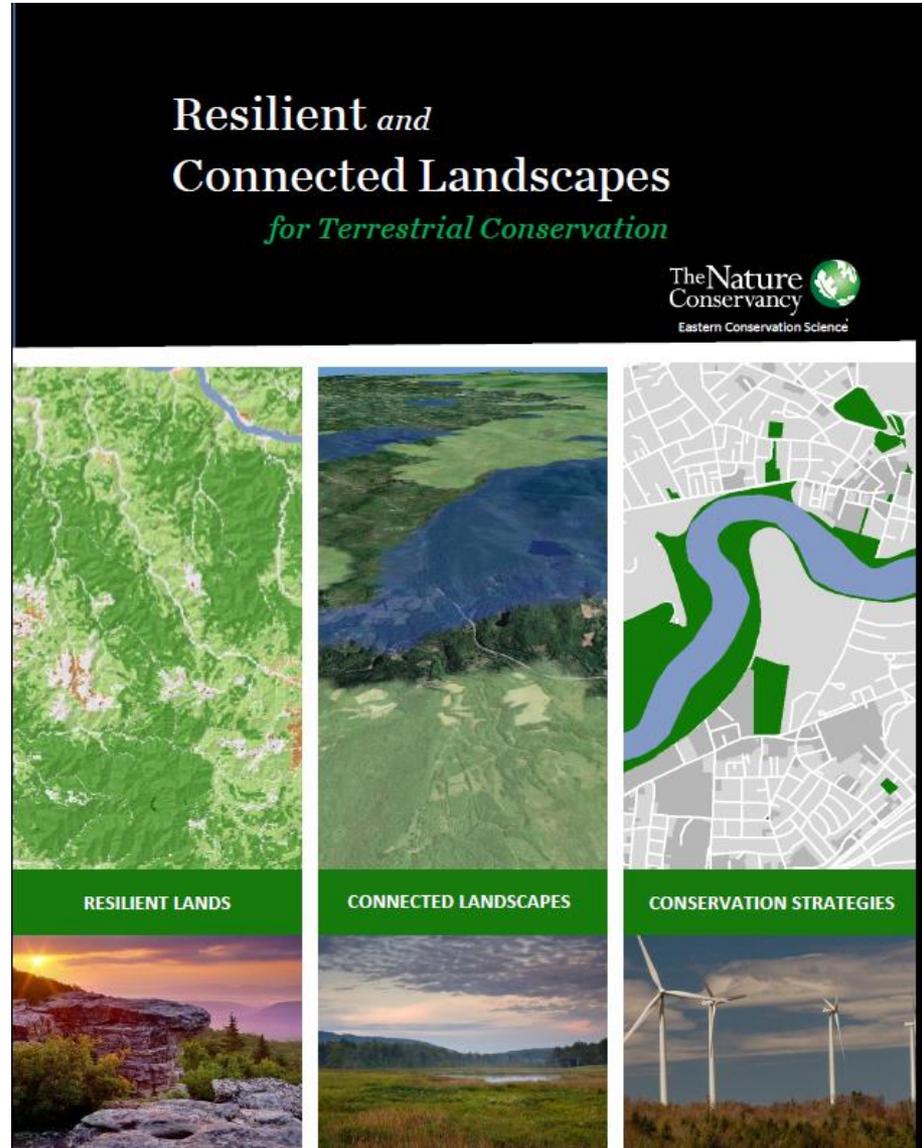


What is a climate corridor and what makes them work?

David Patrick

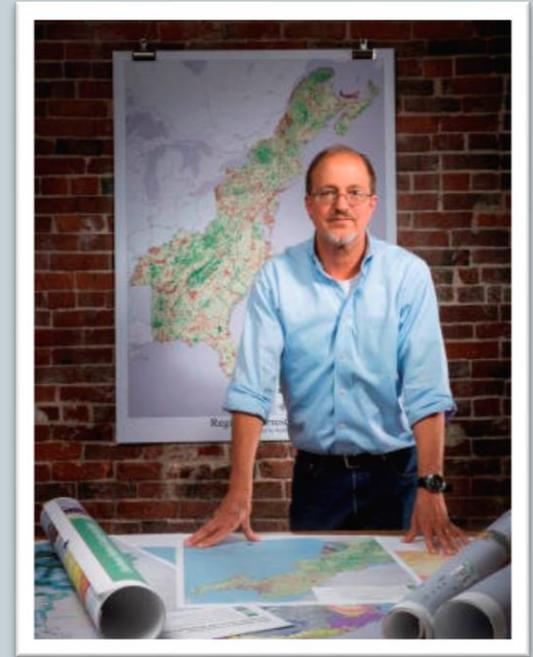
David.Patrick@tnc.org



Acknowledgements



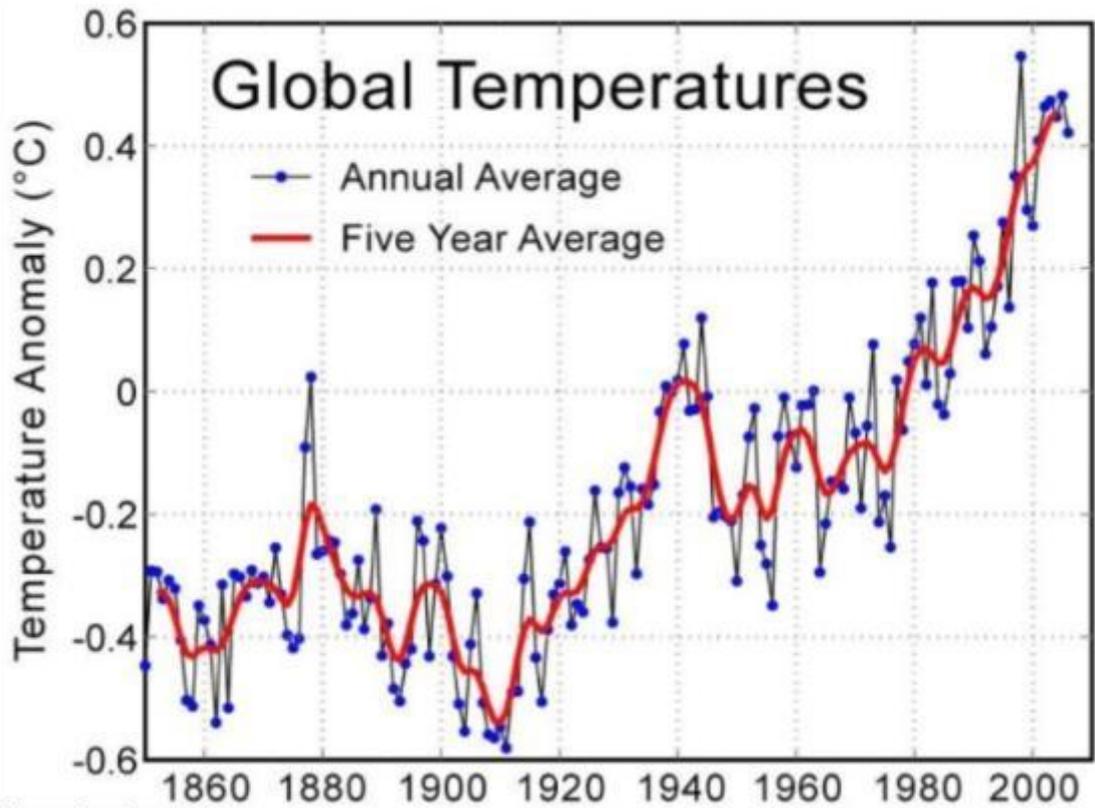
- Mark Anderson and his team
- 75 scientists, 8 years of work



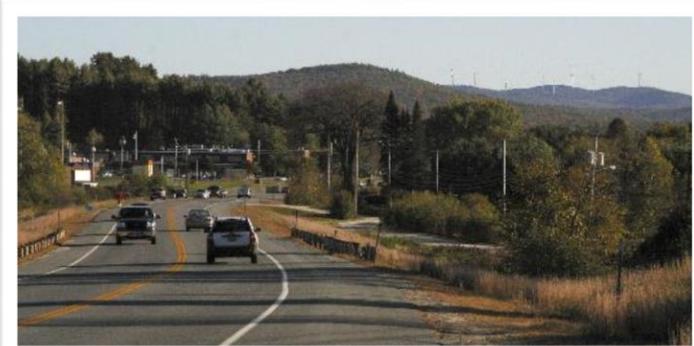
Background



The world is changing



Newscientist.com



Plants and animals must adapt or relocate



Where do we need to focus land conservation efforts to maximize the likelihood that terrestrial biodiversity in eastern North America can redistribute and hence persist in a changing world?



