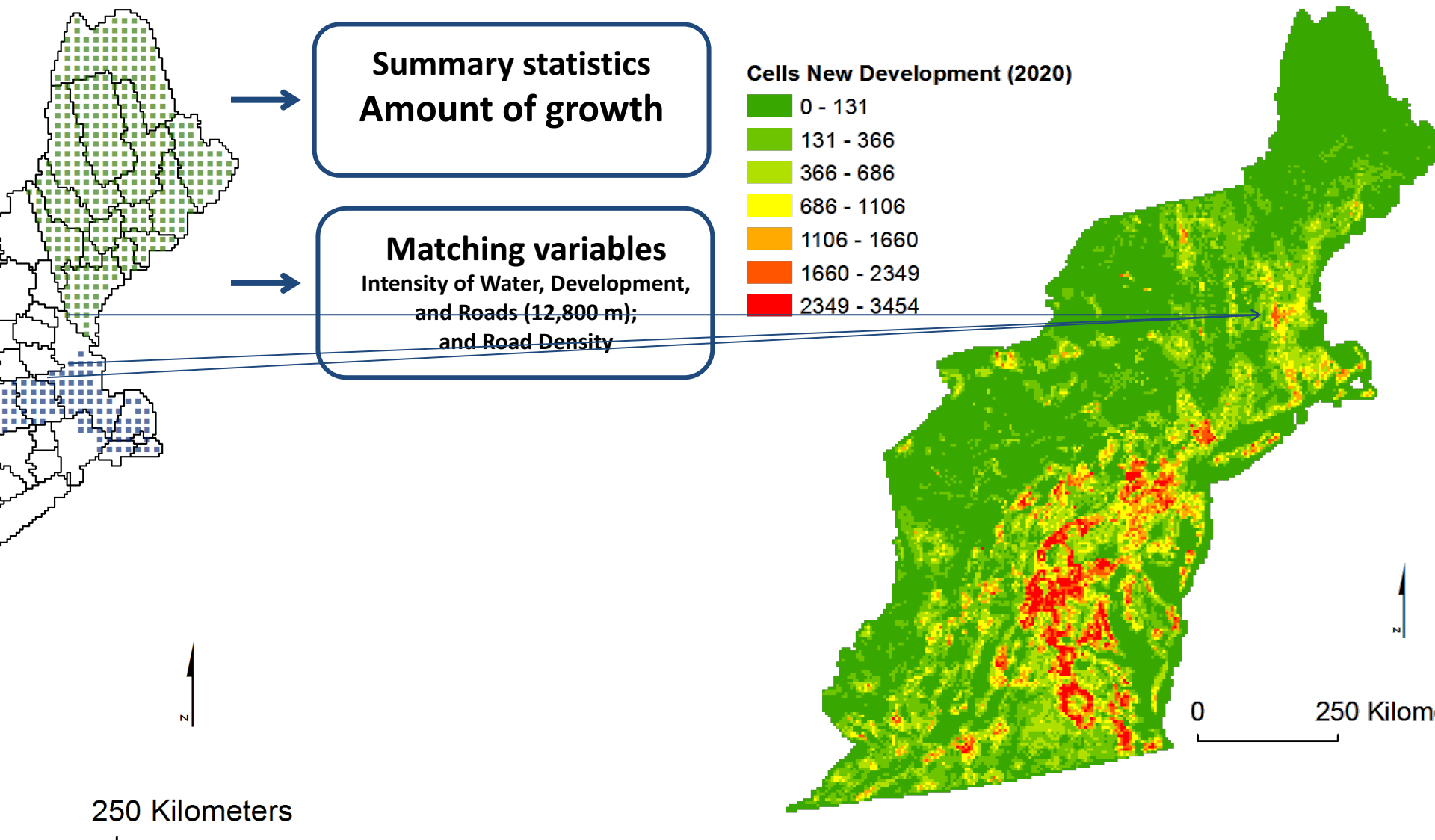
% of land area developed between 2010 and 2080



Wear, D.N. (2011). Forecasts of county-level land uses under three future scenarios: a technical document supporting the Forest Service 2010 RPA Assessment. Gen. Tech. Rep. SRS-141.



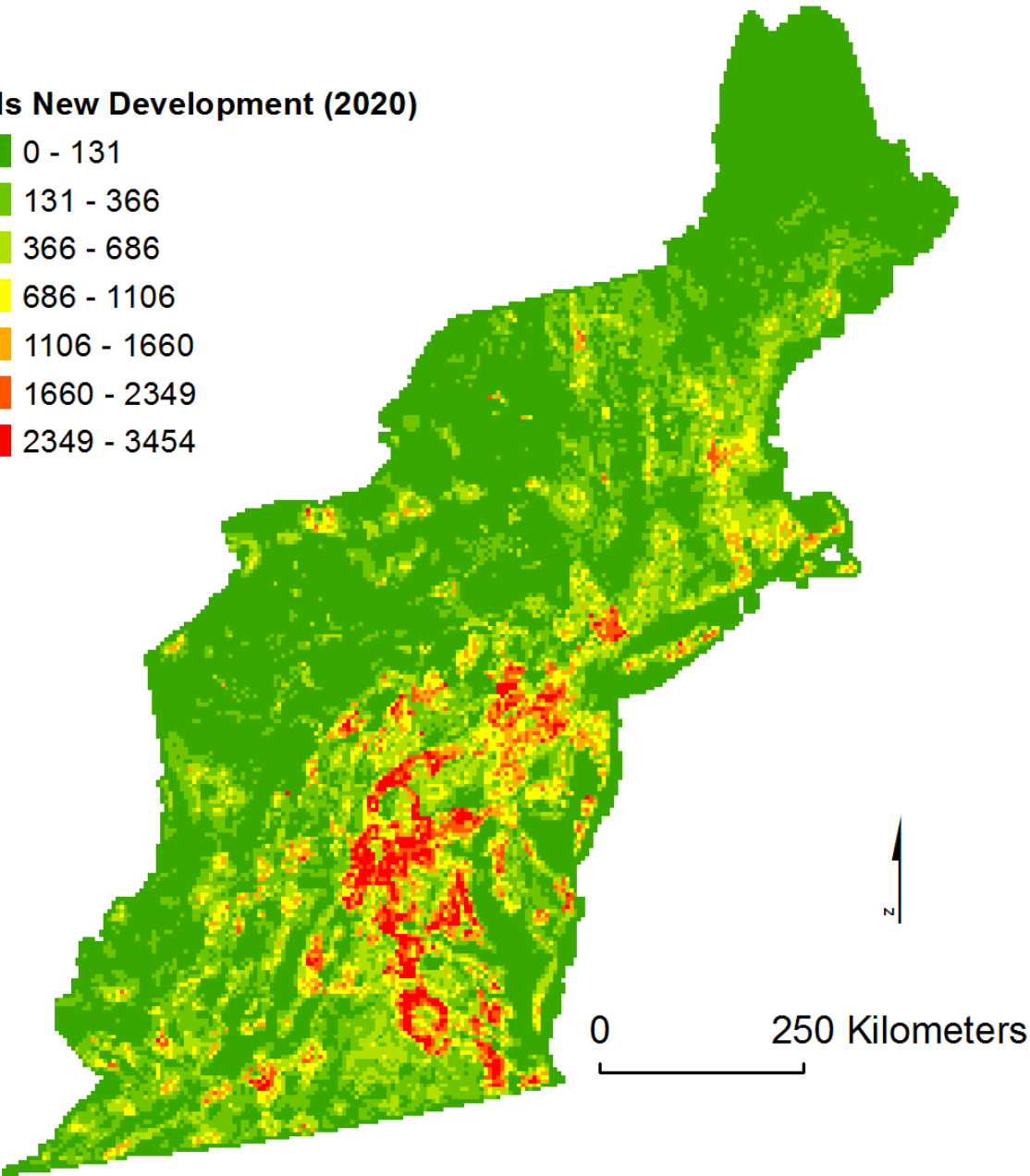
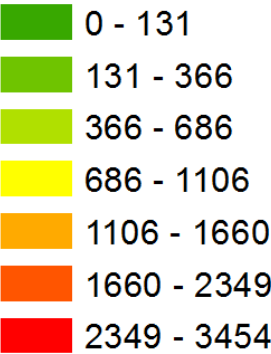
# Urban Growth Model – Allocation





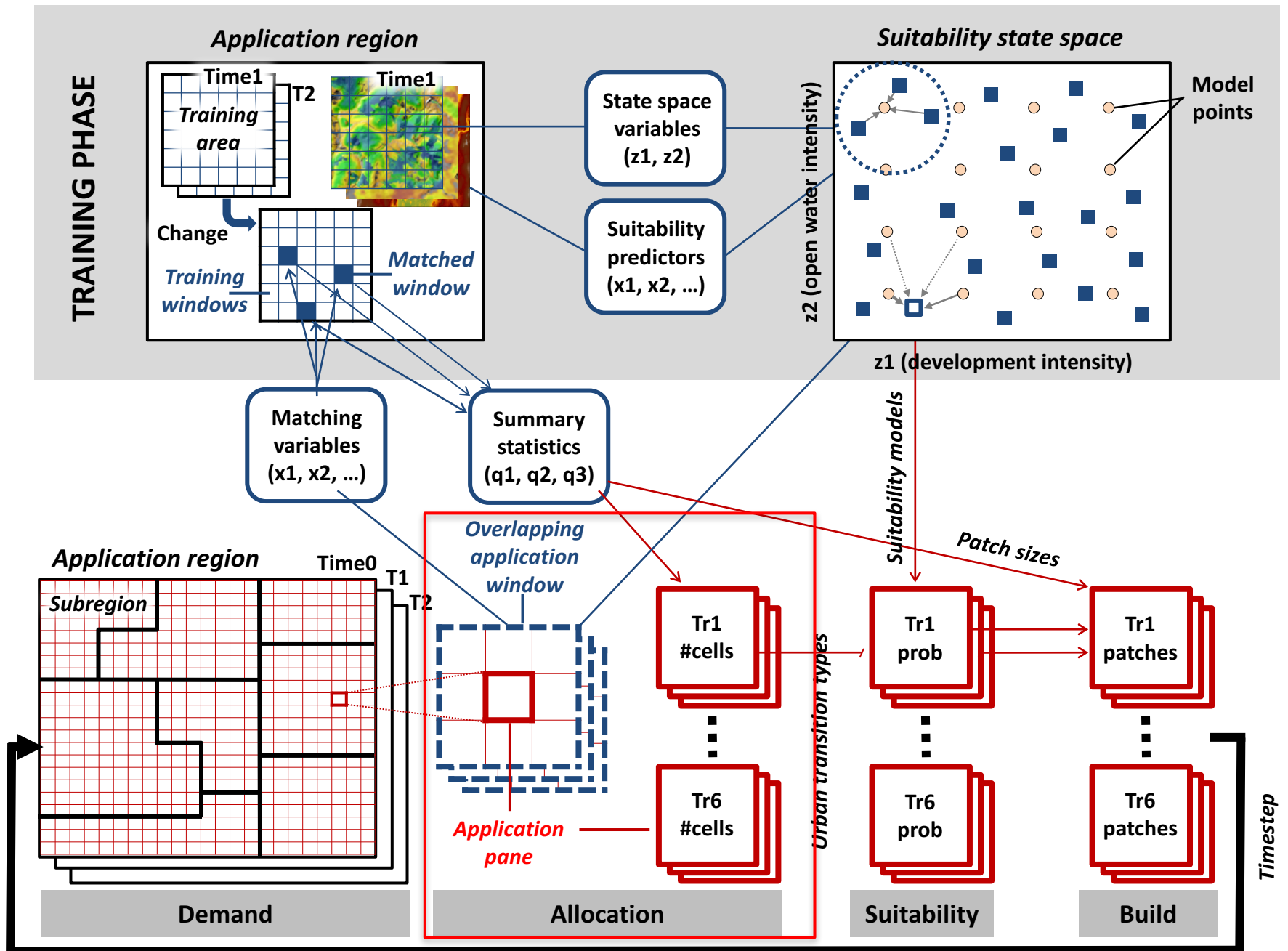
# Urban Growth Model - Allocation

Cells New Development (2020)



