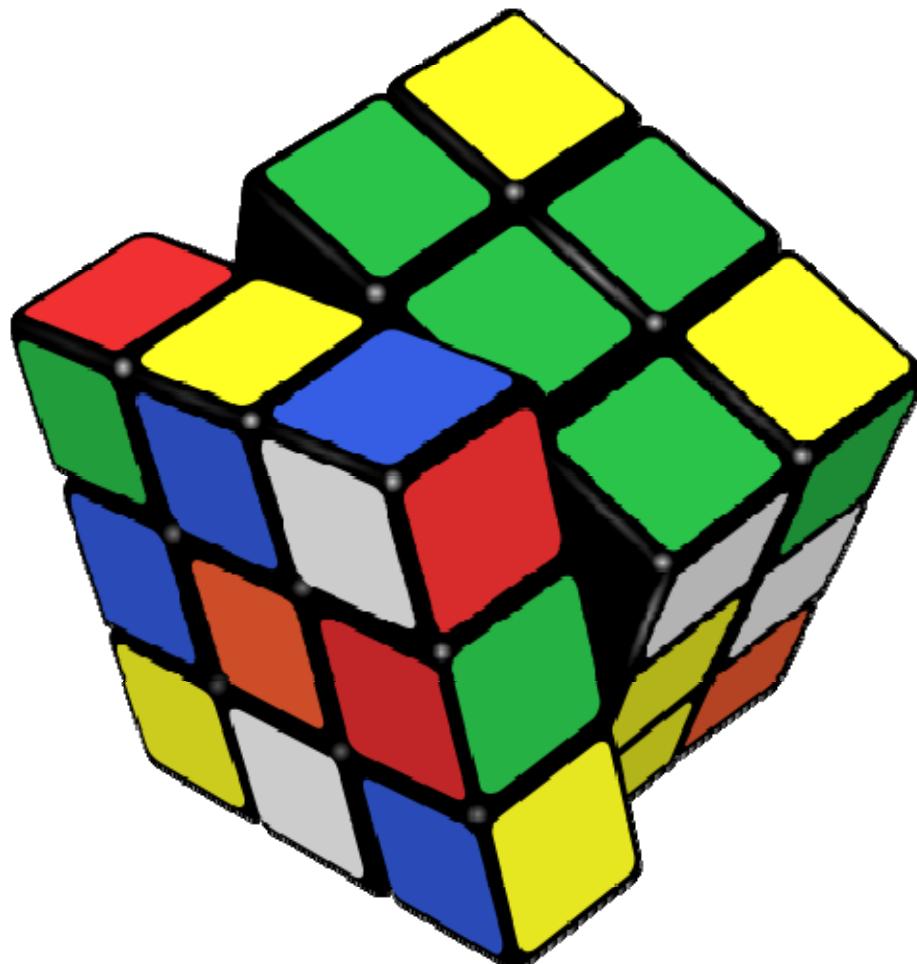




Conserving the Stage: Climate change and the geophysical underpinnings of species diversity.

Dr. Mark Anderson
Dir of Conservation Science
Eastern US Conservation Region

The challenge of thinking about climate change species-by- species



Rubik's cube

Simple

8 corners, 12 edges
= 43 quintillion
permutations

Coarse Filter: Ecosystems

A biotic community plus its geophysical setting

These aren't going to move



Summits



Coves



Steep slopes \ Cliffs



Flats and gentle slopes (Forests)



Rivers & Stream



Freshwater wetlands



Tidal marsh & Beach

Riparian

What factors drive regional diversity?



Ecological Land Units Eastern Conservation Region

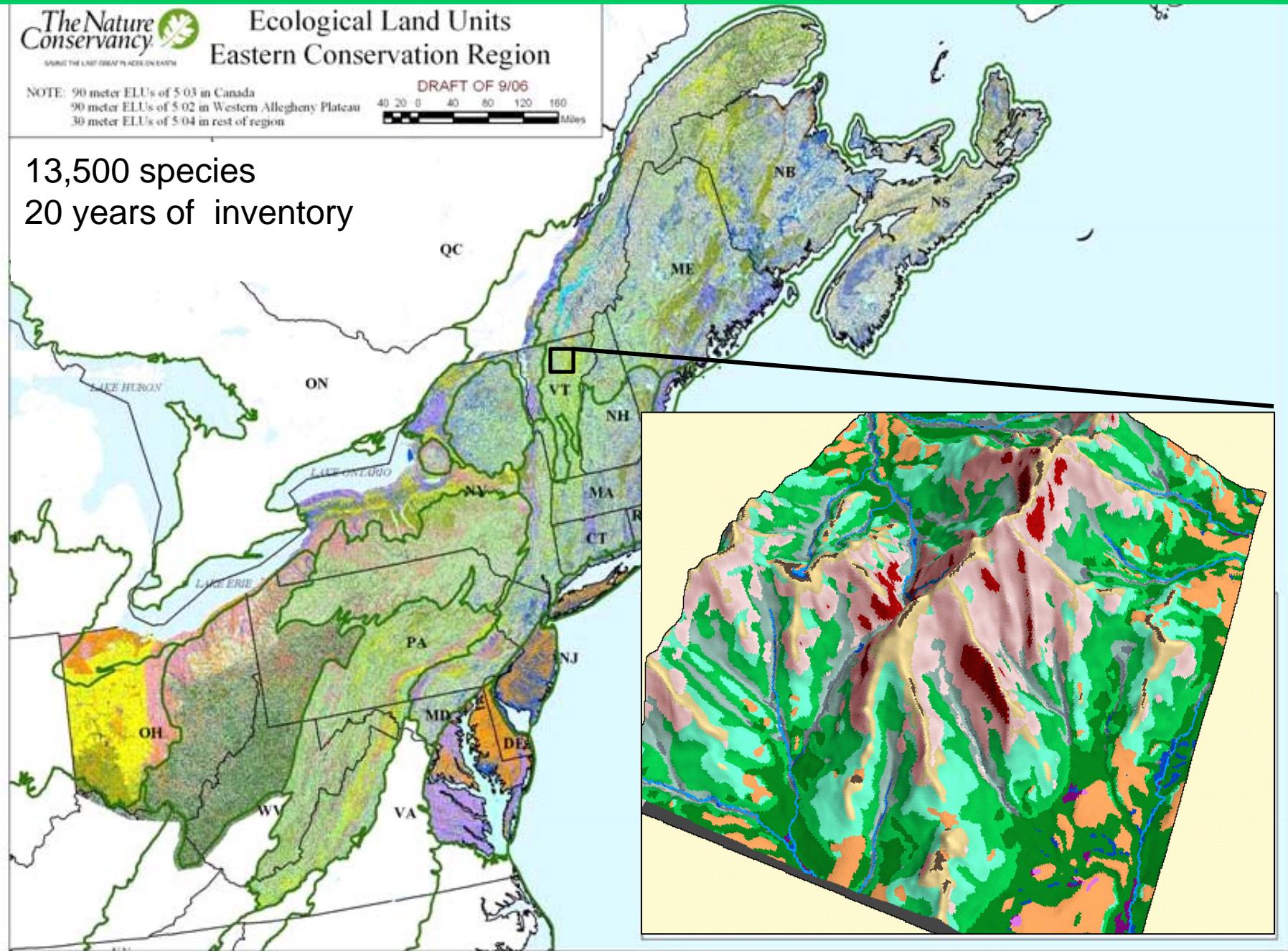
NOTE: 90 meter ELUs of 5'03" in Canada

90 meter ELUs of 5'02" in Western Allegheny Plateau

30 meter ELUs of 5'04" in rest of region

DRAFT OF 9/06
40 20 0 40 60 120 160 Miles

13,500 species
20 years of inventory



For each of 14 States and 3 Provinces:



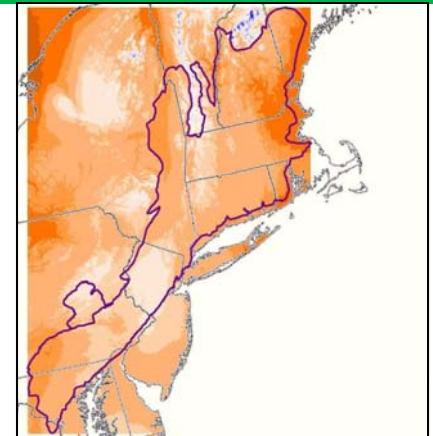
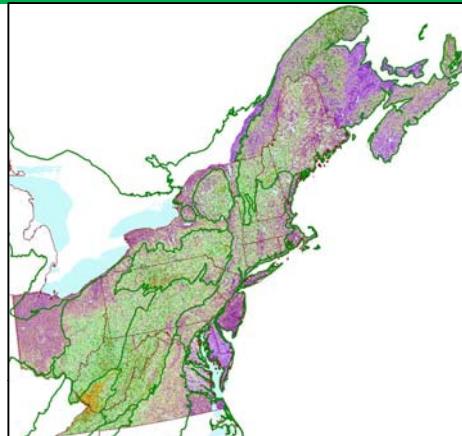
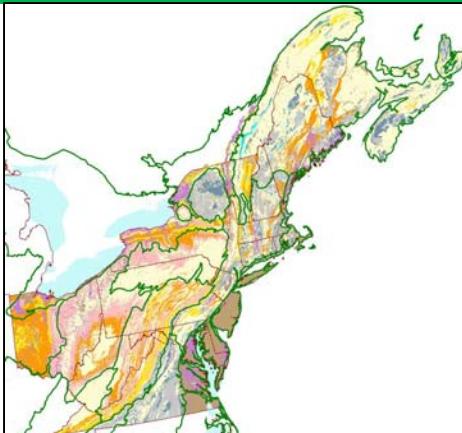
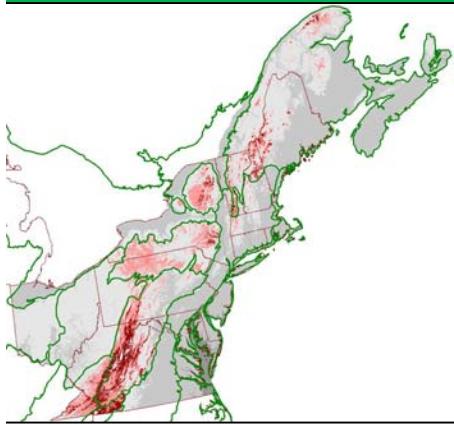
of vascular
and non
vascular plant
species

of vertebrate species

of macro-
invertebrates

Tabulated the total number for each state
based on NHP and Nature Serve inventory

Physical and Climatic Factors (22)



Elevation

Max

Min

Range

Area

Latitude

of Geology classes

Amount of each:

Sedimentary

Shale

Calcareous

Mod Calc

Granite

Mafic

Ultramafic

Coarse sand

Fine silt

of Landforms

Amount of each:

Cliff

Upper slope

Summit

Side slope

Cove

Valley

Wet flat

Dry flat

Mean diurnal temp.

range,

Mean annual temp.

range,

Mean annual temp.

Mean annual

precip.

Precip. warmest

quarter,

Min temp. coldest

month,

Mean temp. coldest

quarter.