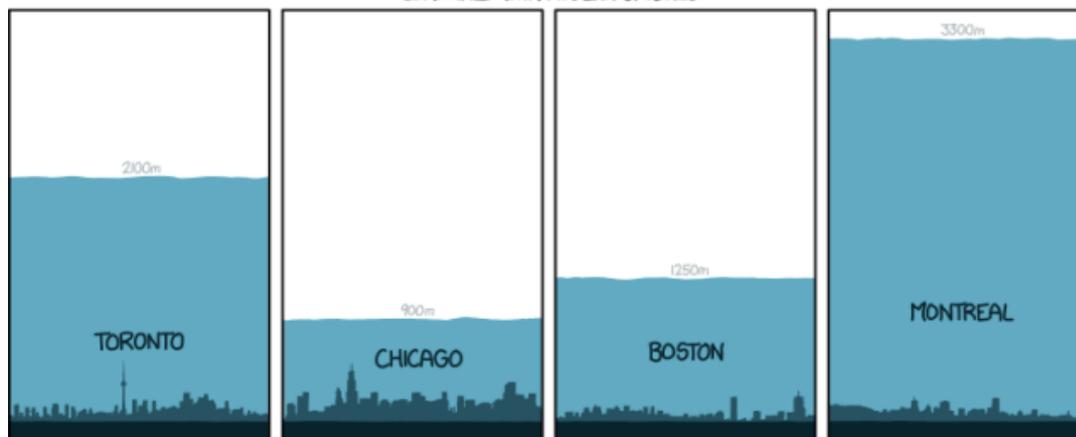
Climate-Resilient Sites



- Identify places where nature's natural resilience is highest:
 - Wide range of micro-climates (driven by diverse topography, bedrock, and soil) within highly connected “local” area
- Select resilient sites within all geophysical settings: “climate-resilient conservation portfolio”



THICKNESS OF THE ICE SHEETS
AT VARIOUS LOCATIONS
21,000 YEARS AGO
COMPARED WITH MODERN SKYLINE



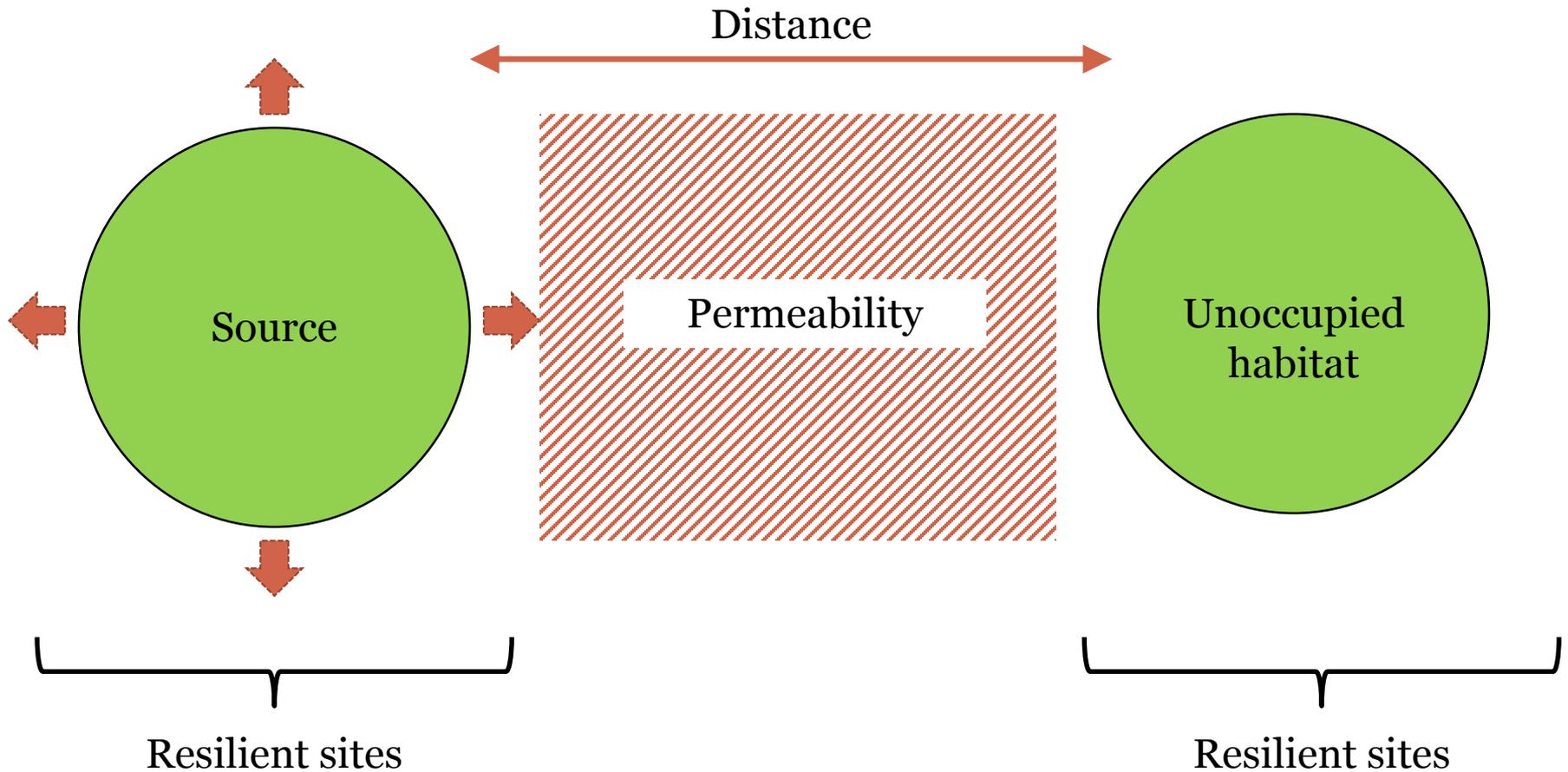
How do distributions shift?



Dispersal



What factors influence the likelihood of dispersal?



Modeling Connectivity



How we identified connecting landscapes



- **Circuitscape**: Imagines “current” passing through landscape
- Suitable habitat allows current to flow more easily
- Habitat alteration creates “anthropogenic resistance”, reducing flow
- Not focused on specific terrestrial species, but general premise that intact natural habitat facilitates dispersal



Resistance

Figure 3.2. Anthropogenic resistance grid used in the Circuitscape analysis. The figure shows the improved and integrated land cover map with each cell reclassified to its assigned resistance score.