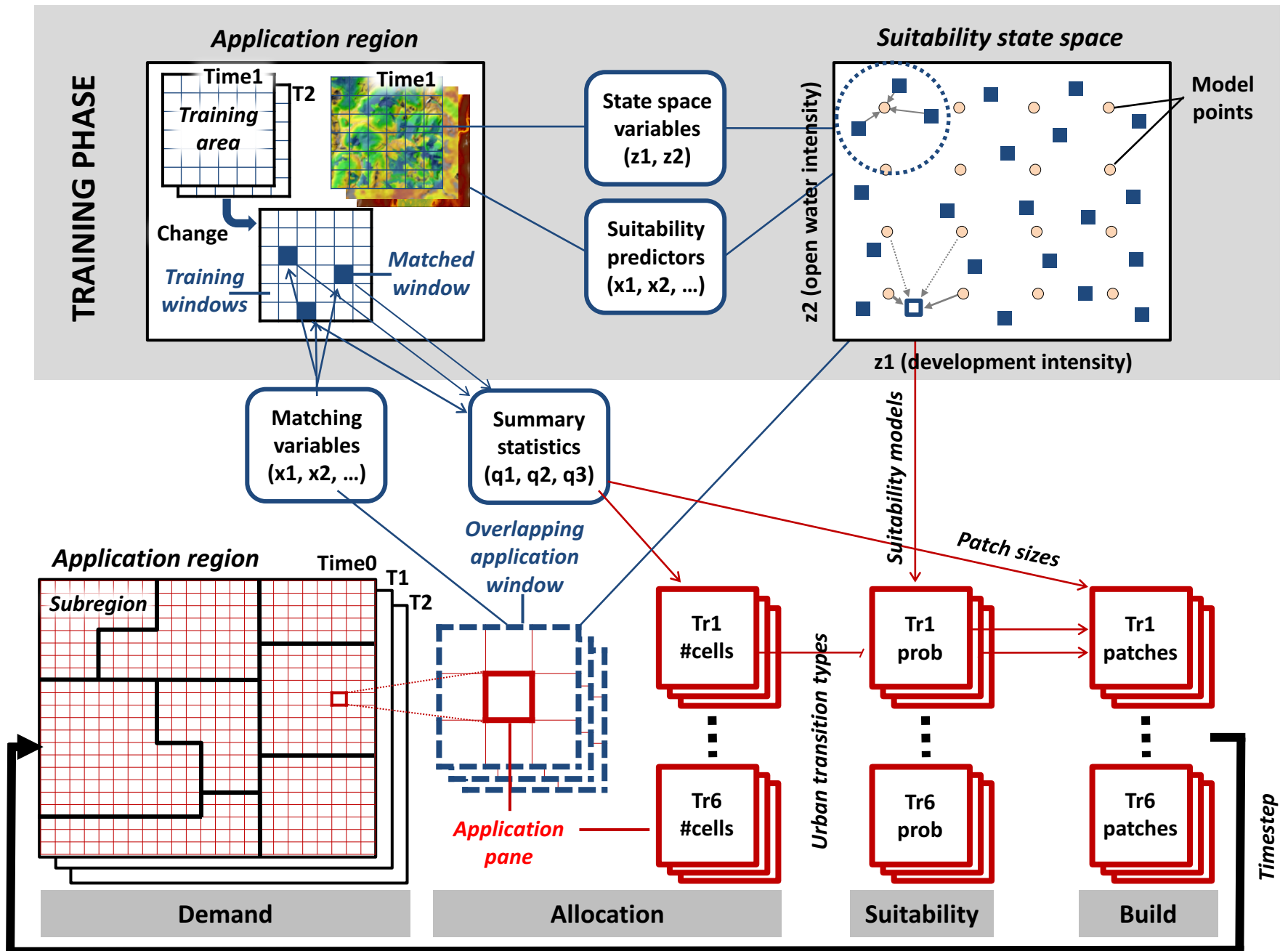


# Urban Growth Model - Allocation



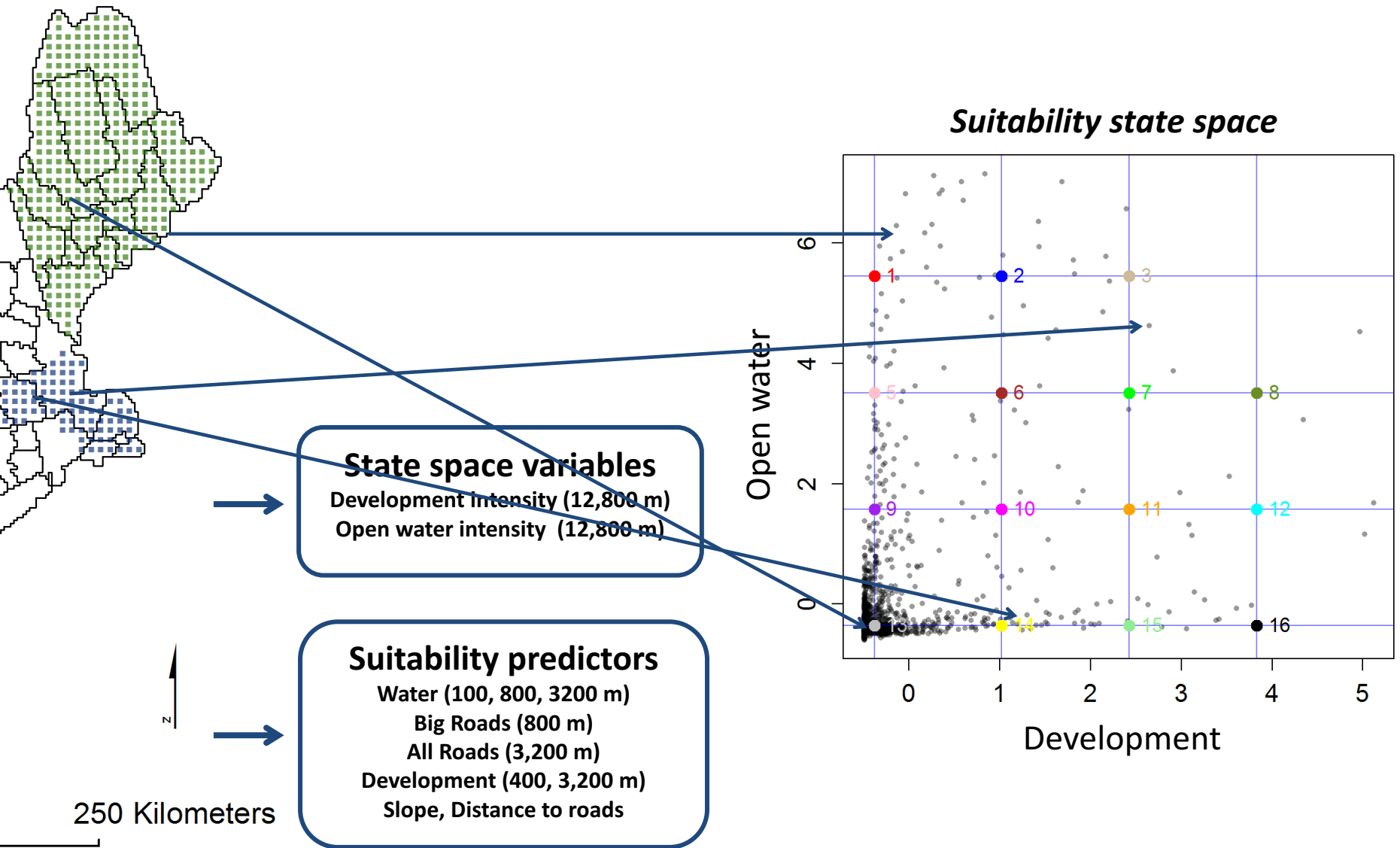


# Urban Growth Model - Suitability





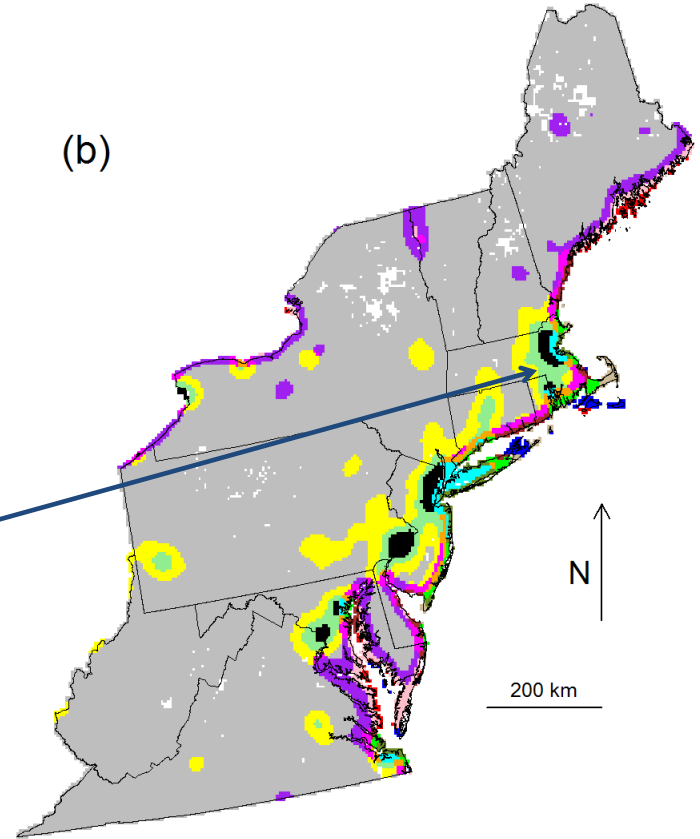
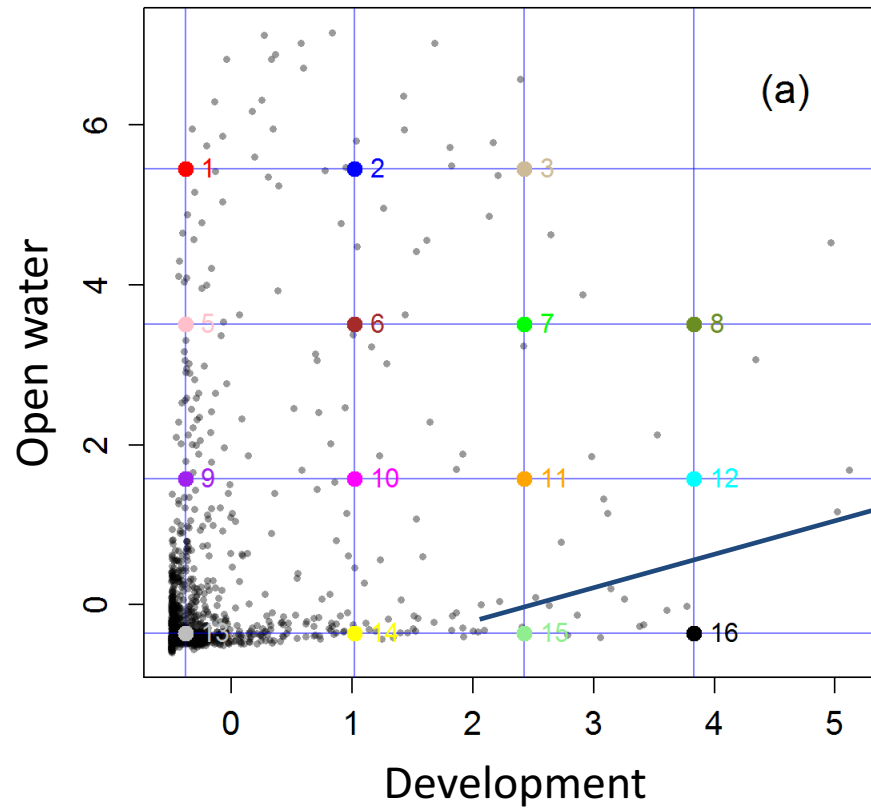
# Urban Growth Model – Suitability





