COMMONWEALTH OF PENNSYLVANIA ENVIRONMENTAL QUALITY BOARD

PETITION FORM FOR THE UPGRADE OF UPPER PARADISE CREEK, MONROE COUNTY, PA

Brodhead Chapter of Trout Unlimited
521 Quail ridge Lane
Stroudsburg, PA 18360

COMMOPNWEALTH OF PENNSYLVANIA
ENVIRONMENTAL QUALITY BOARD

PETITION FORM

I. PETITIONER INFORMATION

A. Name: Brodhead Trout Unlimited

B. Mailing Address: 521 Quail Ridge Lane, Stroudsburg, PA 18360

C. Telephone No. (570) 992-3558

D. Date: June 17, 2014

II. PETITION INFORMATION

A. The petitioner requests the Environmental Quality Board to:

_____ Adopt a regulation

__X__ Amend a regulation (Citation: PADEP Chapter 93 Designation for upper Paradise Creek to Exceptional Value – (EV)

_____ Repeal a regulation

B. Why is the petitioner requesting this action from the Board? (Describe problems encountered under current regulations and the changes being recommended to address the problems. State factual and legal contentions and include supporting documentation that establishes a clear justification for the requested action.)

The Brodhead Chapter of Trout Unlimited requests that upper Paradise Creek, with tributaries Tank Creek, Yankee Run, and Devil's Hole Creek downstream to Lake Crawford, be re-designated exceptional value waters (EV) from its current designation as high quality waters (HQ) based on the fact that the existing water quality is better than criteria applicable to upper Paradise Creek's current designation. Upper Paradise Creek is a tributary to Brodhead Creek in Monroe County, PA. Upper Paradise Creek and its tributaries have exceptional wild trout populations that should be protected by maintaining current water quality. It is a very beautiful and diverse ecosystem, much of which has been recently preserved through open-space purchase of riparian lands. Only the portion of Devil's Hole Creek tributary on PA State Game Lands is currently designated by PA Department of Environmental Protection as Exceptional Value Waters and by PA Fish & Boat Commission as class A Wild Trout Waters. However numerous stations on the upper Paradise and its tributaries have been documented to have wild trout populations far exceeding the minimum Class A standard. These will, no doubt, be

designated class A Wild Trout Waters as the fish & Boat Commission completes their survey of unassessed waters in the Delaware Drainage. Despite the recent acquisition of protected riparian land, the surrounding area is subject to increasing development pressure. There are currently two point-source discharge to Upper Paradise Creek from Paradise Stream Resort and a small school on an unnamed tributary.

In the Brodhead Watershed, there are several small streams on the Department's list of impaired waters - some due to permitted discharges. Since water quality in the watershed has suffered considerable compromise to development and anthropogenic impact, we feel the finest quality waters such as upper Paradise Creek should be preserved at their current quality with no further degradation allowed. The exceptional quality of upper Paradise Creek is supported by biological documentation of fish and macroinvertebrate communities included in the Supporting Material (Section E and Appendices). There appears to be negative impact to a short uppermost section of the Yankee Run tributary probably attributed to run-off from a heavily developed area surrounding the intersections of Routes 611, 940, and Sterling Road in Mount Pocono. However, this uppermost 650 meters of Yankee Run has little to no base flow until it is augmented by a large spring, at which point water quality becomes excellent.

C. Describe the types of persons, businesses and organizations likely to be impacted by this proposal.

Except for uppermost, intermittent portion of the Yankee Run tributary, much of upper Paradise Creek is now surrounded by public lands, and because the existing developments proximal to the stream have two point source discharges, which currently appear to have no noticeable negative impacts, the petitioners anticipate minimal negative economic impact resulting from this proposal. There are three commercial enterprises and one tract with potential for land development on upper Paradise Creek. A section of the stream, including its confluence with Devil's Hole Creek, flows through Paradise Stream Resort The resort is serviced by a small wastewater treatment plant that discharges to Paradise Creek. Several macroinvertebrate and fish studies with stations above and below this discharge indicated that it has no negative impact to stream biota. The petitioners are not aware whether EV designation of upper Paradise Creek would impact Paradise Stream Resort. Just downstream of the resort is a small riding stable where some additional consideration may be required to a riding trail crossing of the stream. Below the Route 940 crossing of Paradise Creek is a tract of land, formerly a resort, which may be developed in the future. Exceptional Value status for upper Paradise Creek may require additional protection for the stream at such time as this property is developed. The other commercial operation is Paradise Trout Hatchery at the lower extent of the segment included in this petition. The petitioners feel that the value of preserving the quality of this exceptional resource would easily balance any additional efforts required by these riparian landowners to achieve that goal.

There are many individuals and organizations that would experience positive benefits of an EV designation for Upper Paradise Creek. Downstream from the stream segment that is subject of this petition, Paradise Creek flows through property of Paradise Trout Hatchery, Paradise Falls Lutheran Association, Henryville Conservation Association, and

Brodhead Forest and Stream. Paradise Falls Lutheran Association uses Paradise Creek and Lake Crawford on the creek as recreational fisheries, along with swimming and boating. Thus, they are very concerned about the quality of water entering their lake and stream. The Henryville Conservation Club and Brodhead Forest and Stream are trout fishing clubs on the Paradise Creek. These historic fishing clubs are fervent protectors of the quality of their waters. Paradise Creek through Henryville Conservation Association has been shown to have a significant wild brown trout population with exceptional growth rates for freestone streams. However, surveys indicate that Paradise Creek in this area does not have an abundance of natural reproduction and may depend heavily on recruitment of young trout from upstream headwaters. Below these fishing clubs, the Brodhead is an important public trout fishery and also serves as a water supply for the Brodhead Creek Regional Authority. The public will also benefit from the preservation of the exceptional water quality of upper Paradise Creek as the recently acquired public access develops as a wild trout fishery and diverse outdoor laboratory. Thus it would serve the interest of many in the area if the water quality of the Paradise headwaters, were maintained at their present quality with no additional degradation allowed.

D. Does the action requested in the petition concern a matter currently in litigation?
Action requested in the petition does not concern any matter currently in litigation to the best of the petitioner's knowledge.

E. Supporting material

Description of the Upper Paradise Creek Watershed

Paradise Creek is a major tributary to the Brodhead Creek in Monroe County. The Brodhead and Paradise are arguably the most historic trout fisheries in the country. In the 19th and first half of the 20th Century, this area was the destination of most of the influential angling writers and angling celebrities of the time. The Henryville House on the Paradise and the Hotel Rapids on the Brodhead were among the most storied hangouts for notable anglers of these eras.

Paradise Creek begins with the confluence of Yankee Run and Tank Creek, two first order tributaries originating on the Pocono Plateau just east and northeast of Mount Pocono respectively (Figure 1). A large portion of these tributaries flows through publicly protected land owned by the state, Pocono Heritage Land Trust, and Paradise Township (Figure 2).Yankee Run begins east of the intersection of PA routes 611 and 940 in Mount Pocono. However, Yankee Run flows intermittently for approximately 650 meters until a large spring augments it flows and produces excellent water quality. The lower half of Yankee Run flows through Pocono Heritage Land Trust (PHLT) property on the Kurmes Preserve (Figure 2). Tank Creek begins in a small wetland on PA State Game Land # 121 and flows southeast for approximately 1 ¼ miles to join Yankee Run and form Paradise Creek. From state land it flows onto Fielstone Farm Preserve property of PHLT, then trough a short section of private land onto PHLT's Kermes Preserve where it joins Yankee Run. A short distance east of this confluence, Paradise Creek is joined by Devil's Hole Creek, a second order stream which flows largely through PA

State Game Lands #121 where it is classified Exceptional Value. Devil's Hole Creek joins Paradise Creek on property of Paradise Stream Resort. A short distance below this confluence, two very small unnamed tributaries join the Paradise, one from the south and another from the north. Below the resort, Paradise Creek flows through small residential lots and through a Paradise Township park, then through property of Paradise Trout Hatchery before entering Lake Crawford on Paradise Falls Lutheran Association property.

Current Designated Uses

With the exception of the Exceptional Value portion of Devil's Hole Creek on PA State Game Land, upper Paradise Creek and its tributaries are listed in Drainage List C in 25 Pa. Code 93.9c, designated High Quality Cold Water Fishery. The current HQ-CWF designation would allow degradation of the existing exceptional quality.

Maps

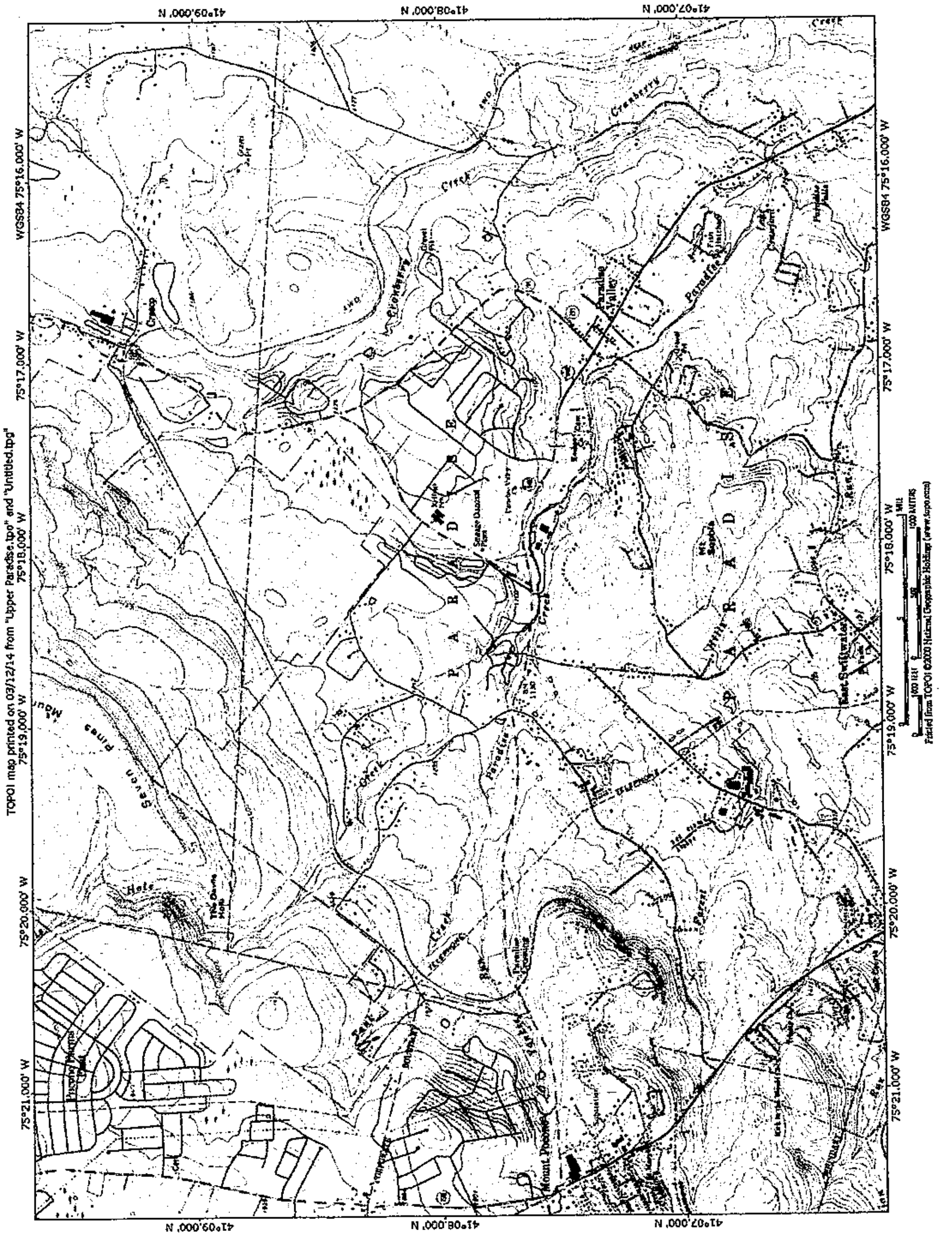


Figure 1. Map showing upper Paradise Creek from headwaters (Yankee Run, Tank Creek, and Devil's Hole Creek, to Lake Crawford.

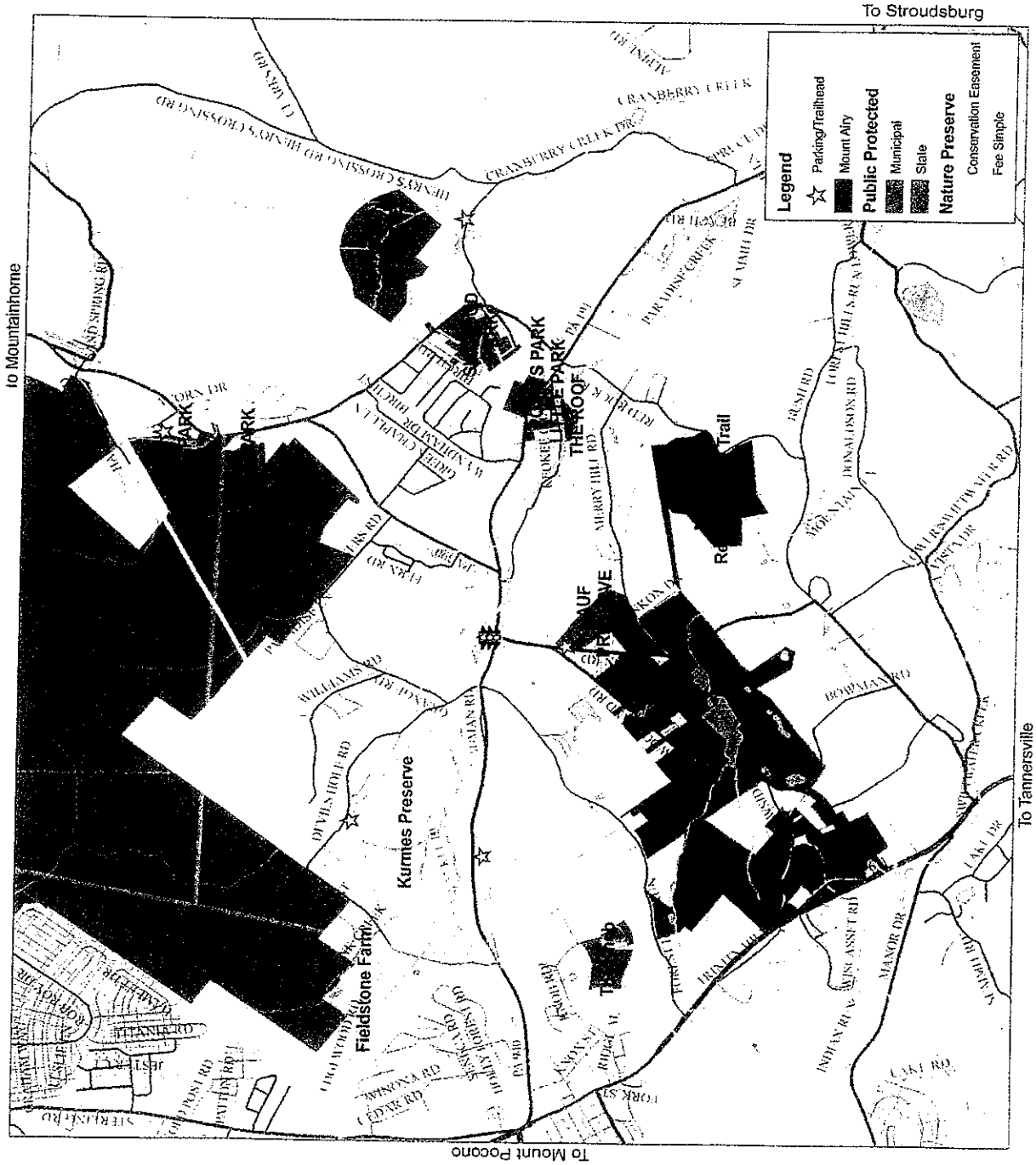


Figure 2. Map showing land protected by PA State Game Land and Pocono Heritage Land Trust property on Paradise Creek headwaters.

Requested Designated Uses

The requested designation for upper Paradise Creek is Exceptional Value. This designation would protect the existing water quality.

Available Technical Data: Water Chemistry, Benthic Macroinvertebrates and/or Fishes.

From 1999 to 2013, Paradise Creek headwaters have been studied extensively using benthic macroinvertebrates and fishes to evaluate water quality. Among the numerous sampling stations in the upper Paradise Creek drainage examined in the following studies, all exhibited excellent, highly sensitive macroinvertebrate populations, with the exception of one uppermost station on the intermittent portion of Yankee Run. Yankee Run begins near the borough of Mount Pocono and exhibits intermittent base flow until a large spring augments the flow. Macroinvertebrate samples suggest that Yankee Run has excellent water quality downstream of the spring where water quality and quantity are greatly improved.

In a series of surveys from 1999 to 2009, numerous stations on upper Paradise Creek and its tributaries were conducted by Aquatic Resource Consulting to evaluate fish populations. All stations on Paradise Creek subject to this petition had wild brown trout populations and some had wild native brook trout. Most stations exceeded the minimum required for classification by Pennsylvania Fish & Boat Commission as Class A Wild Trout Streams. Stations on paradise Creek and on Devil's Hole Creek tributary had excellent wild trout populations exceeding Class A requirements. Tank Creek and Yankee Run each had a predominance of wild brown trout but less than Class A biomass near their mouths in 1999 and exceeding Class A biomass farther upstream in 2009.

Benthic Macroinvertebrates

Benthic Macroinvertebrates of Upper Paradise Creek, April 21, 2013 for Brodhead Trout Unlimited (Appendix A).

In April of 2013, at the request of Brodhead Trout Unlimited, aquatic biologist Don Baylor sampled benthic macroinvertebrates from two stations on upper Paradise Creek following the most recent PA DEP protocols for stream classification. Both samples indicated exceptional water quality. The overall IBI scores were 85.1 and 83.0 out of a possible 100. These scores suggest a very diverse population consisting primarily of taxa very intolerant of environmental perturbation. However, IBI scores were skewed downward, especially at the downstream station by a proliferation of moderately tolerant *Baetis spp.* mayflies. *Baetis spp.* generally have three generations per year, the first being a spring-emerging cohort. The proliferation of these mayflies prior to emergence caused lower scores for Percent Sensitive Individuals and Hilsenhoff Biotic Index.

Benthic Macroinvertebrates of the Paradise Watershed, June 11-26, 2009 for the Paradise Stormwater Facility Retrofit Design Project: a project of the Brodhead Watershed Association funded by a Growing Greener Grant (Appendix B).

In this study of benthic macroinvertebrates by Aquatic Resource Consulting at 21 stations in the Paradise Creek Watershed, 8 stations were located within the portion of upper Paradise Creek drainage being petitioned for upgrade. Two stations on upper Paradise Creek had 88.17 and 95.18 IBI scores. Two stations on Devil's Hole Creek downstream from the existing EV portion on State Game Lands had IBI scores of 93.93 and 100. Two stations on Tank Creek and an unnamed tributary to Tank Creek scored 93.93 and 98.30, respectively. A station below the spring on Yankee Run scored 92.35. The only station in the portion of the watershed subject to this petition that had an IBI score indicating impairment was above the spring on Yankee Run where flows become intermittent and may be influenced by stormwater run-off. That station scored 33.43. All other stations had scores ranging from 88.17 to 100. Although summer seasonal thresholds were applied to these June samples, the scores indicated exceptional water quality which would be very vulnerable to environmental stressors.

Benthic Macroinvertebrates of Paradise Creek headwaters, Monroe County, PA, Spring 200, for Brodhead Watershed Association (Appendix C).

This macroinvertebrate study by Aquatic Resource Consulting examined tributaries to upper Paradise Creek. Two of the stations were on Devil's Hole Creek below the Exceptional Value segment on State Game Land. One station was a short distance downstream of the State Game Lands and another was near the confluence with Paradise Creek. Both stations exhibited excellent water quality with exceptional diversity and Biotic Index values. The station a short distance downstream of State Game Lands had a Hilsenhoff Biotic Index value of 0.57 and the one near the mouth 2.17, both indicative of heavy predominance of pollution sensitive organisms. Shannon Diversity values were also superior at 3.46 upstream and 3.92 downstream. A station on an unnamed tributary to Tank Creek also had exceptional Biotic Index and diversity values – 0.75 and 3.21, respectively. The sample from the station above the spring, where Yankee Run is intermittent, indicated much poorer water quality.

Benthic Macroinvertebrates of Paradise Creek Headwaters, Monroe County, PA, April 11, 1999, for Brodhead Watershed Association (Appendix D).

This study examined six stations within the drainage, all in stream segments subject to this petition: one on Yankee Run, one on Devil's Hole Creek, and two each on Tank Creek and Paradise Creek. Hilsenhoff biotic Index values were exceptional for all stations, ranging from an outstanding 0.72 at the lower Tank Creek station to 2.11 at the Paradise Creek station in the Paradise Township Park. Shannon Diversity values ranged from 3.75 on Paradise Creek at the township park (the best) to 2.44 on the Paradise Creek (mislabeled Tank Creek in the report) above Devil's Hole road. Only the lowest diversity score would have attained slightly less than the optimum Standardized Metric Score using more recent DEP metric analysis.

Fish Populations

Fishery Survey of Paradise Creek and Tributaries prepared for Brodhead Watershed Association, June and July, 2009 (Appendix E).

