Impacts of Climate Change to Eastern Brook Trout and their habitat in the Mid-Atlantic

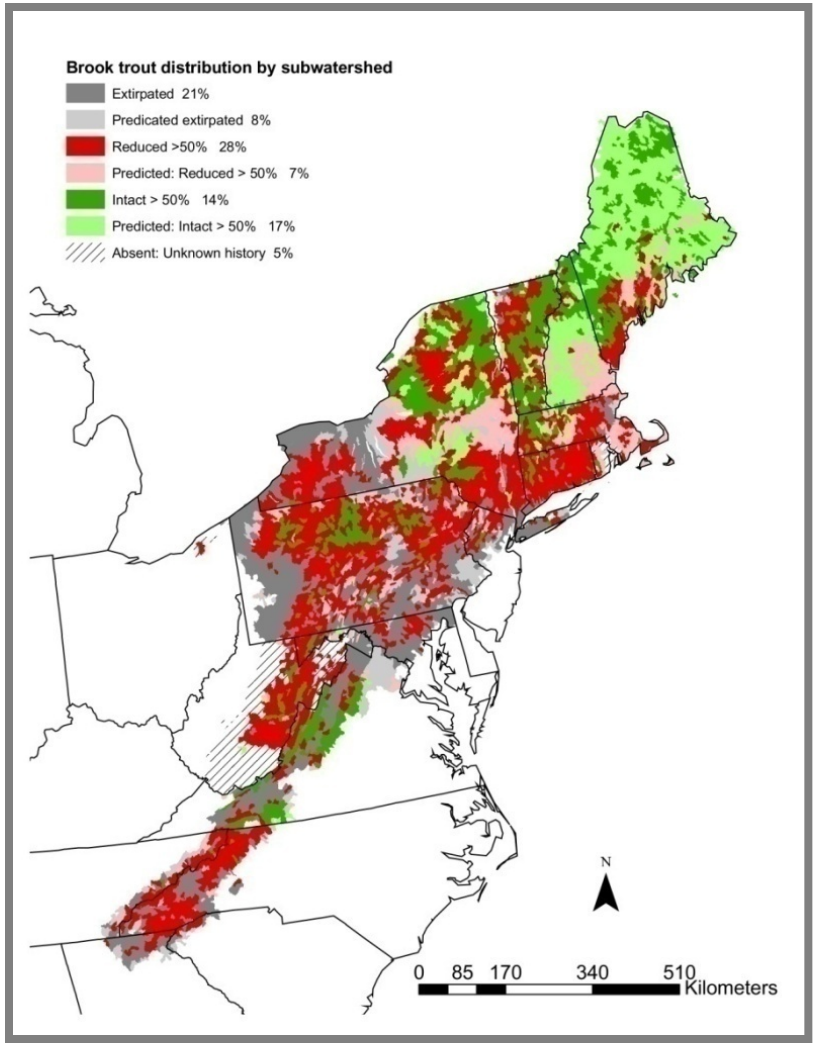
Brad Trumbo
Mark Hudy

USDA Forest Service Fish and Aquatic Ecology Unit

Adapting to Climate Change in the Mid-Atlantic – March 24 2010

EBTJV Perspective

Eastern Brook Trout
JOINT VENTURE



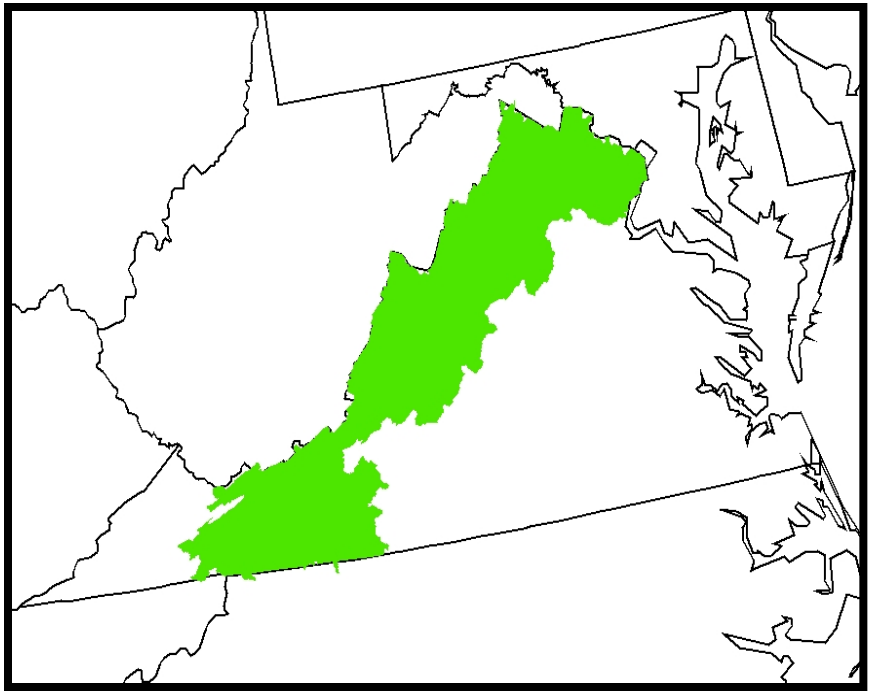
Goals

- Rank individual brook trout habitats for their resiliency to climate change **using a direct measurement approach. Focus on predicted water temperature.**

- Use resiliency rankings for future management, protection, and restoration efforts of brook trout habitat.

Brook Trout Range

- Historically, Virginia brook trout habitat covered nearly the entire western portion of the state.



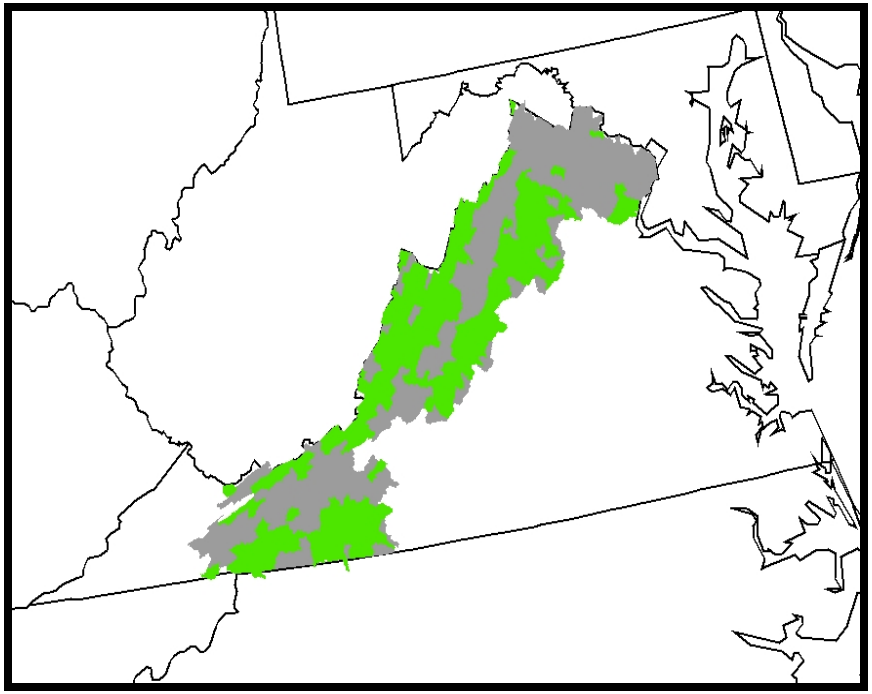
Brook Trout Habitat

Extirpated

Intact

Brook Trout Range

- Presently, Virginia brook trout habitat is **reduced to relatively half** of the historic range

