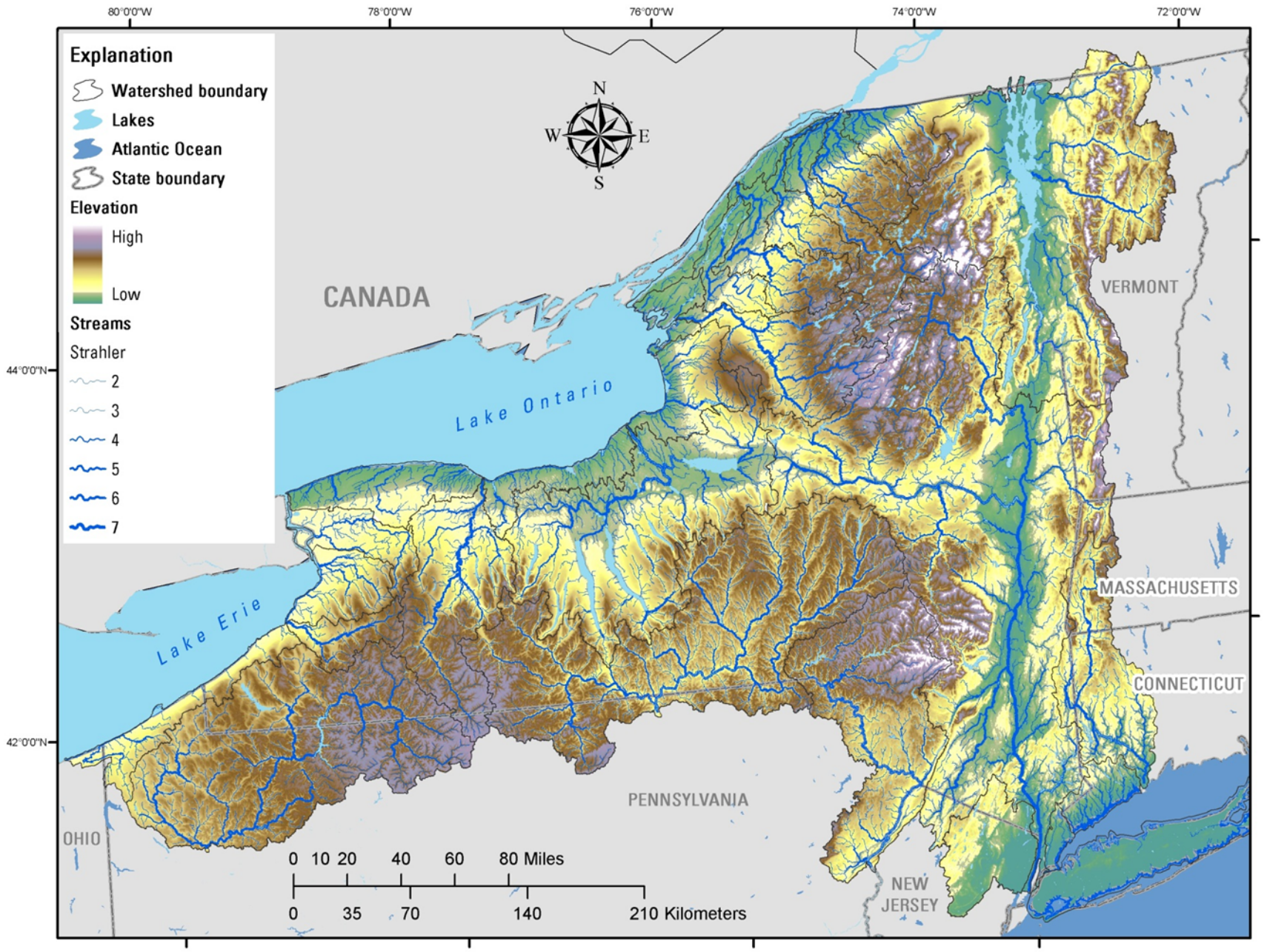
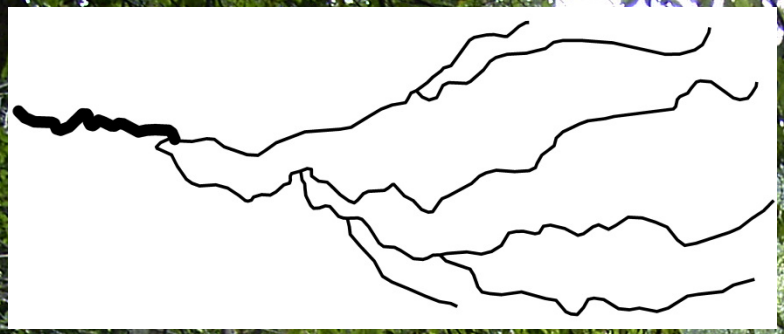
Artificial Neural Network Models of Stream Temperature and Fish in the Great Lakes

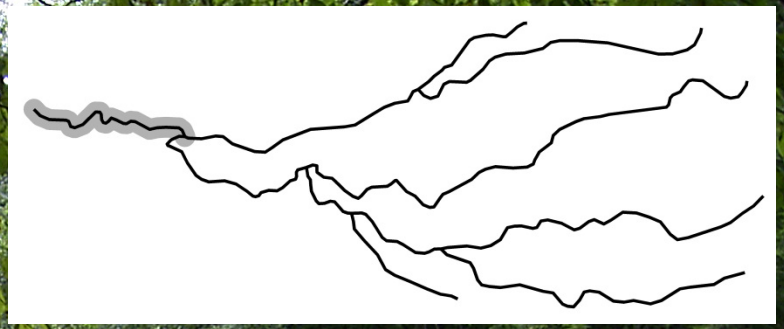
James E. McKenna, Jr. and an army of collegues, cooperators, and collaborators

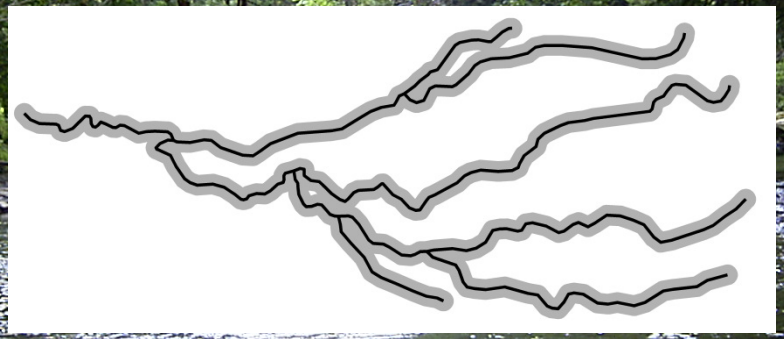
USGS
science for a changing world

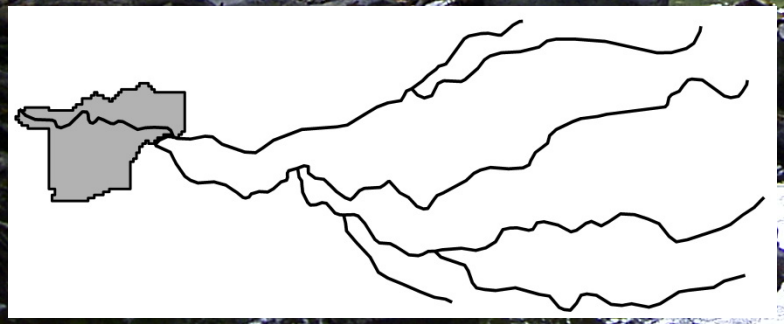
Great Lakes Regional Aquatic Analysis GAP Project

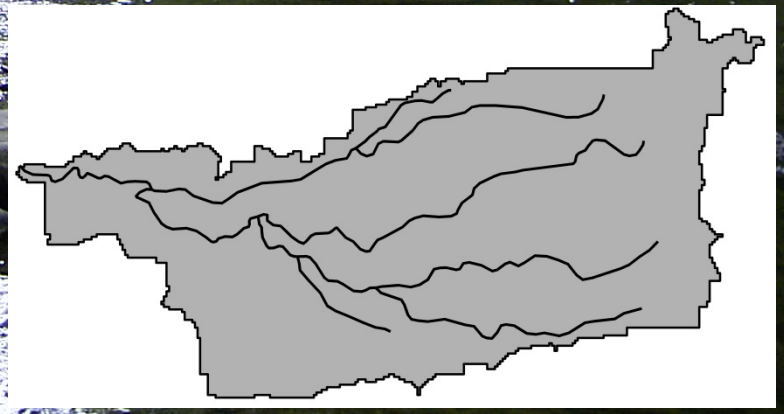

Explanation
Watershed boundary
Lakes
Atlantic Ocean
State boundary
Elevation
High
Low
Streams
Strahler
2
3
4
5
6
7
80°0'0"W
78°0'0"W
76°0'0"W
74°0'0"W
72°0'0"W
44°0'0"N
42°0'0"N
N
W
E
S
CANADA
Lake Ontario
Lake Erie
VERMONT
MASSACHUSETTS
CONNECTICUT
PENNSYLVANIA
OHIO
NEW JERSEY
0 10 20 40 60 80 Miles
0 35 70 140 210 Kilometers





