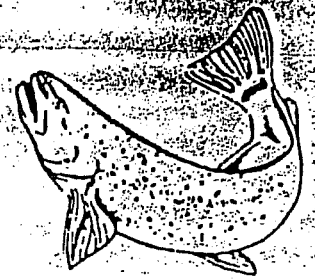


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Fish Inventory of Paradise Creek and Tributaries

September 2003

Prepared for

Paradise Township

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February 2004



BACKGROUND

On September 11 and 12, 2003, Aquatic Resource Consulting (ARC) sampled the fish communities of Paradise Creek and four tributary streams – Butz Run, Indian Run, Forest Hill Run, and Cranberry Creek. The objective was to establish a database to identify the fish species composition of the streams, one important measure of water quality. Paradise Township has developed a comprehensive monitoring program for streams that includes periodic measurements of physical, chemical, and biotic parameters. The information from this electrofishing survey will assist the Township in evaluating each stream's present condition and in assessing possible changes in water quality related to residential, commercial, and industrial development in the Paradise Creek watershed.

ARC conducted electrofishing surveys in 1999, 2000, and 2002 on Paradise Creek and other tributaries, including Swiftwater Creek, Devils Hole Creek, Yankee Run, and Tank Creek. These inventories revealed that most of these streams support reproducing populations of brown trout and often brook trout, two "coldwater" species classified as intolerant to environmental perturbation, such as high water temperatures, sedimentation, pollutants, and habitat degradation. Wild rainbow trout, another salmonid that has a limited distribution in Pennsylvania, were also collected at several locations on Swiftwater Creek.