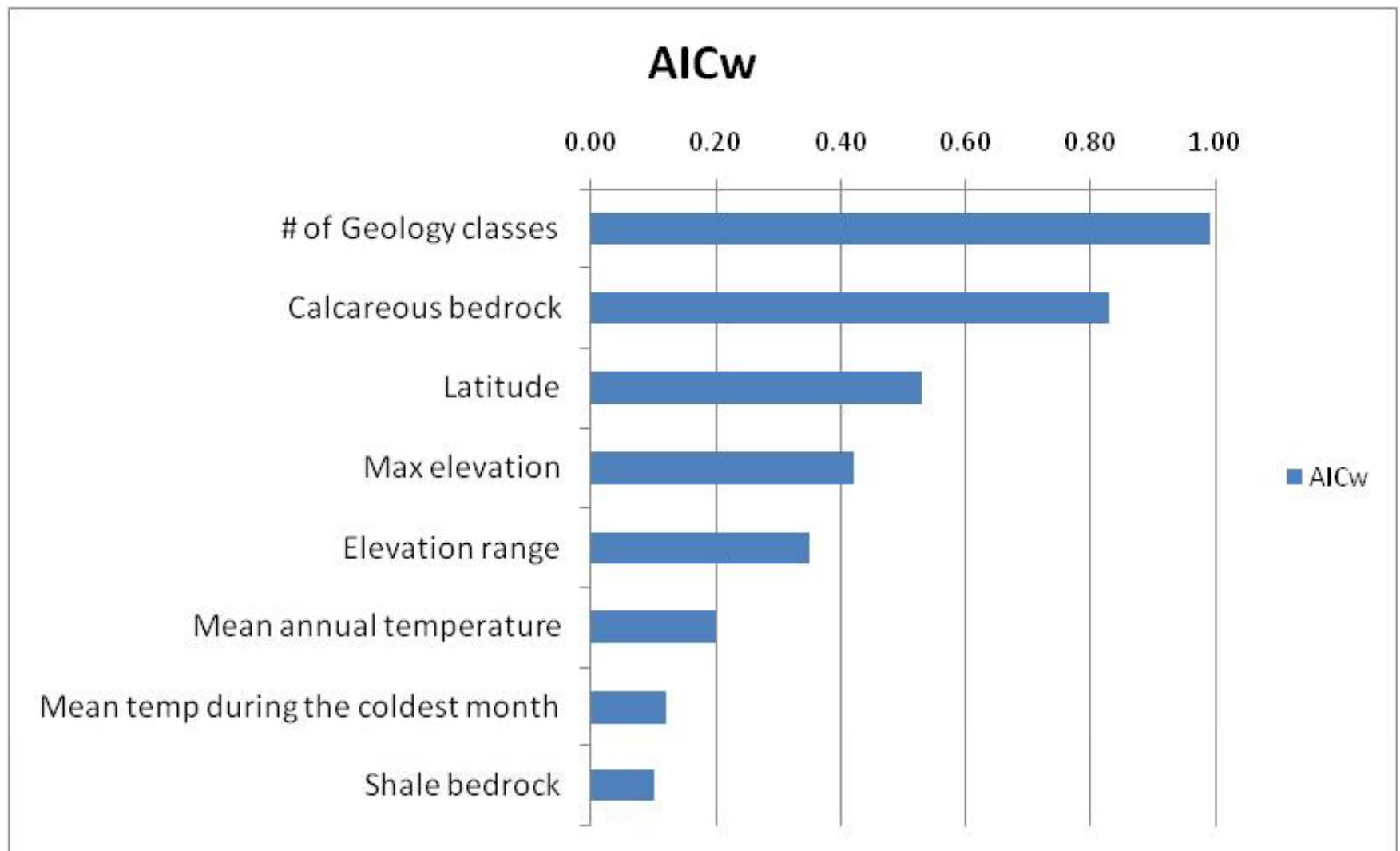
Ran all possible linear models (of 1-4 variables):

- 22 variables, 40,000 plus combinations of one to four variables

For Example

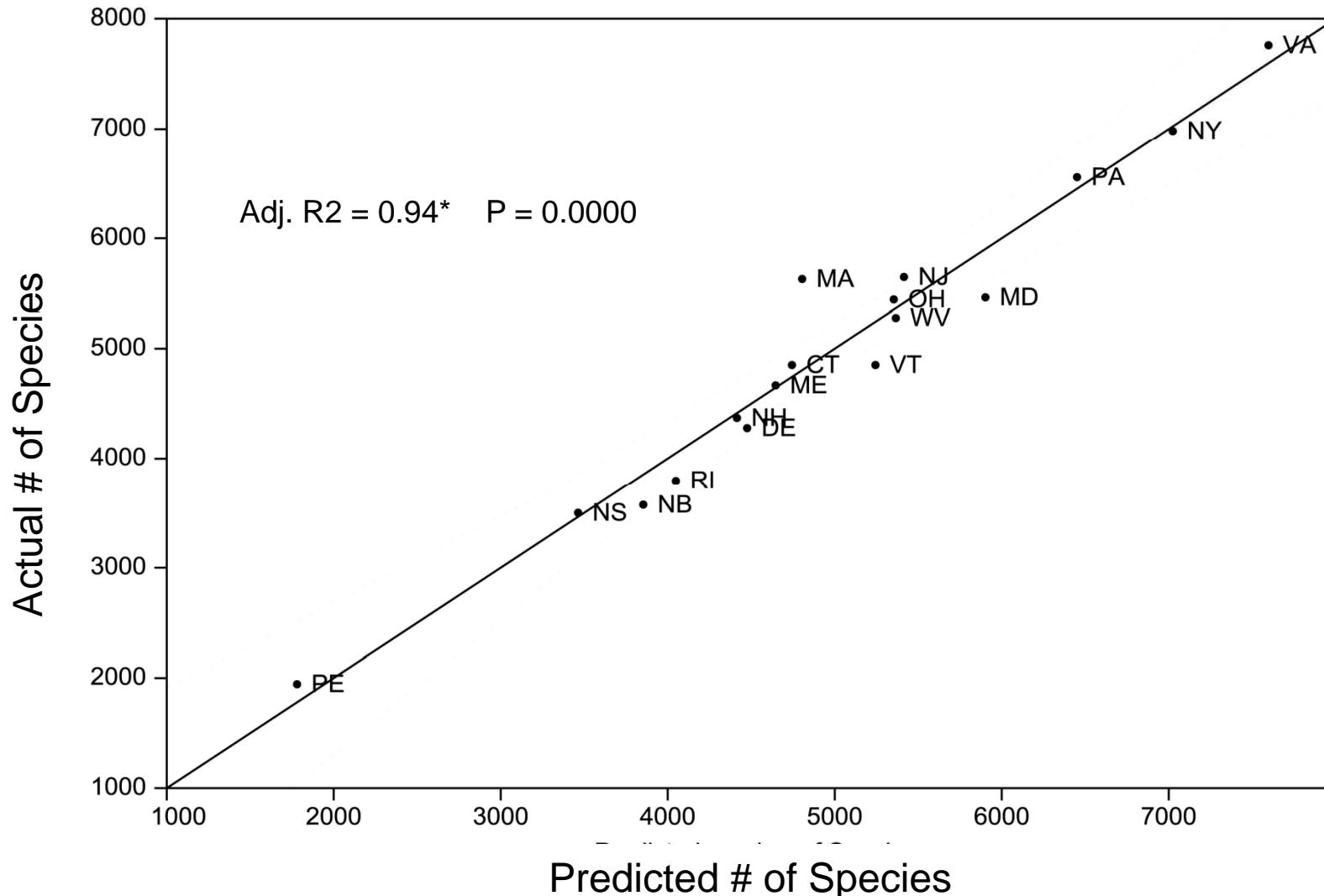
- One variable = temperature
- Two variables = temp & area
- Three variables = temp & area & geology
- Four variable = temp & area & geo & precip.

Akaike Importance Values for the top 284 models with R^2 over 0.90

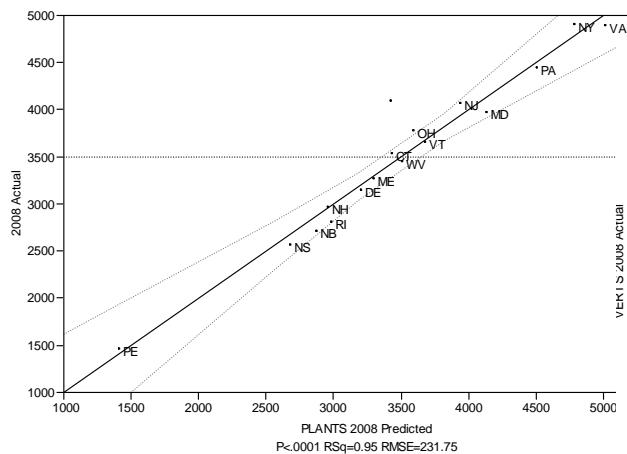


Species Diversity

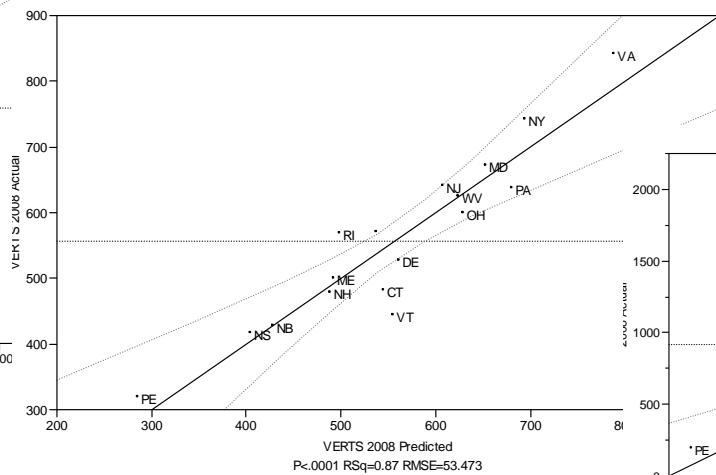
1) # of Geology classes, 2) Latitude, 3) Calcareous substrate, 4) Elevation range



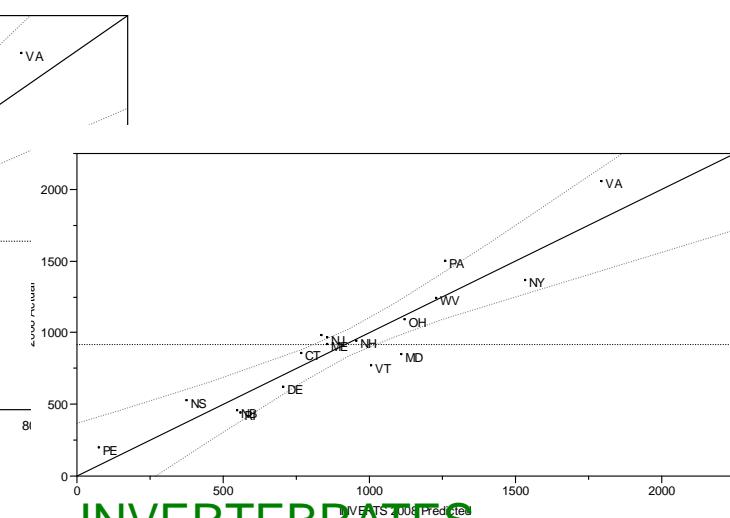
Anderson, M. and C. Ferree. 2010. Conserving the Stage: climate change and the geophysical underpinnings of species diversity. PLoS ONE .5(7) 36 p. <http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0011554>