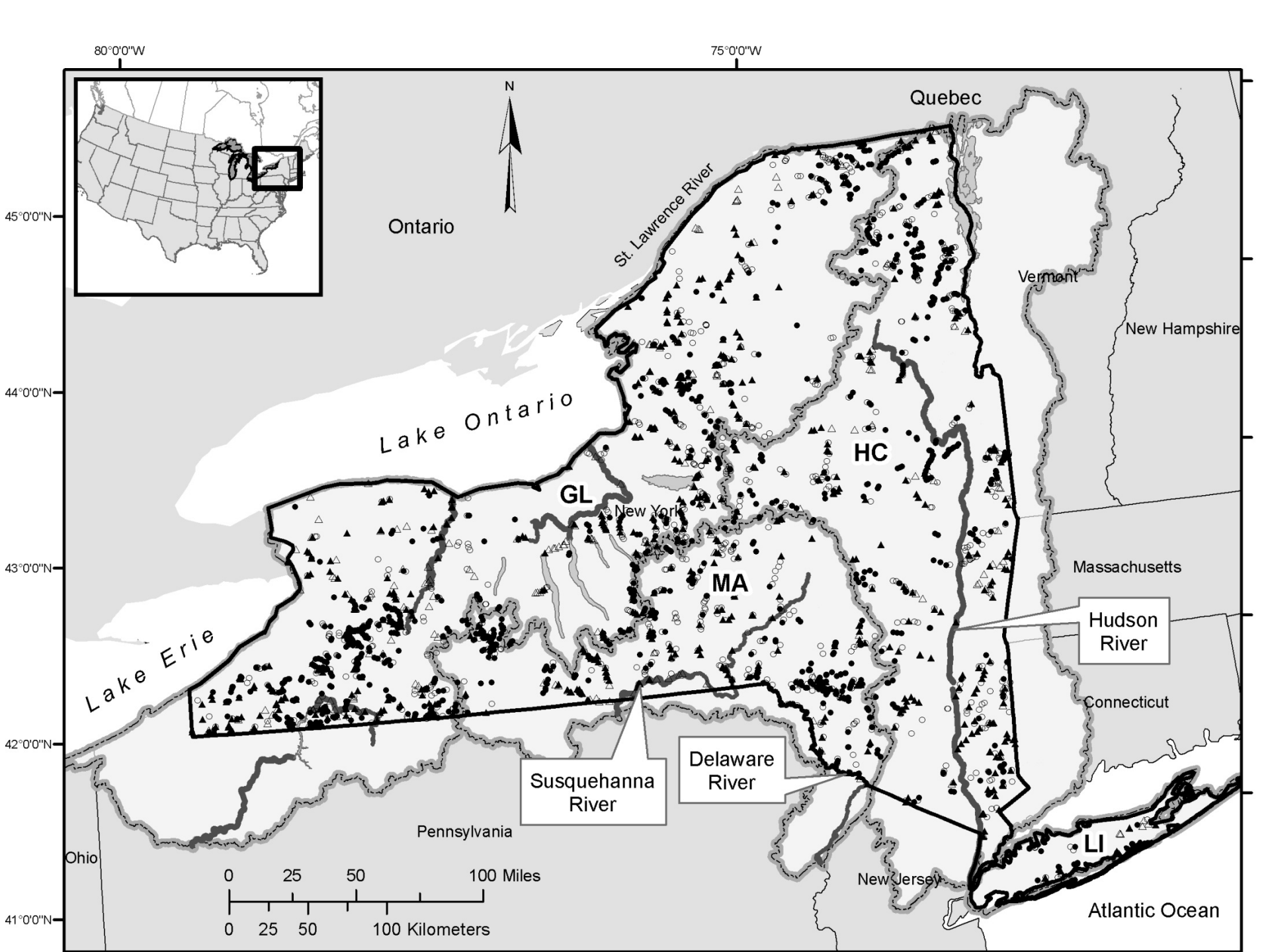


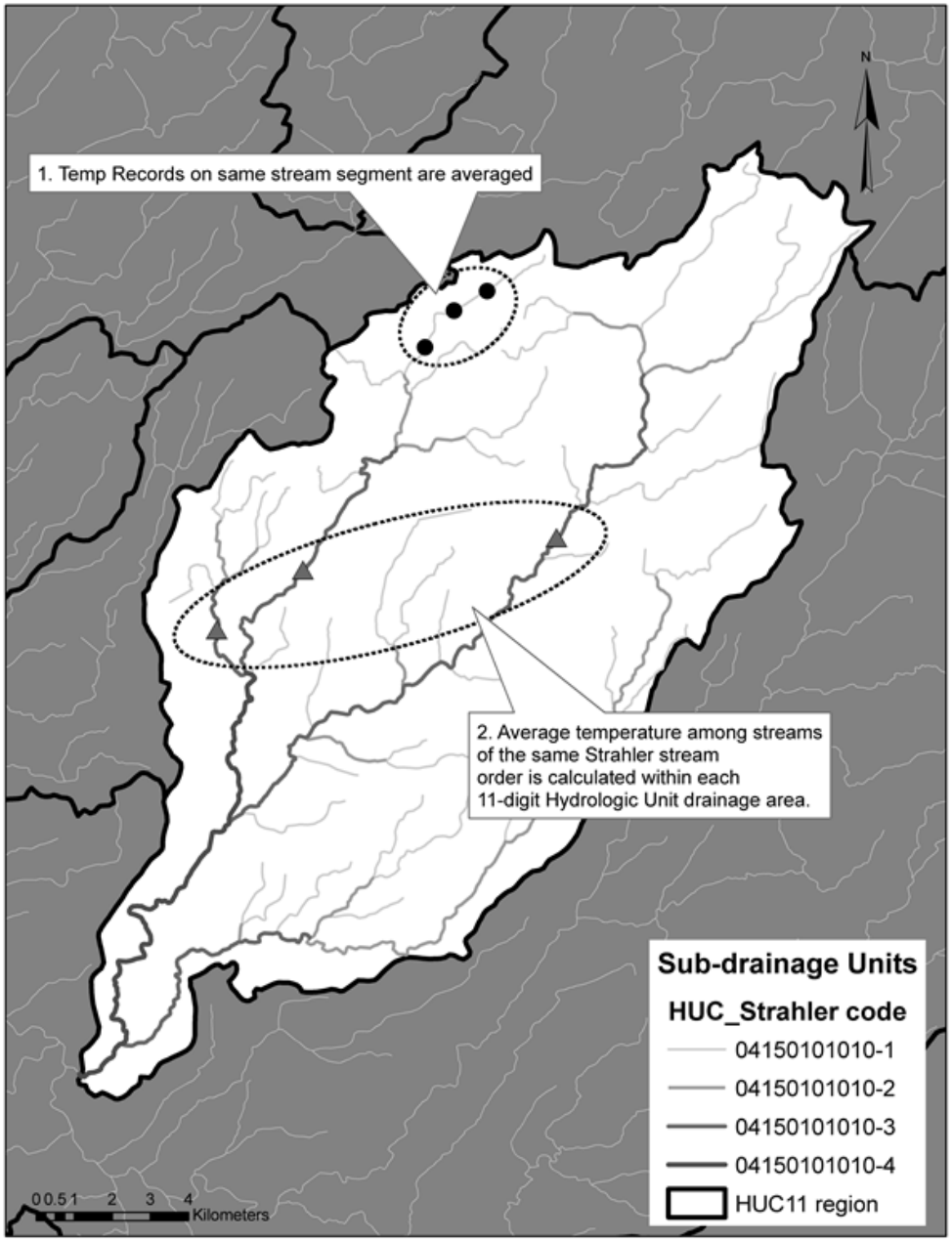




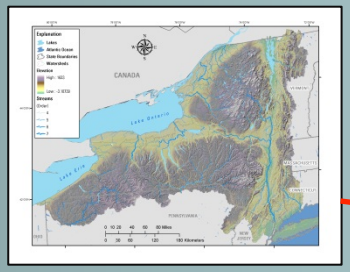
Habitat Variables Used as Model Predictors of Stream Temperature in New York

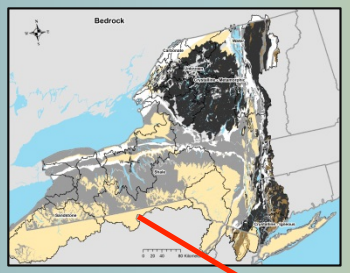
Influence Category	Landscape Variable
Groundwater holding/transporting bedrock	Sandstone or carbonate bedrock
Groundwater holding/transporting surficial geology (sand and gravel)	Sand and gravel layers
Land use influence on solar heating and evapotranspiration	Forest, agriculture, and open water coverage
Index of regional heat budget	Growing-degree Days
Stream geometry metrics	Stream size, elevation, and landscape slope

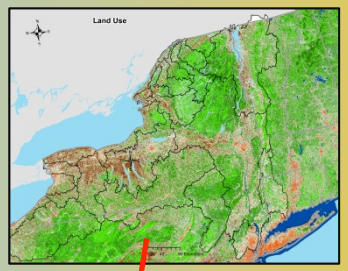

80°0'0"W
75°0'0"W
45°0'0"N
44°0'0"N
43°0'0"N
42°0'0"N
41°0'0"N
N
Quebec
Ontario
St. Lawrence River
Vermont
New Hampshire
Lake Ontario
GL
HC
New York
MA
Massachusetts
Hudson River
Lake Erie
Connecticut
Susquehanna River
Delaware River
Pennsylvania
Ohio
LI
New Jersey
Atlantic Ocean
0 25 50 100 Miles
0 25 50 100 Kilometers