In this 2009 survey, conducted by Aquatic Resource Consulting, six of the seven stations sampled were in the Upper Paradise Drainage subject to this petition. One on Cranberry Creek was outside the subject drainage. Three stations were surveyed on Paradise Creek and one each on Yankee Run, Tank Creek and Devil's Hole Creek. The PA Fish & Boat Commission standard for the very best wild trout waters in the commonwealth is 40 pounds per acre for brown trout (*salmo trutta*) with evidence of reproduction. Wild brown trout were the predominant fish species at all sampling stations. On the headwaters, Tank Creek, Yankee Run, and Devil's Hole Creek, wild brown trout were abundant with biomass ranging from 67.3 pounds/acre at Yankee Run to 110.6 pounds/acre at Tank Creek. All stations exceeded the requirement for Class A wild brown trout waters. Three stations on Paradise Creek were surveyed: Kurmes Preserve, Paradise Park, and Deetz property near the Red Rock Road crossing. Brown trout biomass at the Paradise stations ranged from 60.1 pounds/acre at the Kurmes station to an outstanding 210.6 pounds /acre at the Deetz property.

Electrofishing Survey of Yankee Run, Tank Creek, and Devil's Hole Creek prepared for Brodhead Watershed Association, October 28 and 30, 1999 (Appendix F).

Wild brown trout and book trout were the only fish species collected in Tank Creek and Yankee Run. Devil's Hole Creek had the highest biomass with an estimated standing crop of 114 pounds per acre, nearly three times the PA Fish & Boat commission's Class A standard. Biomass values were much lower on Tank Creek and Yankee Run – 21.1 and 36.6 respectively – and much lower than those found farther up both tributaries in 2009. The low biomass values at these sites may be due to poorer physical habitat. Brook trout were also fund at the stations on Tank Creek and Yankee Run.

1998 Electrofishing Survey of Paradise Creek Prepared for Brodhead Watershed Association (Appendix G).

In this October 1998 survey, two stations on Paradise Creek in the area subject to this petition were electrofished. One was in the area of Paradise Township Park and the other downstream above Red Rock Road on the Deetz property. These stations were similar to two of the stations sampled later in the 2009 survey. These stations had an abundance of young-of-year trout indicative of excellent reproduction. Even though this portion of Paradise Creek is open to public fishing with statewide regulations allowing harvest, a large number of catchable size trout were also collected. These stations had biomass

values over two and three times the PA Fish & Boat Commission standard for Class A Wild Brown Trout Waters. Biomass values were 84.8 pounds per acre at the upstream station and 157.8 pounds per acre downstream.

Description of discharges

There are two point-source discharges of treated wastewater into the upper Paradise Creek Drainage. Caesar's Paradise Stream Resort on Route 940 holds Minor Sewage Facility NPDES Permit No. 0061115 with a design flow of .10 MG/D. Monsignor McHugh Elementary School with NPDES Permit No. 0029190, has a very small treatment plant with a design flow of 0.022 MG/D discharging into a small unnamed tributary.

Biological Assessment Qualifier

The April 2013 benthic macroinvertebrate samples with IBI scores of 85.1 at the Kurmes Preserve and 83.0 at Paradise Township Park suggest that upper Paradise Creek meets the biological qualifier for EV designation. Other available macroinvertebrate data from upper Paradise Creek and tributaries support the findings that it has exceptional water quality. The excellent, abundant, well balanced population of wild trout throughout the upper Paradise supports the petitioner's position that it is an exceptional resource.

Land Use in the Watershed

There are no riparian industrial land uses in the upper Paradise Creek Watershed. Commercial uses exist in Mount Pocono near the uppermost, intermittent portion of Yankee Run. Other commercial uses consist of the Caesar's Paradise Stream Resort and adjacent small riding stable, and the Paradise Trout Hatchery on the main stem Paradise. A small seasonal garden center and a restaurant exist on the small unnamed tributary flowing from the south, and the Monsignor McHugh Elementary School is on the small unnamed tributary entering from the north. The majority of the upper Paradise Watershed is on public protected land, either PA State Game Land, or preserves owned by Paradise Township or Pocono Heritage Land Trust. The remainder of the riparian land consists of small residential lots and a currently undeveloped parcel along Keokee Chappel Road formerly Pocono Gardens Resort.

Municipalities in the Watershed.

Most of the upper Paradise Watershed is contained within Paradise Township. The uppermost portion of the Yankee Run tributary originates in Mount Pocono Borough. The uppermost portions of Tank Creek and Devil's Hole tributaries begin in Coolbaugh Township, and Devil's Hole Creek flows for a short distance through Barrett Township before entering Paradise Township.

Following are contacts in those municipalities:

Gary Konrath, Chairman, Paradise Township Board of Supervisors
5912 Paradise Valley Road, Cresco, PA 18362. phone: 570-595-9880.

Mr. Ralph G. Megliola, Chairman, Barrett Township Board of Supervisors,993 Route 390, Cresco, PA 18326. phone: 570-595-2602.

Lynn Kelley, Chairman, Coolbaugh Township Board of Supervisors5520 Municipal Drive, Tobyhanna, PA 18466. phone: 570-894-8490

Frederick E. Courtright, Mayor, Mount Pocono Borough, 1361 Pocono Blvd., Suite 100 Mount Pocono, PA 18344. Phone 570-839-8436.

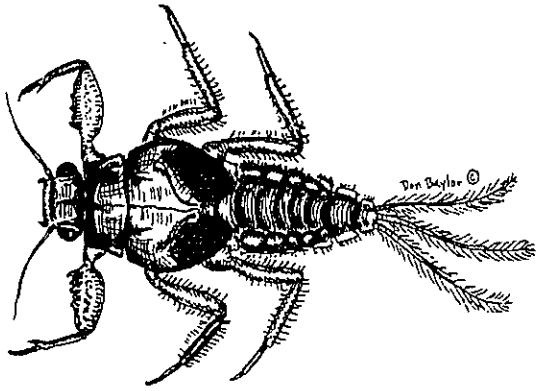
Appendix A.

BENTHIC MACROINVERTEBRATES OF UPPER PARADISE CREEK

APRIL 21, 2013

FOR

BRODHEAD TROUT UNLIMIED



Submitted by:

Don Baylor

521 Quail Ridge Lane

Stroudsburg, PA 18360

BENTHIC MACROINVERTEBRATES OF UPPER PARADISE CREEK, 2013

BACKGROUND

On April 21, 3013, at the request of the Brodhead Chapter of Trout Unlimited, biologist Don Baylor sampled benthic macroinvertebrates at two stations on Paradise Creek The purpose of the study was to determine how the sites compared to Aquatic Life Use (ALU) criteria established for Pennsylvania streams by Pennsylvania Department of Environmental Protection (DEP). One of the stations had been sampled previously as part of a 2009 study of the Paradise Watershed (Baylor 2009).

Aquatic macroinvertebrates are preferred indicators of stream water quality because of their limited mobility, one to three year life cycles, and specific sensitivities to pollutants. Clean streams usually support numerous species of invertebrates, theoretically evenly represented numerically. Impairment may be indicated by low taxa richness, shifts in community balance toward dominance of pollution-tolerant forms, or overall scarcity of invertebrates (Plafkin, et al. 1989). In order to assure an accurate assessment, recent work in bio-monitoring stresses the use of several parameters, or metrics, to measure different components of the community structure.

METHODS

Macroinvertebrate sampling methods followed those recommended by the US Environmental Protection Agency Protocol III (Plafkin, et al., 1989) with the latest modifications adopted by the PA Department of Environmental Protection for stream classification. At each station, six samples were taken with a D-frame kick net (Wildlife Supply Company #425-D5) of 500u nitex from the best riffle/run areas in a one hundred meter stretch. Samples were taken by placing the net against the substrate and disturbing approximately one square meter above the net by foot for one minute. Organisms and debris were composited for each station in a plastic container and preserved in alcohol for transport to the laboratory. Habitat was evaluated at each station using DEP's Water Quality Network Habitat Assessment forms for streams with riffle/run prevalence. Twelve habitat parameters were ranked on a scale of 1-20 and combined for a total habitat score.

In the laboratory, samples were rinsed in a USGS No. 35 sieve and placed in a white pan marked with a grid to delineate 28 squares measuring two inches on a side. Organisms were then picked from randomly selected grids until over 200 organisms were obtained. Organisms were identified to the lowest taxonomic level practicable, enumerated, and assigned a pollution tolerance value (PA DEP, 2009). Metrics for riffle/run freestone streams were calculated for each subsample, including total taxa richness, Ephemeroptera + Plecoptera + Trichoptera taxa richness (EPT), Modified Beck's Index, , Hilsenhoff biotic index, Shannon diversity index, , and percent sensitive individuals. A description and brief rationale for each of the metrics follow:

BENTHIC MACROINVERTEBRATES OF UPPER PARADISE CREEK, 2013

1. **Total Taxa Richness** – is an index of diversity. The number of taxa (kinds) of invertebrates indicates the health of the benthic community through measurement of the variety of species present. Generally, number of species increases with increased water quality. However, variability in natural habitat (stream order and size, substrate composition, current velocity) also affects this number.

2. **Ephemeroptera, Plecoptera, and Trichoptera Taxa Richness** (mayflies, stoneflies, and caddisflies), collectively referred to as EPT, are generally considered pollution sensitive (Plafkin et al. 1989). Thus, the total number of taxa within the EPT insect groups with a pollution tolerance value of 0-4 is used to evaluate community balance. Healthy biotic conditions are reflected when these taxa are well represented in the benthic community.

3. **Modified Beck's Index** is a weighted count of taxa with pollution tolerance values of 0, 1, or 2. This metric is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem, reflecting the loss of pollution sensitive taxa. It is calculated by multiplying by 3 the number of taxa with a pollution tolerance value of 0, multiplying by 2 the number of taxa with a pollution tolerance value of 1, and multiplying by 1 the number of taxa with a pollution tolerance value of 2. The three values are added to yield the Modified Beck's Index score.

4. **Hilsenhoff Biotic Index** – is a direct measure of organic pollution in streams. The biotic index value is the mean tolerance value of all organisms in a sample. Tolerance values range from 0.00 to 10.00; the higher the value, the greater the level of pollution indicated

Table 1. Evaluation of water quality using biotic index values (Hilsenhoff, 1987)

BIOTIC INDEX	WATER QUALITY	DEGREE OF ORGANIC POLLUTION
0.00-3.50	Excellent	None Apparent
3.51-4.50	Very Good	Possible Slight
4.51-5.50	Good	Some
5.51-6.50	Fair	Fairly Significant
6.51-7.50	Fairly Poor	Significant
7.51-8.50	Poor	Very Significant
8.51-10.00	Very Poor	Severe

5. **Shannon Diversity Index** measures taxonomic richness and evenness of numbers of individuals across the taxa of a subsample. This metric is expected to decrease in values with increased anthropogenic stress to a stream ecosystem, reflecting loss of pollution-sensitive taxa and predominance of a few pollution-tolerant taxa.

6. **Percent Sensitive Individuals** is the percentage of individuals in the subsample with pollution tolerance values of 0-3. It is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem.

INDEX CALCULATION

An overall index is used to integrate information from these various metrics and standardize them into one score for a subsample. The values for any standardized core metric are set to a maximum value of 1.00, with values closer to zero corresponding to increasing deviation from the expected reference condition and progressively higher values corresponding more closely to the biological reference condition. The adjusted standardized metric values for the six core metrics are averaged and multiplied by 100 to produce an index score ranging from 0-100. This number represents the index of biotic integrity (IBI) score for a sample. The following table shows metric standardization equations and index calculations for the sub-sample from Station 1 Paradise Creek:

Table 2. Metric standardization and index of biotic integrity calculations for the benthic macroinvertebrate sample from Paradise Creek Station 1 (Kurmes Preserve) on April 21, 2013.

Metric	Standardization Equation	Observed Metric Value	Standardized Metric Score	Adjusted Standardized Metric Score Maximum =1.00
Total Taxa Richness	Observed value / 33	21	0.636	0.636
EPT Taxa Richness	Observed Value/ 19	14	0.737	0.737
Modified Beck's Index	Observed value/38	33	0.868	0.868
Hilsenhoff Biotic Index	10-observed value/ (10-1.89)	2.05	0.980	0.980
Shannon Diversity Index	Observed value / 2.86	3.32	1.00	1.00
Percent Sensitive Individuals	Observed value / 84.5	74.58	0.883	0.883
Average of adjusted standardized core metric scores x 100 = IBI score				**85.1**

BENTHIC MACROINVERTEBRATES OF UPPER PARADISE CREEK, 2013

SAMPLING STATIONS

Two stations were sampled for benthic macroinvertebrates on Paradise Creek On April 21, 3013 (Figures 1-3):

Station 1. – Paradise Creek – on the Kurmes Preserve starting where an old woods road crosses the stream a short distance below the confluence of Tank Creek and Yankee Run at coordinates 41.0748/75.1930.

Station 2. - Paradise Creek – on Paradise Township Park property along Keokee Chapel Road approximately 150 meters downstream from Keokee Chapel at coordinates 41.0736/75.1822.

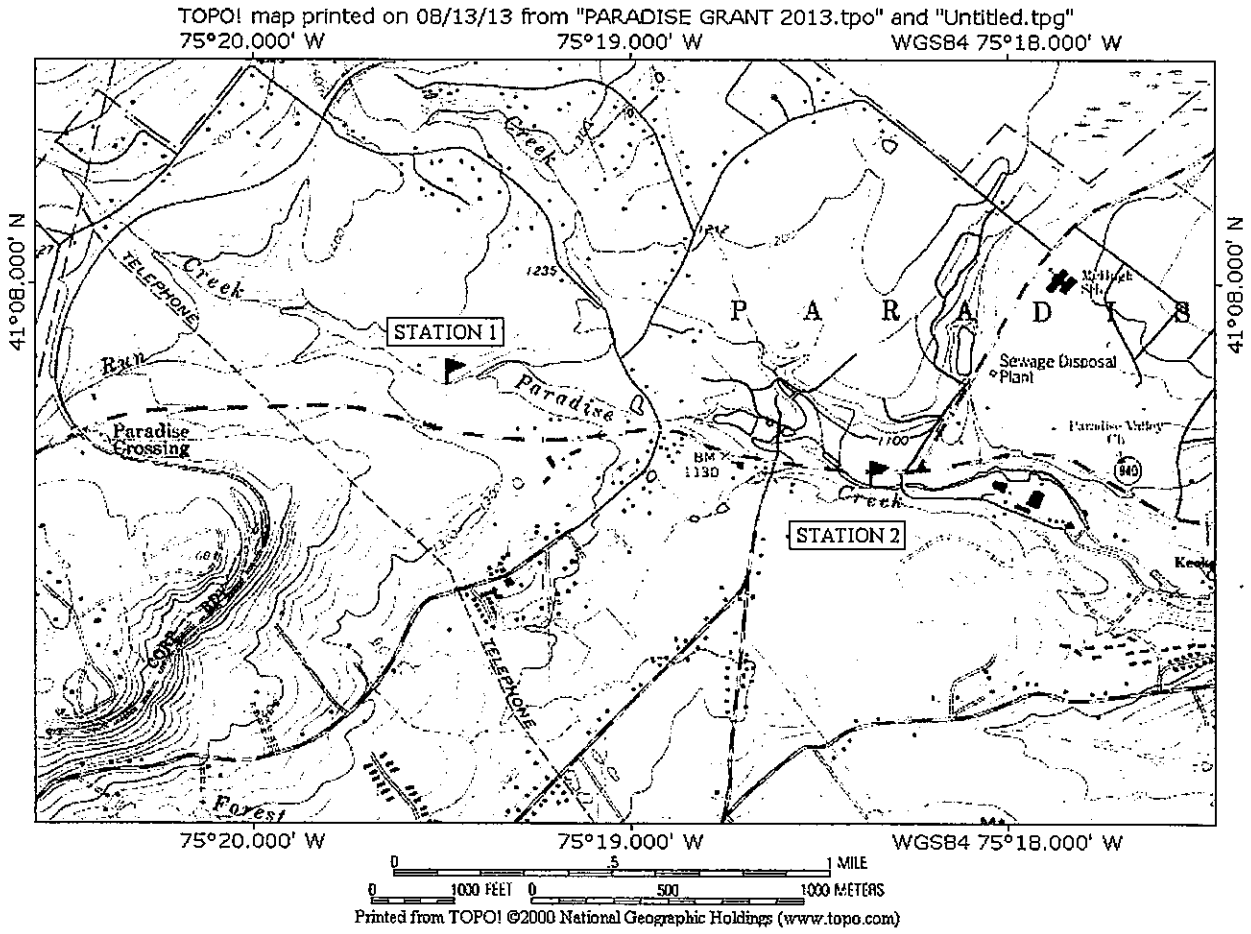


Figure 1. Macroinvertebrate sampling stations on Paradise Creek, April 21, 2013.

BENTHIC MACROINVERTEBRATES OF UPPER PARADISE CREEK, 2013

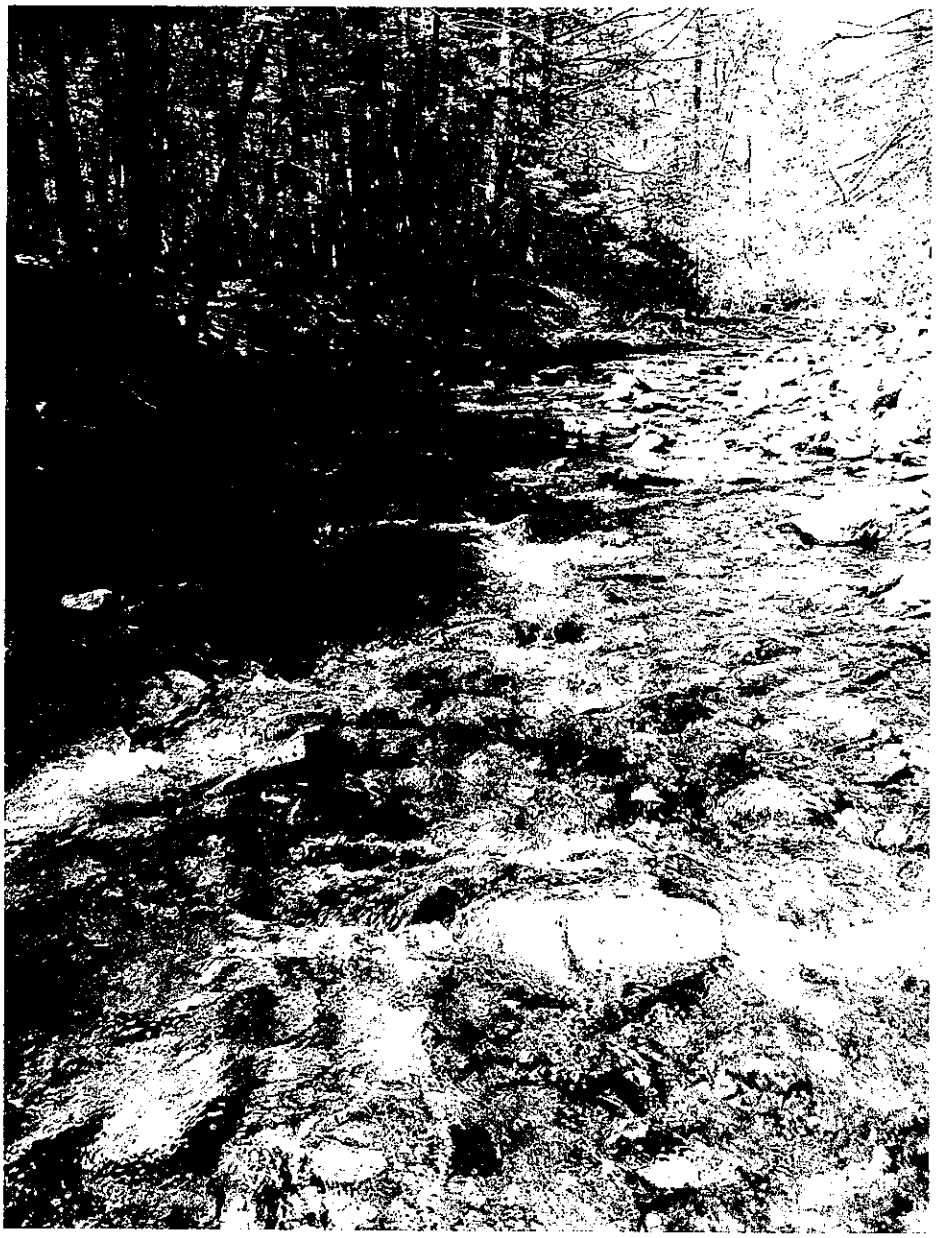


Figure 2. Macroinvertebrate sampling Station 1 above the woods road crossing on the Kurmes Preserve on Paradise Creek, April 21, 2013.

