BROOK TROUT MOVEMENT WITHIN A HIGH-ELEVATION WATERSHED: CONSEQUENCES FOR WATERSHED RESTORATION

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Abstract.—We used radio-telemetry to quantify brook trout (*Salvelinus fontinalis*) and brown trout (*Salmo trutta*) movements in the Shavers Fork of the Cheat River, West Virginia, and an adjacent second-order tributary (Rocky Run). Our objectives were to quantify the overall rate of trout movement, assess spatial and temporal variation in movement behaviors, and relate movement behaviors to variation in stream flow, water temperature, and access to coldwater sources. Brook trout residing in the small tributary demonstrated extremely low movement rates in summer and fall. In contrast, main stem trout exhibited high overall movement rates in the summer but low rates in the fall. Brook trout had a strong tendency to move upstream throughout the summer followed by a final pulse into smaller tributaries to spawn in the fall. Brook trout movements during the summer were significantly related to both maximum water temperature and the distance of fish from a coldwater source. These data indicate that trout inhabiting larger streams are capable of moving considerable distances to access required habitat, such as coldwater refuges and spawning habitat. Our results underscore the importance of a watershed-scale perspective for successful conservation and management of wild trout populations in this region.

INTRODUCTION

Physical, chemical, and biological factors exist within lotic systems as a complex patchwork, rather than as the smoothly continuous gradients of conditions often seen on land (Kotliar and Weins 1990, Giller and Malmqvist 1998). These factors can change dramatically on a temporal and spatial basis (Hildrew and Giller 1994). In particular, stream flow, water temperature, and invertebrate prey densities may vary significantly on a yearly, seasonal, daily, and even hourly basis. As a consequence, stream fishes often experience optimal, suitable, and poor habitat patches within the same general area depending on the time of the year and climatic conditions. In addition, trout require a variety of non-substitutable complementary habitat types (critical refuges, foraging habitat, spawning habitat) to complete their life cycle (Schlosser 1991, Behnke 1992, Schlosser and Angermeier 1995). Anthropogenic impacts usually reduce habitat complexity and quality while increasing the linear distance between high-quality non-substitutable complementary habitat types (Albanese et al. 2004). In response, stream fishes utilize specific sites (microhabitats) that blend an acceptable suite of physical, chemical, and biological characteristics possibly at several spatial scales, depending on conditions and needs (Dolloff et al. 1994, Young 1995, Torgersen et al. 1999).

Given these complexities, the ability of stream fishes to maximize survival, reproduction, and growth depends strongly on their ability to assess habitat quality and to move between different habitat types as needed (Berman and Quinn 1991, Gibson 1996, Torgersen et al. 1999). Movement denotes motion on a small scale, allowing individuals to utilize the best habitat for feeding, reproduction, and refuges from predators and environmental extremes on a daily and seasonal basis (Schlosser 1991, Meyers et al. 1992, Schlosser and Angermeier 1995, Gowan and Fausch 1996, Burrell et al. 2000, Gowan and Fausch 2002). Migration is used to describe extended, directional movement that is an integral part of the life cycle (Behnke 1992). Migration enables fish to reach habitats required

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annually by different life-history stages and to exploit refuges from large-scale disturbances (e.g., floods). Migration also allows gene flow and demographic rescue for small populations, and colonization or recolonization of unoccupied habitats (Northcote 1997, Swanberg 1997, Roghair and Dolloff 2005). Recently Fausch et al. (2002) used the term "ranging behavior," commonly used in landscape ecology and metapopulation biology, to describe fish movement. The main characteristic is not unidirectional movement, as the term "dispersal" implies, but long-distance movement that ceases when fish encounter patches with suitable resources (Fausch et al. 2002). For simplicity, we will use the term "movement" in general terms. Researchers have confirmed that *Salmonidae*, and brook trout (*Salvelinus fontinalis*) in particular, exhibit high levels of movement despite continued discussions over extent, timing, and duration (Curry et al. 2002, Rodriquez 2002).

