Population dynamics of wild trout and associated sport fisheries in two northern Wisconsin streams. No. 141 1983

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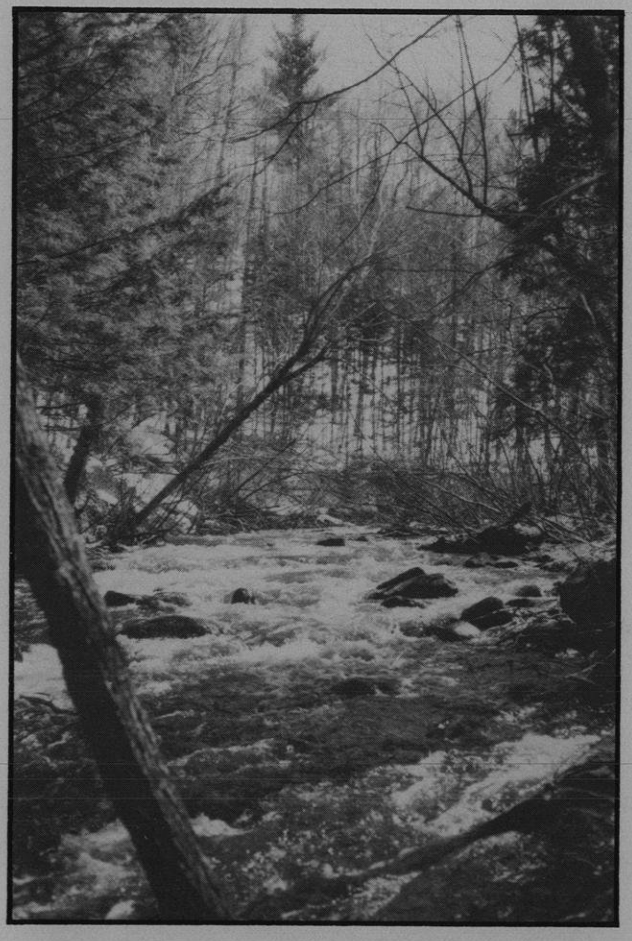

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Population Dynamics of Wild Trout and Associated Sport Fisheries in Two Northern Wisconsin Streams

COVER

A white water reach of Eighteen Mile Creek during spring runoff in mid-April.

ABSTRACT

Angler harvest in central Wisconsin trout streams has substantially reduced normal densities of wild brown trout (*Salmo trutta*) greater than 10 inches, especially age III+ fish. Consequently, recruitment is largely dependent upon only one or two of the younger age groups of spawners. The present study, conducted from April 1979 through April 1981, was undertaken to determine what effect angler harvest is having on wild trout populations in northern Wisconsin streams. The study describes the structure and dynamics of wild brown trout and brook trout (*Salvelinus fontinalis*) populations in two northern Wisconsin streams, characterizes the associated sport fisheries, and discusses the managerial significance of angler harvest on these populations.

Trout populations in the North Branch of Beaver Creek and in Eighteen Mile Creek were inventoried with electrofishing gear each spring, summer, and fall. Characteristics of the sport fisheries were determined by a partial creel census throughout the 1979 fishing season on the North Branch of Beaver Creek and throughout the 1979 and 1980 fishing seasons on Eighteen Mile Creek.

Average spring density and biomass of brown trout in the North Branch of Beaver Creek were 303/mile and 19.2 lb/acre, respectively. In the fall, the average density and biomass increased to 842/mile and 80.2 lb/acre. For brown trout, approximately 43% of the spring population and 48% of the fall population were legal fish, i.e., 6 inches or more in length. In the fall, ages 0, I, II, and III brown trout averaged 3.6 inches, 7.0 inches, 10.4 inches, and 13.9 inches, respectively. Age I brown trout and larger age II+ brown trout ($\geq$10 inches) moved into the study area throughout the summer and fall, followed by a movement out of the study area over winter.

For brook trout, spring density and biomass in the North Branch of Beaver Creek were 63/mile and 3.4 lb/acre, respectively (April 1979 data only). In the fall, the average density and biomass increased to 332/mile and 10.8 lb/acre (1979 and 1980 data). Approximately 51% of the spring population and 29% of the fall population were legal fish. In the fall, ages 0, I, II, and III+ brook trout averaged 3.7 inches, 6.8 inches, 8.1 inches, and 10.8 inches, respectively.

Average spring density and biomass of brown trout in Eighteen Mile Creek were 3,386/mile and 35 lb/acre. In the fall, average density and biomass were 1,914/mile and 97.2 lb/acre, excluding age 0's. Density and biomass of age 0's in 1979 were 4,370/mile and 16.4/acre, respectively. (Age 0's were not estimated in fall 1980.) Roughly 7% of the spring population and 44% of the fall population (excluding age 0's) were legal brown trout. In the fall, age 0, I, II, and III trout averaged 3.0 inches, 5.7 inches, 8.4 inches, and 11.2 inches, respectively (age 0 data from 1979 only). A significant number of age III+ brown trout and brown trout equal to or greater than 10 inches moved into the study area throughout the spring, summer, and fall, followed by movement out of the study area over winter.

For brook trout in Eighteen Mile Creek, spring density and biomass averaged 194/mile and 2.0 lb/acre. The fall average density and biomass was 148/mile and 3.2 lb/acre, excluding age 0's. Approximately 18% of the spring population and 20% of the fall population (excluding age 0's) were legal fish. In the fall, ages 0, I, and II+ brook trout averaged 3.2 inches, 5.5 inches, and 7.6 inches, respectively (age 0 data from 1979 only).

Growth of brook trout during their first year of life was faster than their brown trout counterparts in both the North Branch of Beaver Creek and Eighteen Mile Creek. Subsequent growth of brown trout in both streams was faster than brook trout, however. Growth of both species was faster in Beaver Creek than in Eighteen Mile Creek and resulted in a larger average size at all ages.

Fishing pressure on both the North Branch of Beaver Creek and Eighteen Mile Creek was much lighter than on central Wisconsin trout streams, and brown trout harvested tended to be larger and older than those harvested in central Wisconsin.

In 1979, fishing pressure was 75 hours/acre on the North Branch of Beaver Creek. Fisherman harvested 90 trout/mile weighing 13.4 lb/acre. Although the study area was primarily brown trout water, only 37% of the trout harvested and 54% of the biomass harvested consisted of brown trout. Brook trout comprised nearly all of the remaining harvest. Average sizes of brown trout and brook trout harvested were 10.5 inches and 8.7 inches, respectively.

Fishing pressure during 1979 and 1980 on Eighteen Mile Creek averaged 30 hours/acre and resulted in a harvest of 72 trout/mile weighing 7 lb/acre. An average of 78% of the trout harvested (88% of the biomass) consisted of brown trout, with the remainder consisting of brook trout. Average size of angler-caught brown trout was 9.5 inches in 1979 and 9.6 inches in 1980. Average size of creeled brook trout was 8.2 inches in 1979 and 7.6 inches in 1980.