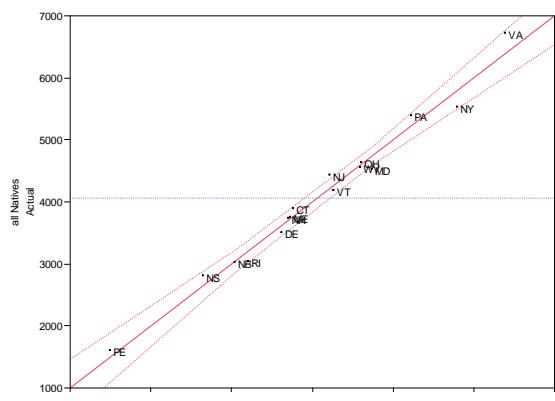
PLANTS
 $R^2 = 0.95$



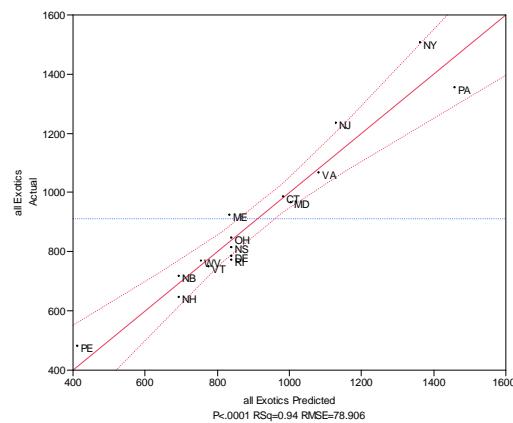
VERTEBRATES
 $R^2=0.87$



INVERTEBRATES
 $R^2 = 0.88$

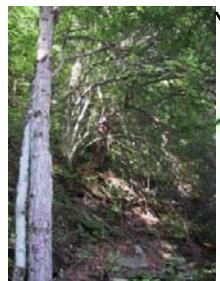


NATIVES SPECIES ONLY
 $R^2 = 0.97$



**INTRODUCED SPECIES
ONLY**
 $R^2 = 0.91$

Bicknell's thrush
High elevation
Granite & mafic



Shale barrens
Shale slopes

Serpentine Aster
Serpentine



Piping Plover
Sandy beaches

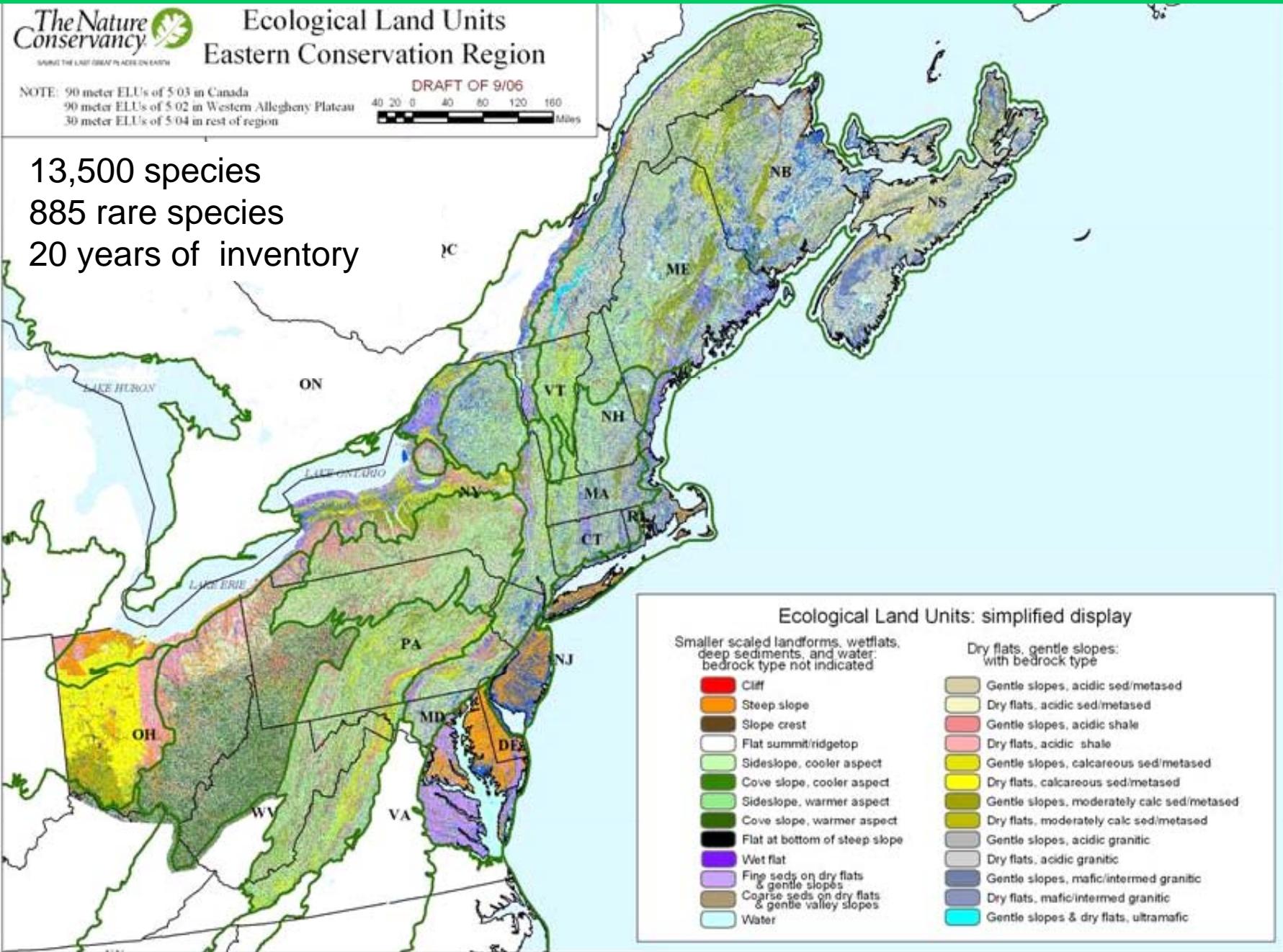


Alasmidonta Mussels
Limestone rivers

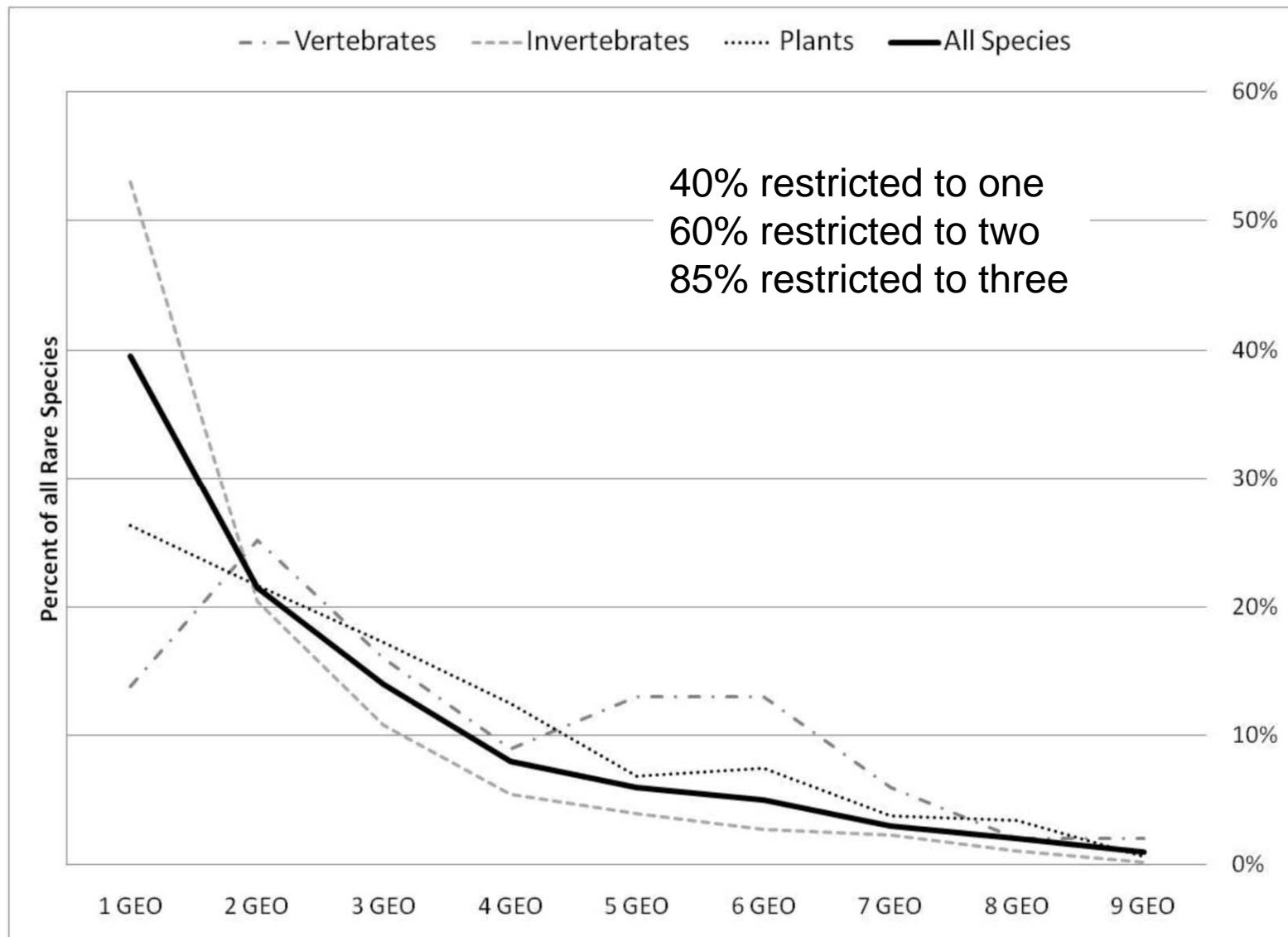


Spartina grass
Fine silts and muds

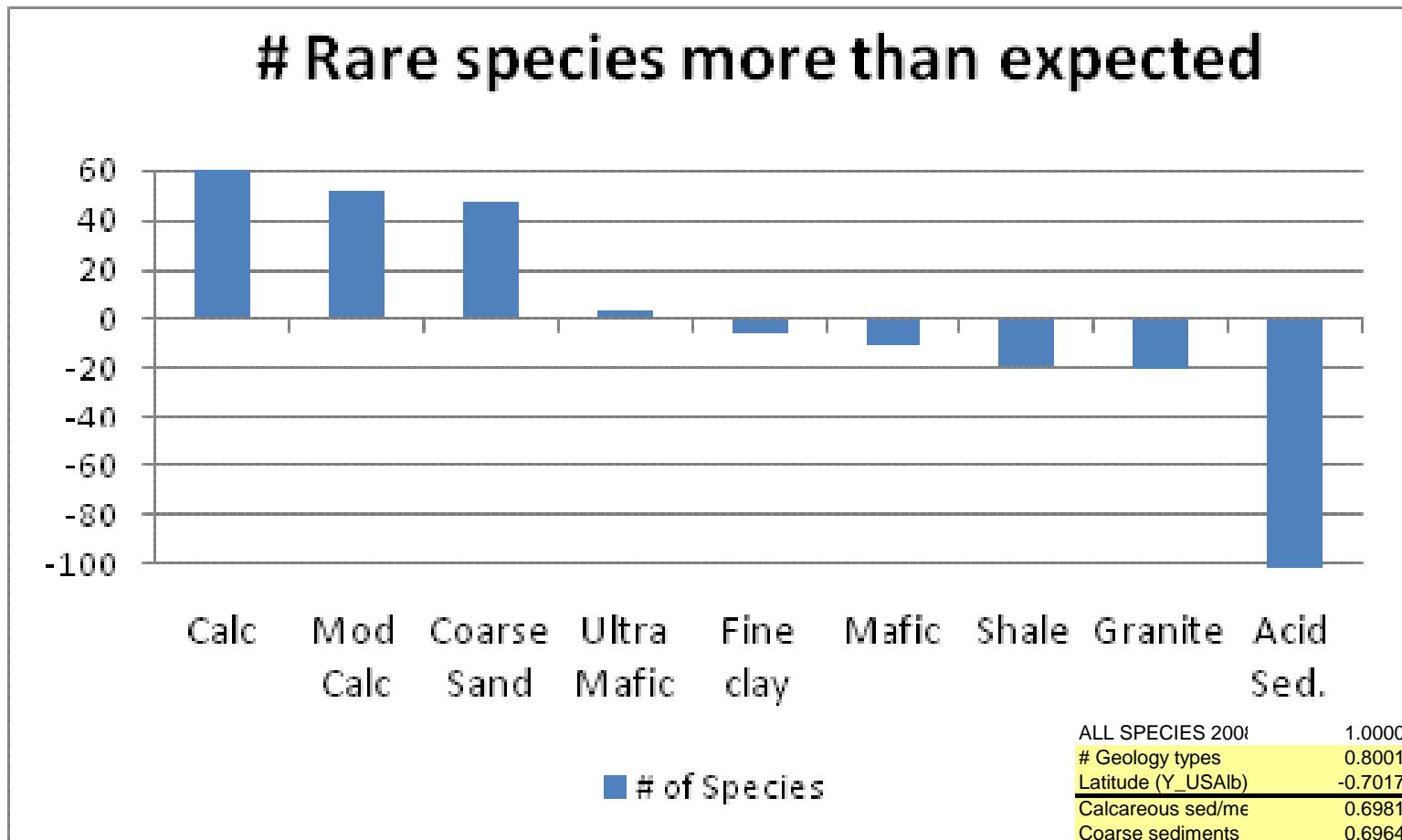
Overlaid locations of 885 rare species (18,705 points)