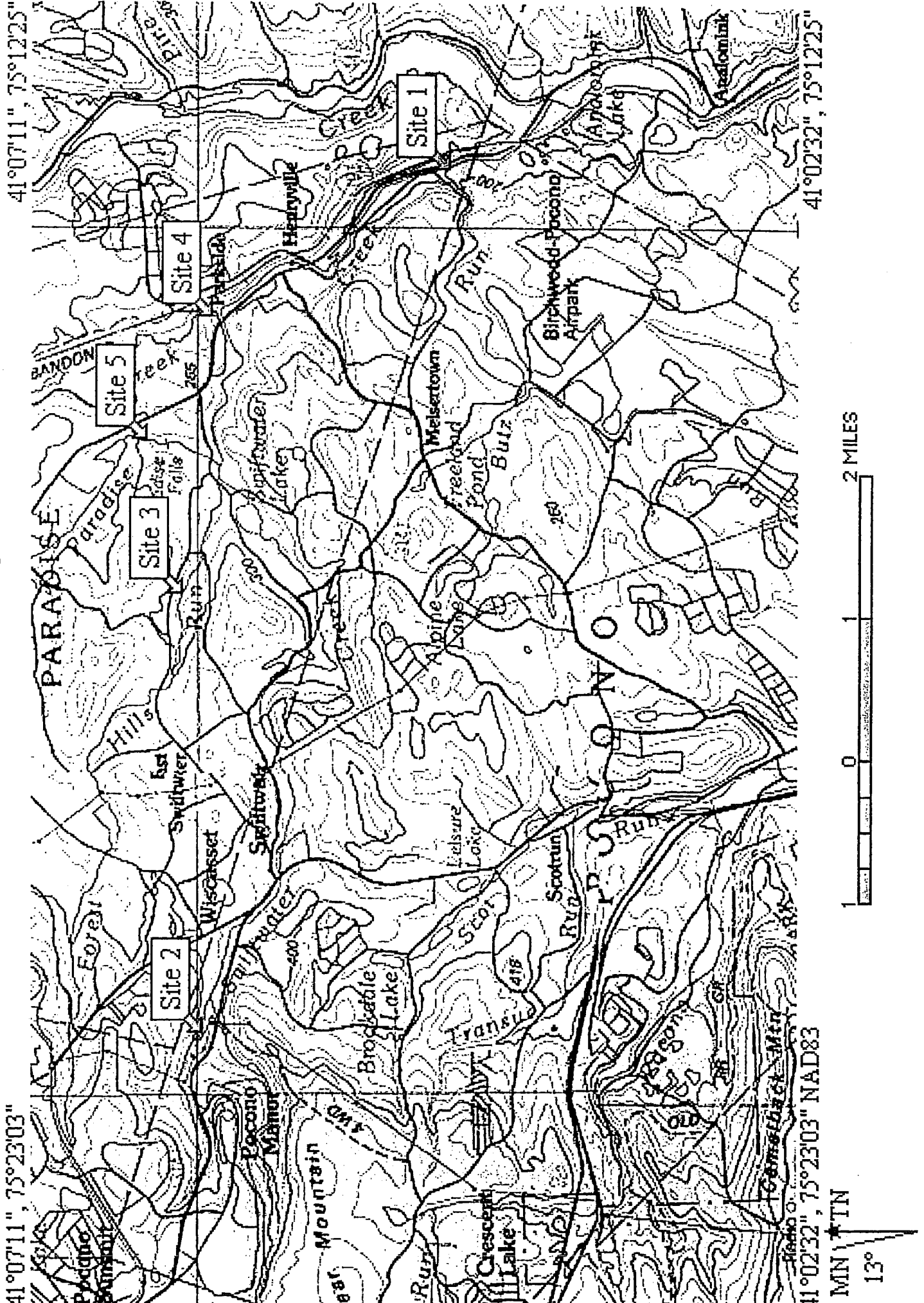
METHODS

Fish communities were sampled by electrofishing with a Coffelt BP1C 300 watt backpack variable voltage (0-600 V) unit with handheld electrodes and nets. Collections were made in an upstream direction, and two or three consecutive runs were made at each station to permit statistical estimates of total abundance (numbers) and biomass (weight per unit area) of wild trout. All trout were netted, anesthetized, weighed and measured. Relative abundance of other fish species was estimated.

Sampling locations (see Figure 1) were as follows (GPS coordinates of starting point in parentheses).

- (1) Butz Run – begin at old logging road just upstream from juncture with Paradise Creek, off Sylvan Cascade Rd. (41 04.683N, 75 13.733W).

Figure 1. Location of electrofishing stations, 2003.



- (2) Indian Run – begin approximately 100 yards upstream from juncture with Swifwater Creek, just off Rt. 314 near power line (41 06.133N, 75 20.842W).
- (3) Forest Hill Run – begin approximately 50 yards below footbridge on Steven's property, off Donaldson Rd. (41 06.262N, 75 17.189W).
- (4) Cranberry Creek – begin approximately 150 yards upstream from Browns Hill Rd., off Rt. 191 (41 06.140N, 75 14.985W).
- (5) Paradise Creek – begin approximately 150 yards downstream from Paradise Lutheran Falls Road bridge (41 06.544N, 75 16.021W).

RESULTS AND DISCUSSION

Fish Species Composition

Brown trout was the predominant fish species at the Paradise Creek station and in all four tributaries (Table 1). This salmonid is the most adaptable of the three species with reproducing populations in Pennsylvania – brook, brown, and rainbow trout – because of its higher temperature tolerance and less demanding spawning requirements. The total weight of wild brown trout exceeded that of any other species at all the sampling locations except perhaps on Paradise Creek, where white suckers were abundant. Numerically, brown trout also ranked first except on Indian Run where both wild brook trout and slimy sculpin were more numerous.

American eel were found at all stations but on Indian Run. This catadromous species ascends most streams tributary to the Delaware River as young-of-year (0+ age) “elvers” after migrating from spawning areas in the Sargasso Sea near Bermuda. After reaching adulthood in 3-5 years, the mature eels migrate downstream in the fall months. Although classified as a “warmwater” species, American eels can be found in many trout streams in the Pocono region, including some higher elevation headwater brook trout streams.