BENTHIC MACROINVERTEBRATES OF UPPER PARADISE CREEK, 2013

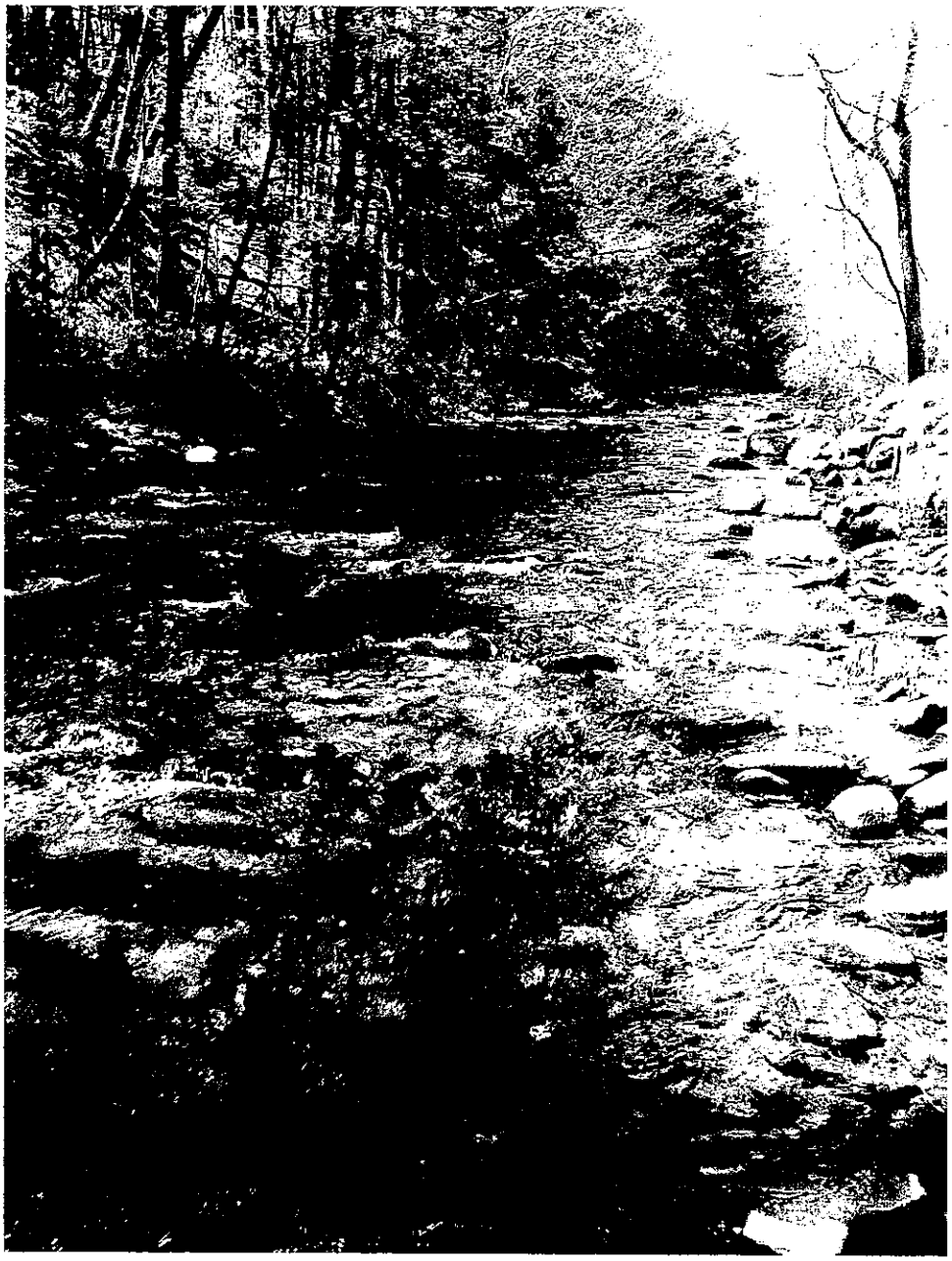


Figure 3. Macroinvertebrate sampling Station 2 approximately 150 meters below Keokee Chapel on Paradise Creek, April 21, 2013.

BENTHIC MACROINVERTEBRATES OF UPPER PARADISE CREEK, 2013

RESULTS AND DISCUSSION

Benthic Macroinvertebrate Communities – Paradise Creek

Appendix A shows the taxa, numbers, and pollution tolerance values (PT) for benthic macroinvertebrates from Paradise Creek on April 21, 2013. Table 3 shows metrics and IBI scores for those samples according to DEP's 2009 protocols.

IBI scores were very similar for both stations (Table 3). The upstream Station 1 scored 85.1 and the downstream Station 2 scored 83.0. These IBI scores are indicative of excellent water quality. Extensive analysis by DEP of samples from unimpaired Special Protection Pennsylvania streams found a natural variability of up to 11 points among samples and that a difference of greater than 11 points in IBI scores is indicative of anthropogenic impairment between stations (DEP 2009). For samples collected from smaller streams between October and May, an IBI score $\geq$ 63 results in Aquatic Life Use (ALU) attainment, and an IBI score < 50 results in ALU impairment. Both IBI scores were well above the PA DEP benchmark of 65 for Aquatic Life Use attainment for October through May samples.

Station 2 actually had superior values for Total Taxa Richness, EPT Taxa, and Becks's Index (Table 3). Values for Shannon Diversity were very similar for both stations. A sample with more numerous taxa, EPT taxa, and Beck's Index (intolerant taxa) would be expected to have better scores overall. However, Hilsenhoff Biotic Index and % Sensitive Individuals values were considerably poorer for Station 2. The cause of the poorer values for two metrics at Station 2 was a proliferation of *Baetis spp* mayflies. Since *Baetis spp.* have a pollution tolerance value of 6, their predominance at Station 2 caused lower values for % Intolerant Individuals and for the Hilsenhoff Biotic Index score, which is based on the average pollution tolerance of the organisms. At Station 1, *Epeorus spp.* mayflies with a tolerance value of 0 predominated constituting 32 % of the organisms. At Station 2, *Baetis spp.* mayflies constituted 42.7%. *Baetis spp.* mayflies typically have 3 generations per year with the first cohort being spring emergers. It is not uncommon in high quality northeastern PA streams for *Baetis spp.* to be prolific just prior to spring emergence.

The 2.1 point difference in IBI scores between the stations is well within the 11 points considered to be within natural variability, unaffected by anthropogenic impact. Although there is a wastewater treatment plant discharge and a riding stable crossing between Stations 1 and 2, the samples collected on April 21, 2013 suggest these had no

impact to Paradise Creek. The increase in taxa and intolerant taxa downstream suggests that the poorer scores for Hilsenhoff Biotic Index and % Sensitive Individuals may have been the result of a natural seasonal proliferation of *Baetis spp.* mayflies prior to their emergence.

Table 3. Benthic macroinvertebrate community metrics for two stations on Paradise Creek, April 21, 2013.

METRIC	STATION 1 KURMES PRESERVE		STATION 2 BELOW KEOKEE CHAPPLE	
	Observed Metric	Adjusted Standardized Metric Score Maximum=1.00	Observed Metric	Adjusted Standardized Metric Score Maximum=1.00
Number of Oganisms	240		218	
Number of Gids Picked /Subsample				
Total Taxa Richness	21	0.636	27	0.818
Beck's Index	33	0.868	43	1.00
Shannon Diversity	3.32	1.00	3.25	1.00
Hilsenhoff Biotic Index	2.05	0.980	3.72	0.774
Percent Sensitive individuals	74.58	0.883	41.74	0.494
Index of Biotic Integrity (IBI) Score		**85.1**		**83.0**
Benchmark for assessment category October to May: >= 63 IBI not impaired				

Habitat

The stations sampled on Paradise Creek in April 21, 2013 had habitat scores well within the optimal range (Table 3). Figures 2 and 3 show that the stations were very similar regarding in-stream physical habitat. Station 1 was in an area where human impact was minimal, while Station 2 has a paved road in close proximity to the east bank. Station 2 scored lower than Station 1 because of the road affecting scores for bank vegetative protection, disruptive pressure, and riparian vegetative zone width.

Table 3. Habitat assessment of sampling stations on upper Paradise Creek, April 21, 2013		
HABAITAT PARAMETER	**STATION 1** Kurmes Preserve	**STATION 2** Below Keokee Chappel
1. Instream Cover	16	16
2. Epifaunal Substrate	18	18
3. Embeddedness	19	19
4. Velocity/Depth Regimes	15	15
5. Channel Alteration	19	16
6. Sediment Deposition	19	19
7. Frequency of Riffles	20	20
8. Channel Flow Status	15	18
9. Condition of Banks	17	18
10. Bank Vegetative Protection	18	14
11. Grazing or Other Disruptive Pressure	19	15
12. Riparian Vegetative Zone Width	19	11
TOTAL SCORE	**214**	**199**
Score Ranges: Optimal 240-192, Suboptimal 180-132, Marginal 120-72, Poor less than 60.6.0		

Appendix A. Taxa, numbers, and pollution tolerance values (PT) for benthic macroinvertebrate samples from Paradise Creek on April 21, 2013			
TAXA	**STATION 1** Kurmes Preserve	**STATION 3** Below Keokee	**PT**

		Chapel	
Ephemeroptera (mayflies)			
Epeorus spp.	77	29	0
McCaffertium spp.	-	4	3
Ephemerella spp.	4	9	1
Drunella spp.	14	4	1
Paraleptophlebia spp.	1	3	1
Baetis spp.	39	93	6
Trichoptera (caddisflies)			
Rhyacophila spp.	12	6	1
Dolophilodes spp.	-	7	0
Lepidostoma spp.	1	-	1
Polycentropus spp.	-	1	6
Ceratopsyche spp	2	18	5
Diplectrona spp.	8	3	0
Cheumatopsyche spp.	1	3	6
Pycnopsyche spp.	1	-	4
Brachycentrus spp.	-	1	1
Plecoptera (stoneflies)			
Pteronarcys spp.	-	1	0
Tallaperla spp.	10	-	0
Leuctra spp.	9	4	0
Amphinemura spp.	17	-	3
Acroneuria	-	2	0
Isoperla spp.	-	5	2
Agnetina spp.	-	1	2
Suwalia/Sweltsa spp.	5	1	0
Clioperla spp.	1	3	2
Capnia spp.	-	2	1
Perlodidae	3	-	2
Diptera (true flies)			
Chironomidae	17	9	6
Prosimulium spp.	16	2	2
Hexatoma spp.	1	4	2
Tipula spp.	1	-	4
Hemerodromia spp.	-	1	6
Coleoptera (beetles)			
Optioservus spp.	-	1	4
Gastropoda (snails)			
Ferrissia spp.	-	1	7

BENTHIC MACROINVERTEBRATES OF PARADISE CREEK, MARCH 30, 2009

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Appendix B.

BENTHIC MACROINVERTEBRATES OF THE PARADISE WATERSHED

JUNE 11-26, 2009

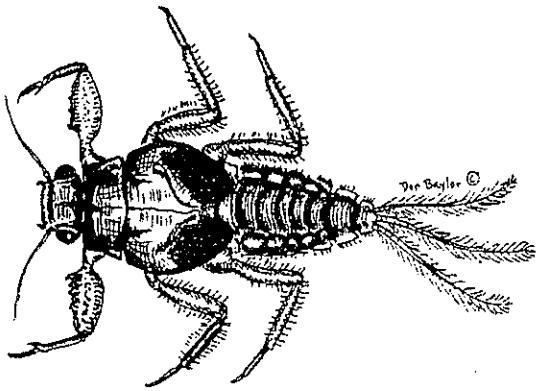
for the

PARADISE WATERSHED
STORMWATER FACILITY RETROFIT DESIGN PROJECT

a project of the

BRODHEAD WATERSHED ASSOCIATION

FUNDED BY A GROWING GREENER GRANT



Submitted by:

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BENTHIC MACROINVERTEBRATES OF THE PARADISE CREEK WATERSHED, JUNE 11-26, 2009

BACKGROUND

From June 11 to June 26, 2009, at the request of at the request of the Paradise Watershed Stormwater Facility Retrofit Design Project, Aquatic Resource Consulting (ARC) biologist Don Baylor, with assistance from Don Miller, sampled benthic macroinvertebrates at 21 stations on the Paradise Creek Watershed. All the sampling sites were on stream segments classified by Pennsylvania Department of Environmental Protection (DEP) as High Quality Cold Water Fisheries. The purpose of the study was to establish baseline water quality data on stream segments that may potentially be impacted by stream work and to determine how the sites compare to designated use criteria established for Pennsylvania streams by Pennsylvania DEP. The study was part of a Growing Greener Grant obtained through the Brodhead Watershed Association.

Aquatic macroinvertebrates are preferred indicators of stream water quality because of their limited mobility, one to three year life cycles, and specific sensitivities to pollutants. Clean streams usually support numerous species of invertebrates, theoretically evenly represented numerically. Impairment may be indicated by low taxa richness, shifts in community balance toward dominance of pollution-tolerant forms, or overall scarcity of invertebrates (Plafkin, et al. 1989). In order to assure an accurate assessment, recent work in bio-monitoring stresses the use of several parameters, or metrics, to measure different components of the community structure.

METHODS

Macroinvertebrate sampling methods followed those recommended by the US Environmental Protection Agency Protocol III (Plafkin, et al., 1989) with the latest modifications adopted by the PA Department of Environmental Protection (PA DEP, 2009). At each station, two samples were taken from a riffle/run area with a D-frame kick net (Wildlife Supply Company #425-D5) of 500u nitex. Samples were taken by placing the net against the substrate and disturbing approximately one square meter above the net by foot. Organisms and debris were composited for each station in a plastic container and preserved in alcohol for transport to the laboratory. Habitat was evaluated at each station using DEP's Water Quality Network Habitat Assessment forms for streams with riffle/run prevalence. Twelve habitat parameters were ranked on a scale of 1-20 and combined for a total habitat score.

BENTHIC MACROINVERTEBRATES OF PARADISE WATERSHED, JUNE 2009

In the laboratory, samples were rinsed in a USGS No. 35 sieve and placed in a white pan marked with a grid to delineate 28 squares measuring two inches on a side. Organisms were then picked from randomly selected grids until over 200 organisms were obtained. Organisms were identified to the lowest taxonomic level practicable, enumerated, and assigned a pollution tolerance value (PA DEP, 2009). Metrics for summer riffle/run freestone streams were calculated for each subsample, including Modified Beck's Index #4, Hilsenhoff Biotic Index, Ephemeroptera + Plecoptera + Trichoptera Taxa Richness (EPT), Modified Caddis Taxa Richness, and Fc + Pr + Sh Functional Feeding Group Taxa Richness. A description and brief rationale for each of the metrics follows:

Modified Beck's Index #4 – is a weighted average of intolerant taxa, calculated by multiplying the Hilsenhoff Biotic Index Scores 0-1 by 2, and scores 2-4 by 1, then summing the results.

Hilsenhoff Biotic Index – is a direct measure of organic pollution in streams. The biotic index value is the mean tolerance value of all organisms in a sample. Tolerance values range from 0.00 to 10.00; the higher the value, the greater the level of pollution indicated

EPT – is the total number of taxa found within the orders Ephemeroptera, Plecoptera, and Trichoptera.

Modified Caddisfly (mcad) – is the number of caddisfly taxa with a Hilsenhoff score of less than five.

FC+PR+SH Richness – is the sum of all the taxa found in these 3 functional feeding groups: Filter Collector (Fc), Predator (Pr), and shredder (Sh).

Table 1. Evaluation of water quality using biotic index values (Hilsenhoff, 1987)

BIOTIC INDEX	WATER QUALITY	DEGREE OF ORGANIC POLLUTION
0.00-3.50	Excellent	None Apparent
3.51-4.50	Very Good	Possible Slight
4.51-5.50	Good	Some
5.51-6.50	Fair	Fairly Significant
6.51-7.50	Fairly Poor	Significant
7.51-8.50	Poor	Very Significant
8.51-10.00	Very Poor	Severe

BENTHIC MACROINVERTEBRATES OF PARADISE WATERSHED, JUNE 2009

INDEX CALCULATION

An overall index is used to integrate information from these various metrics and standardize them into one score for a subsample. The values for any standardized core metric are set to a maximum value of 100, with values closer to zero corresponding to increasing deviation from the expected reference condition and progressively higher values corresponding more closely to the biological reference condition. The adjusted standardized metric values for the five core metrics are averaged to produce an index score ranging from 0-100. This number represents the Total Biological Score for a sample. The following table shows metric standardization equations and index calculations for the sub-sample from Station 1 on Paradise Creek.

Table 2. Example total biological score calculation

Metric	5^{th} or 95^{th} Percentile Value (n=1104)	Equation	Observed Value Paradise Sta #1	Normalized Metric Score	Adjusted Metric Score
Beck's Index #4	19.9	(observed/19.9) x 100	28	140.70	100
EPT Taxa Richness	15.3	(Observed/15.3) x 100	16	104.58	100
Mod. Caddis	3.6	(Observed/3.6) x 100	2	55.55	55.55
FC+PR+SH Taxa Richness	11.6	(Observed/11.6) x 100	10	86.21	86.21
Hilsenhoff Index	3.26	100 x ((10-Observed) / (10-3.26))	3.32	99.11	99.11
Total biological Score					**88.17**
Benchmark for assesment category					**68**

BENTHIC MACROINVERTEBRATES OF PARADISE WATERSHED, JUNE 2009

SAMPLING STATIONS

Twenty-one stations were sampled for benthic macroinvertebrates on the Paradise Watershed (Figure 1):

Paradise Creek #1 – the riffle area below the pool across the road from Keokee Chapel.

Paradise Creek #2 – approximately 20 yards above the bridge crossing on Red Rock Road.

Paradise Creek #3 – approximately 80 yards above Lower Swiftwater Road.

Paradise Creek #4 – approximately 100 yards above the railroad overhead crossing on property of Brodhead Forest & Stream.

Forest Hills Run #1 – upstream of the Mt. Pocono STP outfall, approximately 50 yards above route 611 stream crossing (above all discharge pipes).

Forest Hills Run #2 – below Mount Pocono STP discharge, approximately 75 yards upstream of Grange road stream crossing.

Forest Hills Run #3 – below the Mt. Airy STP discharge, approximately 30 yards upstream of Carlton road

Forest Hills Run #4 – near the mouth, approximately 40 yards upstream of the Lower Swiftwater Road stream crossing.

Cranberry Creek #1 – downstream of the peat mine in Cresco, approximately 670 yards downstream of the railroad stream crossing near Cresco – the first riffle area below the waterfall at the remains of an old dam.

Cranberry Creek #2 – a short distance above the trail footbridge crossing on the Paradise Township (formerly Nothstein) property.

Cranberry Creek #3 – near the mouth, approximately 30 yards upstream of the Cranberry Road stream crossing on Henryville Conservation Association property.

Swiftwater Creek #1 – approximately 25 yards upstream of the route 611 stream crossing.

Swiftwater Creek #2 – approximately 30 yards upstream of the confluence with Forest Hills Run.

BENTHIC MACROINVERTEBRATES OF PARADISE WATERSHED, JUNE 2009

Swiftwater Creek #3 – approximately 50 yards downstream of the confluence with Forest Hills Run.

Devil's Hole Creek #1 – approximately 40 yards below the railroad stream crossing and Approximately 500 yards downstream of the point where Devil's Hole Creek exits State Game Lands #221.

Devil's Hole Creek #2 – approximately 30 yards above the upstream bridge crossing on Paradise Stream Resort, and approximately 1.5 miles downstream of the point where Devil's Hole Creek exits State Game Lands #221.

Yankee Run #1 - approximately 40 yards above the large spring pool or approximately 0.6 mile upstream of Devil's Hole Road.

Yankee Run #2 - approximately 20 yards above Devil's Hole Road.

Unnamed Tributary to Yankee Run between Yankee Run and Tank Creek – approximately 20 yards below Devils Hole Road

Tank Creek - approximately 40 yards below Devil's Hole Road.

Butz Run - approximately 100 yards upstream from the mouth.

RESULTS AND DISCUSSION

A list of the benthic macroinvertebrate taxa collected from the Paradise Watershed is presented in Appendices A and B, along with pollution tolerance value and functional feeding group for each. Habitat scores for the sites are given in Appendix C. Table 3 shows the metric scores, and table 4 shows the Normalized Scores and the Total Biological Scores for the stations.

Seventeen of the 21 stations sampled on the Paradise Watershed had a Total Biological Score well above the DEP summer freestone benchmark score of 68 (Table 4). Two of three stations on Cranberry Creek and one of two on Devil's Hole Creek scored 100, correlating perfectly with the benchmark reference condition, indicating superior water quality. The other 14 of the 17 stations scoring above the benchmark scored in the range 81.90 to 98.30, indicating excellent water quality as well.

BENTHIC MACROINVERTEBRATES OF PARADISE WATERSHED, JUNE 2009

Four stations scored below the benchmark, indicting impairment (Table 4). The station with the lowest Total Biological Score of 6.83, indicating severe impairment, was Forest Hills Run Station 2 below the Mt. Pocono STP outfall (Table 4). On the date of sampling, the outfall appeared cloudy and had a strong sewage odor. Forest Hills Run was cloudy from the effluent to Grange Road. Forest Hills Run Station 1 above the discharge scored 96.94 with a fairly diverse community. Only 4 taxa were collected at Station 2 below the discharge. The sample consisted primarily of aquatic worms, indicating organic enrichment, with only 4 *Baetis* sp mayfly larvae and Chironomid midge and Simulium blackfly larvae also present (Appendix A). Forest Hills Run Station 3 also scored below the benchmark – 33.84 – indicating impairment. Station 3 is a short distance below the Mount Airy STP discharge and a short distance above Carlton Road. Chironomidae (midge larvae) predominated in this sample, which had only 2 mayflies and no stoneflies. Near the mouth of Forest Hills Run, Station 4 water quality had recovered to a score of 88.16.