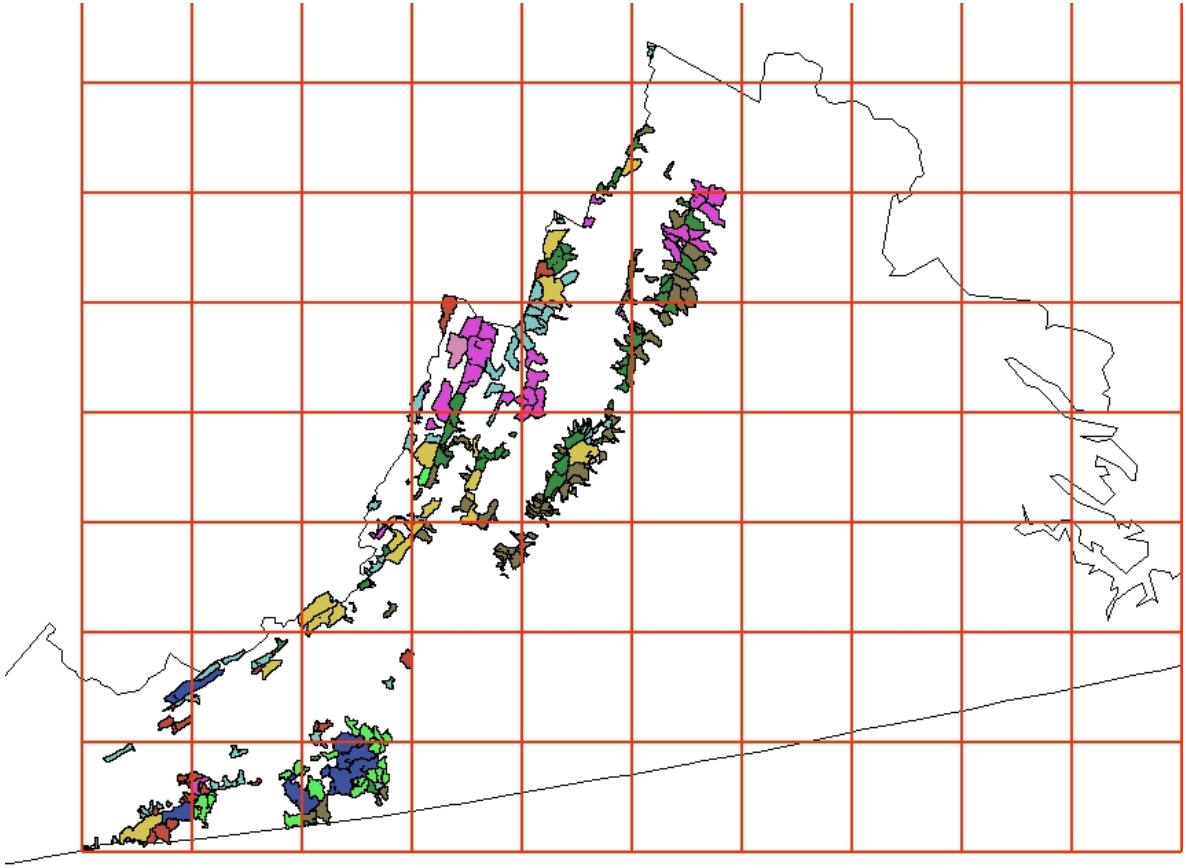


Brook Trout Habitat

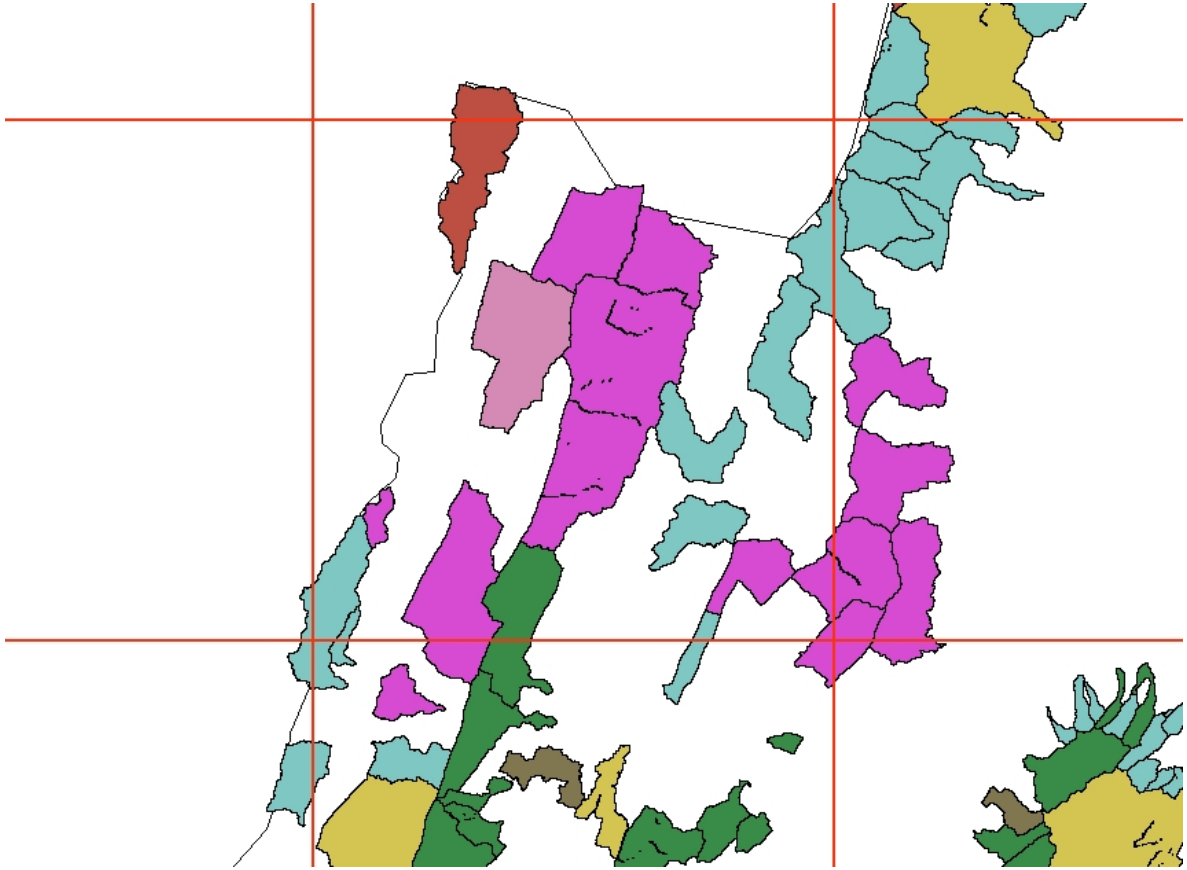
Extirpated

Intact

50 square km



50 square km



Under various climate change scenarios, brook trout are <u>predicted to be extirpated</u> from the state

- Flebbe et al. 2006. **Spatial Modeling to Project Southern Appalachian Trout Distribution in a Warmer Climate.** TAFS

- Clark et al. 2001. **Predicting Climate Change Effects on Appalachian Trout: Combining GIS and Individual –Based Modeling.** Ecological Applications.

- Meisner. 1990. **Effect of Climatic Warming on the southern margins of the Native Brook Trout .** CJAS

Brook Trout Habitat

Extirpated

Intact

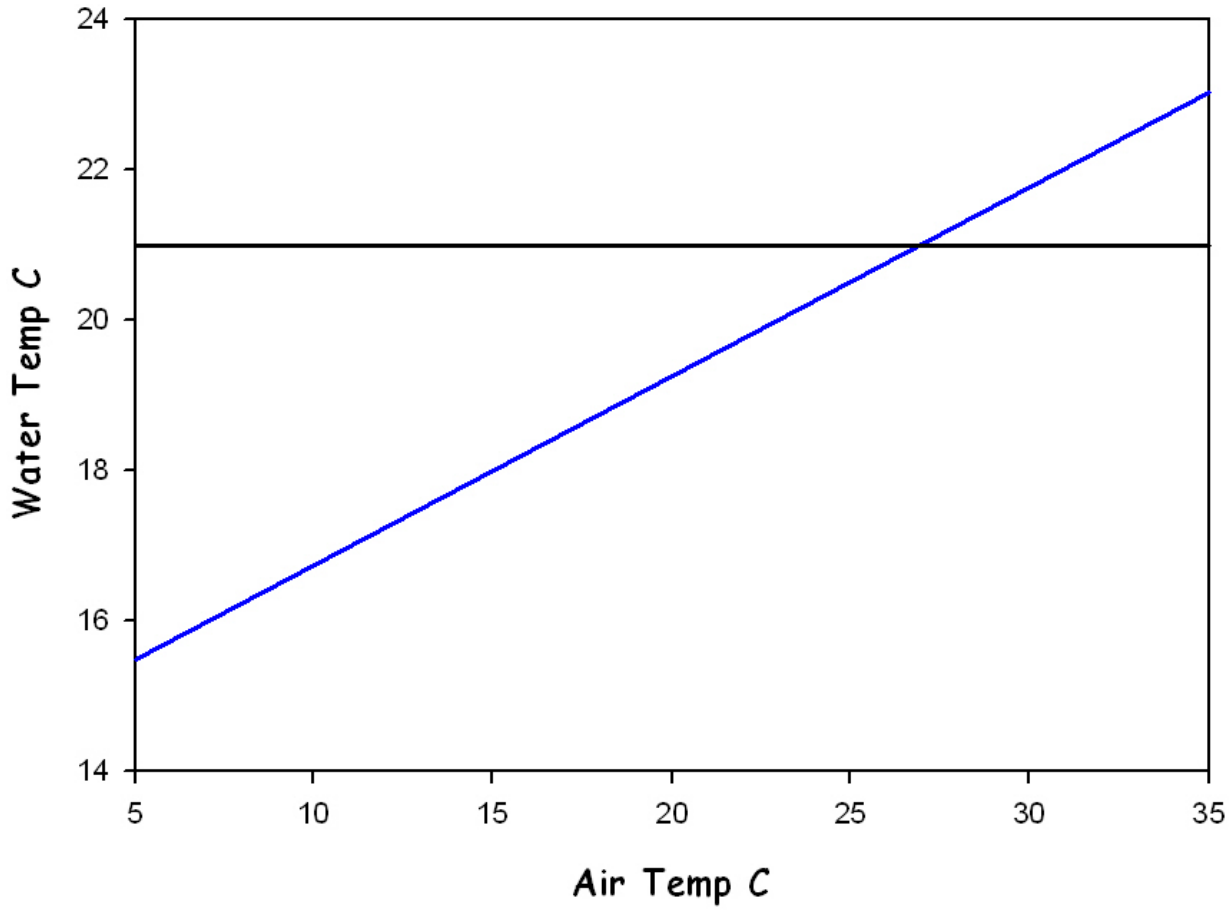
Regional Models

- Assume the air/water temperature relationship is **homogenous** among brook trout habitats at a given elevation and latitude.