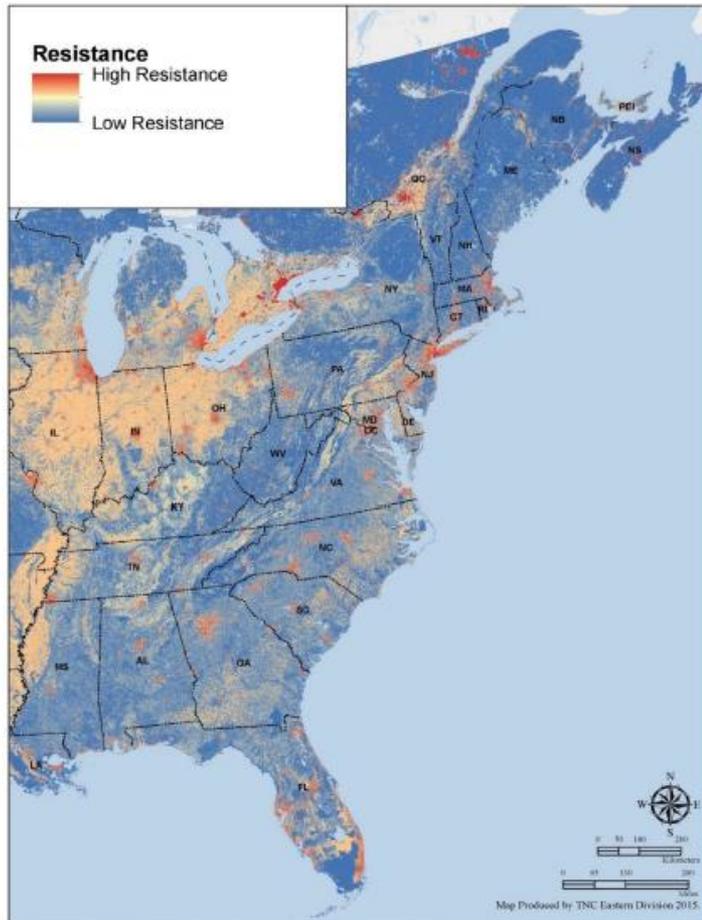
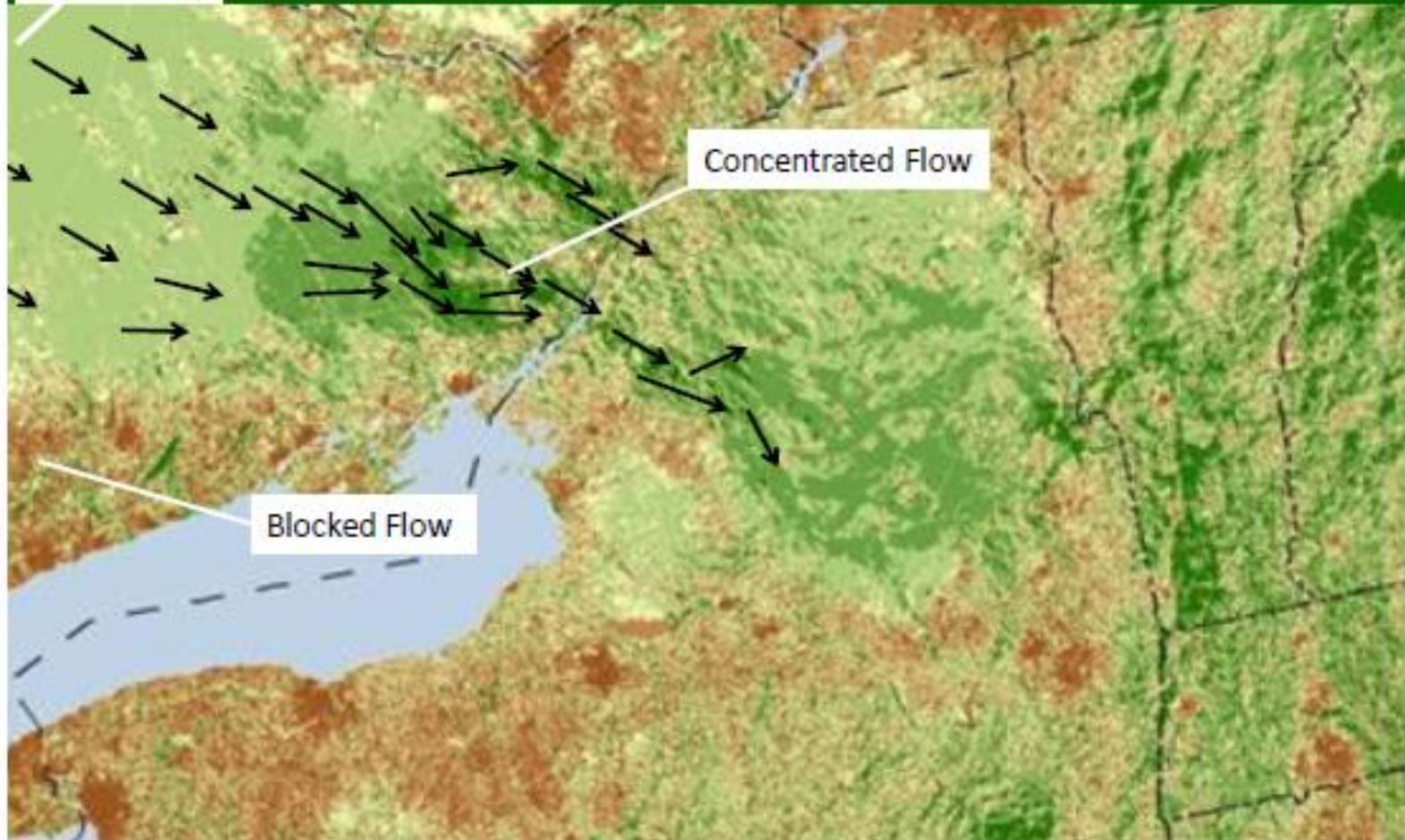


Table 3.2. Land cover types and assigned resistance values. This table shows the available attributes and the resistance score assigned to the land cover category. Resistance scores range from “1,” no resistance, to “20,” very high resistance.

Land cover Code in NLCD (if Applicable)	Land cover description	Resistance	Source
21	Developed, Open Space	8	NLCD 2011
22	Developed, Low intensity	8	NLCD 2011
23	Developed, Medium Intensity	9	NLCD 2011
24	Developed, High intensity	20	NLCD 2011
31	Barren Land, non-natural	9	NLCD 2011
32	Barren Land, natural	1	NLCD 2011
41	Deciduous Forest	1	NLCD 2011
42	Evergreen Forest	1	NLCD 2011
43	Mixed Forest	1	NLCD 2011
52	Shrub/Scrub	1	NLCD 2011
71	Herbaceous	1	NLCD 2011
81	Hay/Pasture (Coastal Plain & Piedmont)	3	NLCD 2011
81	Hay/Pasture (Mountains)	5	NLCD 2011
82	Cultivated Crops	7	NLCD 2011
90	Woody Wetlands	1	NLCD 2011
95	Emergent Herbaceous Wetlands	1	NLCD 2011
11	Open Water, Shoreline Distance <200 m	1	NLCD 2011
11	Open Water, Shoreline Distance 200-400m	3	NLCD 2011
11	Open Water, Shoreline Distance >400 meters	5	NLCD 2011
	Major Roads	20	Tiger 2014 (US)&Open Street Map 2014 (CA)
	Minor Roads	10	Tiger 2014 (US)&Open Street Map 2014 (CA)
	Dirt Roads	Resistance +1	Open Street Map 2014
	Transmission Lines	9	Ventex 2014
	Pipelines	9	Ventex 2014
	Railroads	9	CTS 2015
	Unprotected/Private Industrial Forest (US)	3	SEGAP, Parcelpoint, OSI
	Protected Industrial Forest (US)	1.5	SEGAP, Parcelpoint, OSI
	Industrial Forest Canada	1.5	NE Habitat Map (TNC)

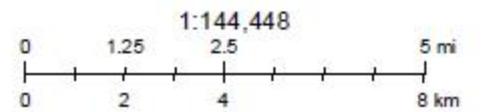
Wall to Wall Circuitscape: Anthropogenic Resistance