For 885 rare species in 18,705 locations



Chi-square test

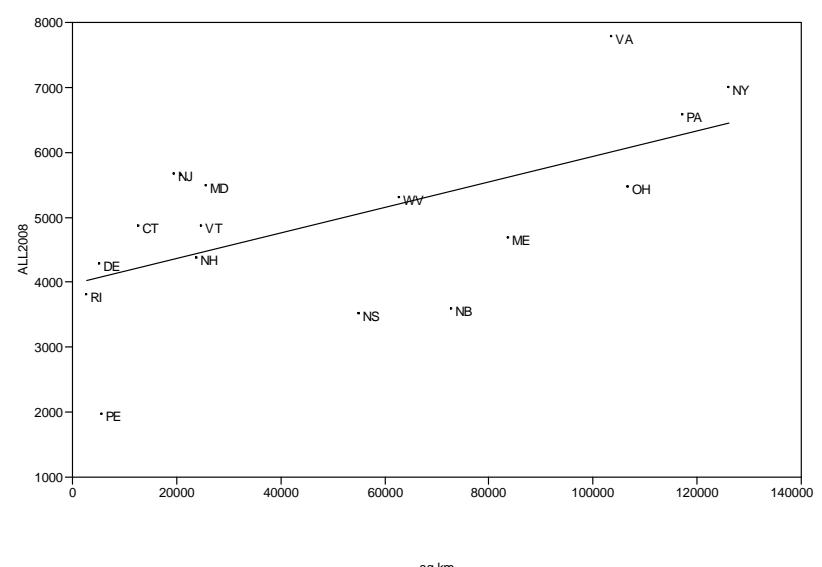
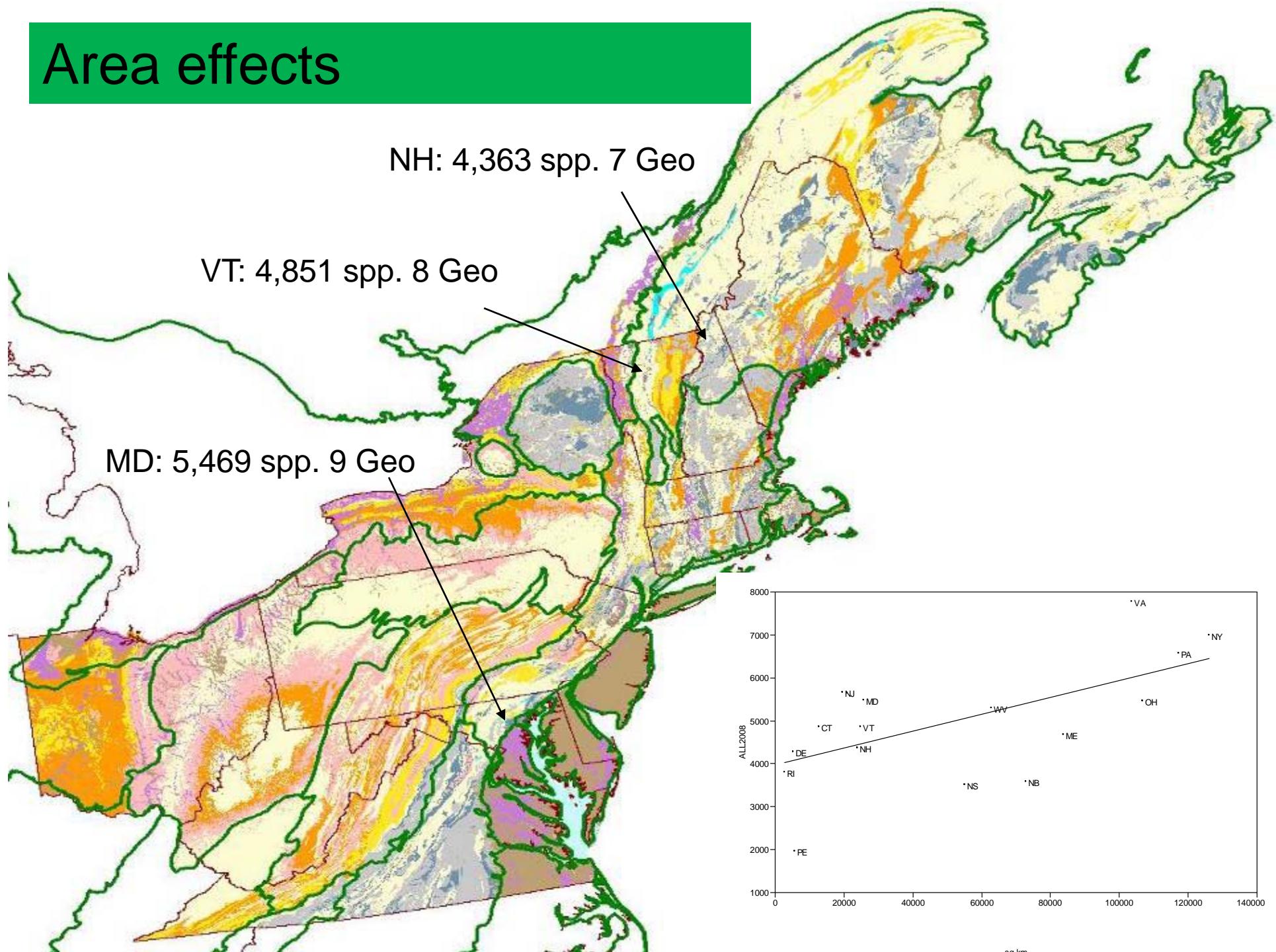


Evidence: Rare Species 80% restricted to calcareous bedrock

(species with 5 or more locations are included, 388 total species)

GROUP	SPECIES	COMMON NAME	TOTAL	Calc+
Amphibian 1	<i>Eurycea lucifuga</i>	Cave Salamander	80	0.875
Fish 10	<i>Percina aurantiaca</i>	Tangerine Darter	27	0.85185
	<i>Noturus flavus</i>	Stonecat	13	0.84615
	<i>Noturus flavipinnis</i>	Yellowfin Madtom	13	1
Mammal 2	<i>Corynorhinus townsendii virginianus</i>	Virginia Big-eared Bat	62	0.87097
	<i>Myotis grisescens</i>	Gray Myotis	11	0.90909
Reptile 4	<i>Nerodia sipedon insularum</i>	Lake Erie Water Snake	13	0.92308
	<i>Nerodia erythrogaster neglecta</i>	Copperbelly Water Snake	11	0.90909
	<i>Apalone spinifera</i>	Spiny Softshell	7	1
Amphipod 25	<i>Caecidotea pricei</i>	Price's Cave Isopod	39	0.92308
	<i>Caecidotea holsingeri</i>	Holsinger's Cave Isopod	37	0.86486
	<i>Stygobromus spinatus</i>	Spring Cave Amphipod	34	0.94118
Insects/Spider 27	<i>Pseudosinella gisini</i>	(blank)	25	1
	<i>Pseudanophthalmus hypertrichosis</i>	A Cave Beetle	21	1
	<i>Litocampa fieldingi</i>	A Cave Obligate Dipluran	13	1
Mussell 22	<i>Pleurobema oviforme</i>	Tennessee Clubshell	101	0.9505
	<i>Lexingtonia dolabelloides</i>	Slabside Pearlymussel	21	0.95238
	<i>Io fluvialis</i>	Spiny Riversnail	21	1
Other inverts 12	<i>Macrocytula hoffmasteri</i>	Hoffmaster's Cave Planarian	11	0.90909
	<i>Pseudotremia fulgida</i>	Greenbrier Valley Cave Millipede	28	0.96429
	<i>Trichopetalum packardi</i>	Packard's Blind Cave Millipede	24	1
Dicots 32	<i>Viburnum rufidulum</i>	Rusty Blackhawk	34	0.85294
	<i>Clematis addisonii</i>	Addison's Leatherflower	33	0.9697
	<i>Leavenworthia uniflora</i>	Michaux? Leavenworthia	31	0.83871
Monocots 12	<i>Trillium recurvatum</i>	Reflexed Trillium	21	0.80952
	<i>Nothoscordum bivalve</i>	Crow-poison	15	0.8
	<i>Clematis addisonii</i>	Plains Muhlenbergia	10	0.8
Ferns 4	<i>Ophioglossum engelmannii</i>	Limestone Adder's-tongue	11	0.81818
	<i>Equisetum fluviatile</i>	Water Horsetail	10	0.9
	<i>Asplenium resiliens</i>	Black-stem Spleenwort	5	1

Area effects



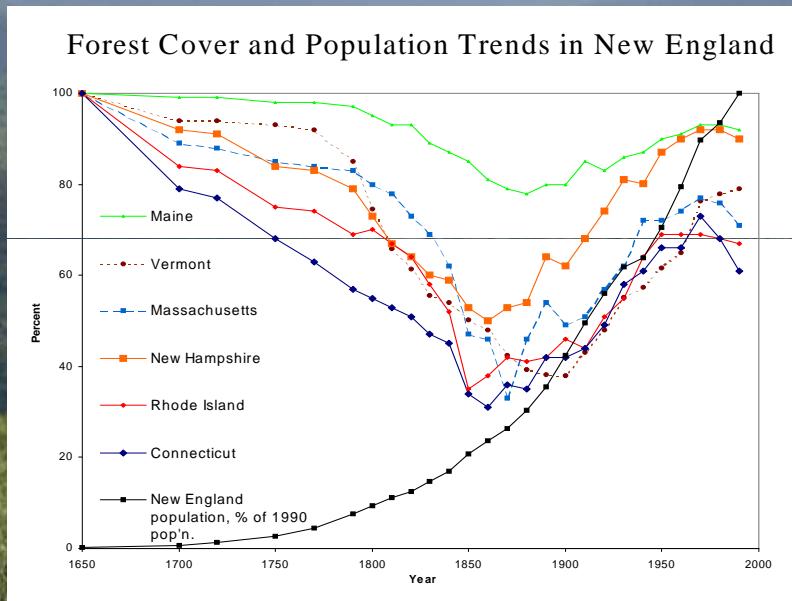
Remarkably strong relationship considering:

- functional extinction:
chestnut, wolf,
cougar, woodland
caribou

- presently 31% of
flora and 10% of
vertebrate fauna
are exotic

- hundreds of
species range
shifts

13,530 species
8,223 plants
5,307 animals
523 vulnerable



CONSERVING THE STAGE:

Create arenas for evolution not museums of the past.

