Building climate-resilient stream and river ecosystems in the northeast US: science and applications

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GOALS

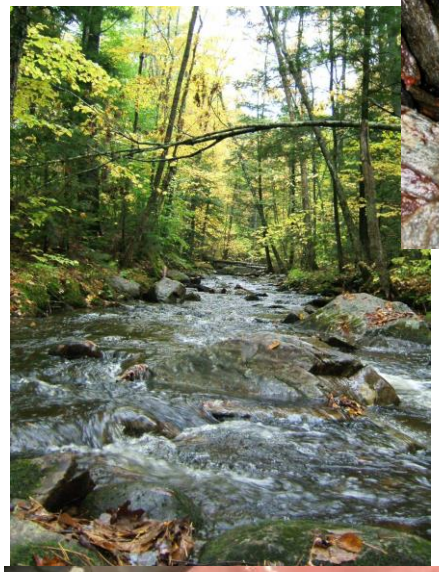
Provide the science and science support to:

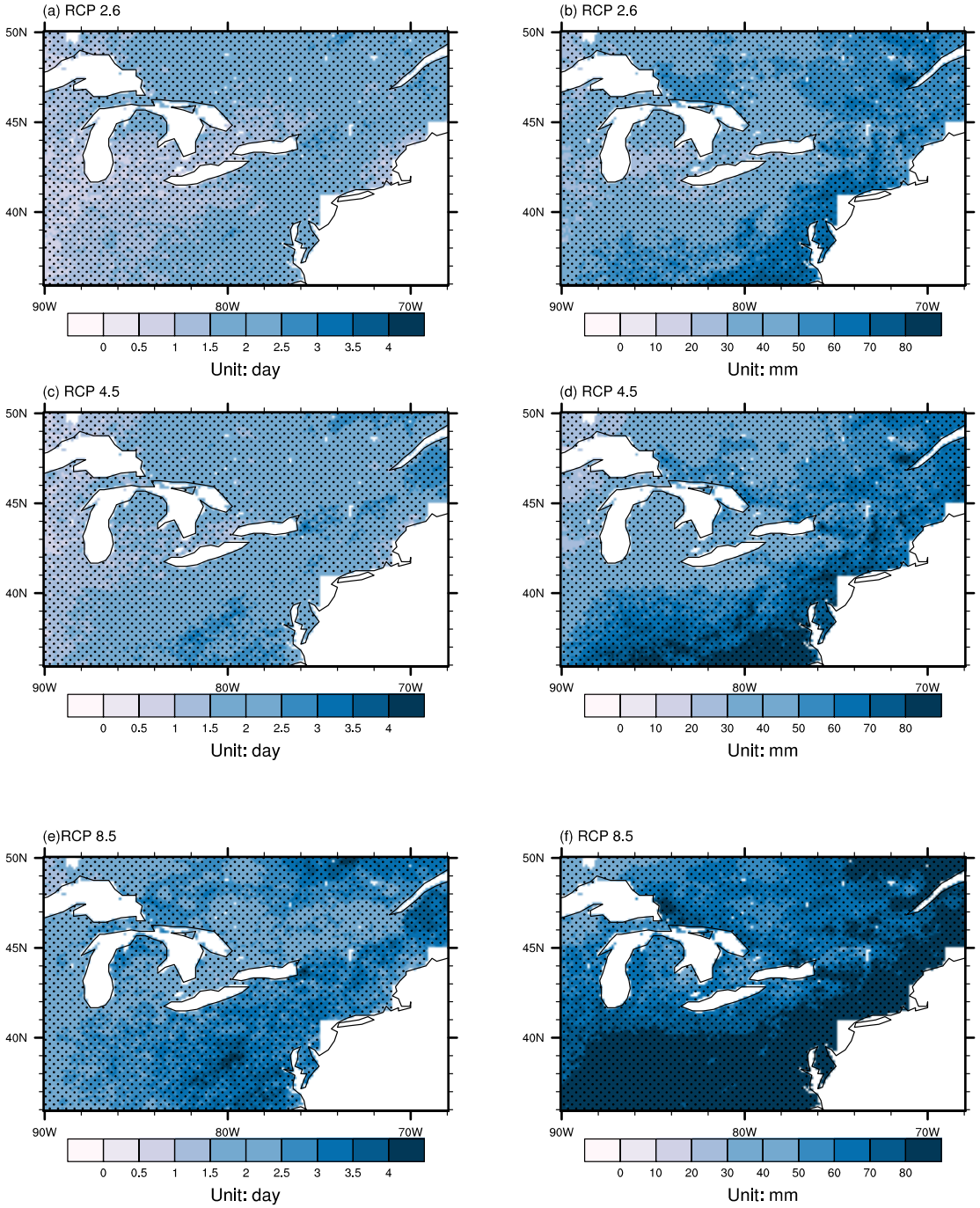
- Identify climate vulnerable species, habitats, and ecosystems
- Evaluate management actions in the context of climate resilience
- Design sustainable landscapes
- Train the next generation of interdisciplinary climate and natural resource professionals

Climate-Vulnerable Ecosystems and Habitats

Montane Forests

Coldwater streams





Climate Impacts on Headwaters in the Northeastern US

- Warmer temperatures
- More precipitation; more as rain
- Increased duration, frequency and magnitude of extremes

From Ning, L., E. E. Riddle, and R. Bradley, 2014: Projected changes in climate extremes over the northeastern United States. J. Climate (accepted pending revision)