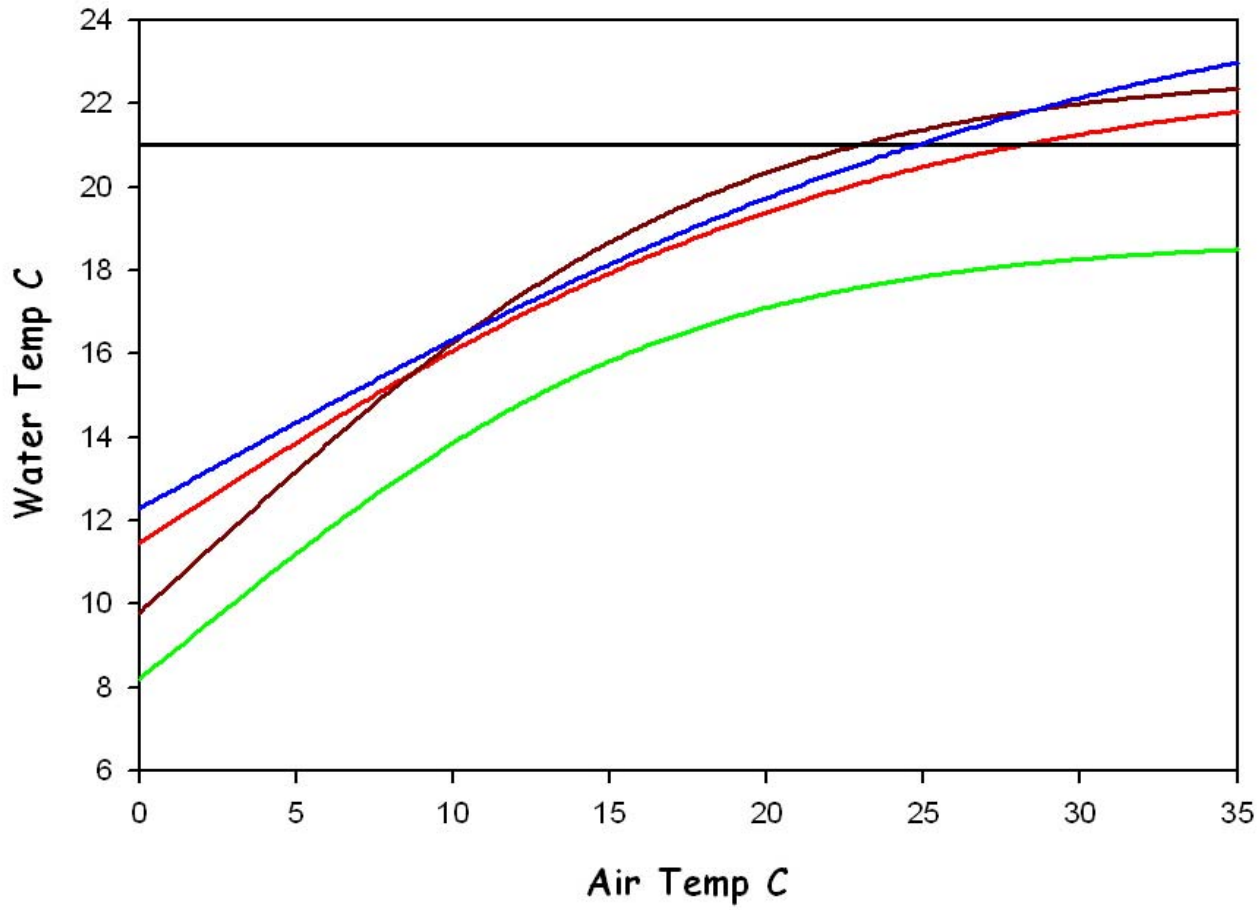
- Assume a **steady relationship** between air and water temperatures **(i.e. 1°C air temp rise = 0.8°C water temp rise)**

- Focus on **elevation** and **latitude** as driving metrics in temperature relationships

Steady Temperature Relationship Under Regional Model



Variable Temperature Relationships Under Small Scale Model

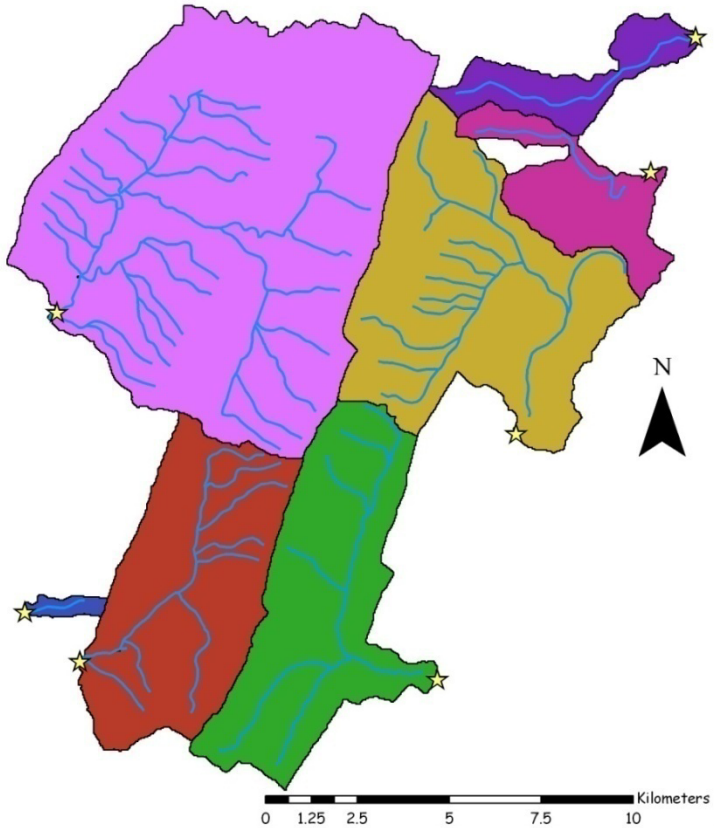


Our interests are in the residuals of the errors in the large scale models. Are small scale refugia possible ?

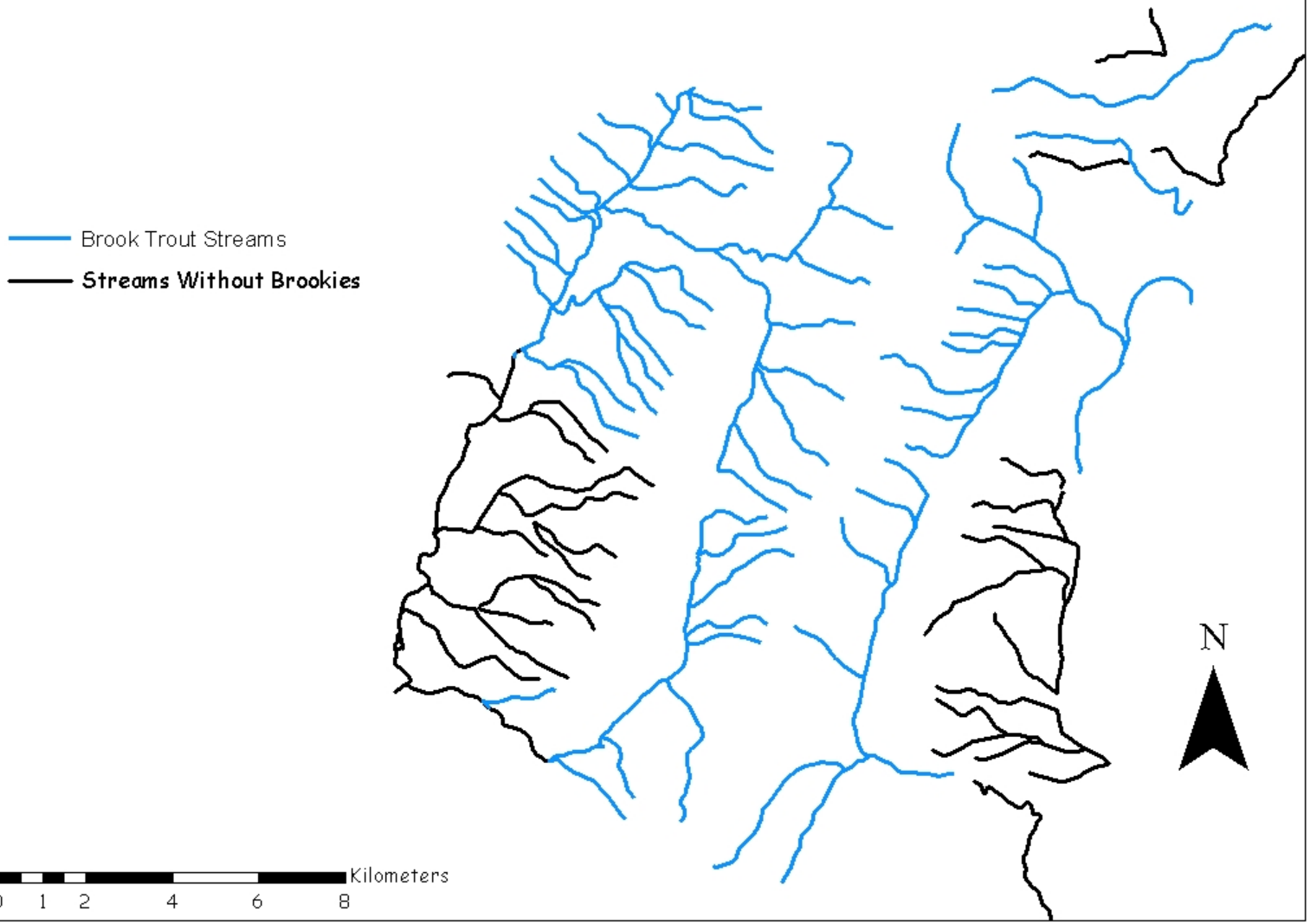
- Small Area Influences
  - Land use
  - Riparian vegetation
  - Springs
  - Aspect
  - Elevation
  - Latitude
  - Solar input