Spring and fall population densities of brown trout in Beaver Creek were lower than in nine other Class I brown trout streams in Wisconsin. Brown trout densities in Eighteen Mile Creek were among the highest observed, however. Spring standing stocks in both study streams were generally below the standing stocks in other Class I trout streams, but in the fall standing stocks compared favorably with northern Wisconsin trout streams. The seasonal movement of larger, older brown trout in northern Wisconsin streams was of much greater magnitude and of much greater importance as a management factor compared to brown trout studied in central Wisconsin streams. No major revisions of harvest regulations are needed in the immediate future to protect wild brown trout populations in northern Wisconsin. The greater vulnerability of brook trout to angler harvest, even at the low fishing pressures observed, emphasizes a need for a more intensive study of wild brook trout and their sport fisheries in northern Wisconsin.

KEY WORDS: Wild Trout, Brown Trout, Brook Trout, Population, Sport Fisheries, Movement, Harvest, Management, Wisconsin.

Population Dynamics of Wild Trout
and Associated Sport Fisheries in Two Northern Wisconsin Streams

by
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INTRODUCTION

The most recent and thorough analysis of wild brown trout (*Salmo trutta*) populations and the associated sport fisheries in Wisconsin was completed in 1978 on four Class I* trout streams in the central region of the state (Avery and Hunt 1981). The present study on two Class I trout streams in northern Wisconsin began in April 1979 and was completed in April 1981. Its objective was essentially the same as that of the study mentioned earlier: 1) to quantify population densities, biomass and growth of the wild brown trout populations; and 2) describe the characteristics of the associated sport fisheries. Inherent in that objective was provision for comparison of data from central Wisconsin streams with those from the northern part of the state, where the growing season is shorter, the winters are more severe, the streams are less productive, and the fishing pressure is less intense. Because both streams in this study had significant populations of brook trout (*Salvelinus fontinalis*), population data for that species are also included in the report.

*Class I streams are high quality trout water with enough natural reproduction to sustain populations of wild trout at or near carrying capacity. Stocking of hatchery trout is not required (Wis. Dep. Nat. Resour., *Wisconsin Trout Streams*, 1980).

THE STUDY STREAMS

Three distinct concentrations of brown trout streams occur in Wisconsin, covering 8 of the state's 72 counties and including 62% of the Class I brown trout water (Fig. 1). Study sites were selected in Marinette and Bayfield counties in order to get information from both the northeast and northwest regions of the state.

The North Branch of Beaver Creek (hereafter referred to as Beaver Creek) is in northeastern Wisconsin in south central Marinette County (Fig. 2). It flows 8.7 miles, merges with the South Branch of Beaver Creek, and subsequently empties into the Peshtigo River 3.0 miles further downstream. The upper 6.3 miles of Beaver Creek is Class I trout water and contains wild populations of brown trout and brook trout. Other fishes present are listed in Table 1.

The study area was a 3.4-mile reach of Beaver Creek from the 25th Street road crossing upstream to the wooden snowmobile bridge accessible via a gated road off of 26th Street (Fig. 2). More than half of the study area was state-owned or leased as public fishing grounds, but the best access was from old logging trails on private lands. Upon request, landowners granted anglers access to the stream on all of these logging trails.

A low gradient, primarily sand-bottomed stream, Beaver Creek is difficult to fish because of vegetation on the stream bank.

Beaver Creek is stained the color of weak coffee and has a pH of 7.8-8.0 and an alkalinity of 114-171 ppm $CaCO_3$ (Table 2). Maximum summer temperatures sometimes exceed 60 F, but average weekly temperatures are in the 50's F from mid-May through late September (Append. Fig. 5). The study area averaged 15.2 ft wide and 1 ft in depth. The entire stream has a gradient of 7.3 ft/mile, the discharge averages 14.9 cfs, and the substrates are primarily sand and silt. Gravel suitable for trout reproduction is scarce.

Aquatic vegetation is moderately abundant where sunlight reaches the

TABLE 1. *Fishes captured in the two study streams, 1979 and 1980.*

Species	North Branch Beaver Creek	Eighteen Mile Creek
American brook lamprey	x	
Burbot	x	
White sucker	x	x
Central mudminnow	x	x
Mottled sculpin	x	x
Longnose dace	x	x
Brook stickleback	x	x
Rockbass	x	
Fathead minnow	x	
Common shiner		x
Brook trout	x	x
Brown trout	x	x
Rainbow trout	x	

TABLE 2. *Chemical parameters of the two study streams.*

Parameter*	Eighteen Mile Creek	North Branch Beaver Creek
pH	7.6	7.8-8.0
Conductivity	140-196	291-416
Alkalinity	54-70	114-171
N (total)	0.12-0.70	0.62-1.62
P (total)	0.01-0.03	0.01-0.03
Ca	16-21	28-38
Mg	5-7	17-21
Na	1-11	1-9
K	0.7-2.3	0.7-1.5
Fe	0.08-0.20	0.08-0.11
Mn	0.03-0.08	0.03-0.07
Cl	1	1-2
SO_4	3-5	7-11
Turbidity	1.5-2.0	1.5-2.4

*Measurements are mg/l except for the following parameters: pH (units), conductivity (micromhos/cm at 25 C), alkalinity (mg/l $CaCO_3$), and turbidity (FTU).

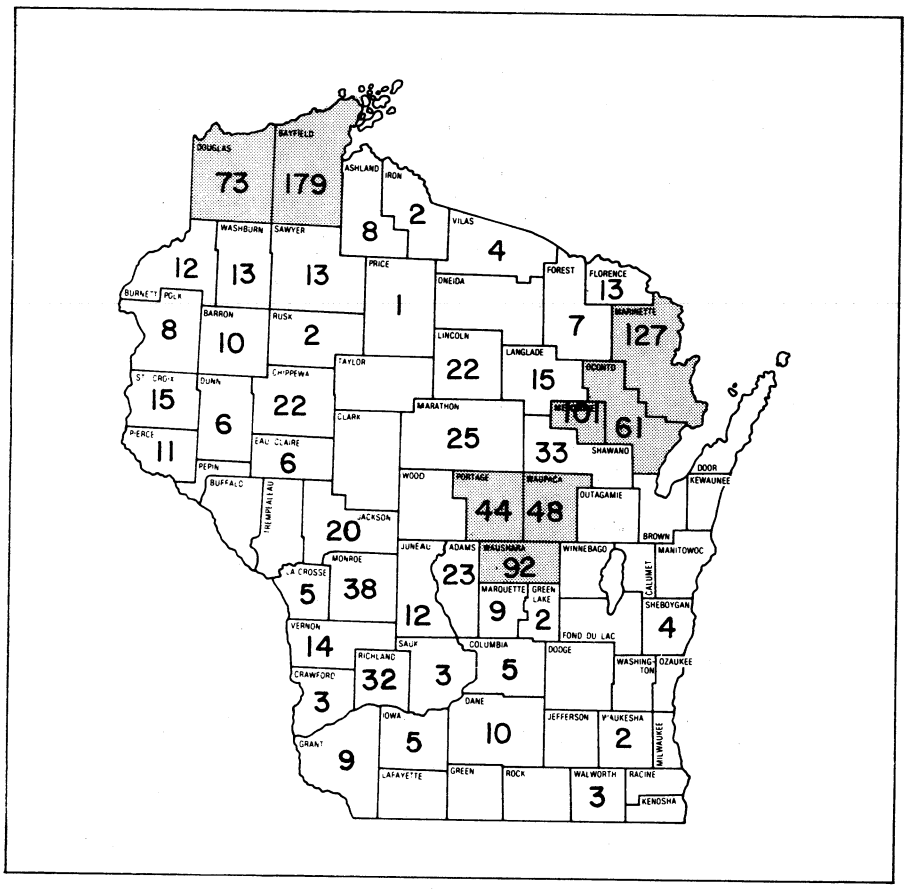


FIGURE 1. Wisconsin counties showing mileage of Class I trout streams containing wild brown trout.

