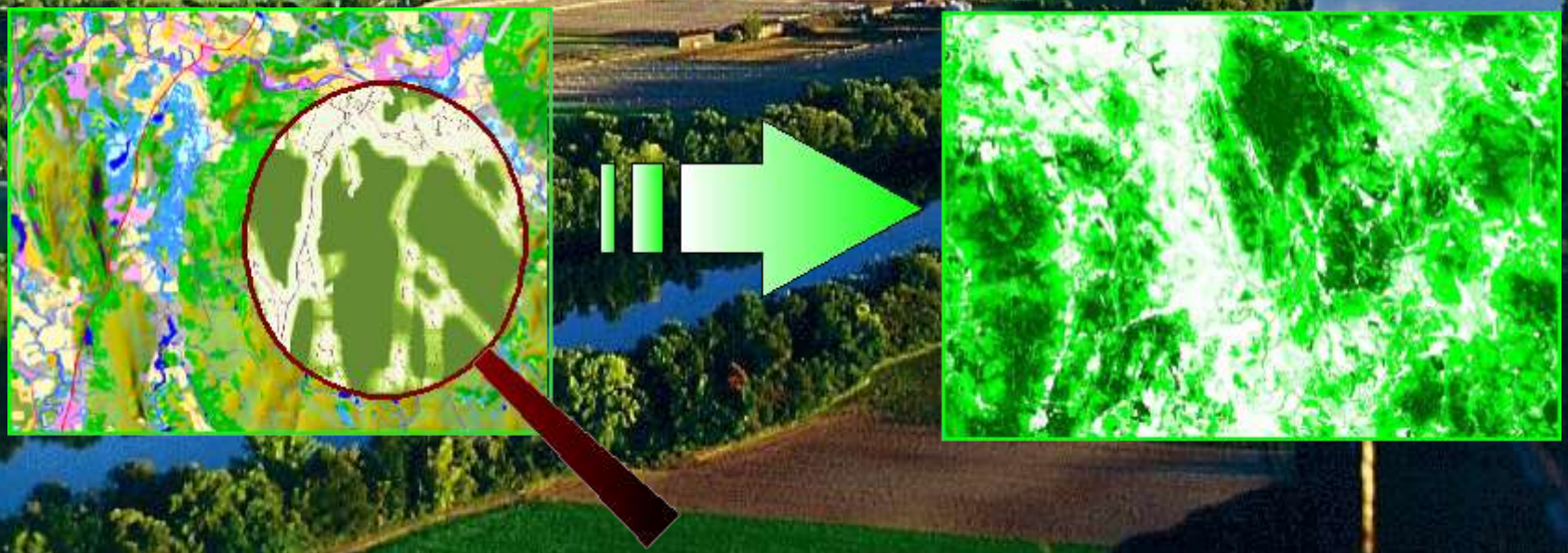
Designing Sustainable Landscapes in the Northeast

A project of the North Atlantic Landscape Conservation Cooperative & Northeast Climate Science Center

Landscape Conservation Design Pilot

March 28, 2014



The UMass Team

UMASS AMHERST

Contributors:
Liz Willey
Scott Schwenk
Curt Griffin
Scott Jackson
Carly Chandler
Janice Zepko
And others

Designing Sustainable Landscapes Project

The **purpose** of the Designing Sustainable Landscapes (DSL) project is to:

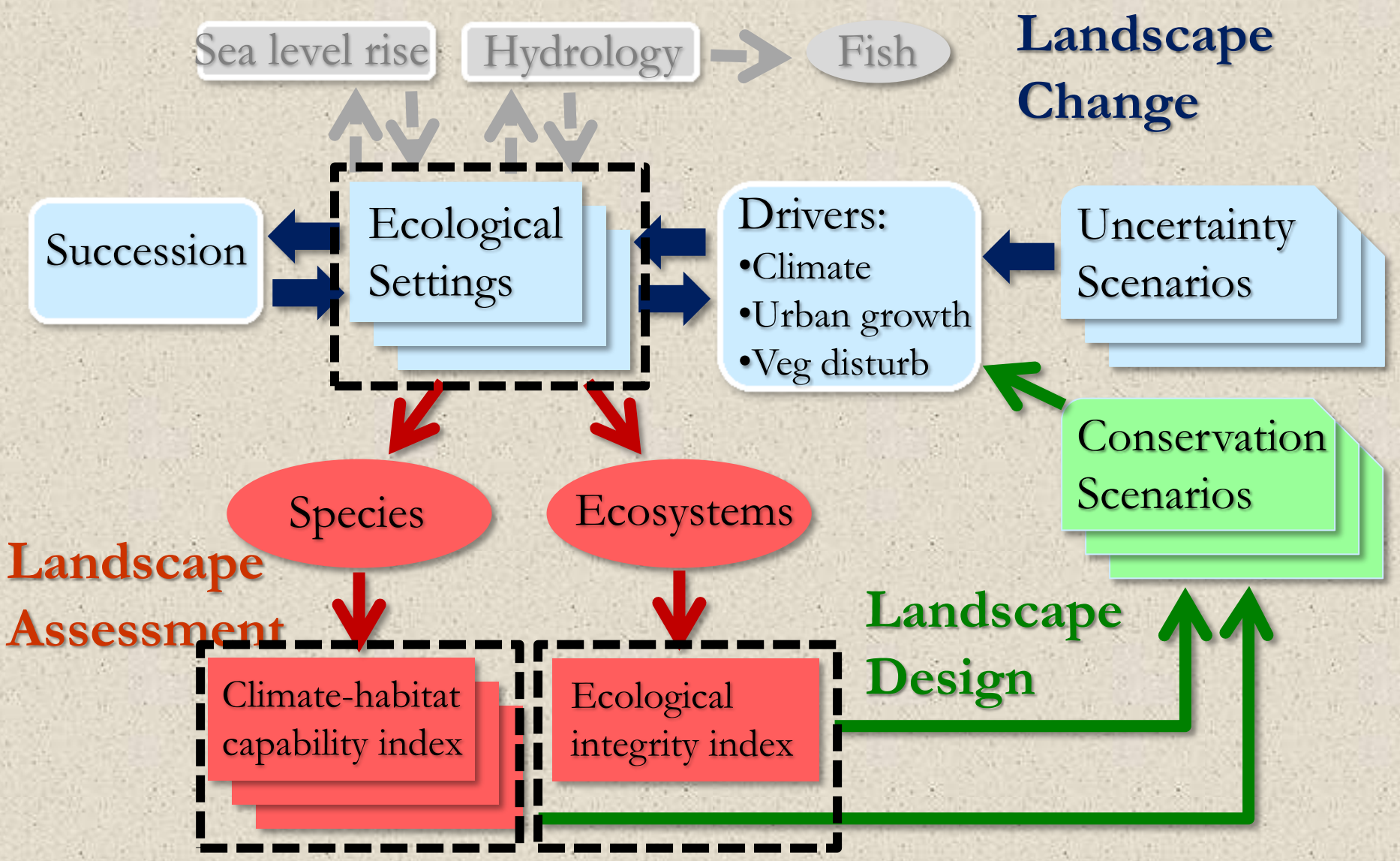
- Assess the capability of current and potential future landscapes to provide integral ecosystems and suitable habitat for a suite of representative species, and provide guidance for strategic habitat conservation

Landscape

- **C**hange
- **A**ssessment
- **D**esign

LCAD Model

LCAD Model

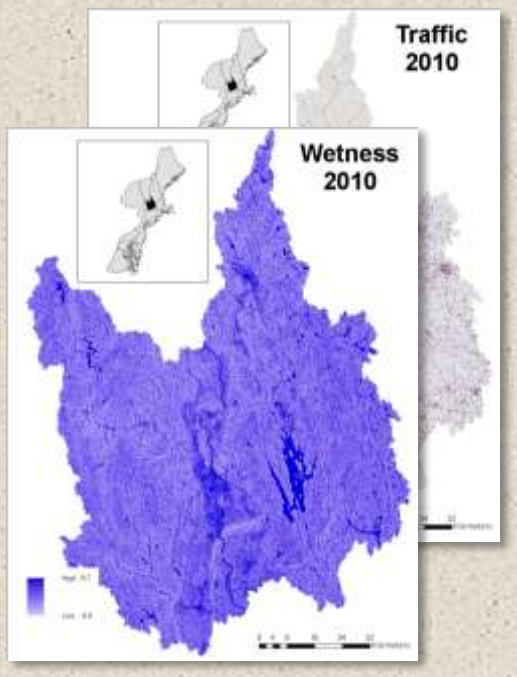

Sea level rise
Hydrology
Fish
Landscape Change
Succession
Ecological Settings
Drivers:
•Climate
•Urban growth
•Veg disturb
Uncertainty Scenarios
Conservation Scenarios
Species
Ecosystems
Landscape Assessment
Landscape Design
Climate-habitat capability index
Ecological integrity index

Landscape Change

Ecological Settings

"GIS layers including a broad but parsimonious suite of biophysical variables representing the natural and anthropogenic environment at each location (cell) at each timestep"

- Measure magnitude of abiotic, vegetation or anthropogenic attributes
- Raw-scaled metrics (most are non-negative and unbounded)
- High value = more of it
- Used to measure ecological dissimilarity and resistance in ecological integrity metrics and in modeling species distributions



Landscape Change

Ecological Settings

Abiotic (14):

- Temperature:
  - Min winter temperature
  - Growing season degree days
  - Heat index (>35^0 C)
- Solar energy:
  - Incident solar radiation
- Moisture & hydrology:
  - Topographic wetness
  - Flow volume
  - Flow gradient
- Chemical & physical substrate:
  - CaCO3 content
  - Soil available water supply
  - Soil depth
  - Soil pH
  - Substrate mobility
- Physical disturbance:
  - Slope
  - Wind exposure

Landscape Change

Ecological Settings

Vegetation (2):

- Potential dominant life form
- Above-ground live biomass

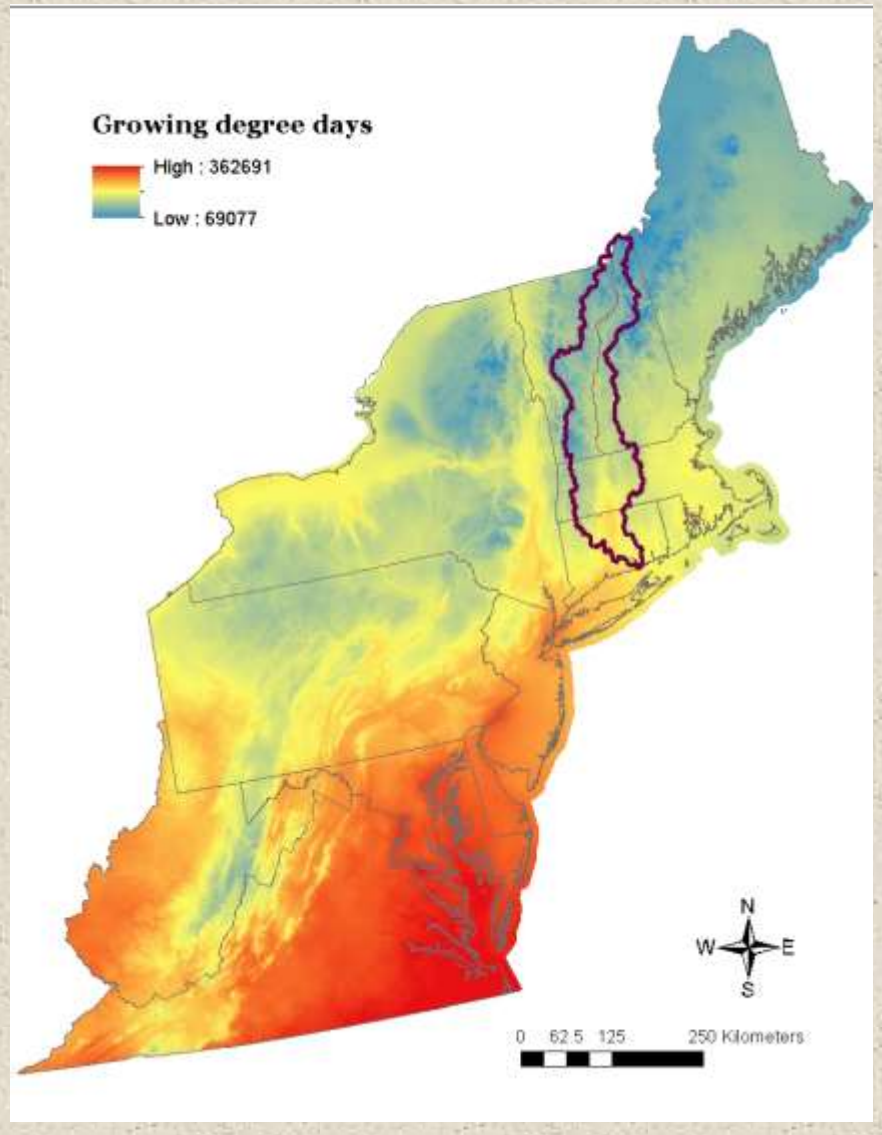
Anthropogenic (6):

- Gibbs traffic rate
- Developed
- Hard development
- Imperviousness
- Terrestrial barriers
- Aquatic barriers

Landscape Change

Ecological Settings

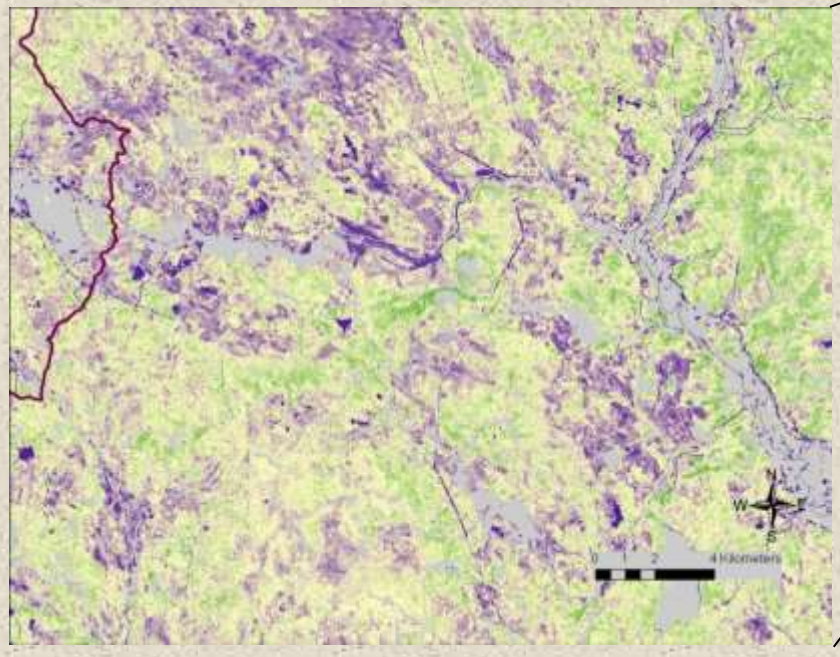
- **Growing degree days…**
  the sum across days of the number of degrees by which the mean daily temperature exceeds a threshold of 10^0 C