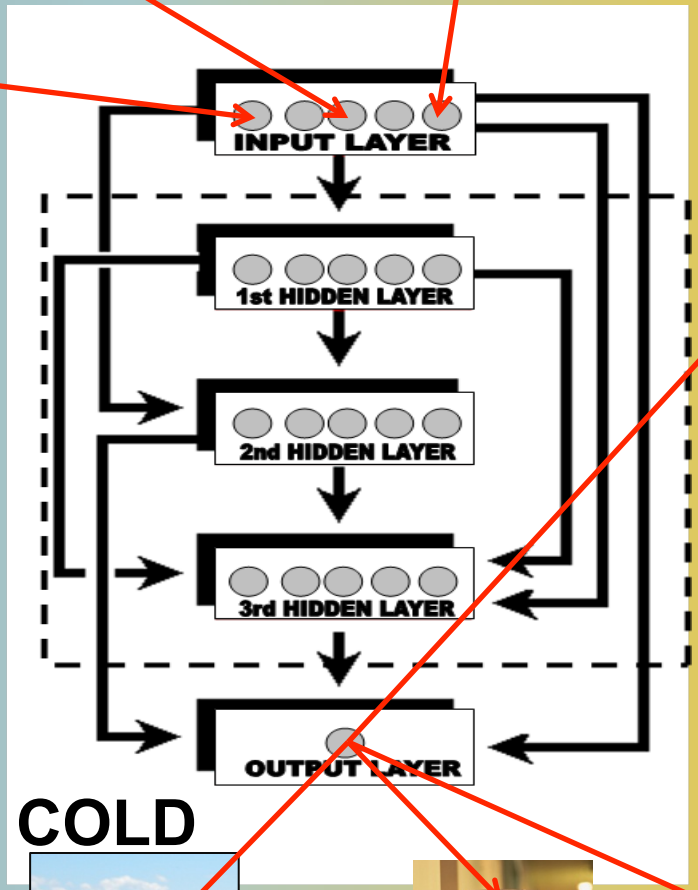

N
1. Temp Records on same stream segment are averaged
2. Average temperature among streams of the same Strahler stream order is calculated within each 11-digit Hydrologic Unit drainage area.
Sub-drainage Units
HUC_Strahler code
04150101010-1
04150101010-2
04150101010-3
04150101010-4
HUC11 region
0 0.5 1 2 3 4
Kilometers

Predicting Water Temperature









Water Temperature Classes

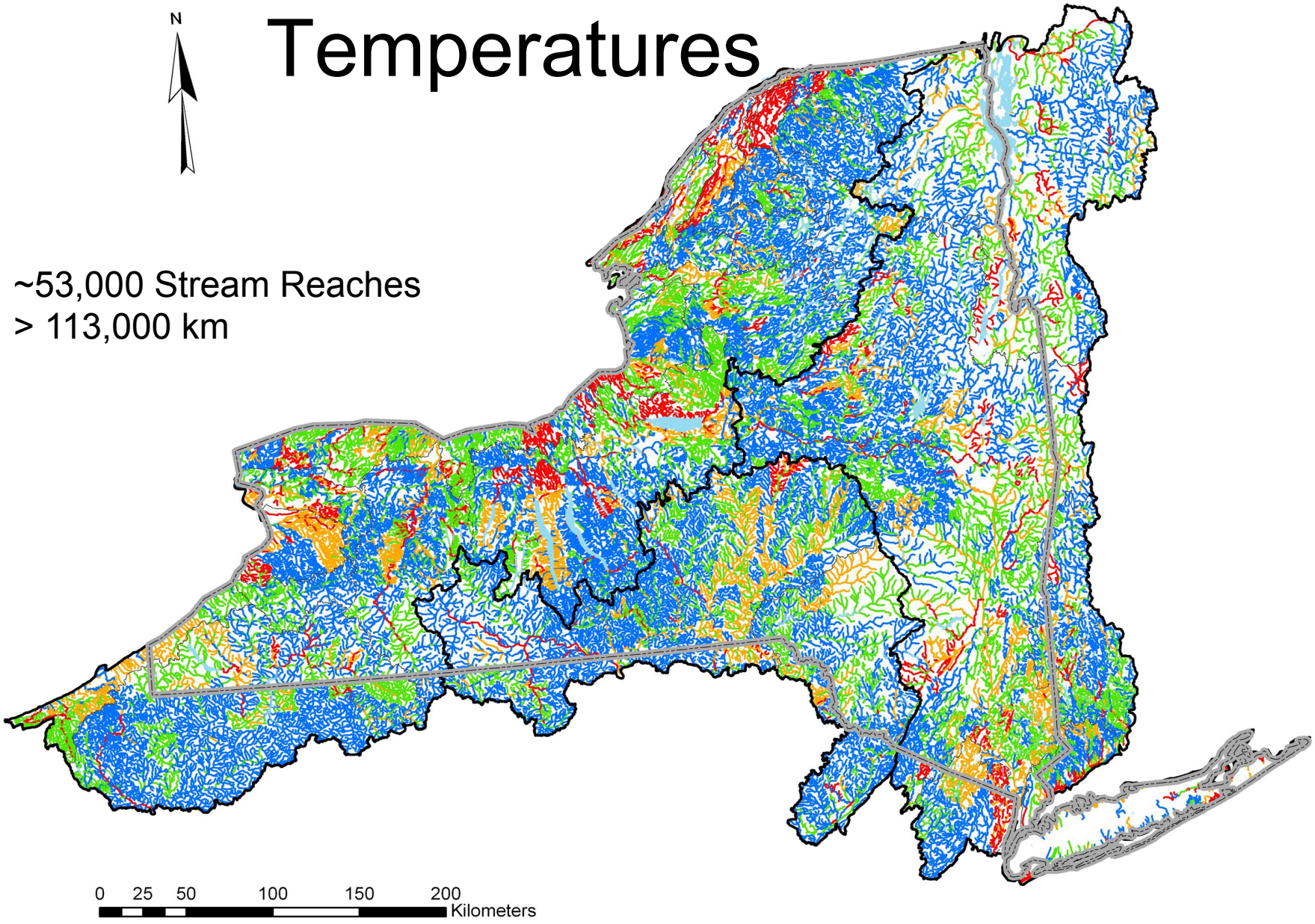
Cold	Cool-Transition	Warm-Transition	Warm
<18°	18 - 20° C	21 - 23° C	>24° C