Our Approach: Brook Trout Patches

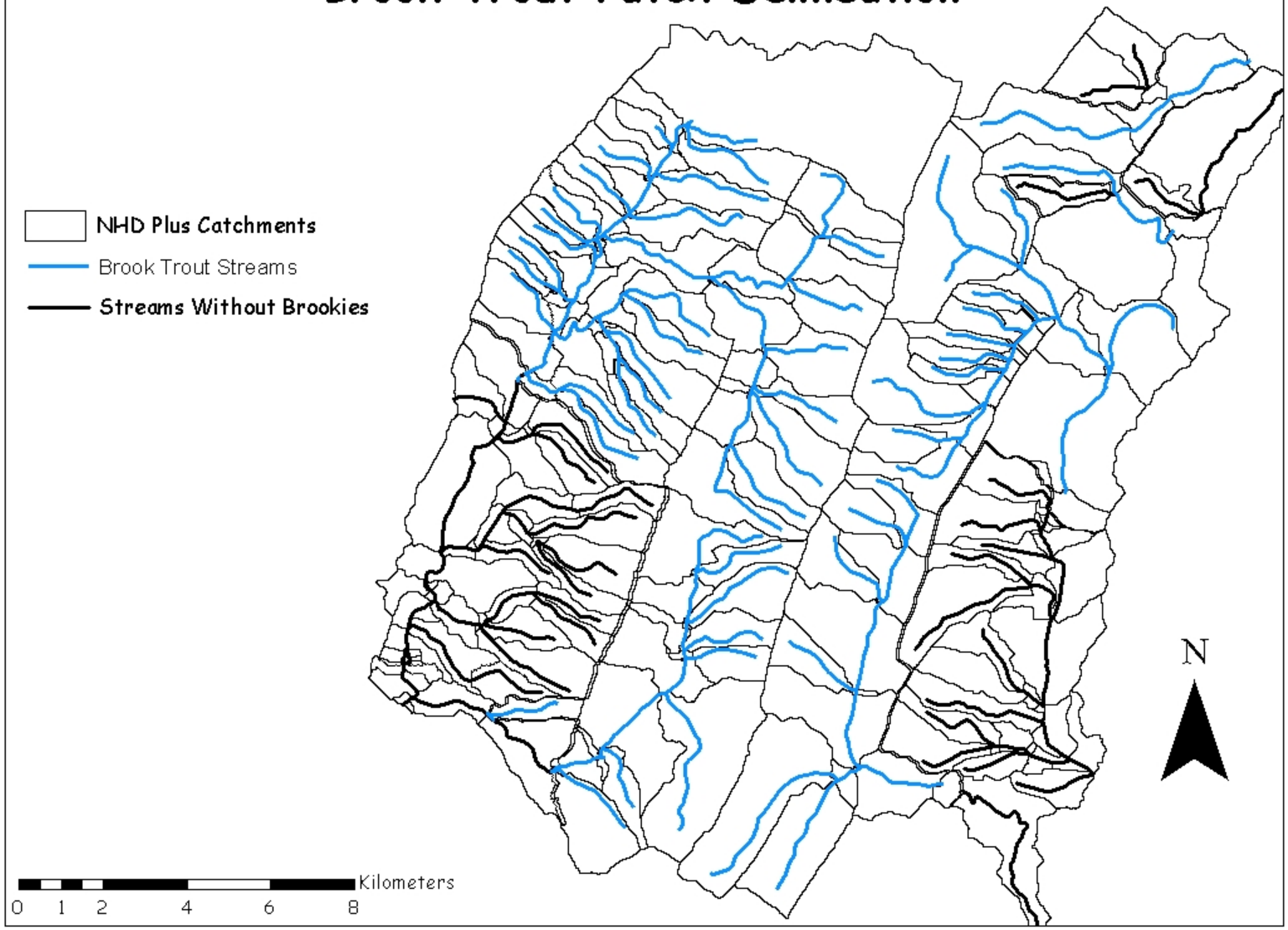
- Patches represent individual, **non-networked habitat units**
- **Virginia currently has 272 patches**