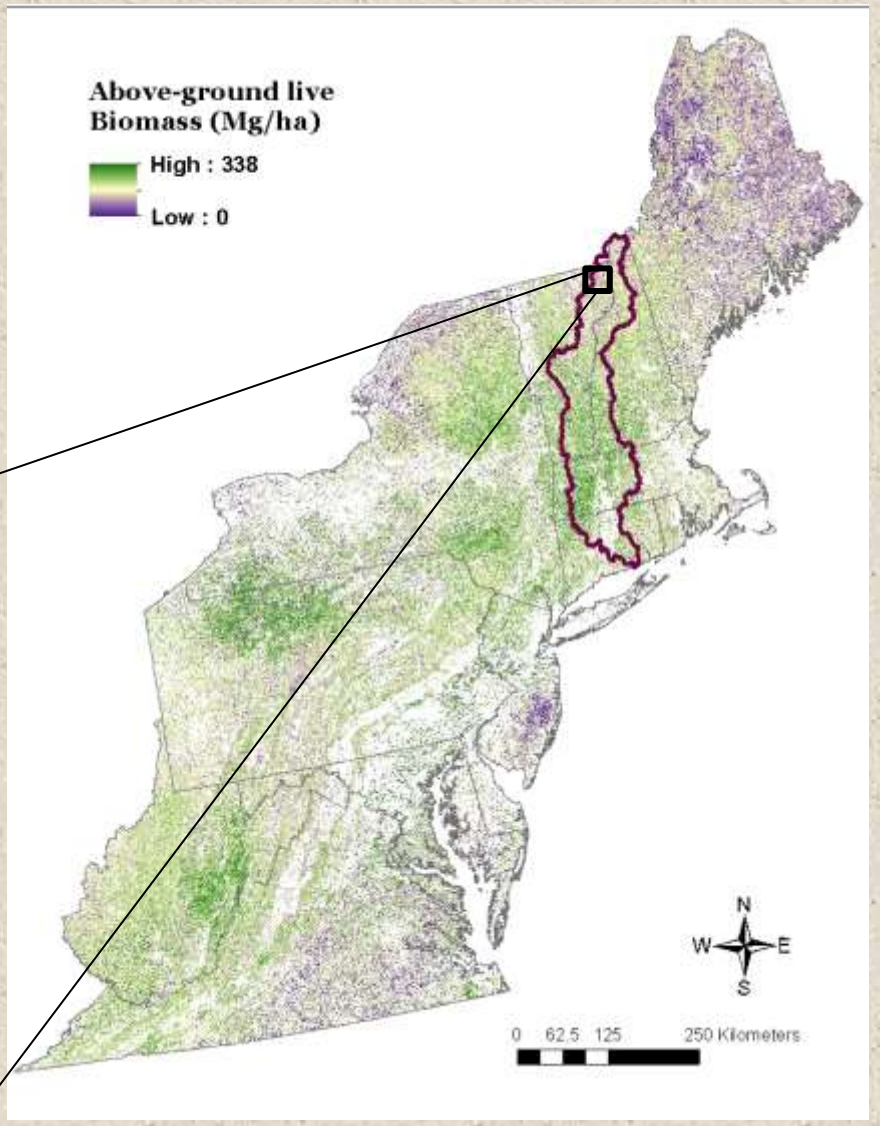


Landscape Change

Ecological Settings

- **Above-ground live biomass…** modified from Woods Hole NACP Above-ground National Biomass and Carbon Baseline Data V.2

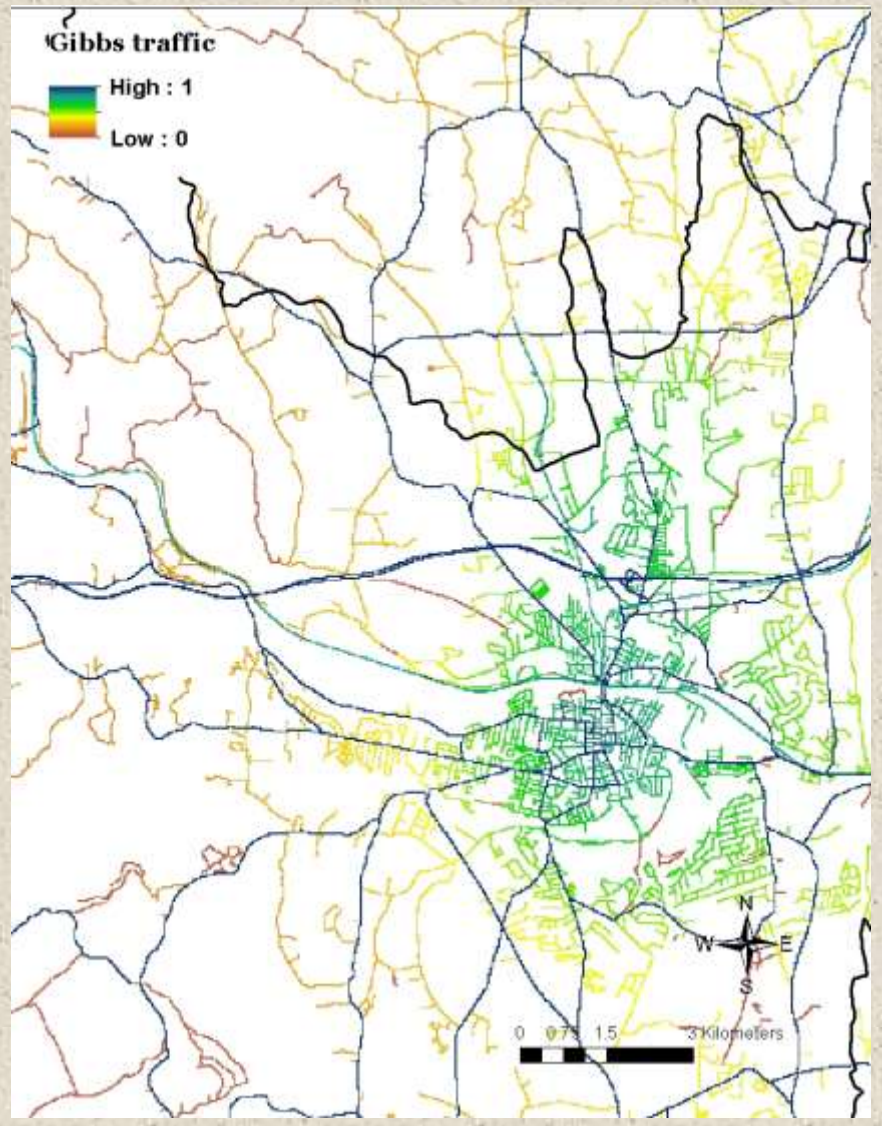




Landscape Change

Ecological Settings

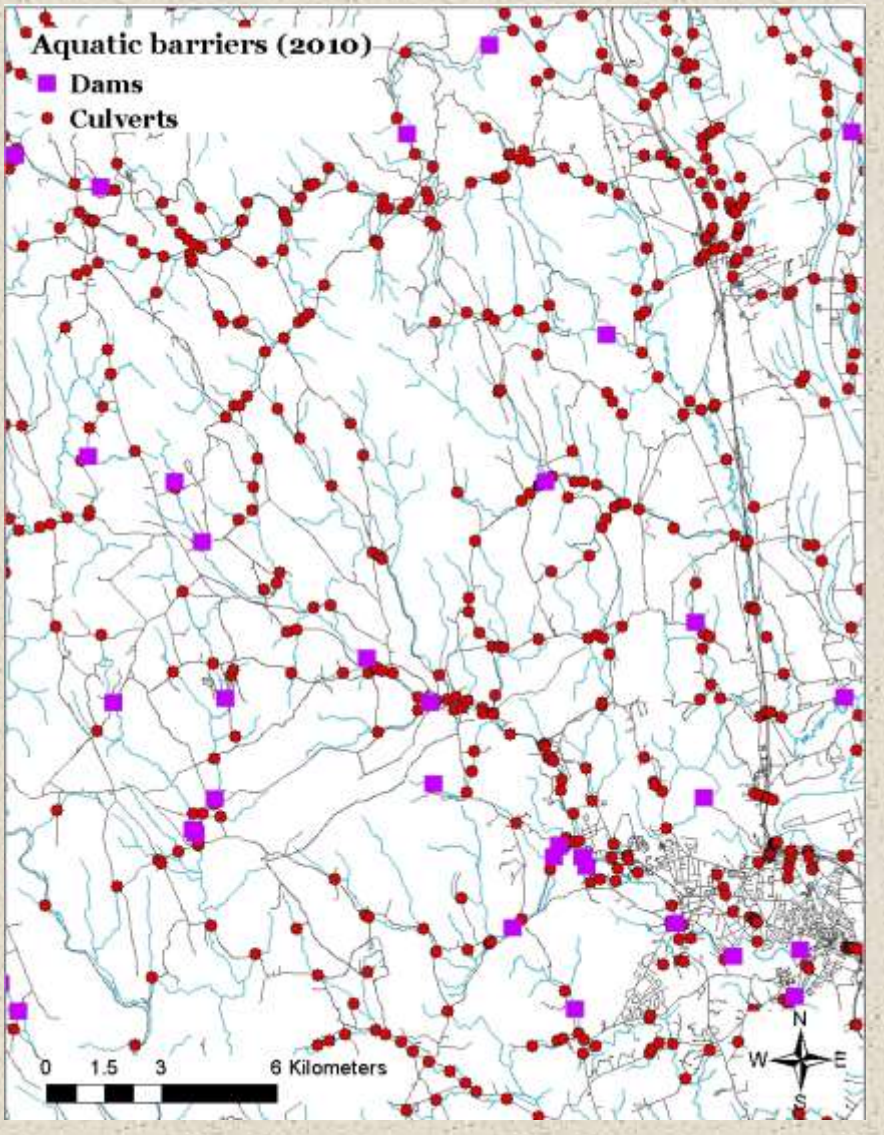
- **Gibbs traffic rate…**
  imputed average number of vehicles per day on roads and railways transformed into probability of road-crossing mortality based on the Gibbs model (Gibbs and Shriver 2002).



Landscape Change

Ecological Settings

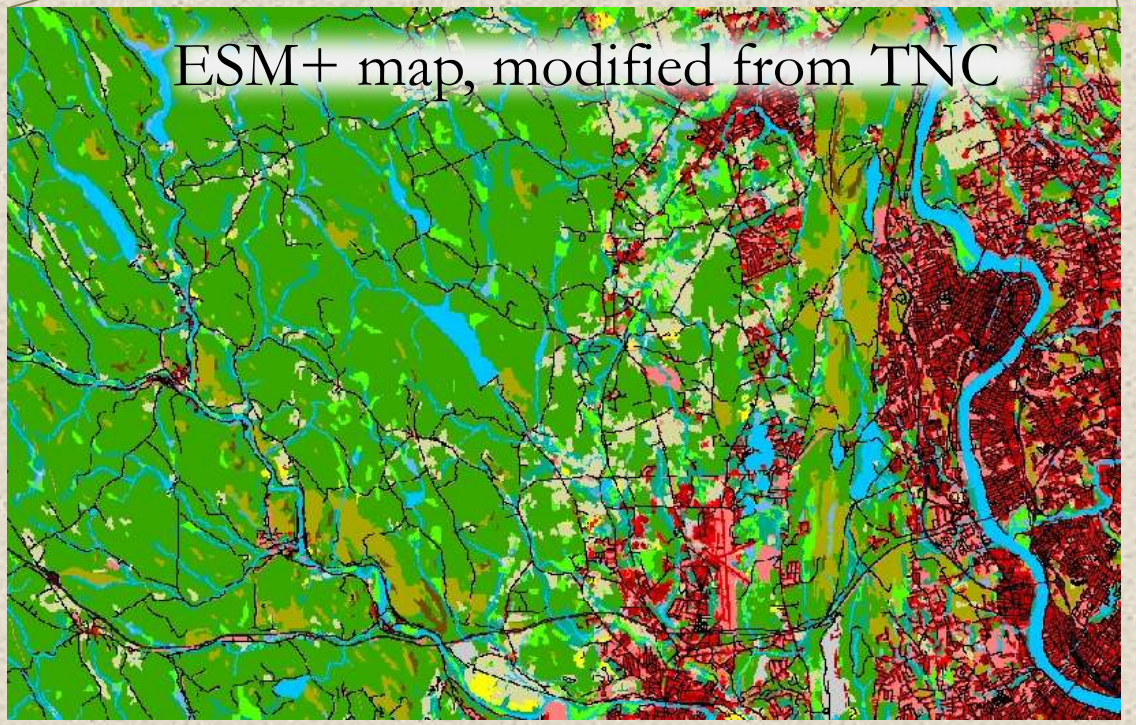
- **Aquatic barriers…** the degree to which culverts and dams may physically impede upstream and downstream movement of aquatic organisms; passability scores derived from custom algorithm based on dams layer and derived road-stream crossings.



Landscape Change

Ecological Settings

"Ecological systems represent recurring groups of biological communities that are found in similar physical environments and are influenced by similar dynamic ecological processes, such as fire or flooding" (Natureserve)



17 formations
27 macrogroups
196 systems

Appalachian hemlock-northern hardwood forest: typic

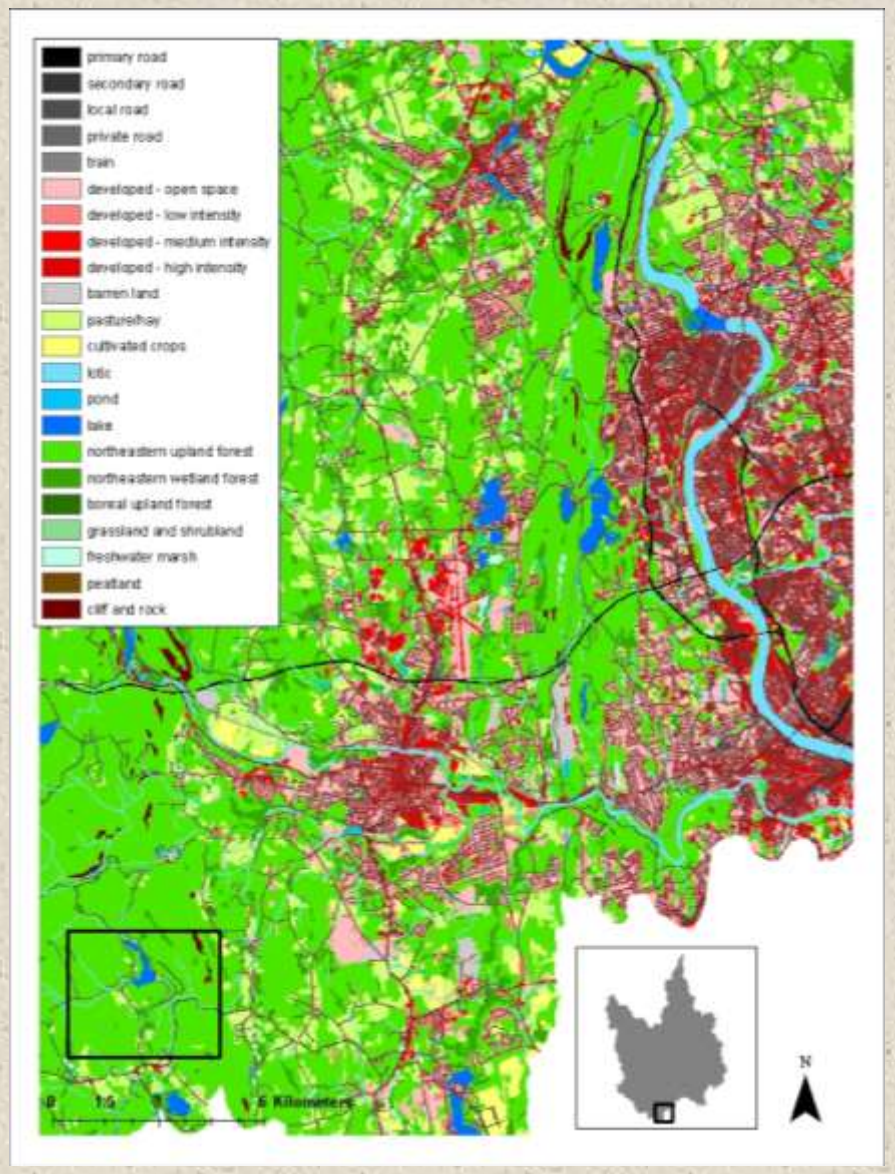
Landscape Change

Ecological Settings

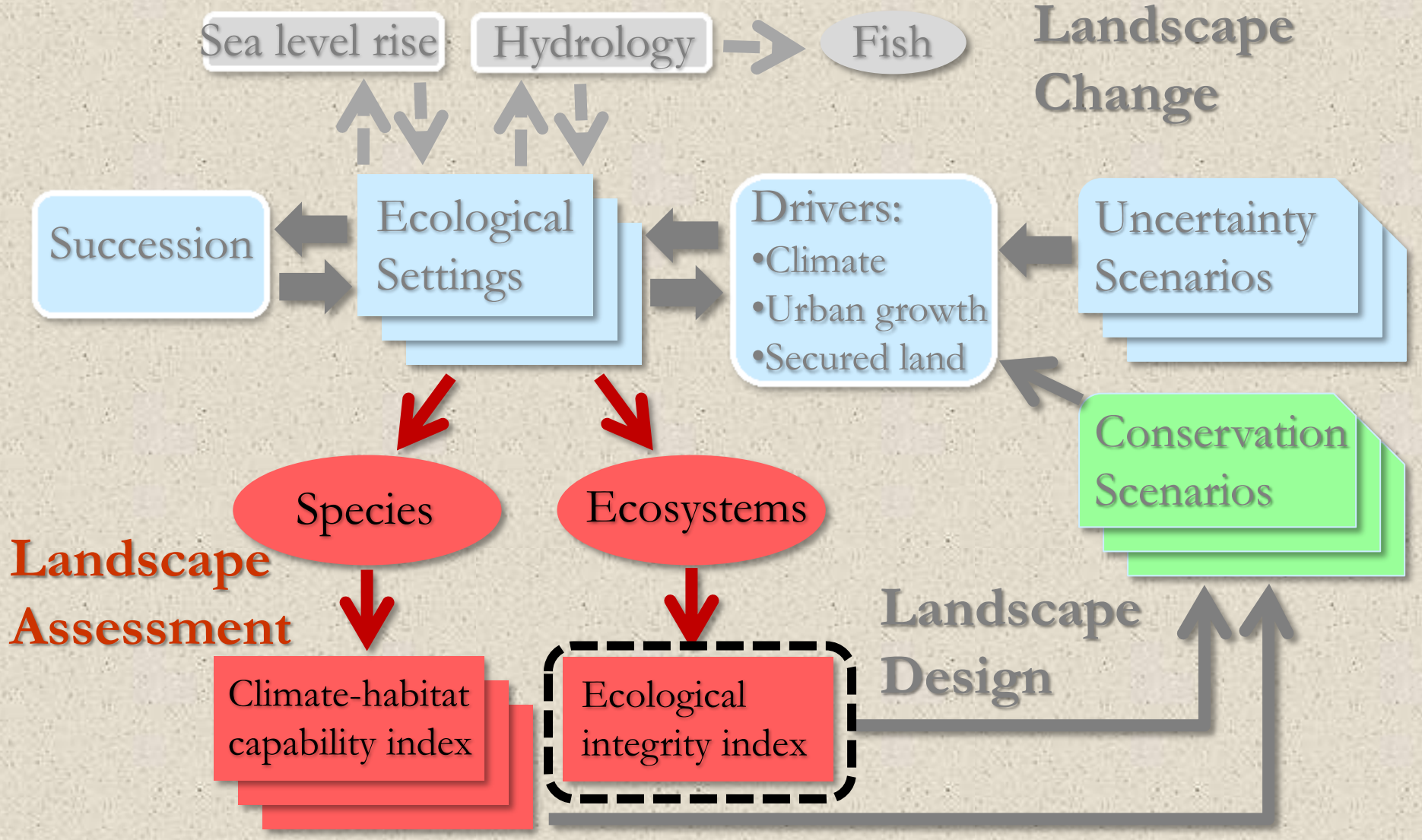
Capsland:

- Version of ESM+ used to scale ecological integrity results
- Categorical (land cover class) and hierarchical (macrogroup and system level)
- Useful for interpreting coarse filter results

34 macrogroups
184 systems



LCAD Model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Landscape Assessment

Ecosystems

Our coarse filter is based on the concept of *ecological integrity* applied to the suite of *ecological systems*

High Integrity

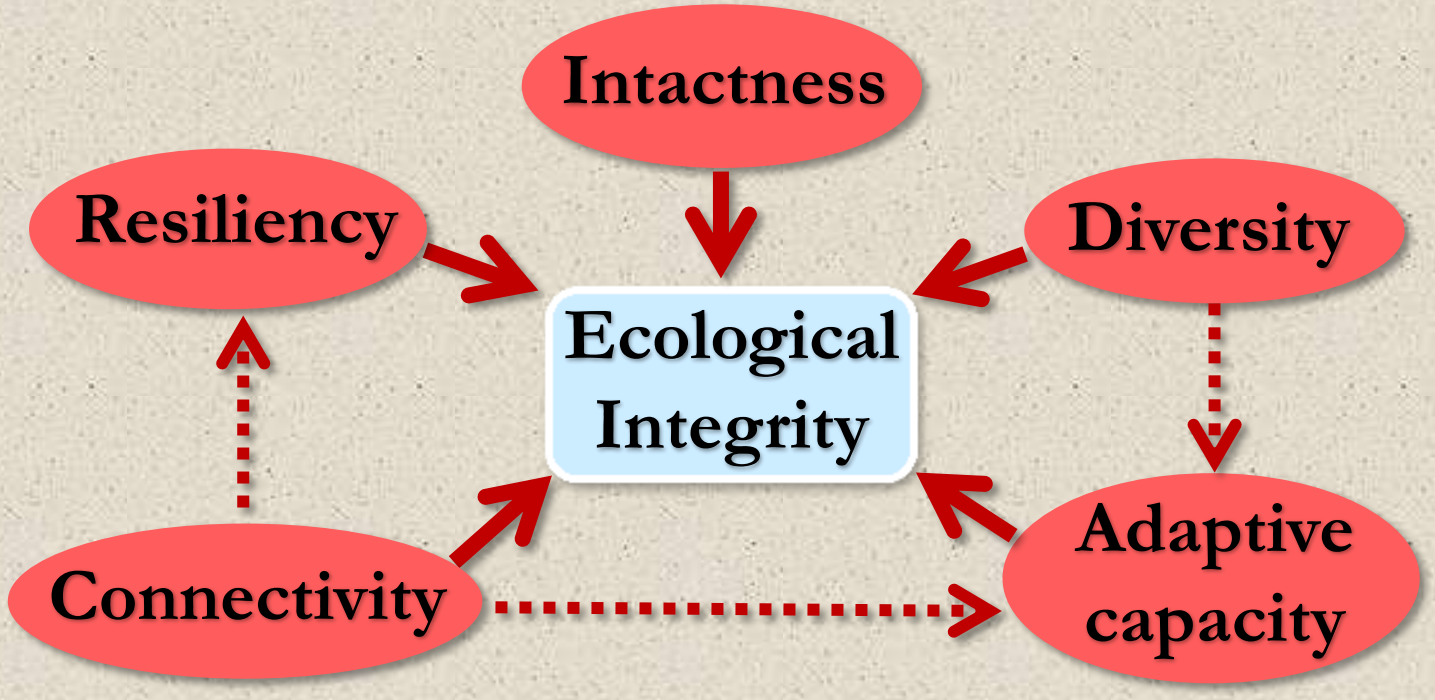
Low Integrity

- *Ecological integrity* refers to the capability of an area to sustain ecological functions over the long term, especially in the face of disturbance and stress

Landscape Assessment

Ecological integrity

"*Ecological integrity* is a multi-faceted and multi-scale concept comprised of several inter-related components that operate at multiple scales"



Each of these components are defined and quantified

Landscape Assessment

Scales of ecological integrity

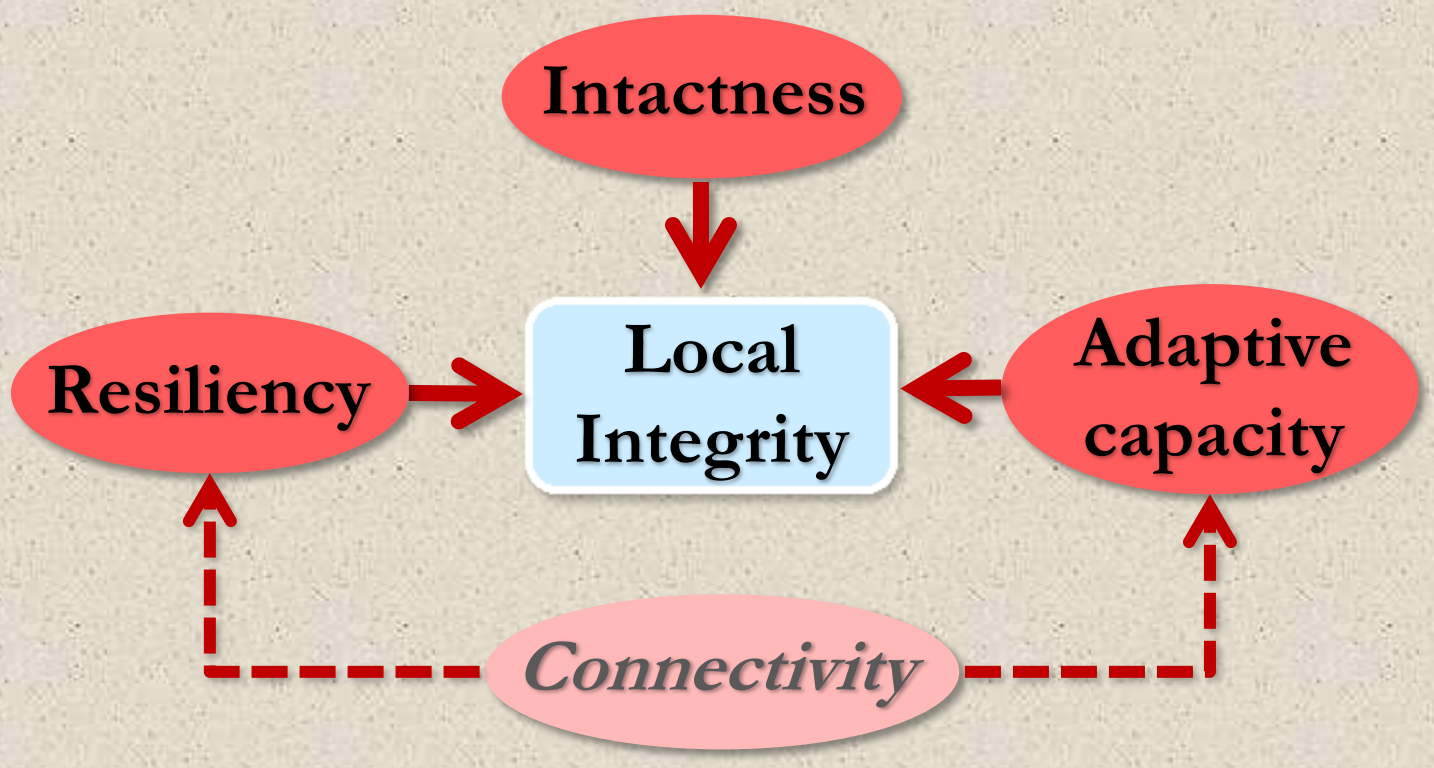
- *Local* …
  a single location
  (pixel or cell)
- *Landscape*
  a meaningful extent
  encompassing many
  sites

What constitutes a meaningful landscape extent?

Landscape Assessment

Local ecological integrity

"An *integral site* is intact and highly connected, resilient, and adaptive"

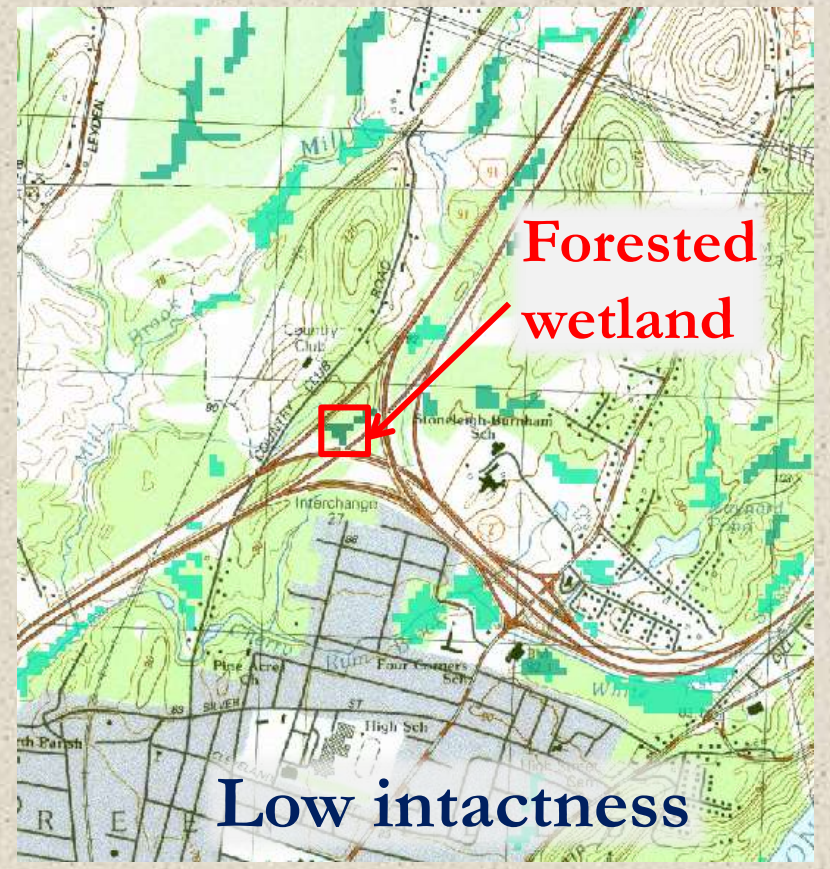


Each of these components are defined and quantified

Landscape Assessment

Local ecological integrity

1. **Intactness…** freedom from human impairment (stressors)
   - Metrics measure magnitude of human stressors, which emanate outward from anthropogenic features independent of ecological system
   - Raw scale (varies)
   - High value = <u>low</u> intactness
   - Used to derive current and future IEI (see below)

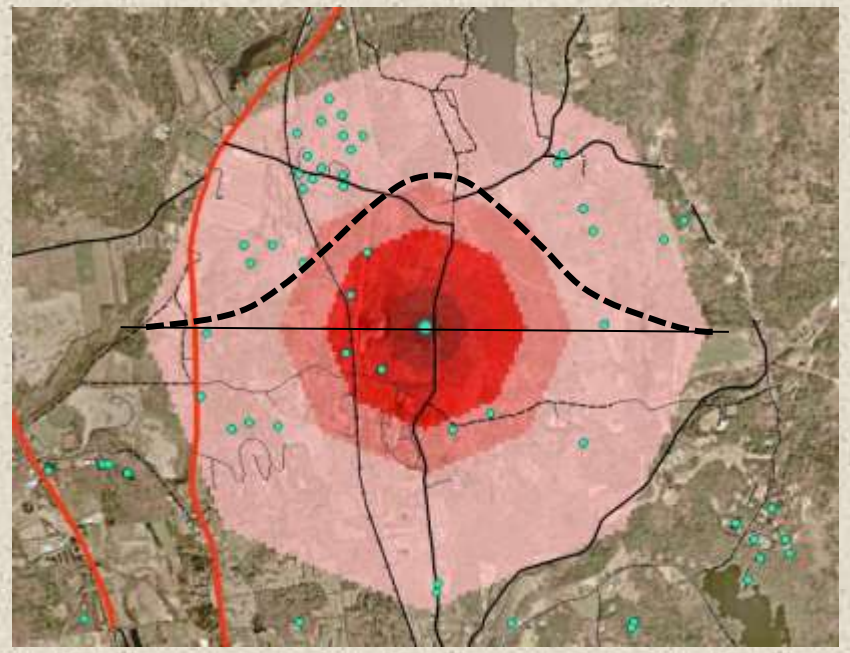


Landscape Assessment

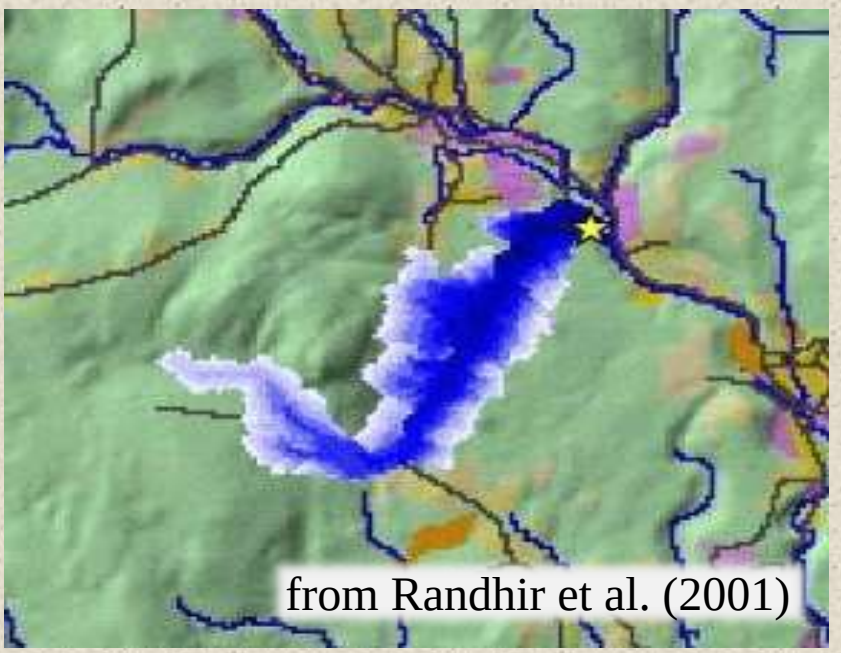
Local ecological integrity

- Kernels to represent nonlinear decrease in ecological influence with increase in distance

