BURIED ALIVE: POTENTIAL CONSEQUENCES OF BURYING HEADWATER STREAMS IN DRAINAGE PIPES

Judy L. Meyer[1], Geoffrey C. Poole[2], Krista L. Jones[3]

AUTHORS: [1]Professor, Institute of Ecology, University of Georgia, Athens, GA 30602; [2] Systems Ecologist, Eco-metrics, Inc., 2520 Pine Lake Rd., Tucker, GA 30084 and Adjunct Research Scientist, Institute of Ecology, University of Georgia, Athens GA 30602; and [3] Graduate Research Assistant, Institute of Ecology, University of Georgia, Athens, GA 30602.

REFERENCE: *Proceedings of the 2005 Georgia Water Resources Conference*, held April 25-27, 2005, at the University of Georgia. Kathryn J. Hatcher, editor, Institute of Ecology, The University of Georgia, Athens Georgia.

Abstract. We investigated the potential impact of a Georgia regulation that allows individual landowners to encase 200-ft sections of small (<25 gal/min mean annual flow) headwater trout streams in buried drainage pipes. In the Blue Ridge physiographic province in North Georgia, 41% of privately held lands drain into these small streams. Hence this regulation applies to a large fraction of the mountain landscape. Small headwater streams in this region have a diverse aquatic biota (~30 taxa) indicating good water quality (10-14 EPT taxa), even though some of the streams are intermittent. Aquatic insects drifting downstream provide food for drift-feeding fishes such as trout. Insect drift immediately downstream from a buried reach was predominantly oligochaetes, indicative of poor water quality, whereas there were 5-6 EPT taxa in the drift from forested headwaters. Burying streams in pipes eliminates aquatic habitat. The impact of this regulation depends upon how widely it is applied, but it has the potential to impact a significant fraction of aquatic habitat in the headwaters of Georgia's trout streams.

INTRODUCTION

Small streams are a common feature of forested mountain landscapes. They recharge the shallow groundwater, maintain water quality, reduce downstream flooding, and provide habitat for aquatic organisms. The aquatic insects that drift downstream from the headwaters provide food resources for drift-feeding fishes. As land development occurs, many small streams are lost from the landscape by burial and piping; for example, drainage density (km stream channel/km^2 catchment) in forested catchments of the Chattahoochee River is 1.35 km/km^2, whereas it is only 0.91 km/km^2 in more urbanized catchments (Meyer and Wallace, 2001).

In 2000, the Georgia legislature passed House Bill 1426 permitting an individual landowner to encase up to 200 feet of any trout stream headwater in a drainage pipe if the stream's mean annual flow is < 25 gal/min (gpm). We initiated this study to examine the potential consequences of this regulation in the Blue Ridge physiographic province. The study had two objectives: (1) Determine the extent of private lands drained by stream channels that could be buried to assess the portion of the Blue Ridge landscape potentially impacted by this regulation; and (2) Assess the potential impact of these drainage pipes on aquatic life in headwater streams in the Blue Ridge.

METHODS

Previous research in the Blue Ridge of North Georgia showed that streams with perennial flow drain catchments of 11 - 32 acres, whereas streamflow is intermittent in channels with smaller catchments (Rivenbark and Jackson, 2004). A defined stream channel can first be recognized in Blue Ridge catchments when they reach about 7 acres in size, and catchments of 16 acres yield a mean annual flow of 25 gpm (Rivenbark and Jackson, 2004). Based on extensive data presented in Rivenbark and Jackson (2004), we considered streams with catchments of 7 - 16 acres as being eligible to be buried in drainage pipes.