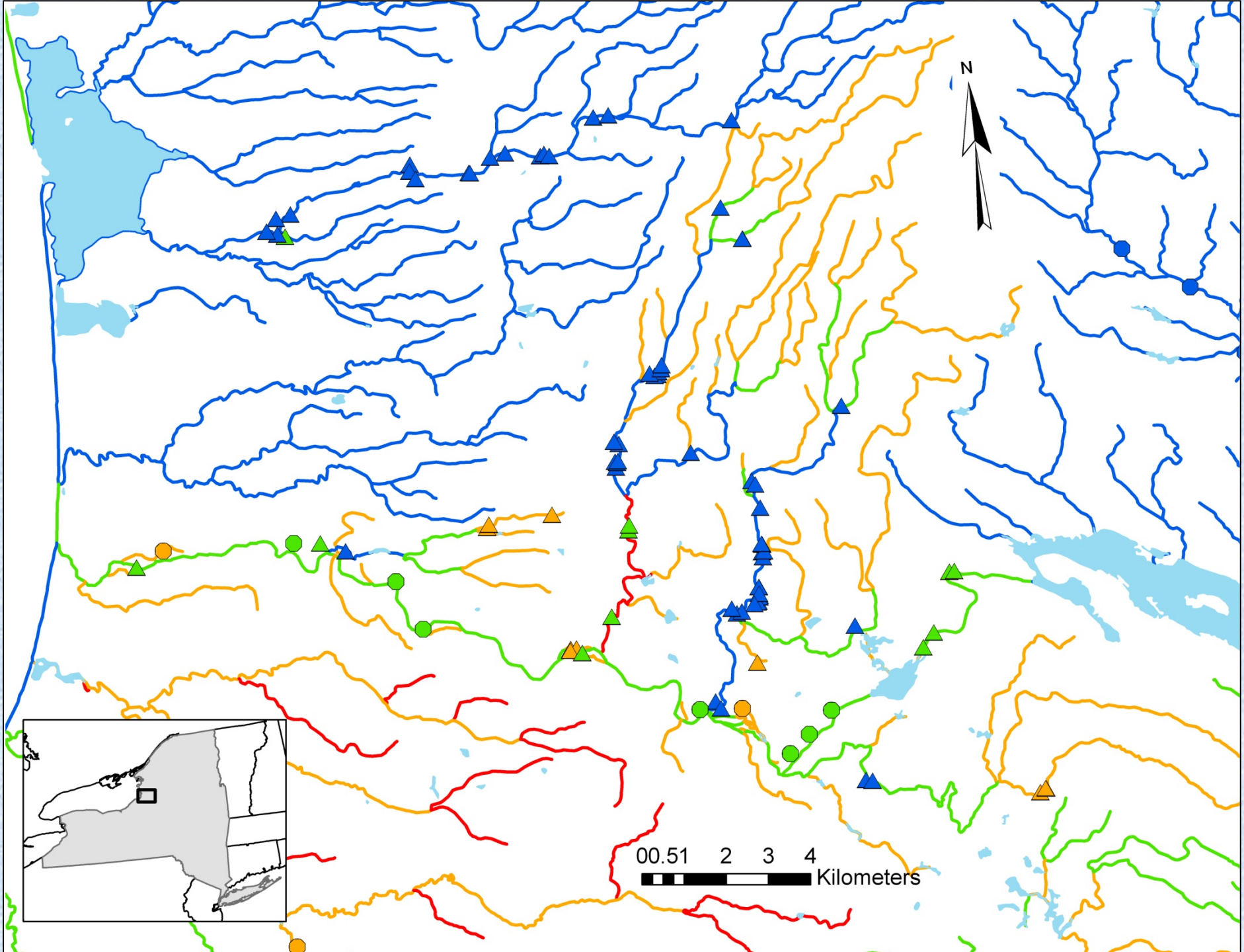
COLD

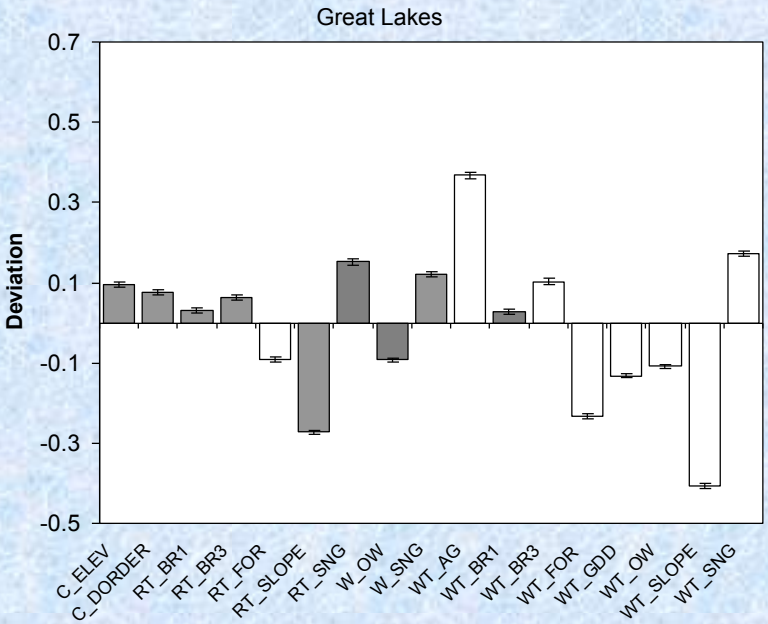
COOL

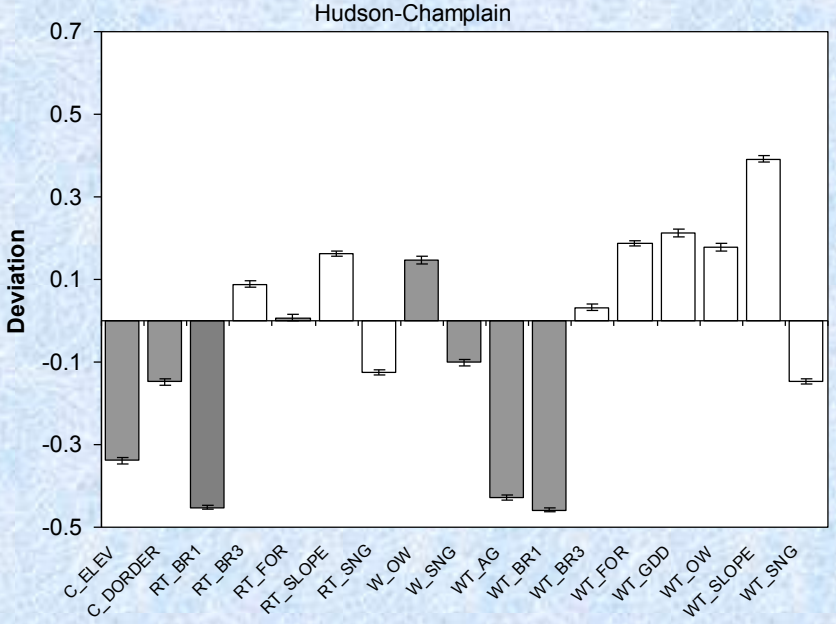
WARM

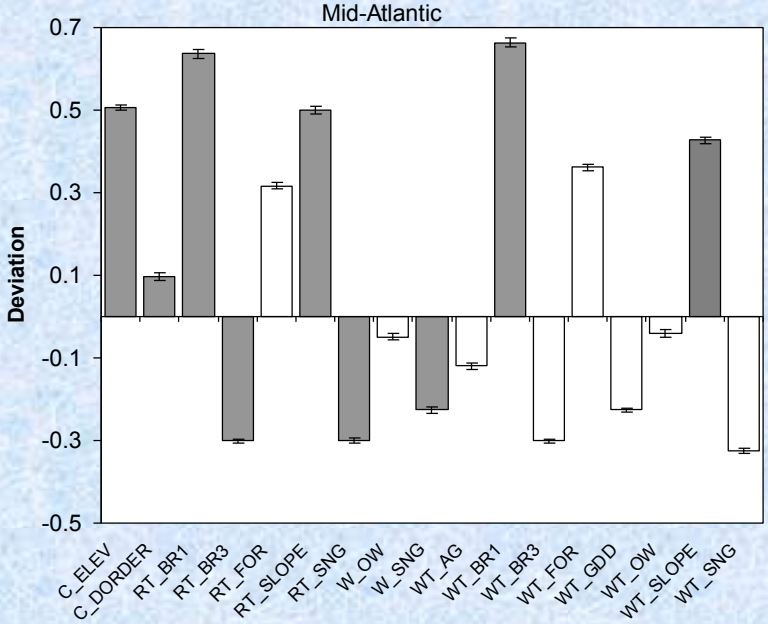
Model-predicted Stream Temperatures

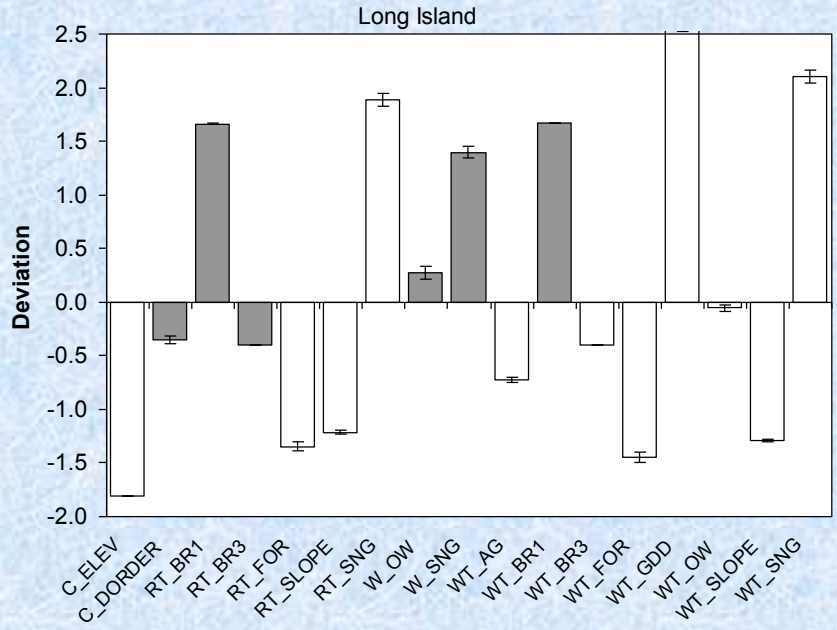



N
00.51 2 3 4
Kilometers

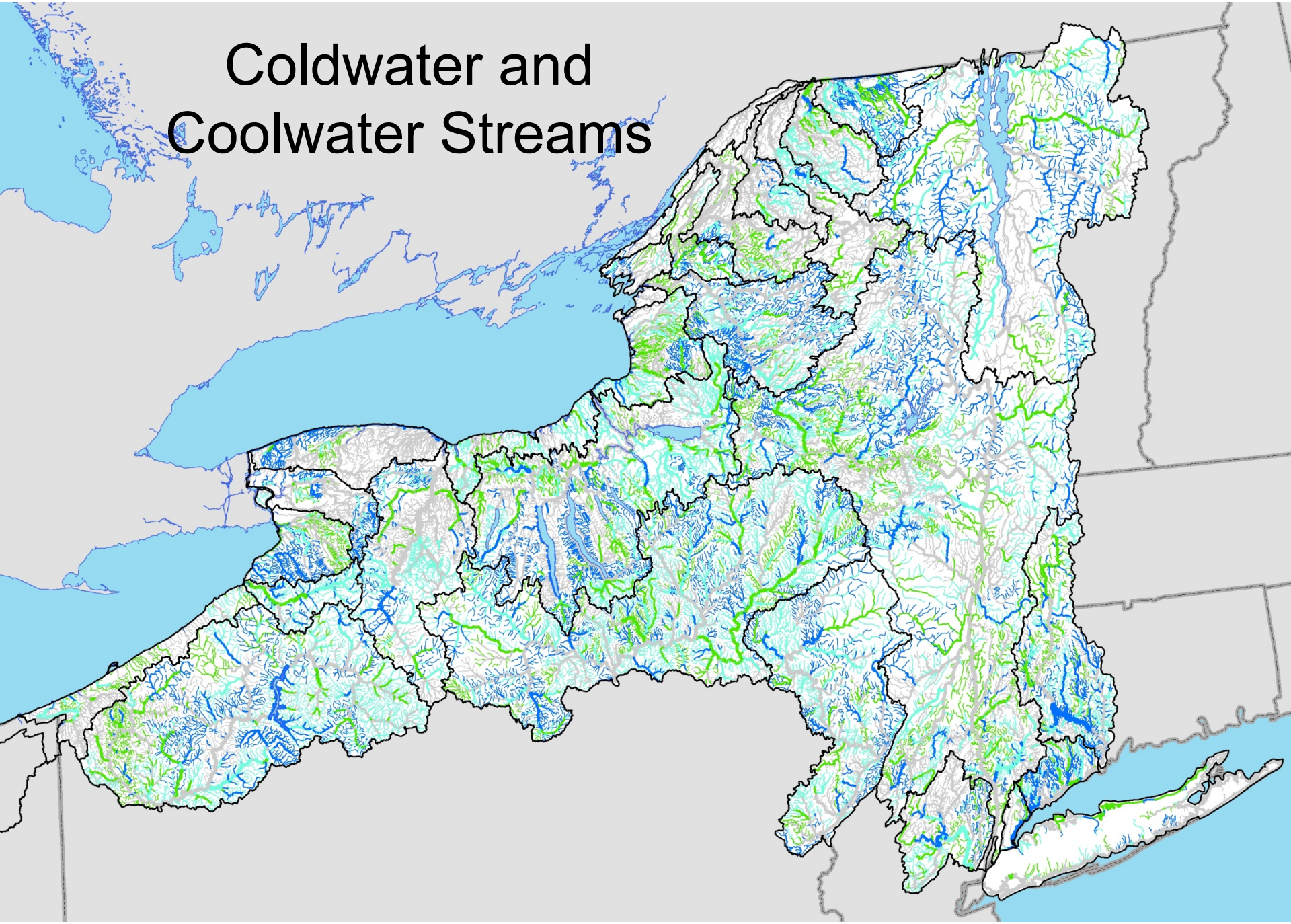

Great Lakes
Deviation
0.7
0.5
0.3
0.1
-0.1
-0.3
-0.5
C_ELEV
C_DORDER
RT_BR1
RT_BR3
RT_FOR
RT_SLOPE
RT_SNG
W_OW
W_SNG
WT_AG
WT_BR1
WT_BR3
WT_FOR