Yankee Run Station 1, above the springs and a short distance below the 5 points intersection in Mount Pocono also scored below the benchmark at 33.43 (Table 4). The area surrounding this station showed evidence of severe run-off. Flows at this station, and habitat quality were considerable poorer than downstream at Yankee Run Station 2, which scored highly – 92.35. Swiftwater Creek Station 3 is the remaining station to indicate impairment, scoring 58.04. Swiftwater stations 1 and 2 scored much higher, 81.90 and 85.01 respectively. The reason for the lower score at Station 3 than at upstream Swiftwater stations is not clear. Swiftwater Station 3 is a short distance below the mouth of Forest Hills Run, which showed severe impairment upstream. However the score for the sample near the mouth of Forest Hills Run – 88.16 - was higher than the score for Swiftwater Creek Station 3.

Only four of the stations sampled scored less than optimal for habitat according to DEP's Riffle/Run Prevalence Habitat Assessment Field Data Sheet (Appendix c). Those four scored in the suboptimal range. The Butz Run station had a high, severely eroded bank on the southern side. Yankee Run Station 1 had minimal flows, and the surrounding area displayed effects of severe run-off. Paradise Creek Station 2 above Red Rock Road scored suboptimal because of severe erosion and unstable banks. And Tank Creek scored suboptimal due to sedimentation, lack of flow diversity, and unstable banks.

BENTHIC MACROINVERTEBRATES OF PARADISE WATERSHED, JUNE 2009

Table 3. Metric scores for benthic macroinvertebrate samples from Paradise Watershed, June 11-26, 2009.

Station	Number of Organisms/ Taxa	Beck's Index #4	Hilsen. Biotic Index	EPT	Mod. Caddis	Fc + Pr +Sh
Paradise #1	203/25	28	3.32	16	2	10
Paradise #2	227/22	27	3.76	17	3	12
Paradise #3	214/21	19	4.37	16	2	10
Paradise #4	208/24	26	3.55	18	3	11
Forest Hills #1	199/20	23	3.72	14	5	14
Forest Hills #2	191/ 4	0	8.72	1	0	1
Forest Hills #3	199/11	2	5.61	5	0	7
Forest Hills #4	180/22	18	4.47	13	3	13
Cranberry #1	210/30	30	2.70	18	14	17
Cranberry #2	231/26	34	2.59	13	3	12
Cranberry #3	221/23	25	2.78	19	3	11
Swiftwater #1	219/17	22	2.49	13	2	8
Swiftwater #2	235/20	18	5.53	13	3	12
Swiftwater #3	187/17	12	5.30	10	0	11
Devil's Hole #1	208/18	24	2.57	14	3	11
Devil's Hole #2	198/23	31	2.25	19	5	12
Yankee Run #1	75/11	9	5.87	4	0	4
Yankee Run #2	204/21	24	2.42	12	3	15
Tank Creek	205/18	23	2.88	14	3	11
UNT to Yankee	197/25	26	1.46	14	5	17
Butz Run	217/25	28	3.89	18	3	13

BENTHIC MACROINVERTEBRATES OF PARADISE WATERSHED, JUNE 2009

Table 4. Normalized (adjusted) metric scores and total biological scores for benthic macroinvertebrate samples from Paradise Watershed, June 11-26, 2009.

Station	Beck's #4	EPT	Mod. Caddis	Fc, Pr & Sh	HBI	Total Biol. Score
Paradise #1	140.70 (100)	104.58 (100)	55.55	86.21	99.11	**88.17**
Paradise #2	135.68 (100)	111.11 (100)	83.33	103.45 (100)	92.58	**95.18**
Paradise #3	95.48	104.58 (100)	55.55	86.21	83.53	**84.15**
Paradise #4	130.65 (100)	117.65 (100)	83.33	94.83	95.70	**94.77**
Forest Hills #1	115.58 (100)	91.50	138.89 (100)	120.69 (100)	93.18	**96.94**
Forest Hills #2	0	6.45	0	8.62	18.99	**6.83**
Forest Hills #3	11.06	32.68	0	60.34	65.13	**33.84**
Forest Hills #4	90.45	84.97	83.33	112.07 (100)	82.05	**88.16**
Cranberry #1	150.75 (100)	117.65 (100)	111.11 (100)	146.55 (100)	108.31 (100)	**100**
Cranberry #2	170.85 (100)	124.18 (100)	138.89 (100)	137.93 (100)	109.94 (100)	**100**
Cranberry #3	125.63 (100)	124.18 (100)	83.33	94.83	107.12 (100)	**95.63**
Swiftwater #1	110.55 (100)	84.97	55.55	68.97	111.42 (100)	**81.90**
Swiftwater #2	90.45	84.97	83.33	103.45 (100)	66.32	**85.01**
Swiftwater #3	60.30	65.36	0	94.83	69.73	**58.04**
Devil's Hole #1	120.60 (100)	91.50	83.33	94.83	110.24 (100)	**93.93**
Devil's Hole #2	155.78 (100)	124.18 (100)	138.89 (100)	103.45 (100)	114.99 (100)	**100**
Yankee Run #1	45.23	26.14	0	34.48	61.28	**33.43**
Yankee Run #2	120.60 (100)	78.43	83.33	129.31 (100)	112.46 (100)	**92.35**
Tank Creek	115.58 (100)	91.50	83.33	94.83	105.64 (100)	**93.93**
UNT to Yankee	130.65 (100)	91.50	138.89 (100)	146.55 (100)	126.71 (100)	**98.30**
Butz Run	140.70 (100)	117.65 (100)	83.33.	112.07 (100)	90.65	**94.80**

BENTHIC MACROINVERTEBRATES OF PARADISE WATERSHED, JUNE 2009

Appendix A. Taxa, numbers, pollution tolerance value (BI), and functional feeding Group (FG)* for benthic macroinvertebrate subsamples collected from 11 stations on Paradise Creek, Forest Hills Run, and Cranberry Creek, June 11-26, 2009

TAXA	STATIONS											BI	FG*
	PARADISE				FOREST HILLS				CRANBERRY				
	1	2	3	4	1	2	3	4	1	2	3		
Ephemeroptera													
Epeorus	1	2	-	-	-	-	-	-	-	-	4	0	Sc
Stenonema	3	-	4	1	-	-	-	4	-	-	2		
Leucrocuta	-	-	-	1	-	-	-	-	-	-	-		
Ephemerella	4	2	1	-	1	-	-	-	-	1	1		
Drunella	17	14	5	1	-	-	-	1	-	3	10	1	Sc
Serratella	1	1	1	64	-	-	-	-	4	1	12	2	Cg
Eurylophella	-	-	-	-	-	-	-	-	1	-	-	4	Sc
Dannella	-	-	-	-	5	-	-	-	-	-	-	2	cg
Paraleptophlebia	1	-	-	-	-	-	-	-	3	3	7	1	Cg
Isonychia	1	1	17	14	-	-	-	-	1	-	1	3	Cg
Baetis	86	102	46	31	73	4	1	21	12	61	53	6	Cg
Acentrella	-	2	21	6	-	-	1	1	1	3	16	4	Sc
Tricorythodes	-	-	-	1	-	-	-	-	-	-	-	4	Cg
Diphetor	-	-	-	-	-	-	-	-	2	-	-	6	Cg
Acerpenna	-	-	-	-	-	-	-	-	1	-	-	6	Cg
Trichoptera													
Rhyacophilla	1	7	-	1	3	-	-	3	5	7	-	1	Pr
Glossossoma	1	-	-	-	-	-	-	6	-	-	-	0	Sc
Dolophilodes	-	27	14	4	15	-	-	3	11	44	24	0	Fc
Chimarra	-	-	-	-	-	-	-	-	1	-	-	4	Fc
Brachycentrus	-	3	-	-	-	-	-	-	-	4	-	1	Fc
Micrasema	-	-	-	-	-	-	-	-	-	3	-	2	Sh
Diplectrona	-	-	1	-	2	-	-	-	2	3	1	0	Fc
Ceratopsyche	5	1	24	17	-	-	50	26	-	2	6	5	Fc
Hydropsyche	1	-	5	-	-	-	22	9	3	-	1	5	Fc
Cheumatopsyche	-	-	5	-	-	-	41	2	-	-	-	6	Fc
Polycentropus	3	12	-	-	3	-	-	-	-	1	3	6	Fc
Neureclipsis	-	-	-	1	-	-	-	5	-	-	-	7	Fc
Lepidostoma	-	-	-	3	2	-	-	-	-	-	1	1	Sh
Neophylax	-	-	-	-	1	-	-	-	-	-	-	3	Sc
Pycnopsyche	-	-	-	1	-	-	-	-	-	-	-	4	Sh
Ceraclea	-	-	-	-	-	-	-	-	-	-	3	3	cg

BENTHIC MACROINVERTEBRATES OF PARADISE WATERSHED, JUNE 2009

Appendix A. continued													
TAXA	STATIONS											BI	FG*
	PARADISE				FOREST HILLS				CRANBERRY				
	1	2	3	4	1	2	3	4	1	2	3		
Plecoptera													
Acroneuria	2	2	6	10	-	-	-	5	3	1	17	0	Pr
Phasgonophora	-	1	-	4	-	-	-	-	-	-	1	2	Pr
Paragnetina	-	-	-	1	-	-	-	-	1	-	-	1	Pr
Isoperla	-	-	1	-	17	-	-	-	5	4	-	2	Pr
Leuctra	53	23	7	5	11	-	-	11	74	8	33	0	Sh
Suwalia/Sweltsa	-	-	-	-	15	-	-	-	-	1	-	0	Pr
Tallaperla	-	-	-	-	-	-	-	-	1	18	-	0	Sh
Amphinemura	1	2	1	-	13	-	-	-	-	-	-	3	Sh
Pteronarcys	-	2	-	-	2	-	-	-	-	12	-	0	Sh
Diptera													
Chironomidae	4	18	43	30	19	22	68	50	21	9	9	6	Cg
Antocha	3	-	2	-	1	-	-	-	-	-	-	3	Cg
Hexatoma	2	1	-	1	5	-	-	7	-	6	2	2	Pr
Simulium	-	-	8	-	3	35	1	5	11	8	3	6	Fc
Dicranota	-	-	-	-	4	-	-	-	-	-	-	3	Pr
Tipula	-	-	-	-	-	-	1	1	1	-	-	4	Sh
Blepharicera	2	1	-	-	-	-	-	-	-	-	-	0	Sc
Chrysops	-	-	-	-	-	-	-	1	2	-	-	7	Pr
Atherix	-	-	-	-	-	-	-	-	3	-	-	2	Pr
Coleoptera													
Psephenus	-	-	-	4	-	-	-	15	1	1	10	4	Sc
Promoresia	1	-	-	-	-	-	-	-	5	22	-	2	Sc
Stenelmis	-	-	1	5	-	-	-	-	13	-	-	5	Sc
Optioservus	3	1	-	1	-	-	-	-	-	-	-	4	Sc
Megaloptera													
Nigronia	5	-	-	-	-	-	5	1	4	3	-	2	Pr
Odonata													
Ophiogomphus	1	-	-	-	-	-	-	-	3	2	-	1	Pr
Progomphus	-	1	-	-	-	-	-	-	-	-	-	5	Pr
Cordulegaster	-	-	-	-	-	-	-	-	1	-	-	3	Pr
Oligochaeta	1	-	-	-	-	130	-	-	-	-	-	10	Cg

BENTHIC MACROINVERTEBRATES OF PARADISE WATERSHED, JUNE 2009

Appendix A. continued

TAXA	STATIONS											BI	FG *
	PARADISE				FOREST HILLS				CRANBERRY				
	1	2	3	4	1	2	3	4	1	2	3		
Turbellaria	-	-	-	-	4	-	-	-	-	-	-	9	Pr
Mollusca													
Pisidium	-	-	-	-	-	-	4	-	14	-	-	8	Fc
Physinae	-	-	1	1	-	-	5	-	-	-	-	8	Sc
Ferrissia	-	-	-	-	-	-	-	2	-	-	-	7	Sc
Gyralus	-	-	-	-	-	-	-	1	-	-	-	6	sc

* (Cg=collector/gatherer, Sc=scraper, Fc=filtering collector, Pr=predator, Sh=shredder)

BENTHIC MACROINVERTEBRATES OF PARADISE WATERSHED, JUNE 2009

Appendix

Appendix B. Taxa, numbers, pollution tolerance value (BI), and functional feeding Group (FG)* for benthic macroinvertebrate subsamples collected from 10 stations on Swiftwater Crek, Devil's Hole Creek, Yankee Run, Tank Creek, Unnamed Tributary to Yankee Run, and Butz Run, June 11-26, 2009

TAXA	STATIONS										BI	FG*
	SWIFTWATER			DEVIL'S HOLE		YANKEE		TANK	UNT YANK	BUTZ		
	1	2	3	1	2	1	2					
Ephemeroptera												
Epeorus	7	-	-	38	21	-	4	29	-	-	0	Sc
Stenonema	-	-	-	-	2	-	-	-	-	4	3	Sc
Ephemerella	4	-	-	18	16	1	-	-	1	1	1	Cg
Drunella	1	1	2	22	35	1	-	28	-	6	1	Sc
Serratella	1	1	2	-	4	-	-	-	-	1	2	Cg
Paraleptophlebia	54	-	-	4	9	-	-	18	-	1	1	Cg
Isonychia	-	-	-	-	-	-	-	-	-	1	3	Cg
Habrophlebiodes	-	-	-	-	2	-	-	1	-	-	6	Sc
Baetis	49	49	64	54	51	6	42	69	3	116	6	cg
Acentrella	6	2	4	-	-	-	2	-	-	-	4	Sc
Trichoptera												
Rhyacophila	-	2	-	10	3	-	6	3	5	-	1	Pr
Agapetus	-	-	-	-	2	-	-	-	-	-	0	Sc
Glossossoma	-	-	-	-	-	-	-	-	-	3	0	Sc
Dolophilodes	58	1	-	7	30	-	45	-	113	20	0	Fc
Polycentropus	-	1	2	1	-	-	-	2	-	1	6	Fc
Nictiophylax	-	-	-	-	-	-	-	-	-	1	5	Pr
Diplectrona	1	-	-	1	1	-	6	5	5	11	0	Fc
Ceratopsyche	6	31	25	-	1	-	-	-	-	2	5	Fc
Hydropsyche	-	-	1	-	-	-	-	-	2	-	5	Fc
Cheumatopsyche	-	7	4	-	-	-	-	-	-	-	6	Fc
Psilotreta	-	-	-	-	-	-	-	1	-	-	0	Sc
Lepidostoma	-	-	-	-	1	-	1	-	3	-	1	Sh
Ceraclea	-	2	-	-	-	-	-	-	-	-	3	Cg
Pycnopsyche	-	-	-	-	-	-	-	-	2	-	4	sh

BENTHIC MACROINVERTEBRATES OF PARADISE WATERSHED, JUNE 2009

Appendix B. continued

TAXA	STATIONS										BI	FG *
	SWIFTWATER			DEVIL'S HOLE		YANKEE		TANK	UNT YANK	BUTZ		
	1	2	3	1	2	1	2					
Plecoptera												
Pteronarcys	-	-	-	5	2	-	16	5	-	-	0	Sh
Tallaperla	-	-	-	5	-	-	1	2	12	-	0	Sh
Leuctra	3	4	11	4	3	-	12	16	3	16	0	Sh
Amphinemura	-	-	-	1	-	-	32	-	2	4	3	Sh
Isoperla	1	-	-	17	1	2	6	2	1	-	2	Pr
Suwalia/Sweltsa	1	-	-	-	3	-	-	4	1	1	0	Pr
Phasgonophora	-	2	-	-	1	-	-	-	-	1	2	Pr
Acroneuria	-	3	1	-	-	-	-	-	2	8	0	Pr
Diptera												
Chironomidae	21	73	48	2	4	43	10	14	19	7	6	Cg
Simulium	1	36	18	15	-	6	-	-	-	1	6	Fc
Crysops	-	-	-	-	-	-	1	-	-	-	7	Pr
Hexatoma	-	-	-	-	3	-	3	3	-	3	2	Pr
Dicranota	-	-	1	3	-	-	-	1	2	-	3	Pr
Chelifera	-	-	-	-	-	-	-	2	8	-	6	Pr
Dolichopodidae	-	-	-	-	2	1	-	-	-	-	4	Pr
Blepharicera	4	-	-	-	-	-	-	-	-	-	0	Sc
Antocha	-	-	-	-	1	-	-	-	-	-	3	Cg
Coleoptera												
Psephenus	-	-	-	-	-	-	-	-	-	4	4	Sc
Promoresia	-	1	-	1	-	-	8	-	1	-	2	Sc
Stenelmis	-	3	-	-	-	-	1	-	-	-	5	Sc
Haliplis	-	-	-	-	-	4	-	-	-	-	5	Sh
Optioservus	-	-	-	-	-	-	-	-	1	1	4	sc
Megaloptera												
Nigronia	1	2	1	-	-	-	-	-	4	2	2	Pr
Odonata												
Progomphus	-	-	-	-	-	-	-	-	1	-	5	Pr
Ophiogomphus	-	1	1	-	-	-	4	-	-	-	1	Pr
Cordulegaster	-	-	-	-	-	-	1	-	-	-	3	Pr
Turbellaria	-	-	-	-	-	-	1	-	-	-	9	Pr
Oligochaeta	-	-	-	-	-	5	-	-	1	1	10	Cg

BENTHIC MACROINVERTEBRATES OF PARADISE WATERSHED, JUNE 2009

Appendix B. continued

TAXA	STATIONS										BI	FG *
	SWIFTWATER			DEVIL'S HOLE		YANKEE		TANK	UNT YANK	BUTZ		
	1	2	3	1	2	1	2					
Isopoda												
Caecidotea	-	-	-	-	-	3	-	-	-	-	6	cg
Amphipoda												
Gammarus	-	-	-	-	-	3	-	-	1	-	4	Cg
Nematomorpha	-	-	1	-	-	-	-	-	1	-	9	cg
Mollusca												
Pisidium	-	13	1	-	-	-	1	-	3	-	8	fc

* (Cg=collector/gatherer, Sc=scraper, Fc=filtering collector, Pr=predator, Sh=shredder)

BENTHIC MACROINVERTEBRATES OF PARADISE WATERSHED, JUNE 2009

Appendix C. Habitat scores for Riffle/Run Prevalence at benthic macroinvertebrate sites on the Paradise Watershed sampled from July 11-26, 2009

Station	Habitat Parameter*												Total
	1	2	3	4	5	6	7	8	9	10	11	12	Score**
Paradise 1	16	18	12	17	18	20	20	20	17	14	16	11	**199**
Paradise 2	16	17	18	17	13	12	16	19	3	10	13	15	**169**
Paradise 3	17	19	15	13	19	14	20	20	14	19	18	19	**207**
Paradise 4	20	17	18	18	15	19	18	20	18	17	18	19	**217**
Forest Hills 1	16	18	16	14	16	16	18	20	6	13	20	18	**191**
Forest Hills 2	19	17	15	17	20	17	19	20	4	10	18	18	**194**
Forest Hills 3	13	15	17	11	15	16	20	20	18	18	18	18	**199**
Forest Hills 4	14	17	16	17	20	15	20	17	10	15	16	18	**195**
Cranberry 1	18	13	15	11	13	18	14	17	20	20	20	20	**194**
Cranberry 2	18	19	19	18	20	18	18	20	20	20	20	20	**230**
Cranberry 3	17	20	18	17	19	20	20	20	16	17	15	16	**215**
Swiftwater 1	18	20	20	18	20	20	20	17	14	18	16	15	**216**
Swiftwater 2	16	18	19	17	18	20	20	20	15	14	15	16	**208**
Swiftwater 3	18	19	14	16	19	18	19	20	13	19	20	19	**214**
Devil's Hole 1	17	18	19	13	20	20	20	19	14	18	19	17	**214**
Devil's Hole 2	16	19	18	17	15	19	20	20	15	17	18	14	**208**
Yankee 1	9	13	10	11	16	15	17	11	10	19	14	13	**153**
Yankee 2	16	18	12	14	19	14	18	20	16	18	20	18	**203**
Tank Creek	14	18	18	14	11	17	19	20	11	14	16	14	**186**
UNT to Yank	13	15	16	13	20	16	17	19	19	20	17	19	**204**
Butz Run	15	16	15	15	18	15	18	17	10	11	12	13	**175**

* 1-instream cover, 2- epifaunal substrate, 3 – embeddedness, 4- velocity/depth regimes, 5 – channel alteration, 6 – sediment deposition, 7 – frequency of riffles, 8- channel flow status, 9 – condition of banks, 10 – bank vegetative protection, 11 – grazing or other disruptive pressure, 12 – riparian vegetative zone width

** Score ranges: Optimal 340-192, Suboptimal 180-132, Marginal 120-72, Poor <60

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Appendix C.

BENTHIC MACROINVERTEBRATES

OF

PARADISE CREEK HEADWATERS

MONROE COUNTY, PA

SPRING 2000

FOR

BRODHEAD WATERSHED ASSOCIATION

Submitted by

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For

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BENTHIC MACROINVERTEBRATES OF PARADISE CREEK HEADWATERS 2000

BACKGROUND

In spring of 2000 Don Baylor of Aquatic Resource Consulting (ARC) and Don Miller of the Brodhead Watershed Association (BWA) sampled benthic macroinvertebrates at four stations on the headwaters of Paradise Creek, Paradise Township, Monroe County, PA. Six stations on Paradise Creek headwaters had been sampled in 1999 for benthic macroinvertebrates (Baylor 1999). The four additional stations sampled in this study were chosen to complete baseline data on water quality in the headwater tributaries of Paradise Creek. Dates of sampling were as follows: Yankee Run – April 14, Upper Devil's Hole Creek - April 16, Lower Devil's Hole Creek – April 20, and tributary to Tank Creek – June 10.