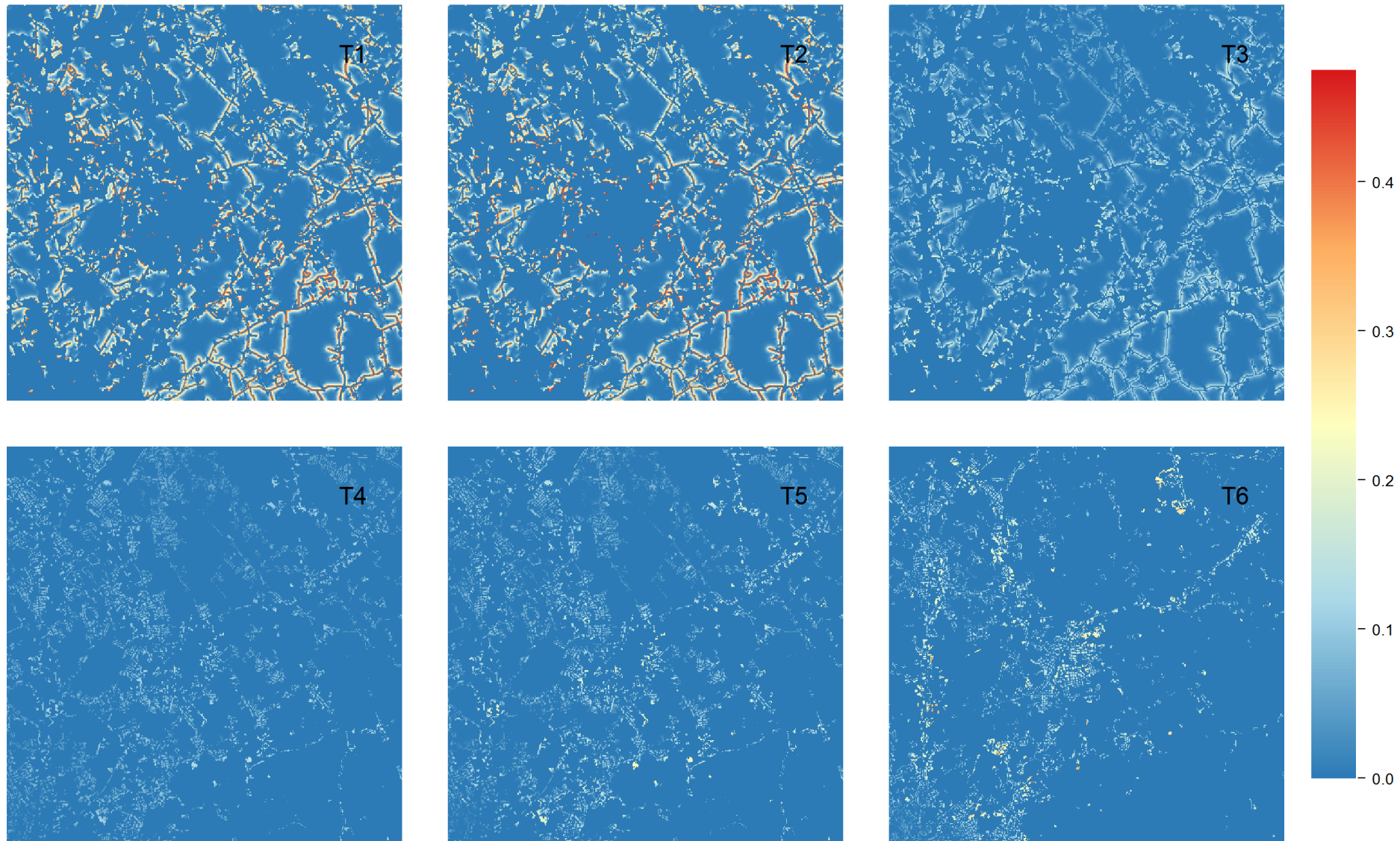
# Urban Growth Model – Suitability

*Suitability state space*

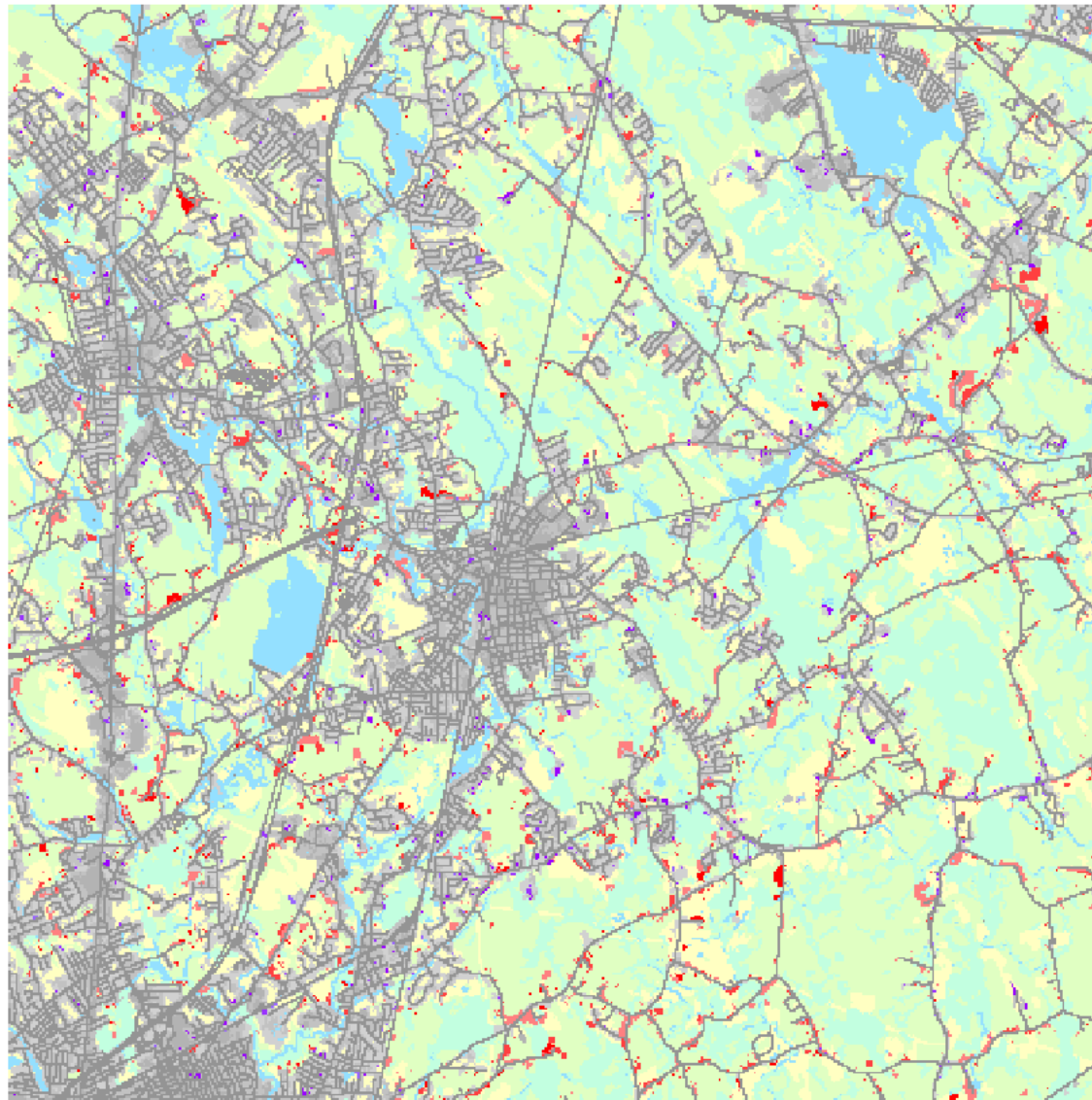




# Urban Growth Model – Suitability



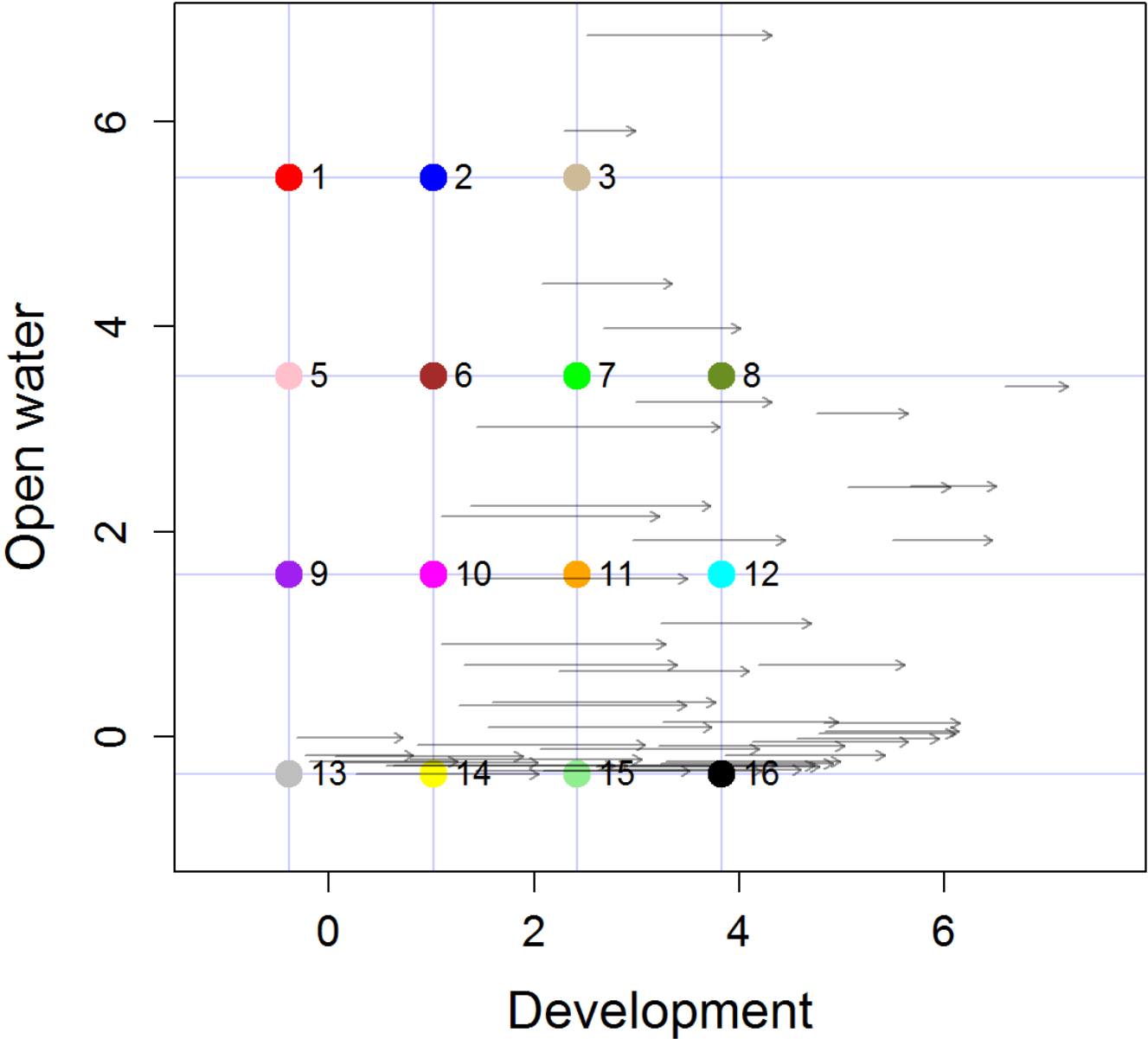
# Urban Growth Model – Building



- Transition 1
- Transition 2
- Transition 3
- Transition 4
- Transition 5
- Transition 6
- Open
- Forest
- Water
- Wetland
- Roads, Trains
- Low Dev.
- Med. Dev.
- High Dev.

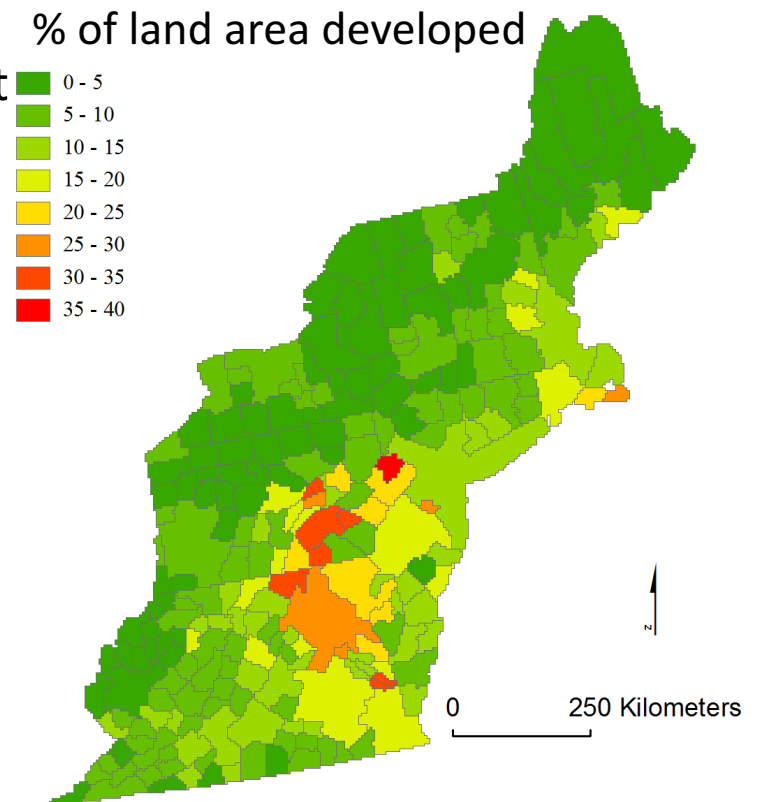


# Urban Growth Model - Non-stationary



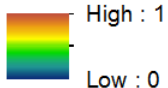
