Ranking Brook Trout Habitats in West Virginia and Maryland to Resiliency to Climate Change

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Deliverables West Virginia ($75,000):

1). Validate all current unique patches of brook trout habitat (N = 234; average size = 1,676 ha).

2). Provide detailed land-use and other associated metrics using GIS for all patches.

3). Sub-sample 50 of the current 234 patches using valid statistical methods.

4). Collect paired air and water temperature measurements every 30 minutes from the pour point of 50 patches year round (July 1, 2010 to Septmeber 15, 2011) and from two critical summer periods (July 1, 2010 through September 15, 2010 and July 1, 2011 through September 15, 2011).

5). Develop air water temperature curves for each of the 50 sub-sample sites.

6). Evaluate resiliency to climate change for each site under various climate change scenarios (three scenarios picked from consultation with USFWS and EBTJV)).

7). Develop predictive model for land use metrics and air and water temperature curves.

8). Model resiliency of unsampled patches.

9) Provide preliminary ranking of climate change resiliency of all 234 patches of brook trout habitat in West Virginia (Oct 1, 2010).

10). Provide final rankings of West Virginia brook trout habitats to resiliency to climate change (October 1, 2011).

<u>Deliverables Maryland ($25,000):</u>

1). Validate all current unique patches of brook trout habitat (N = 87; average size = 1,484 ha).

2). Provide detailed land-use and other associated metrics using GIS for all patches.

3). Sub-sample 20 of the current 87 patches using valid statistical methods.

4). Collect paired air and water temperature measurements every 30 minutes from the pour point of 50 patches year round (July 1, 2010 to Septmeber 15, 2011) and from two critical summer periods (July 1, 2010 through September 15, 2010 and July 1, 2011 through September 15, 2011).

5). Develop air water temperature curves for each of the 20 sub-sample sites.

6). Evaluate resiliency to climate change for each site under various climate change scenarios (three scenarios picked from consultation with USFWS and EBTJV)).

7). Develop predictive model for land use metrics and air and water temperature curves.

8). Model resiliency of unsampled patches.

9) Provide preliminary ranking of climate change resiliency of all 87 patches of brook trout habitat in Maryland (Oct 1, 2010).

10). Provide final rankings of Maryland brook trout habitats to resiliency to climate change (October 1, 2011).

Introduction

Climate change is currently a high risk threat to the current range of brook trout and other salmonid species in West Virginia and Maryland. Changing thermal regimes associated with climate change are predicted to extirpate many of the existing brook trout throughout their native range, and potentially eliminate brook trout in the state of West Virginia and Maryland (Meisner 1990, Clark et al. 2001, Fleebe et al. 2006). The effects of climate change may be exacerbated when coupled with land use changes leading to greater fragmentation of remaining habitat (NAST 2000).

Previous large-scale assessments of the effects of climate change on cold-water fishes used models that assumed a steady relationship between air and water temperature (Clark et al. 2001, Fleebe et al. 2006). While these models were appropriate for large-scale assessments, they may not be accurate at the smaller scales where brook trout management occurs. Regional models may prevent the incorporation of site-specific aspects of streams, therefore limiting interpretations of trout responses to climate change (Clark et al. 2001). Landscape patterns are often disregarded in studies of spatial responses to climate change (Opdam and Wascher 2004), however, these patterns may be important drivers of variation among patches. Many small patches of brook trout habitat may persist in West Virginia and Maryland even under the most pessimistic climate change scenarios due to localized conditions (i.e. springs, aspect). The influence of such metrics as groundwater input at localized scales may play a more important role in stream thermal stability than expected (Meisner 1990, Wehrly et al. 2007).

To rank the resiliency of brook trout habitats to climate change, it is necessary to understand the relationship between air and water temperatures at smaller scales of interest to managers. Paired air and water temperature relationships can be quantified and modeled to rank existing patches of brook trout habitat for their resiliency to climate change. A pilot study in Virginia showed that the relationship between air and water temperature is 1) highly variable at the patch scale; 2) influenced by local conditions (i.e. elevation, aspect, riparian cover, latitude, and ground water sources); and 3) can be effectively used by managers to prioritize brook trout work under various climate change scenarios.

This study builds on previous work by the Eastern Brook Trout Joint Venture in Virginia and will rank patches of brook trout habitat within the states of West Virginia and Maryland for resiliency to climate change under varying climate change scenarios. These resiliency rankings will be useful in determining future brook trout habitat and which patches of brook trout habitat are most important for conservation and restoration (Wehrly et al. 2007).

