Environmental Studies/Summer

1. Abstract
The pristine mountain and densely forested streams that once greatly persisted in southern Appalachian watersheds are dwindling due to urbanization. In today's populated world urbanization has greatly affected aquatic ecosystems and streams exist in both urban and rural areas. Human impacts can greatly affect a stream's productivity, water chemistry, physical habitat and species richness and abundance. The health of a river has been shown to decline with increased land-use pressure. This study will look at the difference in species existing at rural and urban streams in the upper French Broad River basin. Species-area curves will be used to estimate species diversity in urban and rural streams. A 2004 study sampled sixteen sites in the upper French Broad river basin, concluding that urbanization did affect fish assemblages. This study will provide a stronger test of this paper's conclusions, by replicating its methods and sampling additional sites, and including watersheds of different sizes.

2. Description of Research

Introduction

Streams that drain highly urbanized land undergo ecological degradation. The degradation incurred is referred to as the urban stream syndrome (Walsh et al., 2005). Some of the destruction caused by the drainage of urban land into streams includes: an increase in nutrients and contaminants, alterations in the channel, a reduction in biotic richness, inconsistent stream flow and a rise in the dominance of tolerant species (Walsh et al., 2005). All of the effects of urban stream syndrome can alter the species present in particular habitats. If the environment becomes inhospitable for an intolerant fish they must relocate or perish as a result of altered conditions. Ecosystem function such as primary and secondary productivity is believed to be affected by urbanization and is thought to vary with the extent of urbanization (Meyer, 2005). Highly urbanized areas will affect stream function with a greater impact than a less urbanized or nonurban area. Stream health as well as biotic integrity is compromised by urbanization (Walters et al., 2009), with stream chemistry altered by an increase in heavy metals and other chemicals (Perryman, 2011).

A recent study on the relation between environmental characteristics and fish assemblage in the upper French Broad River concluded that the degree of watershed urbanization had an effect on fish assemblages. A multivariate analysis revealed that human impacts reduced the food source available to fishes in urbanized areas which led to a decline in specialized insectivore species. In addition the results of this study found that population density and urban land cover were linked with higher metal concentrations. Results showed that an increase in nonnative and invasive species is possible with the altered conditions resulting from anthropogenic impacts. (Rashleigh, 2004)

The objectives of this study are to use species areas curves to quantify the effects of urbanization on fish species diversity. Species area curves provide a comparison of urban and non-urban streams without watershed area skewing the results. Based on the effects urbanization has on ecosystem health in rivers and streams, I hypothesize that there will be fewer fish in urban watersheds of a given size compared to non-urban watersheds. The findings from this study will help to implicate proper management tactics needed to preserve aquatic ecosystem health.

Methodology

Study Sites

The French Broad River flows through the Appalachian Mountains originating near the border of North and South Carolina and flowing north into Tennessee. Seventy percent of the river basin is forested and Asheville, North Carolina is the major urbanized area affecting the river (Rashleigh, 2004). The river basin contains over 4,000 miles of streams and drains 2,800 square miles of land (DENR, 1998). The

mountainous river basin contains an igneous and metamorphic river bed (USGS, 1971). Agricultural runoff, urban runoff and construction have been major contributors to the decline in water quality in the upper French Broad River basin (DENR, 1998). The sites sampled will include both urban and nonurban streams in the upper French Broad river basin. The urban watersheds will include: Mud Creek, Swannanoa River, Hominy Creek, Reed Creek and Smith's Mill Creek. A total of twenty-three sites will be sampled from these urban watersheds. The non-urban watersheds will include: Cane Creek, Big Laurel Creek, Mills River, Bent Creek and Avery Creek. A total of twenty-three sites will be sampled in these non-urban watersheds.

Sampling Methods

The same techniques used in Rashleigh's (1997) study will be implemented in this study to ensure the most accurate analysis of how urbanization affects fish assemblages. A backpack electro-fisher will be used to collect samples at approximately forty-six sites. A single pass will be made in an upstream direction. Seining will be used when necessary to complement the electro-fisher. The seine will be mostly used for deep pools which the electro-fisher may not be able to access. A length of stream equal to twenty times the stream's width will be used as the sample area at each site. Two pools and two riffles will be included in each of the sites sampled. One collective sample will be produced from the various habitats sampled within each site. Fishes will be identified in the field and any samples that cannot be identified will be preserved and taken to the lab for identification. Some habitat data will be collected at each site including; maximum depth, stream width, temperature, conductivity, dissolved oxygen, turbidity and minimum and maximum flow in the channel. Elevation and coordinates will also be recorded for each site sampled.