Gaussian kernel



Time-of-flow kernel



Landscape Assessment

Local integrity metrics

*future only

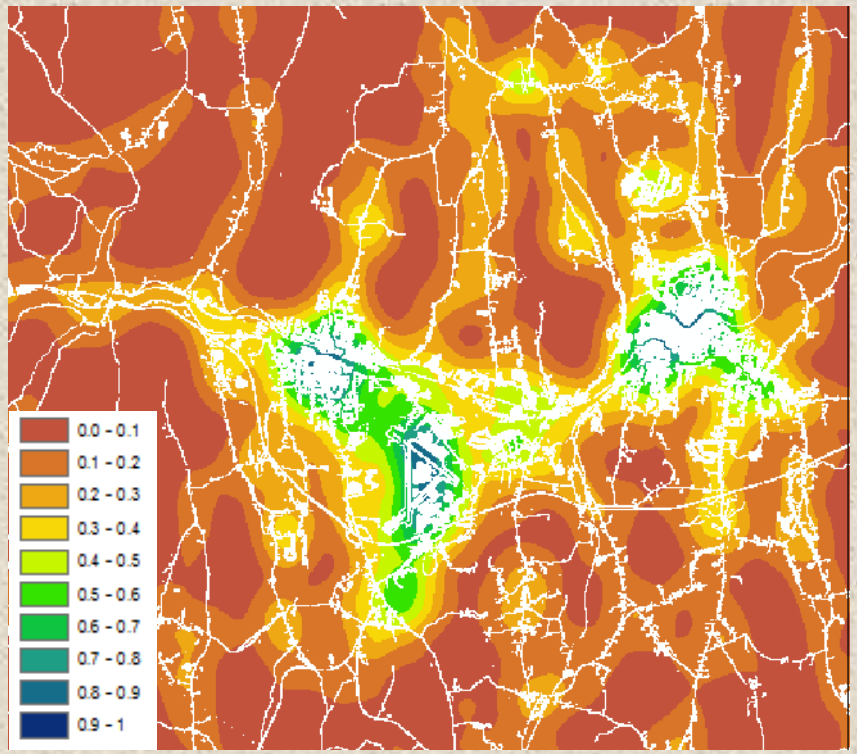
- **Stressor metrics (16)**

- Development and roads:
  - Habitat loss
  - Watershed habitat loss
  - Road traffic
  - Mowing and plowing
  - Microclimate alterations
- Pollution:
  - Watershed road salt
  - Watershed sediment
  - Watershed nutrient enrichment
- Climate change:
  - Climate alteration*
- Biotic alterations:
  - Domestic predators
  - Edge predators
  - Non-native invasive plants
  - Non-native earthworms
- Hydrologic alterations:
  - Watershed imperviousness
  - Dam intensity
  - Sea level rise inundation*
- Coastal alterations:
  - Salt marsh ditching
  - Tidal restrictions
  - Coastal structures
  - Beach pedestrians
  - Beach ORV's

Landscape Assessment

Local integrity metrics

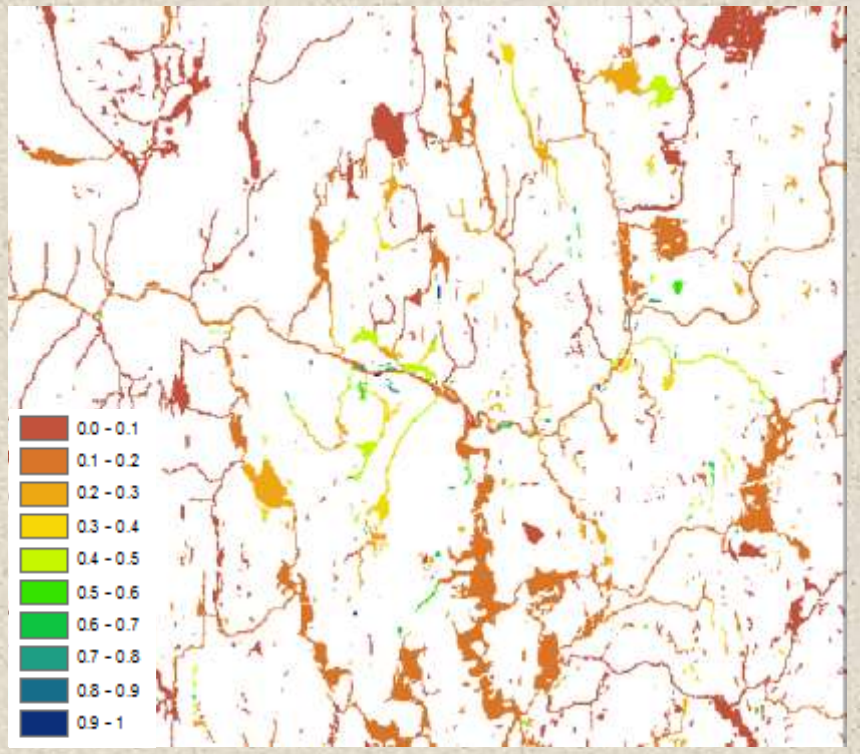
- **Habitat loss…** intensity of habitat loss caused by all forms of development in the neighborhood surrounding the focal cell, based on a *Gaussian kernel*



Landscape Assessment

Local integrity metrics

- **Watershed habitat loss…** intensity of habitat loss caused by all forms of development in the watershed above the focal cell, based on a *time-of-flow kernel*

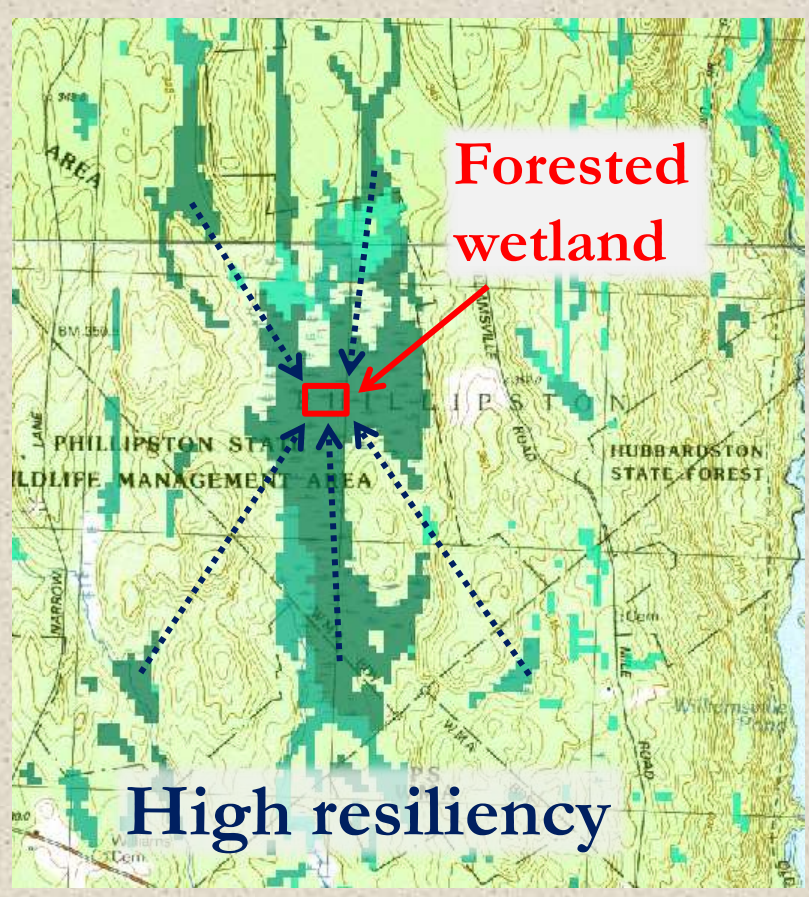


Landscape Assessment

Local ecological integrity

2. **Resiliency…** short-term ability to recover from disturbance and stress

- Metrics measure extent and proximity of similar ecological settings and human impediments to ecological flows [connectivity]
- Raw scale (0-1)
- High value = high intactness
- Used to derive current and future IEI (see below)

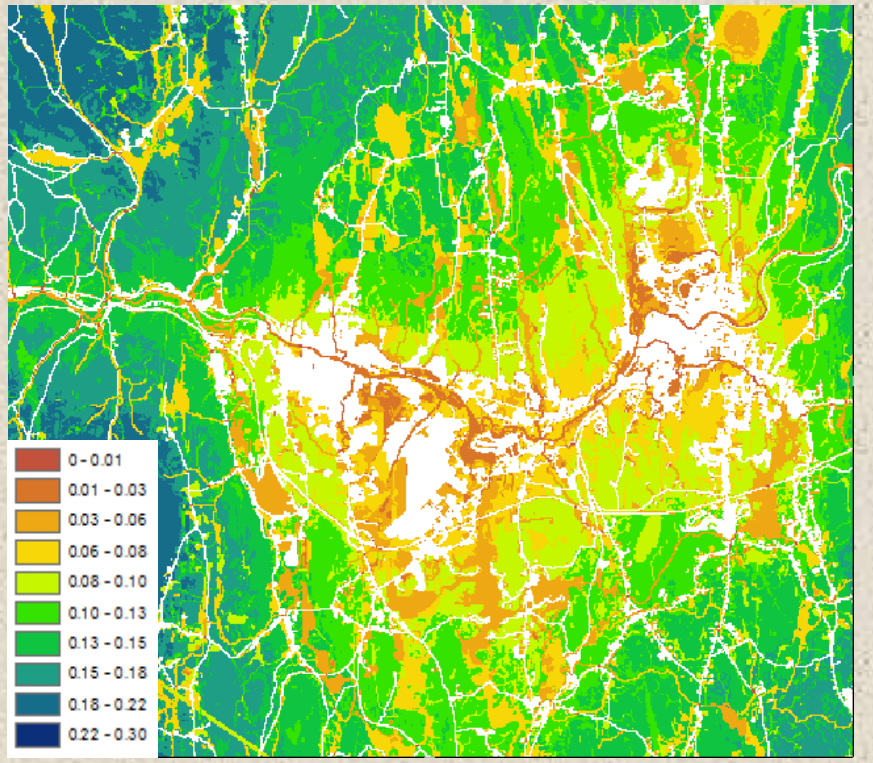


Landscape Assessment

Local integrity metrics

- **Connectedness…** connectedness to neighboring cells of similar ecological setting to the focal cell, based on a *resistant Gaussian kernel*

  ✓For organisms where impediments to movement are important

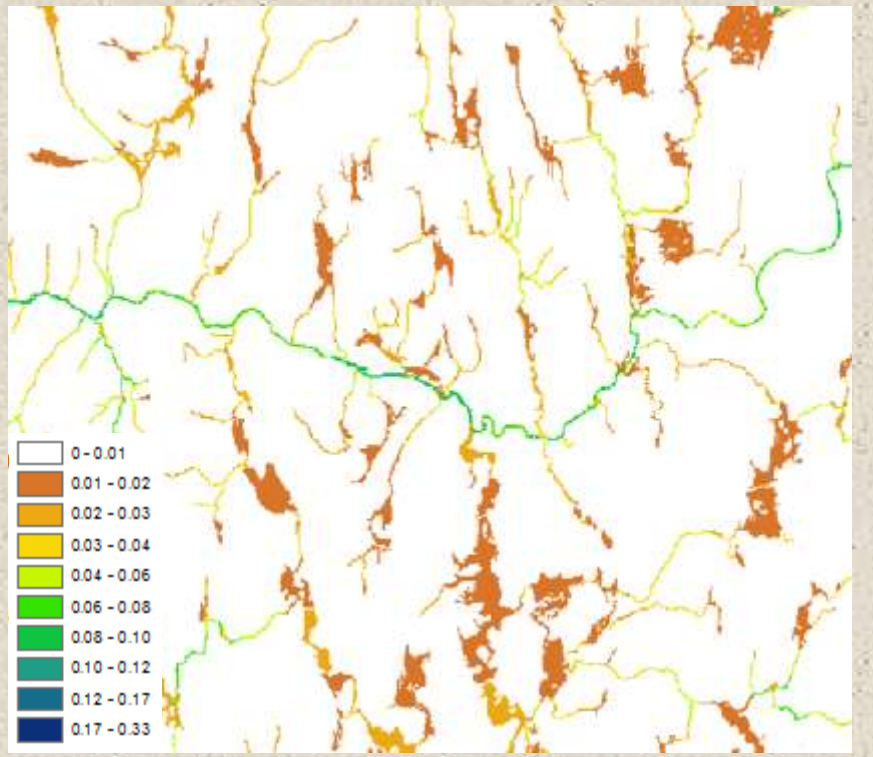


Landscape Assessment

Local integrity metrics

- **Aquatic connectedness…** connectedness to neighboring cells of similar ecological setting to the focal cell, based on a *time-of-flow kernel*

✓For aquatic organisms where impediments to movement are important

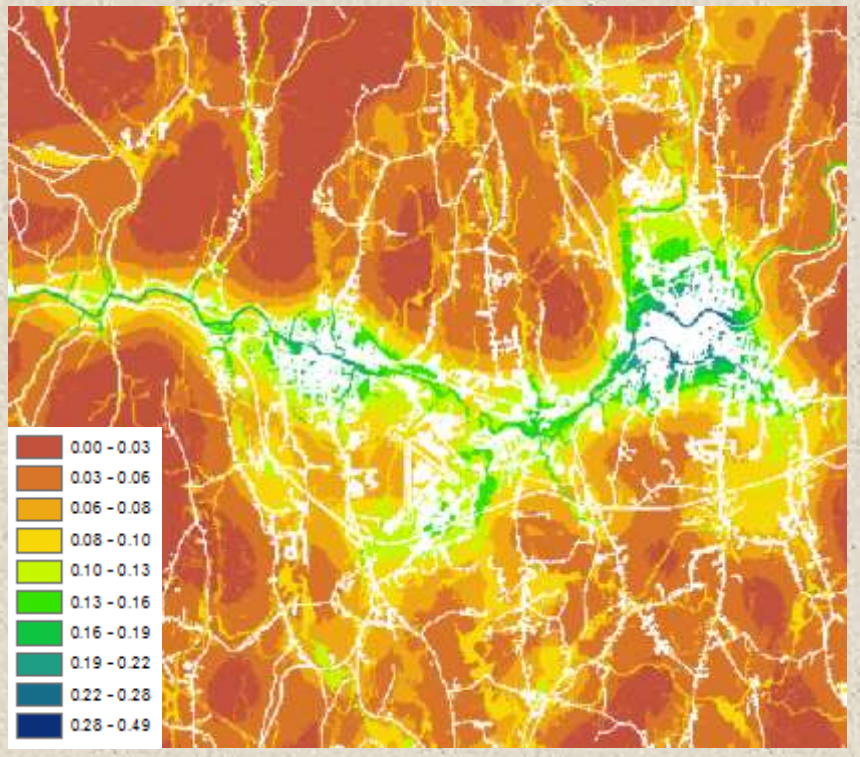


Landscape Assessment

Local integrity metrics

- **Similarity…** similarity of the ecological neighborhood to the focal cell, based on a *Gaussian kernel*

  ✓ for highly vagile organisms where the intervening landscape is not limiting movement



Landscape Assessment

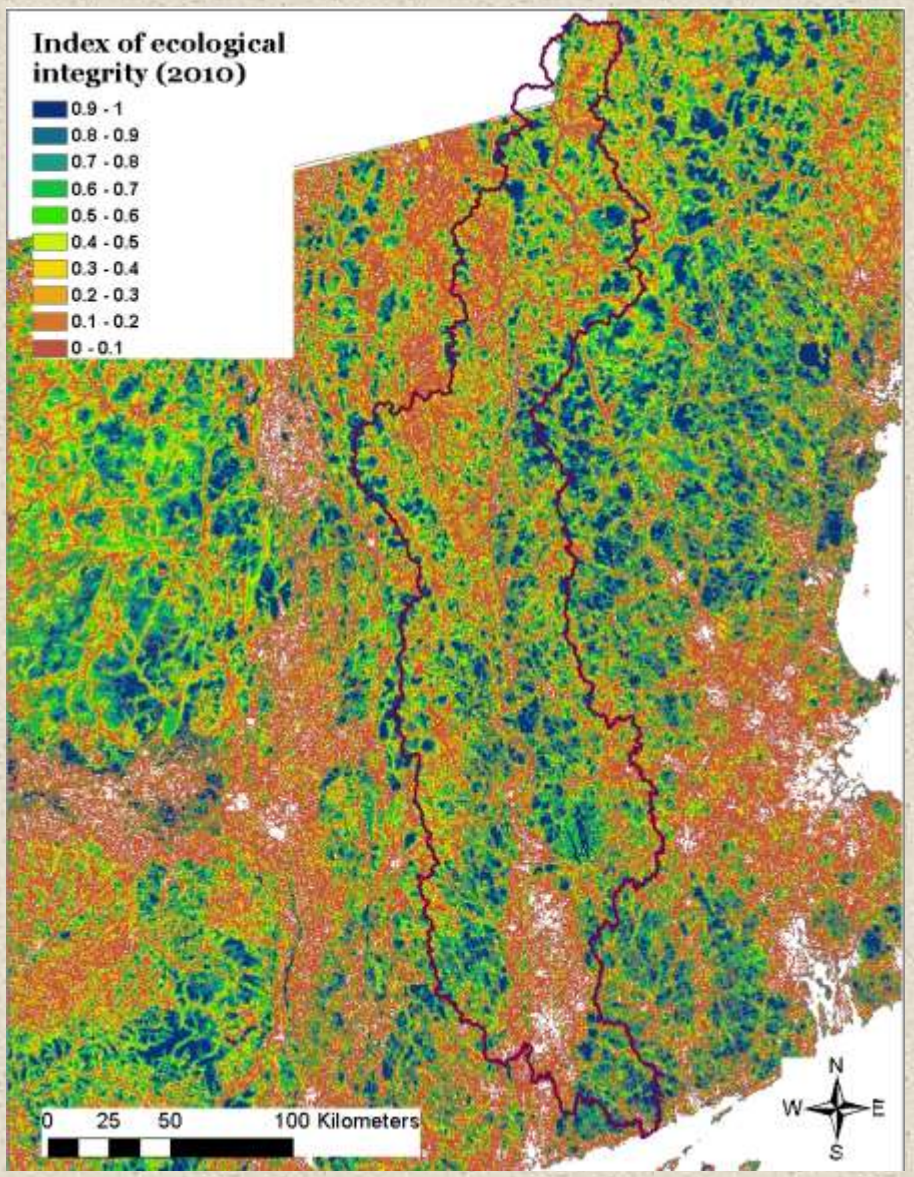
Local ecological integrity

3. **Adaptive capacity…** capacity to adapt to a changing environment (e.g., climate) over the long term (i.e., long-term resiliency)
   - Metric measures capacity to track favorable environments over time as affected by diversity of ecological settings and human impediments to ecological flows [connectivity]
   - Raw scale (0-1)
   - High value = high AC
   - *Currently under development*