Study Area

This project will include all current brook trout habitat within the state of West Virginia and Maryland (Figure 1, 2). Brook trout habitat for this study has been delineated into contiguous patches (WV has 234 unique patches of brook trout habitat (averge size = 1,676 ha) and MD has 87 unique patches of brook trout habitat (average size= 1,484 ha)), each thought to be genetically isolated from one another (Hudy et al. 2008).

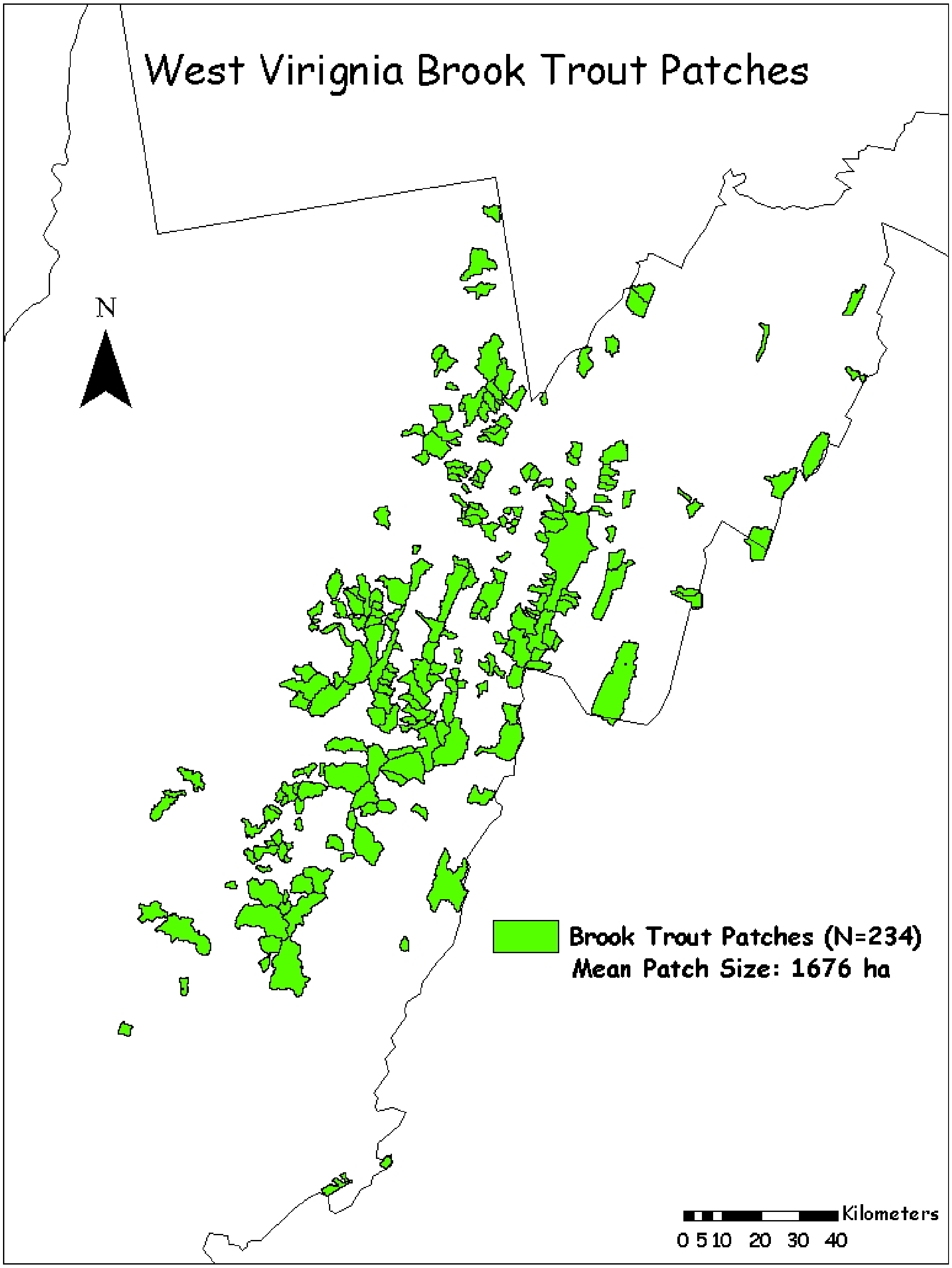

Figure 1. Distribution of patches of brook trout habitat (N= 234) within the state of West Virginia (Hudy et al. 2008). Average patch size = 1,676 hectares.