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North Atlantic LCC

NECSC Northeast Climate Science Center

USGS science for a changing world

The Nature Conservancy Protecting nature. Preserving life.™

University of Massachusetts Amherst 1863

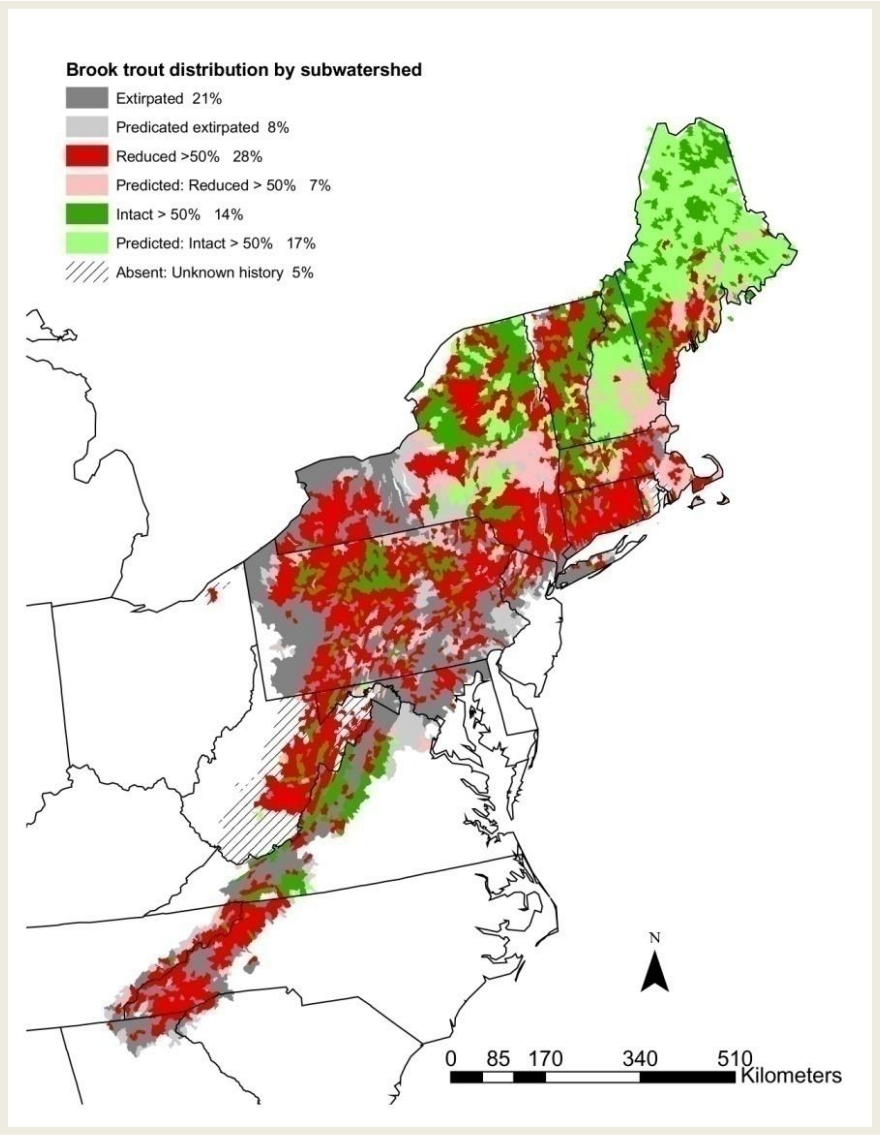
UAS

Appalachian Landscape Conservation Cooperative

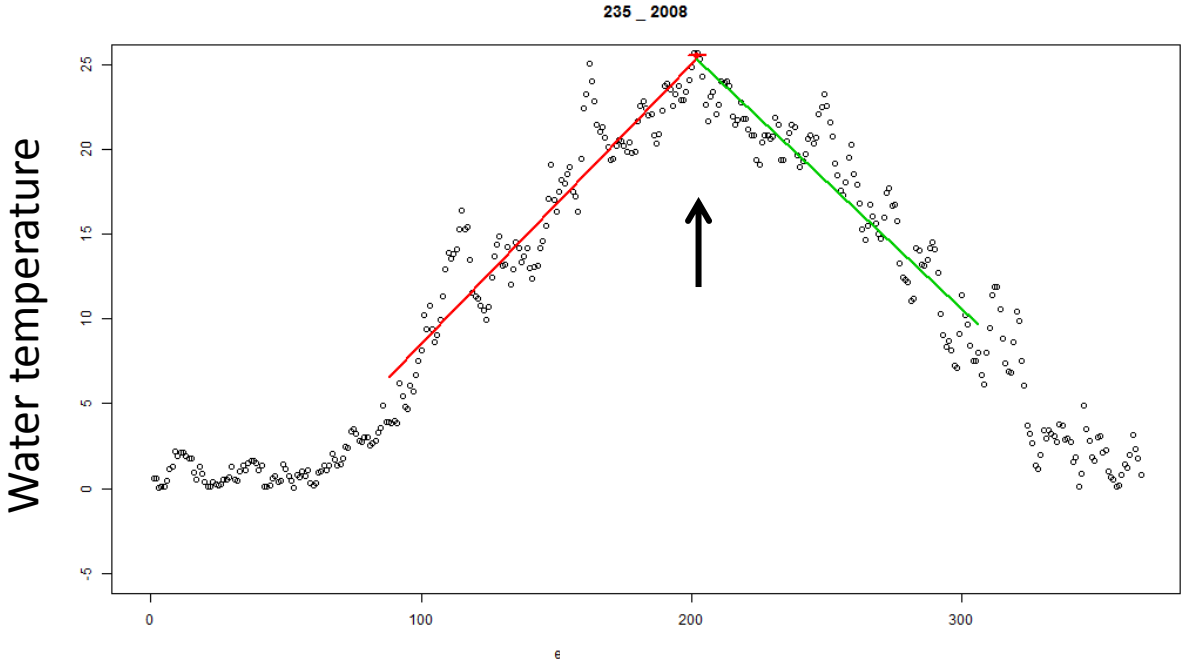
Eastern Brook Trout Joint Venture

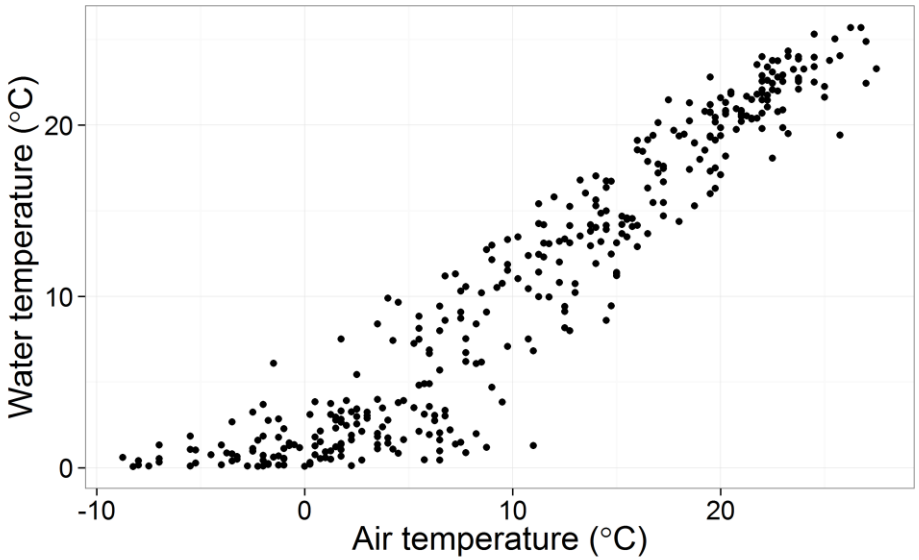
Streams - Forecasts

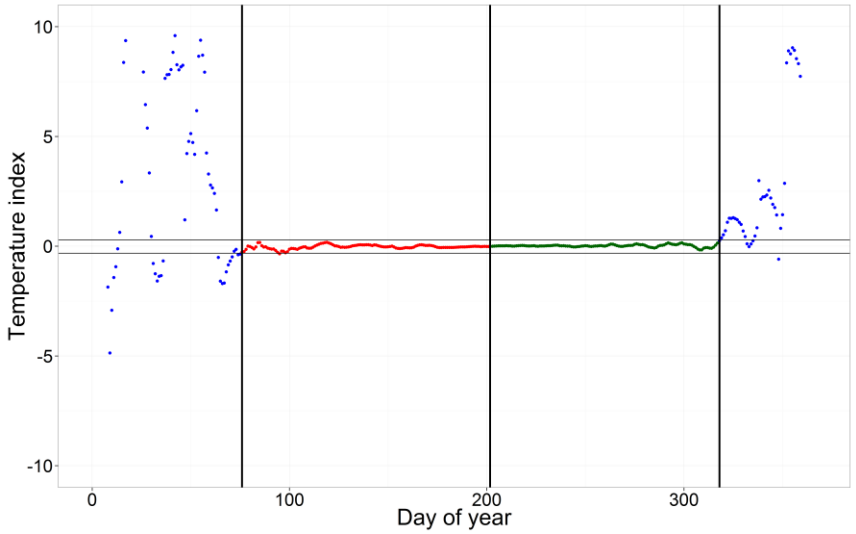
- Which sites will retain coldwater habitat?
- Which sites will retain brook trout populations?

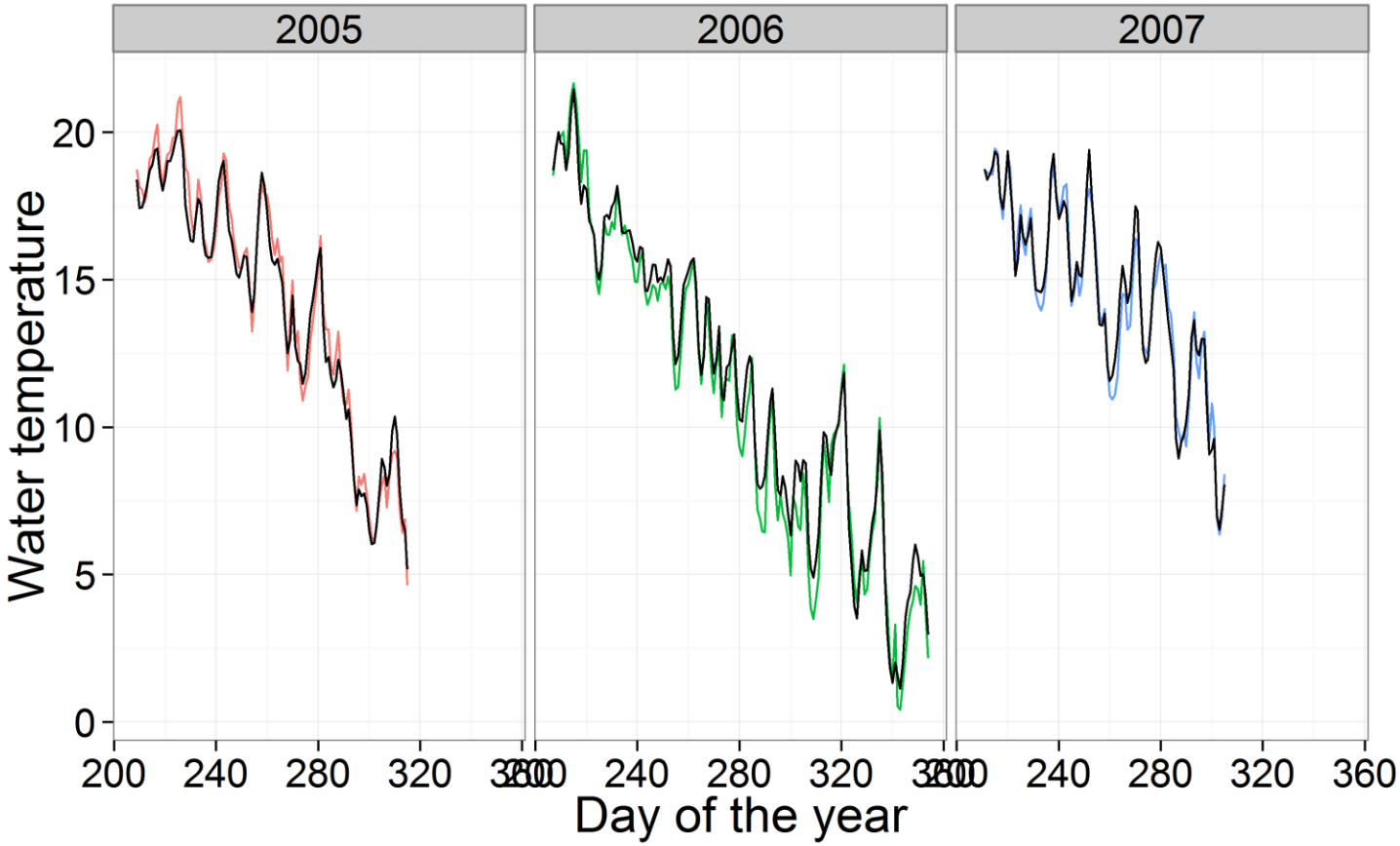


When are stream and air temperature synchronized?