stream and consists primarily of tapegrass (*Vallisneria americana*) and water buttercup (*Ranunculus* sp.). A noticeable increase of aquatic vegetation occurs below the confluence of a tributary entering from the west at the upper limit of stream segment B (Fig. 2). This tributary receives discharge water from a private trout hatchery. White cedar (*Thuja occidentalis*), speckled alder (*Alnus rugosa*), dogwood (*Cornus alternifolia* and *C. racemosa*), and ninebark (*Physocarpus opulifolius*) shade the stream and make fishing difficult.

Eighteen Mile Creek is a Class I trout stream in northwestern Wisconsin in south central Bayfield County (Fig. 3). It begins in the Chequamegon National Forest and flows northeasterly 13.4 miles before entering Long Lake Branch, a tributary of the White River. The stream has both brook trout and brown trout, but the latter are far more numerous in the lower two-thirds of the stream. Other fishes present are listed in Table 1.

The study section was a 5.3-mile reach of Eighteen Mile Creek near the town of Grandview (Fig. 3). Although the study area was on private lands, five bridge crossings provided ample public access and none of the lands were posted against trespass.

Throughout much of the study area the stream is bordered by high steep ridges, confining the stream to a relatively narrow valley floor. White spruce (*Picea glauca*), balsam fir (*Abies balsamea*), and white cedar dominate in these areas. Red maple (*Acer rubrum*), American elm (*Ulmus americana*), ash (*Fraxinus nigra* and *F. americana*), and speckled alder dominate where the valley floor broadens.

The gradient of Eighteen Mile Creek averages 35 ft/mile. The water is lightly stained and has an alkalinity of 54-70 mg/l $CaCO_3$ and a pH of 7.6 (Table 2). Stream discharge varies greatly in April due to spring rains and snow melt, but averages 21 cfs in the study area during the rest of the year. Average stream width in the study area is 22 ft and average depth is 0.8 ft. Gravel and cobble substrates are abundant and aquatic vegetation is scarce. Maximum stream temperatures reach the high 60's F in July and August, but average weekly temperatures fluctuate around 60 F (Append. Fig. 5). Winter conditions for trout are severe, with subfreezing temperatures in long riffle areas and ice as much as 2 ft thick across the stream. Fishability of the stream varies from moderately good to extremely difficult depending upon the dominant vegetation along the stream bank.

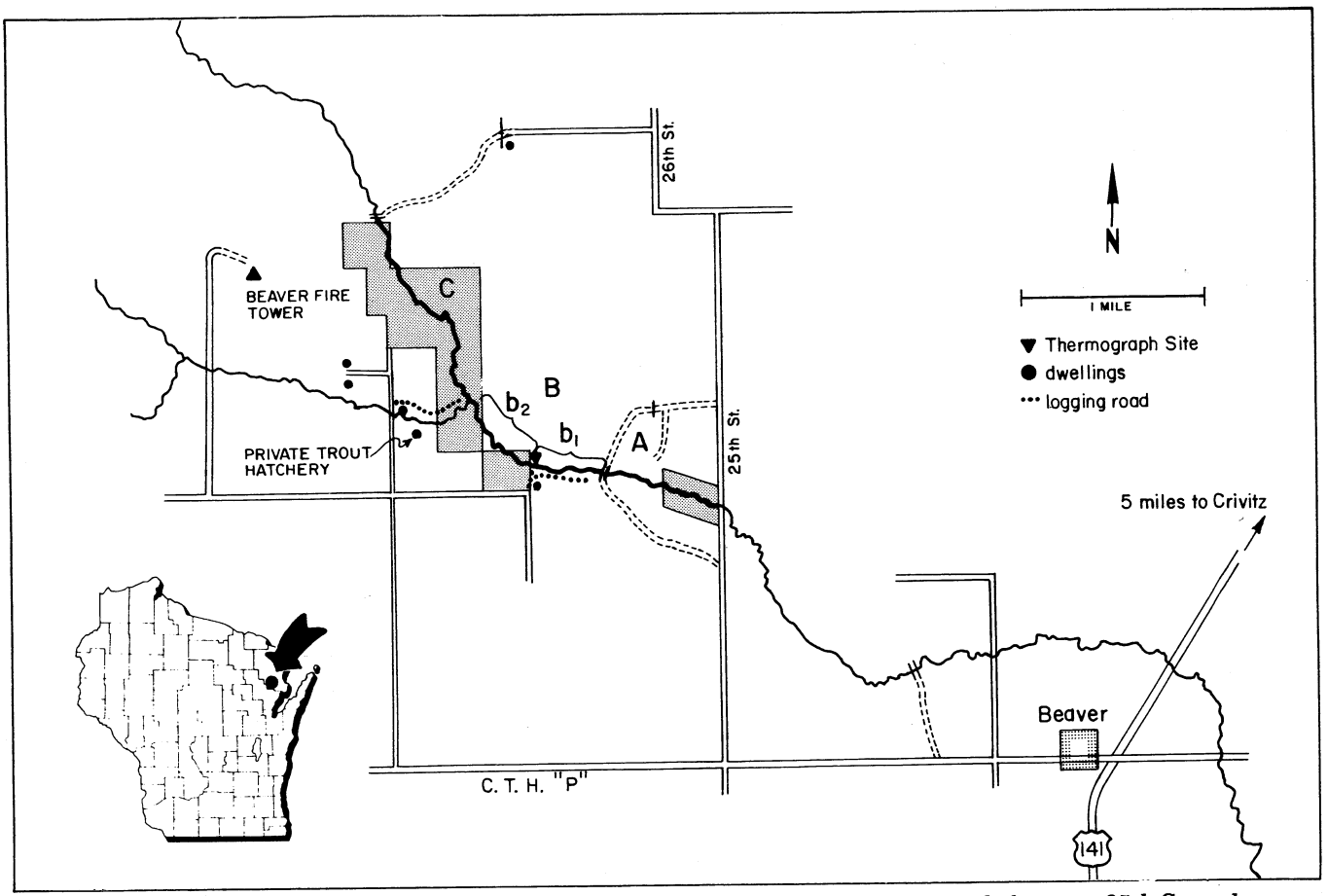


FIGURE 2. The 3.4-mile study area on the North Branch of Beaver Creek. (A=0.8 mile between 25th St. and iron culvert; B=1.1 mile between iron culvert and fence line 50 yards above tributary; b_1=0.5 mile from iron culvert to public land; b_2=0.6 mile from public land to fence above tributary; C=1.5 mile from fenceline to snowmobile bridge; state-owned public fishing areas are shaded.)