Diffuse Flow





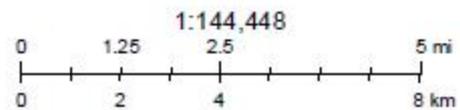
June 21, 2017



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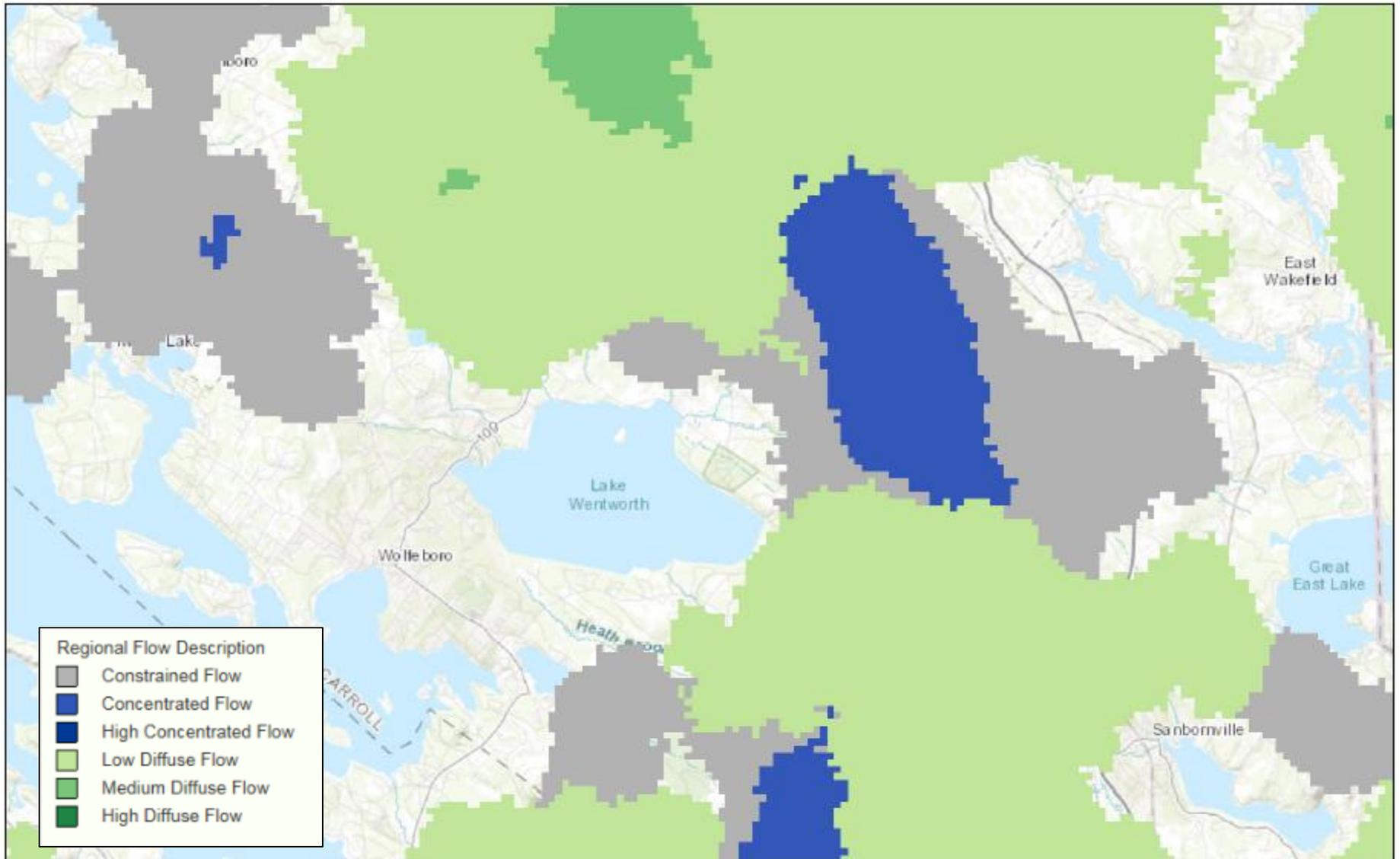


June 21, 2017



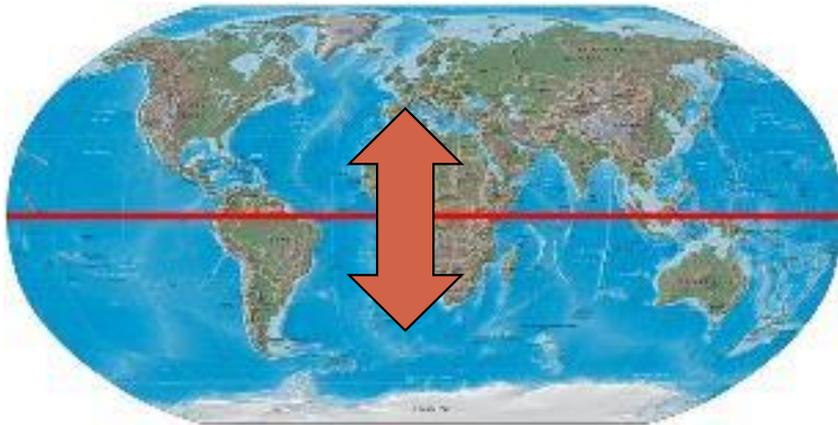
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

- Regional Flows - Description

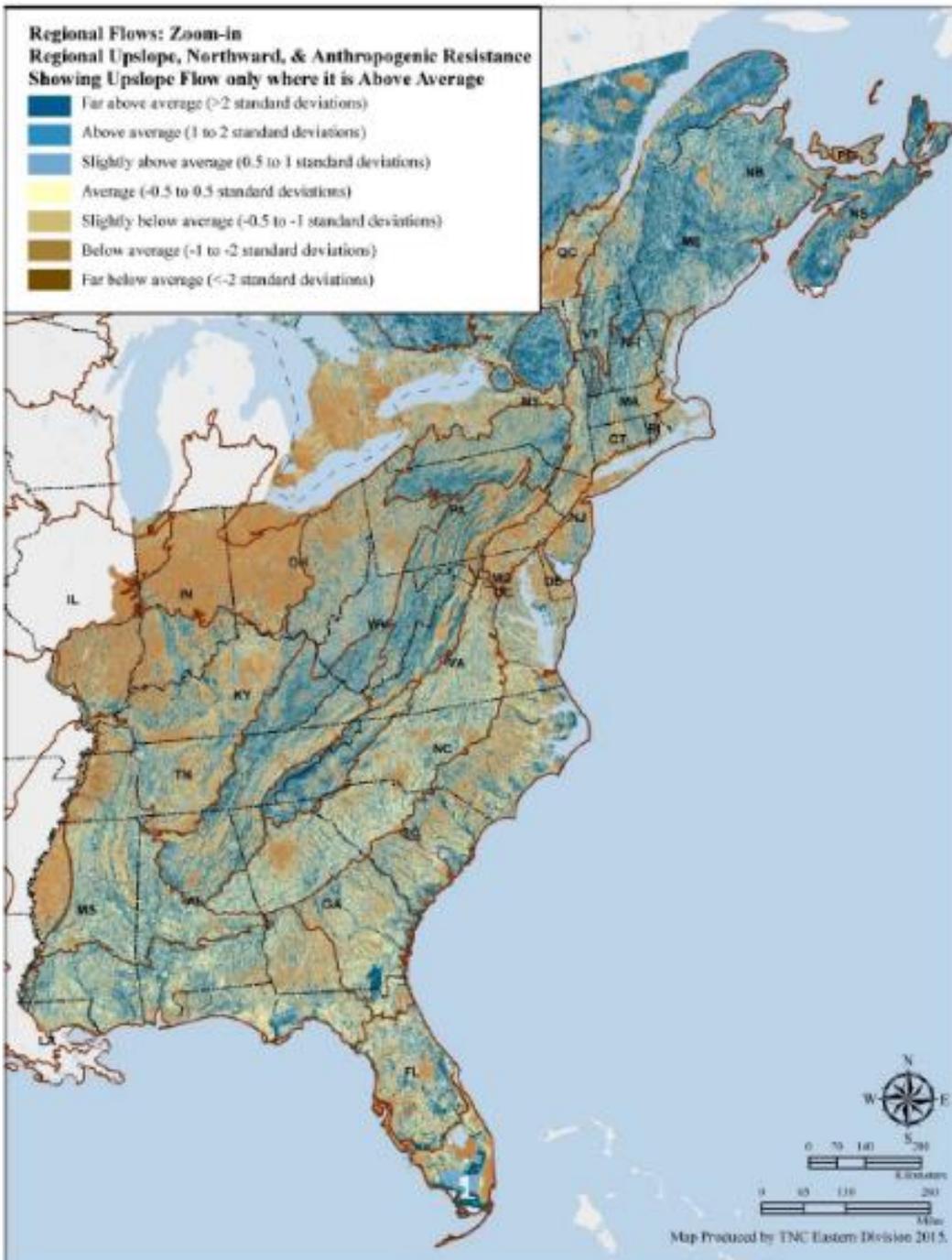


June 21, 2017

Beyond habitat suitability: dispersal in an era of climate change



Weighted connectivity



Upslope, northward and anthropogenic model. Circuitscape analysis applied to a resistance grid derived from landforms and anthropogenic resistance, with northward flows given twice the weight of east-west flows. Areas of high current flow are predicted to be important for upslope range shifts