WT_GDD
WT_OW
WT_SLOPE
WT_SNG

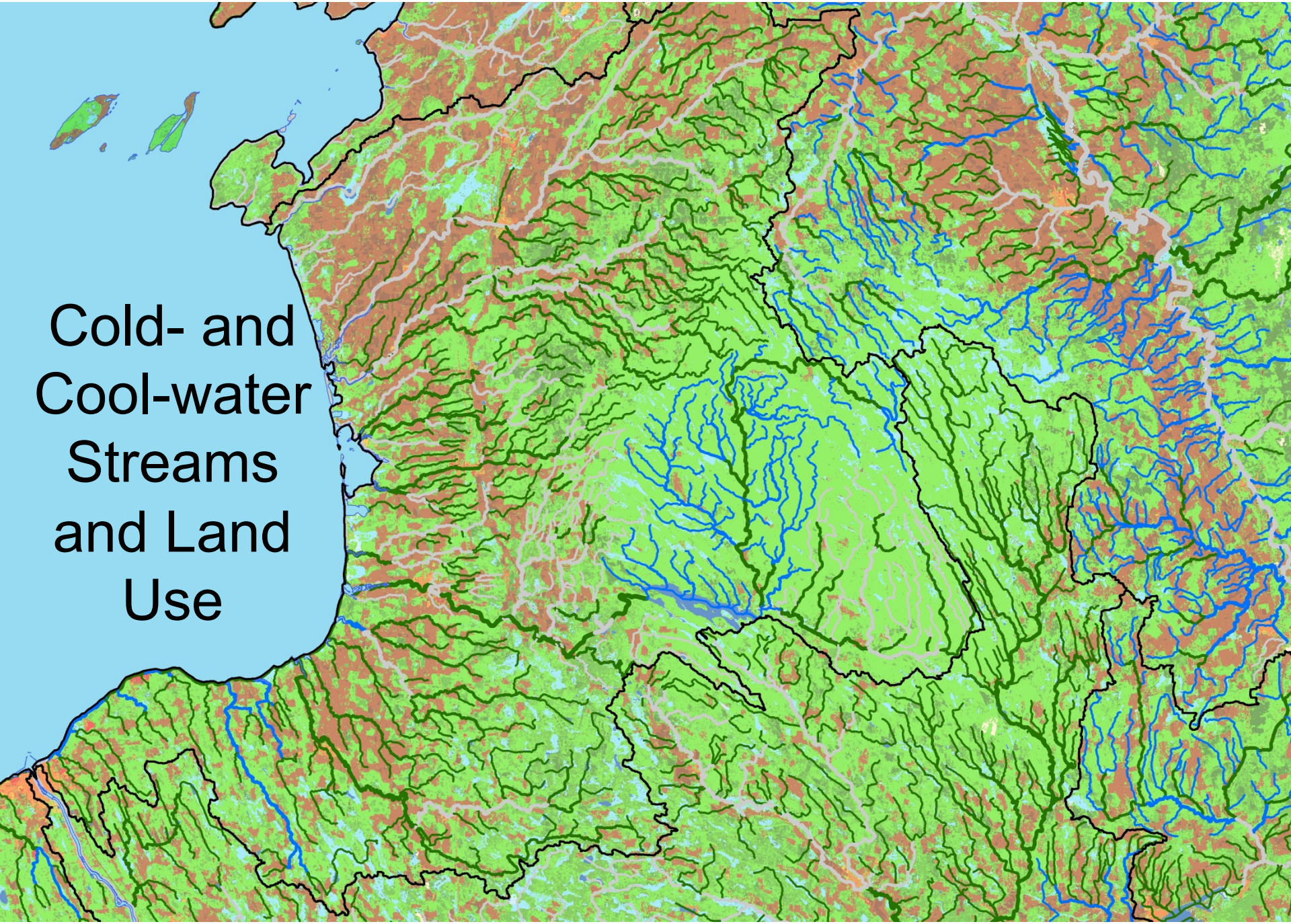

Hudson-Champlain
Deviation
0.7
0.5
0.3
0.1
-0.1
-0.3
-0.5
C_ELEV
C_DORDER
RT_BR1
RT_BR3
RT_FOR
RT_SLOPE
RT_SNG
W_OW
W_SNG
WT_AG
WT_BR1
WT_BR3
WT_FOR
WT_GDD
WT_OW
WT_SLOPE
WT_SNG

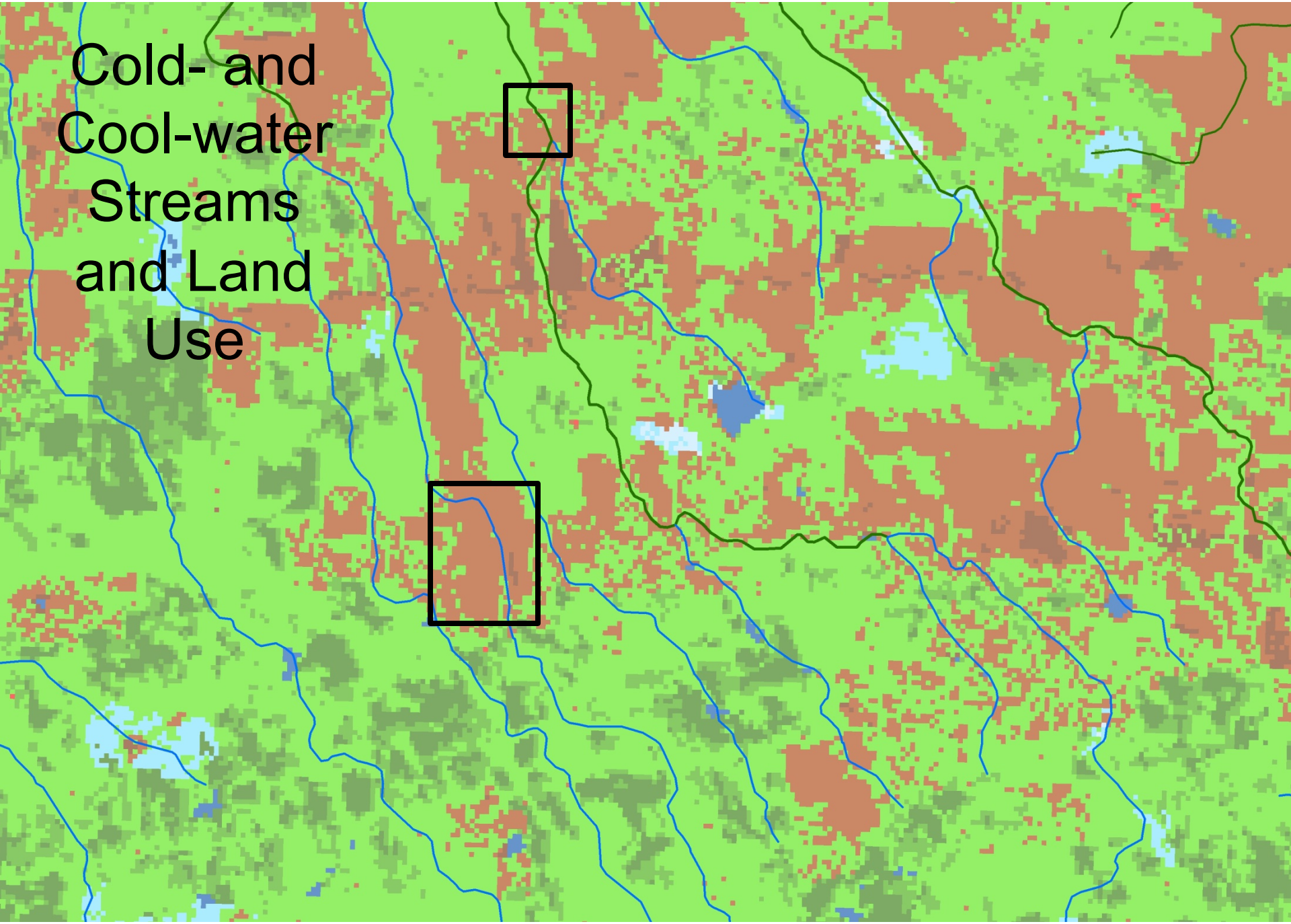

Mid-Atlantic
Deviation
0.7
0.5
0.3
0.1
-0.1
-0.3
-0.5
C_ELEV
C_DORDER
RT_BR1
RT_BR3
RT_FOR
RT_SLOPE
RT_SNG
W_OW
W_SNG
WT_AG
WT_BR1
WT_BR3
WT_FOR
WT_GDD
WT_OW
WT_SLOPE
WT_SNG