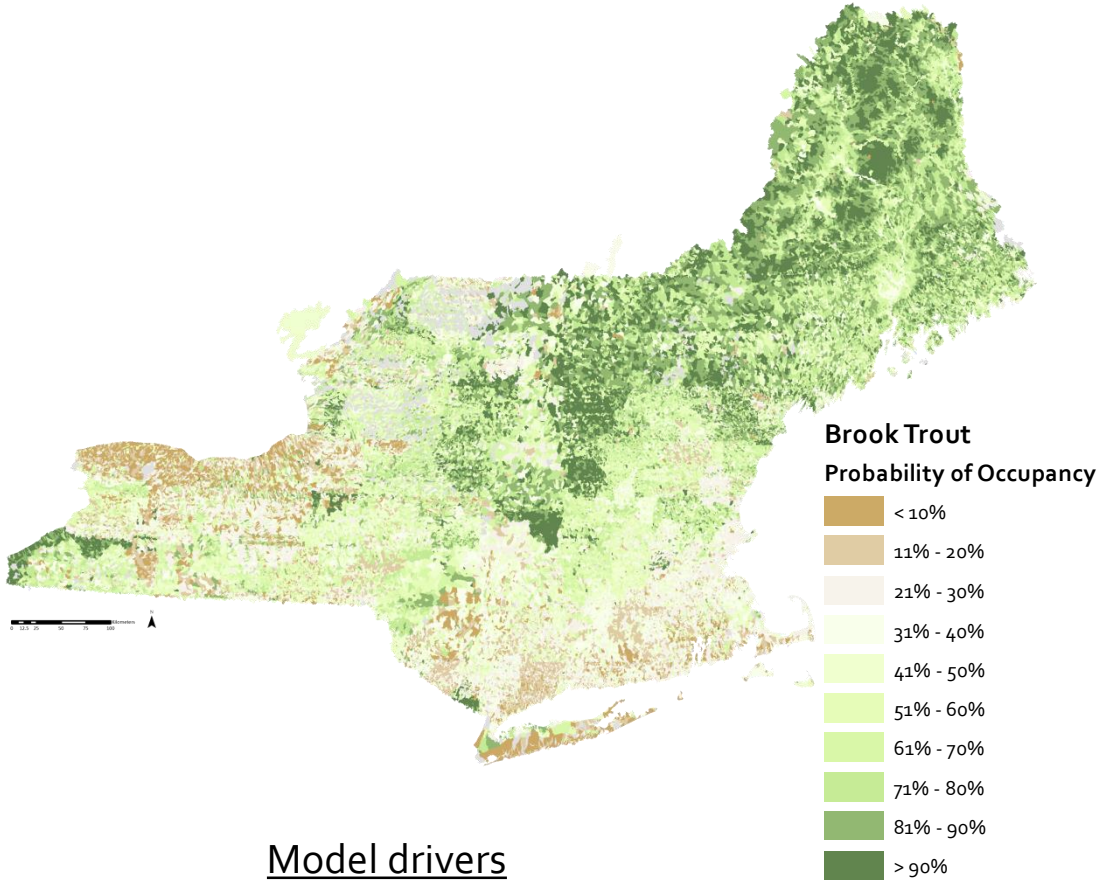


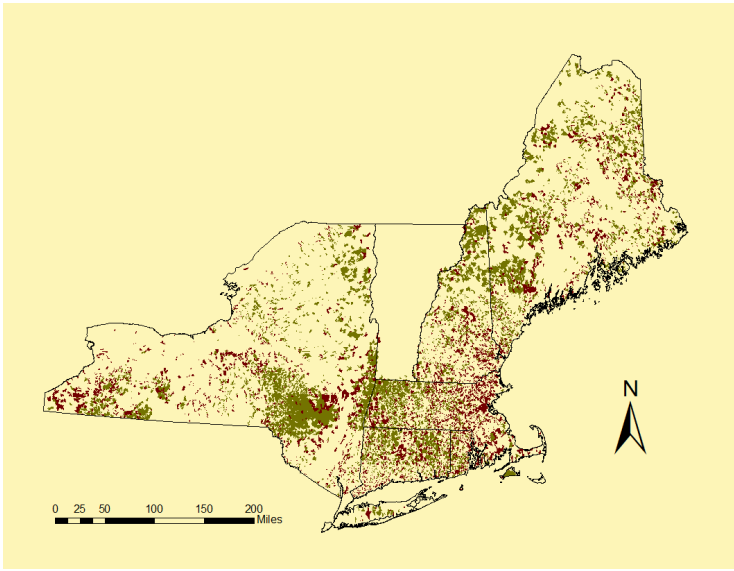





2005
2006
2007
Water temperature
0
5
10
15
20
200
240
280
320
360
Day of the year

Probability of Occupancy for Current Conditions



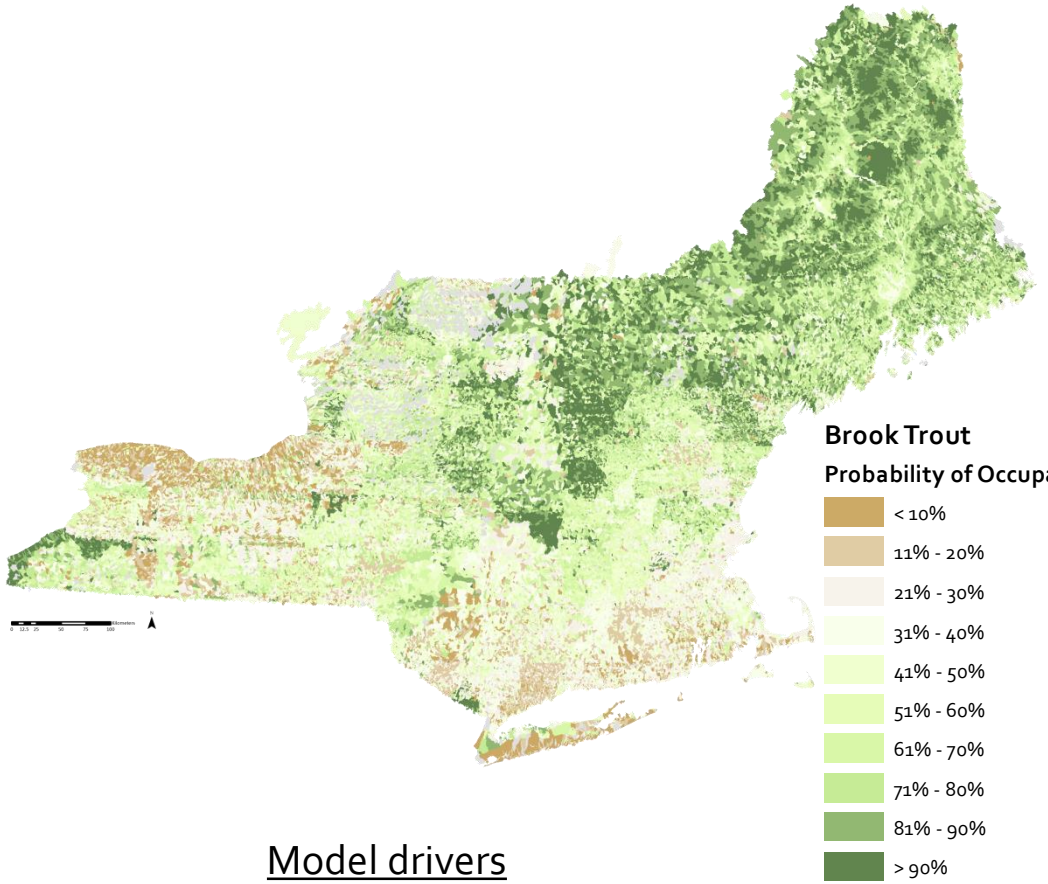


Observed Occupancy

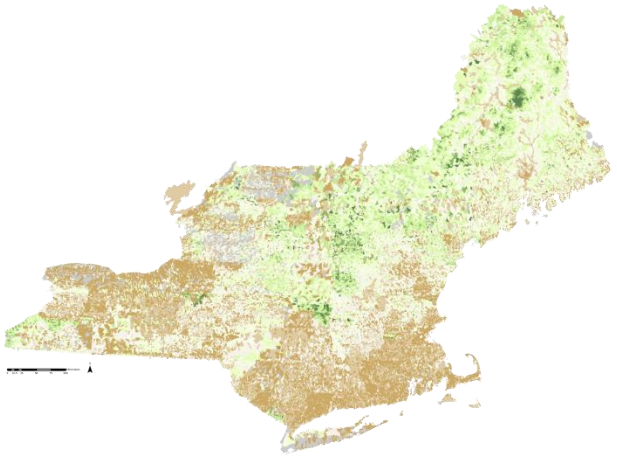
Model drivers

Drainage area	Annual precipitation
Forest cover	Minimum temperature
Stream slope	Soil drainage class