Beyond habitat suitability: dispersal in an era of climate change



Riparian habitat as resilient sites

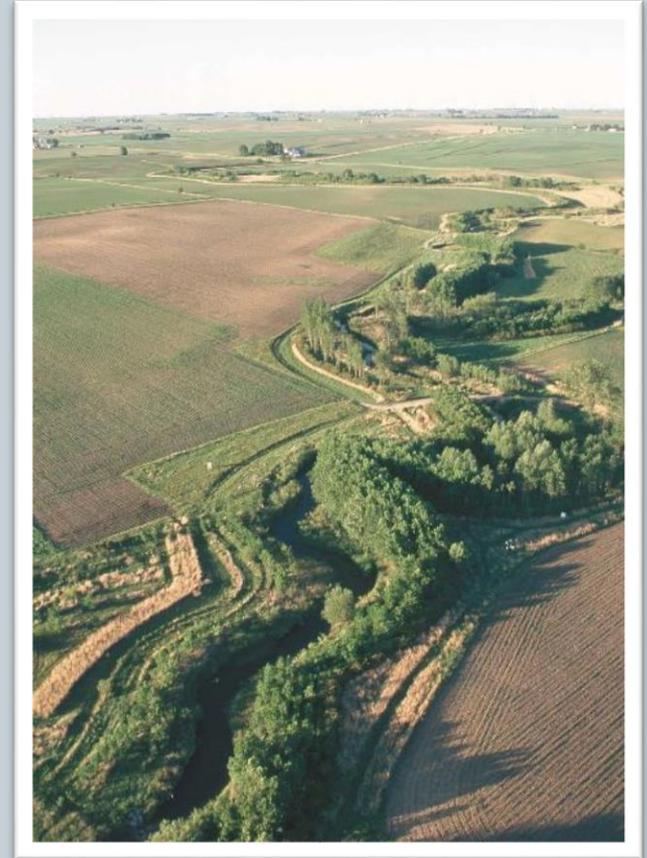


- Resilient sites analysis coincidentally identified many riparian corridors as key landscape features in providing climate adaptation due to:
 - Microclimates cooler (5-20°C) and more humid (10-15% higher) than surrounding areas
 - Often high densities of wetlands (contributing to more microclimates)
 - Great regulation/protection of riparian habitat leading to higher local connectivity scores

Why raise the profile of riparian habitat in our climate resilience models?



- High species richness and associated/obligate species
- Regulation/protection of riparian habitat coupled with high conversion rates of surrounding areas leading to *de facto* corridors
- Higher density of wetlands, allows “leapfrog” dispersal for dispersal-limited wetland species



Approach to identifying riparian habitat protection priorities



- Model based on Active River Area (meander belt, riparian wetlands, and 100-yr floodplain)
- Omitted small headwater streams as riparian areas not easily differentiated from surrounding forest
- Four classes:
 - Creek
 - Small River
 - Medium River
 - Large River

Riparian unit attributes



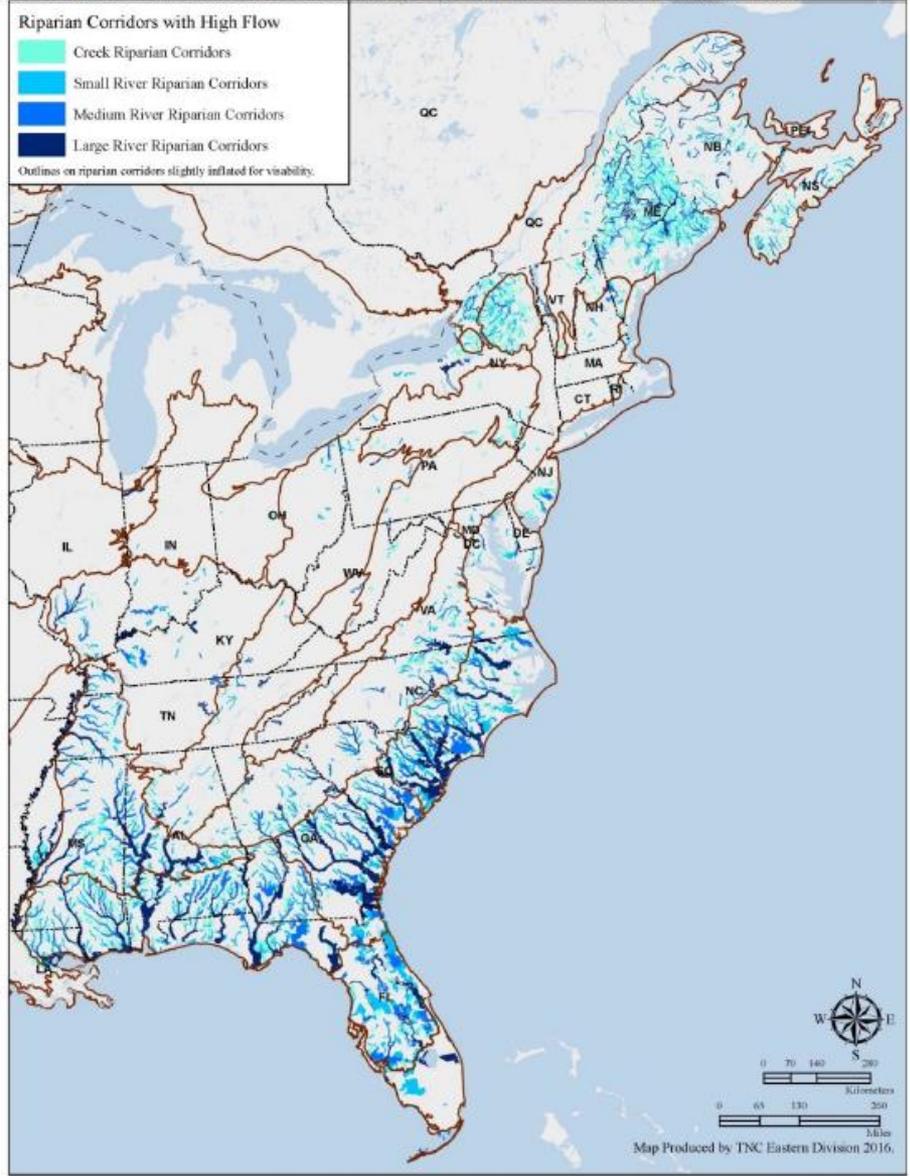
- **Size** of riparian unit in acres: *Larger patch size, higher value for biodiversity*
- **Regional flow** from Circuitscape modeling (anthropogenic resistance only): *High flow indicates concentrated species movement*
- **Contrast.** Local connectedness in riparian unit compared to surrounding buffer: *Higher contrast indicates greater value of riparian habitat as refugia and for connectivity*
- **Resilience.** % of riparian area with above average resilience

Final prioritization



- Identify regionally significant riparian corridors that connect other resilient areas. Limited selection to:
 - Riparian units >1000 acres in size
 - Units that had a high percentage of area in above average regional flow
 - ...or that contained a large contiguous area of high regional flow

Figure 3.23. Regionally significant riparian climate corridors. This map shows the riparian units with above average regional flow based on either the percent of the unit with high flow, or the size of the largest contiguous stretch of high flow.



Integration: Developing a Resilient and Connected Landscape



**WHAT SPATIAL CONFIGURATION IS NEEDED
TO PRODUCE AN ECOLOGICALLY COHERENT
NETWORK THAT ALLOWS FOR ADAPTATION
AND CHANGE?**

Overarching Approach



1. Prioritize a subset of resilient sites using criteria based on diversity, representation, and flow
2. Identify between-site linkages that connect essential features and correspond to areas of concentrated flow

Datasets for Integration



1. Resilient sites (~33% of each of the 61 geophysical settings in the region) as starting point
2. Connections
 1. Permeable climate pathways (diffuse and concentrated flow)
 2. Riparian climate corridors
3. Biodiversity*

Beginning with the flow



- Above average resilience score (>0.5 SD) was qualifying criterion every cell needed to meet
- Started with the natural flow patterns across the region as the spatial template:
 - Concentrated flow areas: $\geq 10,000$ acres, at least 75% within resilient area
 - Riparian corridors: $\geq 1,000$ acres, at least 75% within resilient area
 - Diffuse flow areas: Any cell of high or medium diffuse flow with above average resilience

Figure 5.1. Concentrated flow and riparian climate corridors. This map shows the areas that met the criteria for concentrated flow and riparian climate corridors. Orange indicates features that are mostly within resilient sites. Red indicates features that are mostly outside of resilient sites.