## Some caveats

- It is only a model
- Output should be viewed as an urban growth scenario - at best it projects past pattern into the future
- Depends heavily on the training land cover classification
- Depends heavily on the RPA county level demand
- It does not project new road construction
- Does not include any explicit socioeconomic drivers
- No “rewilding”
- Conserved land is excluded from development
- Wetlands are excluded from development



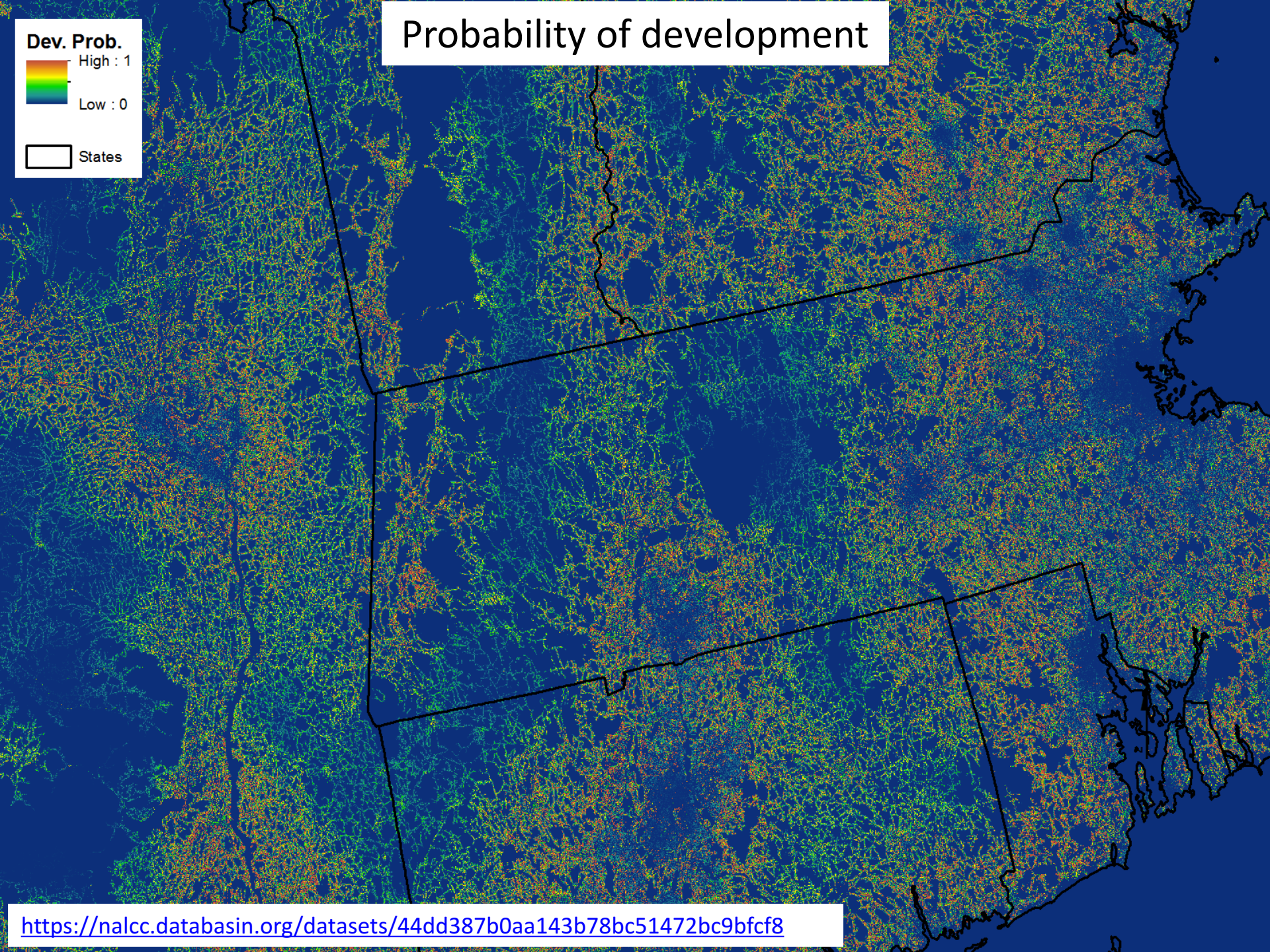


Dev. Prob.