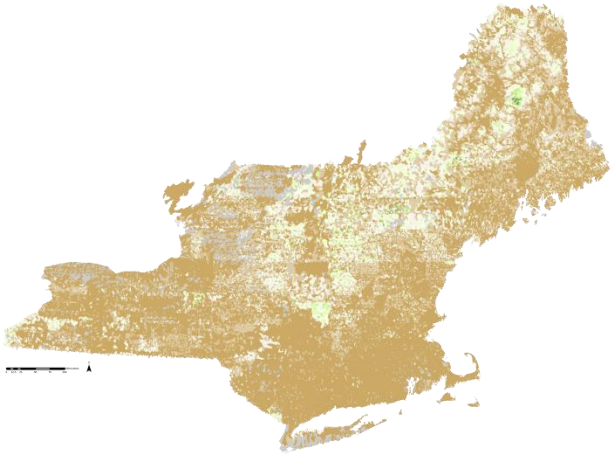
Probability of Occupancy for Current Conditions



Probability of Occupancy 2 C increase



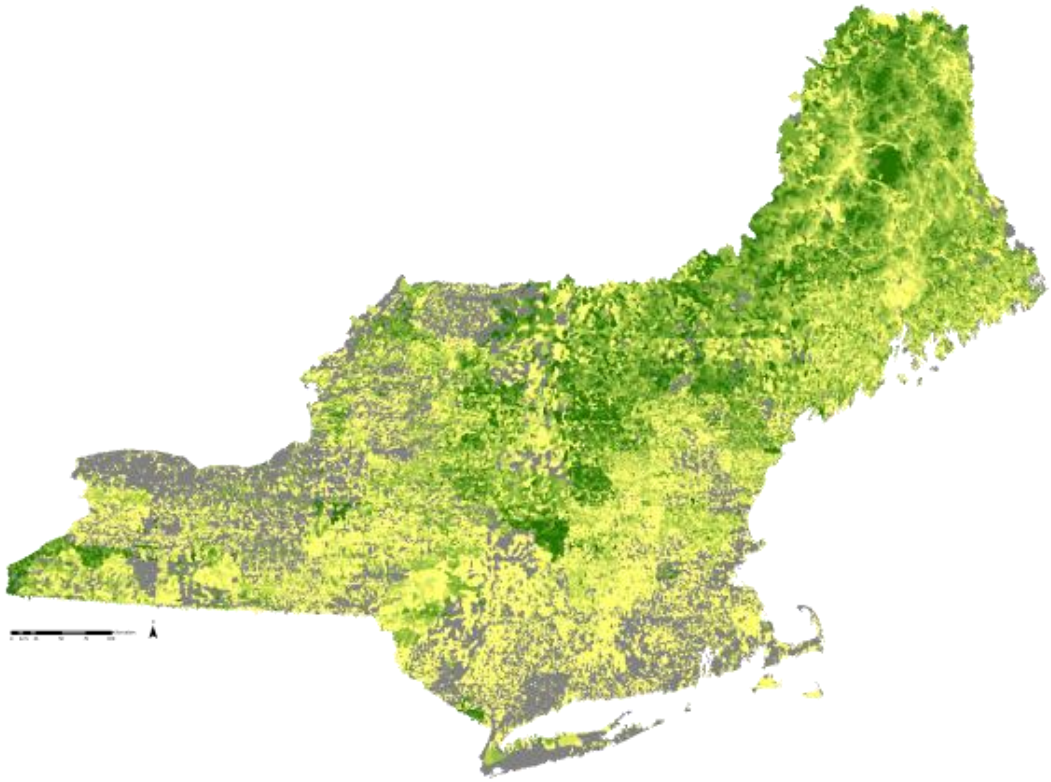
Probability of Occupancy 4 C increase



Model drivers

Drainage area	Annual precipitation
Forest cover	Minimum temperature
Stream slope	Soil drainage class

Resilience of occupancy to temperature increase



Brook Trout Resilience

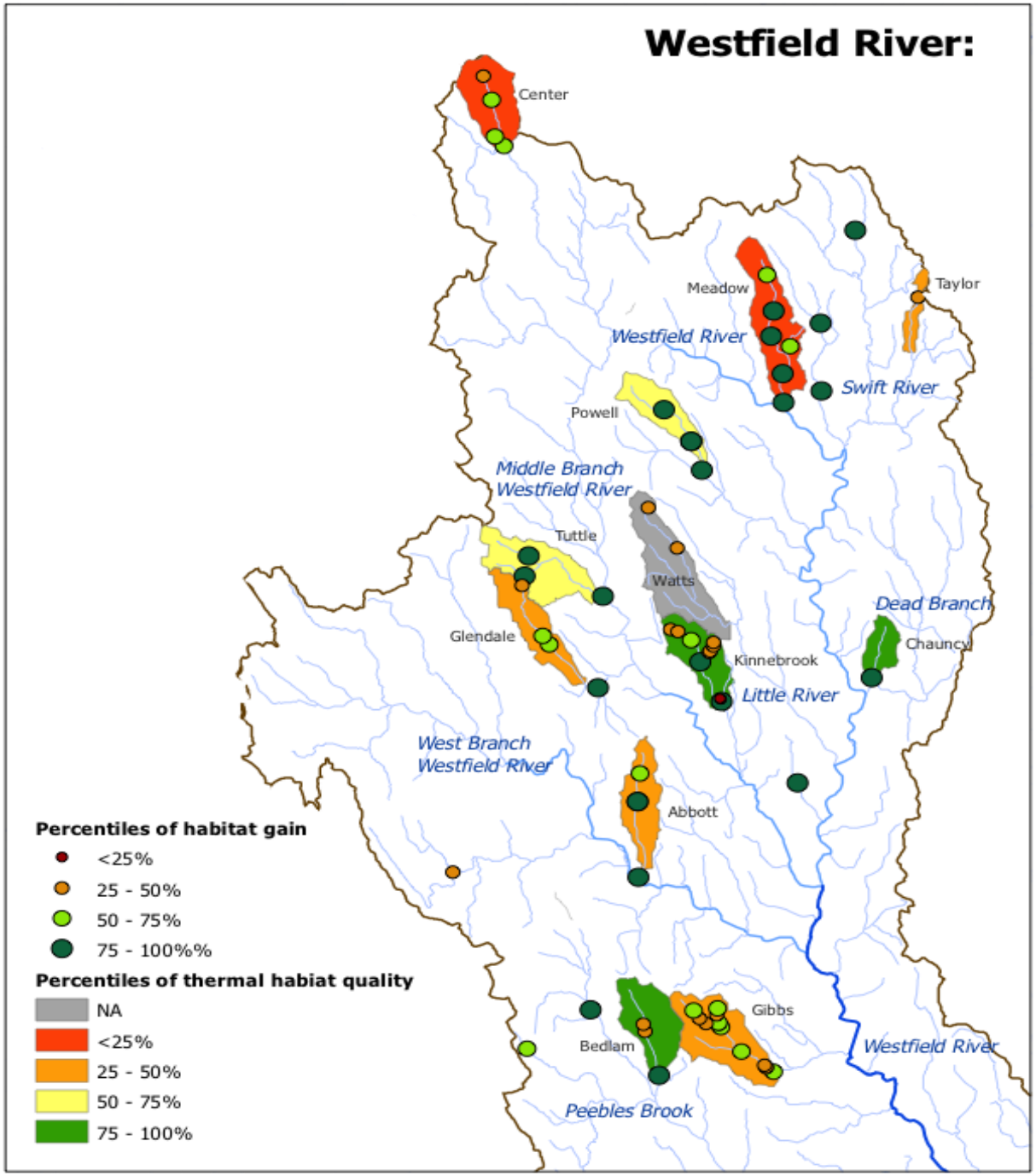
Increase tolerated (°C)