Long Island
Deviation
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
C_ELEV
C_DORDER
RT_BR1
RT_BR3
RT_FOR
RT_SLOPE
RT_SNG
W_OW
W_SNG
WT_AG
WT_BR1
WT_BR3
WT_FOR
WT_GDD
WT_OW
WT_SLOPE
WT_SNG

Coldwater and Coolwater Streams




Cold- and
Cool-water
Streams
and Land
Use


Cold- and
Cool-water
Streams
and Land
Use

New York State Fish Sampling Locations

Explanation

NY Fish Sampling Sites

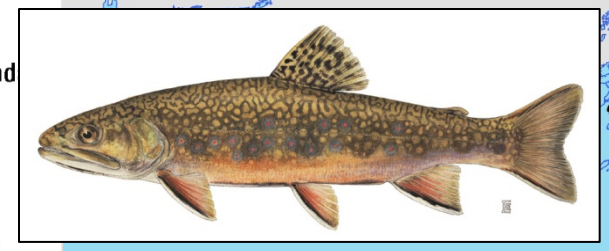
Brook Trout

- 0
- 1
- 2-10
- 11-100
- >100

DEC Regions

0 25 50 100 Kilometers

Streams Predicted to Support Brook Trout



Explanation

- Watershed bound
- Lakes
- Atlantic Ocean
- State boundary

Predicted abundance

- 0
- 1
- 2 - 10
- 11 - 100
- > 100
- No prediction

Thermal-Gamefish Habitats

St. Lawrence River Area Gamefish Predictions

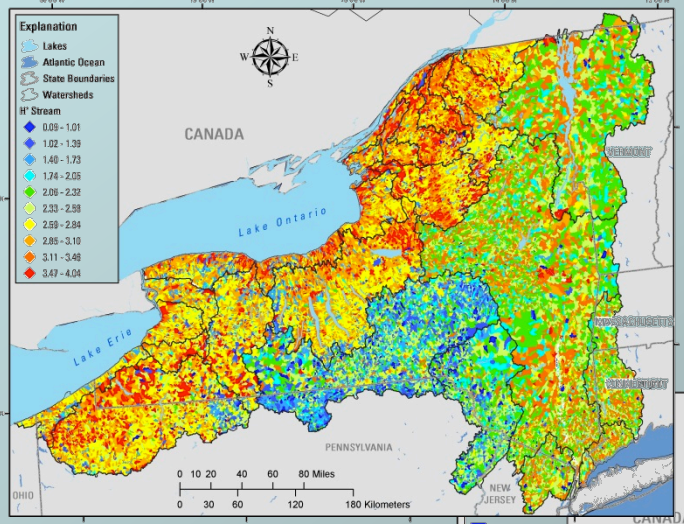
St. Lawrence River

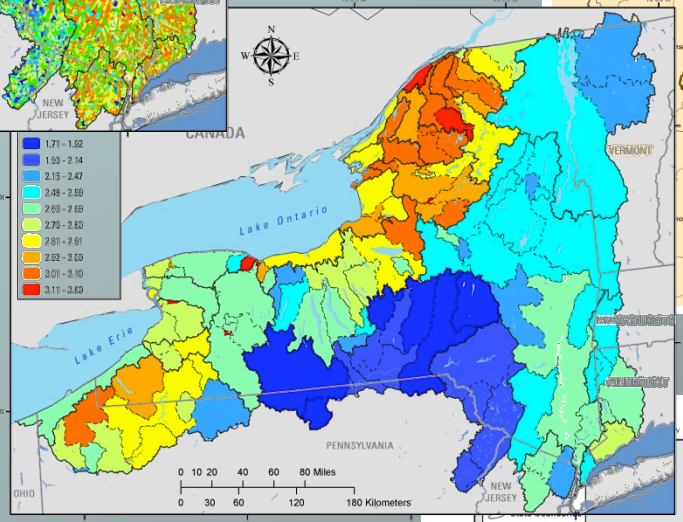
Explanation

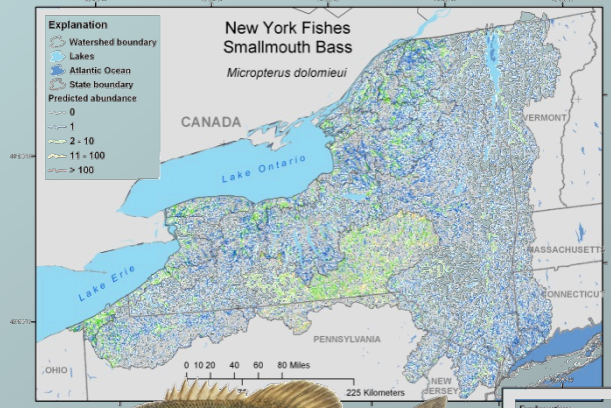
- Watersheds
- Coldwater Gamefish
- Coolwater Gamefish
- Warmwater Gamefish

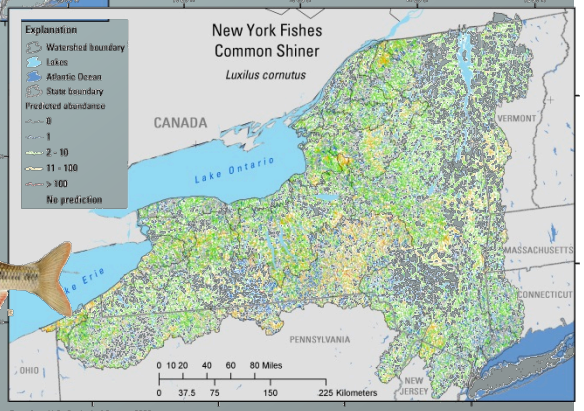
0 10 20 40 Kilometers

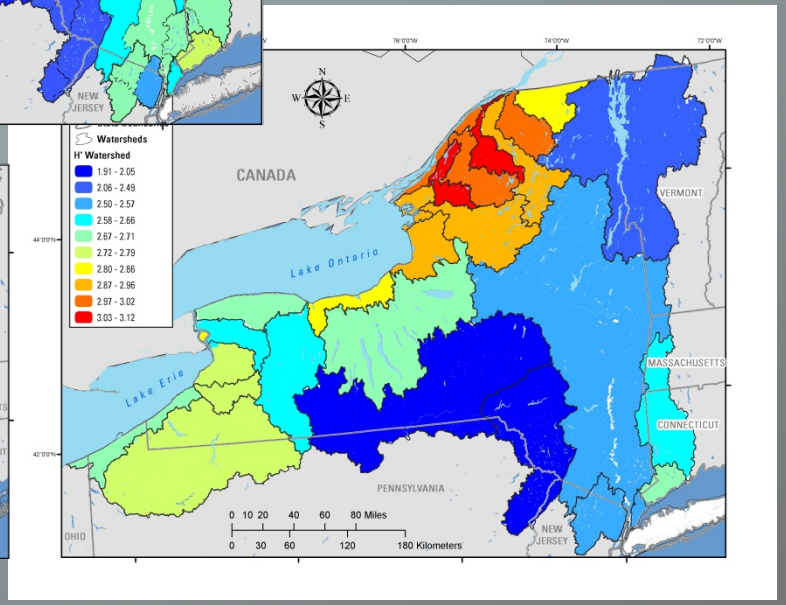
Model Predicted Minimum Fish Diversity & Species Maps