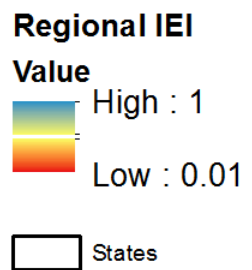
States

# Probability of development

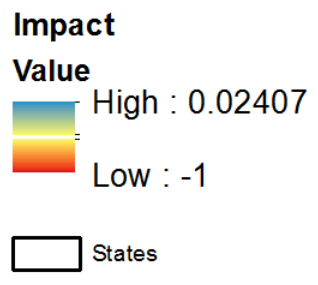




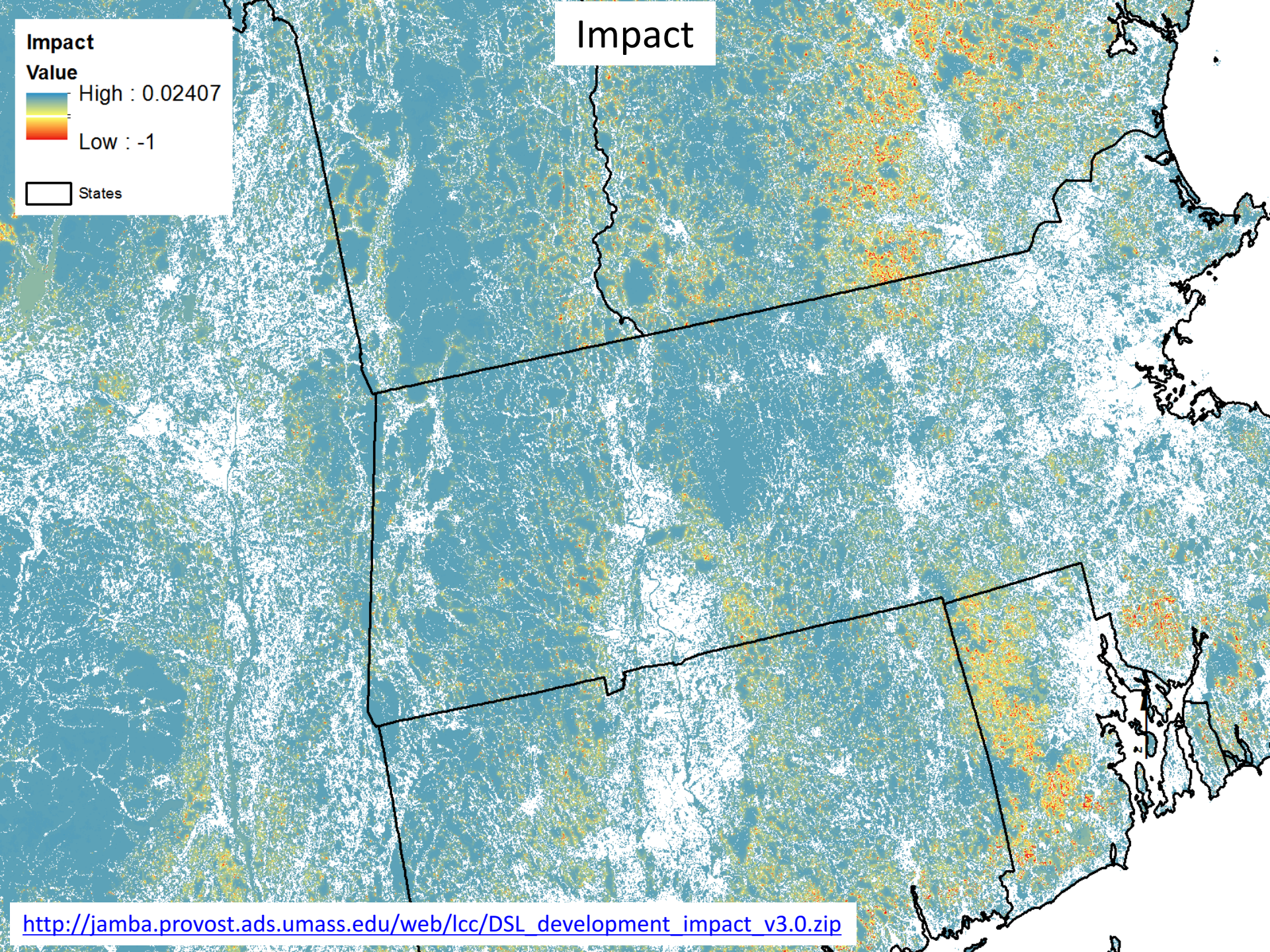
# Index of ecological integrity







# Impact





## Local vulnerability

Value

High : 0.418383

Low : 0

## Local Vulnerability



## Regional conductance

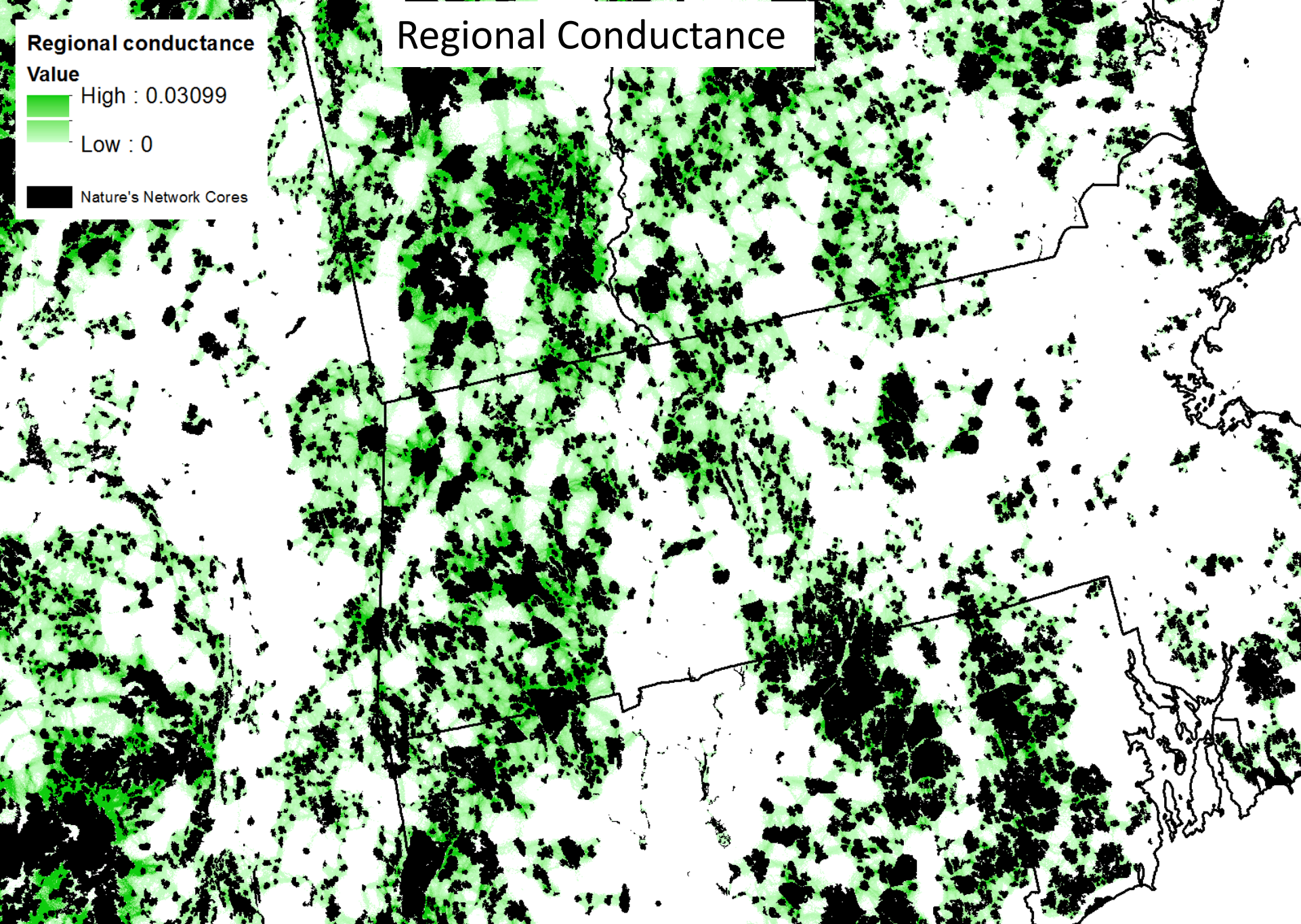
### Value

High : 0.03099

Low : 0

Nature's Network Cores