The study area was the Blue Ridge physiographic province in North Georgia, which includes all or part of the following counties: Murray, Gilmer, Pickens, Fannin, Dawson, Union, Lumpkin, Towns, White, Rabun, Habersham and Stephens (Figure 1). We assessed the extent of the Blue Ridge landscape drained by streams that could be buried in pipes under the regulation with a GIS database and analysis. Using a USGS 30-m digital elevation model (DEM) of the study area, we generated a flow accumulation grid to identify the drainages between 7 and 16 acres in size. The outlet of each of these drainages was identified, and its catchment mapped. Any

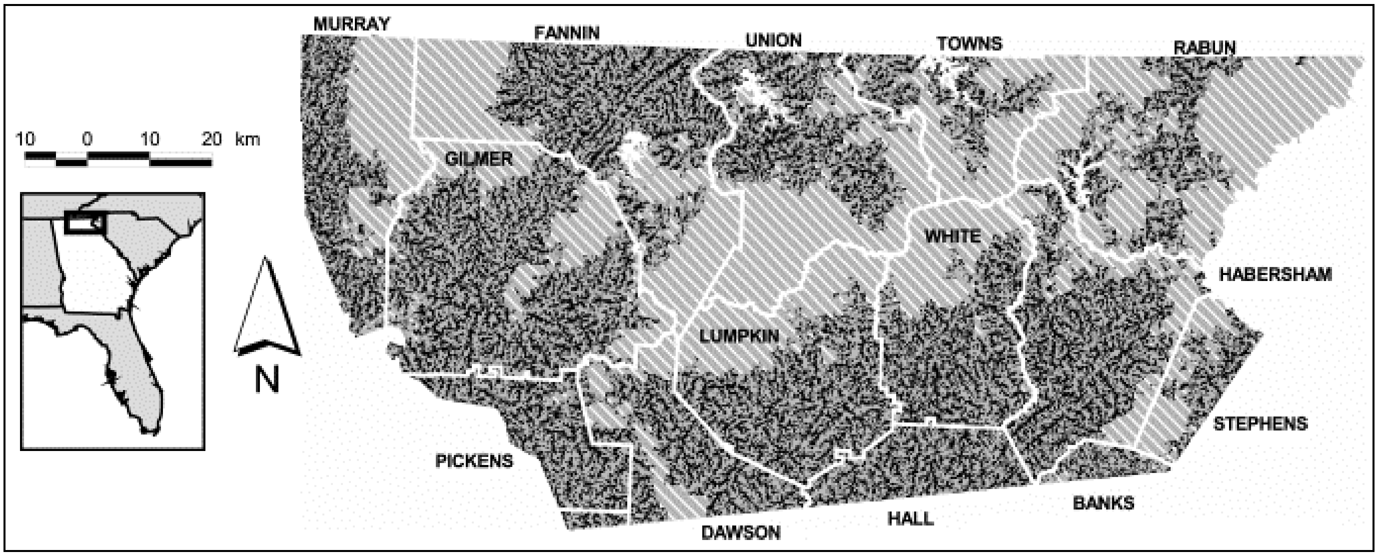

Figure 1. Landscape pattern of basins draining into streams that could be buried. Areas identified in black are basins in private ownership that are 7 to 16 acres in size. These basins are large enough to drain into streams with defined channels and an average annual flow < 25 gpm. Hatched areas are public/conservation lands.

DEM grid cell contained within one of the identified catchments was identified as either private or public lands. A map of Georgia Conservation Lands from the Natural Resources Spatial Analysis Laboratory (Institute of Ecology, University of Georgia) enabled us to distinguish between private vs. public lands in the study area. For this analysis, we consider only private lands, since streams on these lands could be put in drainage pipes by individual landowners. The number of grid cells in the 7 - 16 acre catchments on private lands was summed to determine the private land area potentially affected by the regulations.

To assess the impact of stream burial on aquatic life, we sampled both benthic and drifting insects. The benthic insects were sampled in three small streams that had been gaged by Rivenbark and Jackson (2004). In March 2002, four replicate Surber samples were collected in riffle habitats of each stream by disturbing the streambed for 3 min.

Drifting insects were sampled at the drainage pipe outlet of a buried stream in addition to the three streams sampled for benthic insects. Because state and local issuing authorities do not have a formal mechanism for tracking streams that have been buried, we were only able to locate one small stream in the region that had been routed through a drainage pipe. A French drain collected water from a headwater seep, and a parking lot was built over the 190 ft pipe. The piped section did not receive stormwater runoff from the parking lot. The drift net was placed about 8 inches downstream from the end of the pipe. Nets were in place at all sites for two hours before and after sunset, the time period of maximum drift. All invertebrates were picked from the > 1 mm size fraction, stored in ethanol, and identified to genus when possible.