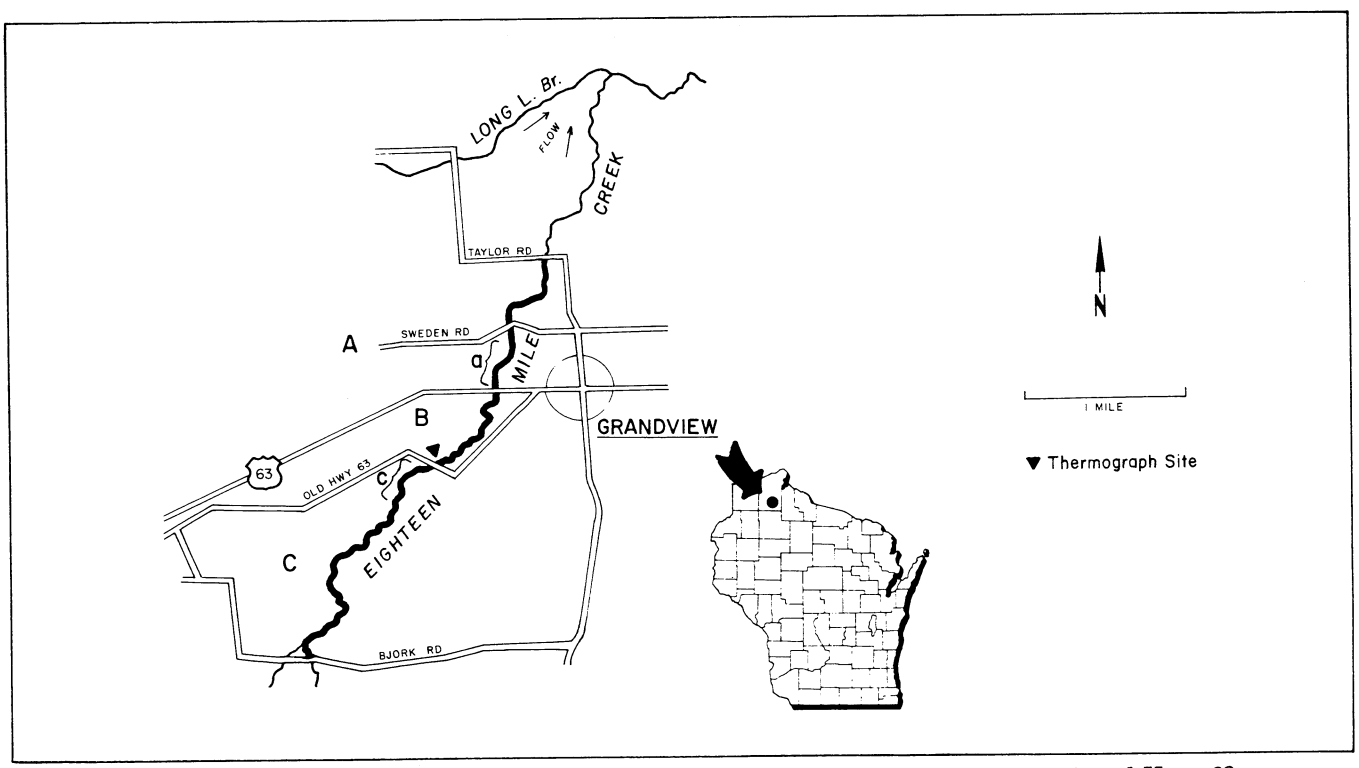


FIGURE 3. The 5.3-mile study area on Eighteen Mile Creek (A=1.4 mile between Taylor Rd. and Hwy. 63; a=0.6 mile between Sweden Rd. and Hwy. 63; B=1.2 mile between Hwy. 63 and old Hwy. 63; C=2.7 mile between old Hwy. 63 and Bjork Rd.; c=0.5 mile immediately above old Hwy. 63).

METHODS

In general, double-run electrofishing surveys of either all or part of the study areas were made in the spring, summer, and fall. During the initial electrofishing runs each year, trout were measured to the nearest 0.1 inch and weighed to the nearest gram. In the spring, age I trout were marked to establish a known-age segment of the population, and in the fall age 0 trout were marked to establish a second known-age segment. To document seasonal movements within the study area, trout captured in different sections of the study area were marked differently than those captured in other sections. Scale samples were collected from 10 to 20 trout/inch group whenever possible. Age structures were based on both known-age trout captured and scale analysis. Populations were either estimated by inch groups or estimated in total and apportioned to groups based on the relative proportions of fish in each inch group captured on both electrofishing runs.

In 1979, the study area on the North Branch of Beaver Creek was a 3.4-mile stretch, but in 1980 this was reduced to a 1.2-mile stretch. In 1979, the study area on Eighteen Mile Creek was a 5.3-mile stretch, but this was reduced to a 4.1-mile stretch in 1980. (However, 1979 spring population estimates for Eighteen Mile Creek are based on a 0.6-mile portion of the study area, section a.)

Electrofishing gear consisted of a small stream shocker boat equipped with a 220-volt DC generator, three positive electrodes, and a negative electrode of sheet metal, which also protected the boat bottom from abrasion. All population estimates were based on the Bailey modification of the Petersen mark and recapture formula (Ricker 1958). The standard error of each estimate was computed as the square root of the variance. For populations estimated by inch groups, the standard error of the total population was the square root of the sum of the variances computed per inch group.

TROUT POPULATION DYNAMICS

North Branch Beaver Creek

Double-run electrofishing surveys of the entire study area were made in the spring and fall of 1979, and of section b_1, during July (Table 3 and Fig. 2). In the spring, scale samples were collected from both brown trout and brook trout (Table 4). Most age I trout were less than 5 inches and were fin clipped to establish a known-age group for future reference. To document seasonal movements within the study area, age I trout captured in sections A and b_1 were marked differently from those captured in sections b_2 and C.

The brown trout population in each inch group was estimated in sections B and C and the totals summed for an estimate within each section. The population in section A was estimated and apportioned to inch groups based on the relative proportions of fish in each inch group captured on both electrofishing runs*. The population estimates in all three sections were summed for a total estimate of brown trout within the study area. Low numbers of brook trout captured in the spring prevented estimates within individual stream sections. Therefore, an estimate of the population within the entire study area was made. Fish were apportioned to inch groups in the same manner as brown trout in section A.