Landscape Assessment

Local integrity metrics

- **Index of ecological integrity (IEI)**
  - Weighted (by ecosystem) linear combination of intactness & resiliency metrics
  - Quantile-scaled (0-1) by ecosystem & extent (benchmarked to 2010)
  - High value = high integrity
  - Top x% interpretation



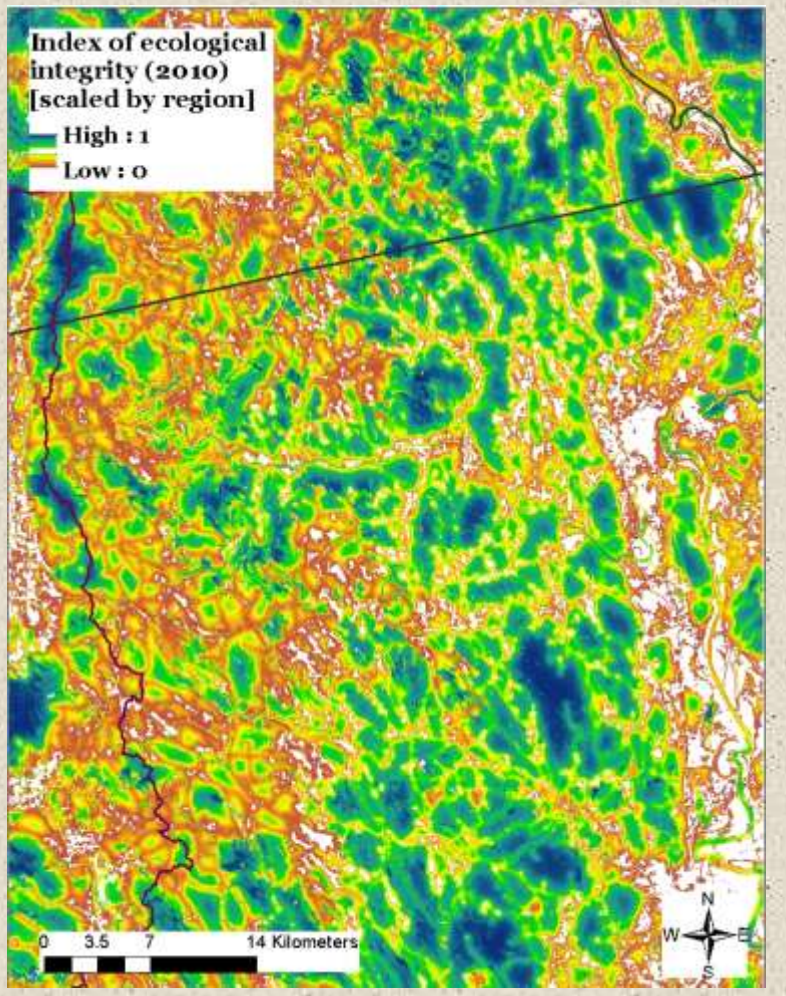
Landscape Assessment

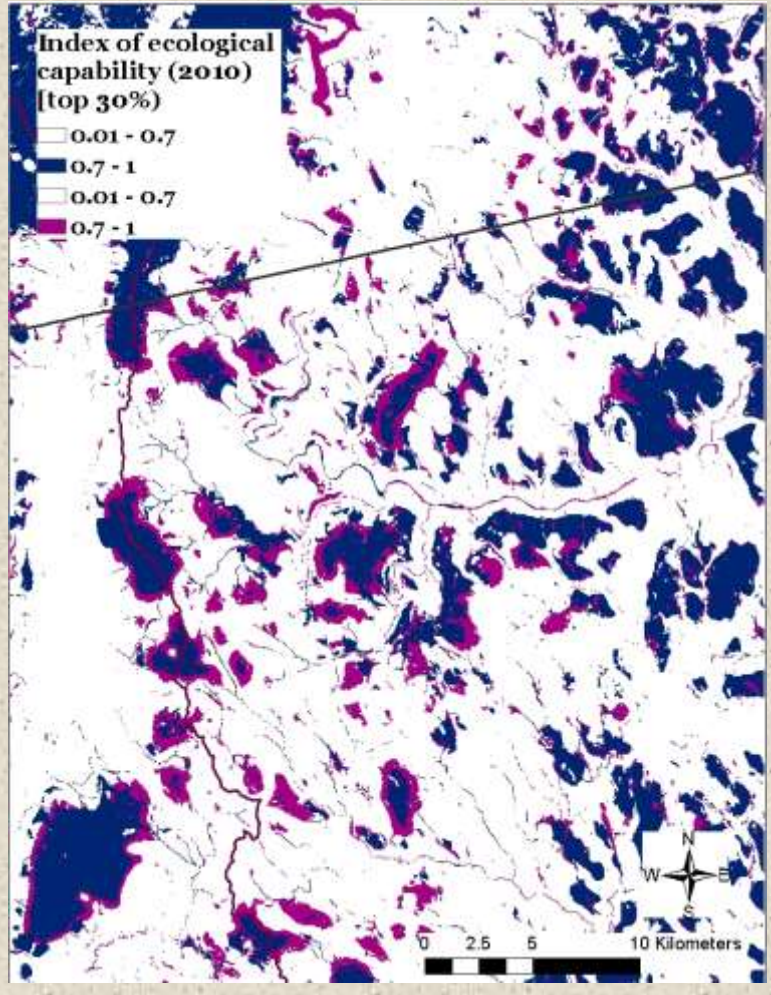
Local integrity metrics

- Interpretation changes with extent

Top 30 in region

Top 30 in state

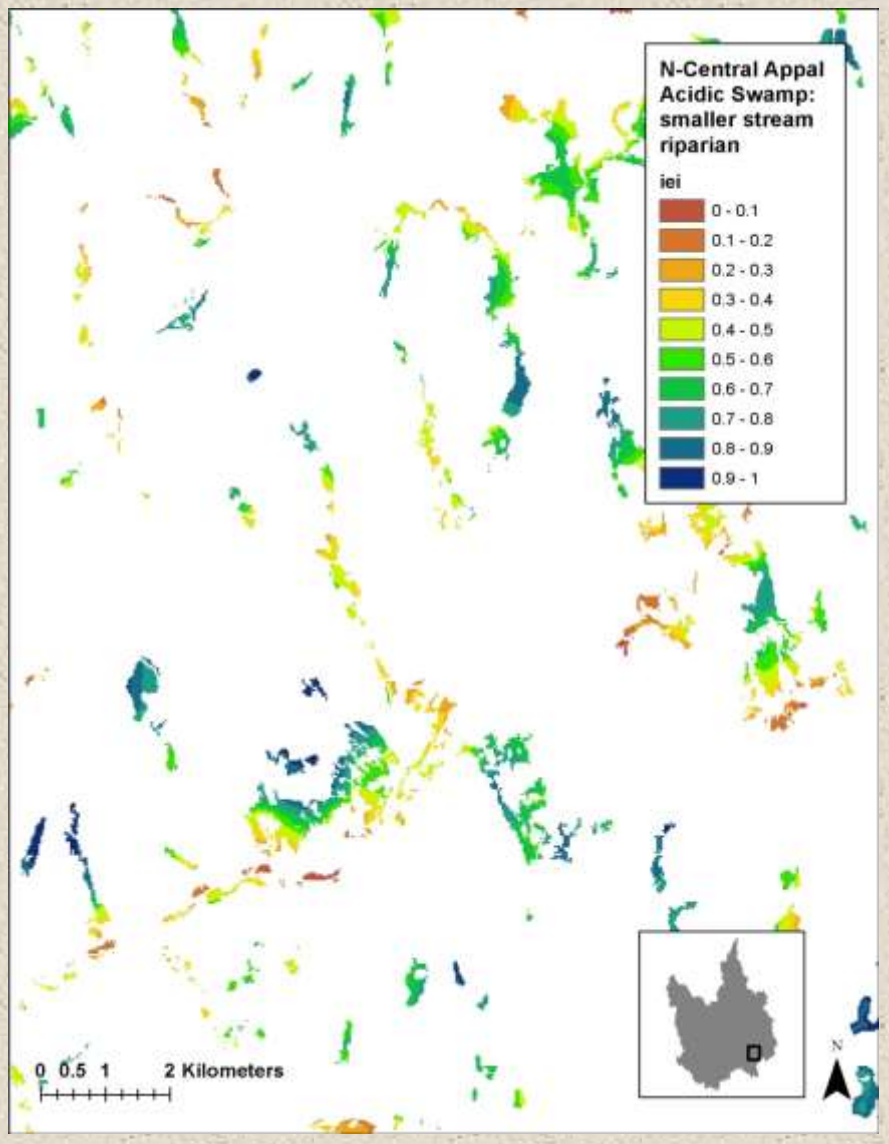




Landscape Assessment

Local integrity metrics

- **Index of ecological integrity (IEI)**
  - Use IEI in combination with capsland to evaluate single ecosystems

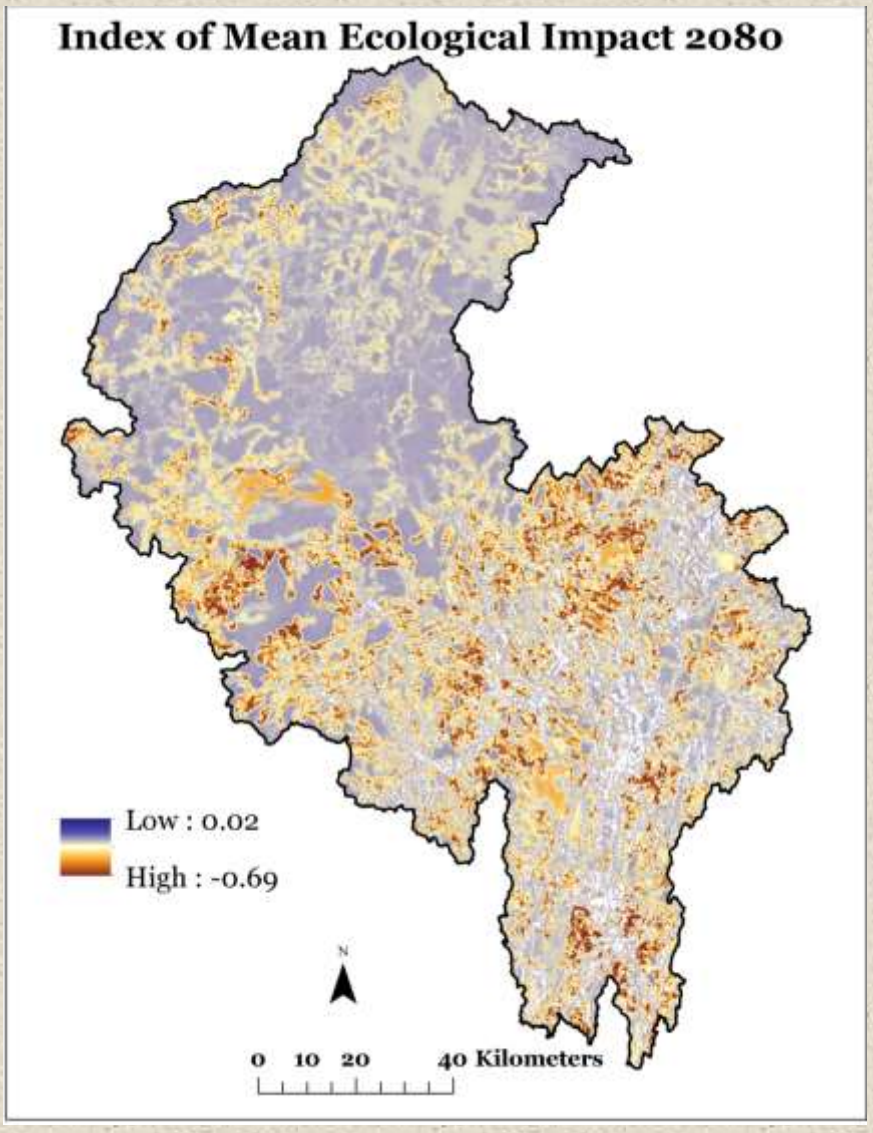


Landscape Assessment

Local integrity metrics

Not yet available

- **Index of ecological impact**
  - Weighted (by ecological system) linear combination of delta-scaled intactness and resiliency metrics multiplied by IEI in 2010
  - Mean Impact across uncertainty simulations
  - Computed for 2030 & 2080
  - Suitable for scenario comparison



Landscape Assessment

Local integrity metrics

Not yet available

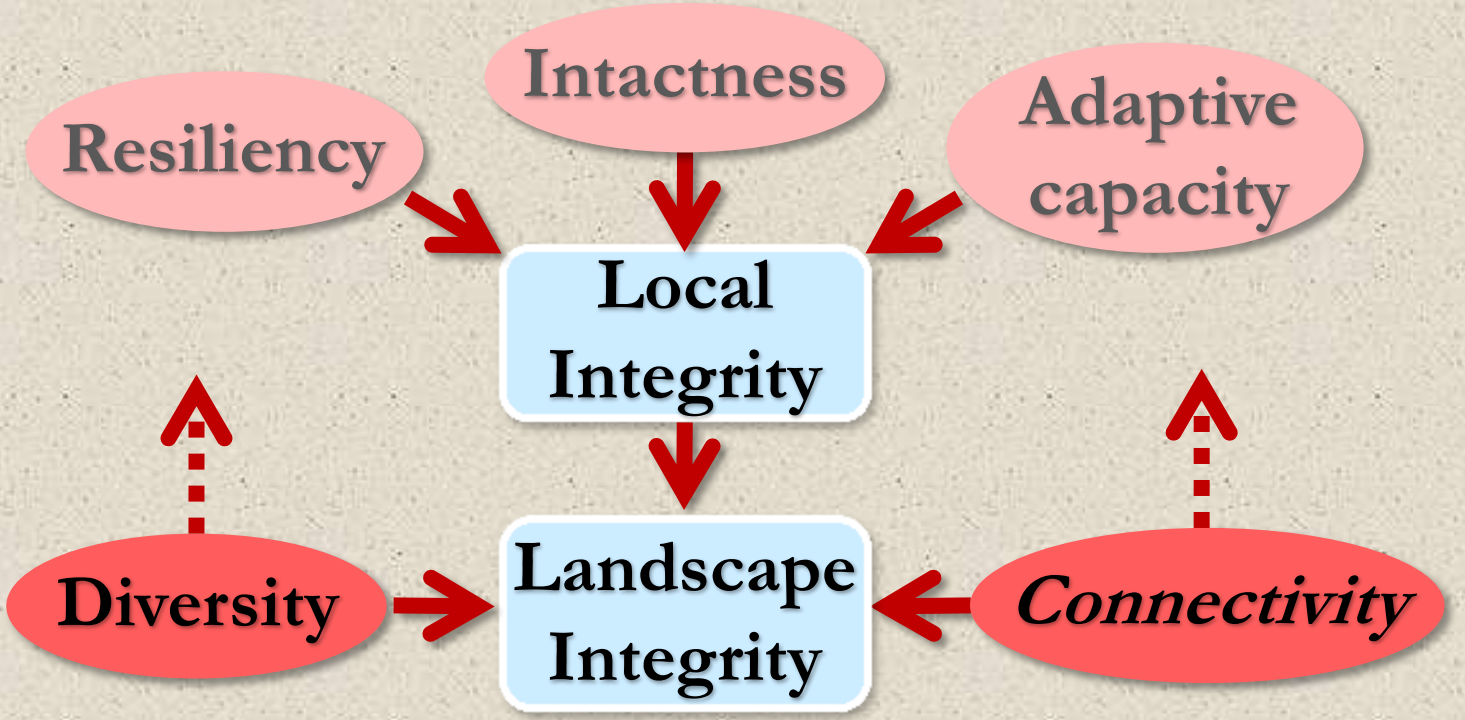
- **Tabular summaries:**
  - Regional ubiquity
  - Landscape ubiquity
  - Landscape importance
  - Index of ecological integrity
  - Index of ecological impact
  - Other?