Two small, closely related minnow species – longnose and blacknose dace – were collected at most of the electrofishing sites (Table 1). Cutlips minnow, another member of the Cyprinidae (minnow) family that prefers slightly higher temperatures, was found in Butz Run and Paradise Creek. All these fish require water temperatures in the 70's to spawn and have a widespread distribution in Pocono area streams. Blacknose dace are probably the most numerous minnow in the region because of their broad tolerance to temperature and generalist feeding habits (Table 2). Whereas blacknose dace commonly school in quiet pools and backwater areas of streams, longnose dace are solitary and prefer torrential flows (riffles and runs). Both species were absent on Indian Run, and blacknose dace were not found at the Forest Hills Run site.

Table 1. Relative abundance of fish species collected in tributaries of Paradise Creek in September, 2003.

Occurrence: A = Abundant (>20 individuals); C = Common (5-20); R = Rare (<5); (--) = Absent.

<u>SPECIES</u>	Butz Run	Indian Run	Forest Hill Run	Cranberry Creek	Paradise Creek
Brown trout <i>Salmo trutta</i>	A	A	A	A	A
American eel <i>Anguilla rostrata</i>	C	--	C	R	C
Longnose dace <i>Rhinichthys cataractae</i>	R	--	R	C	R
Blacknose dace <i>Rhinichthys atratulus</i>	C	--	--	C	C
Cutlips minnow <i>Exoglossum maxillingua</i>	C	--	--	--	C
Slimy sculpin <i>Cottus cognatus</i>	--	A	--	C	--
Brook trout <i>Salvelinus fontinalis</i>	--	A	--	R	--
White sucker <i>Catostomus commersoni</i>	--	--	--	--	A
Margined madtom <i>Noturus insignis</i>	R	--	--	--	--
Brown bullhead <i>Ameiurus nebulosus</i>	--	--	--	--	R
Bluegill <i>Lepomis macrochirus</i>	--	R	--	--	--

Table 2. Classification of fish species collected in tributaries to the Paradise Creek in September, 2003.

<u>SPECIES</u>	<u>Distribution</u>	<u>Temp.</u>	<u>Trophic Class</u>	<u>Tolerance</u>
Brown trout <i>Salmo trutta</i>	S	C	TC	I
American eel <i>Anguilla rostrata</i>	S,L	W	TC	T
Longnose dace <i>Rhinichthys cataractae</i>	B,S	CW	BI	M
Blacknose dace <i>Rhinichthys atratulus</i>	B,S	CW	GF	T
Cutlips minnow <i>Exoglossum maxillingua</i>	S,L	W	BI	I
Slimy sculpin <i>Cottus cognatus</i>	B,S	C	BI	I
Brook trout <i>Salvelinus fontinalis</i>	B,S,L	C	TC	I
White sucker <i>Catostomus commersoni</i>	S,L	CW	GF	T
Margined madtom <i>Noturus insignis</i>	S	W	BI	M
Brown bullhead <i>Ameiurus nebulosus</i>	S,L	W	GF	T
Bluegill <i>Lepomis macrochirus</i>	S,L	W	GF	M,T

KEY

Distribution: B = brooks (flowing waters <5 m wide); S = streams (flowing waters 5-10 m wide); R = rivers (flowing waters >10 m wide); L = lakes (ponds & reservoirs).

Temp. class : C = coldwater (<22 C); W = warmwater (>24 C); CW = coolwater (inhabits both types).

Trophic Class: TC = top carnivore (feeds on fish and insects); BI = benthic invertivore (feeds on aquatic insects); GF = generalist feeder (omnivore, i.e., feeds on available plants and animals).

Tolerance (to environmental perturbation): I = Intolerant; T = Tolerant; M = Intermediate.

Slimy sculpin and brook trout, two “coldwater” species with very demanding spawning requirements, were collected only in Indian Run and Cranberry Creek. Spawning females of sculpin deposit adhesive eggs on the underside of boulders and large cobble in early spring. Brook trout require upwelling groundwater (springs) where a nest is excavated in suitable sized silt-free gravel and cobble in late fall; fry hatch the following spring after a four-month incubation period. Both species are benthic invertivores, i.e., feed primarily on aquatic macroinvertebrates.