All samples were washed through sieves, and invertebrates were picked from the > 1 mm fraction, stored in ethanol, and identified to genus when possible. Benthic samples were measured for length, and biomass was estimated using standard length-mass equations (Benke and others, 1999; Sample and others, 1993).

RESULTS

The study area has 1.29 million acres in private land. Of that area, 524,000 acres drain into streams that could be buried under current regulations (Figure 1). Thus 41% of private lands in the Blue Ridge of North Georgia drain into headwater trout streams that could be buried for distances up to 200 feet by individual landowners under current state regulations.

The small streams sampled had a diverse benthic fauna (Table 1). A total of 54 taxa were collected at all sites, and the number of taxa per site ranged from 29 to 35. Aquatic insects that are in the orders Ephemeroptera, Plecoptera, and Trichoptera (mayflies, stoneflies and caddisflies: EPT taxa) are used as indicators of high stream water quality. The three forested headwater streams sampled each had 10 - 14 taxa in these three groups, indicating high water quality. Abundance of aquatic life in the small streams ranged from 465 to 2,249 individuals/m^2, and biomass ranged from 724 to 1285 mg/m^2. Despite the fact that two of these streams do not flow throughout the year (Rivenbark and Jackson, 2004), all streams support aquatic life that is indicative of high

Table 1. Abundance and biomass of aquatic organisms in the benthos and downstream drift in three forested headwater streams and one buried stream in the Blue Ridge of North Georgia. The forested sites are identified as in Rivenbark and Jackson (2004); (i) denotes an intermittent stream. Values presented are mean ± standard error.

Site	Benthos # taxa	Benthos # EPT taxa	Benthos #/m^2	Benthos mg/m^2	Drift # taxa	Drift # EPT taxa	Drift #/100 m^3
O (i)	35	14	465 ± 198	1285 ± 280	9	4	194
P (i)	29	12	2249 ± 1117	724 ± 200	18	6	1984
N	32	10	506 ± 320	1206 ± 537	22	7	57
Buried	--	--	--	--	3	1	130

water quality.

Insects drifting downstream from the three forested headwater streams were also diverse and indicative of high water quality. From 9 to 22 taxa were found in the drift samples from each stream, 4-7 of which were EPT taxa. In contrast, only one EPT organism was captured in the drift net below the buried stream, and 89% of the organisms collected from that stream were aquatic worms, which are indicative of poor water quality.

DISCUSSION AND CONCLUSIONS

The taxonomic richness and invertebrate abundance we report here is an underestimate of what can be found in headwater streams in the Blue Ridge. This is because we sampled the streams only once and counted only organisms > 1 mm. Organisms >250µm collected from three Blue Ridge streams of similar size (12 - 17 acres) sampled throughout the year are more abundant and diverse than we report (Lugthart and Wallace, 1992). In those more intensely sampled streams, invertebrate abundance ranges from 58,000 to 174,000 individuals/m^2 from over 60 taxa (Lugthart and Wallace, 1992). Those small streams have 18-20 EPT taxa (Wallace and others, 1996). Even very small streams in the Blue Ridge have an abundant and diverse invertebrate fauna, which is eliminated where the stream flows through a pipe.

Stream burial is a common practice as urban centers develop. For example, as the catchment of Rock Creek, Maryland, became more urbanized, 59.5 km of stream were lost, reducing drainage density by 58% (Leopold, 1994). Burying streams is now recognized as a practice with environmental costs, and communities are seeking to rediscover buried stream channels. For example, a group in Toronto has produced maps showing hikers the location of buried streams, inviting them to take "lost river walks" (http://www.lostrivers.ca).