Summary statistics on the species' distribution in the focal landscape relative to the region and other statistics to aid in weighting species in landscape conservation design

Landscape Assessment

Landscape ecological integrity

"An *integral landscape* has a green infrastructure containing a diversity of connected ecosystems with high local integrity (intactness, resiliency and adaptive capacity)"



Each of these components are defined and quantified

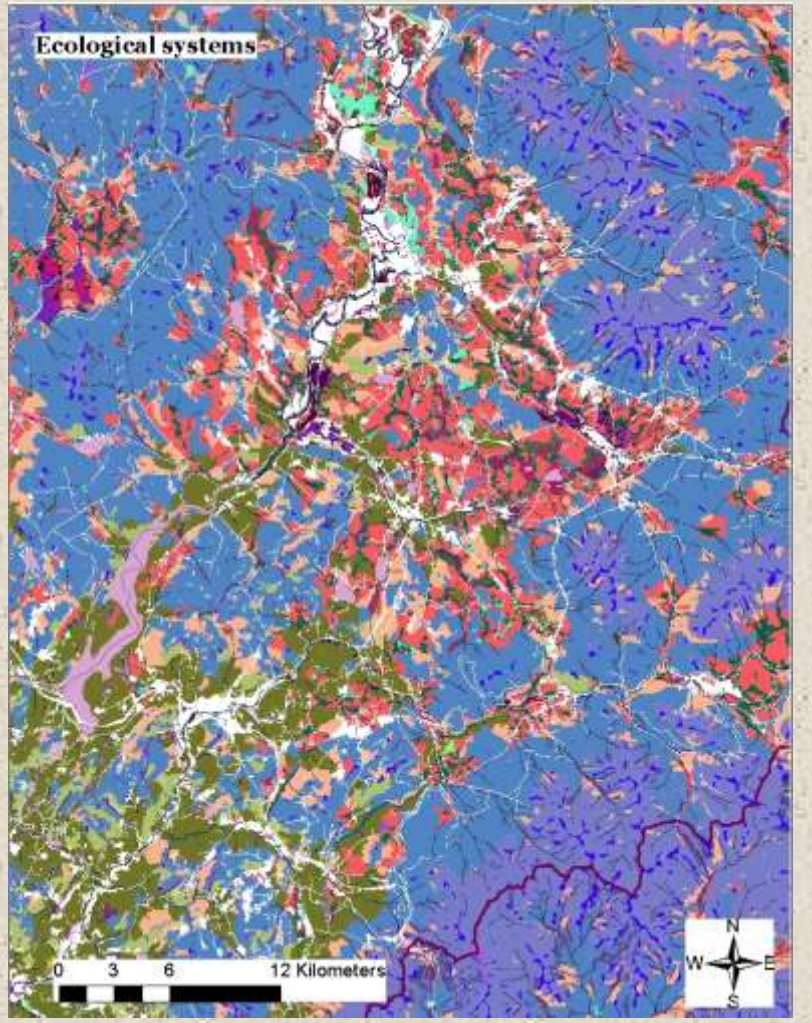
Landscape Assessment

Landscape ecological integrity

1. **Diversity…** variety of ecological settings (ecological systems) with high local integrity

   Function of:

   - Diversity of ecological settings (ecological systems) with high local integrity



Diversity confers landscape resilience and adaptive capacity

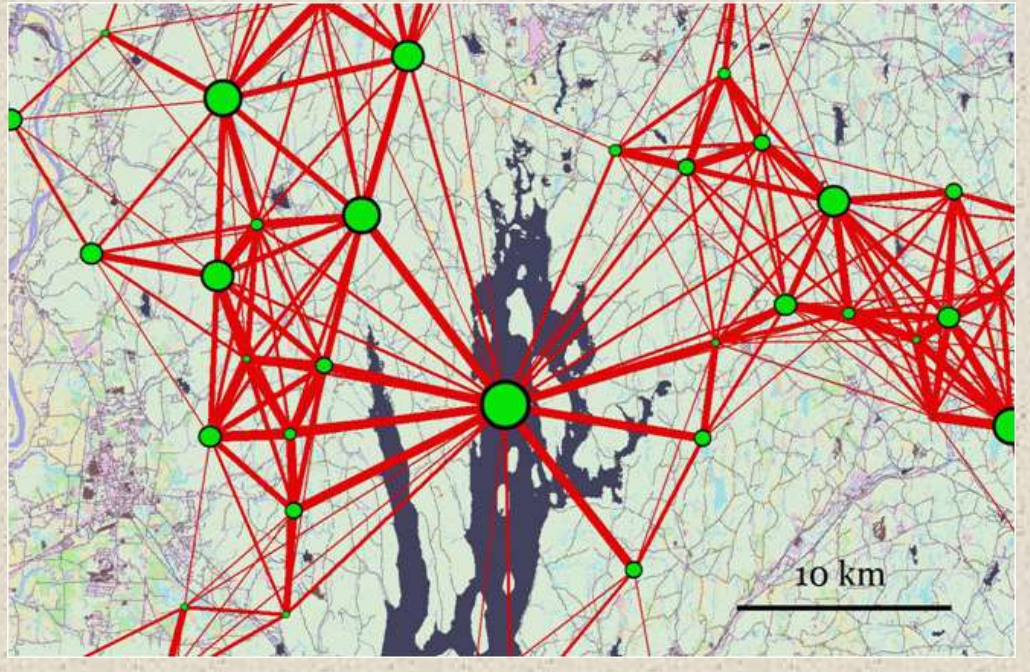
Landscape Assessment

Landscape ecological integrity

2. **Connectivity…** propensity to conduct ecological flows across the landscape

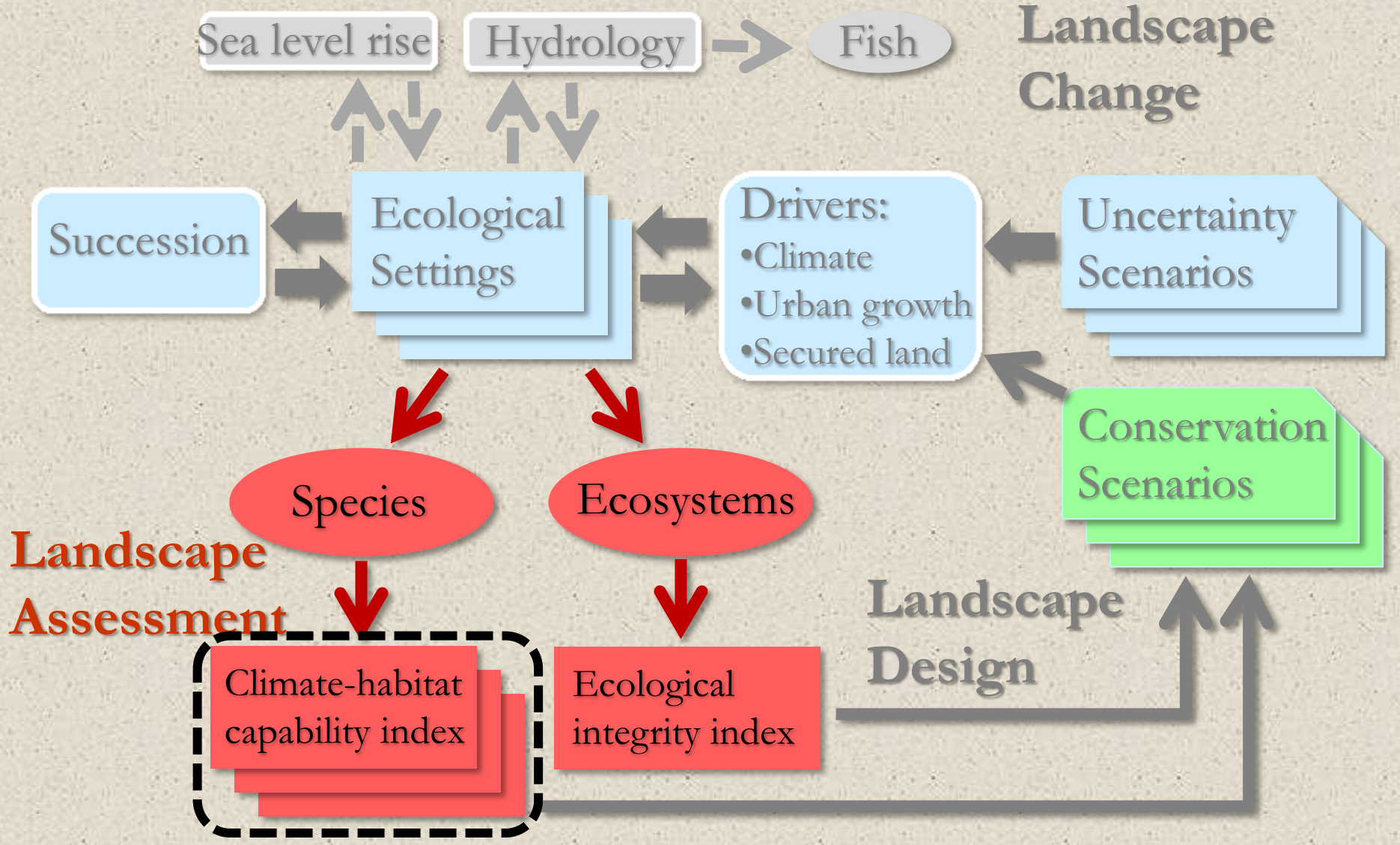
Function of:

- Configuration of natural ecological settings with high local integrity
- Human impediments to ecological flows
- At the regional scale



Connectivity confers landscape resilience and adaptive capacity

LCAD Model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Landscape Design

Landscape Assessment

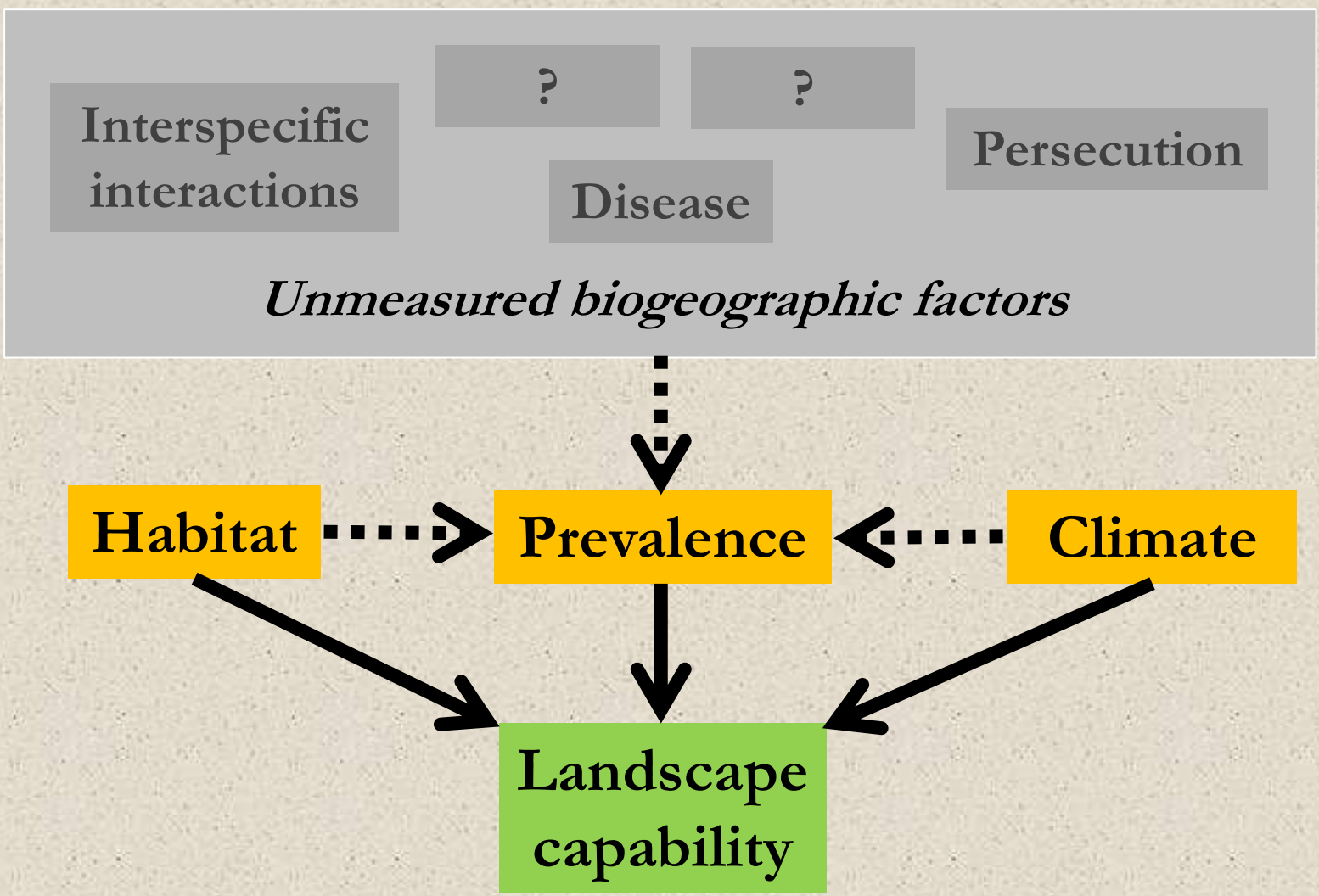
Species

Our focal species approach is based on the concept of *landscape capability* applied to a suite of *representative species*

- *Landscape capability* refers to the ability of the landscape to provide the environment and the local resources (e.g., food and cover) needed for survival and reproduction in sufficient quantity, quality and accessibility to meet the life history requirements of individuals and local populations

Landscape Assessment

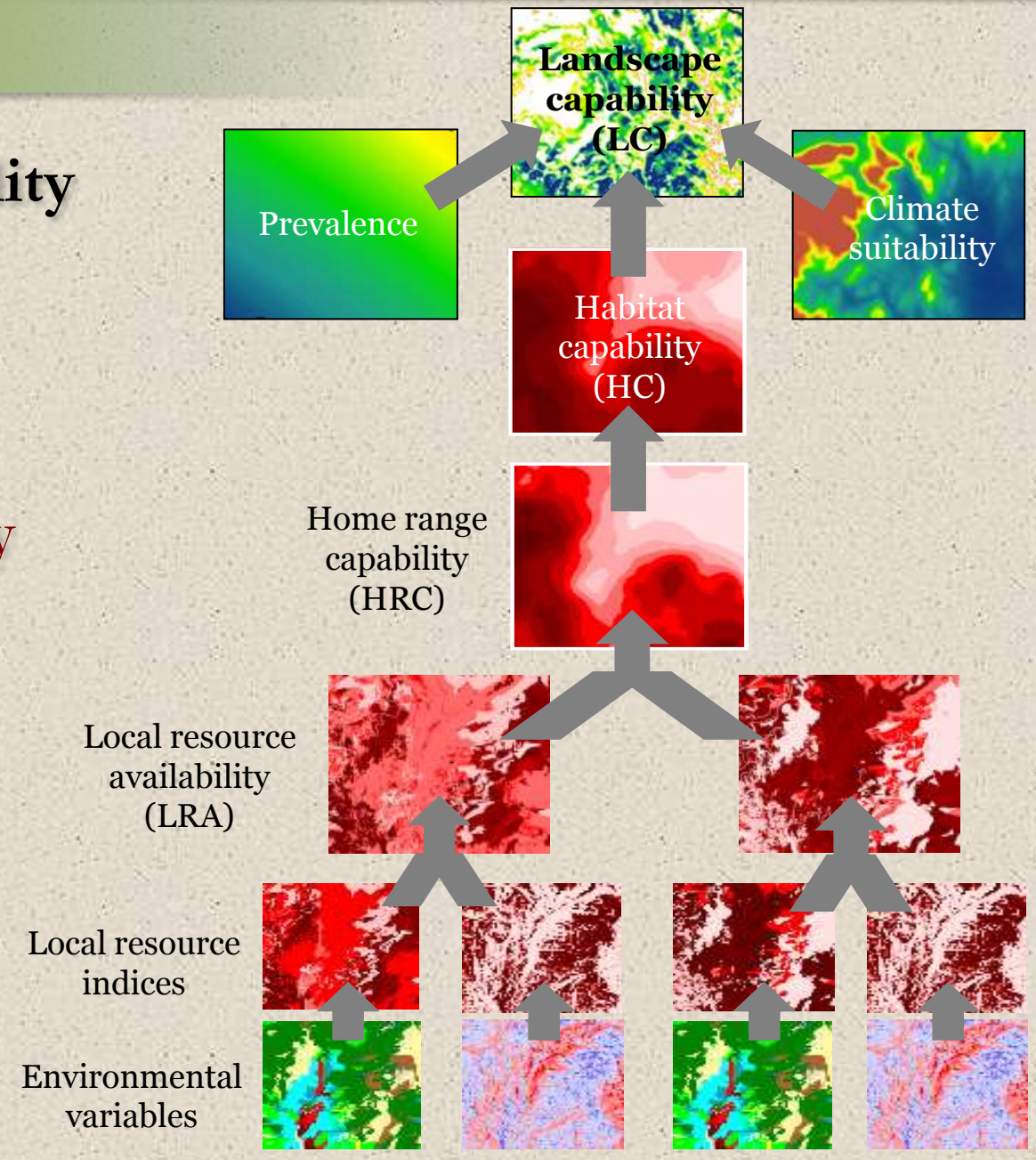
Species



Landscape Assessment

Species

- **Landscape capability index**
  - Spatially-explicit
  - Multi-scale
  - Expert/empirically -derived
  - Synthesis of habitat capability, climate suitability, and prevalence
  - Statistically validated