Four other fish species were sampled, each at only one stream location: White sucker and brown bullhead in Paradise Creek, margined madtom in Butz Run, and bluegill in Indian Run. Both white sucker and brown bullhead are bottom feeders that prefer deep pools with a silty substrate, features more commonly found in warmer, low gradient streams. However, suckers spawn in early spring when temperatures approach 40 degrees F and are often associated with trout in cold, undegraded streams. Distribution of margined madtom, like bullhead a member of the catfish family, is limited to warmer Pocono streams. The presence of bluegill (sunfish) in cooler Pocono streams can often be attributed to individual fish that have escaped from upstream impoundments. Distribution of most members of the sunfish group is restricted to lakes and ponds; spawning in streams is rare.

Salmonids

Numbers and biomass (weight per unit area of stream) of wild brown trout varied widely in the five waterways sampled. These differences, along with the fish species composition, were useful in characterizing the water quality and habitat features of each stream (see next section). Brown trout, although adaptable to a wide range of temperatures and stream conditions, cannot tolerate high water temperatures (>75 degrees F) for extended periods and have very specific requirements in order to survive, grow, and reproduce. Hence, there is a greater focus on this species because their presence is indicative of fairly high water quality and habitat in the resident stream.

Successful reproduction defines whether a wild trout population exists. Young-of-year (0+ age) brown trout were present in Paradise Creek and all four tributaries, evidence for successful spawning in the fall of 2002 (Table 3). These fingerlings measured less than 110 mm (4.3 inches) and were most abundant at the Cranberry Creek and Butz Run electrofishing sites and least numerous in Paradise Creek. [Bear in mind that the total area sampled differed among sites, with the Cranberry and Paradise Creek areas being much larger than the other three]. Adult brown trout apparently found suitable spawning substrate, generally a mix of gravel and cobble at the tails of pools or heads of riffle areas, in all the streams. High natural mortality of eggs, fry and

Table 3. Summary of electrofishing data for wild brown trout in tributaries of Paradise Creek in September, 2003.

	LOCATION				
	Butz Run	Indian Run	Forest Hill Run	Cranberry Creek	Paradise Creek
Sampling - length (feet)	285	260	215	300	330
width (feet)	13	13	15	28	32
area (hectares)	0.035	0.031	0.031	0.079	0.097
(acres)	0.086	0.077	0.076	0.195	0.238
Number of trout collected					
<110 mm (4.3 in.)	32	18	16	50	4
110-199 mm (4.3-7.9 in.)	4	12	24	25	18
>=200 mm (>=7.9 in.)	<u>2</u>	<u>4</u>	<u>22</u>	<u>27</u>	<u>41</u>
Total	38	34	62	102	63
Population estimate					
<110 mm (4.3 in.)	50	21	16	65	4
>=110 mm (>=4.3 in.)	6	17	46	59	62
Total estimated biomass					
kg./hectare	18.5	26.6	139.4	83.5	74.0
pounds/acre	16.5	23.8	124.5	74.6	66.0
Coefficient of condition (k)					
<110 mm (<4.3 in.)	0.86	0.90	0.96	0.93	1.03
110-199 mm (4.3-7.9 in.)	0.95	0.94	0.99	0.98	0.97
>=200 mm (>=7.9 in.)	1.01	1.07	0.97	1.01	0.93

fingerlings may explain the lower numbers on some streams. Since no previous data are available for comparison, the abundance or scarcity of young-of-year trout may represent normal conditions. Additional sampling on other areas of the same stream or in other years would give a more precise picture of reproduction and mortality.

Abundance of adult, legal-size (>200 mm, or >7.9 inches) brown trout also varied among the streams. Larger fish were most numerous in Paradise Creek, Cranberry Creek, and Forest Hill Run, while Butz Run and Indian Run, the smallest (narrowest) waterways, held the least. Larger trout require suitable refuge areas provided by undercut banks, boulders, overhanging roots, and deep pools, where they can escape predators and swift currents, particularly during storm events. Total area provided by these features is generally more limited in small tributaries.