A complete understanding of trout movement and habitat use is therefore critical to fisheries and resource professionals to properly manage trout fisheries in a watershed context, and to enhance or restore their functionality when needed. Nevertheless, few studies have explicitly sought to link trout movements to spatial and temporal variability in habitat quality, especially over multiple seasons within both main-stem lotic systems and smaller associated tributaries (Maki-Petays 1997, Bunnell et al. 1998, Burrell et al. 2000). The objectives of our study were to: 1) quantify the overall rate of trout movement; 2) assess spatial and temporal variation in movement behaviors; and 3) relate movement behaviors to variation in stream flow, water temperature, and access to coldwater sources (CWSs). We will briefly present our results with an emphasis on demonstrating how the data can be used as a guide for future in-stream restoration that meshes with federal (U. S. Forest Service [USFS] Monongahela National Forest Plan), state (Back the Brookie, overall conservation effort), and local goals for the watershed. This watershed is a stronghold for native brook trout in West Virginia and is recognized as such within the Eastern Brook Trout Joint Venture (EBTJV), a national multi-agency partnership established in 2004 to conserve, protect, and re-establish native brook trout through cooperative efforts.

STUDY AREA

The study area was located entirely within the Monongahela National Forest and on Snowshoe Ski Resort property in central West Virginia. We conducted fieldwork within the main stem of the upper Shavers Fork and a second-order tributary, Rocky Run. The physical and biological characteristics of the upper Shavers Fork main stem and Rocky Run study areas differ dramatically. The main stem is relatively wide and shallow, has a low gradient and an open canopy, is warmer, and is more productive than Rocky Run and other tributaries (Bopp 2002). Rocky Run is narrow and has a higher gradient, a dense canopy, and a high occurrence of large boulders and large woody debris (LWD). Although many small streams in the watershed are acidic as a result of acid deposition, both the upper main stem (currently treated with limestone fines by the West Virginia Department of Natural Resources [WVDNR]) and Rocky Run are generally circum-neutral (i.e., possess a baseflow pH between 6.6 and 7.0). Fish assemblages in the upper Shavers Fork and its tributaries are typical for Appalachian streams and include: brook trout, brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), rosyface shiner (*Notropis rubellus*), rosyside dace (*Clinostomus funduloides*), blacknose dace (*Rhinicthys atralatus*), longnose dace (*Rhinicthys cataractae*), central stoneroller (*Campostoma anomalum*), fantail darter (*Etheostoma flabellare*), mottled sculpin (*Cottus bairdii*), northern hog sucker (*Campostoma nigicans*), and creek chub (*Semotilus atromaculatus*).

METHODS

Temperature and Stream Flow Monitoring

An 8 km study reach was delineated on the Shavers Fork main stem and a 2 km reach on Rocky Run (Fig. 1). Wooden stakes with fluorescent tips were placed along the study reaches every 50 m on the main stem, and every 25 m on Rocky Run. Seven continuous temperature loggers (HOBO™, Onset Computer Corporation, Bourne, MA) were anchored within the main-stem study area, and three loggers were anchored in the tributary. Spacing of the loggers was arranged to capture spatial and temporal variation in ambient water temperature throughout the

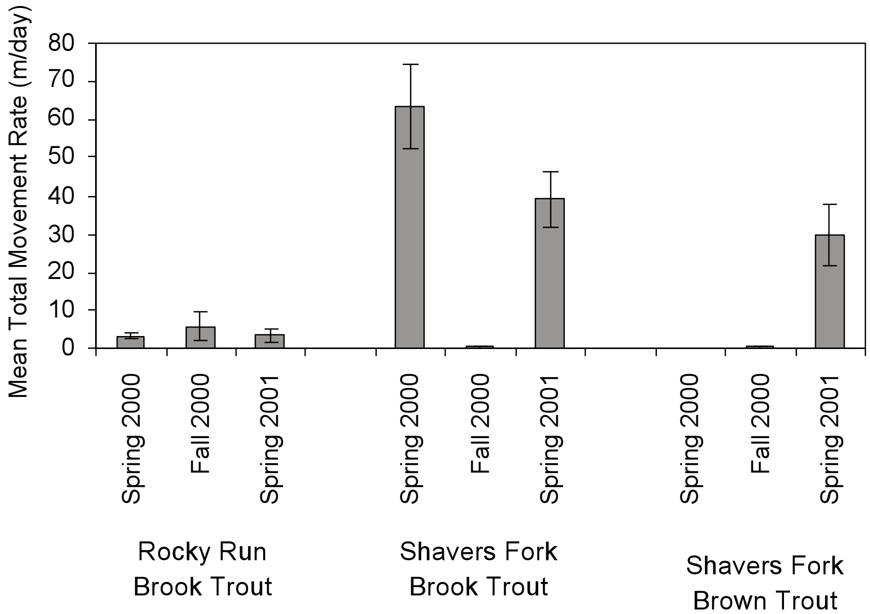

Figure 1.—Mean (+SE) total movement rate of brook trout and brown trout inhabiting Rocky Run and the main stem of the upper Shavers Fork watershed. (Total movement rate = sum of all movements upstream and downstream.)

study area. Shavers Fork stream flow was monitored at the U.S Geological Survey (USGS) gauging station located at Cheat Bridge, WV, approximately 25 km downstream from our study area.

