Riparian Prioritization and Status Assessment for Climate Change Resilience of Coldwater Stream Habitats within the Appalachian and Northeastern Regions

Prepared by:

Jason A. Coombs

Keith H. Nislow

University of Massachusetts Department of Environmental Conservation and US Forest Service Northern Research Station

Prepared for:

Jean Brennan

Appalachian Landscape Conservation Cooperative

Pat Ruble and Scot Williamson

Wildlife Management Institute

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EXECUTIVE SUMMARY

Among a host of other critical ecosystem functions, intact riparian forests can help to reduce vulnerability of coldwater stream habitats to warming regional temperatures. Restoring and conserving these forests can therefore be an important part of regional and landscape-scale conservation plans, but managers need science and decision-support tools to help determine when these actions will be most effective. To help fill this need, we developed the Riparian Prioritization for Climate Change Resilience (RPCCR) web-based decision support tool to quickly and easily identify, based on current riparian cover and predicted vulnerability to air temperature warming, sites that are priority candidates for riparian restoration and conservation. This tool was successfully incorporated into the suite of open-source data layers and delineation tools currently served by the Appalachian Landscape Conservation Cooperative, including the Eastern Brook Trout Assessment. Critical objectives included 1) transfer of the RPCCR to an Open-Source platform (from ARC-GIS) 2) extension of the RPCCR range-wide 3) ability to prioritize sites at any user-determined spatial scale 4) input from, and training for, users and stakeholders. In addition to development and application of the RPCCR, we used the riparian and landscape-level spatial coverages to establish current riparian cover levels across the entire range with the goal of comparing cover levels across jurisdictions and catchments with and

without brook trout and other salmonids, and to serve as a baseline for future detection of status and trends.

BACKGROUND AND JUSTIFICATION

Increased stream temperature as a result of climate change (IPCC 2007) is a major concern for conservation and natural resource management in the eastern US. Temperature exerts a primary constraint on species distribution and abundance in headwater streams, and is particularly important as many species have already experienced decreases in range and occurrence associated with anthropogenic stressors (Hudy et al. 2008). At the same time, the temperature regimes of headwater streams have a significant influence downstream, and may play a key role in maintaining ecological integrity throughout the river network.

Regional climate change predictions indicate a magnitude of stream temperature increase that is likely to threaten the persistence of coldwater dependent species such as the Eastern Brook Trout (*Salvelinus fontinalis*) over much of its native range. For example, models based on simple relationships between increases in air and stream temperatures predict extirpation of eastern Brook trout in the southern Appalachian region (Flebbe et al. 2006). However, streams vary considerably in their sensitivity to increases in air temperature (Trumbo et al. 2013), and resilient streams are likely to provide refugia for coldwater fish in the context of regional climate change, allowing populations to persist.

A major determinant of among-stream variation in both current and predicted future temperature regimes is direct exposure to sunlight (solar gain), which is codetermined by geography (aspect, elevation, topography, and latitude) and the extent to which streams are shaded by riparian vegetation (Fu and Rich 1999). While managers cannot change geography, they can directly influence solar gain to streams by restoring riparian shade through restoration of riparian forests (Moore et al. 2005). Areas with high potential solar gain inputs (due to geographic setting) and a low percentage of canopy cover would be high priority areas for tree plantings to reduce stream temperatures. As an example of the efficacy of these actions, in one of our controlled experiments, artificial shading of only 800 m of stream reduced the summer stream temperatures by 2 C for over a mile downstream (Fink 2006). This shading effect is predicted to mitigate against the equivalent of up to a 4 C increase in air temperatures.

Nationwide, it is estimated that > 1 billion dollars has been spent on stream restoration activities in recent years (Bernhardt and Palmer 2006), with a substantial percentage of these projects involving riparian conservation and/or restoration. Projects targeting restoration of riparian areas are a priority of many federal and state agencies in addition to many Non-Governmental Organizations (NGO's) such as Chesapeake Bay Foundation, Trout Unlimited and the National Fish and Wildlife Foundation. These agencies and organizations focus on re-establishing forested riparian buffers because of the many potential benefits of an intact forested riparian corridor (Lowrance 1998) including but not limited to reduced stream temperatures. Restoration groups need to select projects that are strategic at various scales. Selecting and prioritizing riparian restoration projects that maximize limited restoration dollars have been a challenge because of the lack of prioritization tools at the appropriate scale. Further, restoration efforts that contribute to climate change resilience will be increasingly important, as demands are made on agencies to demonstrate the extent to which their activities foster adaptation to a changing regional climate.