OLD:

Cattail (*Typha latifolia*) – Marsh Marigold (*Caltha palustris*) marsh

Cattail (*Typha angustifolia*, *latifolia*) – Bullrush (*Shoenoplectus spp.*) marsh

NEW:

Freshwater marsh ecosystem on shale at low elevation.

Freshwater marsh ecosystem on granite at high elevation

Limestone valley bottom forest at low elevation

Shale slope woodland at moderate elevations

Summits in the Northeast Portfolios



Sedimentary



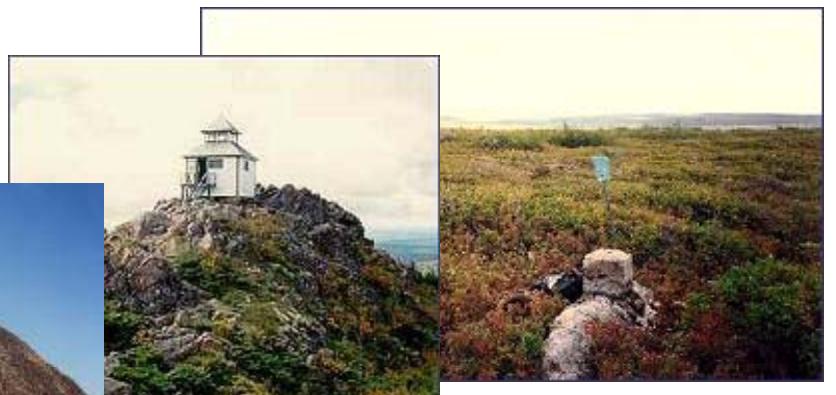
Granite



Granite



Mixed



Mafic -low



Sedimentary: Quartzite

Intermediate (mafic)

Rivers and Riparian Systems



Fresh and Tidal Wetlands



Forests in the Northeast Portfolios



ch

It is still about species

Baseball analogs:

Team remains but players change from year to year.

Functional group: positions

Needs the ballpark and needs the network of other ballparks

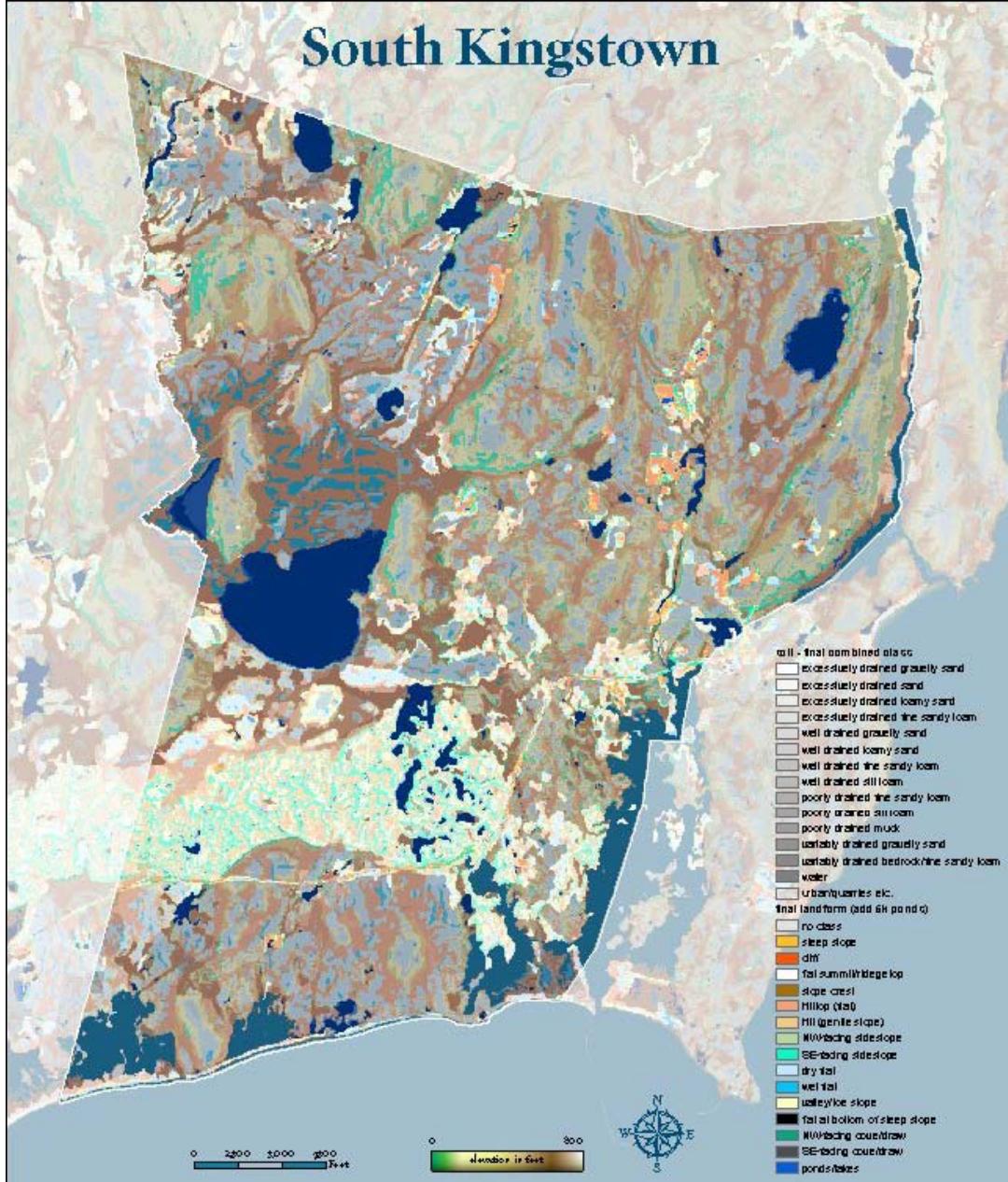
Even though players change, people obsess over team composition

Best predictions are always full of surprises.

Farm system



Redefine species and community sites as settings



Ecological Land Units
(Anderson 1999)

Setting: Low elevation
Granite and Coarse sand

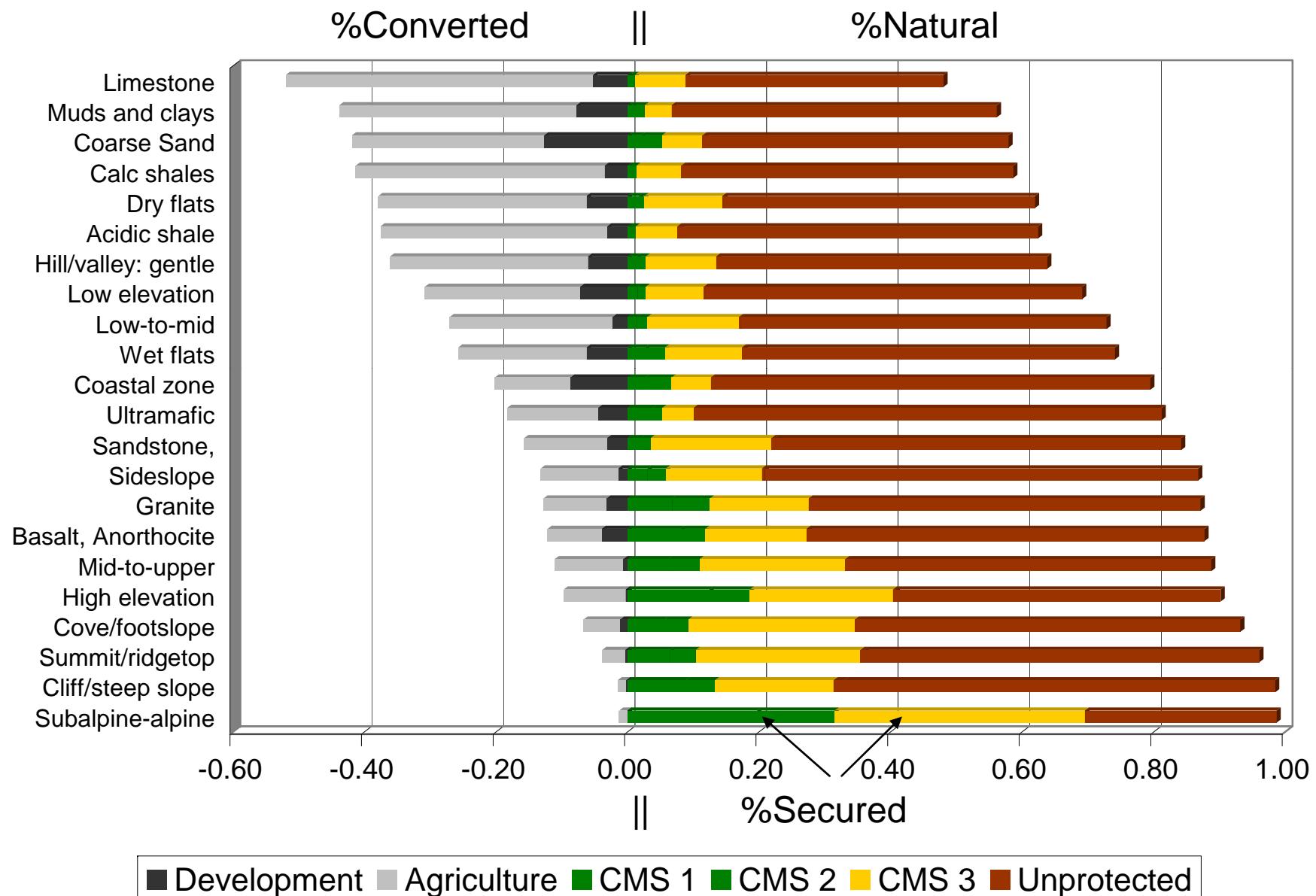
Features:
Low hummock forest in sand
Wet flat marsh on coarse sand
Low summit on granite
Coves and toe-slopes on granite
Wet basins in fine silt pockets

Land Facets
(Bier and Brost 2010)

Where does this lead us?

- 1. Representation:** Represent all geophysical settings in conservation.
- 2. Resilient Networks:** Identify sites with high topographic gradients and connectivity
- 3. Resilient Sites:** Focus on conserving function and process to create ecosystems with high adaptive capacity.