Trout Capture and Tracking

We completed the fieldwork over a period of 60-70 days during three seasons: summer 2000, fall 2000, and summer 2001. The summer sampling season continued from June 5 until August 15 of each year. The fall season ran from September 5 until November 15. Electrofishing and angling were used to capture trout used for the study. In summer 2000, only brook trout were sampled. Brown trout were added to the study design in fall 2000 and summer 2001. All fish were captured within the study region and returned as close to their original location as possible.

Twenty-eight trout were tagged and released each season for a total of 84 trout implanted for the study. Once captured, trout were surgically implanted with Lotek™ (Lotek Wireless Inc., Newmarket, ONT) internal radio transmitters following protocols derived from multiple sources (Courtois 1981, Ross and Kleiner 1982, Winter 1983, Swanberg 1997). Trout were handled according to the guidelines of the West Virginia University Animal Care and Use Committee (Protocol #9801-12). To ensure full recovery and resumption of normal behaviors, official tracking did not begin until 7 days following the release of tagged fish. All fish at large were located using a Lotek™ SRX 600 Datalogger receiver at least twice per week each season between 0600 hours and 2100 hours, completing one "track". Tagged trout were located by use of a WVDNR railcar and walking parallel to and within 50 m of the stream bank until a signal was detected (Young 1995). An exhaustive effort was made throughout each track to locate all tagged trout throughout the watershed. All located fish were visually identified to ensure that the transmitters were still associated with a living fish (Burrell et al. 2000). Tracking continued for up to 71 days each season. Most transmitters had "died" by day 60.

Trout Movement and Microhabitat Use

Upon locating each tagged trout, we collected the following information: 1) geographic location based on the stakes placed along the experimental reaches; 2) time of day; 3) water clarity; 4) hydraulic channel unit type (e.g., pool, riffle, run) (Petty et al. 2001); and 4) physical microhabitat variables at the focal point of observed trout. Microhabitat variables included focal point temperature (°C), pH, water depth (cm), bottom current velocity (m/s), average current velocity (m/s), focal point current velocity (m/s), maximum current velocity within 60 cm (m/s) (Fausch et al. 1981), distance to cover (m), cover type used (wood, rock, combination), and distance to a known CWS (m). We identified nine CWSs to the Shavers Fork main stem distributed throughout the study area. Coldwater sources included tributary confluences as well as identified lateral groundwater seeps along the banks of the main-stem channel. Cover for this investigation consisted of undercut banks, large boulders, and LWD. Current velocities were measured with a Marsh-McBirney™ flow meter (Marsh-McBirney, Frederick, MD). Trout were observed when possible to note their general location and activity before we took microhabitat use measurements. We substituted a reading of 10 cm from the bottom for an adjusted focal point whenever in-stream turbidity prevented the determination of the exact location (Young 1995). Microhabitat data will be discussed only when needed in quantifying trout movement.

Statistical Analysis

Our first and second objectives were to quantify trout movement, and to assess spatial and temporal variation in movement behaviors. Movement was quantified as the distance, in meters, between subsequent fish locations. We arbitrarily assigned positive values to upstream movements and negative values to downstream movements. We then constructed two-tailed, frequency distributions of movement distance for each year. Because movement distance was correlated with the number of days between capture, we converted all measurements of movement to a movement rate by dividing distance by the number of days between subsequent sightings. These data were then analyzed on a track-by-track basis by examining movement rates between subsequent sightings. We also analyzed the data on the basis of overall movement rates of each fish over the course of the study. Specifically, we calculated the total net movement rate (including upstream and downstream movements) and the total absolute movement rate for each fish each season. We used t-tests to test the null hypothesis that overall net displacement by trout did not differ significantly from zero. Rejecting this hypothesis would suggest a directional tendency in trout movements. We tested for differences in movement rates among seasons, years, streams, and species by conducting either t-tests or an ANOVA on log-transformed movement rates.