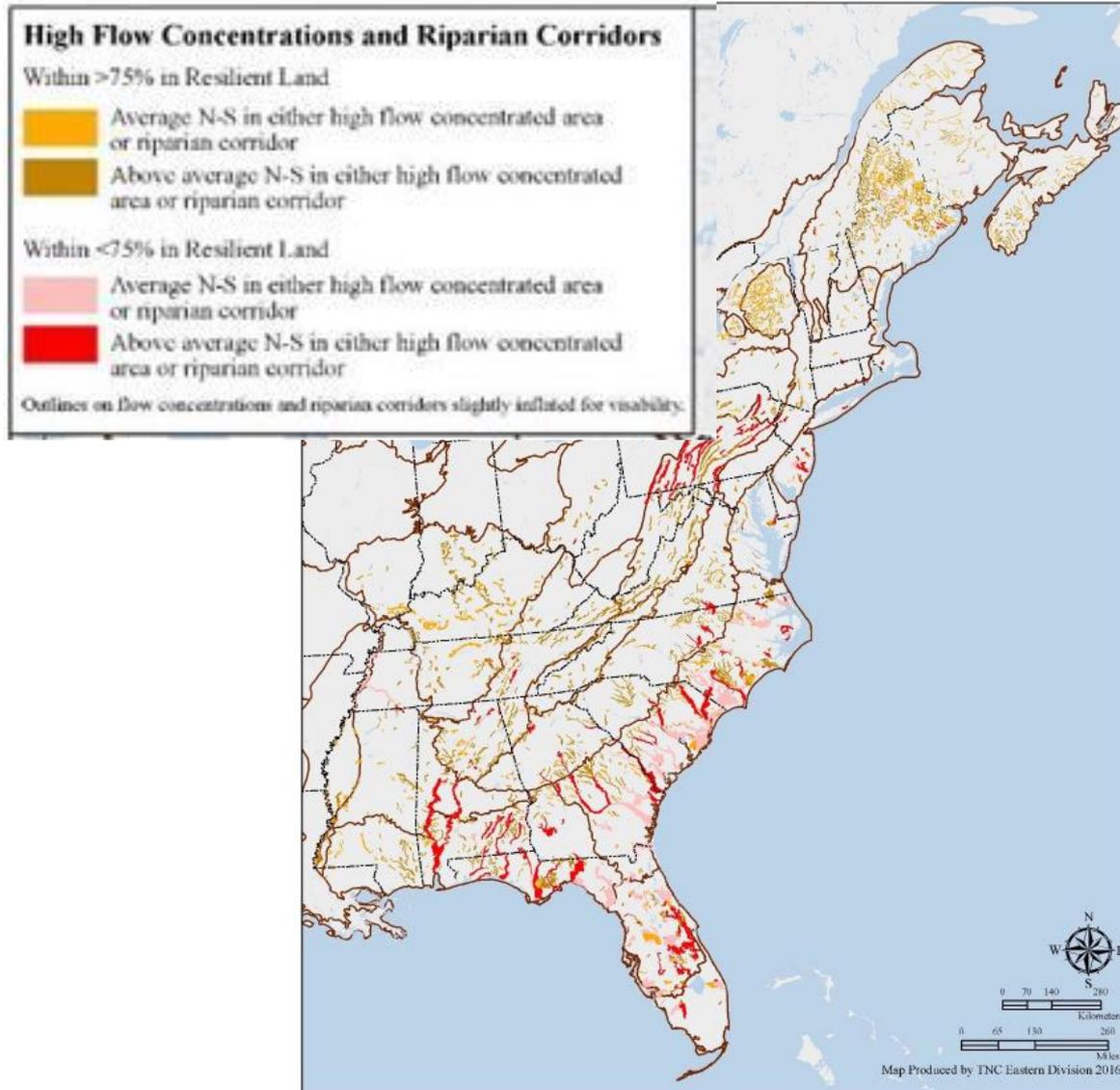
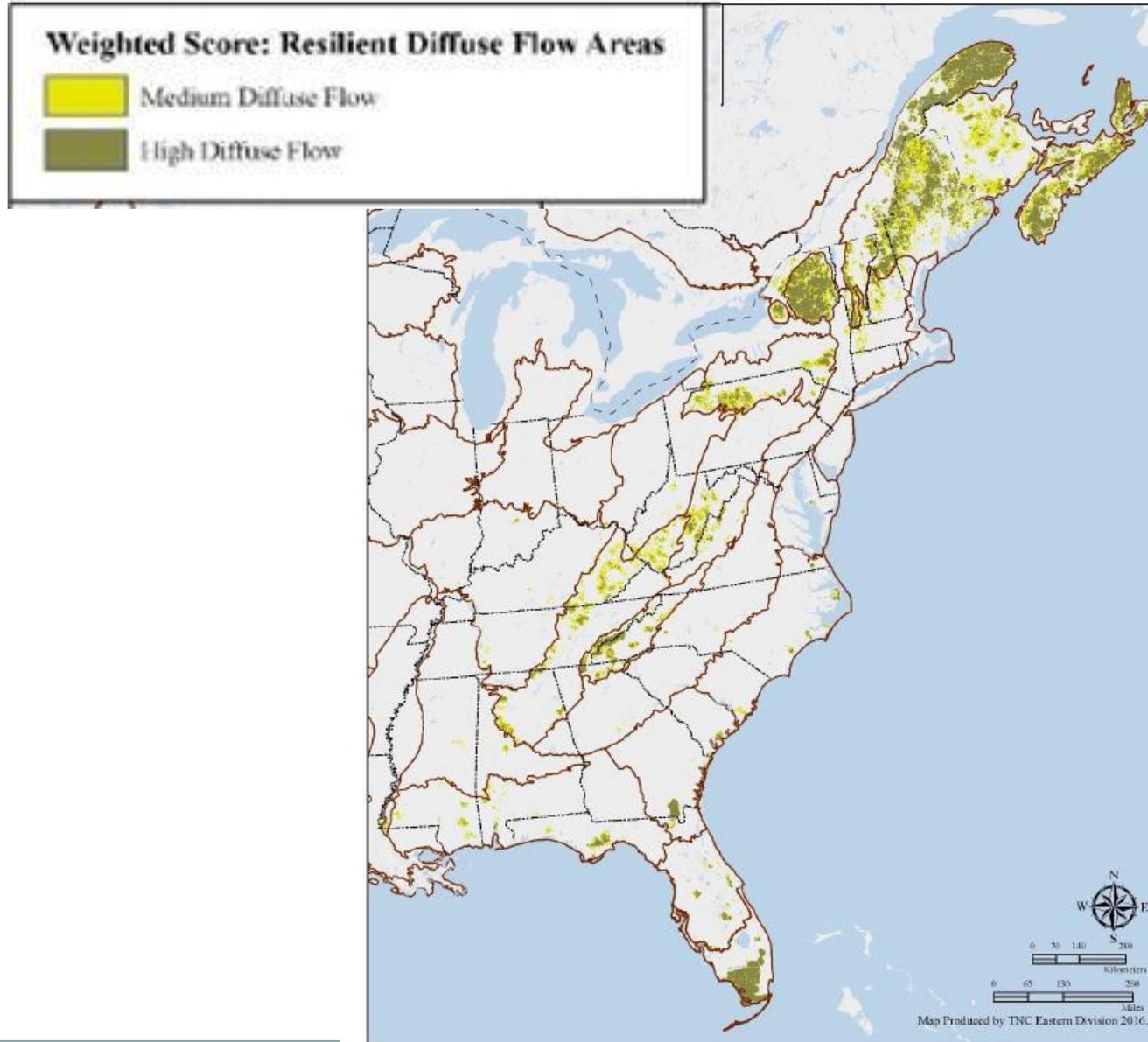


Figure 5.2. Diffuse flow areas. This map shows the areas that met the criteria for diffuse flow. Both high and moderate areas were included if they were within a resilient site.