Aquatic macroinvertebrates are preferred indicators of stream water quality because of their limited mobility, one to three year life cycles, and specific sensitivities to pollutants. Clean streams usually support numerous species of invertebrates, theoretically evenly represented numerically. Impairment may be indicated by low taxa richness, shifts in community balance toward dominance of pollution-tolerant forms, or overall scarcity of invertebrates (Plafkin, et al. 1998). In order to assure an accurate assessment, recent work in bio-monitoring stresses the use of several parameters, or metrics, to measure different components of the community structure.

Taxa Richness

The number of taxa (kinds) of invertebrates indicates the health of the benthic community through measurement of the variety of species present. Generally, number of species increases with increased water quality. Variability in natural habitat, however, also affects this number.

EPT Index

The insect orders Ephemeroptera, Plecoptera, and Trichoptera (mayflies, stoneflies, and caddisflies) collectively referred to as EPT, are generally considered pollution sensitive (Plafkin et al. 1989). Thus, the total number of taxa within the EPT insect groups (EPT index) is used to evaluate community balance. Healthy biotic conditions are reflected when these taxa are well represented in the benthic community.

Percent Mayflies

Pennsylvania environmental agencies use the percent contribution of mayflies to the total number of organisms as an indication of water quality. Mayflies are considered one of the least tolerant orders to organic pollution and acidification. Undisturbed streams generally have an abundance of mayflies.

Biotic Index

Since many of the aquatic invertebrate taxa have been associated with specific values for tolerance to organic pollutants, a biotic index is also used to measure the degree of organic pollution in streams. The biotic index value is the mean tolerance value of all organisms in a sample. Values range from 0.00 to 10.00; the higher the value, the greater the level of pollution indicated (Table 1).

Table 1. Evaluation of water quality using biotic index values (Hilsenhoff, 1987)

Biotic Index	Water Quality	Degree of Organic Pollution
0.00-3.50	Excellent	None apparent
3.51-4.50	Very good	Possible slight
4.51-5.50	Good	Some
5.51-6.50	Fair	Fairly significant
6.51-7.50	Fairly poor	Significant
7.51-8.50	Poor	Very significant
8.51-10.00	Very poor	Severe

Diversity

Species diversity calculations measure the number of taxa present and the evenness of the distribution of numbers of individuals among the taxa. Diversity values in unpolluted streams generally range from 3 to 4; in polluted streams, they often fall below 1 (Wilhm 1973).

METHODS

Sampling methods followed those recommended by Hilsenhoff (1982) and the Environmental Protection Agency (Weber, 1973). At each station, a riffle area was sampled with a kick screen device of 521 micron nytex. Kick samples were taken at each station by placing the screen against the substrate and disturbing the substrate above the screen with a four-pronged cultivating tool. Organisms and debris were composited for each station in a plastic bag and preserved in Kahle's solution for transport to the laboratory.

In the laboratory, organisms were placed in an enamel pan marked with numbered grids and picked from the debris starting with a randomly selected grid until over 100 organisms were obtained. Organisms were identified to the genus level, enumerated, and assigned a pollution tolerance value if known (Bode, et al. 1996 and Environmental Analysts 1990). Taxa richness, EPT index, percent mayflies, diversity, and biotic index values were calculated for each station according to Hilsenhoff (1987), Weber (1973), and Plafkin, et al. (1989).

SAMPLING STATIONS

The following stations on the headwaters of Paradise Creek were sampled for benthic macroinvertebrates in spring of 2000 (refer to map in Figure 1):

Station 1. Upper Devil's Hole Creek a short distance downstream from where The stream enters State Game Land Number 221 and above a waterfall: elevation 1794', latitude N 41 degrees 9.64', longitude W 75 degrees 20.14.'

Station 2. Lower Devil's Hole Creek a short distance above its confluence with Paradise Creek: elevation 1099', latitude N 41degrees 7.71', longitude W 75 degrees 18.50.'

Station 3. Yankee Run above its confluence with the large spring east of Mount Pocono: elevation 1601', latitude 41 degrees 7.59', longitude W 75 Degrees 21.00.'

Station 4. Tributary to Tank Creek draining spring ponds just outside of State Game lands Number 221: elevation 1625', latitude N 41 degrees 8.37', Longitude W 75 degrees 20.76.'

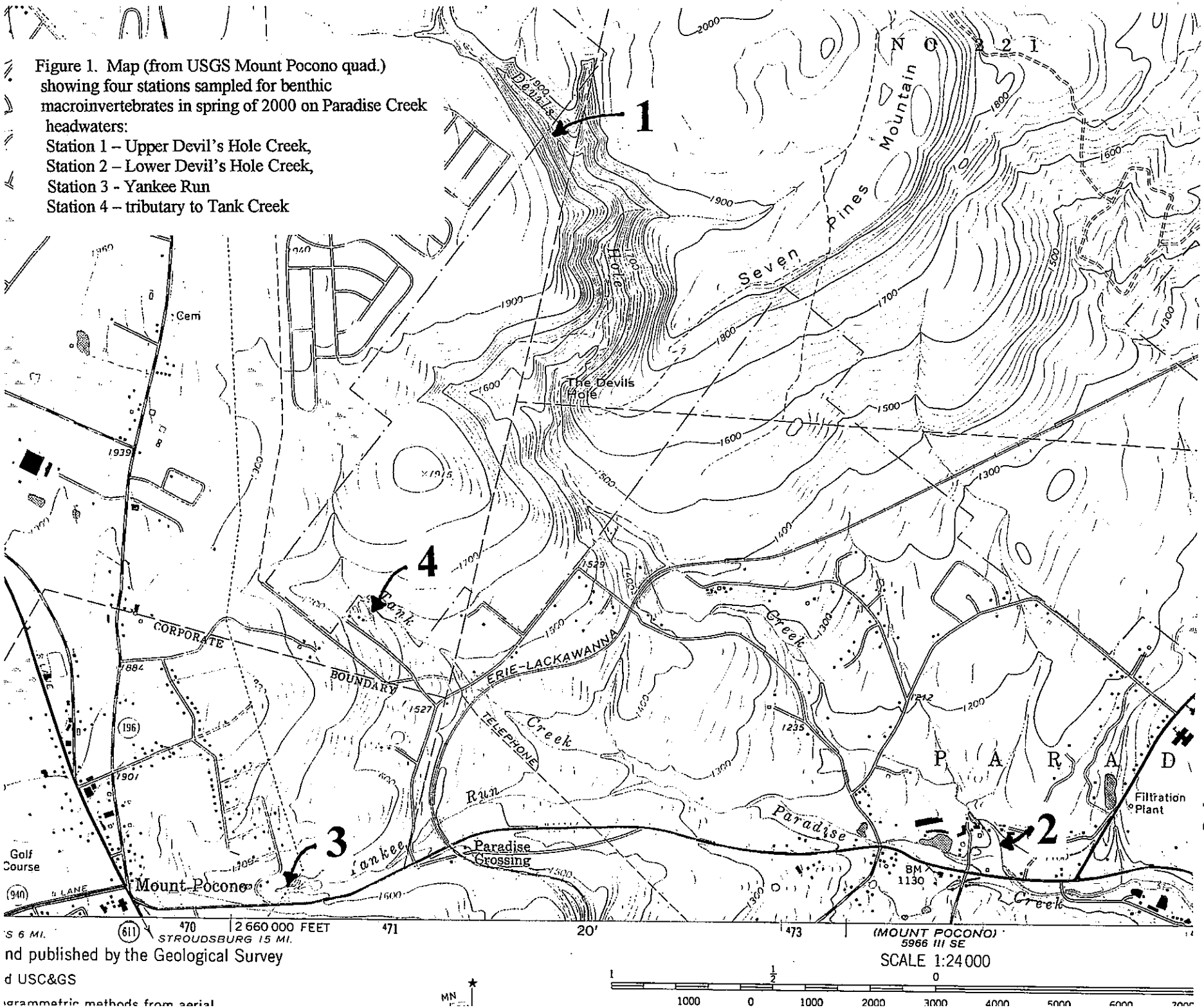

Figure 1. Map (from USGS Mount Pocono quad.) showing four stations sampled for benthic macroinvertebrates in spring of 2000 on Paradise Creek headwaters:
Station 1 – Upper Devil's Hole Creek,
Station 2 – Lower Devil's Hole Creek,
Station 3 - Yankee Run
Station 4 – tributary to Tank Creek

RESULTS AND DISCUSSION

Both stations on Devil's Hole Creek and the one on the tributary to Tank Creek reflected excellent water quality with little or no organic pollution. Station 3, above the springs on Yankee Run had a macroinvertebrate population indicative of some degradation (Table 2). Number of taxa varied from 25 at Lower Devil's Hole Creek - Station 2 to 15 at Yankee Run - Station 3 (Table 2). EPT taxa predominated at all stations, ranging from a high of 19 at Lower Devils Hole Creek-Station 2, to a low of 10 at Yankee Run-Station 3 (Appendix A). Species diversity fell within the expected clean stream range (3.0-4.0) except at Station 3.

Samples from stations 1, 2, and 3 compared favorably to those collected from six stations on Paradise Creek headwaters in April of 1999. Although the biotic index value increased from Station 1 to Station 2 on Devil's Hole Creek in the spring 2000 sampling, it remained within Hilsenhoff's range of "excellent with no apparent organic pollution."

Table 2. Number of organisms, number of taxa, EPT index, diversity, biotic index, and percent mayflies for benthic macroinvertebrate samples from four stations on Paradise Creek headwaters, spring of 2000.

METRIC	STATIONS			
	Upper Devil's #1	Lower Devil's #2	Yankee Run #3	trib. to Tank Cr. #4
Number of Organisms	100	126	130	122
Number of Taxa	20	25	15	23
EPT Index	19	19	10	17
Diversity	3.46	3.92	2.37	3.21
Biotic Index	0.57	2.17	4.70	0.75
Percent Mayflies	32%	52%	1.5%	14%

Metrics for Station 3 on Yankee Run were inferior to those found at a station below the confluence with the spring on Yankee Run in 1999 (Table 3). This was the only sampling station of those sampled on Paradise Creek headwaters in 1999 and 2000 to indicate degraded water quality. Station 3 above the springs on Yankee Run had fewer taxa and EPT taxa, a very low percentage of mayflies, a diversity value below the expected clean stream range, and a biotic index value indicating some organic pollution (Tables 2 and 3). Yankee Run reportedly receives considerable storm run-off above Station 3. The biotic index value of 4.70 indicated some organic loading from run-off. The spring flow was apparently responsible for greatly ameliorating the water quality of Yankee Run. Pollutants in the run-off may, therefore, impact invertebrates more severely upstream from the dilution of the spring. A cursory field investigation of Yankee Run upstream from the spring on April 11, 1999 revealed a very sparse invertebrate population indicating that flows in Yankee Run above the spring may be minimal or intermittent during dry periods.

Table 3. Biotic index values, number of taxa, EPT index, diversity, and percent mayflies for samples from Yankee Run in 2000 at Station 3 above the confluence with a large spring, and in 1999 at Station 6 below the confluence.

STATION/ DATE	BIOTIC INDEX	TAXA	EPT	DIVERSITY	% MAYFLIES
Yankee Run Above spring 2000	4.70	15	10	2.37	1.5%
Yankee Run Below spring 1999	1.85	18	13	3.52	37%

RECOMMENDATIONS

Now that baseline invertebrate data have been established for these stations on Paradise Creek headwaters, periodic monitoring should be conducted to assess water quality and to detect any changes that may occur over time. Measures should be taken to identify sources of degradation and mitigate their impact on Yankee Run.

Apendix A. Taxa, numbers, and biotic index value (BI) of benthic macroinvertebrates collected from 4 stations on Paradise Creek headwaters in spring of 2000.

TAXA	STATIONS				BI
	#1 UPPER DEVIL'S	#2 LOWER DEVIL'S	#3 YANKEE RUN	#4 TRIB. TO TANK	
Ephemeroptera (mayflies)					
Epeorus sp.	21	8	-	-	0
Ephemerella sp.	6	23	-	1	1
Drunella cornuta	1	6	-	11	0
Paraleptophlebia sp.	-	1	-	3	1
Cinygmula subaequalis	-	3	-	-	-
Heptagenia pulla	3	-	-	-	4
Baetis sp.	-	23	2	1	6
Stenonema sp.	-	1	-	-	4
Leptophlebia sp.	1	-	-	-	4
Habrophlebiodes sp.	-	-	-	1	2
Trichoptera (caddisflies)					
Rhyacophila sp.	4	8	21	7	1
Diplectrona sp.	1	-	-	1	0
Glossossoma sp.	-	-	-	1	0
Dolophilodes sp.	2	-	-	35	0
Lepidostoma sp.	3	1	-	1	2
Pycnopsyche sp.	4	3	1	-	3
Psilotreta sp.	1	-	3	2	0
Neophylax sp.	3	-	2	2	3
Limnephilidae	-	-	-	1	3
Ironoquia sp.	-	-	1	-	3
Polycentropus sp.	-	-	2	-	6
Ceratopsyche sp.	1	3	-	-	4
Cheumatopsyche sp.	-	2	-	-	5
Plecoptera (stoneflies)					
Allonarcys comstocki	-	4	-	-	0
A. biloba	1	3	-	-	0
A proteus	-	-	-	1	0

Appendix A. continued

TAXA	#1 UPPER DEVIL'S	#2 LOWER DEVIL'S	#3 YANKEE RUN	#4 TRIB. TO TANK	BI
Tallaperla sp.	26	12	-	5	0
Leuctra sp.	9	1	-	35	0
Amphinemura delosa	-	-	-	3	3
Sweltsa sp.	5	5	1	-	0
Isoperla nemata	-	5	-	-	2
I. sp.	-	3	1	-	2
Acroneuria abnormis	6	-	-	-	0
A carolinensis	1	-	-	-	0
Taeniopteryx sp.	-	-	1	-	2
Diptera (true flies)					
Chironomidae	-	4	23	3	6
Antocha sp.	-	2	-	-	3
Hexatoma sp.	-	1	-	-	2
Tipula sp.	-	1	5	-	4
Simulium sp.	-	-	64	2	5
Prosimulium magnum	1	2	-	-	1
Dicranota sp.	-	-	-	3	3
Odonata (dragonflies)					
Ophiogomphus sp.	-	-	-	1	1
Decapoda (crayfish)					
Cambarus bartoni	-	1	-	-	6
Mollusca (mollusks)					
Physinae	-	-	-	1	8
Amphipoda (shrimp)					
Gammarus sp.	-	-	-	1	6
Turbellaria (planaria)					
Macrostomum sp.	-	-	1	-	8
Hirundinea (leeches)					
Myzobdella lugubris	-	-	2	-	7

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Appendix D.

BENTHIC MACROINVERTEBRATES

OF

PARADISE CREEK HEADWATERS

MONROE COUNTY, PA

APRIL 11, 1999

FOR

BRODHEAD WATERSHED ASSOCIATION

Submitted by

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For

Aquatic Resource Consulting

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BENTHIC MACROINVERTEBRATES OF PARADISE CREEK HEADWATERS

BACKGROUND

On April 11 , 1999,At the request of the Brodhead Watershed Association (BWA), Aquatic Resource Consulting supervised BWA volunteers and students in sampling benthic macroinvertebrates at six stations on the headwaters of Paradise Creek, Paradise Township, Monroe County, PA. The purpose of the sampling was to document water quality as part of a Coldwater Heritage Grant.

Aquatic macroinvertebrates are preferred indicators of stream water quality because of their limited mobility, one to three year life cycles, and specific sensitivities to pollutants. Clean streams usually support numerous species of invertebrates, theoretically evenly represented numerically. Impairment may be indicated by low taxa richness, shifts in community balance toward dominance of pollution-tolerant forms, or overall scarcity of invertebrates (Plafkin, et al. 1998). In order to assure an accurate assessment, recent work in bio-monitoring stresses the use of several parameters, or metrics, to measure different components of the community structure.

Taxa Richness

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EPT Index

The insect orders Ephemeroptera, Plecoptera, and Trichoptera (mayflies, stoneflies, and caddisflies) collectively referred to as EPT, are generally considered pollution sensitive (Plafkin et al. 1989). Thus, the total number of taxa within the EPT insect groups (EPT index) is used to evaluate community balance. Healthy biotic conditions are reflected when these taxa are well represented in the benthic community.

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Table 1. Evaluation of water quality using biotic index values (Hilsenhoff, 1987)

Biotic Index	Water Quality	Degree of Organic Pollution
0.00-3.50	Excellent	None apparent
3.51-4.50	Very good	Possible slight
4.51-5.50	Good	Some
5.51-6.50	Fair	Fairly significant
6.51-7.50	Fairly poor	Significant
7.51-8.50	Poor	Very significant
8.51-10.00	Very poor	Severe

Diversity

Species diversity calculations measure the number of taxa present and the evenness of the distribution of numbers of individuals among the taxa. Diversity values in unpolluted streams generally range from 3 to 4; in polluted streams, they often fall below 1 (Wilhm 1973).

METHODS

Sampling methods followed those recommended by Hilsenhoff (1982) and the Environmental Protection Agency (Weber, 1973). At each station, a riffle area was sampled with a kick screen device of 521 micron nytex. Kick samples were taken at each station by placing the screen against the substrate and disturbing the substrate above the screen with a four-pronged cultivating tool. Organisms and debris were composited for each station in a plastic bag and preserved in Kahle's solution for transport to the laboratory.

In the laboratory, organisms were placed in an enamel pan marked with numbered grids and picked from the debris starting with a randomly selected grid until over 100 organisms were obtained. Organisms were identified to the genus level, enumerated, and assigned a pollution tolerance value if known (Bode, et al. 1996 and Environmental Analysts 1990). Taxa richness, EPT index, percent mayflies, percent dominant taxon, diversity, and biotic index values were calculated for each station according to Hilsenhoff (1987), Weber (1973), and Plafkin, et al. (1989).

SAMPLING STATIONS

The following stations on the headwaters of Paradise Creek were sampled for benthic macroinvertebrates on April 11, 1999:

1. Paradise Creek at the Township Park – the first riffle area upstream from the lower Township Park area, just upstream from the grassy public access area.

2. Paradise Creek at the confluence of Devil's Hole Creek and Tank Creek – the first significant riffle area below the confluence and above an instream log dam and riding stable stream crossing on the property of Mountain Creek Stables.

3. Tank Creek at lower Devil's Hole Road – the first significant riffle on the upstream side of the bridge, approximately one half mile below the confluence of Yankee Run and Tank Creek.

4. Devil's Hole Creek at Koerner Road – the first significant riffle area on the upstream side of the bridge, approximately one quarter mile upstream from the confluence with Tank Creek.

5. Tank Creek at upper Devil's Hole Road – the first significant riffle area on the upstream side of the large, under road culvert pipe, in the approximate middle of the stream's length.

6. Yankee Run at upper Devil's Hole Road – the first significant riffle area on the upstream side of a the small, under road culvert pipe, in the approximate middle of the stream's length.

Figure 1. Map showing 6 stations on Paradise Creek headwaters sampled for benthic macroinvertebrates on April 11, 1999 (from USGS Buck Hill Falls and Mt. Pocono quads.). Stations: 1- Paradise Creek, 2 – Paradise Creek, 3 – Tank Creek, 4 – Devil's Hole Creek, 5 – Tank Creek, 6 – Yankee Run.

RESULTS AND DISCUSSION

All samples from the Paradise Creek headwaters reflected excellent water quality with little or no organic pollution. Number of taxa varied from 18 at stations 2, 3, and 6 to 21 at Station 1(Table 2). EPT taxa predominated at all stations, ranging from a low of 13 at Yankee Run-Station 6, to a high of 17 at Devils Hole Creek-Station 4. Species diversity fell within the expected clean stream range (3.0-4.0) except at stations 3 and 4. However, slightly lower diversity at these stations did not suggest organic pollution. The lower figures were caused by a seasonal proliferation of *Epeorus* sp. mayflies, which have very low tolerance to organic pollution (Appendix A).

Table 2. Number of organisms, number of taxa, EPT index (taxa), diversity, biotic index, and percent mayflies for benthic macroinvertebrate samples from six stations on Paradise Creek headwaters, April 11, 1999.

METRIC	STATIONS					
	Paradise-1	Paradise-2	Tank-3	Devil's-4	Tank-5	Yankee-6
Number of organisms	131	169	163	112	121	134
Number of taxa	21	18	18	20	20	18
EPT index	16	15	15	17	16	13
Diversity	3.75	2.90	2.44	3.46	3.34	3.52
Biotic Index	2.11	1.72	1.31	3.07	0.72	1.94
% mayflies	51%	69%	77%	59%	55%	37%

Hilsenhoff Biotic Index values (BI) ranged from 0.72 at Station 5 – Tank Creek - to 3.07 at Station 4 – Devil's Hole Creek at Koerner road. Although the value at Station 5 was considerably superior and the value at Station 4 was considerably inferior to all others, they were all within the 0 – 3.5 range indicating excellent water quality with no apparent organic pollution (Table 1). All stations had a high percentage of mayfly organisms – Station 6 at Yankee Run was the only one with less than 50% mayflies (Table 2).

The high percentages of mayfly organisms suggest excellent water quality in terms of low organic enrichment. In addition, mayflies are the order least tolerant of acidification. Though these headwaters may be low in buffering capacity, the abundance of mayflies indicated that acidification has not occurred in the Paradise Creek headwaters. Stoneflies, an order intolerant of organic pollution, were also well represented in all samples (Appendix A).