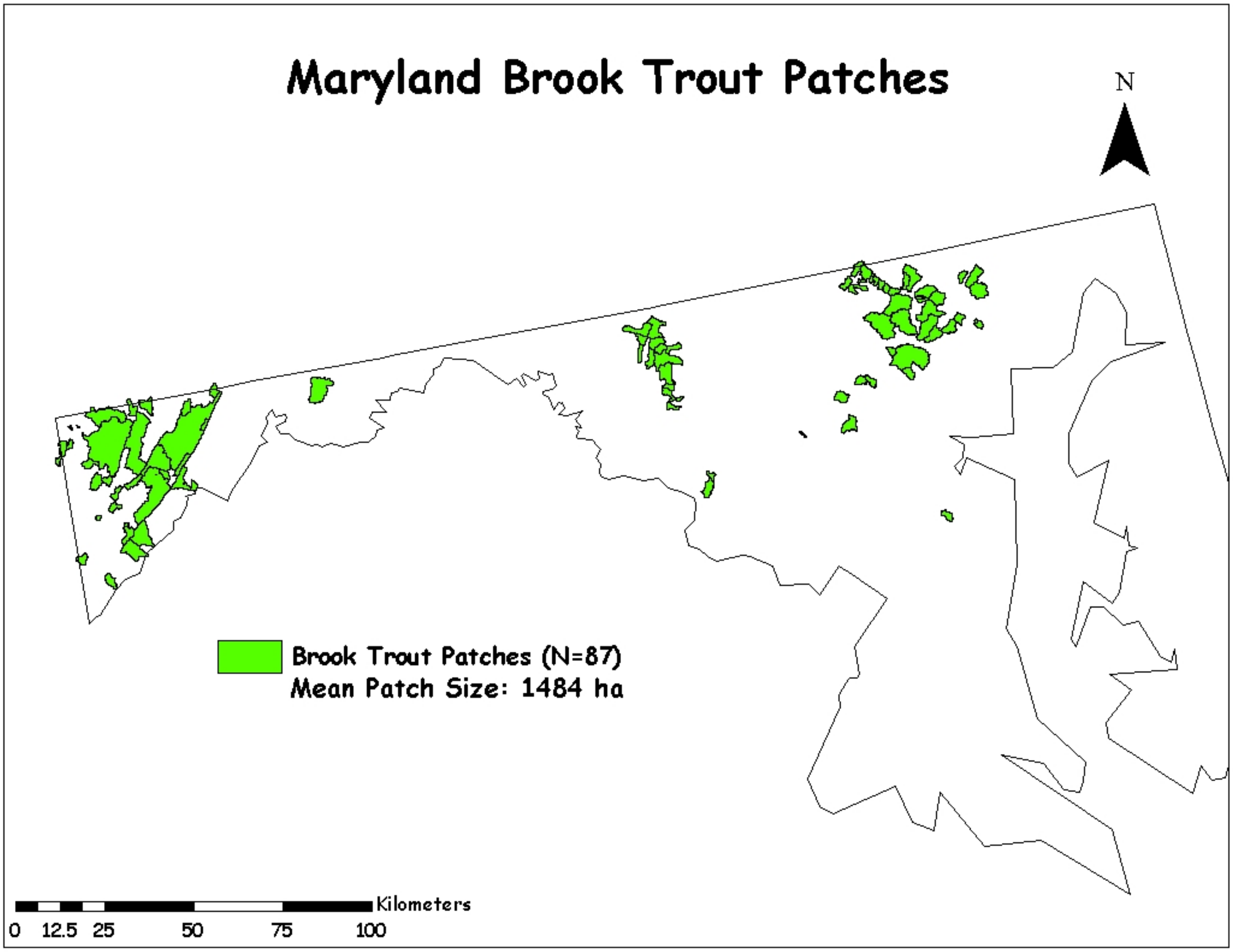

Figure 2. Distribution of patches of brook trout habitat (N= 87) within the state of Maryland (Hudy et al. 2008). Average patch size = 1,484 hectares.