Our third objective was to relate movement behaviors to variation in stream flow, water temperature, and access to CWSs. We examined the effects of daily variation in temperature, flow, and access to known CWSs on trout movements during summer months. These analyses employed simple and multiple linear regressions where the dependent variable was the log-transformed movement rate of fish on a track-to-track basis. Independent variables were the maximum ambient water temperature between subsequent sightings, the 7-day average maximum water temperature, maximum stream stage height, and the distance (in meters) a fish was to a known CWS prior to movement. Our specific objective in this analysis was to examine the degree to which water temperature and distance to CWSs interact to determine trout movement rates during summer months.

RESULTS

Movement rates of brook trout and brown trout varied as a function of season, stream, and species (Fig. 1). Brook trout residing in Rocky Run were generally sedentary, with a median movement rate ranging from 0.1 m/day in fall 2000 to 2.1 m/day in summer 2000. ANOVAs conducted on total movement rates indicated that brook trout overall movements in Rocky Run were highly consistent from season to season ($F = 1.02$, $p = 0.35$). Brook trout inhabiting Rocky Run did not exhibit significant tendencies in upstream or downstream movement in any season. We never sampled a brown trout in Rocky Run, nor did a tagged brown trout ever enter Rocky Run during the study. (A few small [<200 mm] individuals were later captured in routine surveys.) Transmitters lasted up to 71 days, with location and habitat-use data taken 2-3 times per week for each active-transmitter-equipped trout. Some trout were located up to 19 times throughout a season (summer or fall).

In contrast to Rocky Run, brook trout residing in the Shavers Fork main stem exhibited dramatic upstream movement tendencies in summer 2000 and 2001 (Fig. 1). Brook trout in the main stem were observed to move as much as 100-150 m/day and exhibited median movement rates from 40.3 m/day in summer 2001 to 57.8 m/day in summer 2000. Several individuals moved more than 6.5 km during the summer 2000 and 2001 seasons.

Brown trout in the main stem exhibited an upstream movement tendency similar to brook trout in summer 2001 (median dispersal rate = 25.5 m/day). One individual moved as much as 2.6 km upstream and many others moved 1.0-1.5 km in a 65-day period. (No data exist for brown trout in summer 2000.)

High rates of overall movement by brook and brown trout residing in the main stem were not observed in the fall 2000 season. For example, median movement rates by brook trout fell from 57.8 m/day in summer 2000 to 0.4 m/day in fall 2000. Likewise, the median movement rate by brown trout in fall 2000 was 0.3 m/day. Trout in Rocky Run moved at a significantly lower rate than trout in Shavers Fork in summer 2000 and 2001, but not in fall 2000 (Fig. 1). Furthermore, trout movement rates in Shavers Fork were significantly lower in fall 2000 than in summer of either 2000 or 2001. Finally, we observed no significant differences in the overall movement rates of brook trout and brown trout inhabiting the Shavers Fork main stem. By the fall start date of September, most large brook trout had migrated from the main stem into the extreme headwaters of smaller tributaries in preparation to spawn. Trout migrated back to the main stem sometime between sampling periods (November 1-June 5). We are unsure whether brook trout overwinter in the main stem or within tributaries. Brown trout made upstream movements to spawn but were generally confined to the main stem and were not as pronounced. Concurrent routine surveys taken throughout the watershed confirmed this movement and distribution pattern. The spawning migration and its implications for management must be taken into account even though the event was not captured in our tracking results.

Given the high rates of overall movement by brook trout in the Shavers Fork main stem, we examined the effects of temperature, stream flow, and distance to CWSs on brook trout movement for our third objective. Flow did not vary significantly over the course of the study other than what would be expected due to normal precipitation events. Kolmogrov-Smirnov tests further indicated that flows did not differ significantly between years (2000 vs. 2001: $D = 0.03$, $n = 214$, $p < 0.05$). Flow during the fall of 2000 was characteristic of coldwater systems like the upper Shavers Fork under fall conditions and had an average mean daily stage height of 4.85 m. Therefore, habitat availability was sampled at one flow representative of the system during most tracking events. Brook trout movement rates were significantly related to maximum water temperature in the summers of both 2000 and 2001. In summer 2000, movement rates decreased significantly as maximum temperature increased from 12 °C to 18 °C. In contrast, movement rates increased as a function of maximum temperature when temperatures exceeded 18 °C. Habitat use was also strongly influenced by temperature (Fig. 2). At times, trout utilized habitat that was up to 4 °C cooler than ambient temperature levels. With increasing temperature, only habitat influenced by CWSs was utilized, demonstrating a loss of available habitat during warmer periods. We observed significant relationships between brook trout movement rates and distance to a known CWS. In summer 2000 and especially in summer 2001, movement rates tended to increase with increasing distance from cold water or CWSs. Multiple regression analyses further clarified the interactive effects of water temperature and distance to CWSs on brook trout movement behavior. Inclusion of both maximum temperature and distance to a CWS in regression models produced significantly better power to predict trout movement rates ($F = 4.7$, $p = 0.001$, $R^2 = 0.26$).

