RELATING SPECIES RICHNESS, UPLAND COLDWATER FISH SPECIES, AND TEMPERATURE IN NORTH GEORGIA'S TROUT STREAMS

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Abstract. The Georgia legislature recently reduced the mandatory riparian buffer width on primary trout streams from 100 to 50 ft. To evaluate the potential effects of this policy change, the Trout Stream Buffer Study established 30 sites along primary trout streams in North Georgia. We investigated the relationships between fish diversity and temperature conditions. In 2001, fish population data were collected yielding relative abundance data on 49 fish species representing 8 families. Species richness was positively correlated with and significantly related to stream temperatures. Since previous studies have suggested that the species richness measure is likely not to reflect shifts in community composition from upland specialist to lowland generalist fish species, we conducted a preliminary investigation of the relationship between the relative abundance of highland endemic and upland restricted fish species and stream temperature. A significant negative relationship exists between increasing temperature and the relative abundance of highland endemic and upland restricted fish species. This suggests that stream temperature is one of the variables contributing to the distribution of upland coldwater and lowland warm water fishes.

INTRODUCTION

Examining the fish assemblages in North Georgia's primary trout streams is important for two reasons. First, the Georgia legislature decreased the mandatory riparian buffer width on primary trout streams from 100 to 50 ft in 2000. Since reductions in riparian forest cover may lead to higher stream temperatures and sediment loads, it is important to consider how this legislation may impact not only trout but also nongame fishes. Second, the southeastern United States is a hotspot of temperate fish diversity and endemism with the richest and most diverse fish fauna north of Mexico (Warren et al. 1997).

Current research has examined relationships between fish assemblages and habitat and landscape factors in the Etowah basin draining the Ridge and Valley region north of Atlanta, Georgia (Walters 2002) and also the French Broad and Tennessee basins draining the Southern Appalachians/Blue Ridge ecoregion of western North Carolina (Scott 2001). Less research relating fish assemblages to landscape factors has been done in the large area between these two study regions. This area includes portions of the Coosa, Chattahoochee, Tennessee, and Savannah basins and the majority of North Georgia's primary trout streams spanning the foothills and lower regions of the Southern Appalachians/Blue Ridge Mountain ecoregion.

In 2001, 30 sites were chosen using a cluster analysis method to represent the range of existing primary trout stream habitat in terms of elevation, stream basin area, and percent riparian forest cover in the Southern Appalachians/Blue Ridge ecoregion of North Georgia (Kundell et al. 2001). Selected sites vary in elevation (280 - 740 m), stream basin area (6 - 85 km^2), and percent riparian forest cover (29 - 100%). Ideally, these streams represent coldwater mountain streams with high-quality habitat capable of supporting coldwater native fish assemblages and fisheries (e.g., trout). Sites are located in the Coosa, Chattahoochee, Savannah, and Tennessee basins and across 10 counties (Figure 1). In making the final selections, we ensured: 1) the sites were well-distributed spatially; 2) no site was downstream from any other site (to ensure sampling independence); 3) at least two sites were located in each county within our sampling area to ensure study coverage across political county boundaries; and 4) each site had adequate access (Kundell et al. 2001). These streams are embedded within various land-use matrices including public Chattahoochee National Forest land, agriculture, private vacation homes, and urban areas.