In the fall of 1979, scale samples were collected only from brown trout (Table 4). Age 0 brown trout and age 0 brook trout (less than 4.5 inches) were permanently marked to establish a second known-age segment in each population. Age 0's in sections A and b_1 were marked differently from those in sections b_2 and C to document seasonal movements within the stream. Popula-

*Excluding recaptures on the second electrofishing run.

TABLE 3. *Electrofishing surveys in the two study streams.*

Stream		Date of Survey	Section Surveyed
No. Br. Beaver Creek	1979	Apr	A,b_1
		30 Apr, 1 May	b_2, C
		8-9 May	Total (A, B, C)
		17-18 Jul	b_1
		8-12 Oct	Total (A, B, C)
No. Br. Beaver Creek	1980	7-8 Apr	B
		7-8 Jul	B
		9-10 Oct	B
Eighteen Mile Creek	1979	16-19 Apr	Lower ¾ of study area
		2-3 May	Upper ¼ of study area
		3 May	Lower 0.9 miles
		21-24 May	Upper 4.4 miles
		5 Jun	a
		6 Jun	0.3 miles (below study area)
		25-26 Jul	a, c
		17-20 Sep	Total (A, B, C)
		24-27 Sep	Total (A, B, C)
Eighteen Mile Creek	1980	15-23 Apr	A, C
		15-16 Jul	A, C
		22 Sep-1 Oct	a, c
		20 Apr 1981	Two 300-m stretches (below study area)

TABLE 4. *Number and size range of trout from which scale samples were taken during the study.*

			Brown Trout		Brook Trout	
Stream		Date	No.	Length Range (inches)	No.	Length Range (inches)
No. Br. Beaver Creek	1979	Spring	180	3-17	29	3-10
		Fall	244	4-21		
No. Br. Beaver Creek	1980	Spring	84	3-10	28	3-10
		Summer	37	5-15	36	4-11
		Fall	87	4-14	27	4-14
Eighteen Mile Cr.	1979	Spring	231	3-17	76	3-12
		Fall	245	3-21	41	3-6
Eighteen Mile Cr.	1980	Spring	96	2-9	64	2-8
		Summer	67	4-17	18	4-7
		Fall	184	4-21	34	4-9

tions of both brown and brook trout were estimated by inch group in each stream section and summed for a total estimate.

To monitor survival and document any immigration or emigration of trout between April and July, a double-run electrofishing survey of section b_1 (0.5 mile) was conducted in July. Trout were measured and weighed but no scale samples were taken. Population estimates of brown trout were made by inch groups and summed for a total estimate. An estimate of the brook trout population could not be made due to the low number captured.

In 1980, the study area on Beaver Creek was reduced to section B (1.2 mile) because a creel census was not planned for 1980, and section B was considered representative of the trout habitat. During the spring, summer, and fall, double-run electrofishing surveys were made and scale samples were taken from brown trout and brook trout. Age structures were determined based on known-age fish captured and subsequent scale analyses.

In April, brown trout estimates were made by inch groups and summed for a total population estimate. An insufficient number of recaptures prevented an estimate of the brook trout population, so the actual number of brook trout captured is reported. In July, the brown trout population was estimated by inch group, while the brook trout population was estimated and apportioned to inch groups based on the relative proportions found on both electrofishing runs. No attempt was made to capture or estimate the 1981 year class (age 0) of either trout species. In October, estimates of brown and brook trout were made by inch groups and summed to achieve total population estimates. Estimates of both populations included the 1980 year class (age 0).

Eighteen Mile Creek

A double-run electrofishing survey of the 5.3-mile study section was conducted in the spring of 1979 (Fig. 3). Roughly three-fourths of the study section was electrofished in mid-April during exceptionally high flows, and the remainder was electrofished on 2-3 May under normal stream flow conditions (approximately 10 inches below the mid-April level). The second run was completed in the lower 0.9 mile between Taylor and Sweden roads on 3 May and in the remaining 4.4 miles on 21-24 May. Because of the poor efficiency suspected during the initial run conducted in mid-April, a 0.6-mile reference section between Sweden Road and Hwy. 63 (section a, Fig. 3) was electrofished a third time on 5 June.

Much of Eighteen Mile Creek flows through wild country. Water seldom visited by anglers greeted this electrofishing crew.

Scale samples from brown trout and brook trout were collected during the mid-April and early May electrofishing runs (Table 4). Most of the 1978 year class (age I) were smaller than 4.5 inches and were marked to establish a known-age population segment. Different fin clips were given to age I's captured in reaches A, B, and C to determine subsequent movement within the study area (Fig. 3). Brown trout populations were estimated by inch groups, and these were summed for a total population estimate. The brook trout population was estimated and then apportioned to inch groups based on the relative frequency of fish captured in each inch group.

Approximately 0.3 mile of Eighteen Mile Creek below the lower boundary of the study area, i.e., Taylor Road, was electrofished on 6 June 1979. A permanent fin clip was given to 103 brown trout (5.0-14.9 inches) and 5 brook trout (5.0-8.9 inches) to detect trout movement into the study area.

Double-run electrofishing surveys of two sections (a and c) of the study area were conducted in July. Trout were weighed, measured, and examined for permanent fin clips. Brown trout and brook trout populations were estimated with the same procedures used in the spring.

Another double-run survey of the entire study area was conducted in the fall of 1979 (Table 3). Population estimates by inch groups were summed for total estimates of both trout species and scale samples were collected (Table 4). The 1979 year class (age 0) was given a permanent and characteristic mark corresponding to stream sections A, B, and C to establish known-age populations and determine subsequent movement within the study area. Most trout less than 4.0 inches and a few between 4.0 and 4.4 inches were marked as age 0's.

In 1980, double-run electrofishing surveys of only 4.1 miles of the original study area were conducted. Section B (1.2 miles) was eliminated because of its high gradient, relatively poor trout population, and lower use by anglers (Table 3, Fig. 3). In April and September, population estimates in sections A and C were made by inch groups and summed. Estimates in both sections were summed for a total. Scale samples from both trout species were also taken in April and September (Table 4).

In addition to the spring and fall population inventories in 1980, double-run electrofishing surveys in July were conducted in sections a and c. Scale samples were taken from both trout species and populations were estimated in each section and summed for a total estimate. Within each section, brown trout less than 9.0 inches were estimated by inch group. Brown trout 9.0 inches or more were estimated and apportioned to inch groups. Brook trout in each section were estimated and apportioned to inch groups. No attempts were made to capture the 1980 year class (age 0).

In April 1981, a single electrofishing run was made in two 300-m reaches below the study area to capture marked trout and verify downstream overwinter movement. One reach originated at the stream mouth and the other was approximately halfway between the stream mouth and Taylor Road. Trout were measured to the nearest 0.1 inch and examined for identifying fin clips. Age I trout in the upper 300-m reach were tallied.