The historic range of the Eastern brook trout comprises a generally forested landscape and the presence of forest cover appears to be generally positively associated with brook trout presence (Hudy et al. 2008). However, over their native range, trends in land use and forest cover over the last century have been highly heterogeneous with some areas (interior New England) exhibiting increases in cover, while others (central and southern Appalachians (particularly in lowlands and valleys), coastal and lowland northeast) have shown decreases (associated with agriculture, the forest products industry, and residential and urban development). At the same time, given broad recognition of the important role of intact riparian forests in promoting a range of ecological values, agencies at all levels have enacted best management practices and policies to conserve and restore them. The riparian cover layer of the RPCCR enables assessment of status and trends in riparian forests at a wide range of spatial scales up to range-wide. Further it allows calculation of the contribution of riparian restoration and conservation efforts to overall riparian and landscape-level forest cover at a range of scales.

Riparian Prioritization for Climate Change Resilience (RPCCR) Web-Based Decision Support Tool

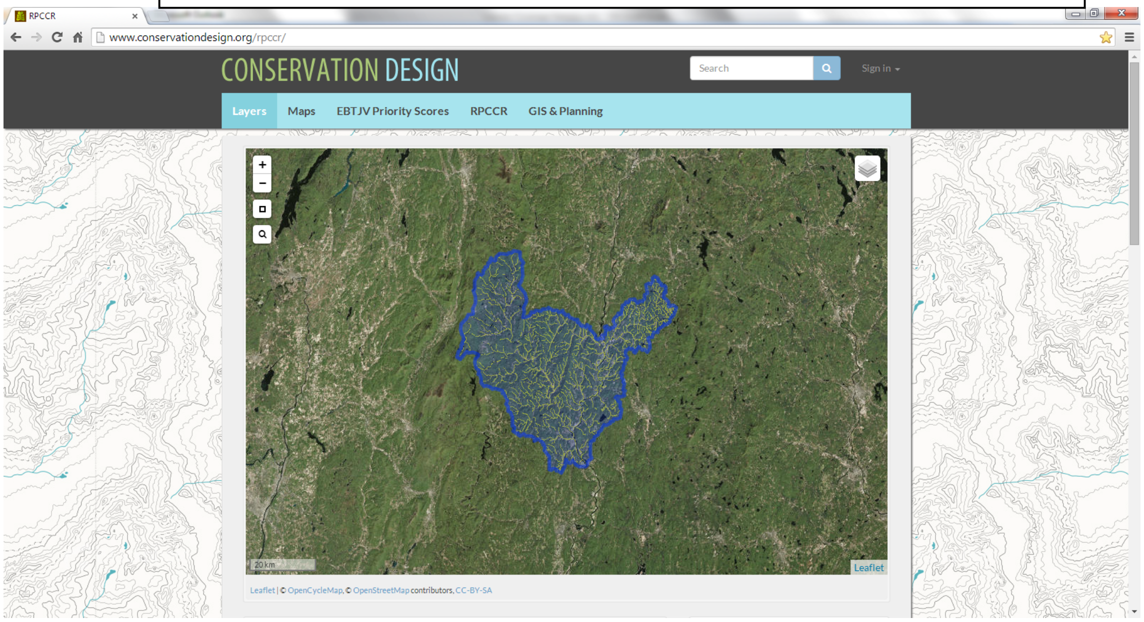
We developed and implemented a user-friendly web-based tool to identify priority areas for riparian restoration in the context of predicted climate change at the appropriate scale needed by practitioners. The Riparian Prioritization for Climate Change Resilience (RPCCR) tool, through static maps and a GIS server based system prioritizes riparian corridors (defined as within 100 meters of the NHD+ stream layer) within the target area. It is available on the Appalachian Landscape Conservation Cooperative website at:

http://www.conservationdesign.org/rpccr/

The RPCCR is focused on two essential metrics: metrics - solar gain and percent canopy cover – that jointly determine exposure of stream channels to direct insolation – a primary determinant of risk to warming in many small and elevation (Fu and Rich 1999; PRISIM 2007; USGS 2008; USGS 2009). The RPCCR allows users to select/specify an area of interest at any scale (from catchment to entire range) and identify sites with relatively high solar gain and low canopy cover. Two additional metrics in the initial dialog box, elevation and impervious surface can be used to further refine priority areas as the longitudinal distributions of many aquatic species (e.g. brook trout) are constrained by elevation (EBTJV 2006; Flebbe et al. 2006; Hudy et al. 2008) and impervious surface is an integrative metric of watershed development and ecological status.

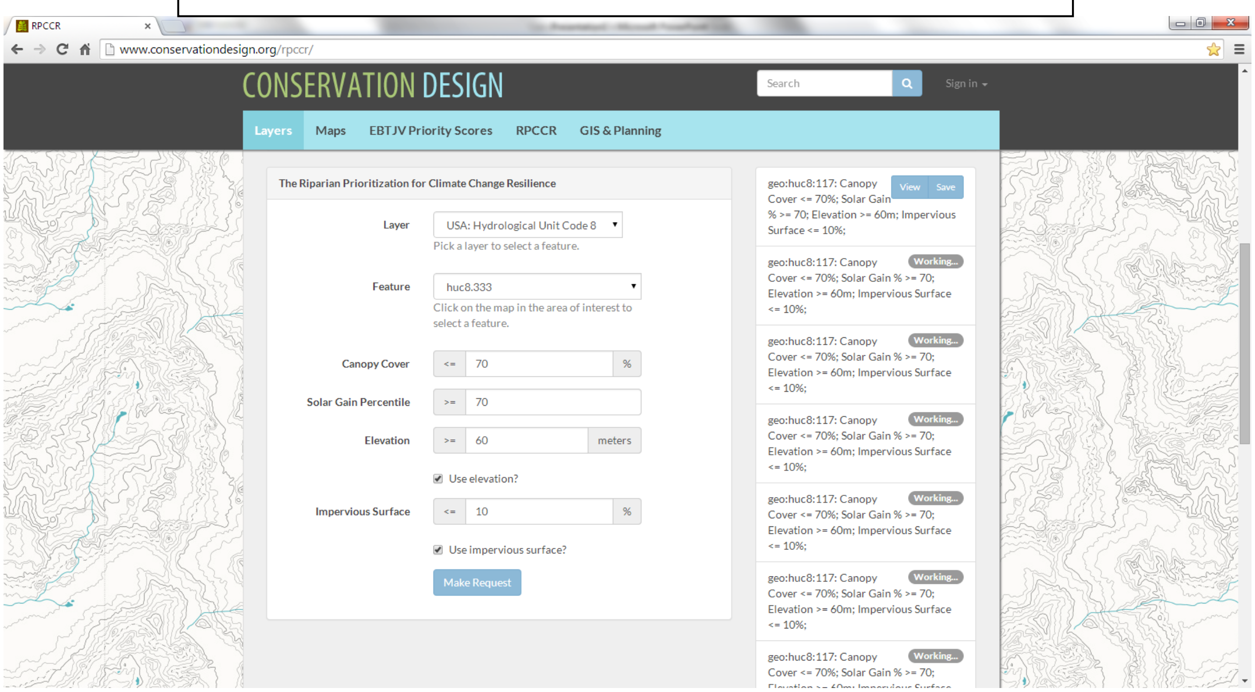
The user begins by selecting a spatial unit of interest (which can be either watershed or political-boundary-ba