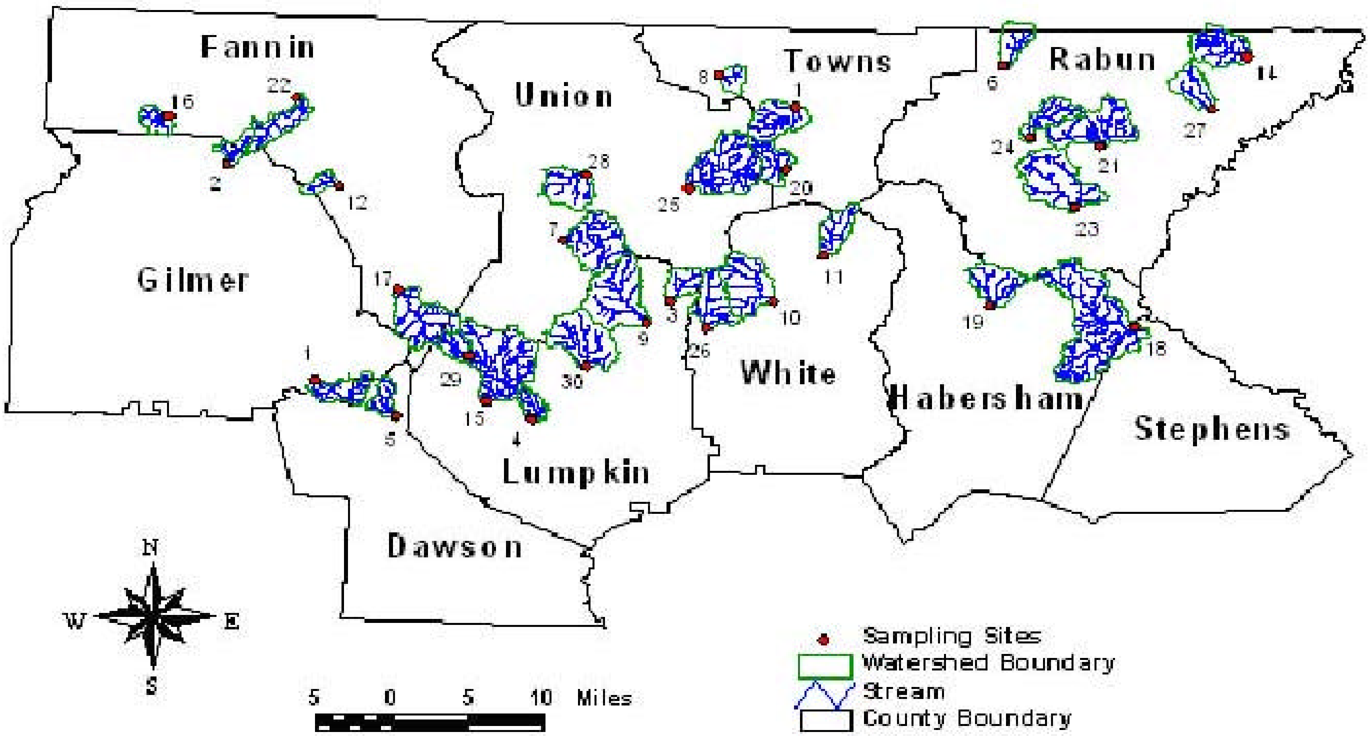

Figure 1. Locations for 30 sampling sites across 10 counties unties and 4 drainage basins in North Georgia (for further site information, see Kundell et al., 2001).

The objectives of this paper are to: 1) report on our summer 2001 sampling efforts; 2) examine the relationship between species richness and 2001 stream temperatures; and 3) offer a preliminary consideration of the relationship between the relative abundance of highland endemic and upland restricted fish species and stream temperatures in North Georgia's primary trout streams.

METHODS

Fishes were sampled at all 30 sites from June to August 2001 using an electro shocker, dip nets, and seine net. First, a designated 50 m reach containing a mixture of pool, riffle, and run habitats was shocked and seined in one pass for a quantitative fish sample. Second, we conducted extended qualitative sampling to capture any additional species. Overall, we sampled an area approximately 30 times the stream width at each site. Trout were released after being identified to species and by class (naturalized or stocked) and total length was measured (see Kundell et al. 2001 for methods). Nongame species caught within the 50 m reach were preserved in the field and identified in the laboratory.

Temperature data loggers (Onset Corporation HOBO®) were deployed at all sites from May – August 2001. Stream temperatures were recorded every 15 minutes. A temperature (°C) index was calculated by taking the average of the maximum daily stream temperatures during the warmest 7-day period of the year (M7DAM).

Fish species were divided into four categories following Scott (2001) and Mayden (1987): 1) highland endemics—species found only in higher elevations and are specialized for cold, swift water and coarse substrates conditions; 2) upland restricted species—species that tend to be located in upper elevations due to thermal tolerances; 3) lowland species—species that are native to the region and adapted to warmer temperatures, increased sediment loading, and higher nutrient conditions; and 4) cosmopolitan species—species that are considered habitat generalists and exotics with wide ranging distributions. For our purposes, naturalized rainbow and brown trout were included in the analyses as

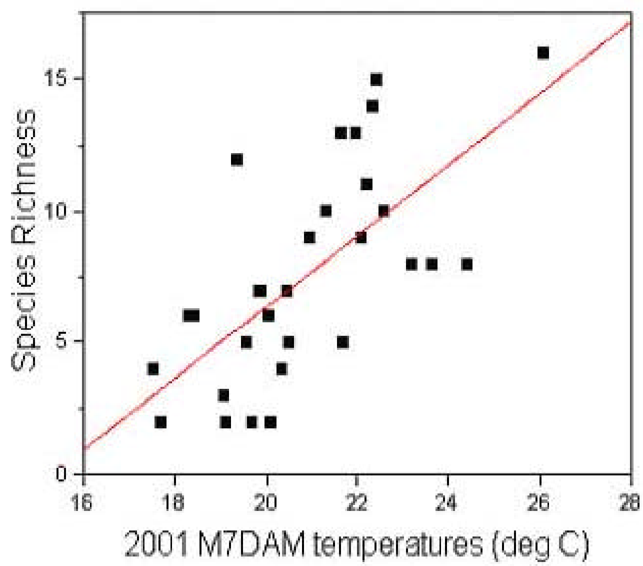

Figure 2. Species richness versus 2001 M7DAM stream temperatures (°C) (r^2 = 0.45; p < .0001).