TROUT SPORT FISHERIES

Wisconsin's general trout seasons in 1979 and 1980 opened the first Saturday in May and extended through September. A bag limit of 10 trout/day in May, of which only 5 could be rainbow or brown trout in aggregate, and 10 trout/day from June through Septem-

ber was in effect during this study. The minimum legal length was 6 inches.

The sport fisheries on Beaver Creek and Eighteen Mile Creek were studied in 1979 by means of a partial creel census throughout the fishing season. For the census, 50% of the effort covered weekends and holidays and 50% covered weekdays. Census clerks normally worked one of two 8-hour shifts on each census day (5:30 a.m. to 1:30 p.m. or 1:30 p.m. to 9:30 p.m.), and averaged 40 hours/week on each stream. Double shifts (16-hour days) were used on opening weekend to strive for a complete census. Thereafter, census days and 8-hour shifts were randomly selected within the constraints of a 40-hour workweek to best represent all days as well as a.m. and p.m. shifts. This still resulted in some 16-hour workdays, especially on weekends. The census was conducted for 68 days of the 149-day fishing season on Beaver Creek and included 24 weekend days and holidays plus 44 weekdays. On Eighteen Mile Creek, the census was conducted for 90 days and included 39 weekend days and holidays plus 51 weekdays.*

In 1980, a partial creel census similar to the one conducted in 1979 was run on Eighteen Mile Creek only. Since data from 1979 suggested that approximately 40% of the fishing pressure occurred on weekends and holidays and 60% occurred on weekdays, census effort was stratified in this manner.** The census was conducted on 91 days of the 151-day season and included 33 weekend days and holidays and 58 weekdays.

The creel censuses in both 1979 and 1980 consisted of two main parts: estimates of fishing pressure and catch statistics. Fishing pressure was estimated by tallying cars at or near bridge crossings or where the stream came closest to the road. The tally was made in 2-hour intervals between 6:30 a.m. and 8:30 p.m. A 15½-hour fishing day was assumed on opening weekend in May and throughout June, July, and August. A 15-hour fishing day was assumed during the remainder of May and in September. Time intervals for the 6:30 a.m. and 8:30 p.m. car counts varied month by month. Time intervals at these two times of the day were determined by the earliest angler on the stream and the last angler leaving the stream, respectively. Consequently, the start and end of census days varied, but total length of the fishing day conformed to the 15½-hour or 15-hour periods mentioned previously. All other car counts represented 2-hour time intervals.

Between counts, anglers were interviewed for information on the number in their party, their residence, length of time fished, fishing methods, and their catch. Most were interviewed as they returned to their cars in order to gather information from completed trips as much as possible. All creeled trout were measured to the nearest 0.25 inch and examined for age-specific fin clips. Scales were taken from unmarked trout to facilitate age analysis.

Fishing pressure was estimated on a monthly basis during each fishing season. Monthly totals were summed to achieve a season's estimate. Data collected on weekends and holidays vs weekdays were computed separately each month.

Monthly fishing pressure (as angler hours) was estimated by the formula:

$$\left[\sum_{i=1}^{n}(\overline{C}_i T_i)\right](A_{wd})(WD) + \left[\sum_{i=1}^{n}(\overline{C}_i T_i)\right](A_{wed})(WED)$$

where n = number of car counts possible/day; maximum of 8

$\overline{C}_i$ = mean number of cars present at each car count period

T_i = the time interval represented by each car count, usually 2 hours

A_{wd} = mean number of anglers/car on weekdays

A_{wed} = mean number of anglers/car on weekend days plus holidays

WD = number of weekdays in the month

WED = number of weekend days and holidays in the month.

Fishing pressure on opening weekend in May was considered separately and was computed by the formula:

$$\left[\sum_{i=1}^{n=2}(\overline{C}_i T_i)\right](A_{owed})(OWED)$$

where OWED = number of days in opening weekend

A_{owed} = mean number of anglers/car on opening weekend.

Pressure exerted by anglers without vehicles was determined by multiplying the estimated fishing pressure (by day type each month) of anglers with vehicles x the ratio of anglers without vehicles to anglers with vehicles.

Monthly trout harvest was computed by multiplying the season catch rate (trout creeled/hour) by the estimated fishing pressure for the particular month. Catch rates were based on completed fishing trips. Brown trout and brook trout in the estimated harvest were apportioned based on their observed frequency in the creel, and the season harvest was derived by summing the monthly estimates.

*Although the hours/week worked by census clerks were the same on both streams, a 2-hour drive to and from Beaver Creek vs a ½-hour drive to and from Eighteen Mile Creek resulted in fewer census days worked on Beaver Creek.

**Actual effort was split 36/64 due to unforeseen conflicts of census clerk, i.e., car trouble, etc., and inability to substitute other census days for those missed.

RESULTS

TROUT POPULATIONS

North Branch Beaver Creek

Beaver Creek had a standing stock of 34 lb/acre and a density of 487 trout/mile in April 1979 (Table 5). Brown trout comprised 87% of the population and 90% of the biomass, with the remainder consisting of brook trout. Legal-sized trout (at least 6 inches) comprised 37% of the spring population and had a density of 181/mile. Legal brown trout outnumbered legal brook trout more than 4 to 1.

Density of brown trout in April was 424/mile and included five age groups (Table 5). Ages II, III, and IV trout constituted 95% of the legal fish. All yearlings (age I) and 55% of the age II's were not legal. Table 5 shows average lengths for various age groups. Average size of legal trout was 9.2 inches. A 5-year-old fish in the 17-inch group was the largest brown trout captured.

Only 63 brook trout/mile were present in Beaver Creek in April (Table 5). Although four age groups were represented, age II and III brook trout comprised 93% of the legal population and averaged 6.6 inches and 9.1 inches, respectively. The average legal brook trout was 7.8 inches and the largest captured was an age IV fish in the 10-inch group.

In October 1979, the standing stock of trout in Beaver Creek was 101.8 lb/acre and represented almost a threefold increase since April (Table 6). A density of 1,658/mile was more than 3 times the spring density. Brown trout comprised 71% of the fall population and 87% of the biomass, while brook trout accounted for the remaining 29% and 13%, respectively. Legal trout comprised 35% of the fall population at a density of 587/mile. Legal brown trout outnumbered legal brook trout about 3.7 to 1.

The fall brown trout population consisted of 1,177/mile and included age groups 0-VII (Table 6). Young-of-the-year (age 0) trout were 52% of the population and were all sublegal (less than 6 inches). Only 24% of the age I's were sublegal, and the remaining 76% comprised 69% of all legal fish present. Together, ages I, II, and III brown trout comprised 96% of the legal population. Table 6 shows average lengths for various age groups. Average size of legal trout was 9.0 inches, and a 6-year-old measuring 21.7 inches was the largest brown trout captured.

The fall density of brook trout in Beaver Creek was 481/mile and included at least five age groups (Table 6). Age 0's were sublegal and comprised 60% of the total brook trout population. Approximately 61% of the yearling population was legal and together with age II's comprised 97% of the legal fish. Yearling brook trout averaged 6.3 inches, while age II's averaged 7.8 inches. Average size of legal brook trout was 7.4 inches, and the largest fish captured was a 16.1-inch male that was at least age IV.