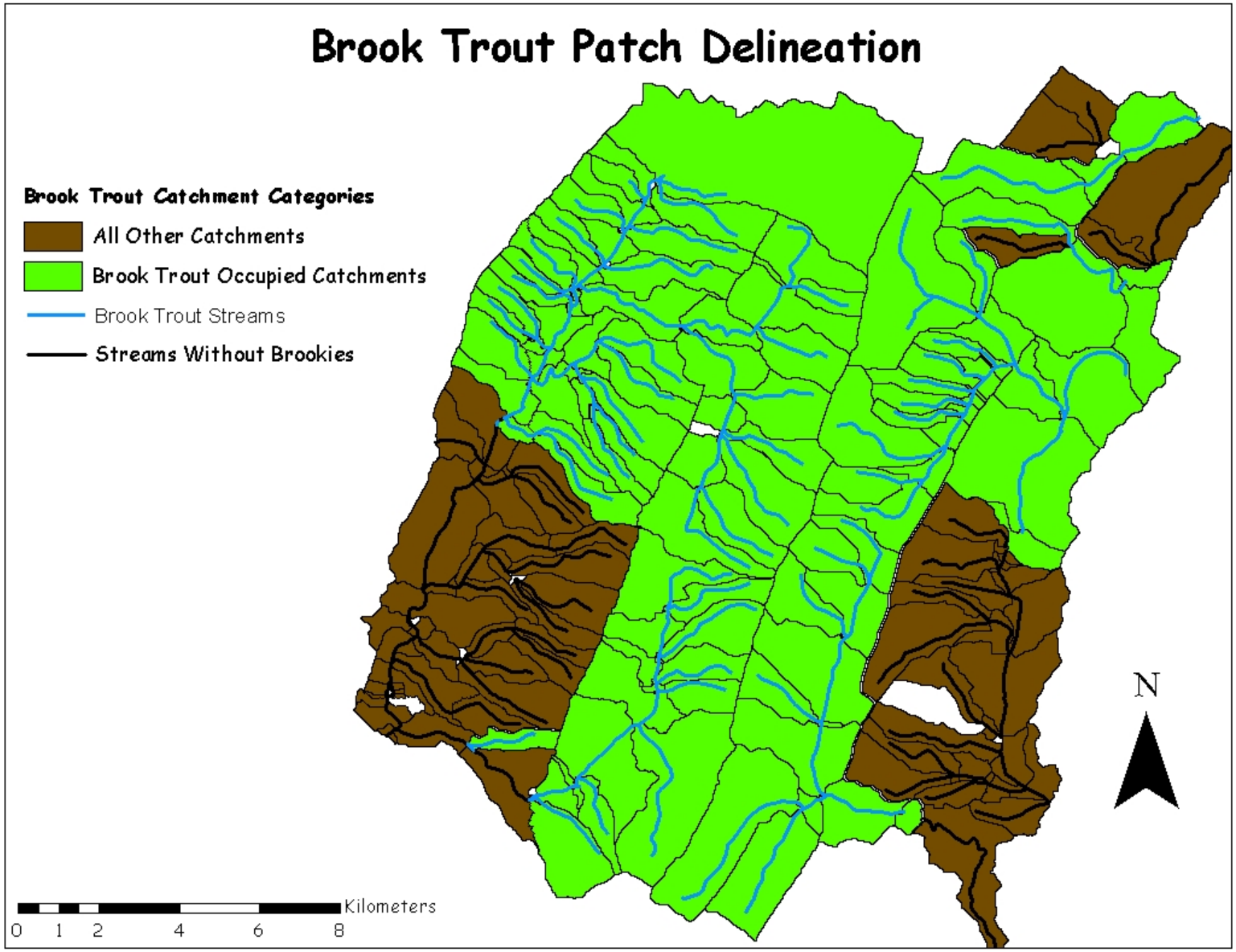
Brook Trout Patch Delineation



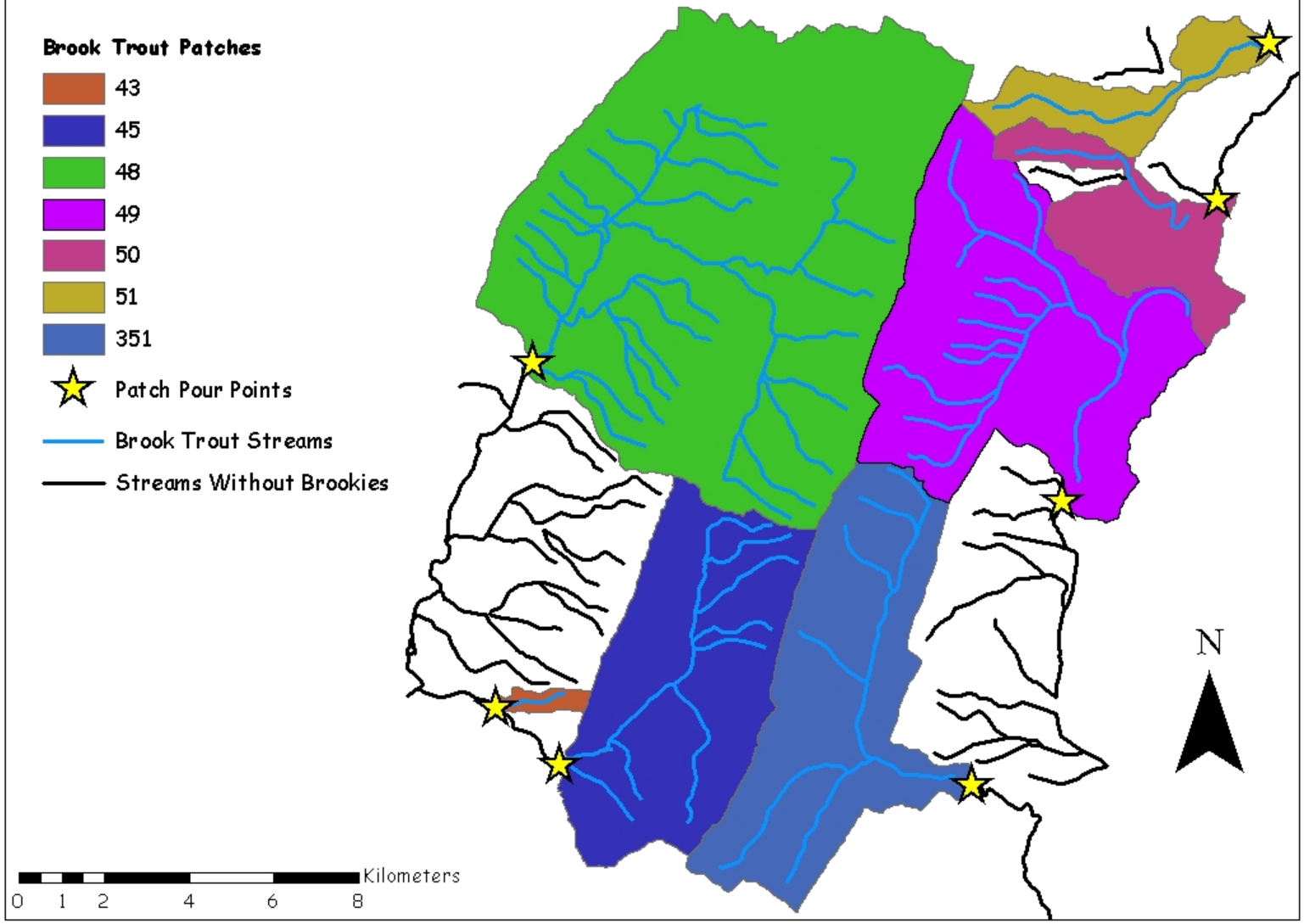
Brook Trout Patch Delineation



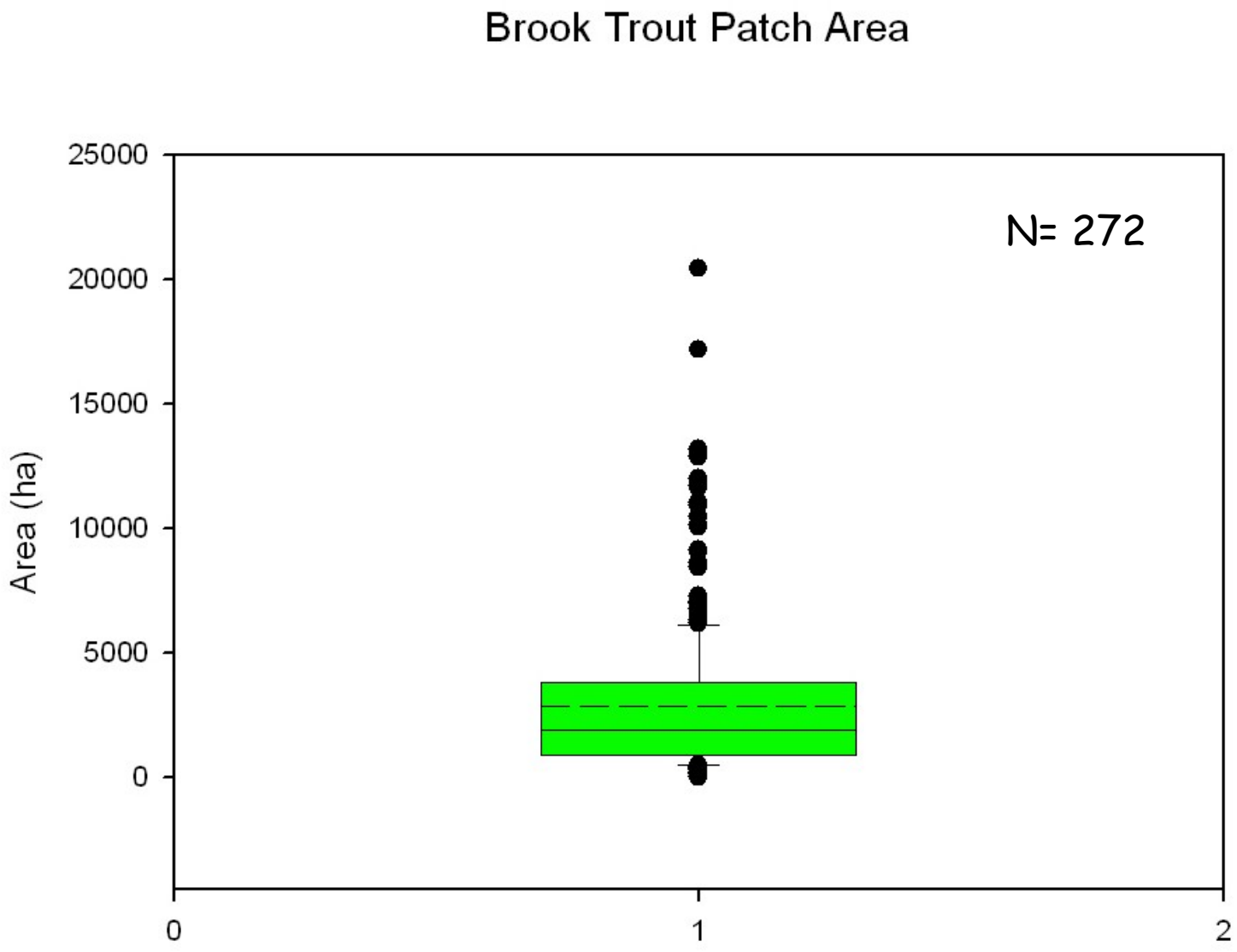
Brook Trout Patch Delineation



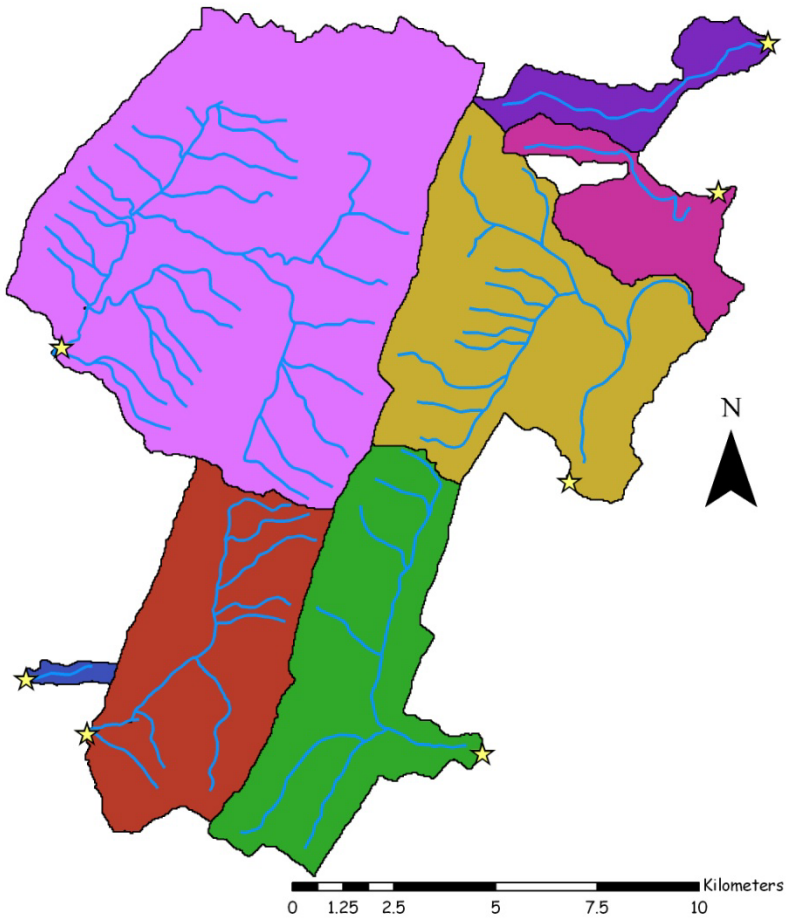
Brook Trout Patch Delineation



Virginia Brook Trout Patches


Brook Trout Patch Area
N= 272
Area (ha)
25000
20000
15000
10000
5000
0
0
1
2

Prioritize Patches



Working Hypothesis:

- Different patches have different air/water **temperature relationships with predictable variability** that can be used to model resiliency to climate change.
- The **air /water relationship** not the water temperature **is the key component** for ranking resiliency.

Choosing Patches for Sampling

- Various metrics summarized for each patch (GIS):

  1) Percent Riparian Canopy Cover

  2) Total Annual Riparian Area Solar Gain (kWh)