DISCUSSION

Movement is an adapted behavior used by large, dominant, resident trout in the Shavers Fork to adjust to spatially and temporally varying in-stream habitat conditions and productivity, and to reach non-substitutable complementary and supplementary habitat distributed at a watershed scale (Meyers et al. 1992, Schlosser and Angermeier 1995, Fausch et al. 2002, Gowan and Fausch 2002, Petty et al. 2005). Our findings are in agreement with Gowan et al. (1994) and Albanese et al. (2004), who stated that movement may be more common in variable or harsh systems (e.g., the Shavers Fork main stem) and less common in more constant or benign ones (e.g., Rocky Run). Past land-use practices have made the upper Shavers Fork main stem habitat marginal but highly productive, with reaches of excellent habitat separated by long, shallow expanses of low in-stream complexity. Thermal constraints greatly compound the need for trout to

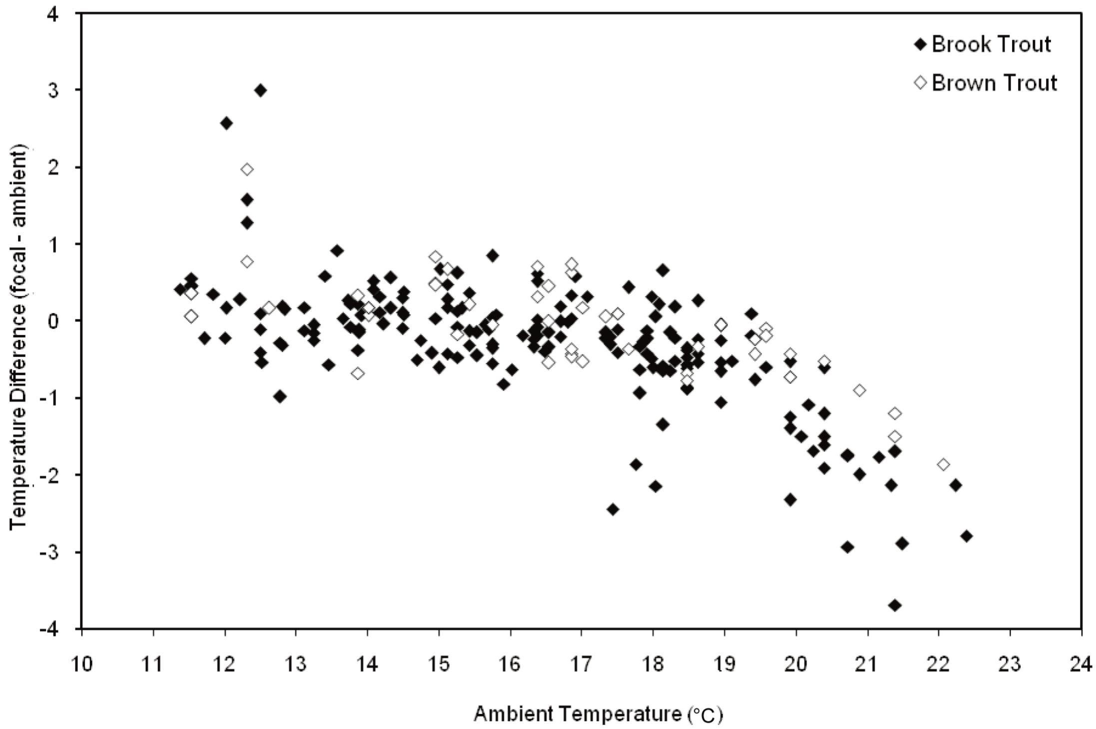

Figure 2.—Variation in the difference between focal point temperature and ambient water temperature as a function of ambient water temperature for summer 2000 and summer 2001 (N = 221). (Note brook and brown trout are separate series.)

move and seek out suitable habitat. Species that exhibit reach affinity (like trout) under ideal conditions in complex, productive habitats usually show increased movement if in-stream habitat becomes homogenized (Albanese et al. 2004), as we observed in the upper Shavers Fork.