- 0°
- 0.1° - 0.5°
- 0.6° - 1°
- 1.1° - 1.5°
- 1.6° - 2°
- 2.1° - 2.5°
- 2.6° - 3°
- 3.1° - 8.5°

Currently below threshold

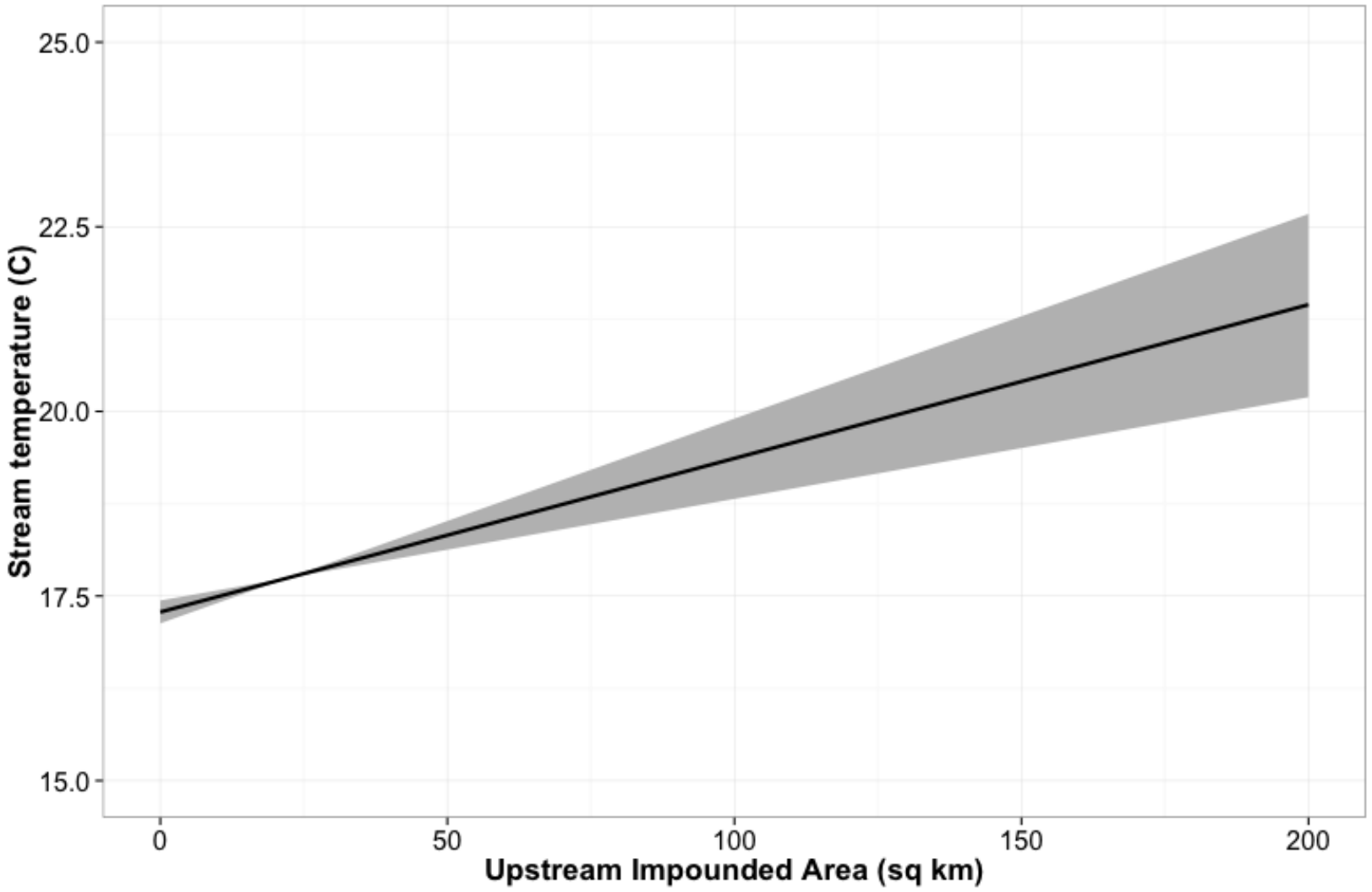
Management Actions

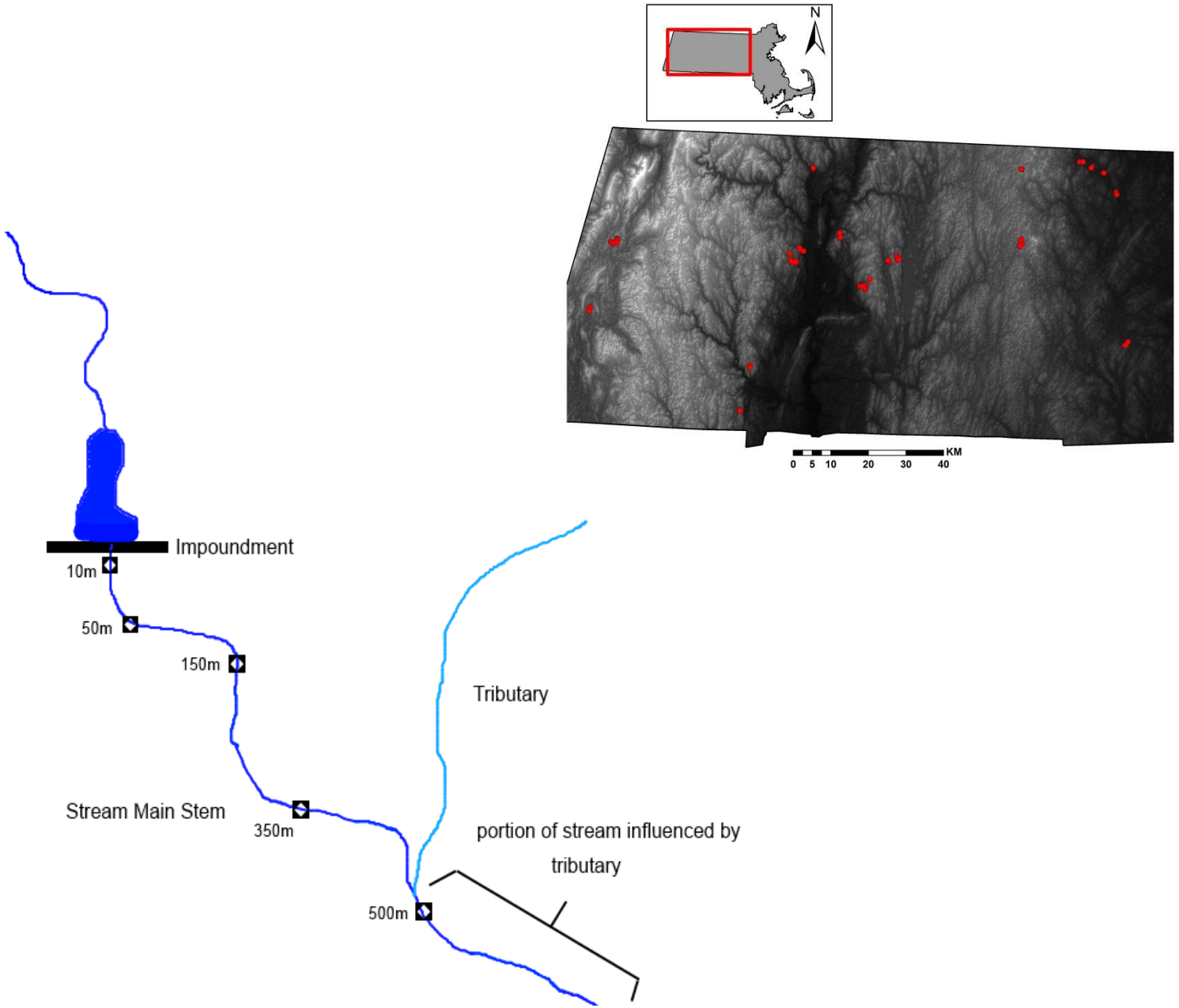
- Incorporating thermal habitat resilience into road-stream crossing assessment and prioritization
- Habitat quantity plus habitat quality


Westfield River:
Center
Meadow
Taylor
Westfield River
Swift River
Powell
Middle Branch
Westfield River
Tuttle
Watts
Dead Branch
Glendale
Chauncy
Kinnebrook
Little River
West Branch
Westfield River
Abbott
Gibbs
Bedlam
Westfield River
Peebles Brook
Percentiles of habitat gain
<25%
25 - 50%
50 - 75%
75 - 100%%
Percentiles of thermal habiat quality
NA
<25%
25 - 50%
50 - 75%
75 - 100%