  3) Total forest area in each patch

  4) Pour Point Elevation

  5) 30 year annual mean max air temperature at the Pour Point

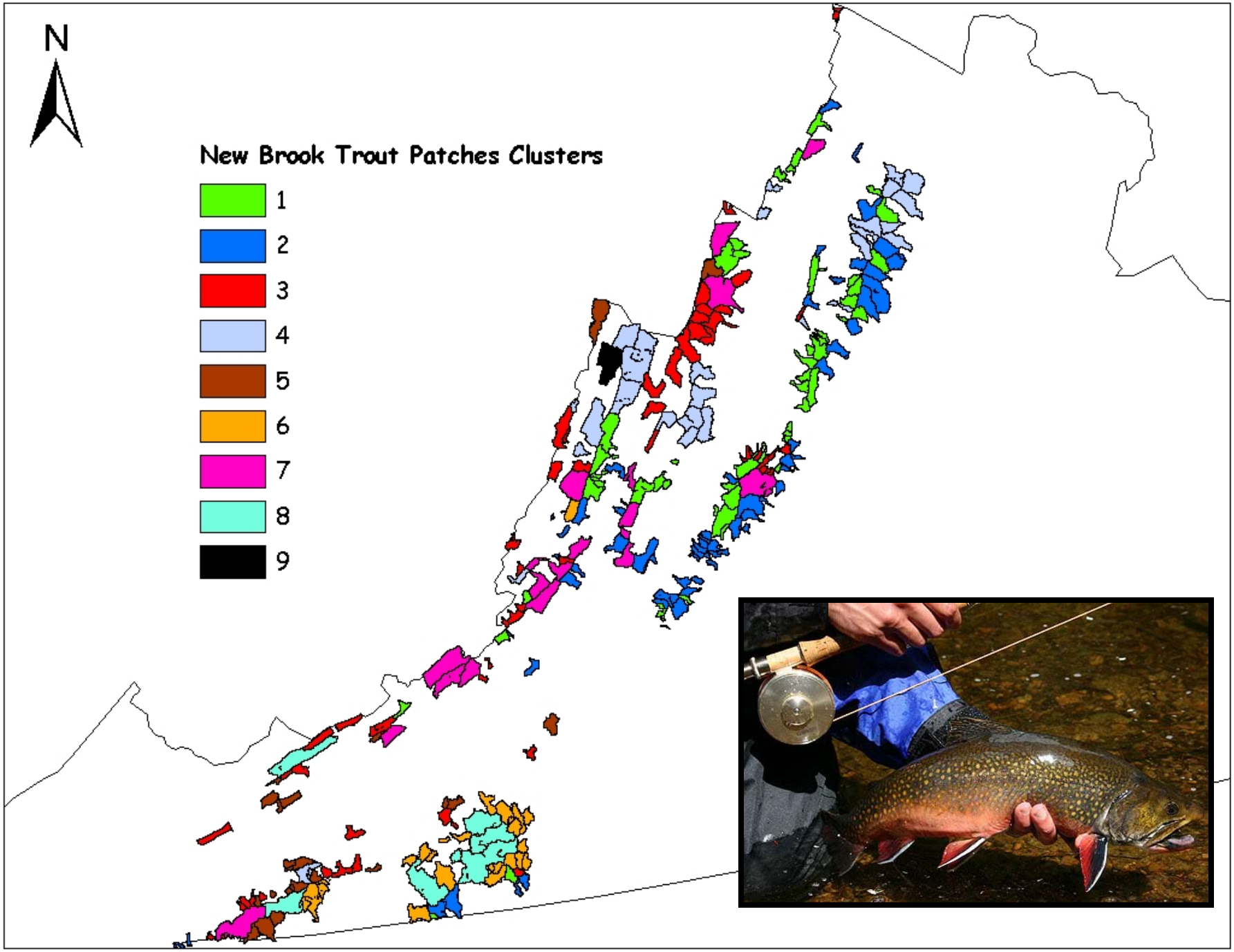
  6) Number of springs in each patch

Choosing Patches for Sampling

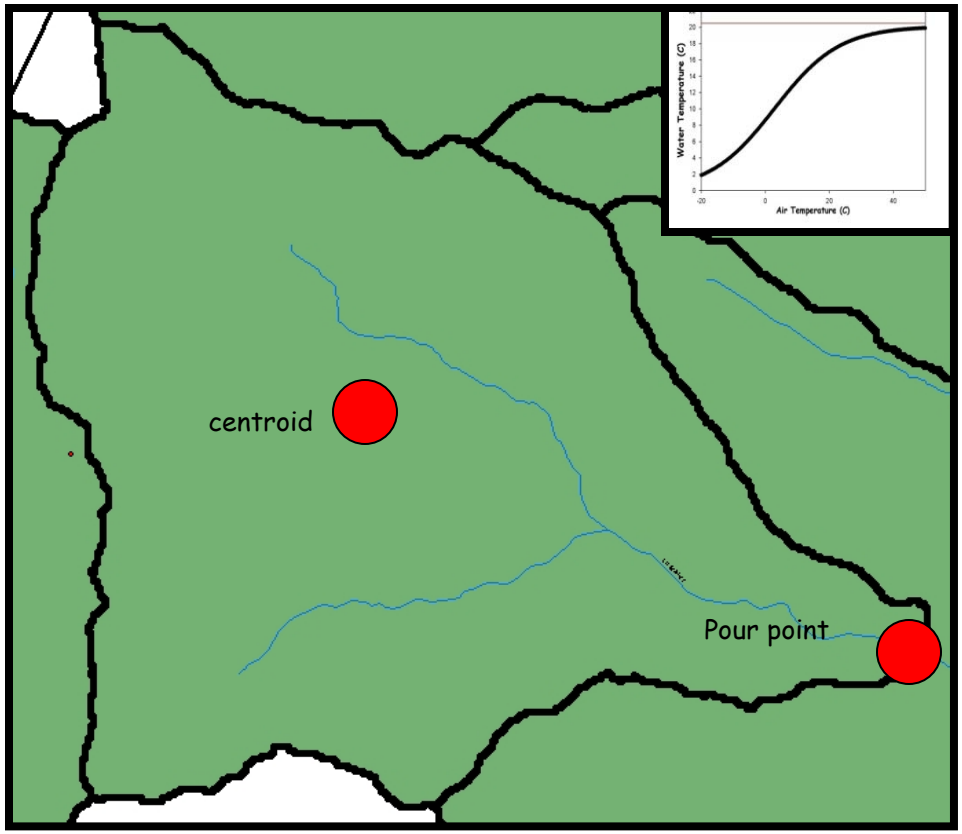
- Cluster analysis used to group patches
  - **Pseudo F value greatest at 9 clusters**
  - 50 of the 272 patches randomly selected from the cluster analysis groupings
  - Paired air and water thermographs placed at the pour point and centroid of each sampled patch (50/272)

Table Comparing Cluster Metrics

Cluster	# Patches	# Sampled	Solar Gain	# Springs	% Canopy	Pour Pt Elev	Pour Pt Max Air Temp	Patch Forest Area
1	56	9	Low	Low	High	Low	High	High
2	61	10	Low	Low	Medium	Low	High	High
3	56	8	Low	Low	High	Medium	Medium	High
4	25	5	Low	Medium	Low	Medium	Medium	Medium
5	23	5	Medium	Low	High	High	Low	High
6	25	5	Medium	Low	Medium	High	Medium	Low
7	18	4	High	Medium	High	Medium	High	High
8	7	3	High	Low	Medium	High	Medium	Low
9	1	1	Medium	High	Low	High	Low	Low
Sum	272	50						


N
New Brook Trout Patches Clusters
1
2
3
4
5
6
7
8
9

Sampling Methods



- Paired air and water temperature data will be used to develop the **unique sigmoid curve function** for the pour point and centroid of each selected patch.
- Relationships from sampled patches used to **model the remaining patches (cluster analysis groupings) (n=272).**

Sample Duration

- Temperature data is being collected at **30 minute intervals** for **17 months** including **two critical summer periods (July-September 15)**

Thermograph Specifications

Onset HOBO Water Temp Pro v2

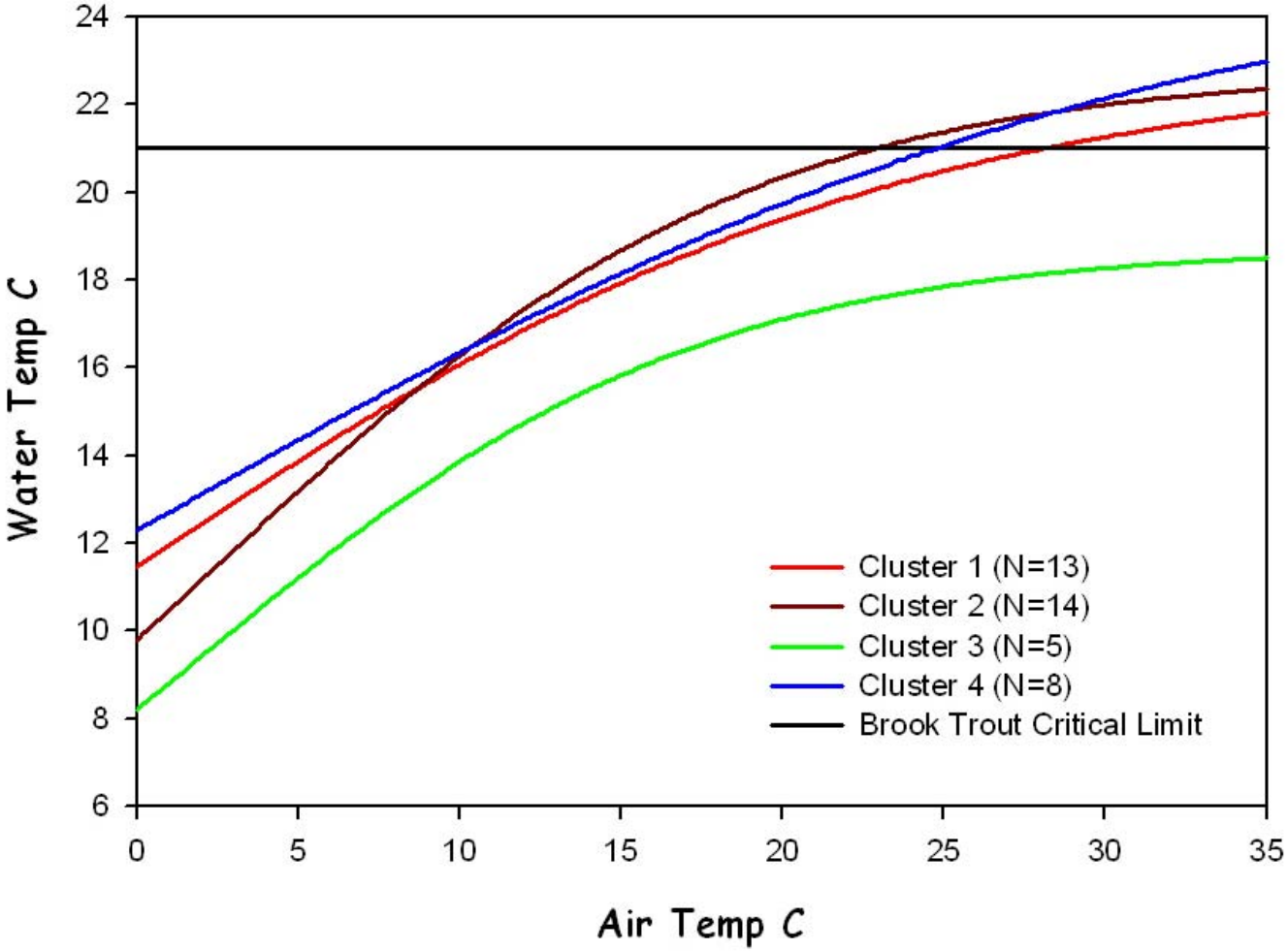
- Operation Range: -20 to 70°C
- Accuracy: 0.2°C over 0° to 50°C
- Resolution: 0.02°C at 25°C
- Approximate Cost: <u>$85 each</u> (lowest bid)