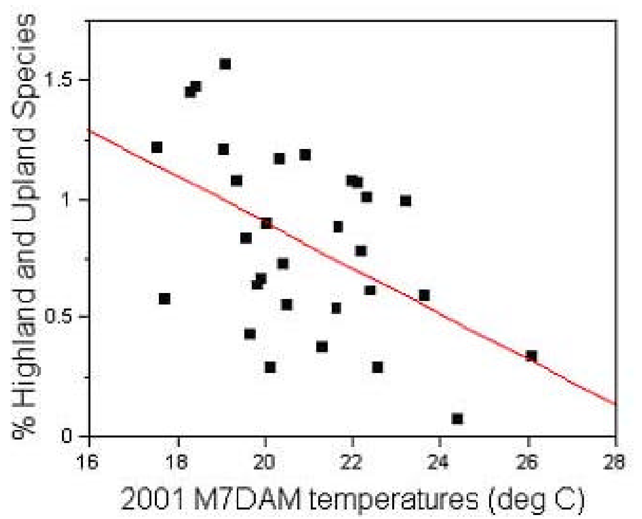

Figure 3. Relative abundance of highland endemics and upland restricted species versus 2001 M7DAM stream temperatures (r^2 = 0.25, p = 0.0045)

upland restricted species due to observed thermal tolerances (i.e., Kundell et al. 2001 and 2002). The relative abundance of highland endemic and upland restricted species was arcsine-square root transformed to increase normality and statistical power of analyses.

RESULTS

Overall, we collected 49 species (5,853 individual fish) representing 8 families. Species richness ranged from 2 to 16 per site. The family Cyprinidae made up 51.3% of the total catch. Other families include: Cottidae (32.1%), Salmonidae (6.2%), Percidae (4.3%), Catostomidae (3.6%), Centrarchidae (1.4%), Ictaluridae (0.8%), and Petromyzontidae (0.4%). *Cottus sp.* was the single most abundant species (32.1% of total catch) and was collected at 21 of the 30 sites.

Species richness, measured simply as the number of species per site, was related to 2001 M7DAM temperatures (Figure 2). The positive correlation between these two variables was significant (r^2 = 0.45; p < .0001). Highland endemics and upland restricted species were combined into one group, as were lowland and cosmopolitan species. We related the relative abundance of highland endemic and upland restricted species to stream temperatures (Figure 3) and found a significant negative relationship (r^2 = 0.25; p = 0.0045).

DISCUSSION

Our sampling collection efforts illustrate that naturalized rainbow and brown trout make up a relatively small proportion of the fish assemblages (~6%). Concentrating solely on trout presence may ignore other components of fish assemblages in North Georgia that may also be indicative of the health of these streams. Centrarchid species comprised a small (1.4%) proportion of our sample, or never more than 6.8% of the fishes at a site. These species are often considered as indicators of sediment impairment in the Southeast (Jones et al. 1999 and Walters 2002). This suggests that the habitat conditions of a majority of streams sampled were relatively good, but at those sites where centrarchids were present, habitat conditions may be degrading and stream temperatures warming.

Species richness is positively correlated with 2001 M7DAM temperatures (Figure 2). This significant trend is expected, as warmer streams tend to be more nutrient rich and have a higher level of productivity than cooler streams. Scott and Helfman (2001) have suggested that species richness is a misleading bioassessment metric because typically there is no discrimination made between species traditionally found in a location and invasive species. Since species richness highlights the number of species per site while sacrificing a more detailed description of the types of fish present, we conducted a preliminary investigation into the relative abundance of highland endemic and upland restricted species in relation to stream temperature. In general, as stream temperatures increase, the relative abundance of these coldwater species declines, suggesting that temperature change is one possible variable influencing these fish assemblages. Since a large amount of variance exists in this relationship, the roles of other factors such as habitat degradation via sediment loading and natural background factors such as stream slope should also be considered. These preliminary findings support conclusions reached in more detailed studies (e.g., Scott 2001, Scott and Helfman 2001, and Walters 2002), which have argued that stream temperature increases caused by development and deforestation will extend the range of lowland and generalist species at the cost of restricting the ranges of highland endemics and upland restricted species including trout.

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