Management Actions

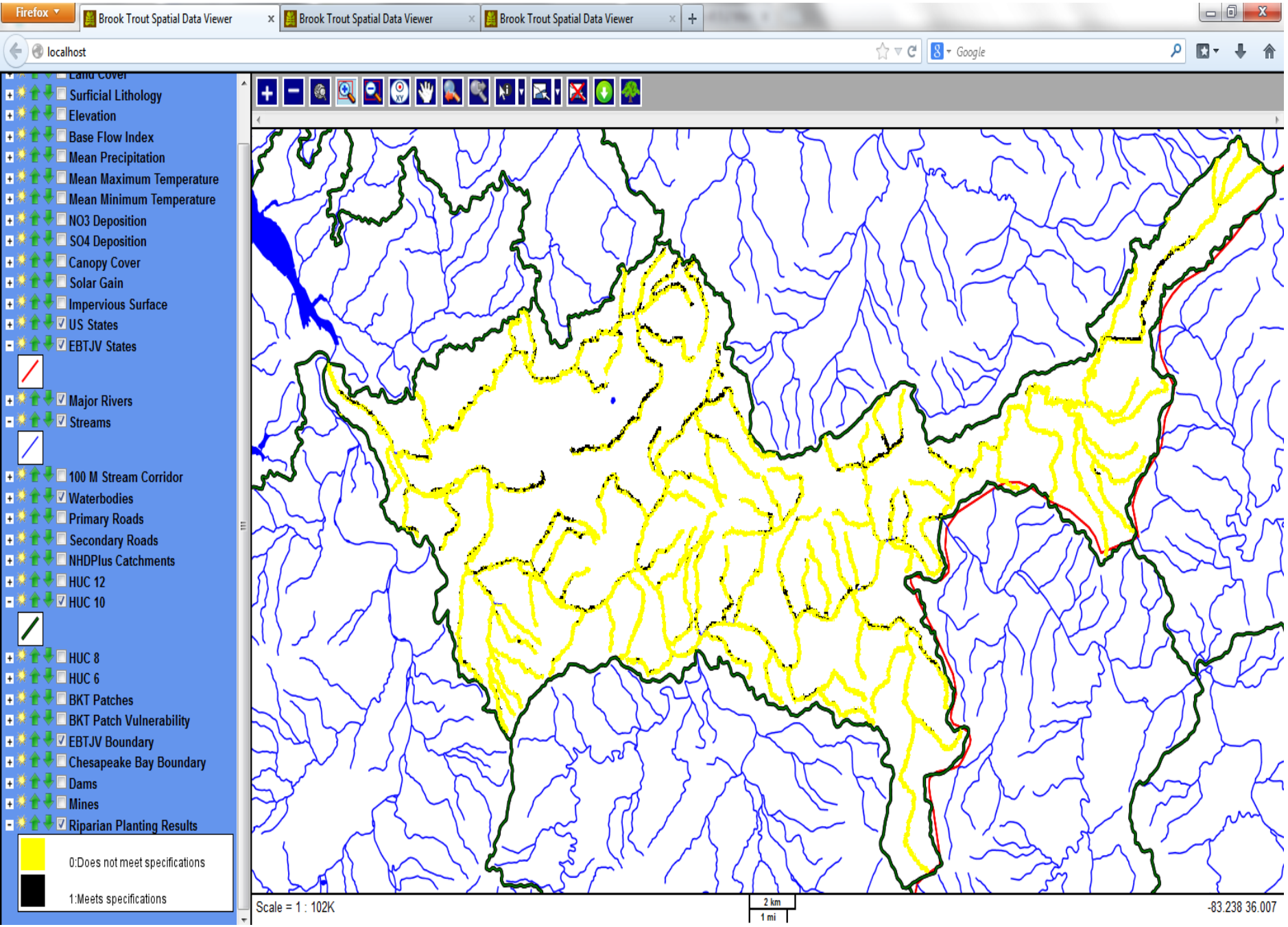
- Effects of dams and dam removal on downstream thermal regimes


25.0
22.5
20.0
17.5
15.0
Stream temperature (C)
0
50
100
150
200
Upstream Impounded Area (sq km)


N
0 5 10 20 30 40
KM
Impoundment
10m
50m
150m
350m
500m
Tributary
Stream Main Stem
portion of stream influenced by
tributary

Management Actions

- Restoring riparian cover to warming-vulnerable habitats

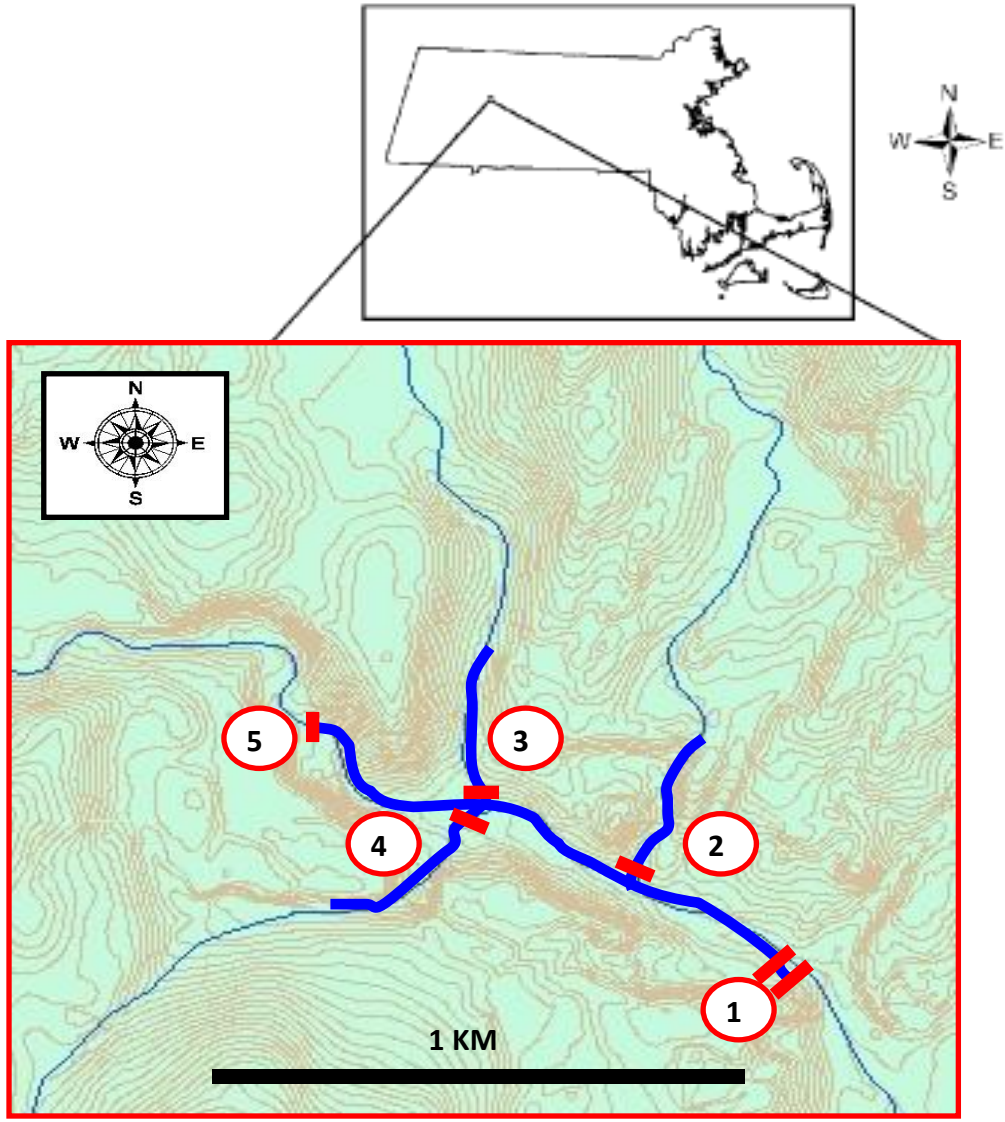

Firefox
Brook Trout Spatial Data Viewer
Brook Trout Spatial Data Viewer
Brook Trout Spatial Data Viewer
localhost
Google
Land Cover
Surficial Lithology
Elevation
Base Flow Index
Mean Precipitation
Mean Maximum Temperature
Mean Minimum Temperature
NO3 Deposition
SO4 Deposition
Canopy Cover
Solar Gain
Impervious Surface
US States
EBTJV States
Major Rivers
Streams
100 M Stream Corridor
Waterbodies
Primary Roads
Secondary Roads
NHDPlus Catchments
HUC 12
HUC 10
HUC 8
HUC 6
BKT Patches
BKT Patch Vulnerability
EBTJV Boundary
Chesapeake Bay Boundary
Dams
Mines
Riparian Planting Results
0:Does not meet specifications
1:Meets specifications
Scale = 1 : 102K
2 km
1 mi
-83.238 36.007