Numbers of fish in balanced populations normally declines as fish grow due to mortality, and on most of the streams sampled this was the case (Table 3). Each size group (<110 mm, 110-199 mm, >200 mm) represents a specific age class, e.g., 0+, 1+, 2+ years, etc. Mortality thins the ranks, so that fingerlings are usually much more numerous than yearlings, which in turn are more abundant than legal-size trout. Paradise Creek displayed the worst balance, with numbers of young-of-year fish depleted while catchable-size trout were very abundant. These proportions can change yearly depending upon a myriad of factors – spawning success, stream discharge, and mortality (both natural and fishing, even cannibalism). However, streams with stable trout populations show the least year-to-year fluctuation.

Estimated biomass of wild trout on four of the five stream areas sampled exceeded 40 kg/hectare, the PA Fish & Boat Commission's standard for Class A waterways (Table 3). Only the weight of trout on Butz Run fell below this level. [The biomass of trout in Indian Run totaled 47.6 kg/hectare when the weight of wild brook trout was included.] Forest Hill Run clearly supported the highest weight per unit area of stream – almost 140 kg/hectare. Large numbers of legal-size trout in Cranberry and Paradise Creeks also sent biomass levels far above the standard. Indian Run was unique because the stream ecosystem supported an almost equal number and weight of both wild brook and brown trout – sympatric populations.

Growth rates of wild brown trout, based upon the length-frequency distribution (LFD) of fish, were similar among four of the streams sampled. Only Indian Run deviated somewhat with lower values than in Paradise Creek and the other tributaries. The LFD plots the number of trout collected in each size group; peaks in the graph represent the average size of a specific age group. For example, for Cranberry Creek these peaks occur at 80-90 mm, 170 mm, and 260 mm, corresponding to 0+, 1+, and 2+

year-old brown trout (Figure 2). Columns (points) to the left or right of the average represent fish of that age group that are smaller or larger, respectively. Cranberry Creek was chosen for graphing because more trout were collected there. If only a few larger trout are collected, such as in Butz Run, there aren't adequate numbers to create peaks, and estimation of growth using the LFD method is not recommended. More accurate aging of trout is possible by the microscopic examination of boney parts (scales, otoliths, fin rays) for annuli (annual rings).