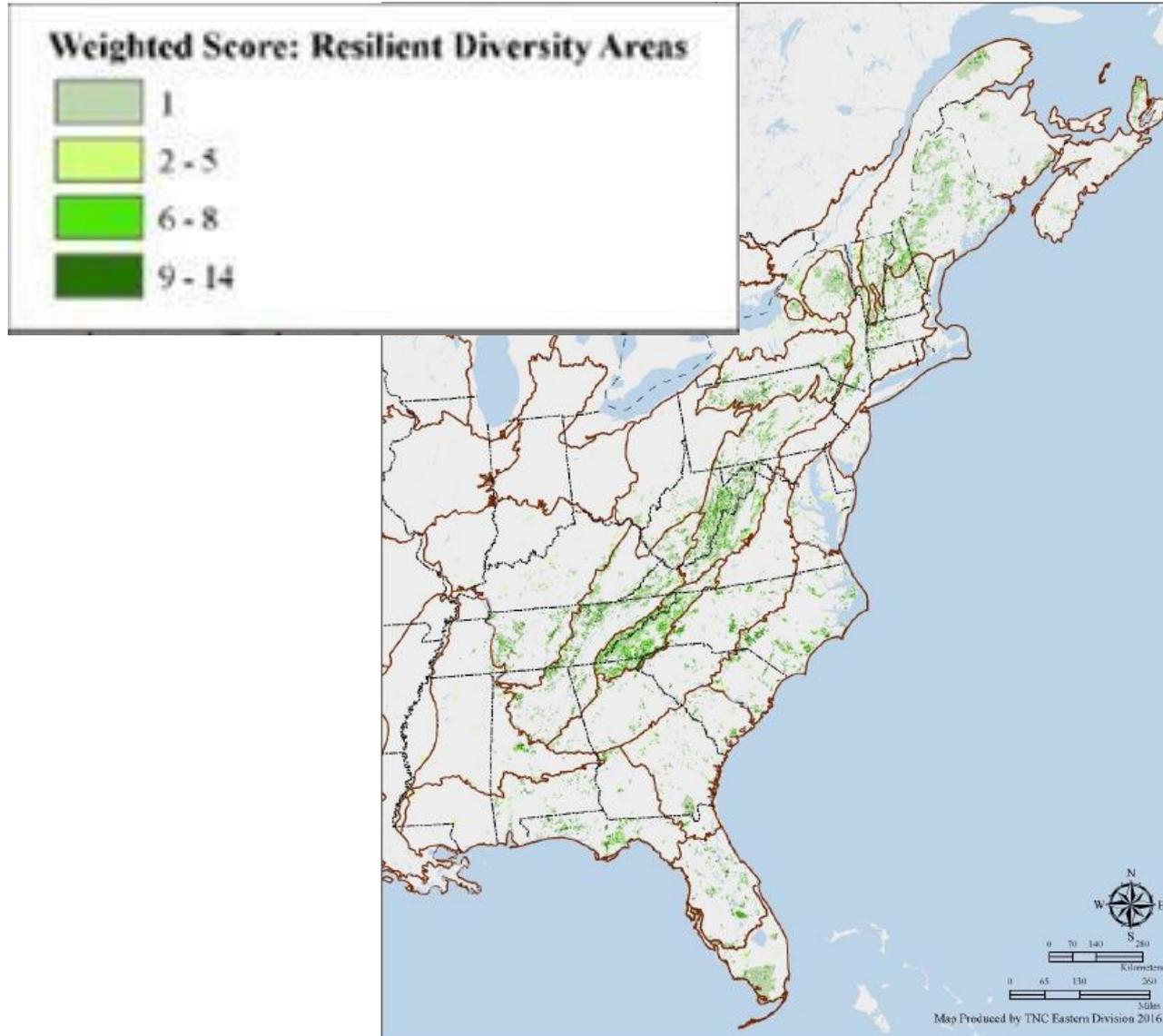


....and then add Diversity



1. Confirmed presence of rare species: NHB G1 to G4
2. High taxa diversity: More rare taxa than expected for the geophysical setting
3. Confirmed presence of exemplary natural communities
4. Resilience patches: Large (>1000 acres) roadless patches with many EOs
5. Large contiguous areas of each geophysical setting: Minimum 500 acres
6. Underrepresented geophysical settings: Settings underrepresented in existing conserved lands given minimum of 50,000 acres. Well represented settings had minimum of 25,000 acres

Figure 5.3. Diversity features. This map show the total number of diversity features present in each hexagon of resilient land. Features are either a confirmed occurrence of a rare species (G1-G4), a high quality occurrence of a natural community, or the largest continuous examples of a geophysical setting.



And finally...linkages



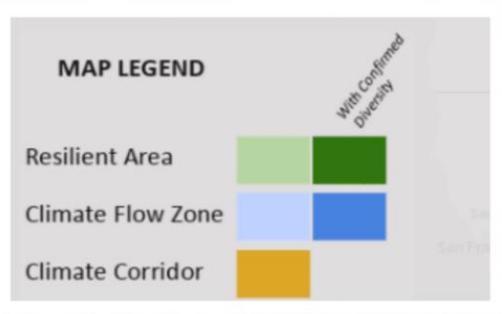
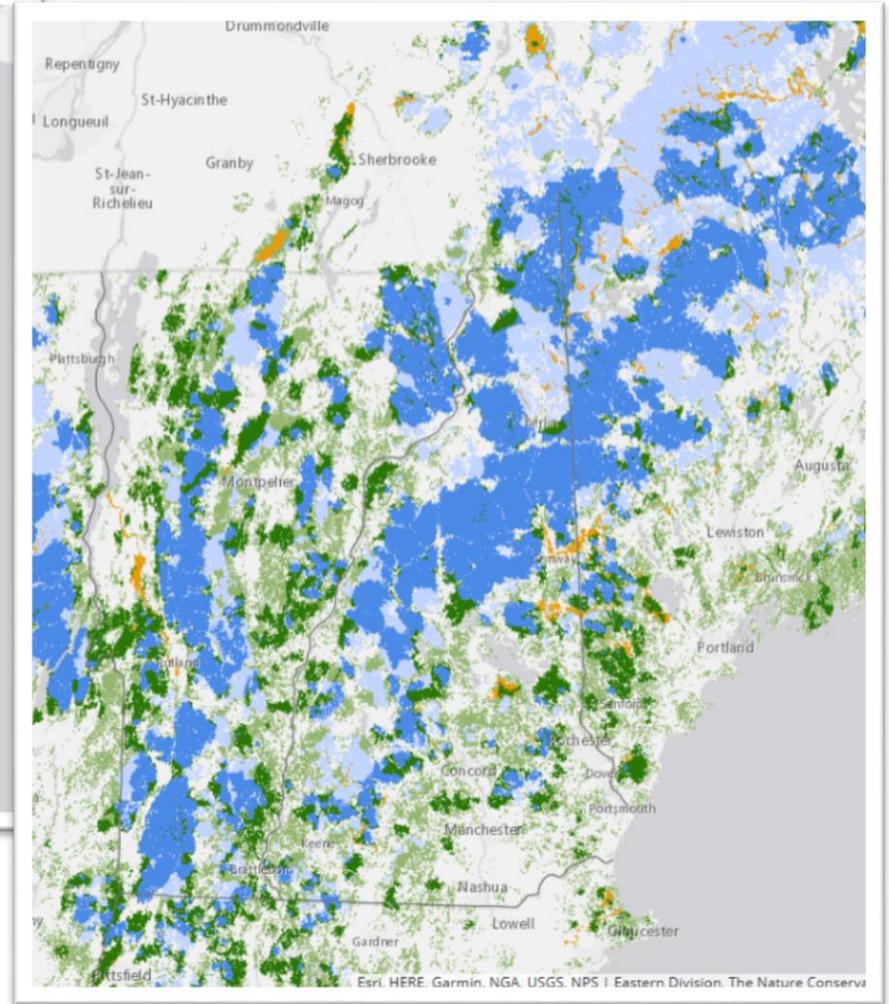
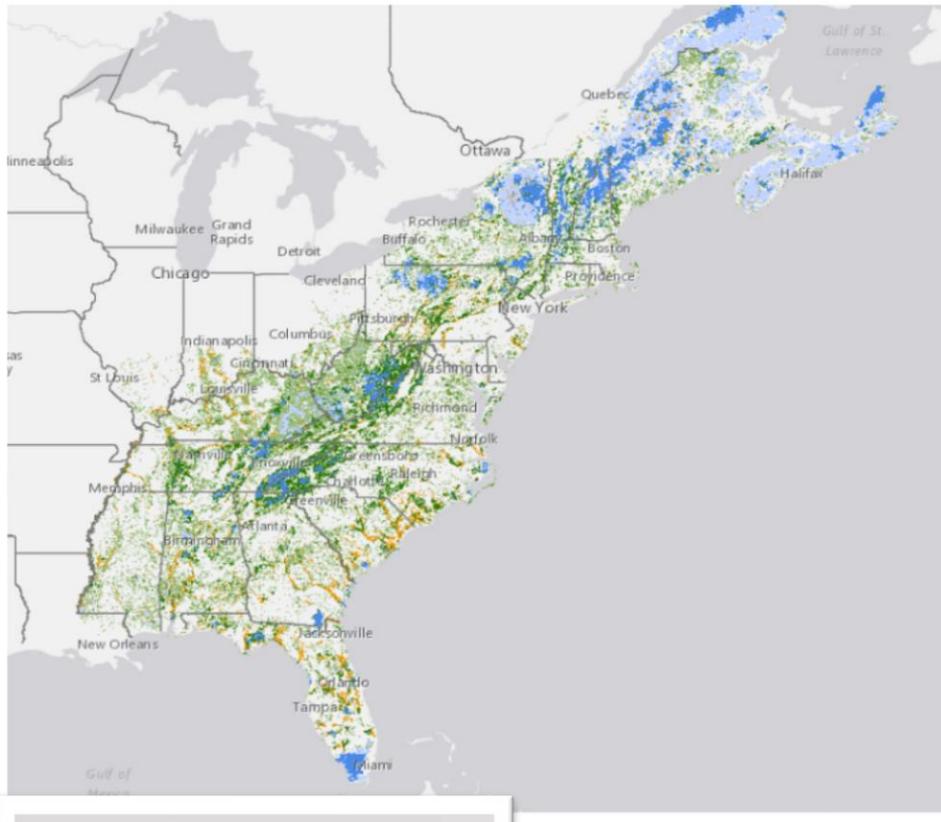
- Linkages occur outside of resilient sites, but link together diversity features
- Identified based on:
 - Concentrated flow areas: Largely outside of resilient site (75%), minimum 5,000 acres, touched at least three prioritized diversity features
 - Riparian corridors: Same criteria as above