Fig. 1 Selected watershed for RPCCR analysis



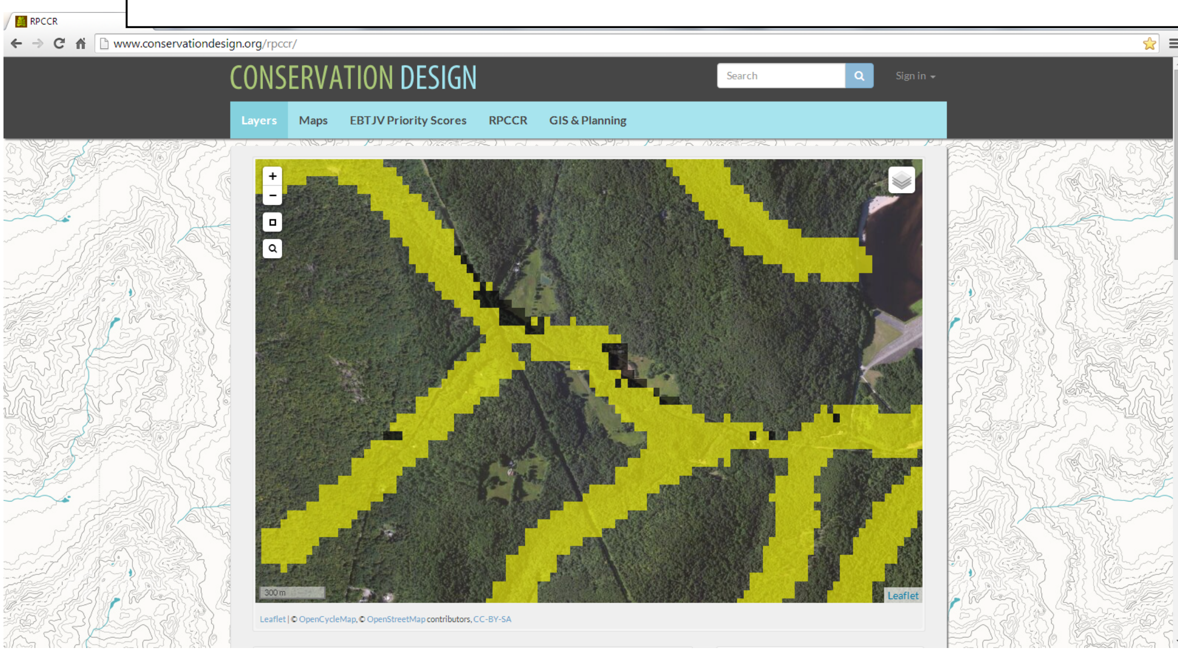
The user then can set values for solar threshold criteria (or use the default 70%) and also set thresholds for minimum elevation and impervious cover (Fig. 2). Once done the user hits the request report button.

Fig. 2 RPCCR Dialog box



The report returns an image with showing all pixels that meet the specified criteria, within the specified area, and these indicate priority sites for riparian restoration (Fig. 3). Reports are linked to GoogleEarth and GoogleMaps layers allowing users to orient and zoom in towards landmarks (roads, access points) and can be converted and saved as TIFF files for downloading, storage and export. The RPCCR tool is collocated and shares a web interface with the Eastern Brook Trout Joint Venture Status Assessment. As such, users can easily cross-reference brook trout status within the selected area, and use additional tools associated with the assessment as they are developed.

Fig. 3 Output from RPCCR report showing pixels meeting specified criteria (magnified)