In April 1980, the study area on Beaver Creek was reduced from 3.4 miles to a 1.2-mile reach designated as section B (Fig. 2). Spring density and standing trout stock were 206/mile and 8.7 lb/acre, respectively (Table 7). These figures include only the total number of brook trout captured on both electrofishing runs* because too few recaptures were made to make a separate population estimate. Brown trout again dominated, comprising 88% of the total population and 91% of the biomass. At a density of 100/mile, legal trout were 48% of the spring population. Legal brown trout outnumbered legal brook trout 11 to 1.

The spring density of brown trout was 182/mile and included ages I-IV (Table 7). Yearling and 2-year-old trout comprised 92% of the population, while age II and age III fish accounted for 98% of the legal trout. All age I's were sublegal and averaged 3.8 inches. Average lengths of age II and age III brown trout were 6.8 inches and 9.0 inches, respectively. Legal brown trout averaged only 7.2 inches, and the largest fish captured was in the 10-inch group.

*Excluding recaptures on the second electrofishing run.

TABLE 5. *Trout population characteristics in a 3.4-mile reach of the North Branch of Beaver Creek, April 1979.*

Inch Group	Brown Trout Population Estimate by Age Group I	II	III	IV	V	Total	Biomass (lb/acre)	Brook Trout Population Estimate by Age Group I	II	III	IV	Total	Biomass (lb/acre)
2	287					287	0.2	6				6	
3	371					371	0.7	58				58	0.1
4	69	42				111	0.5	21				21	0.1
5		165				165	1.5		21			21	0.2
6		123				123	1.8		39			39	0.5
7		43	33			76	1.7		17			17	0.3
8			63	5		68	2.2		12	19		31	1.0
9			34	12		46	2.2			5	5	10	0.5
10			47	27		74	5.0			10	2	12	0.7
11			8	28	7	43	3.8						
12			2	26	5	33	3.8						
13			7	16		23	3.2						
14				5	6	11	2.0						
15				3	4	7	1.7						
16					1	1	0.3						
17					1	1							
Total	727	373	194	122	24	1,440*	30.6	85	89	34	7	215*	3.4
Avg. size (inches)	3.2	5.9	9.3	11.7	13.6			3.6	6.6	9.1	9.7		
No./mile						424						63	
Legals/mile						149						32	
Avg. size legals (inches)						9.2						7.8	

*The standard errors for the population estimate of brown trout and brook trout are ± 222 and ± 48, respectively.

TABLE 6. *Trout population characteristics in a 3.4-mile reach of the North Branch of Beaver Creek, October 1979.*

	Brown Trout										Brook Trout						
	Population Estimate by Age Group									Biomass	Population Estimate by Age Group						Biomass
Group	0	I	II	III	IV	V	VI	VII	Total	(lb/acre)	0	I	II	III	IV+	Total	(lb/acre)
2	326								326	0.3	90					90	0.1
3	1,478								1,478	3.8	587					587	1.4
4	285	143							428	1.8	286	144				430	1.7
5	11	192							203	1.8	13	85				98	0.7
6		416							416	5.7		185	22			207	2.8
7		387							387	8.5		117	13			130	2.8
8		170	32						202	6.6		38	13	3		54	1.8
9		81	90						171	7.7		13	11	2		26	1.2
10		21	76						97	6.1		4	3	2		9	0.6
11			47	26	4				77	6.5				1		1	
12			18	32	6				56	6.1				1		1	
13			7	27	10				44	5.8							
14				46					46	8.0					1	1	0.2
15				18	12	3			33	7.1							
16				5	15				20	5.2					1	1	0.3
17				3	5	2			10	3.2							
18					5				5	1.7							
19								3	3	1.2							
20							1		1	0.5							
21							1		1	0.6							
Total	2,100	1,410	270	157	57	5	2	3	4,004*	88.2	976	586	62	9	2	1,635*	13.6
Avg. size (inches)	3.6	6.9	10.3	13.6	15.2	16.3	21.0	19.5			3.8	6.3	7.8	9.8	15.4		
No./mile									1,177							481	
Legals/mile									461							126	
Avg. size legals (inches)									9.0							7.4	

*The standard errors for the population estimate of brown trout and brook trout are ± 111 and ± 98, respectively.

The density of brook trout captured in the spring of 1980 was 24/mile (Table 7).* Yearlings and age II's comprised 96% of the fish captured. Age I's averaged 4.7 inches and were all sublegal; age II's represented 90% of the legal fish and averaged 7.2 inches. The average legal brook trout was 8.0 inches, while the largest fish captured was a 3-year-old in the 10-inch group.

Mid-summer trout density in Beaver Creek was 388/mile with a biomass of 27.2 lb/acre (Table 8). This was almost twice the density and more than three times the standing stock in April. Brown trout were still dominant, but brook trout comprised 32% of the population and 25% of the standing stock. The fact that a brook trout estimate was possible in July but not in April is responsible for much of the apparent increase in brook trout numbers. A density of 210 legal trout/mile comprised 54% of the summer population and was more than twice the density of legal trout in April. Most of the increase in density and biomass since April was due to a 2.8-fold increase in the yearling population (age I) and to growth within the various age groups. Legal brown trout outnumbered legal brook trout more than 2 to 1.

*A population estimate could not be made.

The brown trout population in July consisted of ages I-V with two 16-inch trout that could only be attributed to age IV+. Yearling and age II trout comprised 95% of the population and 91% of 144 legal fish/mile. (See Table 8 for average lengths of various age groups.) The average legal fish was 8.0 inches.

The summer brook trout population consisted of 122/mile (Table 8). The biggest increase in the population since April occurred in the yearling segment, which now comprised 87% of the population. Many age I's may have been present in April, but were simply not captured due to their small size and dark color. Age I's averaged 6.0 inches, while the average legal brook trout was 7.0 inches.

By mid-October 1980, the trout population in the study zone of Beaver Creek had increased to 691/mile and had a biomass of 80.1 lb/acre (Table 9). This was more than 3 times the April population and 9 times the standing stock. Brown trout comprised 73% of the population and 90% of the biomass. A density of 350 legal fish/mile was 3½ times the density of legal trout in April. The ratio of legal brown trout to brook trout was almost 5 to 1.

In the fall, brown trout density was 507/mile and included seven age groups (Table 9). Forty percent of the population were young-of-the-year (age 0), all of which were sublegal. Approximately 89% of the age I's were legal and these fish comprised 51% of the legal population. Ages I, II, and III comprised 97% of the legal population. (See Table 9 for average lengths.) The largest brown trout captured was 24.8 inches and appeared to be age IV from scale analysis. Four other trout larger than 18 inches were captured, and all of these were age IV's, too. An age VI trout in the 17-inch group was the oldest trout captured.