Methods

Patch Delineation

This study uses brook trout habitat patches delineated from the National Hydrography Dataset seventh level Hydrologic Unit Code (HUC) catchment polygons. Each HUC specifies an area of land that drains into a specific stream segment. The catchment level is the finest scale of Hydrologic Unit (USGS 2008). Catchments were coupled with brook trout presence/absence data from the states of WV and MD (EBTJV 2006, Hudy et al. 2008) to determine which catchments contain reproducing populations of brook trout. Contiguous catchments containing brook trout were then dissolved into one patch.

Choosing Sample Patches

Metrics important to potential air temperature and water temperature relationships will be summarized using a Geographic Information Systems (GIS) for all patches (Table 1).

Table 1: Metrics for use in analyzing patches of brook trout habitat

Metric	Units	Source
Patch Area	Hectares	
Riparian Area	Hectares	
Patch Total Annual Solar Gain	kWh	ESRI 2009
Riparian Total Annual Solar Gain	kWh	ESRI 2009
Patch Mean Annual Solar Gain	kWh/30m pixel	ESRI 2009
Riparian Mean Annual Solar Gain	kWh/30m pixel	ESRI 2009
Pour-point Elevation	meters	USGS 2008
Centroid Elevation	meters	USGS 2008
Pour-point 30-year Mean Max Temp	Celsius	PRISM 2009
Centroid 30-year Mean Max Temp	Celsius	PRISM 2009
% groundwater flow in patch	Percentage	USGS 2010
Patch Mean Canopy Cover	Percentage	NLCD 2001 (USGS 2008)
Riparian Mean Canopy Cover	Percentage	NLCD 2001 (USGS 2008)
Patch Landuse Area by Category (N=15)	Hectares	NLCD 2001 (USGS 2008)
Riparian Landuse Area by Category (N=15)	Hectares	NLCD 2001 (USGS 2008)
Geology Type (N=58)		Webb 2009
Geology category (N=5)		Webb 2009

Because funding is not available to census all patches, the following sub-sampling protocol will be used to sub-sample streams. A cluster analysis (Wards method) using six metrics (Table 2) from all patches will determine the number of clusters that have the greatest power of separation among the patches. From the clusters, a total of 50 patches (WV; 20 patches MD) were selected for a proportional number of patches sampling.

Table 2: Six brook trout patch metrics used for cluster analysis

Metric	Units
Riparian Total Annual Solar Gain	kWh
Pour-point Elevation	meters
Pour-point 30-year Mean Max Temp	Celsius
% of patch flow in groundwater	Percentage
Riparian Mean Canopy Cover	Percentage
Total Forest Area per Patch	Hectares

Sampling Materials and Standard Operating Procedures

The HOBO Watertemp Pro v2 (accuracy 0.2˚C; drift <0.1 annually; costs $110 each (Onset computer Corporation 2008) thermograph will be used for water and air temperature monitoring for consistency with previous Eastern Brook Trout Joint Ventures climate change work in Virginia.

Paired air and water thermographs were placed at the pour-point (downstream population boundary of patch) of each sampled patch. Thermographs will be left in place for 17 months (July 2010 to September 2011) collecting temperature readings every 30 minutes. The sample period will include two critical summer periods of July 1st through September 15th. The critical summer period typically produces greater stress on wild trout due to low water levels and maximum annual stream temperatures.

Variables such as private land access and dry stream conditions may alter locations of actual pour-point sites.

I. Site Location

1) Before departing headquarters, it is necessary to have a route plan as to which site are to be set. The use of a handheld GPS unit, as well as a map will allow for more expedient travel

2) Handheld GPS units should be pre-programmed with "theoretical" pour-point locations for each patch. Theoretical centroid points will not likely be directly overtop of stream segments on the GPS unit. It is necessary to determine the closest stream segment to the centroid point as the site for deploying HOBOs in each patch.

- The goal should be to navigate to the closest possible location to the “theoretical” centroid and pour-point in the GPS unit
- IF the point falls WITHIN, or requires passing THROUGH PRIVATE property, try to contact the landowner.
- If a remote site and landowner cannot be contacted, one of the following options should be based upon best professional judgment:
    - a site may be set as close as possible to the theoretical site where access is granted or public land is available
    - in cases of danger or serious inconvenience a new patch may be randomly selected for sampling

3) Once a site is located, HOBOs placed in the water should be placed near maximum residual pool depth. Residual depth is defined as “the difference in depth or bed elevation between a pool and the downstream riffle crest” (Lisle 1987).
    - Pools with at least knee depth should be selected when possible to ensure the HOBO will be submersed throughout late summer