Understanding Mechanisms

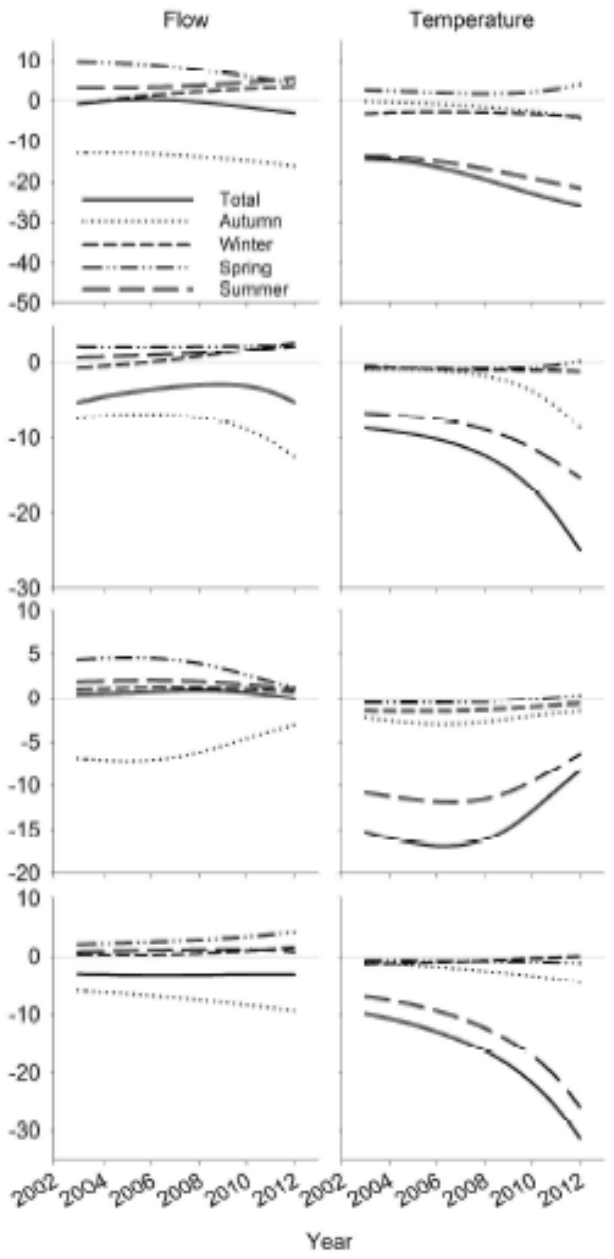
Multiple influences at multiple life-history stages

- Interactive and season, site and age-dependent effect of temperature and flow regime

- Using long-term data to parameterize population models



- Justifies a focus on summer temperature as a general determinant of population persistence



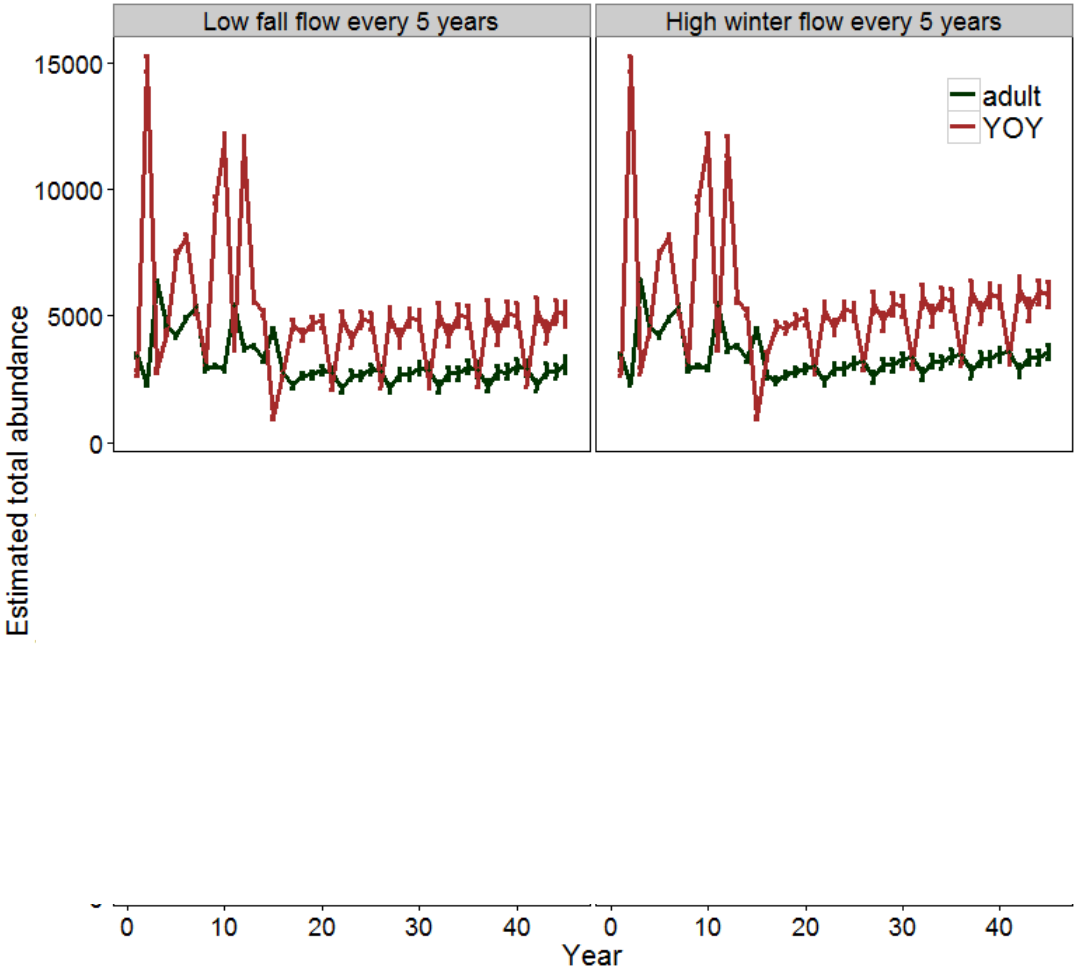
Extreme Climate Events

- Influence and attention way out of proportion to their frequency

Management Implications

- Influence predictions of distribution and abundance?

- Change prioritization and relative value of management actions?


Low fall flow every 5 years
High winter flow every 5 years
adult
YOY
Estimated total abundance
15000
10000
5000
0
0
10
20
30
40
Year