Measuring Conservation: Geophysical patterns



Resilient Sites: Rebuilding Adaptive Capacity

Resilience: Definition

The capacity for renewal in a dynamic environment
- Gunderson 2000

- 1) Allow space for dynamics.
- 2) Encompass topographic gradients
- 3) Maintain key processes, replenish soil and nurture sources of recovery
- 4) Preserve options: maintain diversity and functional groups

Resilient Networks: Estimating the Adaptive Capacity of a Place

Heterogeneity

Elevation gradients

Topographic diversity

Connectivity

Local Connectedness

Regional flow concentrations
(pinch points)

TNC is reviewing all their identified biodiversity sites for these four characteristics

Heterogeneity

Landforms control the distribution of moisture, nutrients and climatic effects

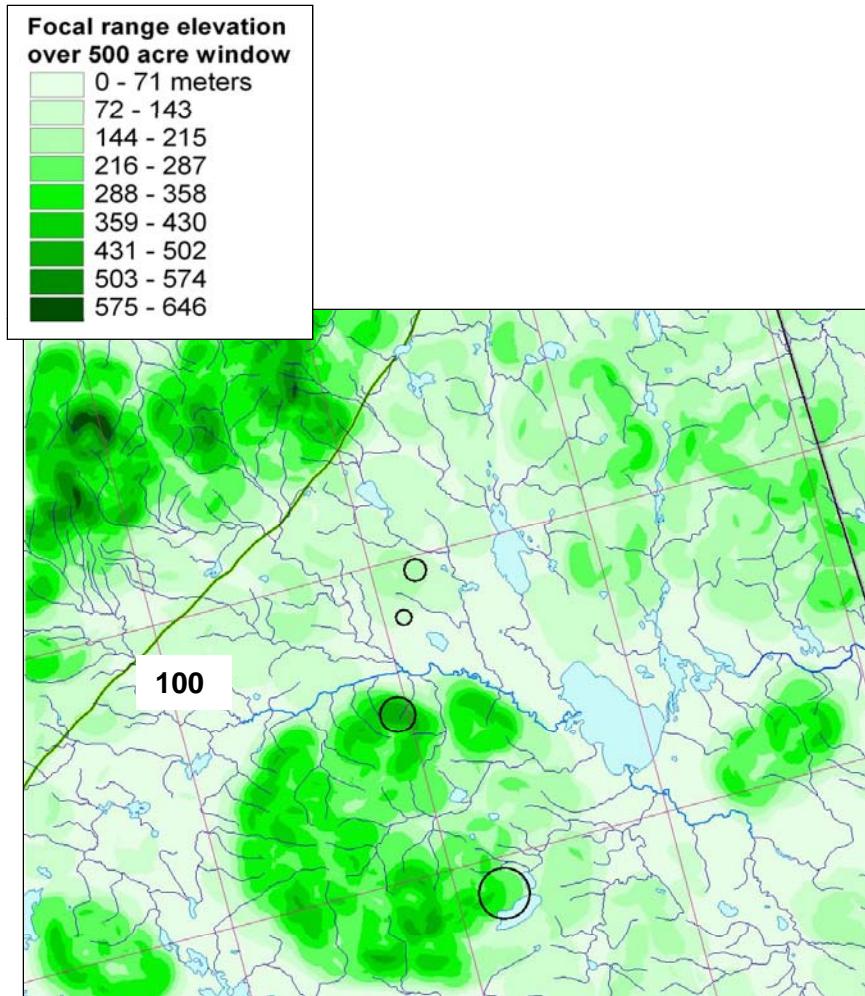


More Heterogeneity
= more options for
species to move and
rearrange at a given
site

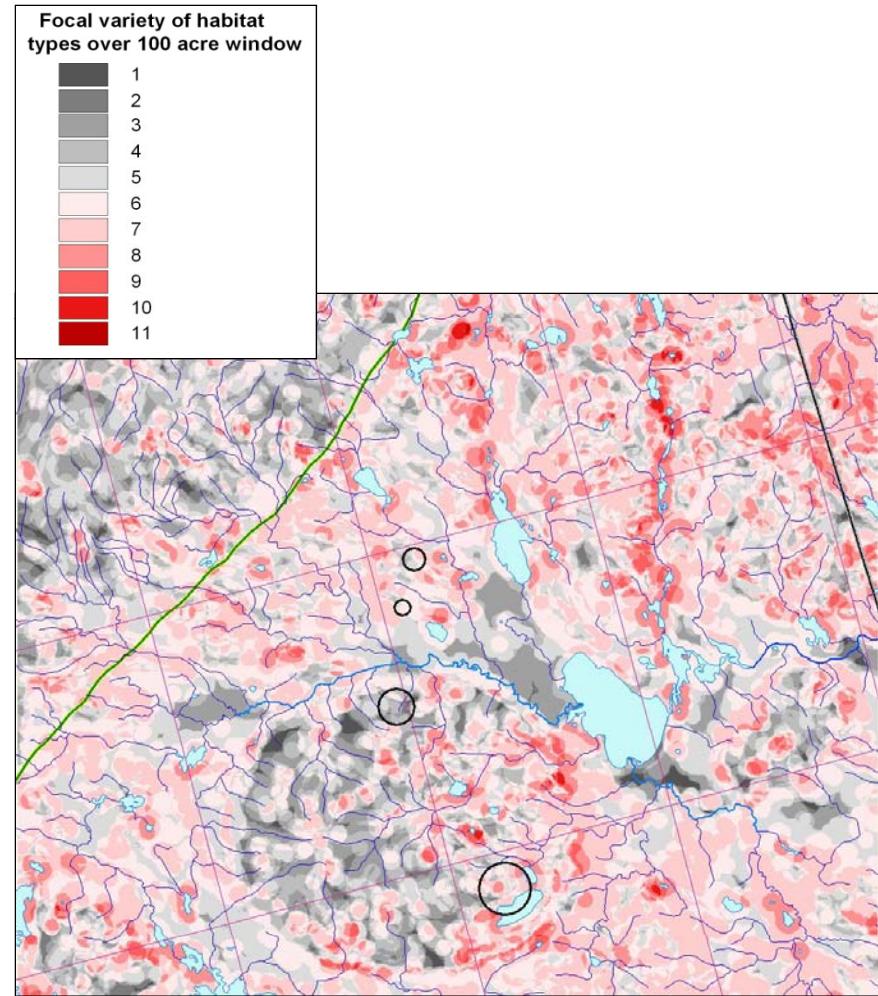
Ridges
Summits
Side-slopes
Toe-slopes
Cliffs
Coves
Valleys
Wetlands

Landscape Heterogeneity : Ossipee Mountains

Elevation surface (100 acre)