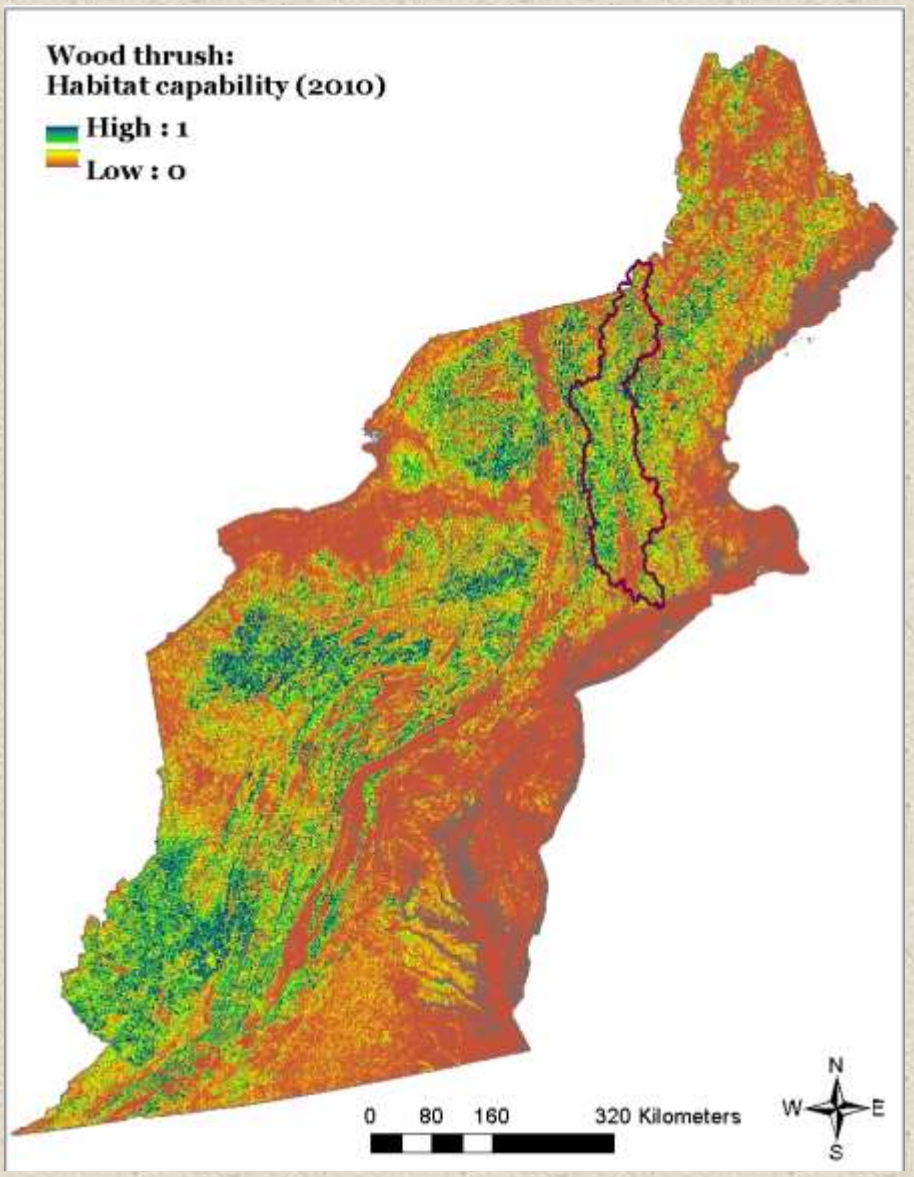
Landscape Assessment

Species

- **Habitat capability index**

Where is the *capable habitat* in 2010, without regard to climate suitability and species' prevalence?

Wood thrush



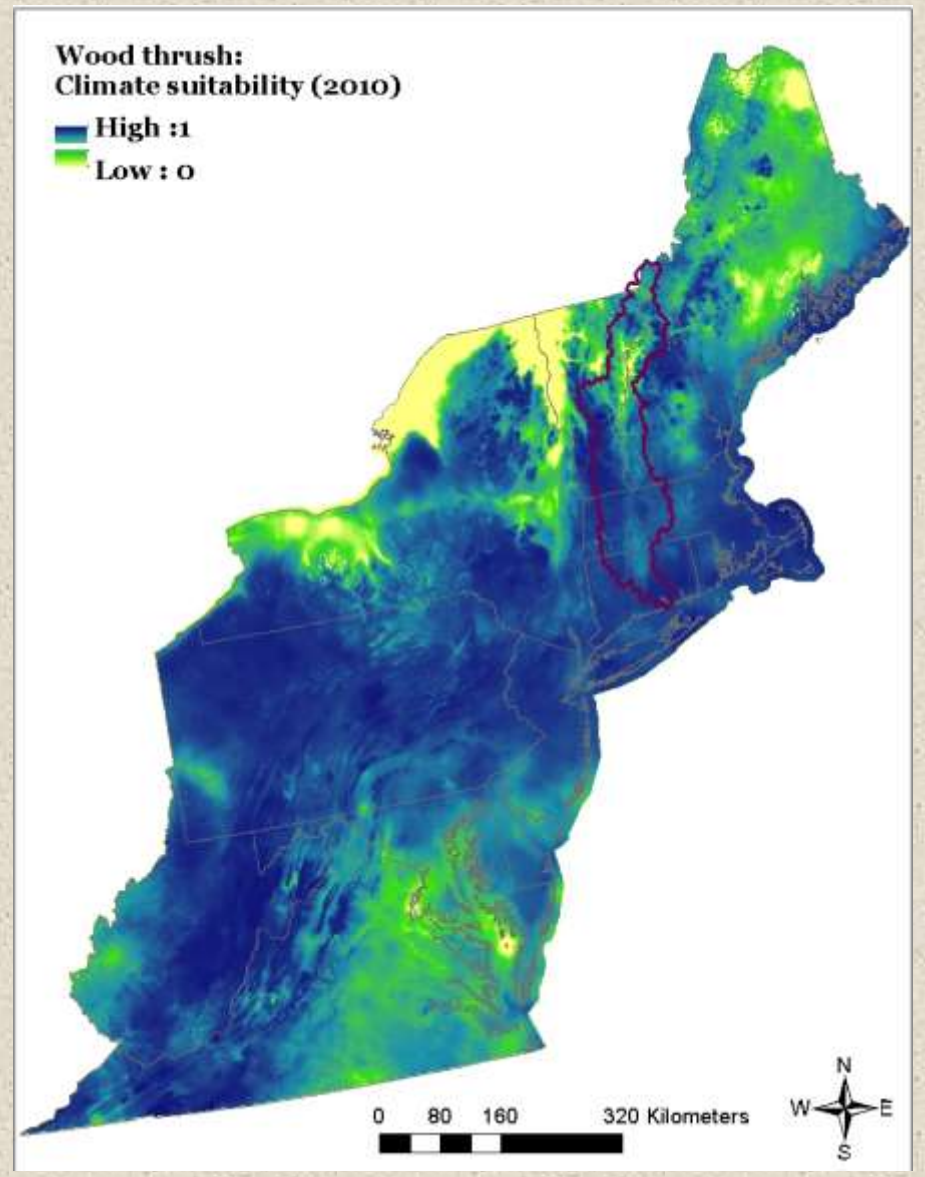
Landscape Assessment

Species

- **Climate suitability index**

Where is the *suitable climate* in 2010, without regard to habitat and species' prevalence?

Wood thrush



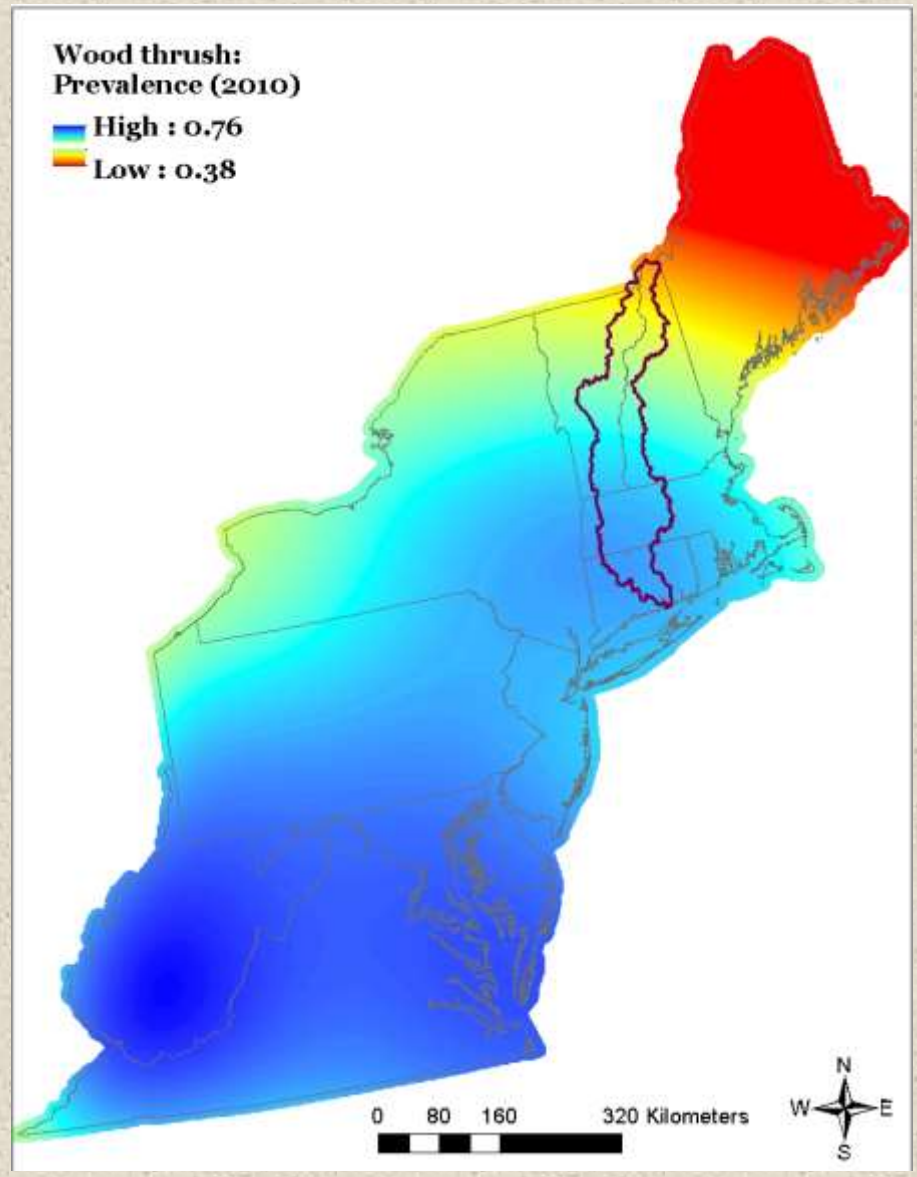
Landscape Assessment

Species

- **Prevalence index**

Where is the species most *prevalent* in 2010, without explicit regard to habitat and climate suitability

Wood thrush



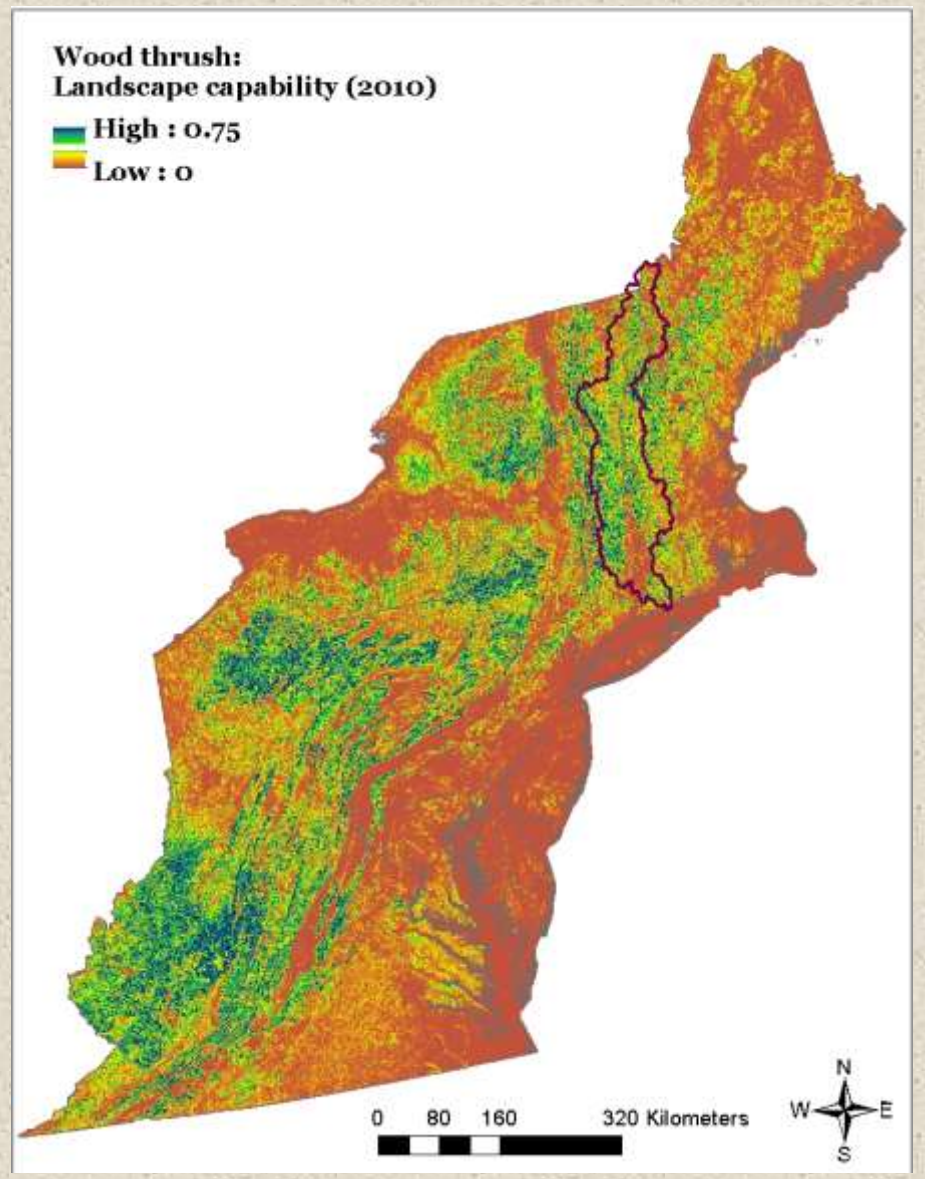
Landscape Assessment

Species

- **Landscape capability index**

Where is the species' most likely to *occur* in 2010, based on habitat capability, climate suitability and prevalence?