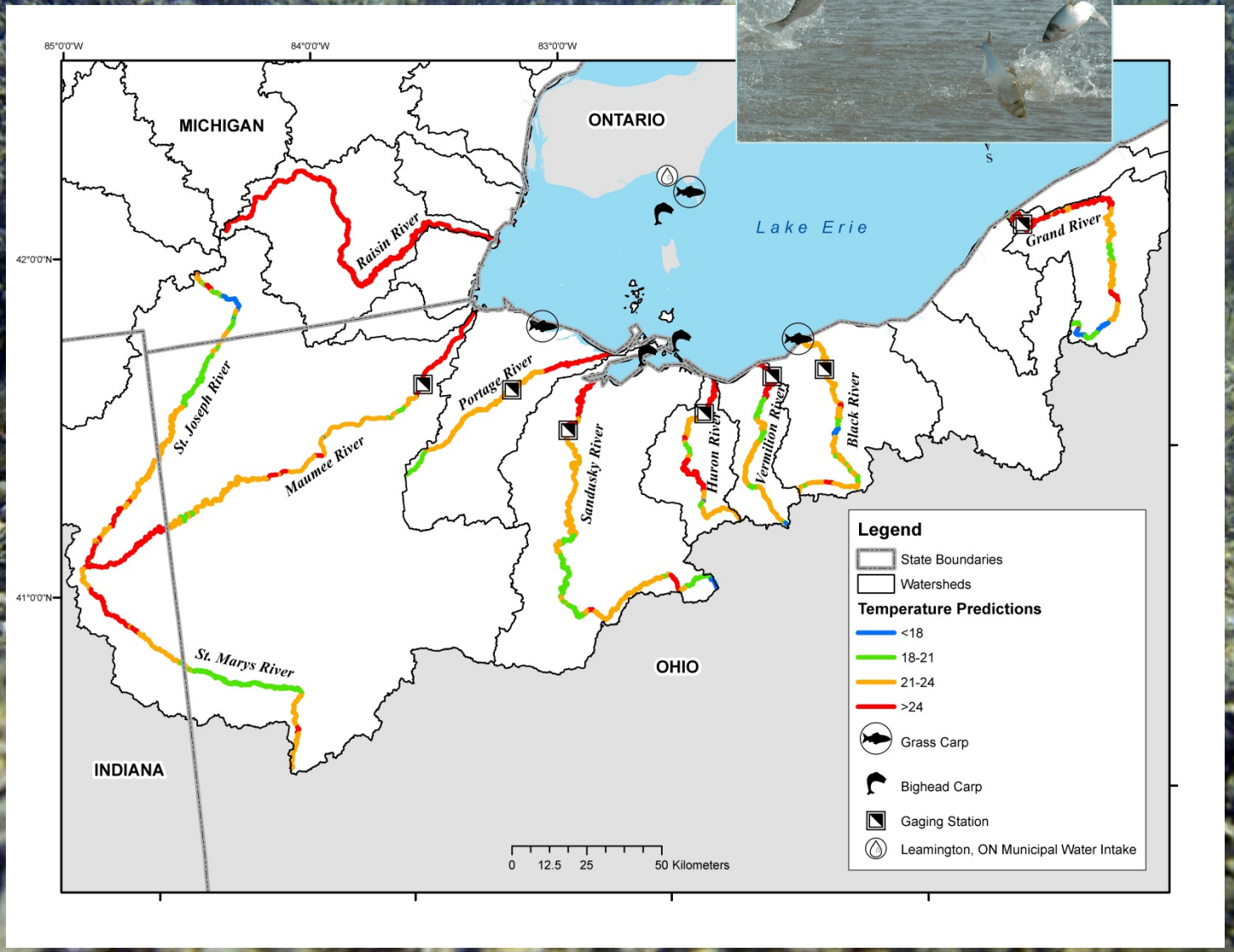


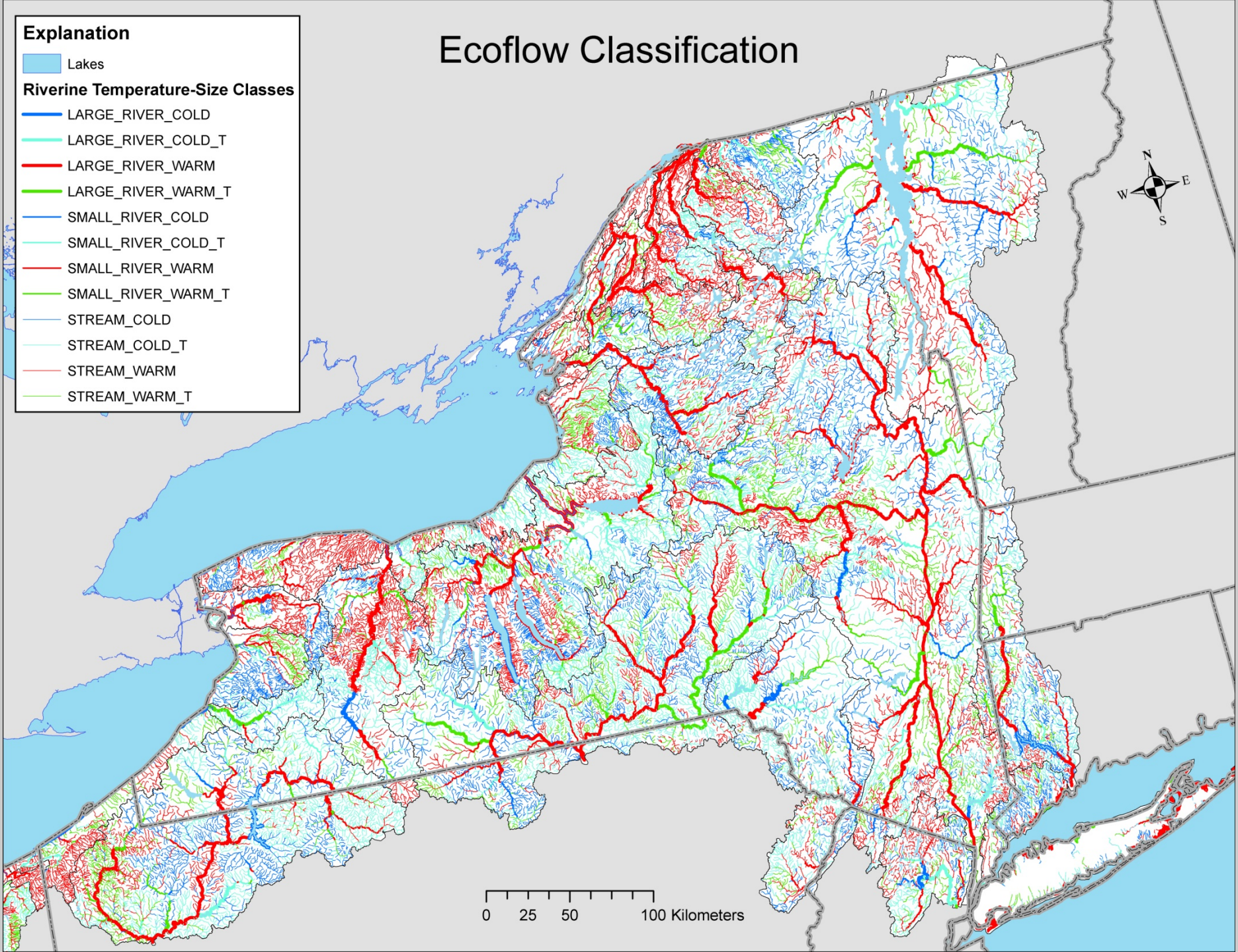




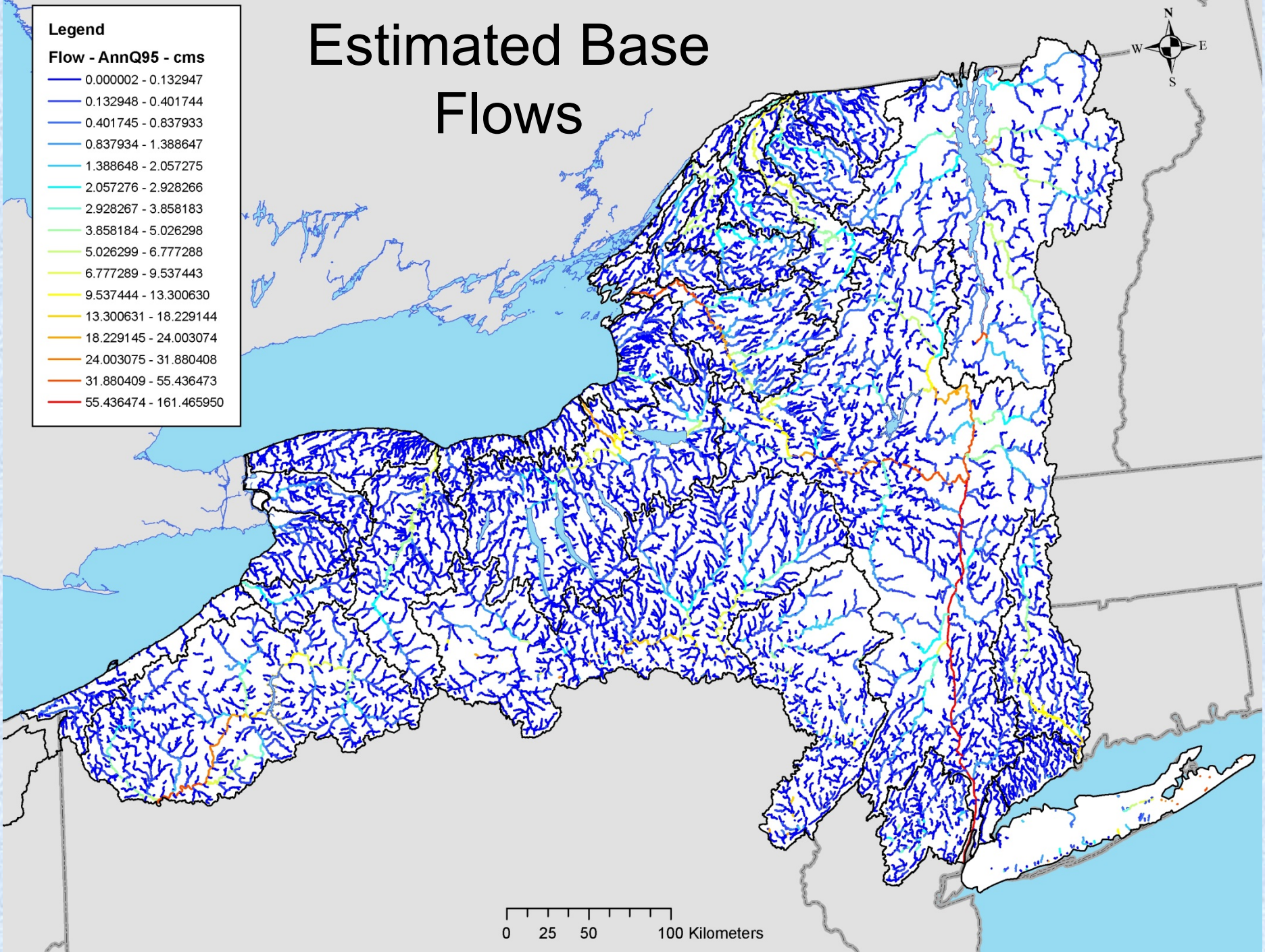


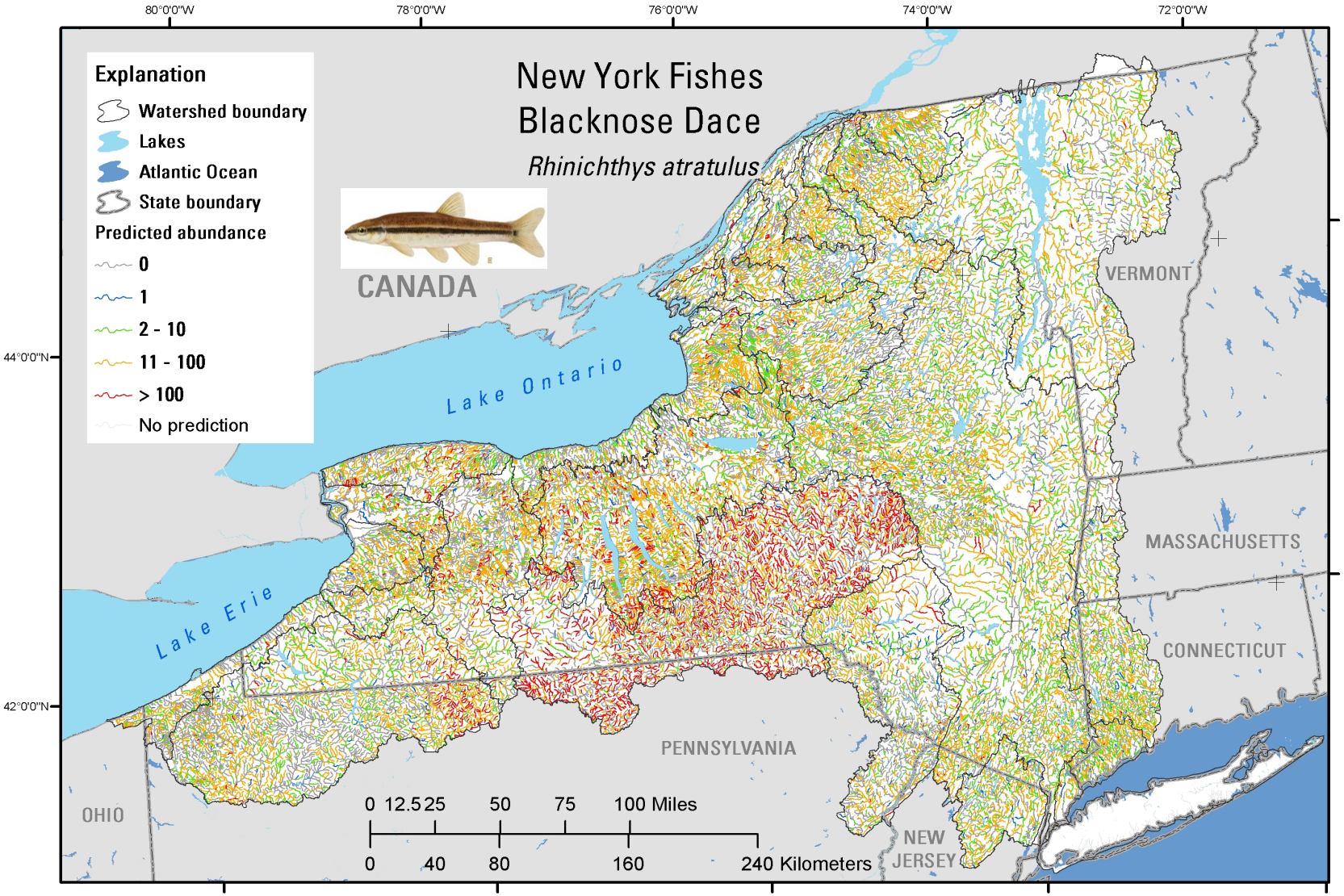
Invasive Species




Ecoflow Classification
Explanation
Lakes
Riverine Temperature-Size Classes
LARGE_RIVER_COLD
LARGE_RIVER_COLD_T
LARGE_RIVER_WARM
LARGE_RIVER_WARM_T
SMALL_RIVER_COLD
SMALL_RIVER_COLD_T
SMALL_RIVER_WARM
SMALL_RIVER_WARM_T
STREAM_COLD
STREAM_COLD_T
STREAM_WARM
STREAM_WARM_T
N
W
E
S
0
25
50