Despite the prevalence of buried streams, there is not a rich literature of studies on them. *E. coli* concentrations were doubled below buried sections of a Virginia stream because a microbial mat that developed on the interior of the pipe was vulnerable to sloughing and downstream transport (Simmons et al., 2002). Concentrations of pesticides were higher in a buried section of an agricultural stream in Sweden than in its open sections (Kreuger, 1998).

Much of our understanding of the impacts of stream burial comes from the improvements seen when streams are removed from pipes, an increasingly common stream restoration practice known as "daylighting." One classic study of this in Strawberry Creek, California, showed decreases in fecal coliform levels and increasing taxa richness of invertebrates after sections of a stream were daylighted (Charbonneau and Resh, 1992). Communities across the nation are spending millions of dollars to remove streams from pipes (Pinkham, 2000); in contrast, current state regulations could result in an increase in buried streams in the North Georgia mountains. The potential impact of this is dependent on how many stream sections are buried.

Burying one section of a single headwater stream will eliminate 200 feet of aquatic habitat and reduce the amount of insect drift immediately below the pipe. A single length of pipe will have only a local effect. What is of greater potential impact is the cumulative effect of many individual sections of pipe. Each individual landowner can bury 200 feet of each headwater stream on a piece of property, and there can be many landowners in the headwaters of a trout stream. The fact that we were able to locate only one buried section to sample suggests either that permit-issuing authorities are not keeping complete records of pipe installations or that very few streams have been buried under this regulation to date.

The future impact of this regulation depends upon how many sections of stream are buried. As our landscape analysis demonstrated, the potential for cumulative impact is great because a large fraction, 41%, of the privately-owned Blue Ridge landscape drains into headwater trout streams that may be buried. Some limits on the number or proportion of headwater streams that can be buried within a drainage network could reduce the potential damage to Georgia's valuable trout streams.

ACKNOWLEDGEMENTS

Thanks to: Lane Rivenbark, Sabrina White-scarver, Austin Meadows, and Drew Taylor for assistance in the field; Drew Taylor, Keneshatta Watkins, and Grant Galland for picking samples in the lab; Sue Eggert for insect identification; and many North Georgia landowners for allowing us to sample streams on their property. We received funding for this study from Georgia Environmental Protection Division through the Vinson Institute for Government, University of Georgia.

LITERATURE CITED

Charbonneau, R. and V.H. Resh. 1992. Strawberry Creek on the University of California, Berkeley Campus: A case history of urban steam restoration. Aquatic Conservation: Marine and Freshwater Ecosystems 2: 293-307.

Kreuger, J. 1998. Pesticides in stream water within an agricultural catchment in southern Sweden, 1990-1996. The Science of the Total Environment 216: 227-251.

Leopold, L.B. 1994. *A View of the River*. Harvard University Press, Cambridge MA.

Lugthart, G.J. and J.B. Wallace. 1992. Effects of disturbance on benthic functional structure and production in mountain streams. Journal of the North American Benthological Society 11: 138-164.

Meyer, J.L. and J.B. Wallace. 2001. Lost linkages and lotic ecology: rediscovering small streams. In: M.C. Press, N.J. Huntly and S. Levin. *Ecology: Achievement and Challenge*. Blackwell Science. pp. 295-317.

Pinkham, R. 2000. *Daylighting: New Life for Buried Streams*. Rocky Mountain Institute, Snowmass, Colorado. 73pp.

Rivenbark, B.L. and C.R. Jackson. 2004. Average discharge, perennial flow initiation, and channel initiation - small southern Appalachian streams. Journal of the American Water Resources Association 40(3): 639-649.

Simmons, G.M. Jr., D.F. Waye, S. Herbein, S. Myers, and E. Walker. 2002. Estimating nonpoint source fecal coliform sources using DNA profile analysis. In: *Advances in Water Monitoring Research*. T. Younow (ed.) Virginia Water Resources Research Center. Water Resources Publications, LLC, P.O. Box 260026, Highlands Ranch, Colorado 80163-0026. pp. 143-167.

Wallace, J.B., J.W. Grubaugh and M.R. Whiles. 1996. Biotic indices and stream ecosystem processes: results from an experimental study. Ecological Applications 6: 140-151.