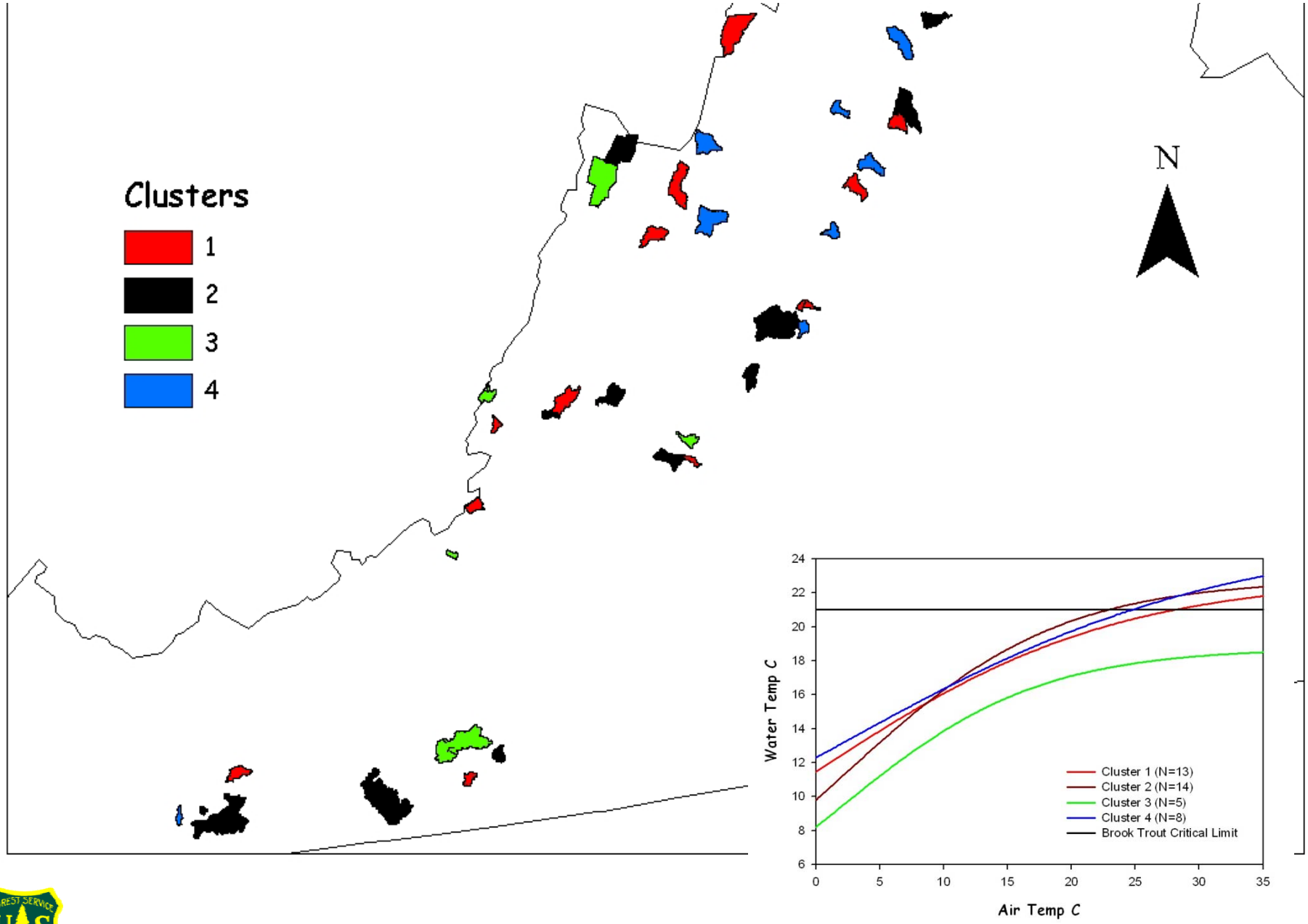
<u>For our study:</u>
50 patches X 4 HOBOs = 200 HOBOs
~$85 per HOBO X 200 = **~$17,000**

Critical Period Results
(July 1st through September 15th)

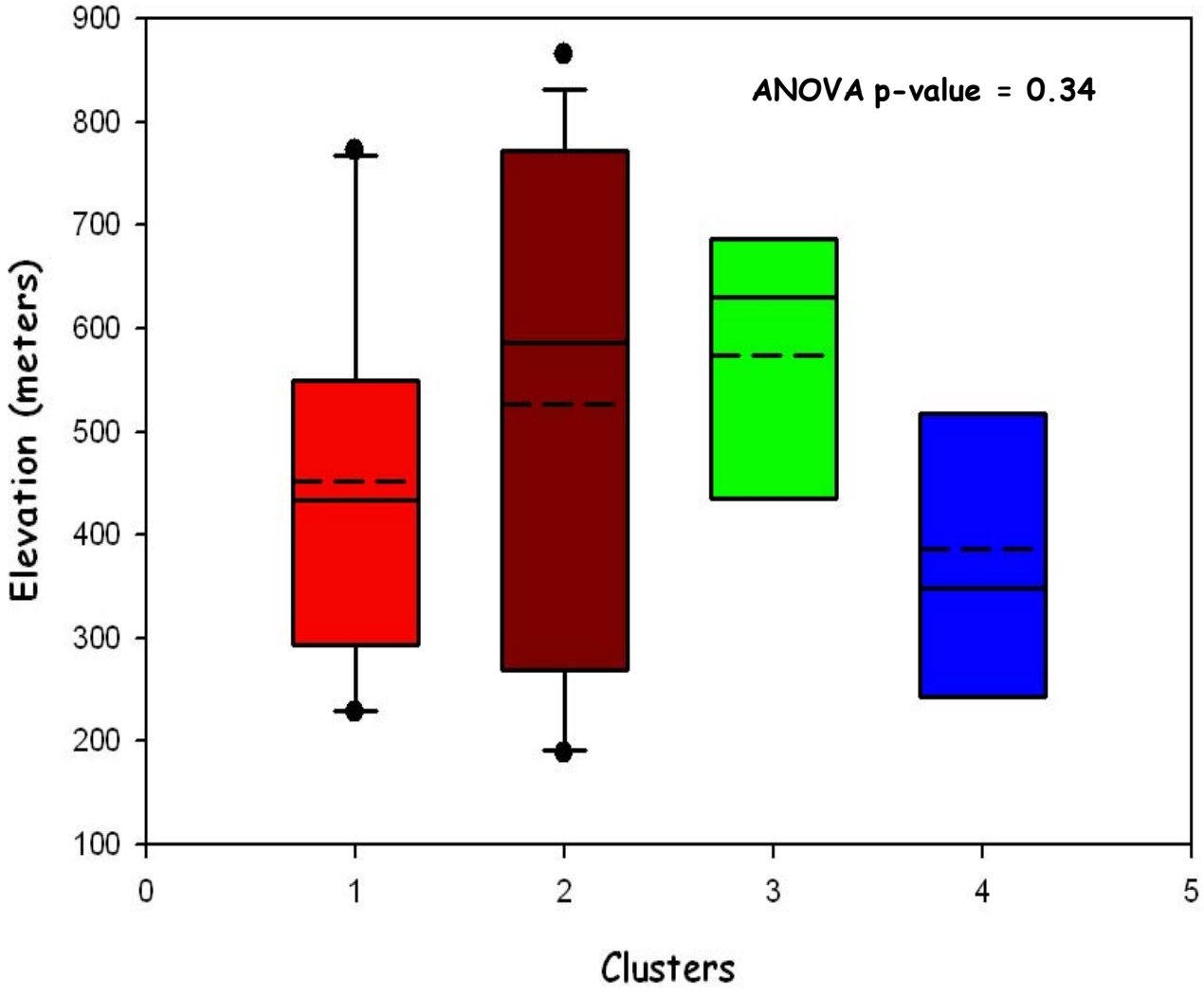
- 2009 Critical Period data analyzed from 50 sampled patches
  - Compared differences among air/water temp relationships of the 50 patches
  - **Significant difference ($p<0.0001$) among patches in air water temperature relationships**

Patch air/water temp relationships cluster into 4 groups based on linear fit (July 1st through September 15th)



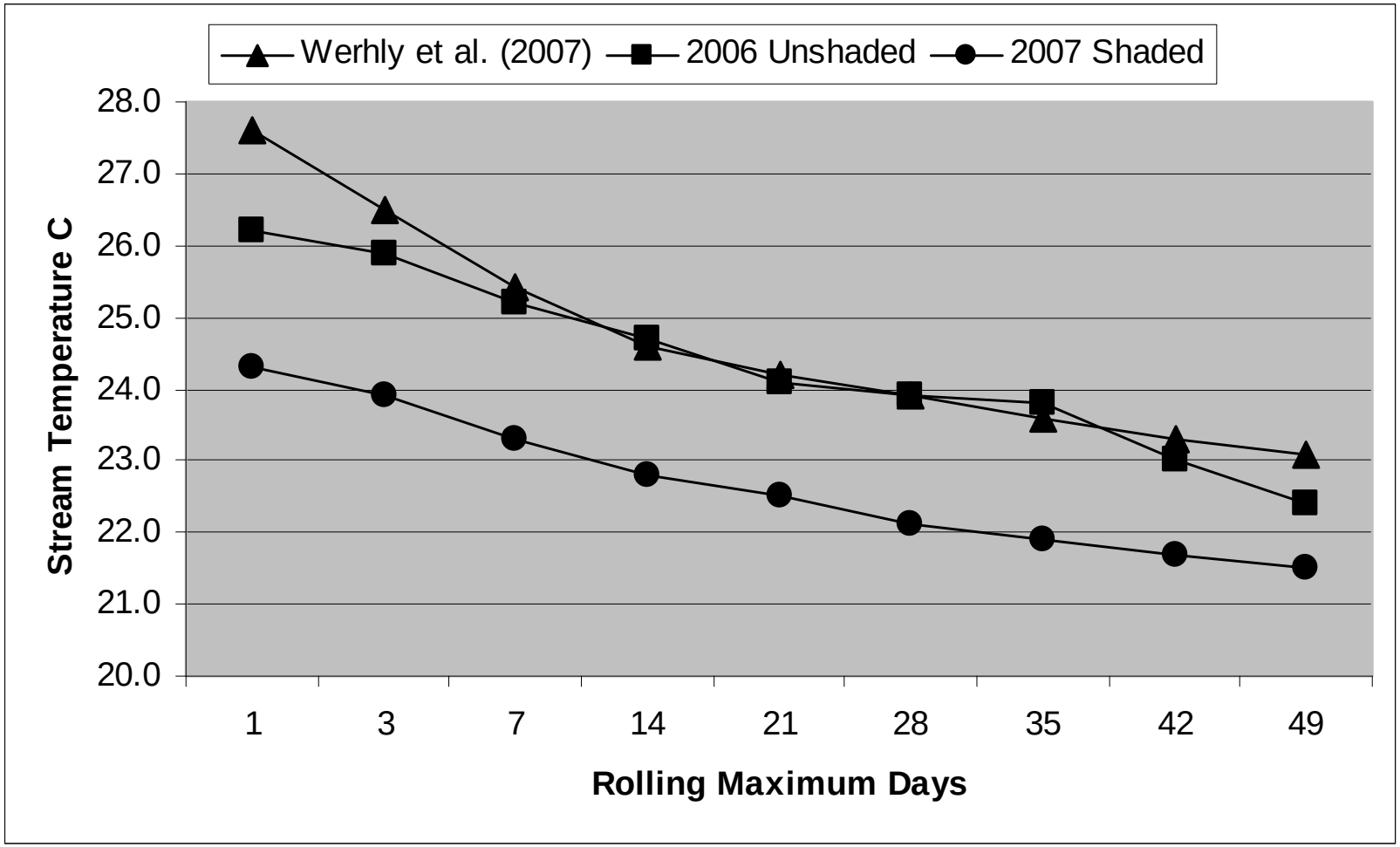

Clusters
1
2
3
4
N
Water Temp C
Air Temp C
Cluster 1 (N=13)
Cluster 2 (N=14)
Cluster 3 (N=5)
Cluster 4 (N=8)
Brook Trout Critical Limit
24
22
20
18
16
14
12
10
8
6
0
5
10
15
20
25
30
35

Critical Period Results
(July 1st through September 15th)



Climate Change Adaption/Mitigation Land use Practices ?