## Regional Conductance





## Regional vulnerability

### Value

High : 0.00017

Low : 0

Nature's Network Cores

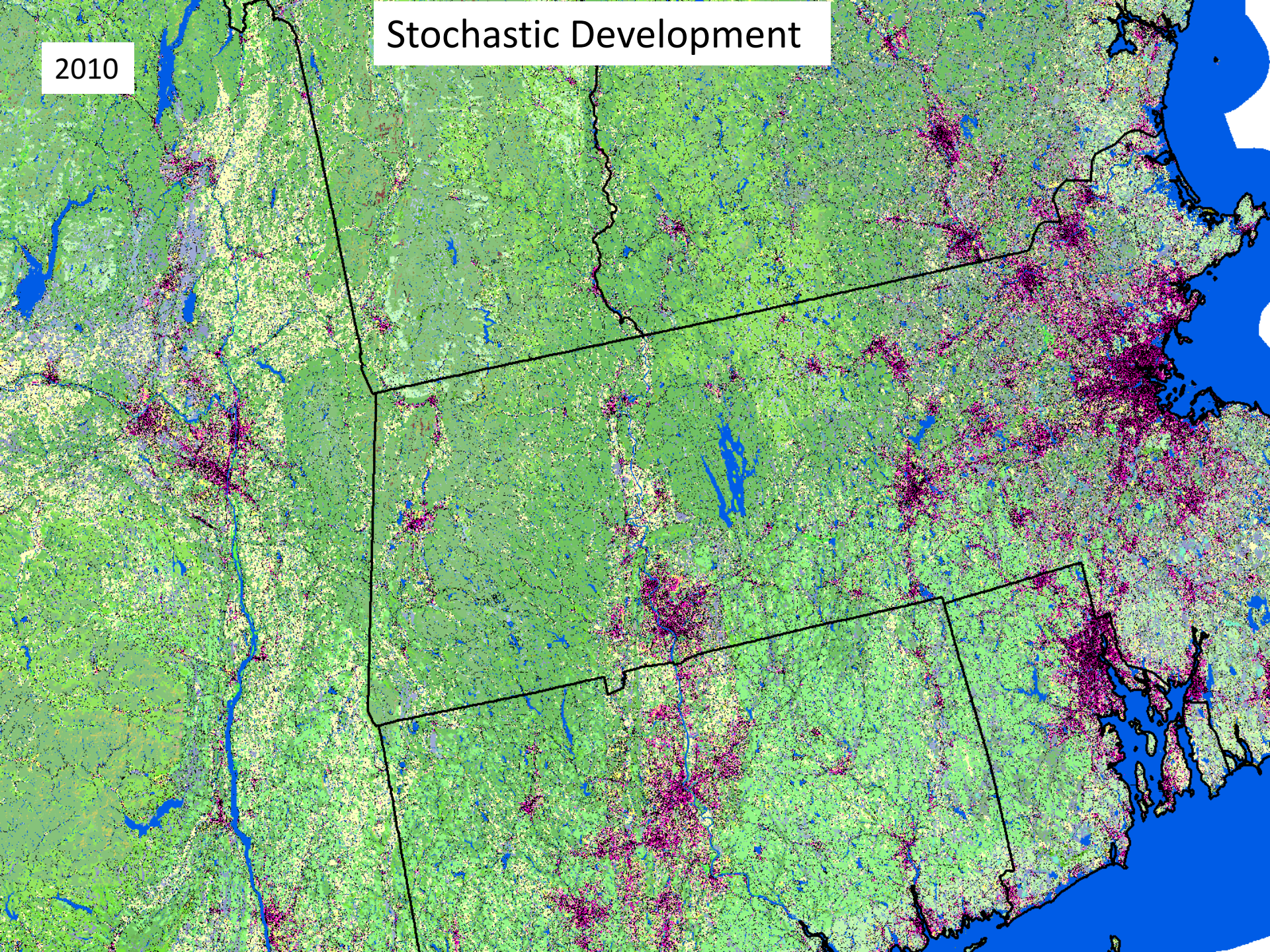
## Regional Vulnerability





2010

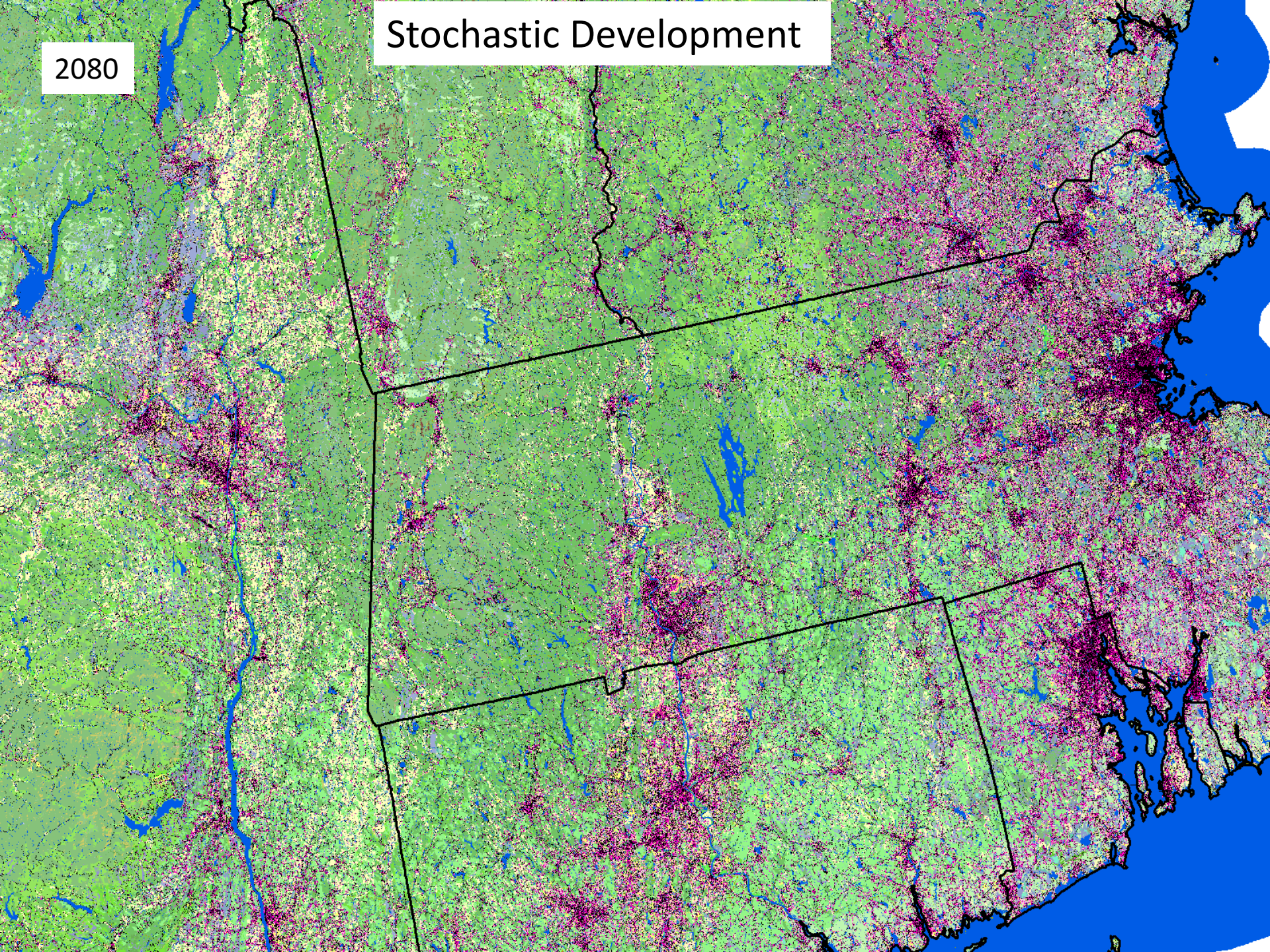
# Stochastic Development





# Stochastic Development

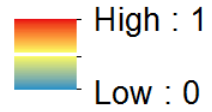
2080





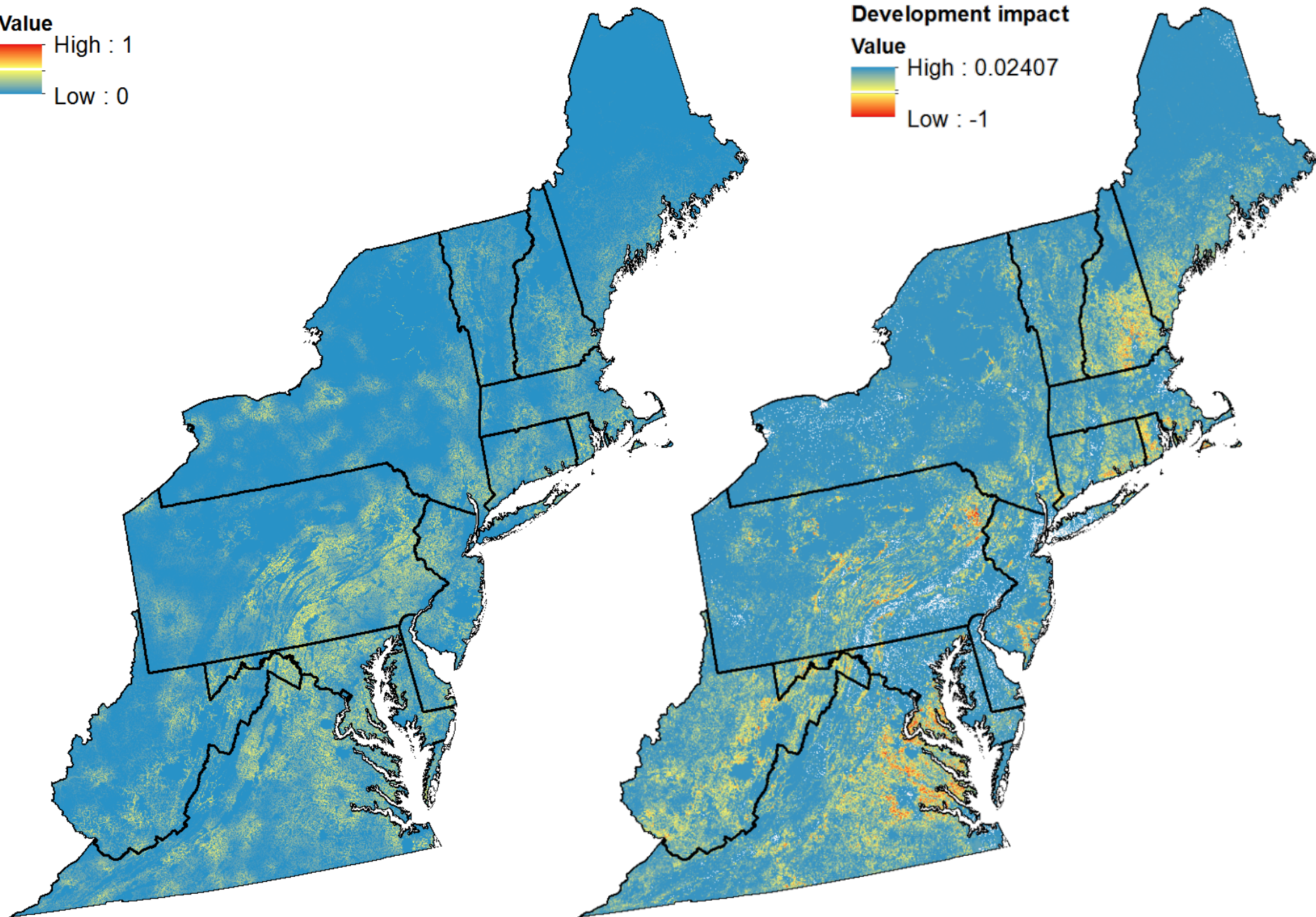
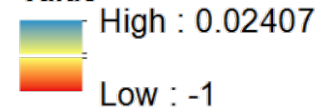
**Dev. Prob.**