We believe that high mobility was common when fluvial brook trout inhabited the upper Shavers Fork and other lotic systems of pre-development West Virginia. We cannot make valid comparisons between today and the past, however, because of anthropogenic effects on current movement rates/behavior and the lack of historic records of trout movement in unspoiled systems. We nonetheless feel the upper Shavers Fork was not unique in a world of similar unspoiled habitat and rivers. It is very unusual today due to the possibility of restoring the remnants of a once-common fluvial brook trout population in a remarkable Appalachian lotic system.

Our findings also highlight the issue of proper scale for ecological studies and successful management (Hildrew and Giller 1994, Cooper et al. 1998, Fausch et al. 2002, Rodriquez 2002). Findings from either water body (or one season) taken alone would be incorrect in assessing the entire trout population's habitat use and movement in the watershed. For example, our findings are applicable only to summer and fall. Potential mortality and habitat use within the upper Shavers Fork during the winter need to be researched. Further shortcomings include the short timeframe when fish were at large, and the incomplete size range of fish tracked. Improvements in transmitter technology have negated these problems for future studies.

Maximum summer water temperature is the single most important factor limiting the geographic distribution of brook trout, a coldwater fish with strict temperature requirements (Flebbe 1994, McRae and Edwards 1994). Brook and brown trout have very similar total temperature ranges and critical thermal maxima (29.8 °C and 29.9 °C, respectively); brook trout prefer a cooler range (10-12 °C) than brown trout (12-17 °C) (Wehrly et al. 2007). This preference is the main reason brown trout are rare and brook trout are abundant in the colder Shavers Fork tributary, Rocky Run. Mortality occurs quickly above 25 °C for both species, with delayed mortality at extended periods above 20 °C. Both movement and habitat selection by trout in the upper Shavers Fork are highly negatively affected by temperature (Hansbarger et al. 2005). Overall available habitat is reduced or gained depending on in-stream temperature levels in the upper Shavers Fork. During critical thermal periods, main-stem trout found and used CWS-influenced habitat that was up to 4 °C cooler than the in-stream ambient temperature. High levels of productivity in the main stem spur resident trout to stay and feed despite high in-stream temperatures during the summer months (Bopp 2002). This type of thermal regulation by salmonids is heavily documented in current literature and highlights their amazing adaptability despite strict habitat requirements (Bermann and Quinn 1991, Dolloff et al. 1994, Torgersen et al. 1999, Baird and Krueger 2003). Movement by tagged trout at times was for the sole purpose of locating and using habitat associated with CWSs, rather than for "normal" activities (i.e., feeding, avoiding avian predators). Another consequence of adaptability, however, is their susceptibility to harvest: anglers generally know the location of CWSs.

An overall reduction of in-stream temperature levels through specific restoration actions would increase habitat quality and availability year-round while reducing the distance between required habitat. The resulting reduction in the need for movement, especially during critical energy periods (i.e., summer), would benefit trout condition and fitness. Energy used for higher metabolic demand associated with increased temperature would not be diverted from other needs, and trout would not be as prone to the delayed mortality associated with secondary impacts from high temperature (pathogens, disease, winter mortality). Appalachian freestone streams are typically infertile and limited in food resources, making this possible gain in energy extremely valuable to Shavers Fork trout (Cada et al. 1987, Ensign et al. 1990, Hartman and Sweka 2001). With improved overall temperature levels, trout would also not congregate as severely during warm periods. The potential for overharvest would be limited, and delayed mortality arising from catch and release handling would decline. The main stem of the upper Shavers Fork actually benefits from additional autochthonous energy sources because its more exposed canopy makes it more productive than usual. Conversely, the more open canopy provides too much heat during the summer when coupled with in-stream geomorphology (wide, shallow debris flows; wide main channel).

The most successful method of habitat rehabilitation has been watershed protection (Meehan 1991). The higher the level of protection, the greater the likelihood that restoration efforts will be well spent and not wasted. Successful watershed restoration and enhancement requires multiple steps and planning (Roni 2006). The first step in a successful restoration plan is to construct an accurate conceptual model. Step two involves providing a biophysical and socio-political profile that identifies objectives, strategies, and targets that must be met to achieve overall goals. Step three produces a watershed plan that explains how these objectives, strategies, and goals will be met and by whom. Step four spells out actions and commitments for implementing the plan, monitoring its effectiveness, and periodically reviewing and improving it.