II. Setting In-stream HOBOs

1) Copper wire (coated 14ga.) has been used with great success in Virginia. It is necessary to use some type of extremely tough material for attaching HOBOs to the stream bank, etc., since debris will likely catch on, and greatly stress the material

2) Protective rubber boots with caps should be used to set HOBOs in water to prevent surfaces and serial numbers from being worn off. Friction between substrate particles and the clear surface where data is transferred could be damaged causing potential data lost

3) Once maximum residual pool depth has been located, determine what stream bank structure will be used to anchor the HOBO. Be certain the tree, root, boulder, log etc. is PERMANENT

4) Secure wire tightly around structure wrapping wire back upon itself a minimum of five wraps

5) Estimate the length of wire necessary to reach the location where the HOBO is to be placed

6) Cut wire to length leaving extra length for movement around substrate. Attach HOBO, and place HOBO in stream
    - Place HOBO FIRMLY under a rock large enough to be stationary with high flow
        - DO NOT bury HOBO into substrate
    - Lay wire along substrate burying it under rocks, etc. It is necessary to have wire hidden as well as possible from human detection, but more importantly from debris such as leaves that may catch and dislodge the HOBO

7) Use handheld GPS to collect a “Waypoint” while standing where the HOBO was placed. These coordinates are required for future mapping and locating the HOBO
    - Rename the waypoint to the population number, centroid or pour-point, air or water
        - Example: 172CW = Population 172 Centroid, Water

8) Place a tree tag in plain view of the HOBO attachment point from the most likely direction of approach

- Tree tag placement has proven to be highly beneficial when finding set HOBOs since it offers a visual cue to the submerged HOBO

III. Setting Air Temperature HOBOs

1) Carry copper wire for attachment, PVC shield (Figure 2) to reduce direct UV contact with HOBO (Dunham et al. 2005), tree tags and GPS unit for air set

2) If possible, locate a tree within 50m of stream set, upslope (Dunham et al. 2005), away from stream

- Not all sites will offer "upslope" areas, or a 50m wide buffer zone. Use best professional judgment to find a suitable area

3) Use GPS unit to locate NORTH aspect/compass direction

4) Run wire through PVC shield cap, attach HOBO to wire, and then attach wire to tree at approximately head height

- Head height may vary depending upon who is setting the HOBO. Keep in mind that someone else may be checking the HOBO at a later date; therefore, anyone greater than 6 feet in height should set HOBOs at shoulder height

5) Use handheld GPS to collect a "Waypoint" while standing where the HOBO was placed. These coordinates are required for future mapping and locating the HOBO

6) Place a tree tag in plain view of the HOBO attachment point from the most likely direction of approach

Figure 2. PVC shield for air temperature HOBO. Dimensions: 3in PVC, 6in long, ½in drilled holes for air flow (12)

IV. Site/HOBO Documentation

1) A “Site Description” datasheet should be completely filled out upon setting HOBOs at a site.

2) Site Description datasheet requirements:

- Date
- Time
- Unique patch number
- Pour-point or Centroid
- Datum and UTM zone
- Serial Number for both In-Stream and Near-Stream HOBOs
- GPS coordinate for both In-Stream and Near-Stream HOBOs
- Driving direction and drive time from headquarters (may be filled in at the office)
- Hiking directions, time, and distance from vehicle
- Physical description of location of both In-Stream and Near-Stream HOBOs with photo numbers noted
    - Should include tree tag placement and what the HOBO was attached to

V. Site Photography

This may appear to be common sense, but guidelines may actually result in better quality, more useful photos.

1) Understand how to use your camera thoroughly

2) Take photos of In-Stream and Near-Stream (Figure 2) HOBO locations from the most likely direction of approach

3) Be certain the person taking photos is far enough from the site that recognizable landmarks such as unique trees or boulders, etc. may be included in the photo.

4) Be certain the person taking photos is close enough to the site that landmarks and tree tags are recognizable

5) Photos organized by date and camera (given there are multiple crews working) are easily matched to the “Site Description” datasheet by photo number for future reference

Data Analysis

Linear and logistic regression will be used to look at relationships among air temperature, water temperature and patch metrics. Rolling maximums (Werhly et al. 2007, Fink 2008) will be determined for each water temperature dataset in order to plot relationships under various climate change senarios.

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