**Value**



**Development impact**

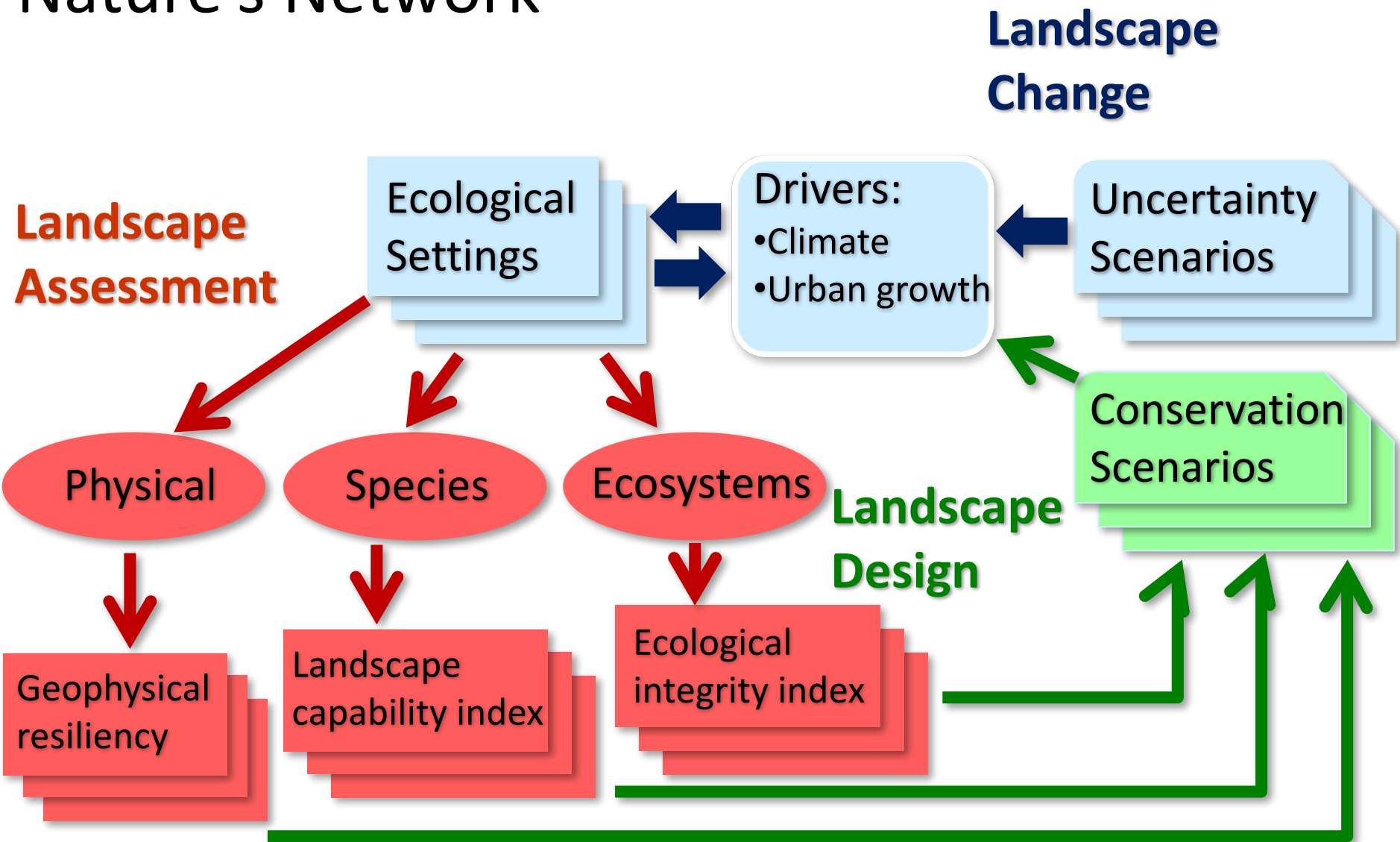
**Value**



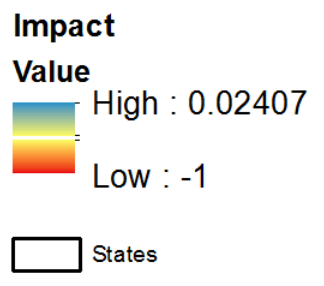


# Designing Sustainable Landscapes

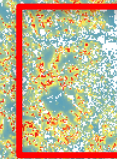
## Nature's Network







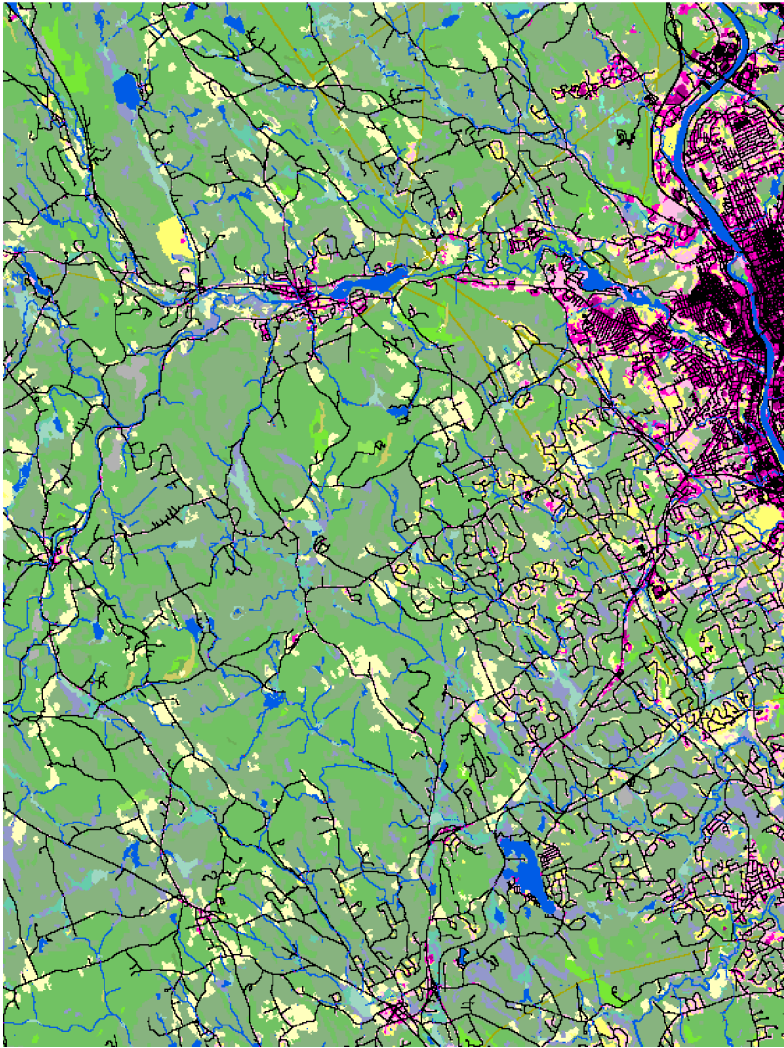
Impact



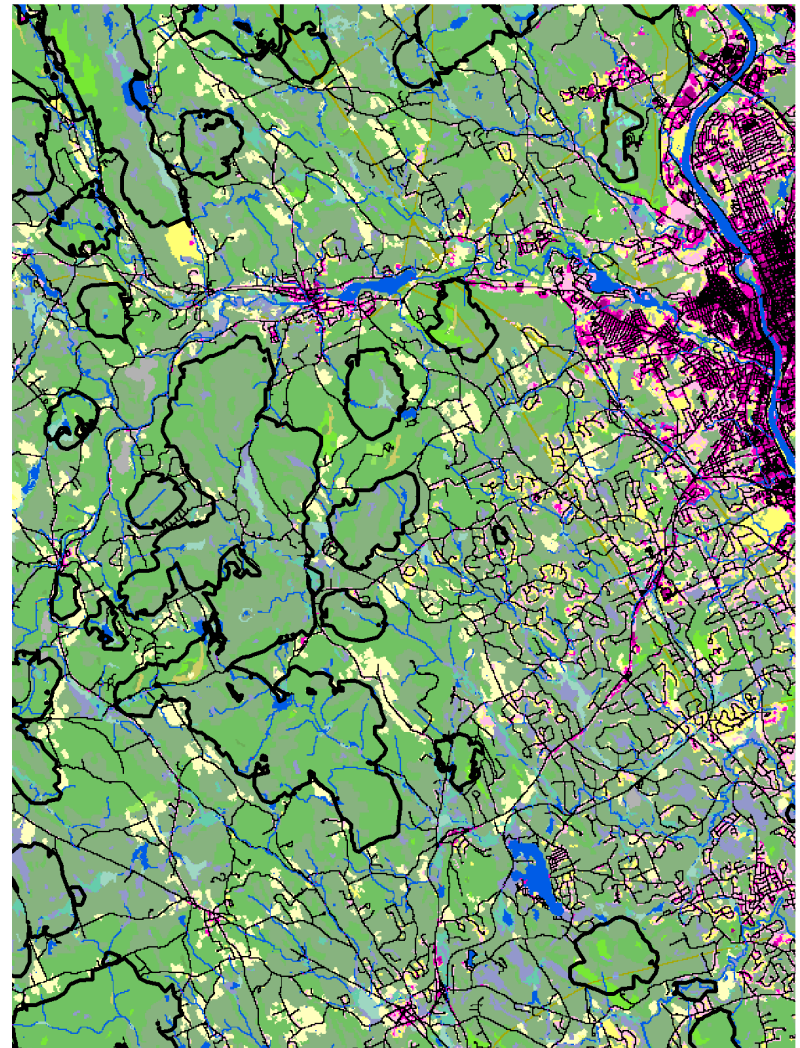


# Conservation design evaluation

2010 Land cover



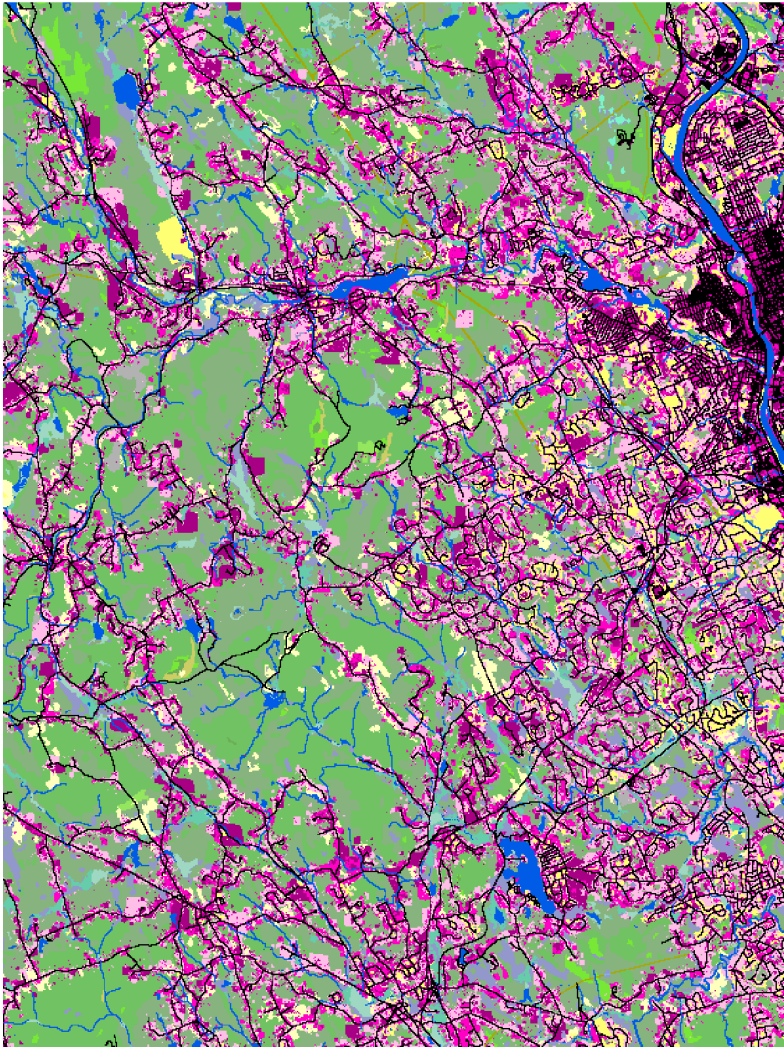
2010 Land cover with cores



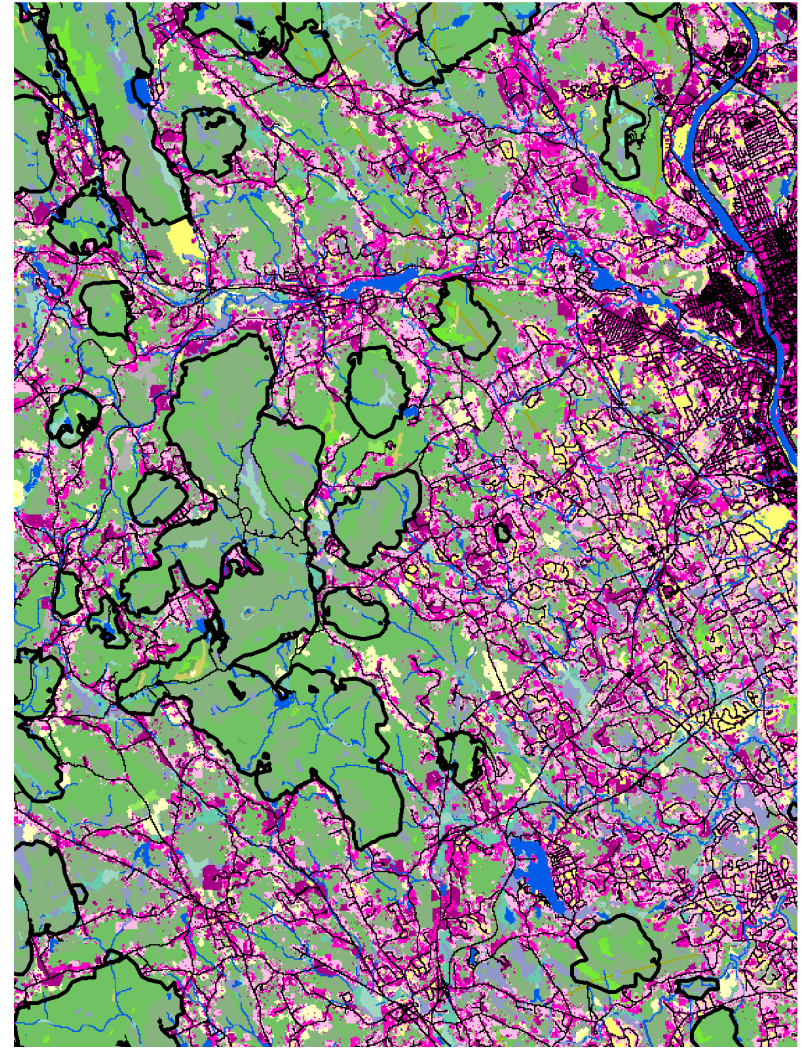


# Conservation design evaluation

2080 Land cover



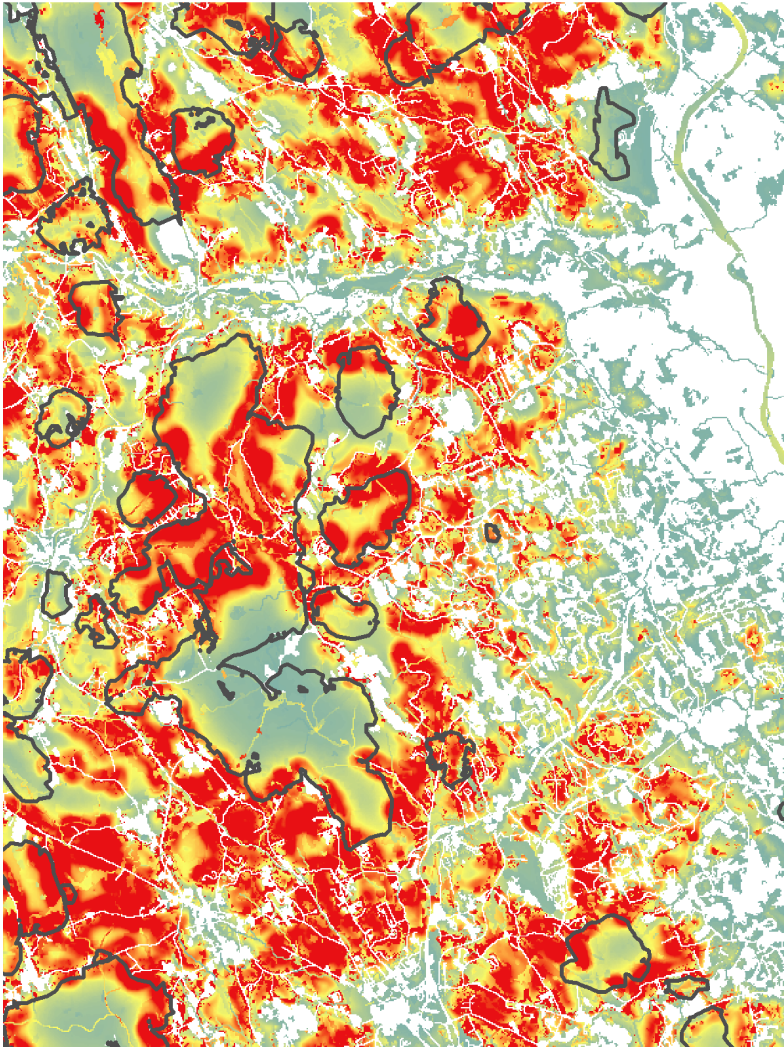
2080 Land cover with cores



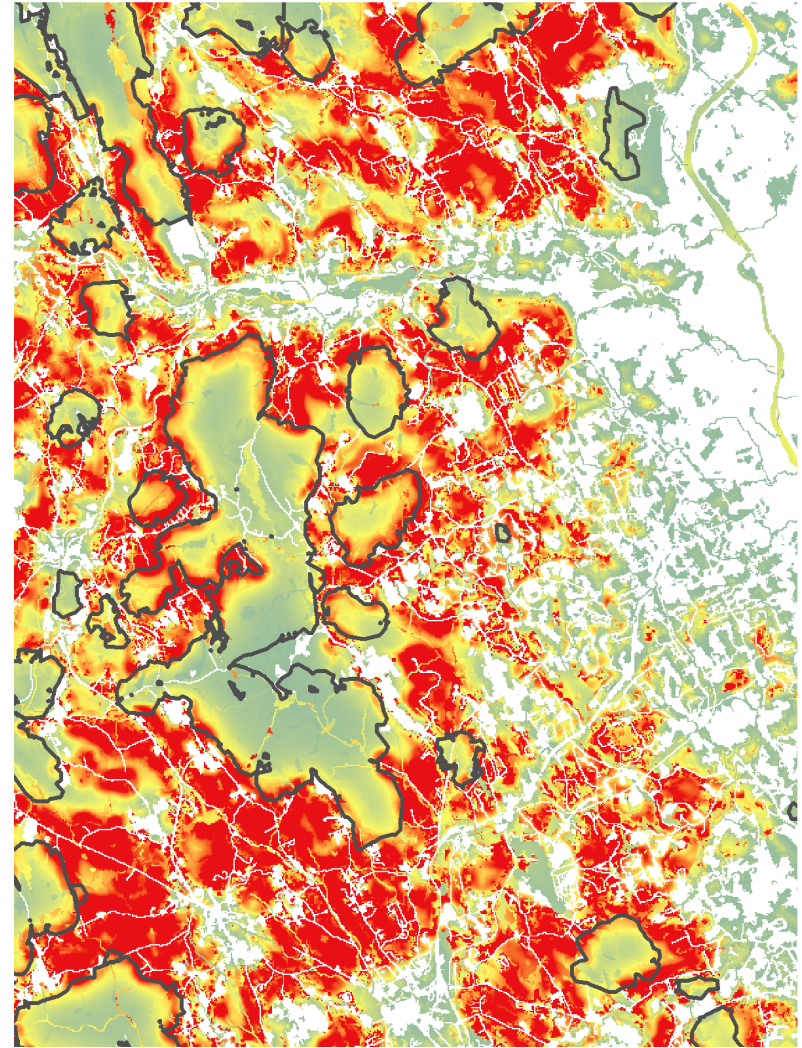


# Conservation design evaluation

2080 Impact



2080 Impact with cores





# Natures Network design reduces impact on ecological systems

<b>Formation</b>	<b>Percent of baseline impact</b>
Alpine	100.0
Boreal Upland Forest	91.4
Cliff & Rock	78.2
Coastal Scrub-Herb	78.3
Grassland & Shrubland	85.3
Northeastern Upland Forest	80.1
Northeastern Wetland	86.4
Peatland	99.4
Lentic	92.0
Stream	90.0
Estuarine Intertidal	75.6
Marine Intertidal	93.2
<b>Overall</b>	<b>81.1</b>





## **Acknowledgements:**

**Scott Schwenk**

**Andrew Milliken**

**Ken Elowe**

**Nancy McGarigal**

**Renee Vieira**

**Bridget Macdonald**



**Table 1.** SPRAWL model evaluation based on hindcasting, including for each of six development transition types (1-3 represent new development from undeveloped land; 4-6 represent redevelopment) the following statistics: 1) ratio of the average computed probability of development for cells that underwent development in the hindcast dataset (~2000-2010) to that of the corresponding available cells, 2) area under the Receiver Operating Characteristic Curve Area (AUC), 3) coefficient of concordance (CC), and 4) weighted skewness statistic.

Transition type	Use/availability ratio	AUC	CC	Weighted skewness
1 (undeveloped to low-intensity developed)	11.14	0.93	0.70	-0.73
2 (undeveloped to medium-intensity developed)	11.70	0.94	0.77	-0.71
3 (undeveloped to high-intensity developed)	9.86	0.93	0.80	-0.61
4 (low- to medium-intensity developed)	1.08	0.53	0.93	0.05
5 (low- to high-intensity developed)	1.25	0.60	0.98	-0.31
6 (medium- to high-intensity developed)	1.26	0.57	0.77	-0.17