The scale of movement documented and information derived from other studies in the watershed show that a watershed-scale perspective is needed to adequately manage and restore the upper Shavers Fork trout fishery (Petty et al. 2001, Petty et al. 2005). A restoration plan for the upper Shavers Fork watershed should first address temperature as a limiting factor, followed by targeted structural enhancements to increase the availability of multi-factor or diverse habitats. Temperature mitigation would increase available habitat year-round. If temperature issues are not addressed first, subsequent restoration actions would prove to be ineffective or limited in effectiveness. Incorporating advanced remote sensing data along with in-stream temperature logger data would prove invaluable in determining heating zones (i.e., surface temperature mapping) to be targeted for enhancement (Fausch et al. 2002). Mitigation would be accomplished by planting trees for shading in the upper headwaters on Snowshoe property and around Spruce and other exposed "heating zones" lacking riparian cover, and through specific in-stream enhancement work covered below. Priority fish passage barriers (culverts and road crossings) could be improved or replaced to increase available habitat while promoting dispersal, genetic diversity, and system integrity and limiting population fragmentation (Wofford et al. 2005, Freeman et al. 2007, Poplar-Jeffers et al. 2008). Headwater areas could be improved by targeting specific reaches for expanded limestone treatment, increasing the overall spawning potential of resident trout in the watershed (Clayton et al. 1998, Petty and Thorne 2005).

The next step would involve specific enhancement actions directed at further reducing in-stream temperature levels, while increasing the availability of multi-factor or diverse habitats to increase overall habitat suitability (Hansbarger et al. 2008). A decrease in the residence time of water in wide, shallow "heating zones" by reducing channel width and increasing depth would lower overall in-stream temperature levels further. Reaches with adequate gradient could next be targeted for boulder and LWD placement, allowing erosion and deposition to create multi-factor habitat. A combination of appropriate cover, depth, and current velocity is needed to provide suitable habitat. If specific reaches or sections are to be set aside for special management, managers must decide whether these areas are to contain the full range of movements of resident trout and if so, how large an area to designate. Finally, successful long-term management will require cooperation from multiple landowners (i.e., USFS, Snowshoe Ski Resort, and private landholders) and continued public relations to be successful.

Issues that could further impact the upper Shavers Fork watershed must also be considered and planned for within any restoration plan. They are: 1) the placement of a wastewater treatment plant for Snowshoe Ski Resort; 2) long-term development and land use; 3) long-term thermal impacts of global warming on the upper Shavers Fork and other coldwater lotic systems in West Virginia; and 4) exotic fish and genetic concerns. Many local public meetings already have been held, and stakeholders have vigorously contested the proposed locations of the wastewater treatment plant and the choice of stream into which effluent should be discharged, the Elk or the upper Shavers Fork. Both are exceptional trout streams with high recreational value, attracting resident as well as non-resident anglers year-round. The unspoiled nature and remoteness of the upper Shavers Fork are among its most alluring qualities. We must ensure that development and other land uses do not ruin these key features.

The trout fishery in the watershed exists tenuously during the summer months (Hansbarger et al. 2008). Cold water discharged from tributaries and seeps literally sustain trout throughout the critical summer period. Predicted temperature increases from global warming could push the upper Shavers Fork to either a cool-water or warm-water stream, rendering resident trout extinct unless steps are taken to combat climate change on multiple scales. Without critical thermal refuges during summer periods and open corridors to reach them, trout would not be able to persist in the watershed (Hartman and Sweka 2001, Baird and Krueger 2003, Poplar-Jeffers et al. 2008). If the re-establishment of a fluvial native brook trout fishery is the goal of a restoration plan, the impact of exotic rainbow and brown trout needs to be examined further. These exotic species could hurt brook trout growth and ultimately survival (Fausch and White 1981, Hansbarger 2005). Eradication of exotics is usually not possible, and the benefit of these nonnative trout to anglers weighs heavily in comparison to their negative impacts on brook trout. Finally, stocking brook trout in the upper Shavers Fork should be reviewed for long-term genetic implications. Both the WVDNR and the Cheat Mountain Club, a private club located near Cheat Bridge, stock the river.

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