100 Kilometers

Estimated Base Flows





Base from U.S. Geological Survey, 2002
National Hydrography Data, 1:100,000

Blacknose Dace

Rhinichthys atratulus

92°0'0"W 84°0'0"W 76°0'0"W

50°0'0"N 45°0'0"N 40°0'0"N

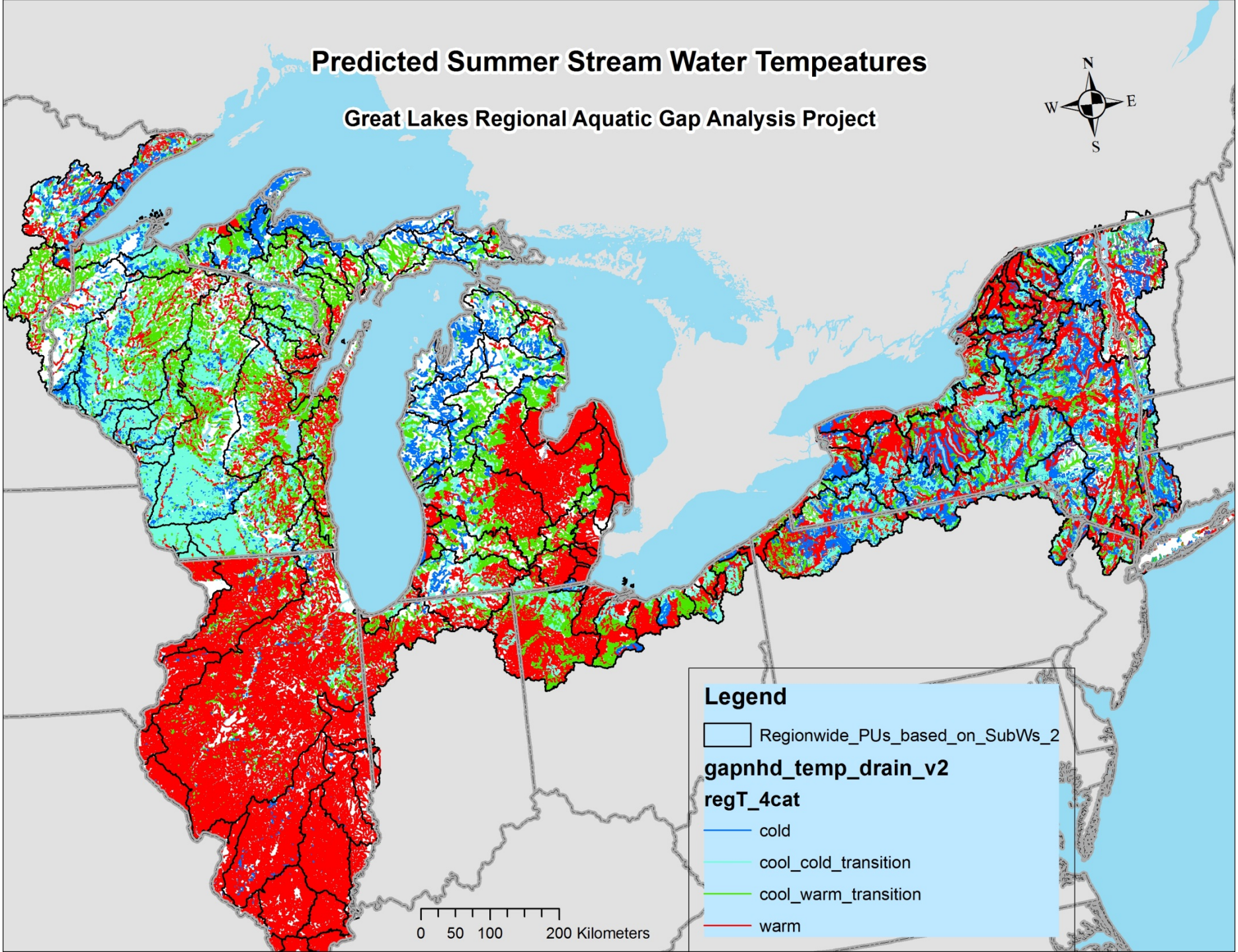
Explanation

- Lakes
- State boundary
- Great Lakes Basin

Predicted abundance

- 0
- 1-10
- >10
- Not modeled

0 100 200 400 Kilometers

Predicted Summer Stream Water Tempeatures

Great Lakes Regional Aquatic Gap Analysis Project