The Results



- Prioritized resilient sites and linkages combined to create a resilient and connected network of sites covering 23% (106 million acres) of region
- Represents all geophysical settings
- Contains over 8,000 known rare species or communities
- 23 million acres of riparian corridors
- 12% of region currently in some form of conservation, so lofty goal, but not infeasible

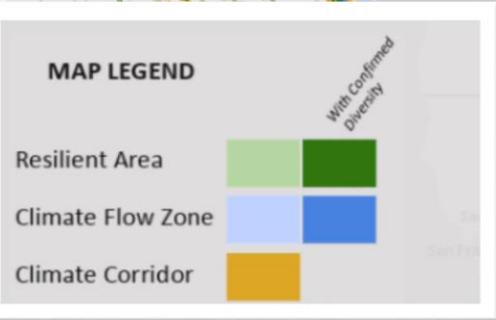
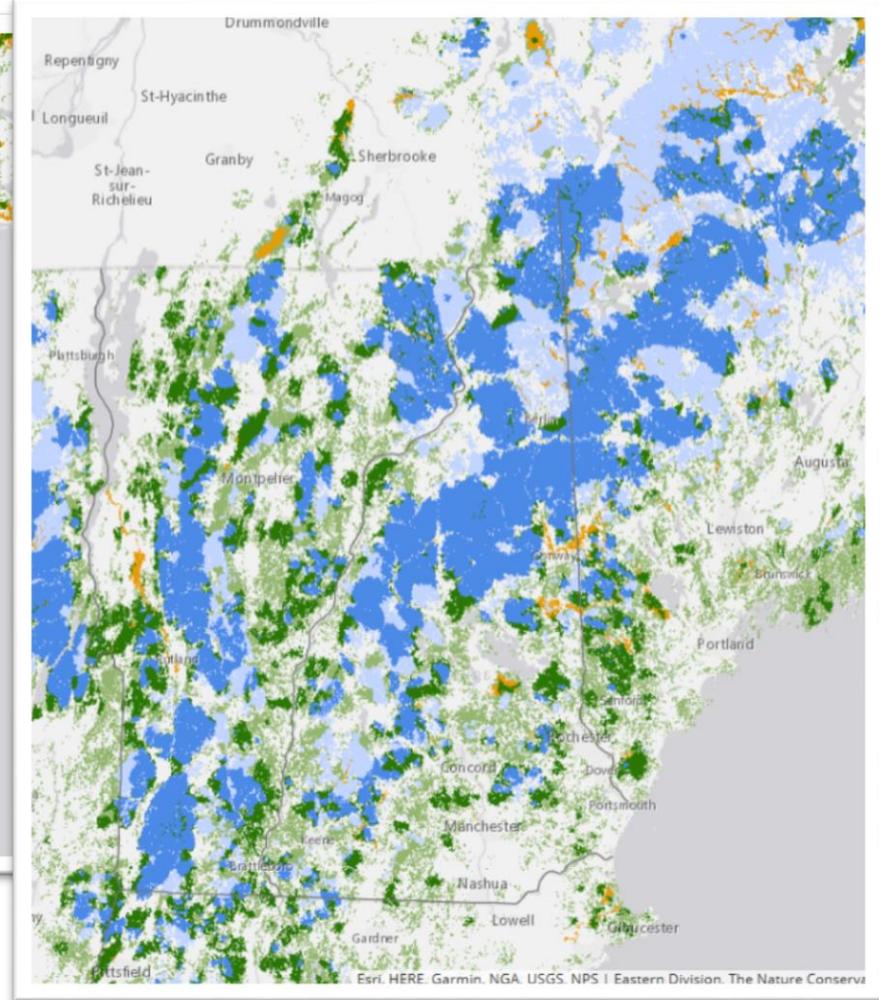
Resilient and Connected Landscapes



Wrapping up



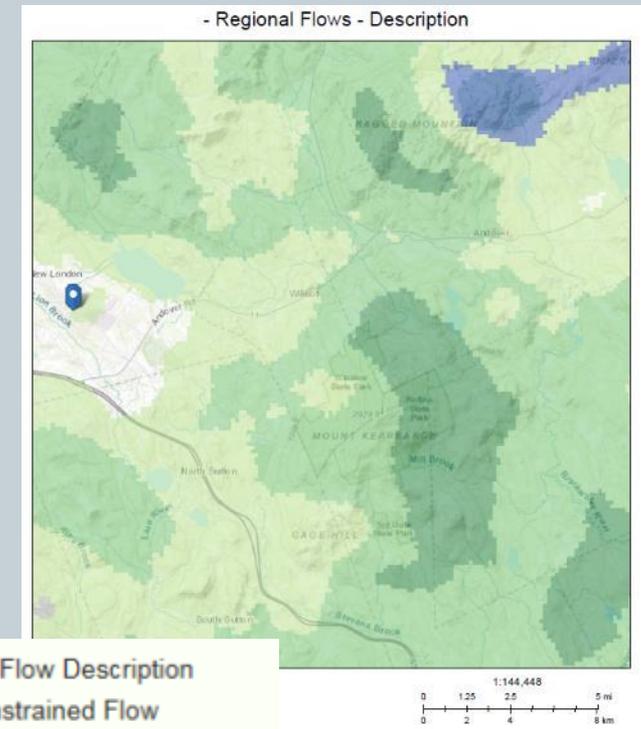
Putting the northeast in context



Resilient & Connected Landscapes Key Products



- Resilience data
- Regional connections
 - Regional flows (diffuse and concentrated)
 - Riparian climate corridors
- Resilient and Connected Network (regionally prioritized)



Thanks and Questions