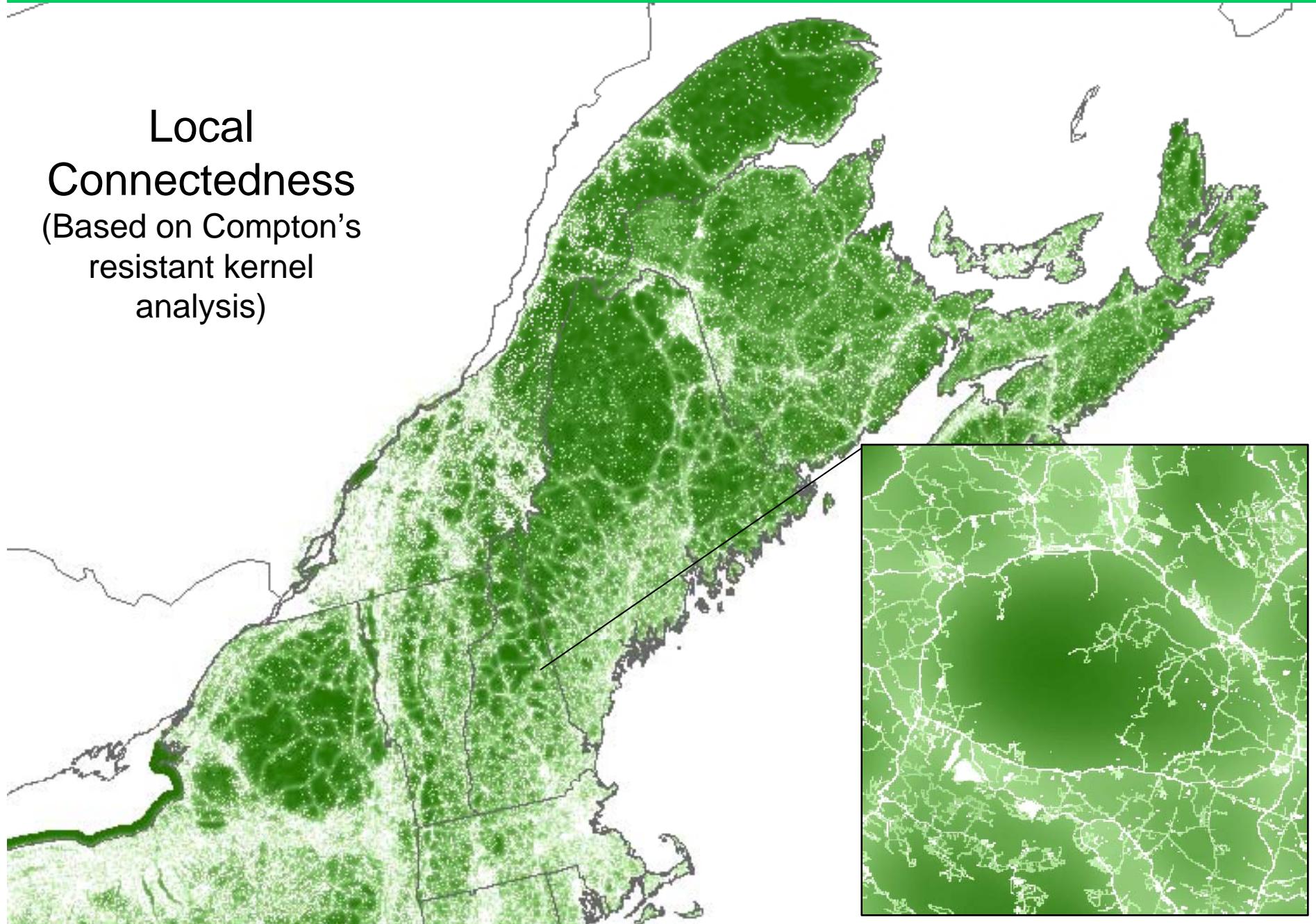


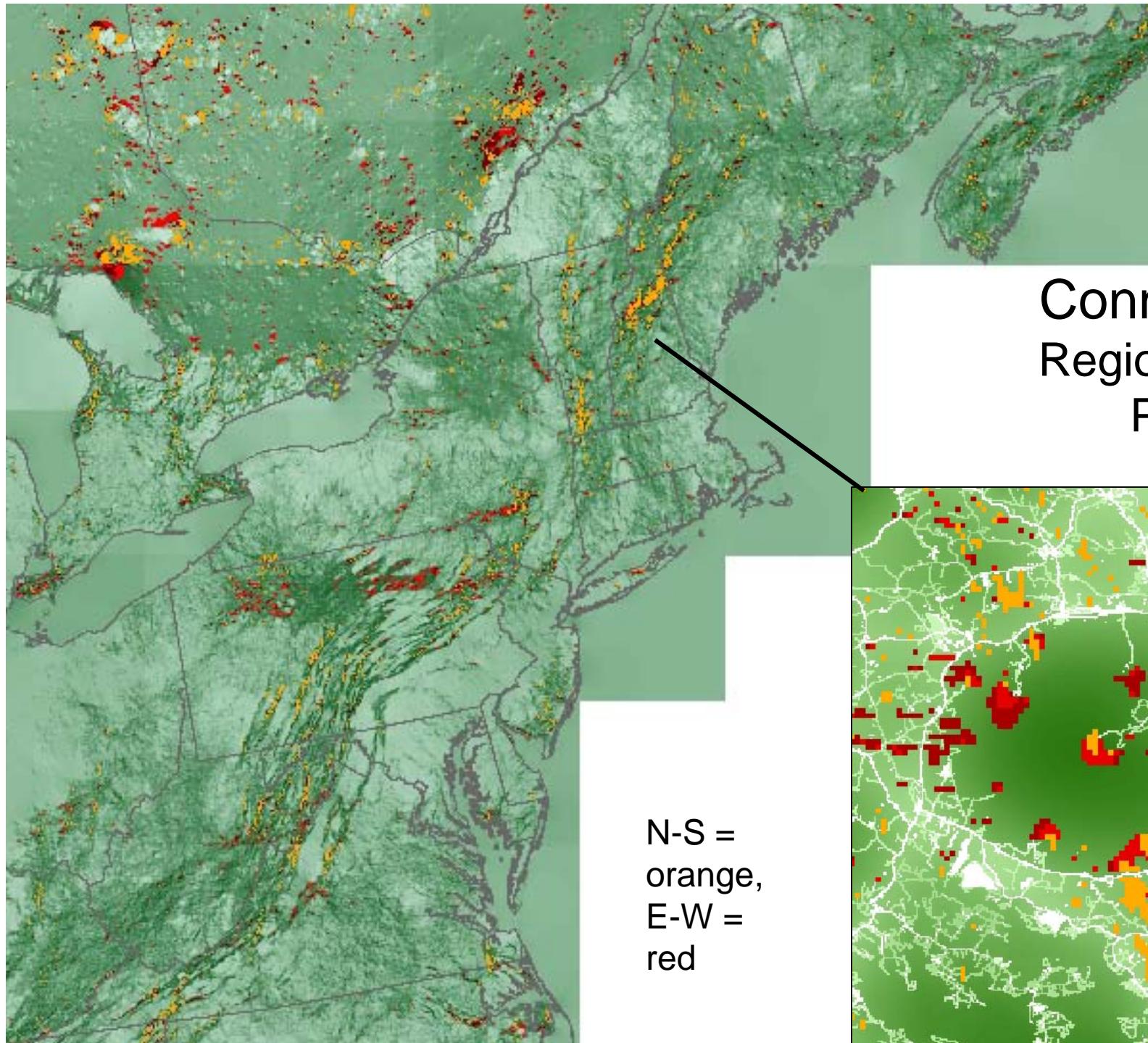
Landform diversity surface



Connectivity

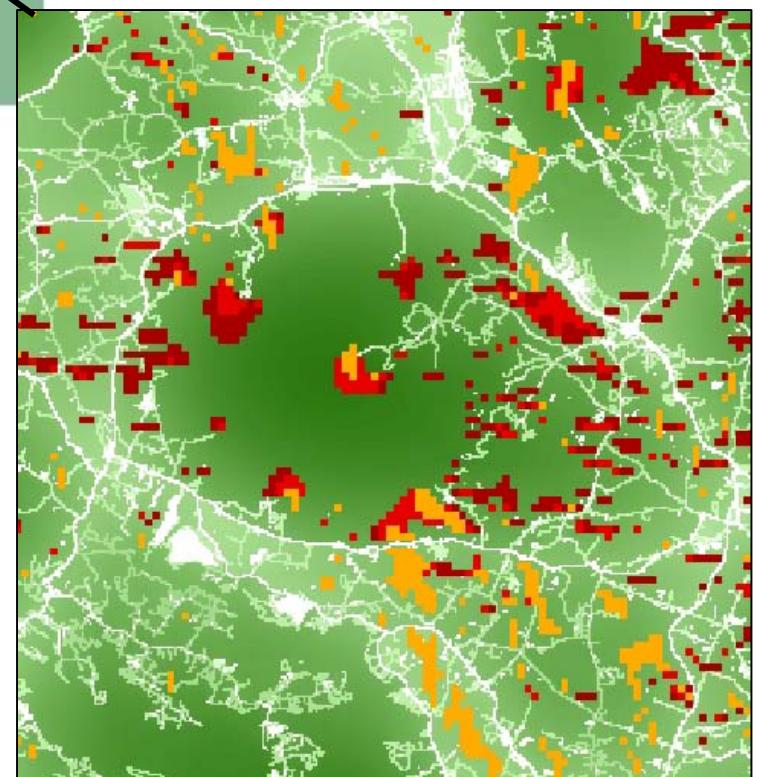
Local
Connectedness
(Based on Compton's
resistant kernel
analysis)





N-S =
orange,
E-W =
red

Connectivity:
Regional Pinch
Points

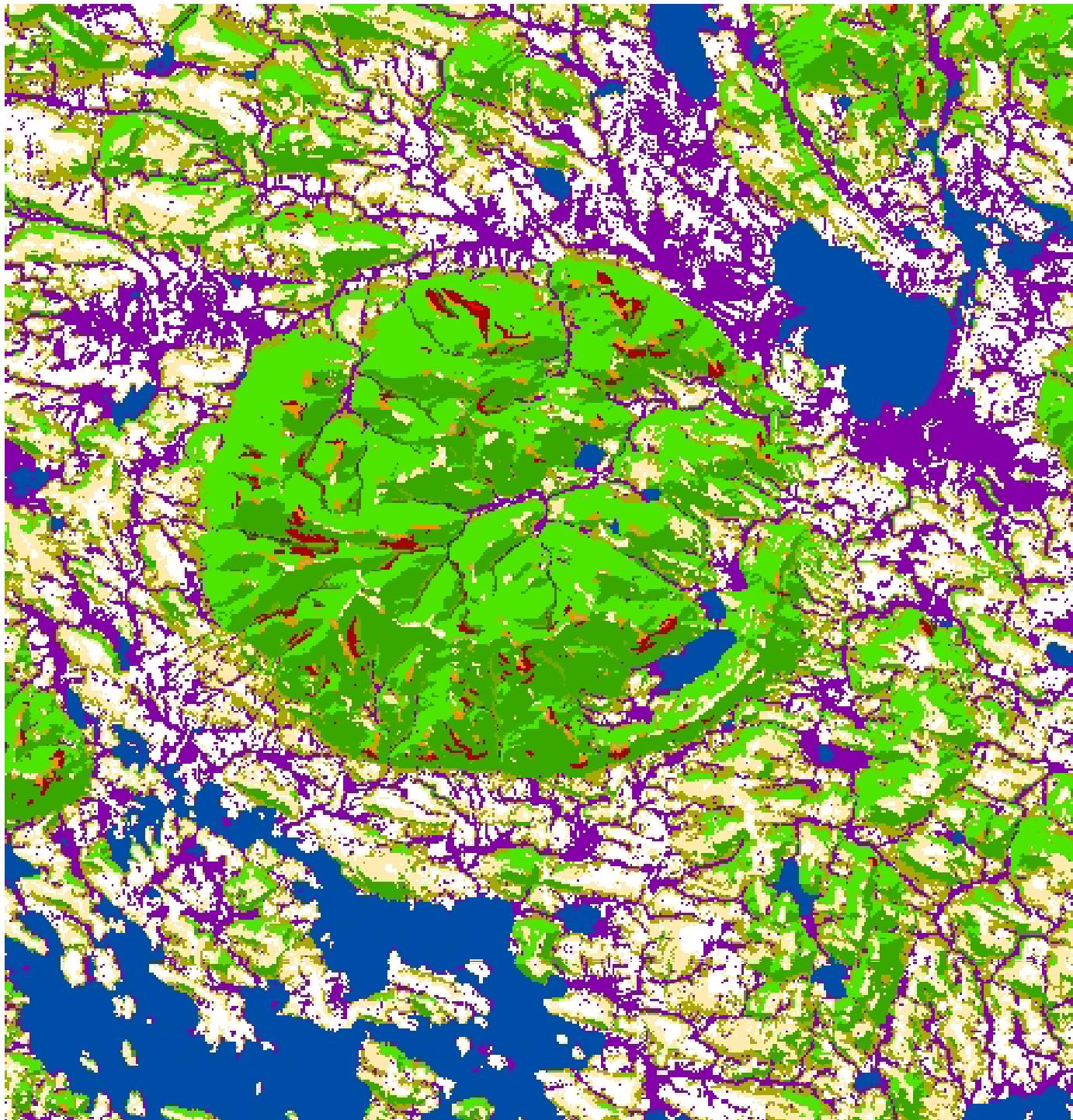




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D R A F T

**Southern States Geology
Coded to
Eastern Conservation Science
Classes**

Though Tennessee is not in the Eastern Division, it was included due to its part in the Southern Blue Ridge Ecoregion Matrix Forest Analysis.

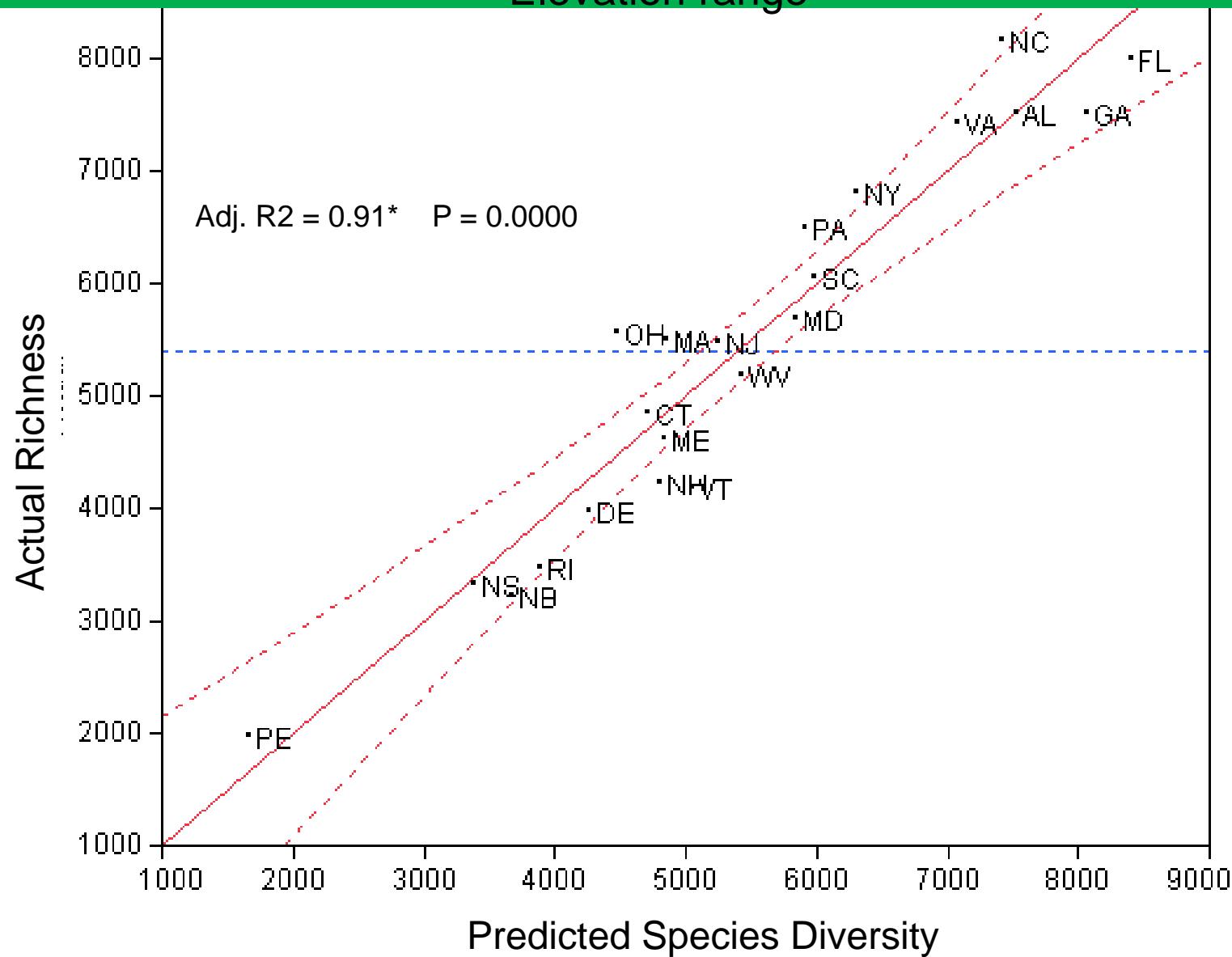
Legend

- 100: acidic sed/metased
- 200: acidic shale
- 300: calc sed/metased
- 400: mod calc sed/metased
- 500: acidic granitic
- 600: mafic/intermed granitic
- 700: ultramafic
- 800: coarse seds
- 900