The flow in Yankee Run was augmented substantially by a large spring upstream from Station 6. A cursory field investigation of Yankee Run upstream from the spring revealed a very sparse invertebrate population on April 11, 1999. The spring was apparently responsible for greatly ameliorating the water quality of Yankee Run.

RECOMMENDATIONS

Now that baseline invertebrate data have been established for these stations on Paradise Creek headwaters, periodic monitoring should be conducted to assess water quality and to detect any changes that may occur over time. A fall sampling would be useful to document species present at that time of year so that future conditions could be compared in spring or fall. Additional stations on Yankee Run should be sampled to assess water quality above and below the large spring above Station 6 since preliminary field investigations suggest a considerable difference in water quality. Surveys of the fish populations at these headwater locations would provide additional baseline environmental data.

Apendix A. Taxa, numbers, and biotic index value (BI) of benthic macroinvertebrates collected from 6 stations on Paradise Creek headwaters on April 11, 1999.

TAXA	STATIONS						BI
	#1	#2	#3	#4	#5	#6	
Ephemeroptera (mayflies)							
Epeorus sp.	28	55	89	22	47	12	0
Paraleptophlebia sp.	2	2	3	-	9	-	1
Stenonema ithaca	16	-	-	-	-	-	3
Stenonema vicarium	1	-	-	-	-	-	1
Stenonema sp.	-	1	-	7	-	-	4
Ephemerella sp.	9	31	5	8	1	19	1
Drunella cornuta	-	-	1	2	4	-	0
Baetis sp.	11	26	28	24	1	18	6
Cinygmula subaequalis	-	1	-	3	5	-	-
Heptagenia sp.	-	-	-	1	-	-	4
Trichoptera (caddisflies)							
Rhyacophila fuscula	-	-	-	-	4	-	0
Rhyacophila nigrita	-	-	-	-	1	-	1
Rhyacophila sp.	4	-	1	4	2	27	1
Lepidostoma sp.	-	-	2	-	1	-	2
Diplectrona modesta	-	-	-	-	4	3	0
Ceratopsyche sp.	11	1	-	2	-	-	4
Hydropsyche betteni	1	-	1	1	-	1	6
Cheumatopsyche sp.	1	-	-	-	-	3	5
Brachycentrus sp.	1	-	-	-	-	-	1
Dolophilodes distinctus	5	-	-	3	-	-	0
Plecoptera (stoneflies)							
Amphinemura sp.	-	-	-	-	-	4	3
Tallaperla sp.	-	2	6	-	12	11	0
Yugus sp.	-	1	3	1	3	1	-
Clioperla sp.	-	-	-	2	-	1	1
Sweltsa sp.	11	24	10	5	7	10	0
Diploperla sp.	-	-	-	-	-	11	-
Pteronarcys sp.	1	3	2	1	3	-	1
Leuctra sp.	1	-	1	1	2	-	0
Paragnetina sp.	2	-	-	1	-	-	1
Isoperla sp.	-	6	2	-	-	-	2
Diura sp.	-	1	-	-	-	-	-

Appendix A. continued.

TAXA	STATIONS						BI
	#1	#2	#3	#4	#5	#6	
Agnetina sp.	-	2	-	-	-	-	2
Strophopteryx sp.	-	1	-	-	-	-	3
Acroneuria sp.	-	-	2	-	-	-	0
Diptera (true flies)							
Chironomidae	6	9	-	19	5	3	6
Hexatoma sp.	7	2	5	3	5	4	3
Tipula sp.	-	-	-	-	1	-	4
Simulium sp.	-	1	-	-	-	-	6
Prosimulium sp.	7	-	1	2	4	1	2
Antocha sp.	-	-	-	-	-	4	4
Blepharicera sp.	-	-	1	-	-	-	0
Megaloptera (helgramites)							
Nigronia serricornis	4	-	-	-	-	-	0
Nematophora (horsehair worm)	-	-	-	-	-	1	-
Oligochaeta (aquatic earthworm)	2	-	-	-	-	-	8

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Appendix E.

AQUATIC
RESOURCE
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RR 6, Box 6562 - Saylorsburg, PA 18353 – (570) 992-6443; 992-3558; 685-7171

Fishery Survey of Paradise Creek and Tributaries

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Prepared for

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Brodhead Watershed Association

Jim Hartzler
Aquatic Biologist
September 2009

Background

In June and July, 2009, Aquatic Resource Consulting conducted a fisheries investigation of streams in the Paradise Creek watershed. The survey was requested by the Brodhead Watershed Association with the cooperation and management of the Paradise Township Supervisors and Ms. Debra Brady, Township Planner and Zoning Officer. Funding was provided by a Growing Greener grant from PA Department of Conservation and Natural Resources. The objective of the investigation was to document the fish communities on the streams, in particular the distribution and abundance of reproducing salmonids – wild brook and brown trout. These two coldwater species are indicators of high water quality because of their extreme sensitivity to low oxygen conditions caused by sewage pollution, sedimentation, and other forms of environmental degradation related to human activity.

Paradise Creek and the four tributaries sampled – Yankee Run, Tank Creek, Devil's Hole Creek, and Cranberry Creek – are classified by the PA Department of Environmental Protection as either Exception Value or High Quality Coldwater Fisheries.

Methods

The fish community was sampled with a variable voltage DC backpack Smith-Root L-24 electrofishing unit with handheld and trailing electrodes and hand nets. Three consecutive runs were made at each station, with all species collected and enumerated on the first run; during the second and third runs, only trout were netted. Voltage, pulse frequency and duration were adjusted to create electrotaxis (orientation toward the electrode) by small fish. All trout were anesthetized, measured (mm) and weighed (grams), then released unharmed. Population and biomass estimates for trout were made using the depletion removal (Zippin) method.

Sampling Locations

Seven stations in the Paradise Creek watershed were selected for sampling the fish communities (Figure 1):

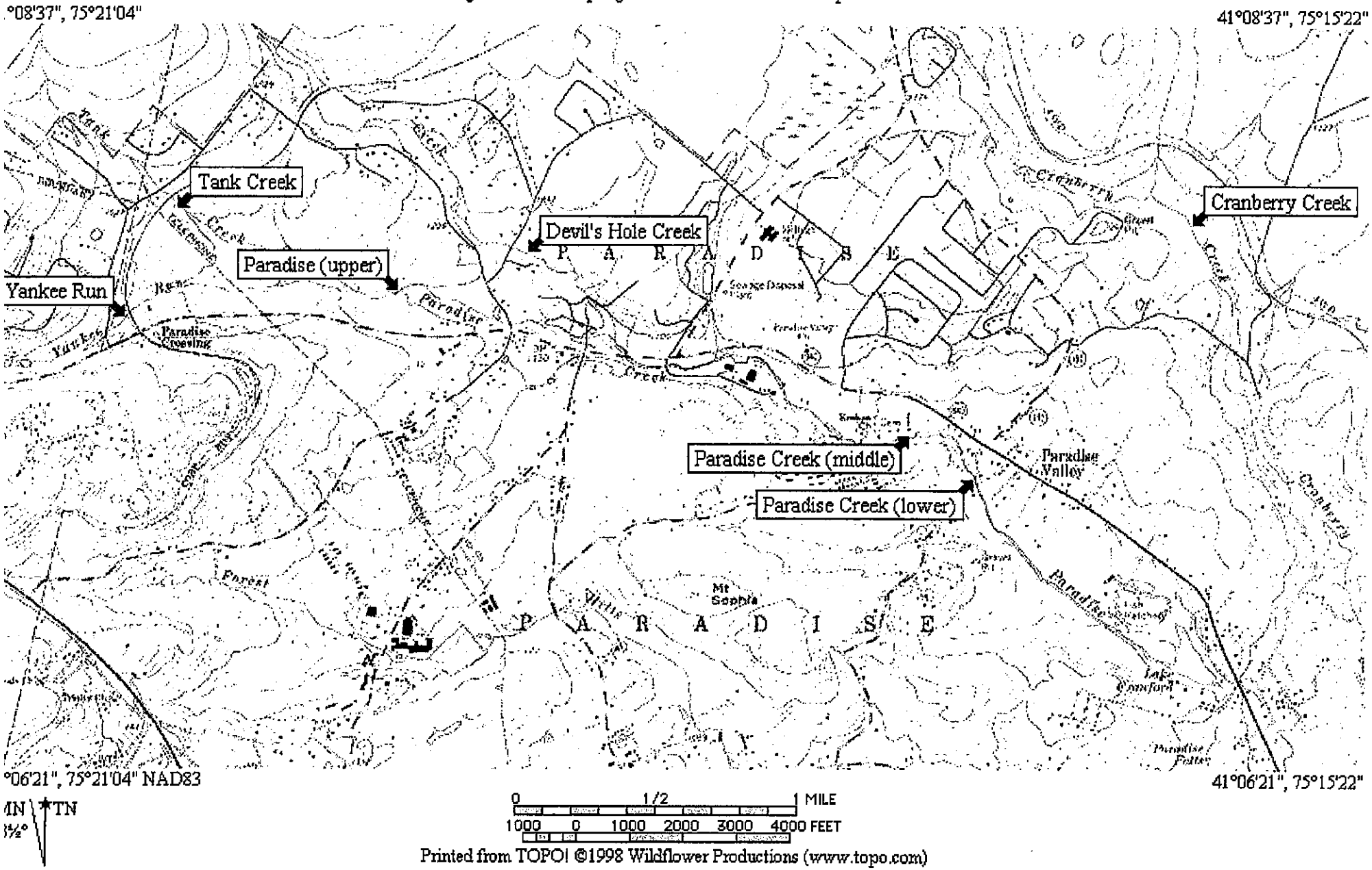
(1) Yankee Run – downstream from Upper Devil's Hole Road and upstream from the railroad culvert pipe.
(2) Tank Creek – downstream from Upper Devil's Hole Road and the railroad culvert pipe on the property of the Kurmes Paradise Creek Preserve.
(3) Devil's Hole Creek – downstream from Koener's Road off Lower Devil's Hole Road, adjacent the Henderson residence.
(4) Cranberry Creek – above and below a wooden footbridge on the property of the Nothstein Cranberry Creek Preserve.
(5) Paradise Creek (upper) – downstream from a steel bridge on access road to Poplar Swamp Club on the property of the Kurmes Paradise Creek Preserve.
(6) Paradise Creek (middle) – adjacent to Paradise Township Park along Keokee Chapel Road.
(7) Paradise Creek (lower) – upstream and downstream of Red Rock Road on the Dietz property.

Results and Discussion

Wild brown trout (***Salmo trutta***) was the predominant fish species at all seven sampling stations on the five streams in the Paradise Creek drainage. Since the fish communities reflected the effects of several different physiographic features, e.g., elevation, slope, flow, temperature, substrate, etc., at the sampling locations, they will be discussed separately, as follows:

1. Headwaters – Tank Creek, Yankee Run, and Devil's Hole Creek;
2. Cranberry Creek – one station, on the Nothstein Preserve.
3. Paradise Creek – three stations, on the Kurmes Preserve, at Paradise Township Park, and on the Dietz Property;

Figure 1. Fish Sampling Stations in Paradise Township in 2009.



The upper Paradise site (Kurmes Preserve) could be considered a headwater site because of its location (Figure 1). However, since it was situated downstream from the juncture of Tank Creek and Yankee Run, this station was included with the other Paradise Creek stations. The Cranberry Creek was considered separately because it joins the Paradise Creek several miles downstream from the lower Paradise Creek site at a lower elevation, drains a large watershed area, and has a more moderate gradient than the other streams.

HEADWATERS

Wild brown trout was the exclusive fish species collected in Tank Creek and Devil's Hole Creek (Table 1). This species predominated in Yankee Run as well, but one wild brook trout (***Salvelinus fontinalis***) measuring 140 mm (5.5 inches) was also collected at this station. Both species are classified as coldwater taxa intolerant to water pollution, including siltation, chemicals and materials that create low oxygen conditions, such as sewage effluent (Table 2). Spawning requirements for both are very demanding – a silt-free, gravel/cobble substrate that is relatively stable, since after fish spawn in the fall, the eggs are covered with gravel and incubate for a 3-4 month period overwinter before hatching in the spring.

Wild brown trout were abundant at all three headwater stations, with fish in the 3-8 inch size range most numerous (Table 3). It appears that three age classes were represented: young-of-year (0+), yearling (1+), and older (>1+), denoted as small, medium, and large, respectively, in Table 3. Age can be estimated from the length-frequency distribution, a graph displaying the number of trout according to size, with peaks in the curve representing the average size of a particular age group. As the key in Table 3 indicates, size ranges for age classes in Yankee Run, Tank Creek, and Devil's Hole Creek vary somewhat. This is because growth rates differ due to the ambient thermal regime throughout the year. Temperature is the primary growth regulator. Growth rates for these three streams are typical of other headwater streams in the Pocono region. In addition, it is important to note that although few young-of-year brown trout were collected, the collection efficiency of fish this size (<3 inches) with electrofishing apparatus is poor. Numbers collected undoubtedly would have been higher in late summer, not because more young-of-year are present but because at a larger size, they intercept more of the electrical field and are more vulnerable to capture.

Table 1. Fish species composition at sampling stations on streams in the Paradise Creek drainage in June and July, 2009.

Key: A = Abundant (>20); C = Common (5-20); P = Present (<5); (-) = absent.

SPECIES	LOCATION						
	Yankee Run	Tank Creek	Devil's Hole Creek	Cranberry Creek	Paradise Creek Upper	Paradise Creek Middle	Paradise Creek Lower
Brown trout *Salmo trutta*	A	A	A	A	A	A	A
Brook trout *Salvelinus fontinalis*	P	-	-	P	P	-	-
Slimy sculpin *Cottus cognatus*	-	-	-	C	-	-	-
Blacknose dace *Rhinichthys atratulus*	-	-	-	P	-	C	P
White sucker *Catostomus commersoni*	-	-	-	-	-	C	-
American eel *Anguilla rostrata*	-	-	-	P	-	P	P
Longnose dace *Rhinichthys cataractae*	-	-	-	-	-	P	P
Cutlips minnow *Exoglossum maxillingua*	-	-	-	-	-	C	-
Pumpkinseed/bluegill *Lepomis gibbosus/macrochirus*	-	-	-	P	-	P	-
Brown bullhead *Ameiurus nebulosus*	-	-	-	-	P	-	-

Table 2. Classification of fish species collected from streams in the Paradise Creek watershed in June and July, 2009.

Key: Temperature: C = Coldwater; CW = Coolwater; W = Warmwater.
Tolerance (to environmental perturbation): I = Intolerant; M = Intermediate; T = Tolerant.
Trophic Class: TC = Top Carnivore; BI = Benthic Invertivore; GF = Generalist Feeder.

SPECIES	Temperature	Tolerance	Trophic Class
Brown trout *Salmo trutta*	C	I	TC
Brook trout *Salvelinus fontinalis*	C	I	TC
Slimy sculpin *Cottus cognatus*	C	I	BI
Blacknose dace *Rhinichthys atratulus*	CW	T	GF
White sucker *Catostomus commersoni*	CW	T	GF
American eel *Anguilla rostrata*	W	T	TC
Longnose dace *Rhinichthys cataractae*	CW	M	BI
Cutlips minnow *Exoglossum maxillingua*	W	I	BI
Pumpkinseed/bluegill *Lepomis gibbosus/macrochirus*	W	M,T	GF
Brown bullhead *Ameiurus nebulosus*	W	T	GF

Table 3. Number, size, and estimated population and biomass of wild brown trout collected on four tributaries of Paradise Creek in June and July, 2009.

	LOCATION			
	Yankee Run	Tank Creek	Devil's Hole Creek	Cranberry Creek
Stream length (feet)	450	280	270	300
Mean width (feet)	9.4	15.8	21.8	17.3
Area (acres)	0.10	0.10	0.14	0.12
(hectares)	0.039	0.041	0.055	0.048
Number of trout				
*Size: small	2	4	13	11
medium	78	53	74	65
large	1	11	4	33
Total	81	68	91	109
Population estimate				
*Size: small	2	4	20	15
medium	81	54	86	72
large	1	11	4	34
Estimated biomass				
Kg/hectare	75.4	123.9	100.1	151.3
Pounds/acre	67.3	110.6	89.4	135.0

*Key to size: small: <80 mm for Cranberry Creek, Yankee Run and Tank Creek; <90 mm for Devil's Hole Creek.
medium: 80-200 mm for Cranberry Creek; 80-210 mm for Yankee Run; 80-220 mm for Tank Creek; 90-230 mm for Devil's Hole Creek.
large: >200 mm for Cranberry Creek; >210 mm for Yankee Run; >220 mm for Tank Creek; >230 mm for Devil's Hole Creek.

The estimated biomass of wild brown trout in all three Paradise Creek tributaries far exceeded the 40 pounds/acre (44 kg/hectare) standard of the PA Fish and Boat Commission for Class A wild trout streams. Tank Creek was highest with 110+ pounds/acre, followed by Devil's Hole Creek (89+ pounds/acre), then Yankee Run (67+ pounds/acre). The greater number of larger, heavier trout (>8 inches) in Tank Creek compared to the other two tributaries contributed to this result (Table 3). Physical features, such as water depth and the amount of refuge sites (deadfalls, boulders, pools) can limit the number of larger adult fish that a stream can support.

CRANBERRY CREEK

Cranberry Creek supported a diverse fish community, again dominated by wild brown trout (Table 1). Four wild brook trout were also collected, ranging in size from 128 mm to 168 mm (5.0-6.6 inches). In addition, another fish species, slimy sculpin (***Cottus cognatus***), that is found in only colder, silt-free, unpolluted streams was collected. Its habits of benthic (bottom) foraging for small aquatic macroinvertebrates and spawning on the underside of rocks make it extremely sensitive to sedimentation. Three other species were also found – blacknose dace (***Rhinichthys atratulus***), American eel (***Anguilla rostrata***), and sunfish, either pumpkinseed (***Lepomis gibbosus***) or bluegill (***L. macrochirus***). Blacknose dace, probably the most widespread minnow in the northeastern U.S., is classified as a warmwater species tolerant to environmental disturbance, but often coexists with wild trout if a stream warms sufficiently for dace to spawn. Eels are found in almost every stream system in the Atlantic coast drainage, warm or cold. They are catadromous – spawn in saltwater, but migrate to fresh water where they grow to adulthood – and can ascend to even headwater streams if no obstructions to movement exist, such as steep falls. The sunfish that were taken probably escaped from a pond upstream from the collection site since pumpkinseeds or bluegills rarely spawn in colder, turbulent streams inhabited by wild trout.

More wild brown trout, including more than 30 fish exceeding 8 inches, were collected at the Cranberry Creek stretch than at any other sampling station. All size groups, corresponding to 0+, 1+, and older fish, were well represented in the collection (Table 3). In addition, the estimated biomass (151+ kg/hectare, 135 pounds/acre) was much higher than at the headwater stations. The greater number of adult trout, which comprise a larger percentage of total weight than smaller fish, was responsible. Also, the Cranberry Creek sampling site displayed a more moderate gradient and complex stream features – riffle/run/pool sequences instead of turbulent

runs and scour pools – that promote trout growth and survival. However, based upon the length-frequency distribution for wild brown trout at this location, growth is slightly slower than at the other stream locations, perhaps due to cooler summer temperatures.

PARADISE CREEK

Wild brown trout dominated the collections at the three Paradise Creek stations. The middle sampling site at Paradise Township Park supported the most diverse fish community with seven fish species, while only four species were found several hundred yards downstream above and below the bridge on Red Rock Road (Table 1). The upper station, located just below the juncture of Tank Creek and Yankee Run, contained only wild brown trout and one young-of-year brook trout, similar to the electrofishing results from the latter stream. Other species common to both the middle and lower stations on Paradise Creek were blacknose dace, American eel, and longnose dace (***Rhinichthys cataractae***), a closely related species to blacknose dace that grows somewhat larger and prefers torrential flows. Longnose dace are considered less tolerant of warm temperatures and degraded water quality than blacknose although the two species are often sympatric (inhabit the same stream). In addition to several sunfish, cutlips minnow (***Exoglossum maxillingua***), a warmwater species often found in less turbulent reaches of lowland trout streams, were taken at the middle Paradise site. Unlike brook and brown trout, which spawn in the fall when the temperature cools, cutlips minnow, like others in the minnow family, reproduce when water temperature reachs a certain minimum in summer. Hence, temperature is a major factor limiting distribution. One other species, brown bullhead (***Ameiurus nebulosus***), was collected at the upper Paradise Creek station. Like the sunfish found at two other stations on Paradise Creek, the bullhead is classified as a warmwater species. These individuals probably escaped from upstream ponds discharging into the stream. White suckers (***Catostomus commersoni***) were also common at the Paradise Creek Park station but nowhere else. This bottom-feeder is maligned as a "trash fish" that competes with trout, when in fact its tolerance to sediment, warmer temperatures and a host of environmental stresses allow it to survive in streams with both high and low water quality.

Wild brown trout have good reproductive success in Paradise Creek, as evidenced by the numbers of small (young-of-year) fish in collections, particularly at the upper (Kurmes) station. This produces good recruitment of yearling trout and also older, larger fish, particularly at the lower (Dietz) station, where more than 40 wild brown trout over 8 inches long were collected in

only 240 linear feet of stream (Table 4). Although only two 0+ trout were found at the lower site, this paucity may be the result of predation by larger trout, not necessarily poor reproduction. Also, torrential flows at this station, just above and below a bridge, reduced collection efficiency.