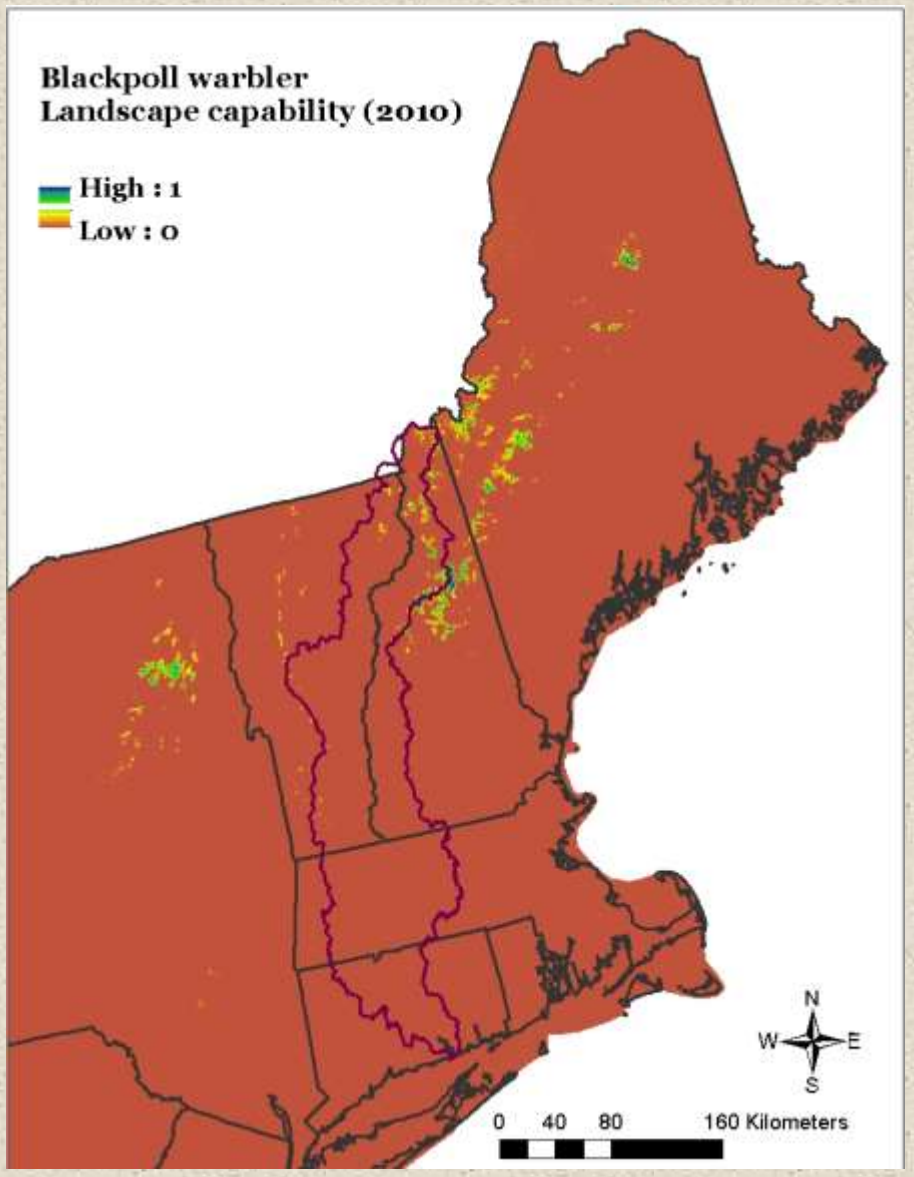
Wood thrush



Landscape Assessment

Species

- Habitat capability index
- Climate niche
- Prevalence (n/a)
- Landscape capability index



Blackpoll warbler

Landscape Assessment

Species

Not yet available

- **Tabular summaries:**
  - Regional ubiquity
  - Landscape ubiquity
  - Landscape importance
  - Climate vulnerability
  - Landscape capability
  - Protected status
  - Other?

Summary statistics on the species' distribution in the focal landscape relative to the region and other statistics to aid in weighting species in landscape conservation design

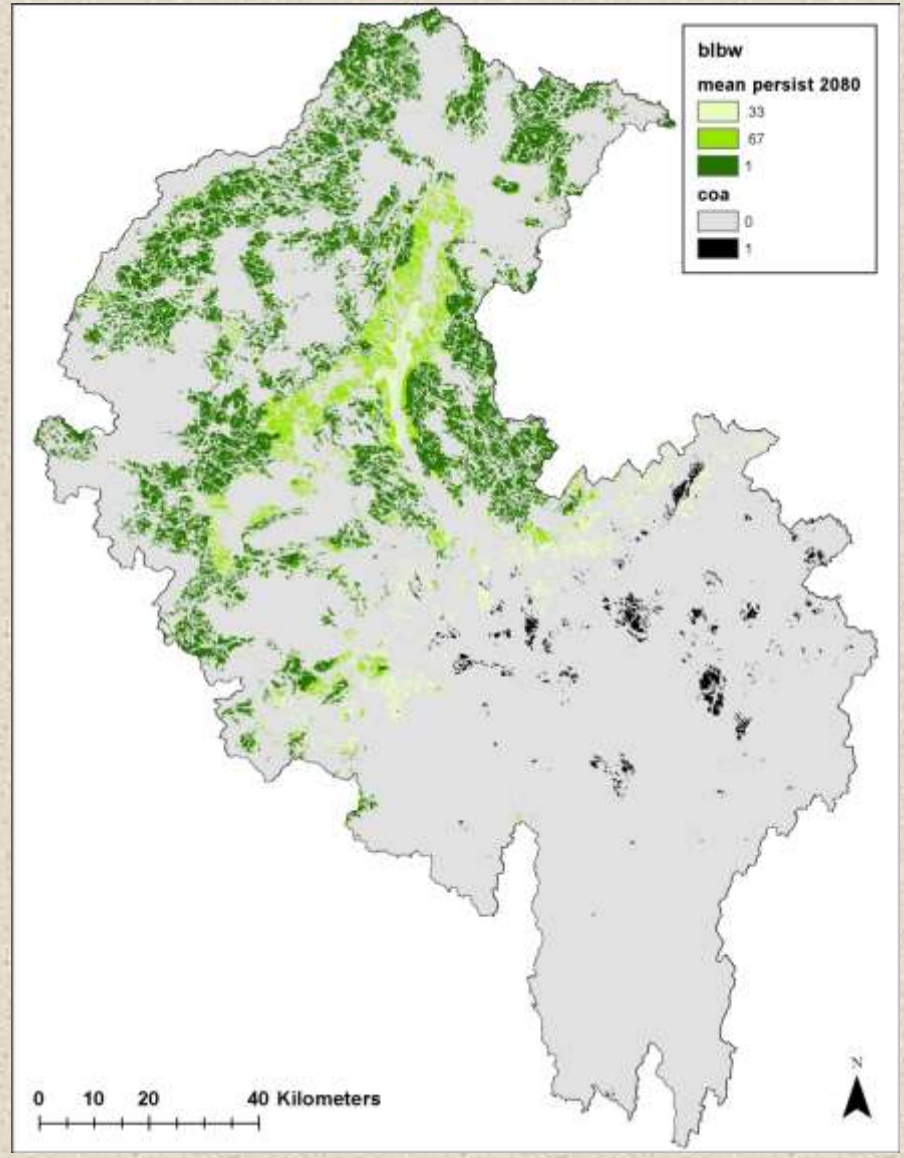
Landscape Assessment

Species

Not yet available

- **Habitat-Climate uncertainty**

Zone of Persistence = Persistent future habitat and suitable climate within the species' current optimal area



Blackburnian warbler

Landscape Assessment

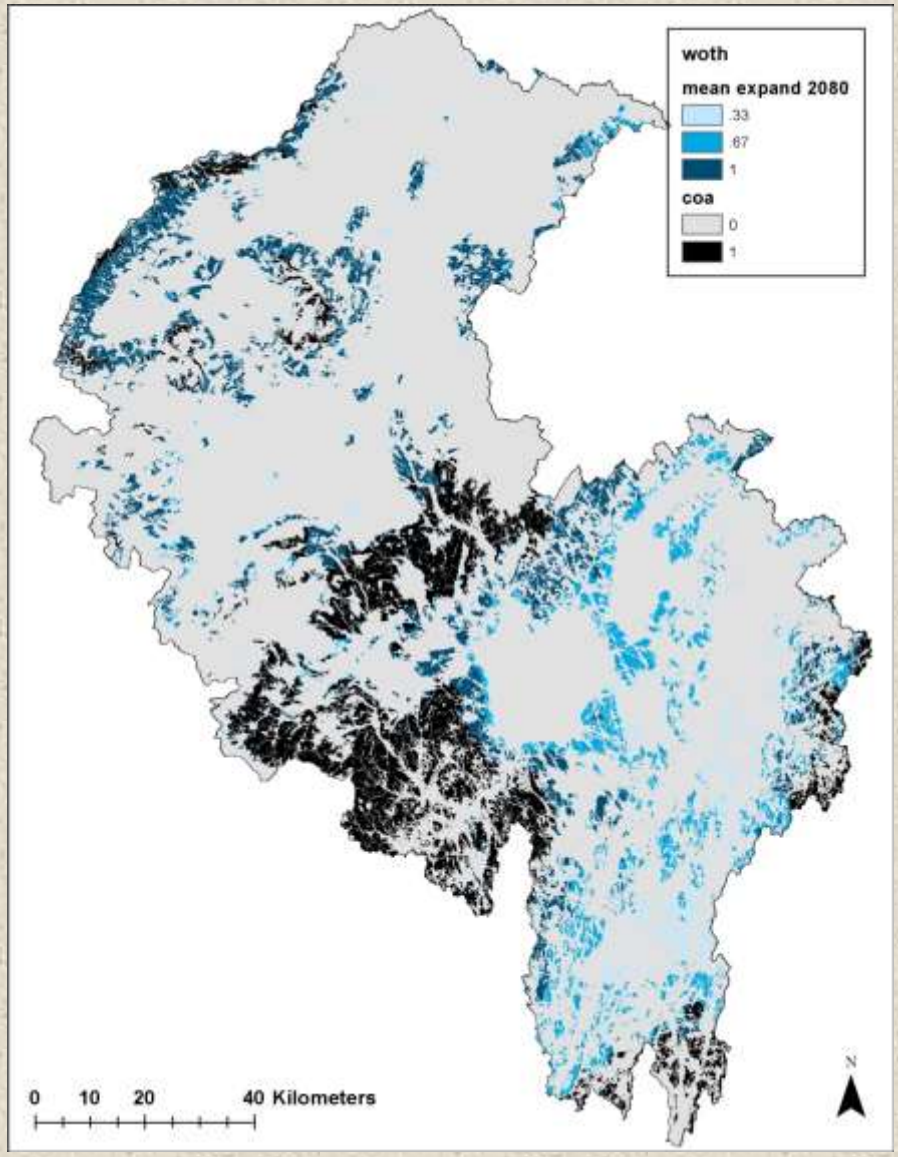
Species

Not yet available

- **Habitat-Climate uncertainty**

Zone of Expansion = Future habitat and suitable climate, but outside the current optimal area

Wood thrush



Landscape Assessment

Species

Not yet available

- **Habitat-Climate uncertainty**
  - **Landscape capability indices…** based on sum of species' prob(occur) values across cells within the *region* or *landscape* under different climate change assumptions

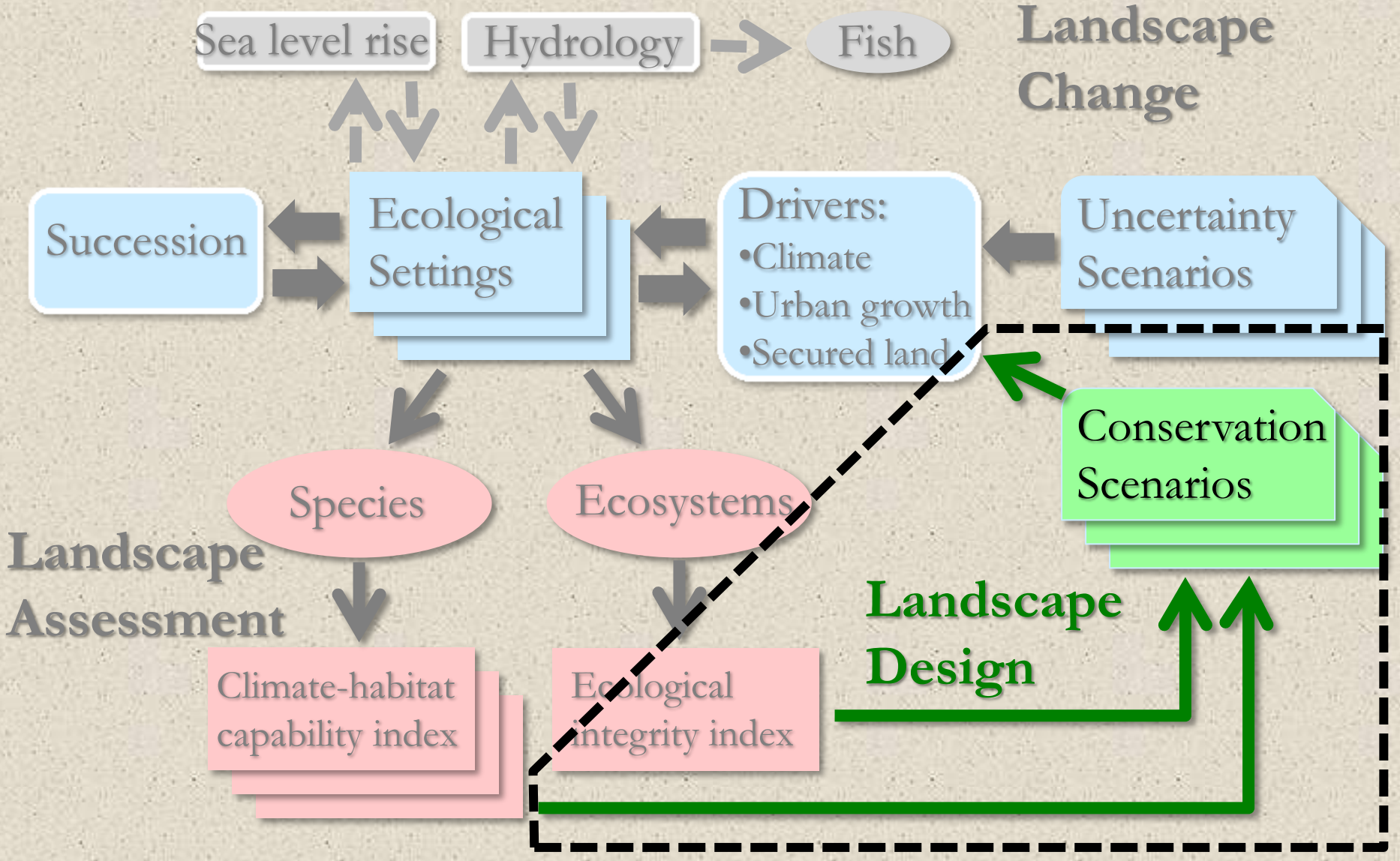
			Species Response to Climate Change					
			None		Immediate Range Contraction		Immediate Range Shift	
Species	Statistic	2010 (ha)	2030	2080	2030	2080	2030	2080
blbw	mean	184,281	1.01	1.01	0.87	0.21	0.87	0.21
	min		1.01	1.00	0.83	0.12	0.83	0.12
	max		1.01	1.01	0.90	0.32	0.90	0.32
woth	mean	398,441	1.00	0.99	1.00	0.99	1.00	0.99
	min		1.00	0.98	1.00	0.98	1.00	0.99
	max		1.00	0.99	1.00	0.99	1.00	1.00

Landscape Assessment

Species

- **Representative species (completed or in progress)**
  - Brown-headed nuthatch
  - Blackburnian warbler
  - Blackpoll warbler
  - Louisiana waterthrush
  - Marsh wren
  - Northern waterthrush
  - Ovenbird
  - Red-shouldered hawk
  - Wood turtle
  - Wood thrush
  - American black duck (B)
  - American black duck (NB)
  - American woodcock
  - Bicknell's thrush
  - Black bear
  - Box turtle
  - Common loon
  - Diamondback terrapin
  - Easter meadowlark
  - Moose
  - Prairie warbler
  - Ruffed grouse
  - Saltmarsh sparrow
  - Wood duck
  - American oystercatcher

LCAD Model


Sea level rise
Hydrology
Fish
Landscape Change
Succession
Ecological Settings
Drivers:
•Climate
•Urban growth
•Secured land
Uncertainty Scenarios
Conservation Scenarios
Species
Ecosystems
Landscape Assessment
Landscape Design
Climate-habitat capability index
Ecological integrity index

Landscape Conservation Design

Major Decision Points

- Establishing conservation goals & objectives
- How to weight ecological systems and focal species?
- How to weight predictions of current versus future conditions
- What external data products to include and how?
- How much area to include in the conservation network?
- How to ensure a well-distributed network?

Landscape Conservation Design

Adaptive Landscape Conservation Design