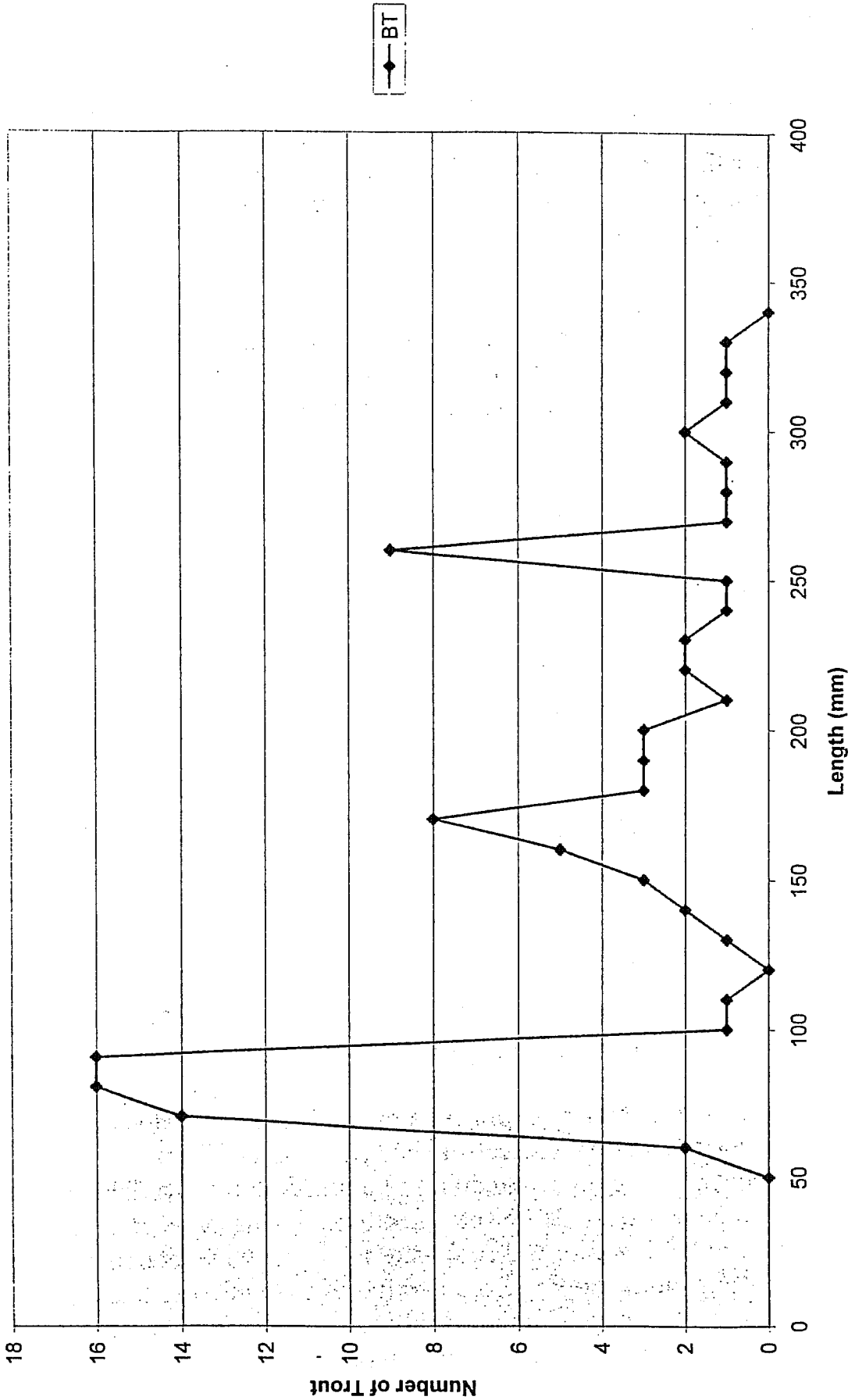
The condition of individual trout at the five locations sampled was generally good. Condition factor (K) is a statistical measure of a fish's weight in relative to its length; more robust fish have a higher condition. K for wild trout usually falls within the 0.90-1.10 range. Almost all size groups of wild brown trout on the five stream electrofished had values in this range (Table 3). Diseased or starving fish can exhibit low K values, and competition among fish for food and space can affect condition as well as high metabolism caused by elevated water temperatures. The lowest coefficient of condition recorded was for fingerling (mostly young-of-year) trout in Butz Run. Condition of the same size group in Indian Run was below the average K value calculated for trout in the other streams.

Stream Characterization

Each stream ecosystem, and stream area within that waterway, has a host of physical, chemical, and biotic features that regulates the number and species of fish found there. Water analysis is often used to measure water quality. However, water chemistry can change momentarily, whereas fish species composition usually remains fairly stable. Furthermore, each taxa can be classified using a number of criteria, including preferred temperature regime, habitat requirements, foraging strategy, and tolerance to environmental disturbance (Table 2). Hence, an assessment of the fish community can be used as a benchmark to measure and monitor changes in water quality. Following is a brief description or characterization of the five stream areas on the Paradise Creek watershed sampled in 2003 based upon the electrofishing results.

Paradise Creek – The “main stream” had the highest species diversity as expected since three of the other streams electrofished are smaller tributaries. This finding can be attributed to the more complex and diverse habitat features – variable depth, width, velocity, substrate, instream debris, etc. – offered by this larger stream. Paradise Creek supports a mix of cold, warm, and coolwater taxa with wide tolerances to environmental stress and feeding habits ranging from carnivores to omnivores to exploit the available forage. Wild brown trout predominated in collections, which had an abundance of legal-size fish (>200 mm) but few young-of-year (0+ age).