Estimated biomass for wild brown trout at the lower Paradise Creek site (245+ kg/hectare) was more than five times the PA Fish and Boat Commission's standard (44 kg/hectare, 40 pounds/acre) for Class A wild trout water (Table 4). As expected, this value declined in an upstream direction – approximately 100 kg/hectare (89+ pounds/acre) at the middle (Park) site and 67+ kg/hectare (60+ pounds/acre) at the upper (Kurmes) station. Generally, lowland trout streams support more and larger trout, hence a higher biomass, than headwater reaches because of the larger forage base, such as aquatic macroinvertebrates and other fish, that trout feed on. In addition, growth is slightly faster as you proceed downstream due to slightly warmer temperatures during the growing season – spring through fall.

SUMMARY

An electrofishing survey of the Paradise Creek and four tributaries – Yankee Run, Tank Creek, Devil's Hole Creek, and Cranberry Creek – revealed fish communities dominated by wild brown trout (***Salmo trutta***). Seven stream areas were sampled, three on the main stem of Paradise Creek and one site on each of the tributaries. All fish species were identified, and all wild brown trout collected in three runs were weighed and measured to permit estimation of the total population and biomass. Wild brown trout were the exclusive species on Tank and Devil's Hole Creek, while only wild brook trout (***Salvelinus fontinalis***) and brown trout were found on Yankee Run and the upper headwaters site on Paradise Creek. Slimy sculpin (***Cottus cognatus***), like both salmonid species a coldwater taxa intolerant to warm temperatures, sedimentation and other pollutants, were present only in Cranberry Creek. The middle Paradise Creek station, located within Paradise Township Park, had the most diverse fish population with several minnows (blacknose and longnose dace, cutlips minnow), white suckers, American eels and sunfish (pumpkinseed or bluegill). These species are classified as either cool or warmwater species with varying tolerances to environmental degradation. Several of these taxa were also collected on Cranberry Creek and the lower Paradise Creek site.

Based upon the presence of wild brown trout ranging in size from 35 mm (1.5 inches) to 480 mm (19.0 inches), natural reproduction appears adequate to maintain the population.

Table 4. Number, size, and estimated population and biomass of wild brown trout collected at three stations on Paradise Creek in June and July, 2009.

	LOCATION		
	Upper (Kurmes)	Middle (Park)	Lower (Dietz)
Stream length (feet)	300	250	240
Mean width (feet)	17.6	32.2	24.2
Area (acres)	0.12	0.19	0.13
(hectares)	0.049	0.075	0.054
Number of trout			
*Size: small	31	19	2
medium	65	50	50
large	4	19	45
Total	100	88	97
Population estimate			
*Size: small	37	20	2
medium	66	60	71
large	4	23	47
Estimated biomass			
Kg/hectare	67.3	100.7	245.9
Pounds/acre	60.1	89.9	219.6

*Key to size: small: <80 mm for upper Paradise Creek; <90 mm for middle and lower Paradise Creek.
medium: 80-210 mm for upper Paradise Creek; 90-220 for middle and lower Paradise Creek.
large: >210 mm for upper Paradise Creek; >220 mm for middle and lower Paradise Creek.

Appendix F.

AQUATIC
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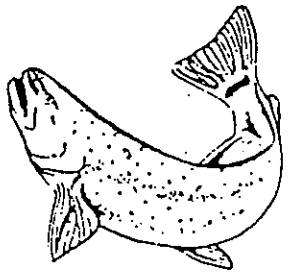

ELECTROFISHING SURVEY OF YANKEE RUN, TANK CREEK AND DEVILS HOLE CREEK

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Prepared for

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Brodhead Watershed Association

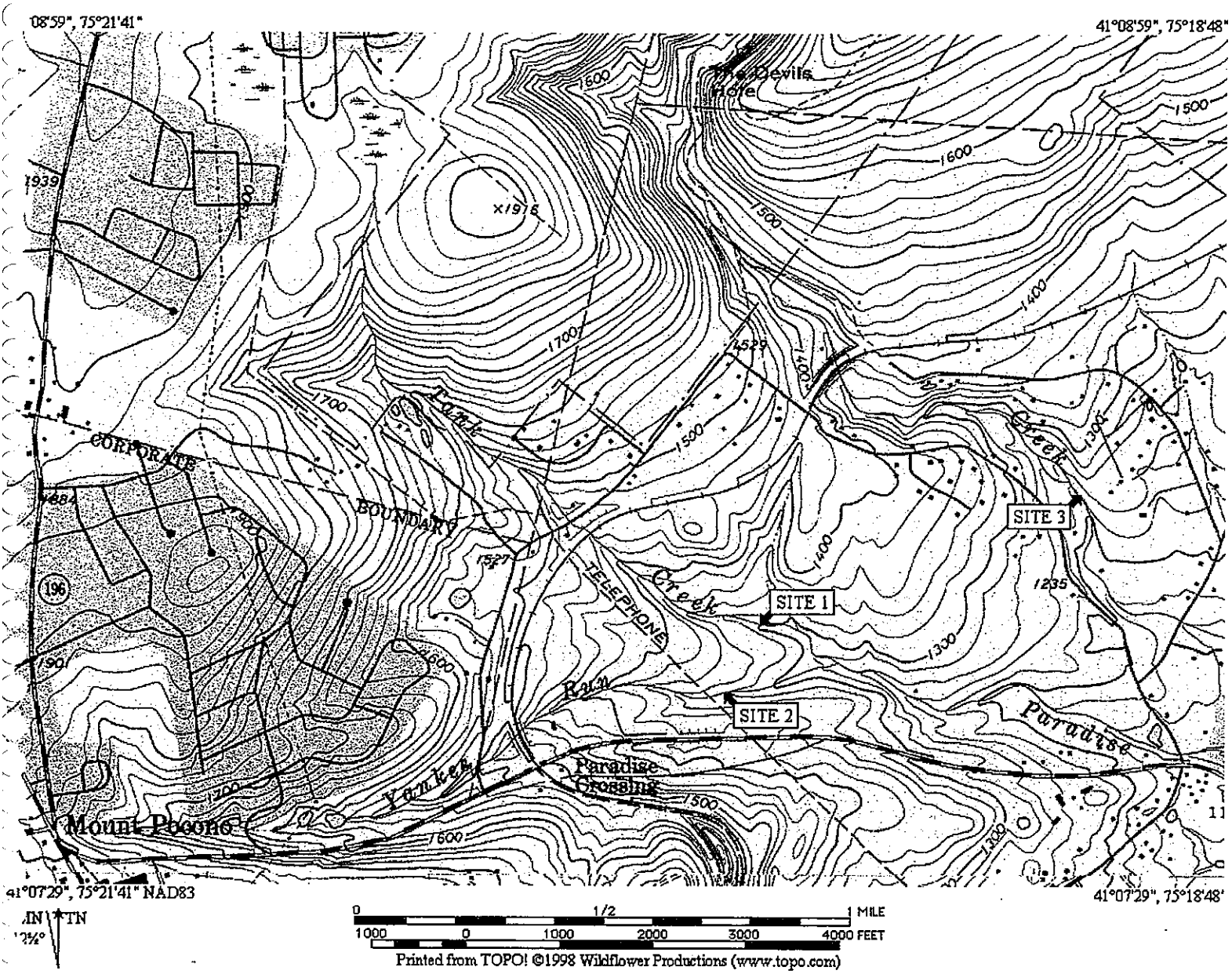
Jim Hartzler
March 2000

BACKGROUND

On 28 and 30 October 1999, Aquatic Resource Consulting conducted an electrofishing survey of three tributary streams to the Paradise Creek – Tank Creek, Yankee Run, and Devils Hole Creek. The purpose of the investigation was to document the fish community of these headwater streams as part of an ongoing investigation funded by the Brodhead Watershed Association (BWA) to assess the existing water quality and aquatic biota of the upper Paradise watershed. The PA Department of Conservation and Natural Resources (DCNR) had recently awarded the Association a Coldwater Heritage Grant through PA DCNR's Watershed Restoration and Assessment Program (WRAP) to conduct the study. The information gathered from this program can assist local municipalities and county agencies in making management decisions for land use activities which may impact surface and groundwater quality.

Tank Creek and Yankee Run are first order tributaries to the Devils Hole Creek which originate on the Pocono Plateau and converge approximately 2 miles east of Mt. Pocono, PA before merging with Devils Hole Creek 1 mile downstream (Figure 1). The main stem of Devils Hole Creek, a second order tributary to the Paradise Creek, begins in a wetland area 4 miles north of Mt. Pocono. The three streams drain steep, heavily forested terrain with sandstone geology. A large spring which historically was utilized as a public water supply is the primary water source on Yankee Run. However, groundwater erupts at several locations on all three streams, and this spring flow undoubtedly has a strong influence on water temperature and chemistry, as well as the biotic community. PA State Game Lands 221 comprises a large portion of the the Devils Hole sub-watershed. There is dense residential development within parts of the Devils Hole Creek and Tank Creek sub-watersheds, and extensive commercial development has occurred in the Yankee Run headland area in Mt. Pocono, PA, where Routes 940, 611, and 196 converge. No point source discharges occur in this stream area, but Yankee Run receives heavy surface runoff from roadways and parking areas. Like many Pocono area streams, the water in all three streams is slightly acid with a low mineral and nutrient content.

Figure 1. Location of electrofishing sites on Tank Creek, Yankee Run, and Devils Hole Creek in October 1999.



METHODS

Portions of Tank Creek, Yankee Run, and Devils Hole Creek were sampled using a Coffelt backpack BP1C electrofishing unit with handheld electrodes and nets. Three consecutive runs were made in an upstream direction at each station to allow estimates of trout abundance (numbers) and biomass (weight per unit area). All fish species were identified and released; trout were also weighed and measured.

Sampling locations were as follows (Figure 1and Figures 2a, b, and 3):

(A) Yankee Run – begin approximately 200 yards above the confluence with Tank Creek (sampling distance = 210 feet).

(B) Tank Creek – begin approximately 100 yards above the confluence with Yankee Run (sampling distance = 250 feet).

(C) Devils Hole Creek – begin off Devils Hole Road approximately ½ mile north of Route 940 (sampling distance = 250 feet).

RESULTS AND DISCUSSION

Wild brown trout (***Salmo trutta***) and brook trout (***Salvelinus fontinalis***) were the only fish species collected in Tank Creek and Yankee Creek. Brown trout was the exclusive taxon in Devils Hole Creek. Such low diversity is uncommon in most Pocono streams except in the smallest, most torrential headwater areas. No stocked trout were collected although catchable-size hatchery trout are released in the Paradise Creek less than 2 miles downstream. In addition, white suckers, blacknose dace and cutlips minnow are found less than 3 miles downstream in the Paradise Creek (Hartzler 1999). The lack of some habitat feature, perhaps suitable spawning habitat, refuge sites, or sufficiently warm temperatures, apparently limits the colonization and establishment of populations of other fish species in the sampled areas. Although the interactions between the physical, chemical, and biological components in any ecosystem are complex, the structure in cold, headwater stream is fairly simple – the top carnivore is trout, which will cannibalize smaller trout but feed primarily upon benthic macroinvertebrates, which in turn forage on algae, smaller insects, and organic debris. This low

Figure 2a. Electrofishing station on Yankee Run (looking upstream).

Figure 2b. Electrofishing station on Tank Creek (looking upstream)

Figure 3. Electrofishing station on Devils Hole Creek (looking downstream).

diversity within the biotic community – trout and aquatic invertebrates – makes it quite sensitive to even minor disruptions in water quality. Salmonids, particularly brook trout, are considered to be the fish taxon least tolerant to high water temperatures, low dissolved oxygen, siltation, and habitat destruction in the northeastern U.S.

Brown trout were most abundant and had the highest biomass by far in Devils Hole Creek (Table 1). The estimated standing crop here – 128 kg/hectare – was more than threefold the PA Fish & Boat Commission's Class A standard of 40 kg/hectare and was comparable to values measured recently on the Paradise Creek (Hartzler 1999). Biomass values on Tank Creek and Yankee Run were much lower – 23.6 and 40.6 kg/hectare, respectively. These tributaries have similar physical features (width, depth, slope, substrate material, flow rate) but are about half the width and have a much lower discharge (volume of flow) than Devils Hole Creek. Larger fish (>7 inches), which normally comprise the bulk of weight in a trout population, were much more abundant in the Devils Hole Creek. This finding could be attributed to deeper pools, larger substrate material (boulders), and a greater living area which provided large trout with more and better refuge and holding sites than in the two smaller streams. An insufficient number of brook trout were collected in either Tank Creek or Yankee Run to accurately estimate the biomass of this species.

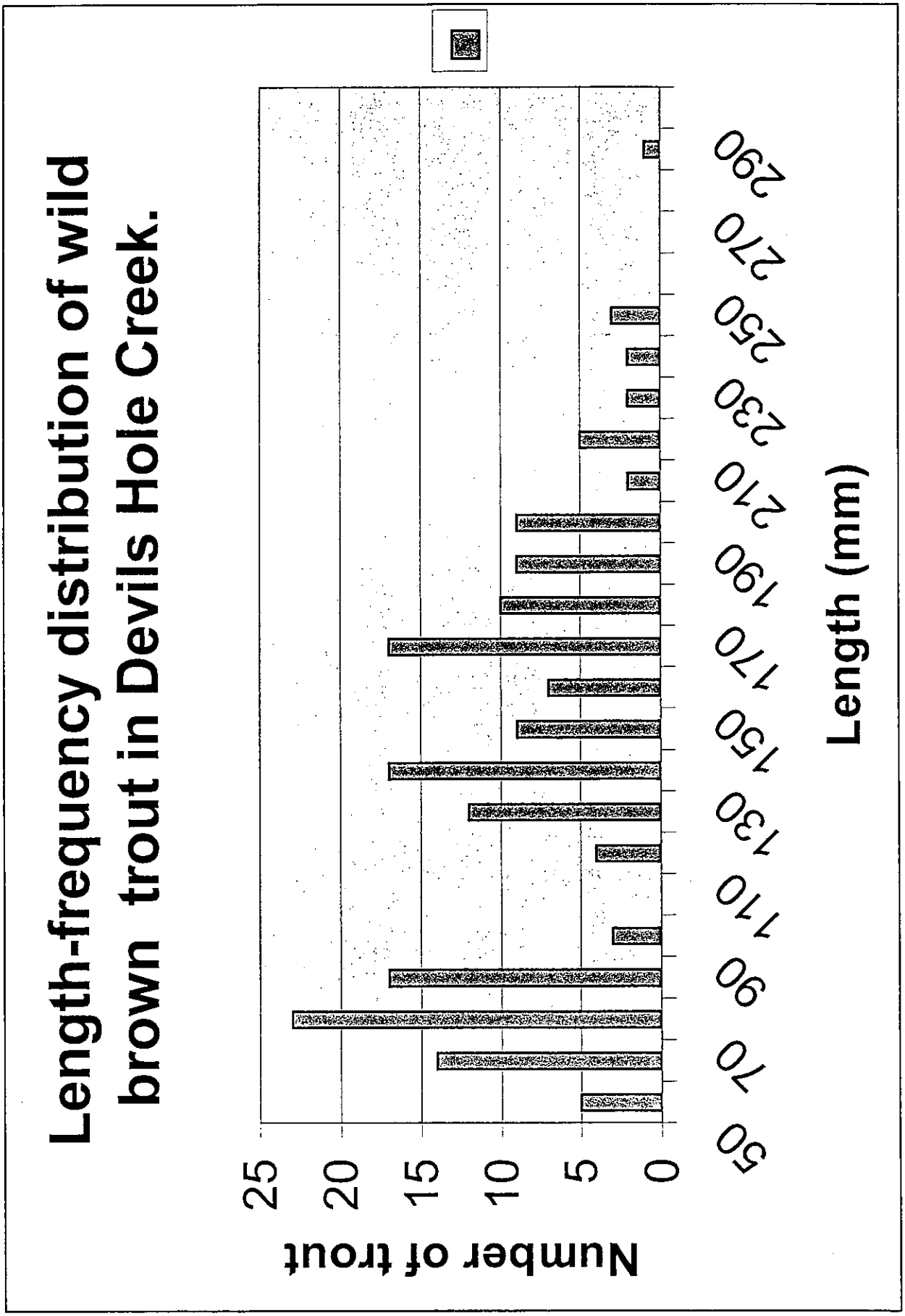
Brown trout populations in all three streams were balanced, with all size groups well represented in the sample. The size groups in Table 1 correspond to age classes as determined by a length-frequency (L-F) distribution. Individual fish are graphed according to length (Figure 3). Peaks in the graph correspond to the average size of a particular age group, and valleys in the curve are used to separate each age class. L-F curves for fish sampled in Tank Creek, Yankee Run, and Devils Hole Creek revealed the same distribution, indicating that growth rates in the three streams are similar. It appears that young-of-year (0+) brown trout were less than 4 inches (100mm) long, yearling (1+) fish fell in the 4 to 7.5 inch range, and 2+ trout were larger than 7.5 inches (194 mm). These growth rates are similar to values found on other headwater streams in the Pocono region. In general, water temperature regulates fish growth in freshwater ecosystems, and rates vary little from year to year.

Table 1. Summary of electrofishing survey of Paradise Creek tributaries, 28 & 30 October 1999.

		LOCATION		
		Tank Cr.	Yankee Run	Devils Hole Cr.
Stream length	(feet)	250	210	250
mean width	(feet)	11	9	17
area	(acres)	0.063	0.045	0.096
	(hectares)	0.026	0.018	0.039
Number of wild trout collected		35	45	172
Brown trout		32	40	172
<100 mm	(<4 in.)	11	18	63
100-194 mm	(4 - 7.5 in.)	19	20	94
>194 mm	(>7.5 in.)	2	2	15
Brook trout		3	5	0
<100 mm	(<4 in.)	2	1	-
100-194 mm	(4 – 7.5 in.)	1	4	-
>194 mm	(>7.5 in.)	0	0	-
Population estimate				
Brown trout				
<100 mm	(<4 in.)	15	33	107
100-194 mm	(4 - 7.5 in.)	19	20	97
>194 mm	(>7.5 in.)	2	2	15
Biomass - brown trout	(kg/hectare)	23.6	40.6	128
	(pounds/acre)	21.1	36.3	114.3
Condition (K) [1] of wild trout				
Brown trout				
<100 mm	(<4 in.)	0.66	0.80	0.77
100-194 mm	(4 - 7.5 in.)	0.84	0.91	0.88
>194 mm	(>7.5 in.)	0.93	0.97	0.95
Brook trout				
<100 mm	(<4 in.)	0.60	0.61	-
100-194 mm	(4 – 7.5 in.)	0.82	0.82	-

1 – Condition (K) is a statistical measure of a fish's weight relative to length; more robust fish display a higher K. Normal values for trout fall within the range 0.90-1.10.

Figure 3.


Length-frequency distribution of wild brown trout in Devils Hole Creek.
Number of trout
0
5
10
15
20
25
Length (mm)
50
70
90
110
130
150
170
190
210
230
250
270
290

The condition factors (K) of brook and brown trout in the three streams were lower than values typically displayed by wild trout (Table 1). K values for all size groups were below or near the lower limit (0.90). Most fish collected were relatively thin. These values may be normal for trout in this ecosystem – no prior data are available for comparison. Studies have shown that condition often declines in headwater streams, particularly in late summer, perhaps due to overcrowding and competition. The seasonal emergence of larval forms of aquatic insects in spring and early summer causes a severe reduction in the forage base for trout. Fish may be too numerous for the available space and food supply. This theory is supported by data in this survey: Fingerling trout, the most abundant group, had the lowest K on all three streams; less numerous legal-size browns displayed the highest condition factor.

The paucity of wild brook trout in these three tributaries of the Paradise watershed may be a consequence of natural features or manmade impacts. Brook trout are the predominant salmonid in many headwater streams draining the Pocono Plateau. These areas are the last refuge for this native species, which has been supplanted by brown trout in most high quality, coldwater streams wherever they have been stocked. Both species spawn in the fall, and eggs incubate overwinter in gravel/cobble redds (nests) constructed by the female. There is evidence that brook trout also require upwelling groundwater (springs) to spawn successfully. Brown trout are less demanding; fry (small trout) will hatch and develop as long as there is intergravel flow to oxygenate the developing eggs. Tank Creek, Yankee Run, and Devils Hole Creek may not have adequate spring flow to create sufficient spawning habit for brook trout to remain the dominant species. It's also possible that groundwater release has declined with increased withdrawal by private wells. Furthermore, temperature extremes and scouring of the stream substrate from episodic stormwater flows may have adversely affected the survival and reproduction of this species, since brook trout are known to have a lower tolerance to high temperatures and habitat destruction than brown trout.

SUMMARY

Only two fish species, brown trout and brook trout, were collected by electrofishing three streams – Tank Creek, Yankee Run, and Devils Hole Creek – in the upper Paradise Creek watershed. Both taxa are classified as coldwater species intolerant to organic (oxygen-demanding) pollution.

Brown trout predominated at sampling stations on Tank Creek and Yankee Run and was the exclusive species in Devils Hole Creek. All three streams have reproducing (wild) brown trout populations, and it appears that three age groups (0+, 1+, and 2+ years) were represented. Brown trout abundance and biomass were 4-5 times greater on the Devils Hole, possibly due to better foraging and refuge sites for larger trout. Condition factors for all sizes of trout were low.