Hydrologic Extremes in River Systems

- Floods

Headwaters – less vulnerable

-reduced increases in per unit power during flood generation

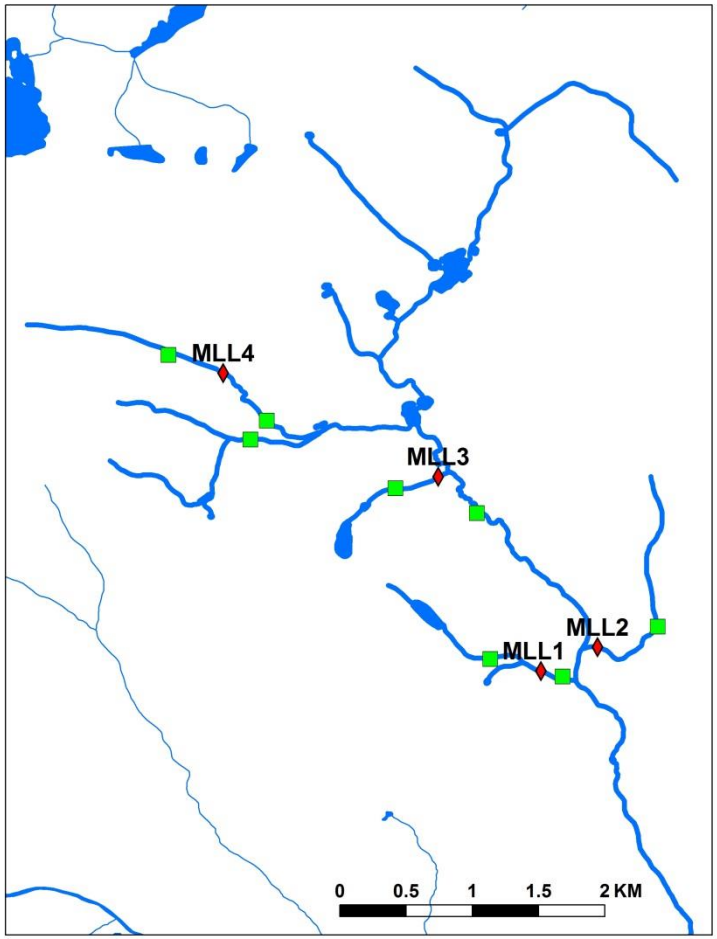
Mid-Reaches – more vulnerable

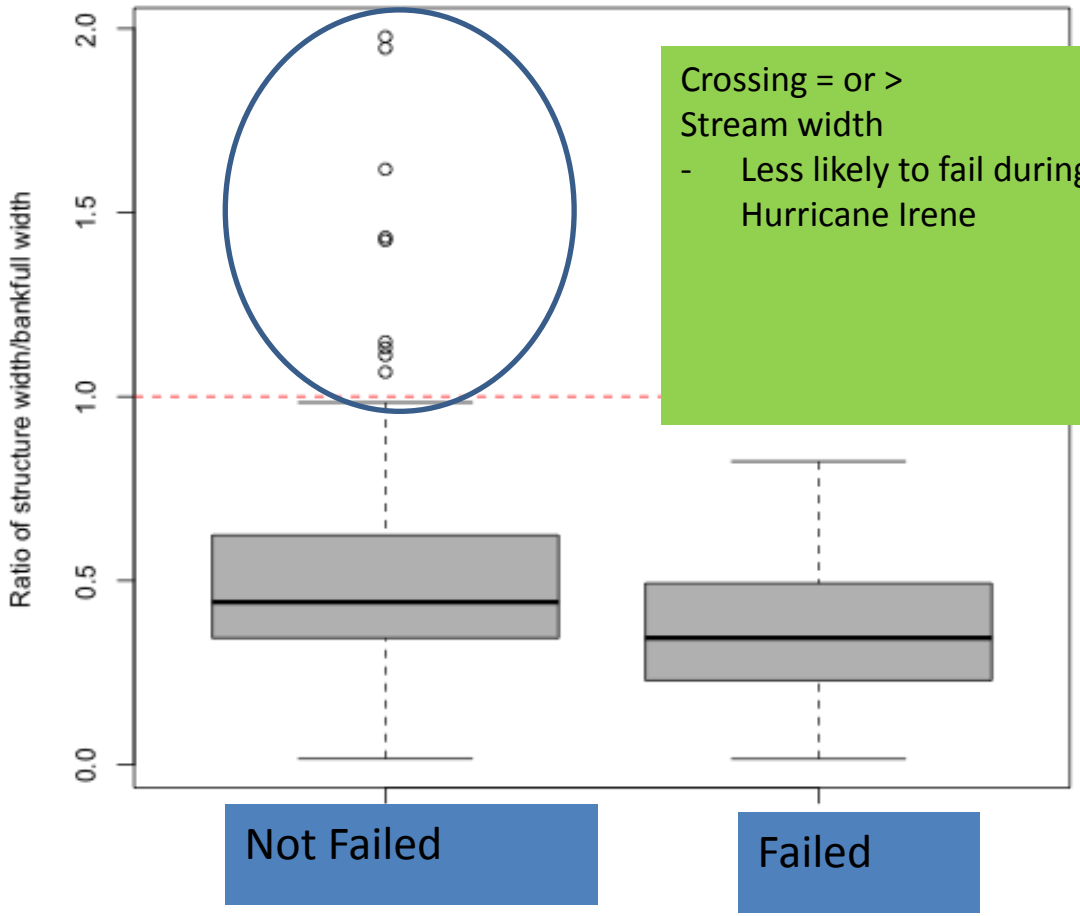
- Increased stream power, bed movement, overbank floods

- Droughts

The opposite?

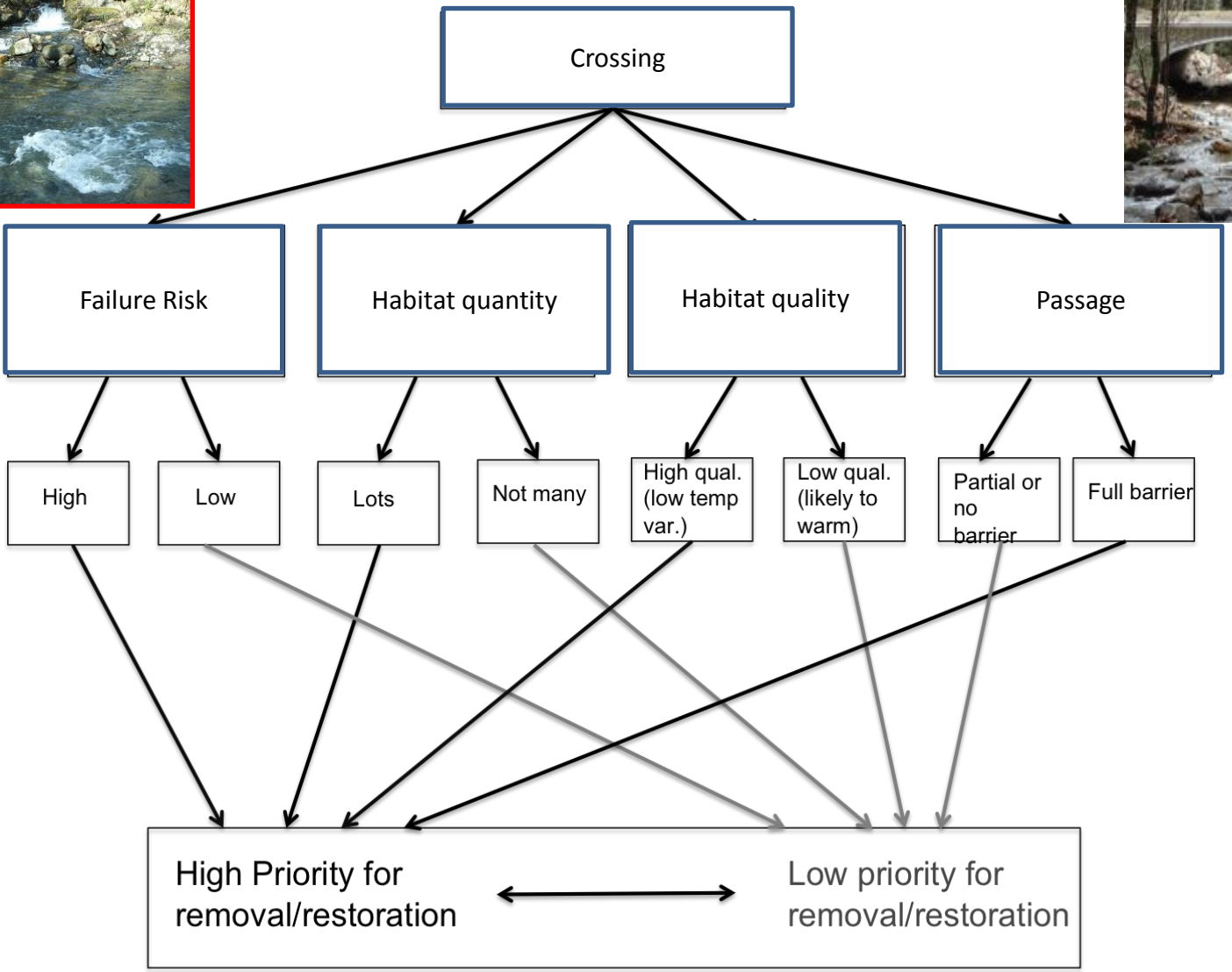
Headwaters at the threshold of perennial flow





Crossing = or >
Stream width

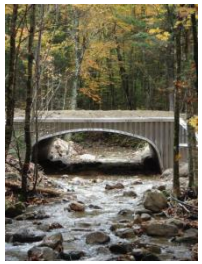
- Less likely to fail during Hurricane Irene


Crossing
Failure Risk
Habitat quantity
Habitat quality
Passage
High
Low
Lots
Not many
High qual. (low temp var.)
Low qual. (likely to warm)
Partial or no barrier
Full barrier
High Priority for removal/restoration
Low priority for removal/restoration

Human Responses

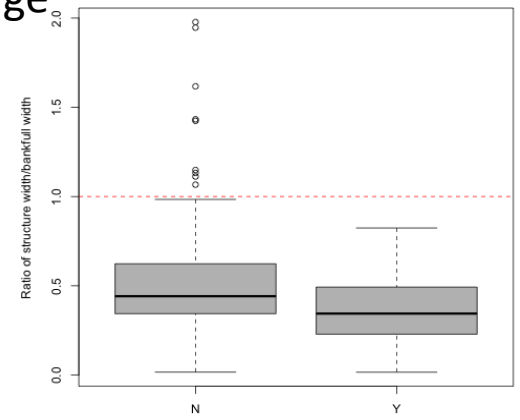
- Response to events
- Response to risk
- In highly-settled regions human response may override natural dynamics
- Catalyze ‘virtuous’ vs. ‘vicious’ cycles of response and impact

Catastrophic flooding



Right-sized Road-stream crossings

Less Damage Next Time



Habitat Connectivity

Resilient Populations