Figure 2. Length-frequency Distribution of Brown Trout in Cranberry Creek, 2003



Cranberry Creek – Biomass estimates for wild brown trout in this large tributary to the Paradise Creek were slightly higher than in the main stream. More fingerling trout were found here than at any other electrofishing station, indicative of excellent spawning conditions – suitable substrate, stable temperatures and flows. In addition, the wild trout population in this stream displayed the best balance among size (age) groups. The presence of brook trout and slimy sculpin and absence of several warmwater species found in the main stream suggests slightly cooler temperatures in summer.

Butz Run – Clearly, the fish species composition in this tributary that discharges into the lower Paradise Creek reflected the warmer temperature regime. Upstream impoundments may have a significant effect on water temperature and quality. Most taxa collected are classified as warm or coolwater, with brown trout the only coldwater species. The presence of numerous young-of-year indicated excellent reproductive success but adult trout were rare. Due to the sampling site's close proximity to the main stream, it's possible resident adults in Paradise Creek ascend Butz Run to spawn, then return to the main stream.

Indian Run – Located at the highest elevation in the watershed of the five electrofishing sites, this small tributary had only four fish species but probably the highest quality habitat and coolest summer temperatures. All taxa except the single bluegill, which probably escaped from a pond at the source, were coldwater species. Biomass estimates for wild brook trout (21.0 kg/hectare) were comparable to weight of brown trout (26.6 kg/hectare). Slimy sculpin, whose distribution is limited to only the coldest, least-degraded, sediment-free Pocono streams, were abundant.

Forest Hills Run – With its relatively steep gradient and boulder strewn, silt-free channel, this stream was a study in contrasts. Only three fish species were collected – one classified as coldwater, one warmwater, and one coolwater. Yet the wild brown trout biomass, almost 140 kg/hectare, far exceeded the estimated weight at the other stations and was well above the state standard for Class A wild trout waterways. The high productivity may be attributable to excellent habitat features, such as refuge provided larger trout by boulders and plunge pools, or possibly are a consequence of nutrient enrichment from upstream sewage discharges that “feed” the food chain (algae, aquatic macroinvertebrates).

SUMMARY

Electrofishing surveys of Paradise Creek and four tributaries revealed a diverse mix of fish species, reflecting the influence of water temperature, width, depth, sediment load, substrate composition, and habitat features on relative abundance. Eleven taxa were collected at the five stations, with the highest number taken on Paradise Creek (7) and the least on Indian Run (4) and Forest Hill Run (3). Wild brown trout predominated at each sampling site. American eel, longnose dace, and blacknose dace were the next most common species collected. Distribution of wild brook trout and slimy sculpin, two other "coldwater" species with demanding spawning requirements and an even lower tolerance to environmental degradation than brown trout, was limited to Indian Run and Cranberry Creek. Butz Run had the highest number of warmwater species.

Water quality at the five stream areas can be characterized as very good/excellent, based upon the abundance and biomass of brown trout. Fingerling (0+ years) brown trout were found at all five stations, indicative of successful reproduction in the fall of 2002. Total estimated biomass of trout on each stream showed extreme variation as did the relative number of fish in size groups that corresponded to age classes. Forest Hill Run had the highest weight per unit area, nearly 140 kg/hectare (125 pounds/acre), while Butz Run displayed the lowest – 18+ kg/hectare (17 pounds/acre). All the streams except Butz Run had values exceeding the Pa Fish & Boat Commission's standard for Class A Wild Trout Waters. On Indian Run, weight of wild brook trout nearly equaled that of brown trout. Legal-size brown trout (>200 mm, or 7.8 inches) were abundant on the largest streams – Paradise Creek, Cranberry Creek, and Forest Hill Run – but relatively scarce on the smallest, Butz Run and Indian Run. Average condition factors of different size (age) groups of brown trout were generally within normal ranges.