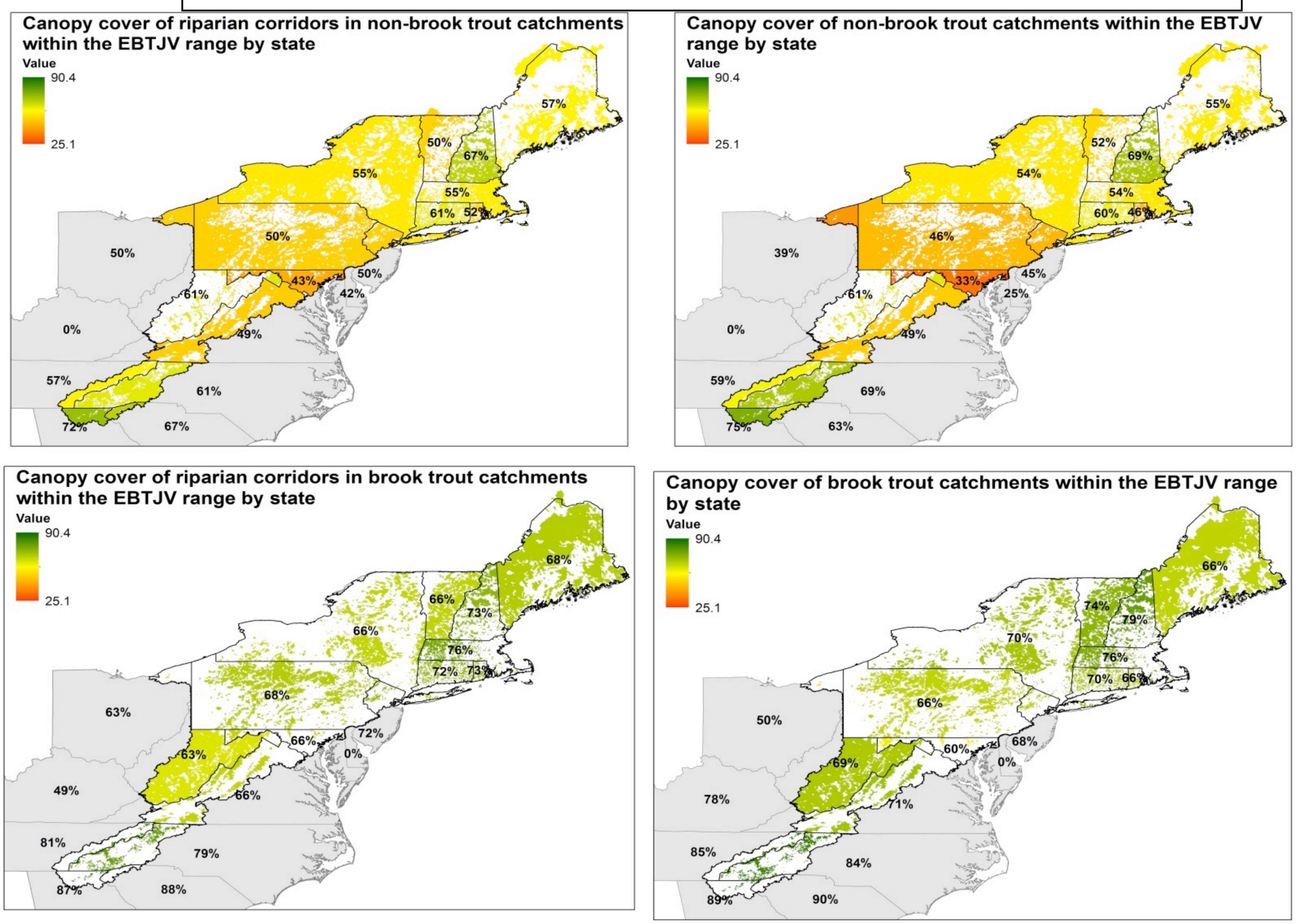


In developing the RPCCR, we presented our progress and brought in user and stakeholder input in workshops, EBTJV annual meetings and as contributors to a brook trout symposium at the Northeast Association of Fish and Wildlife Agencies meeting. This input has guided development throughout the duration of the project. The final rollout of the RPCCR is scheduled for the 2014 EBTJV annual meeting in September 2014.

<u>Riparian Forest Cover Status with the Eastern Brook Trout Historical Range</u>

Within the historic range forest cover differed substantially among states, between riparian corridors and entire catchments, and with respect to both riparian corridors and whole catchments for catchments occupied or unoccupied by brook trout or other salmonids (Appendix 1, Figs 4-5). Northern New England and the southern Appalachians had the highest levels of forest cover, with lower levels in southern New England and the mid-Atlantic states. There was some tendency for riparian corridors to have higher canopy cover than entire catchments, particularly in states with relatively low catchment-scale cover values, suggesting an influence of riparian management guidelines and protection. In general, however, riparian corridor and whole catchment values were closely correlated. Most striking however, was the substantially greater canopy cover, both with respect to catchment-level and corridor-level values, between brook trout/salmonid occupied compared to non-occupied catchments. These differences, suggest that while restoration in currently occupied patches offer some scope for increasing resilience to temperature change, adjacent unoccupied patches, because of their current lower values, may offer greater scope for positive change. Overall, this assessment serves as a robust benchmark for future change in canopy directly relevant to brook trout population persistence in a changing regional environment.

Figure 4. Among-state, among-status, and corridor-catchment differences in canopy cover



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