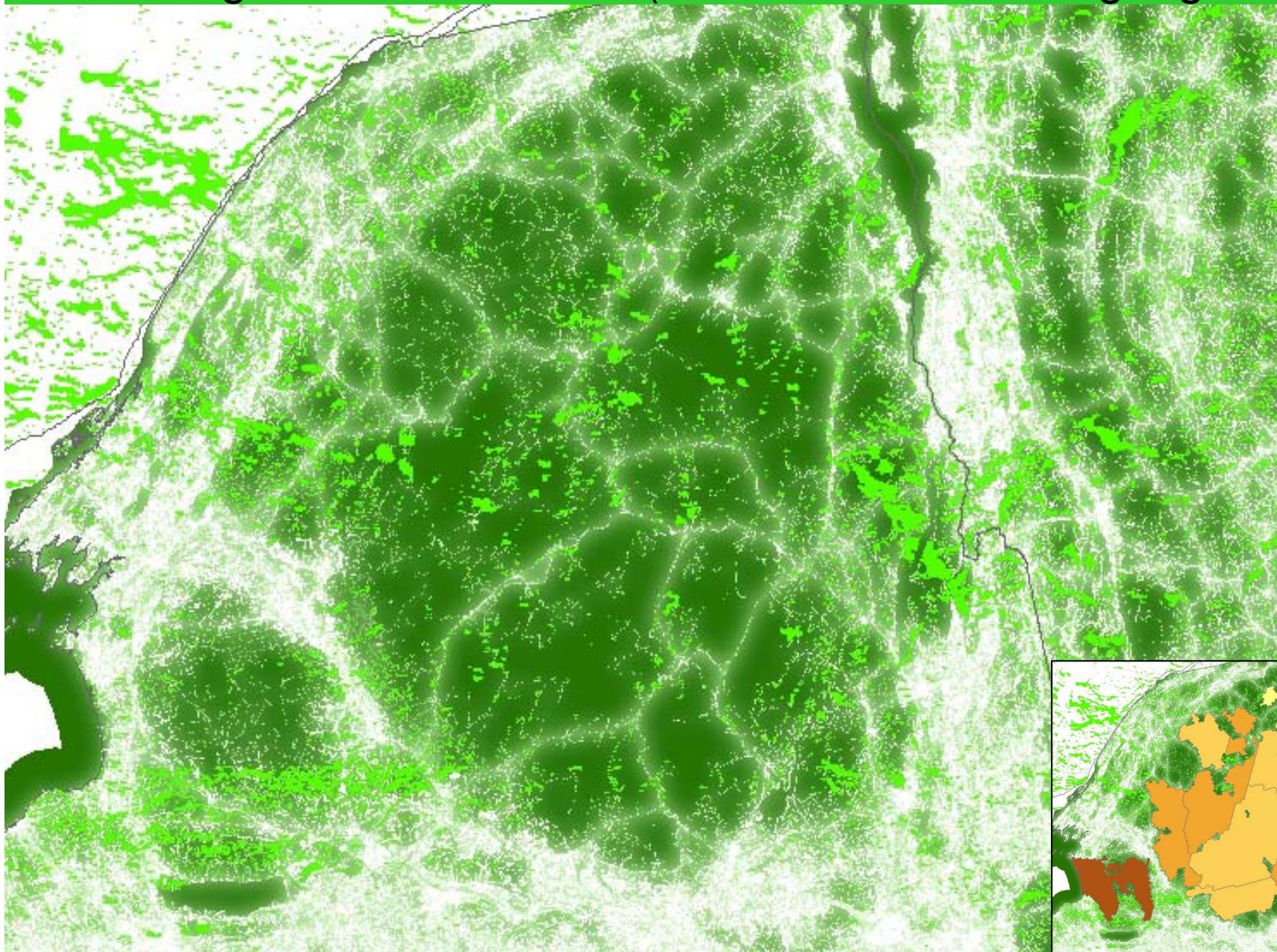
Species Diversity

1) # of Geology types, 2) Latitude, 3) Amount of calcareous substrate and 4)
Elevation range

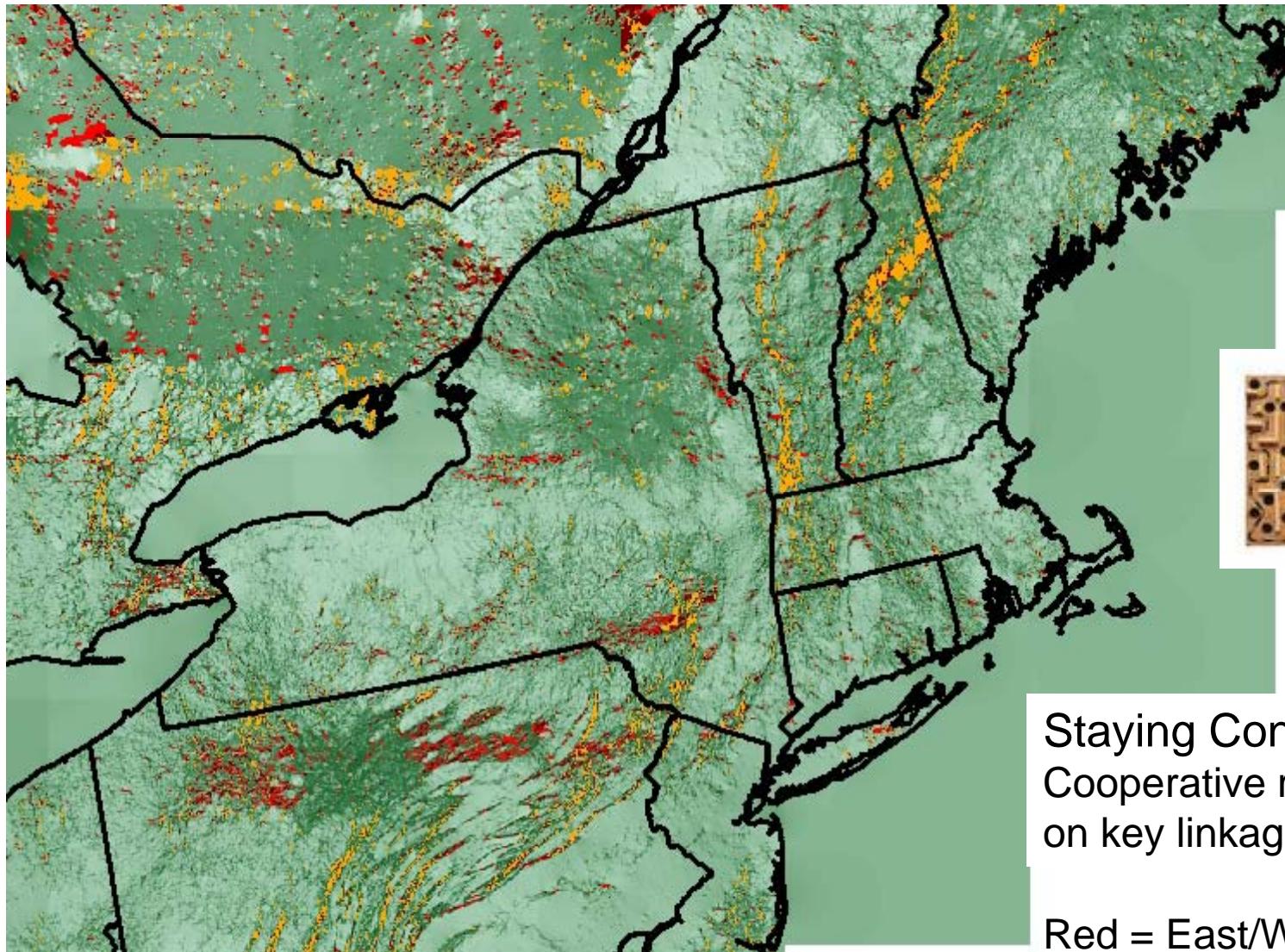


Connectivity:

Regional Pinch Points (East-West axis in bright green)



Connectivity: Movement Pinch Points



Staying Connected:
Cooperative research
on key linkages

Red = East/West
Orange = North /South

GEOLOGY

Northeast and Mid-Atlantic

Acidic sedimentary or metased.

Acidic shale

Calcareous sedimentary

Moderately calcareous

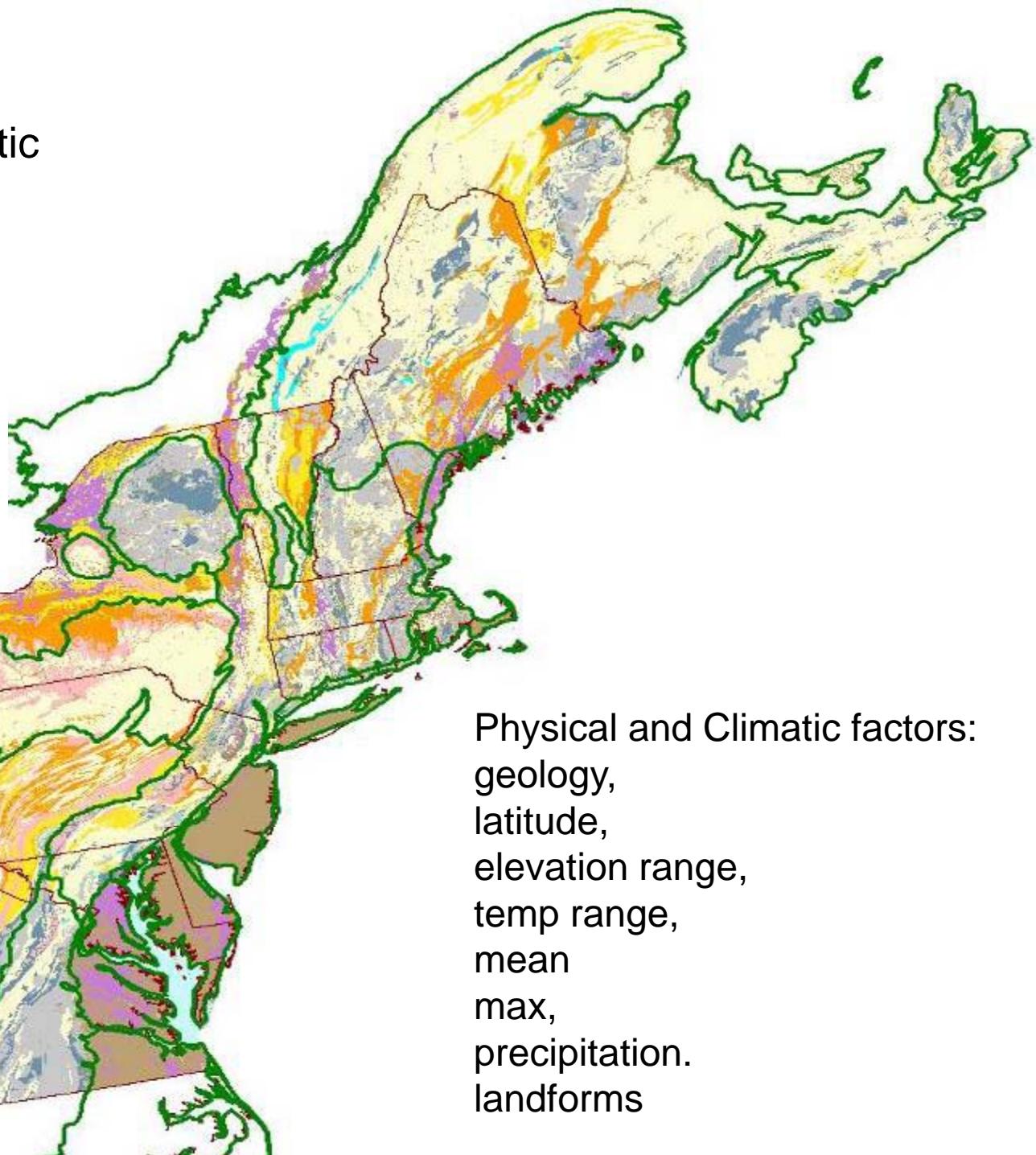
Acidic granitic

Mafic

Ultramafic

Coarse surficial

Fine surficial



Physical and Climatic factors:
geology,
latitude,
elevation range,
temp range,
mean
max,
precipitation.
landforms