Shade it and they will come !


Werhly et al. (2007)
2006 Unshaded
2007 Shaded
28.0
27.0
26.0
25.0
24.0
23.0
22.0
21.0
20.0
Stream Temperature C
1
3
7
14
21
28
35
42
49
Rolling Maximum Days

adidas

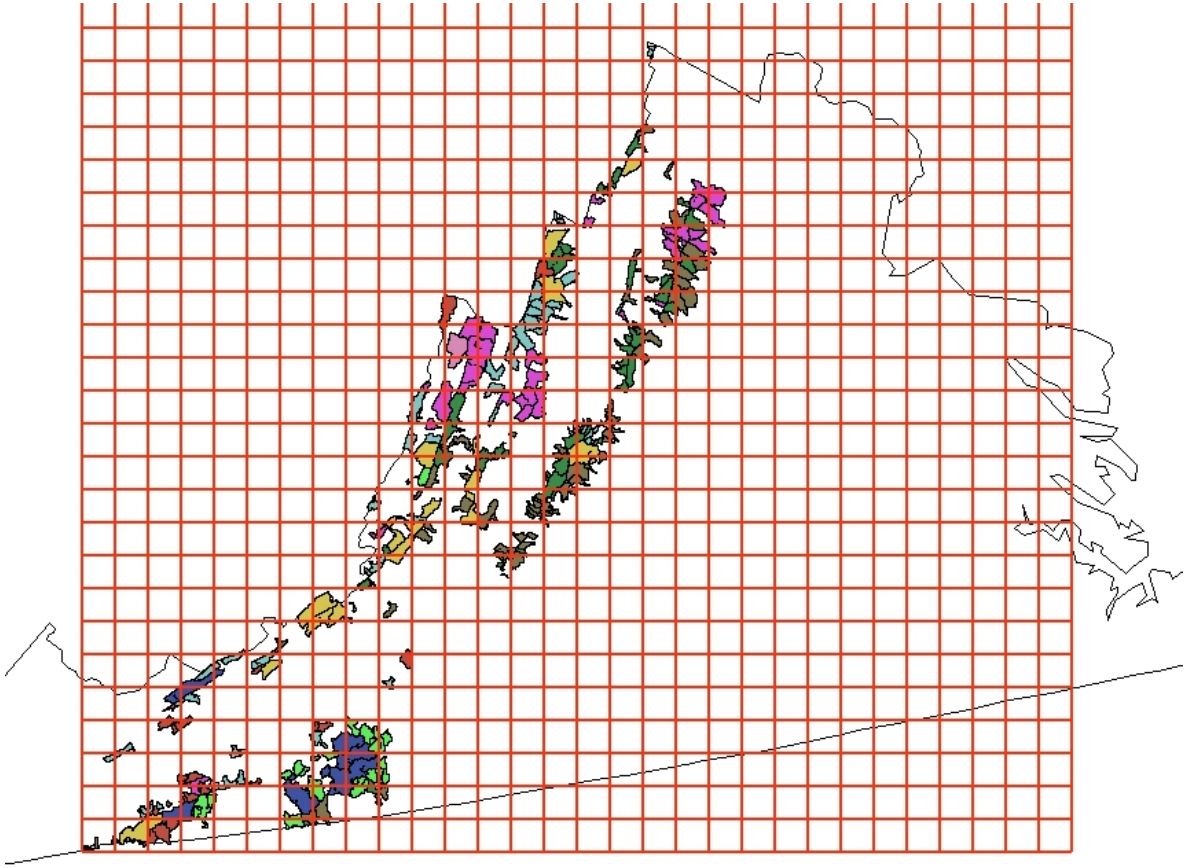
Next Steps

- Relate land use metrics to air/water curves.
- Expand throughout the EBTJV range.
- Apply air temperature predictions (50 sq km or 15 sq km) to local patch air/water temperature curves
- Prioritize restoration investment efforts for brook trout

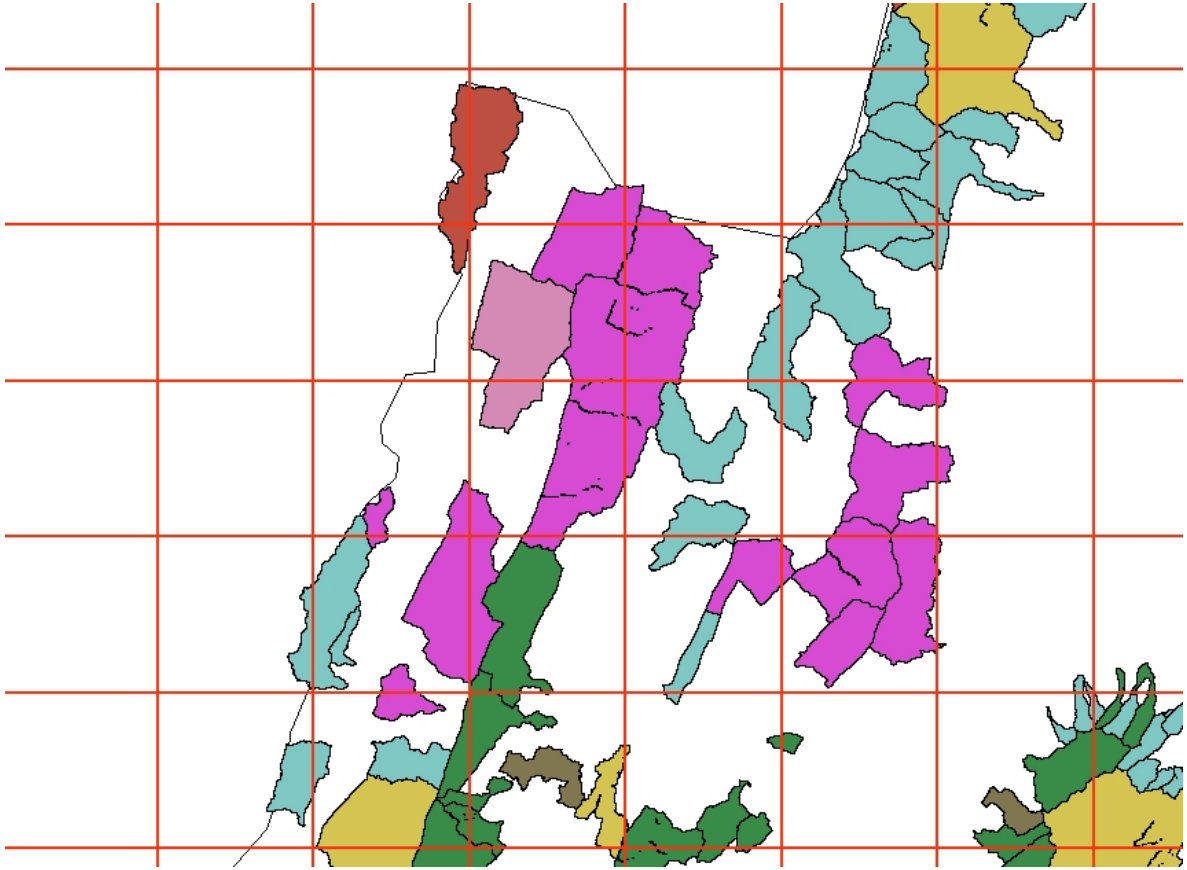
Direct measurement Approach

- Complementary to downscale modeling efforts
- Useful to validate downscale models
- Direct benefits to managers
- Active participation by publics/agencies
- Better accuracy at finer scales??

15 square km



15 square km



Summary

- <u>Working Hypothesis:</u>
  Different habitats have different air/water temperature relationships with predictable variability that can be used to model resiliency to climate change

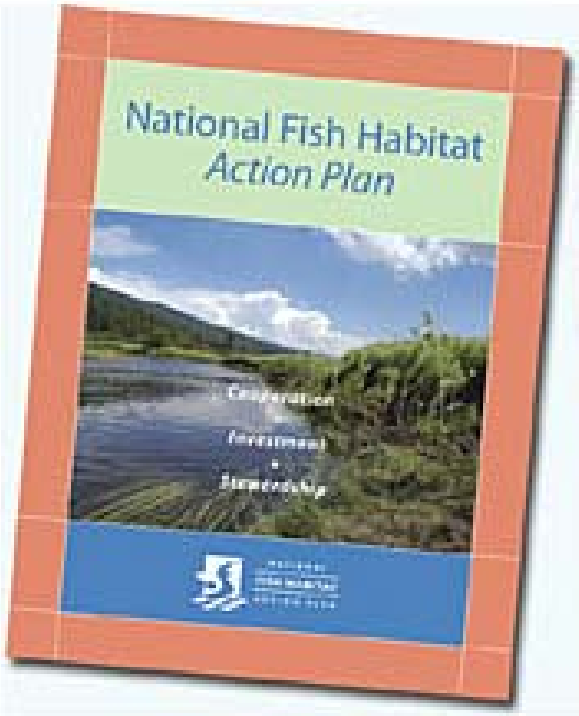
- Identified unique brook trout patches
- Clustered patches by various metrics
- Sampled patches (n=50) selected from cluster groupings
- Currently collecting air/water temperature data at pour point and centroid (17 months)
- Air/water temperature relationships to be modeled to land use characteristics

Acknowledgements

- VA Department of Game and Inland Fisheries for HOBO funding
- James Madison University, Department of Biology
- US Forest Service
- Chas Kyger, Lisa Wise, Ali Fitzgerald (VT), Scott Riley (VT)

Dr Bruce Wiggins (JMU)

Dr Heather Griscom (JMU)

Dr Eric Smith (VA Tech)

Thanks to the EBTJV Partners!