Analysis

Species diversity among sites sampled will be measured using species-area curves. A comparison of the number of species to habitats of varying size can be made using species area curves (Angermeier and Schlosser, 1989). "Ecological response curves can provide valuable insight into causal relationships between land-use impact and a decline in stream condition" (Karr, 1999). The species diversity in urban and nonurban streams will be compared based on the data collected and the formulated species-area curve. One curve will demonstrate the number of fish species in relation to the watershed area of urban watersheds. A second curve will demonstrate the number of fish species in relation to the watershed area of non-urban watersheds. Habitat complexity such as stream width, depth and current will be correlated with species richness and abundance in both urban and nonurban streams (Angermeier and Schlosser, 1989).

Body

Anthropogenic pressure on land use influences rivers globally by affecting their ecological status (Allan, 2004). Visible effects are seen on stream integrity that is drained by land with any levels of impervious cover above zero (Clapcott, 2012). Severe ecosystem affects are caused by highly urbanized areas. By understanding the direct and indirect effects urbanization has on ecosystems, regulations can be implemented to diminish the harmful effects. Fish are good indicators of ecological health within an aquatic ecosystem. By understanding the affect land use has on fish assemblage we can formulate an idea on the effects urbanization has on the health of the stream. The implications that urbanization has on biodiversity can be quantified using a species-area curve. This will give management policies a workable figure to ensure the preservation of rivers and streams in urbanized areas. Without necessary management the decline in biological integrity could occur (U.S. Environmental Protection Agency, 2011).

3. Time Period

The proposed research will begin with most of the sampling conducted during the month of May and continuing through August until all forty-six sites have been sampled. The data analysis will take place during the summer months through early fall.

4. Proposed Budget

Item	Quantity	Source	Price Per Unit	Total Price
Battery for HT2000 Electrofisher	1	Halltech, Inc.	300.00	300.00
Charger for HT2000 Electrofisher Battery	1	Halltech, Inc.	400.00	400.00
Travel to Study Sites	700 miles total to 16 watersheds	UNC-Asheville	0.37 (minvans) and 0.41 (SUV)	270.00
"Rite in the Rain" Notebook for recording data	1	Forestry Suppliers, Inc.	15.30	15.30
Student Stipend				1,500.00
Total				**$2,485.30**

5. The research and findings will be presented at the undergraduate research symposium at UNCA in the Spring of 2013, and submitted for publication to the UNCA Journal.

6. References

Allan J.D. 2004. Landscapes and riverscapes: the influence of land use on stream ecosystems. *Annual Review of Ecology, Evolution and Systematics* 35: 257–284.

Angermeier, P. L. and I. Schlosser. 1989. Species-area relationships for stream fishes. *Ecology* 70 (5): 1450-1462.

Clapcott J.E., Collier K.J., Goodwin E.O., Harding J.S., Kelly D., Leathwick J.R. and Young R.G. 2012.Quantifying relationships between land-use gradients and structural and functional indicators of stream ecological integrity. *Freshwater biology* 57: 74–90.

Harmsworth G. R., Young R. G., Walker D., et al. 2011. Linkages between cultural and scientific indicators of river and stream health. *New Zealand Journal of Marine and Freshwater Research.* 45 (3): 423-436.

Karr, J.R. 1981. Assessment of biotic integrity using fish communities. *Fisheries* 6: 21–27.

Meyer, J.L., Paul, M.J. and Taulbee, W.K. 2005. Stream ecosystem function in urbanizing landscapes. *Journal of the North American Benthological Society.*24 (3): 602-612.

North Carolina Department of Environment and Natural Resources. 1998, Basinwide assessment report: French Broad River Basin. Division of Water Quality, Raleigh, North Carolina: 203.

Perryman, S. E., Rees, G. N. and Grace, M. R. 2011. Sediment bacterial community structure and function in response to C and Zn amendments: urban and nonurban streams. *Journal of the North American Benthological Society*. 30 (4): 951-962.

Rashleigh B. 2004. Relation of environmental characteristics to fish assemblages in the Upper French Broad River Basin, North Carolina. *Environmental monitoring and assessment* 93: 139-156.

U.S. Environmental Protection Agency. 2001, Protecting and Restoring America's Watersheds. EPA 840-R-00-001: 56.

U.S. Geological Survey.1979, Water Quality of the French Broad River, North Carolina, Water Resource Investigations 79-87. Raleigh, North Carolina, 53 pp.

Walsh, C.J., A. Roy, J. Feminella, P. Cottingham, P. Groffman and R. Morgan. 2005. The urban stream syndrome: current knowledge and the search for a cure. *Journal of the North American Benthological Society.*24(3): 706-723.

Walters, D.M., A. Roy and D. Leigh. 2009. Environmental indicators of macroinvertebrates and fish assemblage integrity in urbanizing watersheds. *Ecological Indicators.* 9 (6): 1222-1233.