A few young-of-year (0+) and yearling (1+) brook trout were collected from Tank Creek and Yankee Run, evidence of spawning at or near the sample locations. The lack of some natural feature, such as groundwater release, suitable spawning substrate, or a more stable temperature regime, may limit reproduction and survival of this species, particularly on the Devils Hole Creek. However, the scarcity of wild brook trout, which have a wide distribution in headwater streams on the Pocono Plateau, may also be attributable to the effects of some manmade perturbation – groundwater mining, excessive surface runoff, siltation, or pollution. Biotic communities with such low ecological diversity are highly sensitive to such impacts.

Appendix G.

AQUATIC
RESOURCE
CONSULTING

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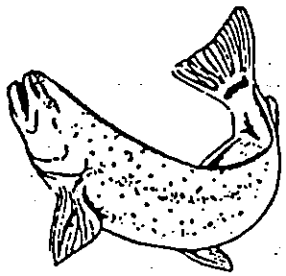


ELECTROFISHING SURVEY OF PARADISE CREEK

Prepared for
Brodhead Watershed Association

Jim Hartzler
Aquatic Biologist

May 1999

BACKGROUND

On 11 and 16 October 1998, Aquatic Resource Consulting conducted an electrofishing inventory of the Paradise Creek at the request of the Brodhead Watershed Association. The purpose of the survey was to document fish species diversity. Of particular interest was the numerical abundance and biomass of wild trout because these species are considered an indicator of high water quality because of a low tolerance to high water temperature, low oxygen conditions, siltation, and pollutants. The Association had received a Coldwater Heritage Grant from the PA Department of Conservation and Natural Resources to establish a database for the aquatic macroinvertebrate and fish community on a headwater stream area in the Pocono region, and the upper Paradise Creek watershed was chosen. This report documents results from the electrofishing survey.

METHODS

The fish community of Paradise Creek was sampled using a 300 Watt Coffelt BPIC backpack electrofishing unit with hand-held electrodes and nets. Voltage setting was 400 VAC. Sampling locations and distances were as follows (Figure 1):

(1) Upper station - downstream boundary at a riffle area located approximately 250 feet below a grassy area on the bank next to the picnic pavilion at Paradise Township Park (distance = 420 feet). (Figure 2a).
(2) Lower station - downstream boundary at a riffle area located approximately 100 feet above a bridge on Red Rock Road (distance = 275 feet). (Figure 2b).

Sampling followed US EPA Rabid Bioassessment V Protocol, which recommends electrofishing at least two riffle, two run and two pool habitats at each station. The stream channel on Paradise Creek was well contained at both sample locations, and gradient (slope) was moderate. Substrate was primarily cobble and gravel with some boulders and bedrock at the upper station, which also contained two relatively shallow boulder dams filled with bedload (deposits of sand, gravel, and cobble). The lower station retained its natural form (no dams had been constructed) and was somewhat narrower.

Figure 1. Location of upper (U) and lower (L) electrofishing stations on Paradise Creek, sampled on 11 and 16 October 1998.

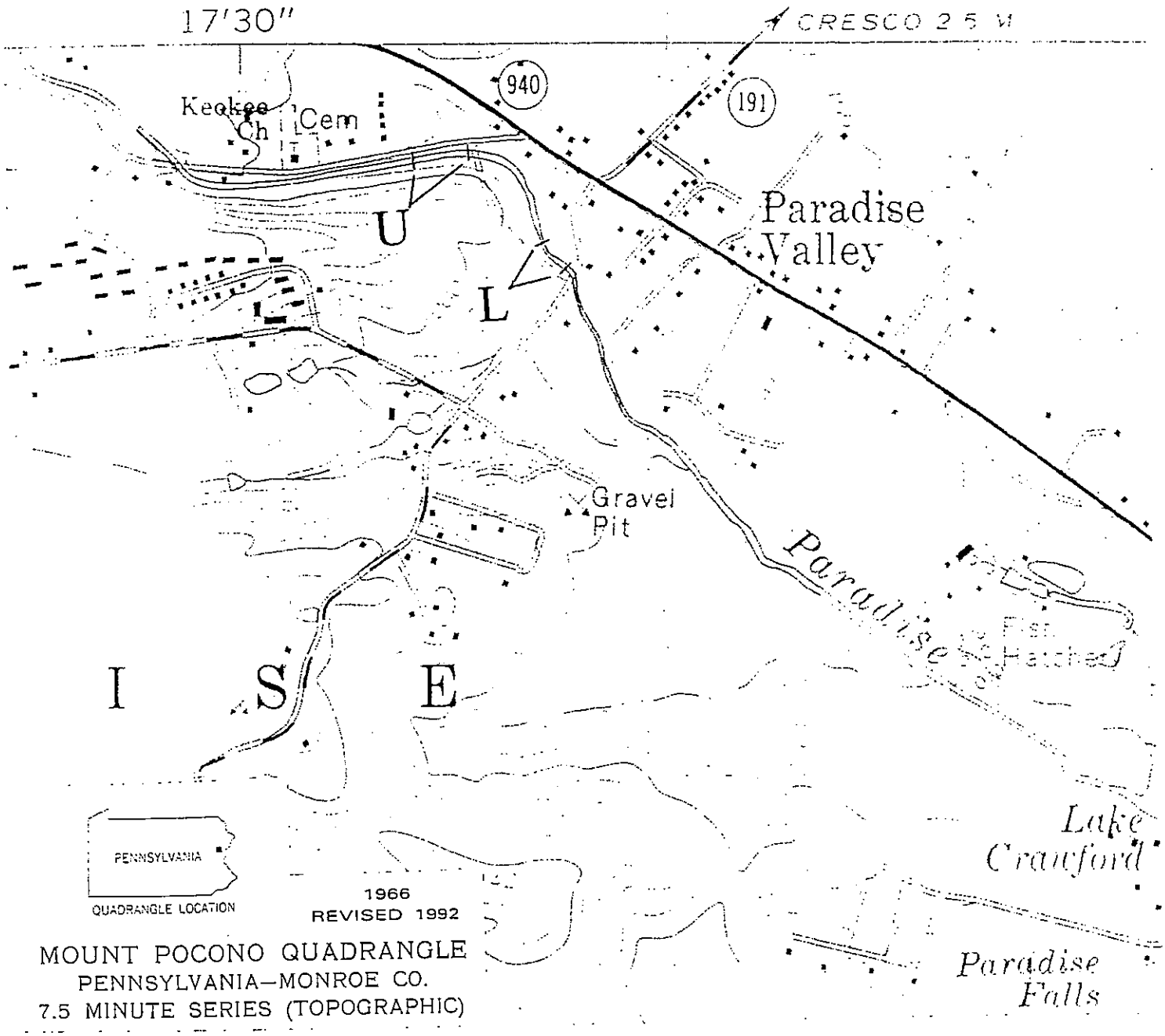


Figure 2a. Upper sampling station on Paradise Creek.

Figure 2b. Lower sampling station on Paradise Creek.

All trout were collected in three consecutive runs, anesthetized, measured, and weighed to permit estimation of total number, biomass (weight per unit area) and condition of wild trout. Relative abundance of other fish species was reported as abundant (>50 fish on 1st run), common (20-50 fish), present (5-20 fish), or rare (<5 fish). After collection, all fish were released.

RESULTS AND DISCUSSION

Wild brown trout (*Salmo trutta*) and white sucker (*Catostomus commersoni*) were the predominant fish species collected at both the upper and lower stations on Paradise Creek (Table 1). Next in abundance were blacknose dace (*Rhinichthys atratulus*) and longnose dace (*Rhinichthys cataractae*), two species often associated with trout in coolwater streams in the Pocono region. Both white suckers and blacknose dace have a more widespread distribution than brown trout because of their greater tolerance to warm water temperatures and silty substrates, and ominivorous feeding habits; trout forage on macroinvertebrates and other fish. Longnose dace, a close relative taxonomically to blacknose dace, seem to prefer more torrential flows. A few individuals of three other fish species - American eel (*Anguilla rostrata*), cutlips minnow (*Exoglossum maxillingua*), and bluegill (*Lepomis macrochirus*) - were also collected at both stations. American eels are a catadromus species - spawning in salt water but migrating to fresh water streams along the Atlantic coast where they spend most of their adult lives. They are quite abundant in streams of the Delaware drainage, often ascending to colder headwater areas unless impeded by obstructions. Cutlips minnow is classified as a warmwater fish species which prefers sluggish, lowland streams in the Northeast, including the Brodhead Creek and its tributaries. The few bluegills collected were probably escapees from impoundments in the upper Paradise Creek, since they are also considered a warmwater species which inhabits primarily lakes and ponds.

The relatively low diversity of the fish community in Paradise Creek is normal for streams draining the Pocono Plateau. These waters are typically infertile (low nutrient content), rarely exceed 70 degrees F (21 degrees C) throughout most of the year because of steady groundwater release (springs), and exhibit moderate to steep gradients. These features limit distribution to fish species which can subsist primarily on benthic macroinvertebrates, which spawn at a relatively low temperature, and which can survive periodic torrential flows. Historically, these streams have been the least degraded by point source pollution and siltation from non-point source runoff. Hence, they are the last refuge for coldwater, pollution intolerant species such as trout. Increasing residential and commercial development in headwater areas of the Pocono region may change that.

Table 1. Summary of electrofishing survey at two sites on Paradise Creek, conducted for Brodhead Watershed Association on 11 and 16 October, 1998.

		STATION	
		Upper	Lower
		---	---
Length	(feet)	420	275
Avg. width	(feet)	28	19
Area	(acres)	0.265	0.122
	(hectares)	0.108	0.049

FISH SPECIES (A = abundant; C = common; P = present; R = rare.)

brown trout	*Salmo trutta*	A	A
white sucker	*Catostomus commersoni*	C	A
blacknose dace	*Rhinichthys atratulus*	C	C
longnose dace	*Rhinichthys cataractae*	P	P
cutlips minnow	*Exoglossum maxillingua*	P	P
American eel	*Anguilla rostrata*	R	R
bluegill	*Lepomis macrochirus*	R	R

BROWN TROUT

Number collected			
< 130 mm	(<5.1 inches)	130	108
130-210 mm	(5.1-8.3 inches)	80	69
> 210 mm	(>8.3 inches)	26	15
Population estimate			
< 130 mm	(<5.1 inches)	163	142
130-210 mm	(5.1-8.3 inches)	84	70
➢ 210 mm	(>8.3 inches)	26	15
Condition factor (K)[1]			
< 130 mm	(<5.1 inches)	0.96	1.08
130-210 mm	(5.1-8.3 inches)	0.94	0.97
➢ 210 mm	(>8.3 inches)	0.93	0.92
Biomass	(kilograms/hectare)	94.8	176.6
	(pounds/acre)	84.8	157.8

1 - Condition factor is robustness, or weight relative to length, and is calculated as $\text{WEIGHT (grams)} \times 100{,}000 / \text{LENGTH (mm)}^3$. Values for wild trout are typically within the range 0.90-1.10.

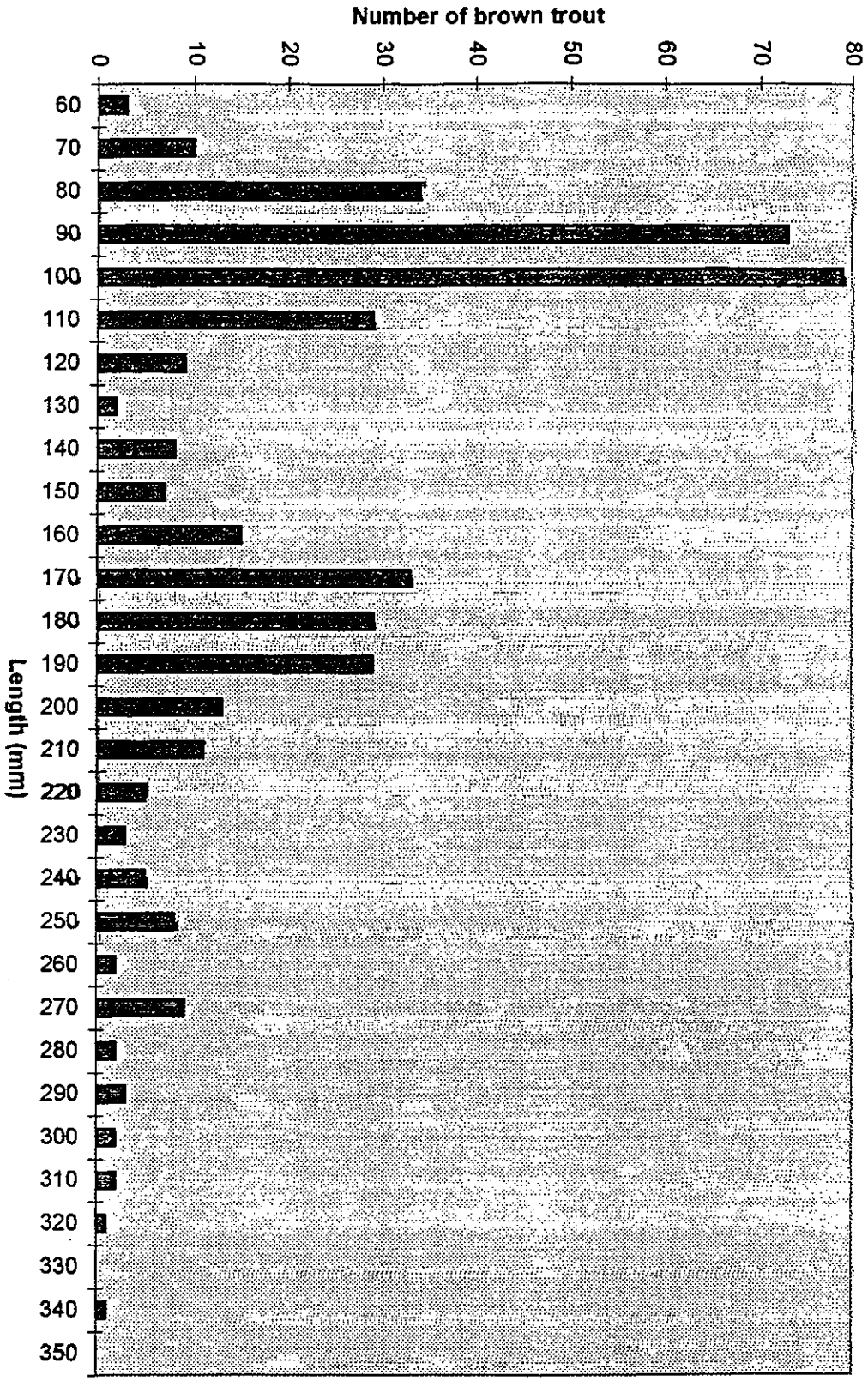
Reproduction of brown trout appears to be excellent on the electrofished portions of Paradise Creek. Young-of-year (0+ years) trout, which hatched from eggs spawned in fall 1998, were less than 5.1 inches in length, based upon the length-frequency distribution, a tool for estimating size at age. Each individual fish collected is graphed according to its length (Figure 3). This produces a set of bell-shaped curves with the peaks representing the average size of fish of a particular age. For example, the first peak between 90 and 100 mm represents 0+ trout, the second at 180 mm is 1+ (yearling) trout, etc. On either side of the peak are fish slightly smaller or larger than the average. Valleys separate different ages groups. According to this technique, young-of-year brown trout comprised 55% and 56% of collections at the upper and lower samples areas, respectively - an indication of highly successful spawning and fry survival in this portion of Paradise Creek.

Brown trout on the Paradise Creek appear to grow at a rate comparable to trout in at least one other Pocono streams. Based upon the length-frequency distribution, average size of 0+ and 1+ wild brown trout in October was approximately 95 mm (3.7 inches) and 180 mm (7.1 inches), respectively (Figure 3). Values obtained for brown trout at the same elevation on McMichaels Creek are similar (Hartzler, personal communication). Fish are poikilothermic organisms, i.e., body metabolism varies directly with temperature. Hence, water temperature is the primary regulator of fish growth, at least for younger age groups. When wild brown trout reach maturity, other factors such as the available forage and habitat features can influence growth. Hence, predicting the age of larger fish from the length-frequency chart is not recommended.

Despite the fact that this portion of the Paradise Creek is open to public fishing, a reasonably large number of catchable-size (>8 inches) wild trout were collected by electrofishing - 27 at the upper station, 28 at the lower. However, more larger trout were taken at the upper site, where 13 fish over 10 inches were found compared to nine at the lower site. This could be attributed to habitat differences. For example, the upper area contained two log-boulder dams with scoured spill pools which larger fish could utilize for refuge and protection from predators and during flood events. The lower electrofishing station was primarily a fast-water run with a few scattered boulders. The largest brown trout, measuring 13.5 inches and weighing 0.8 pounds, was collected at the upper station.

Mortality of young-of-year (0+ years) trout does not appear to be excessive. Roughly 50% as many yearling trout were found as young-of-year, suggesting a similar survival rate for the year (Table 1). However, the mortality rate from 1+ years to 2+ years appears to be much higher, with less than one-third of yearling fish surviving. This is not abnormally high for trout populations in Pocono streams since many fish are also removed by anglers during the fishing season; natural mortality is not the sole cause of fish loss.

Figure 3. Length-frequency distribution of wild brown trout collected at the upper and lower (combined) electrofishing stations on Paradise Creek on 11 and 16 October 1998.



Length-frequency Distribution

The total estimated biomass of wild trout was quite high at both the upper and lower sample locations on Paradise Creek (Table 1). Although more trout were collected at the upper station, the lower station had far less area. Therefore, the weight per unit area was far greater at the lower location, approaching four times the PA Fish & Boat Commission's standard of 40 pounds per acre (44 kg/hectare) for Class A wild trout waters. This is extraordinarily high for a relatively infertile, headwater stream in the Pocono region. An estimated biomass of less than 30 kg/hectare was obtained for wild brown trout on a shallower, more habitat-deficient portion of Paradise Creek located approximately one mile downstream (Hartzler, 1999). Values on McMichaels Creek, a sister stream in the Brodhead watershed, rarely exceed 50 kg/hectare (Hartzler, personal communication). Biomass calculations do not include weight of fish removed by angler harvest, so values would undoubtedly have been higher had these fish been included in the total. These estimates suggest that habitat in this area of Paradise Creek is adequate to support not only a large number of trout, but also white suckers, which far outnumbered brown trout at the lower sampling station.

The average condition of all size groups of brown trout in Paradise Creek fell within the range typically calculated for wild populations (Table 1). Condition compares the weight of fish relative to length. Condition factor of individual trout normally declines during the summer and fall months in response to the diminished biomass of benthic macroinvertebrates, which transform from the aquatic larval and nymphal stages to the terrestrial adult form in spring and summer. Warmer water temperatures also increases metabolism, so all activities, including foraging for food, demand higher energy expenditure, limiting weight gain. Despite this natural process, brown trout on this portion of Paradise Creek were in good condition. This suggests that forage is adequate to support all age groups of trout in the population, and that deeper pools, boulders, and instream obstructions provide sufficient refuge and feeding habitat to sustain the trout population.

SUMMARY

Paradise Creek contained a fish community of relatively low diversity dominated by wild brown trout and white suckers, two species with a widespread distribution in coldwater streams in the Pocono region. Several other species common to cool and warmwater lowland streams in the Brodhead drainage were also collected, including blacknose and longnose dace, American eel, and cutlips minnow.

Large numbers of fingerling brown trout were evidence of excellent reproductive success in this portion of the Paradise Creek. Growth rates were similar to another stream of similar size and elevation in the Brodhead watershed, with 0+ and 1+ trout averaging 95 mm (3.7 inches) and 175 mm(6.9 inches), respectively, in October. Mortality does not appear to be excessive, and condition of all age groups were within normal ranges. Larger

trout were not numerous but angling may have depleted their numbers. Biomass estimates for wild brown trout were quite high on both portions electrofished, averaging 95 kg/hectare (85 pounds/acre) at the upper station and 177 kg/hectare (158 pounds/acre) at the lower station. This far exceeds the PA Fish & Boat Commission's standard of 44 kg/hectare (40 pounds/acre) for Class A wild trout waters. Differences in carrying capacity between the two stations may be attributed to variation in habitat features (pools, substrate, instream debris) which offer trout feeding and refuge areas.

RECOMMENDATIONS

1. Consider implementation of special regulations (reduced harvest, catch-and-release, fly fishing only) to protect the wild trout population, particularly older, larger individuals, from overexploitation by anglers. Encourage discussion between the managing agency, the PA Fish and Boat Commission, and interested parties, including Paradise Township, local landowners, Brodhead Chapter of Trout Unlimited, and the Brodhead Watershed Association, to consider these options and their potential impact.

2. Inventory tributary streams in the Paradise Creek watershed to evaluate the status of the wild trout populations. The feeder streams may be valuable nursery areas for brook and brown trout.

3. Consideration of additional protection for stream biota - aquatic macroinvertebrates and fish - as well as riparian (streamside) and wetland areas in the upper watershed by reclassification of all headwater stream areas from High Quality Coldwater Fishery to Exceptional Value (EV). Presently only the headwater area of Devil's Hole Creek is classified as EV. The EV classification prohibits point-source discharges which degrade water quality and encourages wise land use planning. Consult with county and municipal officials, local landowners, and other interested individuals and groups concerning the long-term impact of this change in stream designation.

4. Allocation of funds to stabilize eroding banks and streamside trails at several locations. Increased recreational use of stream areas open to the public by anglers, hikers, and bikers is a certainty, as is accelerated surface runoff from commercial and residential development in the Mt. Pocono area, where the tributary streams originate.

5. Placement of boulders to enhance fish habitat by providing additional feeding and refuge sites. These instream structures provide fish protection from predators and during flood events.