In addition to the brown trout, a population of 184 brook trout/mile was present in October 1980 (Table 9). Of the four age groups present, age 0's comprised 59% of the population and were all sublegal. Yearlings were 28% of the population and 58% of the legal fish. All age II's were legal and comprised 32% of the legal fish. The largest brook trout captured was 14.6 inches and was age III+.

Eighteen Mile Creek

Because of extremely high stream flow and associated low efficiencies during most of the electrofishing surveys in April 1979, the validity of the spring estimates that year is suspect. Near normal stream flows during both the "marking" and "recapture" electrofishing surveys were encountered in only two reaches of the study area: (1) the 0.56-mile reach between Sweden Road and Hwy. 63; and (2) a 1.3- to 1.8-mile reach below Bjork

Road. The estimate of the trout population between Sweden Road and Hwy. 63 (section a, Fig. 3) was the most reliable index of the total spring population because of the known length of the area sampled. Data from the electrofishing surveys in mid-April and late May were combined and served as the "marking run" (Table 3). The electrofishing survey made on 5 June served as the "recapture run".

Density and standing trout stock in section a was 4,098/mile and 50.1 lb/acre in April (Table 10). Brown trout comprised 97% of the population and 96% of the biomass with the remainder consisting of brook trout. Legal brown trout outnumbered legal brook trout more than 8 to 1.

Five age groups of brown trout were sampled in April (Table 10). Yearlings and age II's comprised 95% of the population. All yearlings were sublegal. Age II and III trout comprised 90% of the legal fish. Average lengths are shown in Table 10. Average size of legal fish was 8.6 inches. Density and biomass of brown trout were 3,977/mile and 48.2 lb/acre, respectively.

Brook trout were scarce in April, with a density of 121/mile and a biomass of 1.9 lb/acre (Table 10). Average size of legal fish was 6.9 inches. All yearlings were sublegal, while 55% of age II's and all age III's were legal. Table 10 shows average lengths for various age groups.

In July 1979, the trout population in section a was 1,825/mile with a standing stock of 56.4 lb/acre (Table 11). This was a 55% decline in density but a 13% increase in biomass since April. In a 0.54-mile reach immediately above old Hwy. 63 (section c, Fig. 3), trout density was 1,977/mile and the standing stock was 56.5 lb/acre. In both stream sections, brown trout comprised more than 97% of the population and 98% of the legal fish present. Legal-size trout comprised 22% and 15% of the trout populations,

TABLE 7. *Trout population characteristics in a 1.2-mile reach (section B) of the North Branch of Beaver Creek, April 1980.*

Inch	Brown Trout Population Estimate by Age Group					Biomass	Brook Trout No. Caught by Age Group*				Biomass
Group	I	II	III	IV	Total	(lb/acre)	I	II	III	Total	(lb/acre)
2	3				3						
3	66				66	0.5	1			1	
4	30	2			32	0.3	11			11	0.1
5		8			8	0.2	6	2		8	0.1
6		63			63	2.7		2		2	
7		19	2		21	1.4		2		2	0.1
8		12	3		15	1.3		4		4	0.3
9			7		7	0.9					
10			2	2	4	0.6			1	1	0.2
Total	99	102	14	2	219**	7.9	18	10	1	29	0.8
Avg. size (inches)	3.8	6.8	9.0	10.1			4.7	7.2	10.8		
No/mile					182					24	
Legals/mile					92					8	
Avg. size legals (inches)					7.2					8.0	

*A population estimate could not be made due to insufficient recaptures.
**The standard error is ± 38.

TABLE 8. *Trout population characteristics in a 1.2-mile reach (section B) of the North Branch of Beaver Creek, July 1980.*

Inch	Brown Trout Pop. Est. by Age Group						Biomass	Brook Trout Pop. Est. by Age Group			Biomass
Group	I	II	III	IV	V	Total	(lb/acre)	I	II+	Total	(lb/acre)
4	60					60	1.0	9		9	0.1
5	86					86	2.2	59		59	1.5
6	47	12				59	2.5	48	9	57	2.6
7	8	23				31	2.2	12	3	15	1.0
8		50				50	5.1		1	1	0.1
9		13				13	1.9		1	1	0.1
10		4	3			7	1.3		3	3	0.7
11		1	1	1		3	0.9		2	2	0.6
12					3	3	1.0				
13				3		3	1.2				
14			1			1	0.6				
15			1			1	0.6				
16				2*		2					
Total	201	103	6	6	3	319**	20.5	128	19	147**	6.7
Avg. size (inches)	5.6	8.2	11.9	12.7	12.5			6.0	8.0		
No/mile						266				122	
Legals/mile						144				66	
Avg. size legals (inches)						8.0				7.0	

*No readable scales; assigned to group IV+.
**The standard errors for the population estimate of brown trout and brook trout are ± 62 and ± 15, respectively.

TABLE 9. *Trout population characteristics in a 1.2-mile reach (section B) of the North Branch of Beaver Creek, October 1980.*

Inch Group	Brown Trout Population Estimate by Age Group 0	I	II	III	IV	V	VI	Total	Biomass (lb/acre)	Brook Trout Population Estimate by Age Group 0	I	II	II+	Total	Biomass (lb/acre)
2	4							4		8				8	
3	184							184	1.3	103				103	0.7
4	45	2						47	0.7	19				19	0.2
5	4	20						24	0.7		20			20	0.5
6		81						81	3.6		27			27	1.0
7		51	7					58	3.8		14	10		24	1.5
8		36	24	1				61	5.8			6		6	0.6
9		8	27	3				38	5.2			4		4	0.6
10			27	3				30	5.6			3	4	7	1.5
11		1	11					12	3.2				1	1	0.3
12			15	4	1			20	6.4						
13			12	3	1			16	6.6				1	1	0.4
14			5	6	4			15	8.1				1	1	0.6
15			1	2				3	2.8						
16				1	1			2	1.5						
17				2			1	3	2.8						
18				1	1			2	2.5						
19				1	1			2	3.0						
20				3	1			4	6.7						
21					1			1	1.9						
24					1			1							
Total	237	199	129	30	12		1	608*	72.2	130	61	23	7	221*	7.9
Avg. size (inches)	3.7	7.2	10.4	14.2	17.1		17.5			3.6	7.2	8.4	11.8		
No./mile								507						184	
Legals/mile								291						59	
Avg. size legals (inches)								9.4						7.8	

*The standard errors for the population estimate of brown trout and brook trout are ± 48 and ± 40, respectively.

TABLE 10. *Trout population characteristics in a 0.6-mile reach (section a) of Eighteen Mile Creek, April 1979*.*

Inch Group	Brown Trout Population Estimate by Age Group I	II	III	IV	V	Total	Biomass (lb/acre)	Brook Trout Population Estimate by Age Group I	II	III	Total	Biomass (lb/acre)
2	245					245	2.2					
3	1,374					1,374	11.1	19			19	0.2
4	227	91				318	5.1	13	3		16	0.2
5		109				109	3.4	1	11		12	0.3
6		40	2			42	2.2		12		12	0.6
7		29	13			42	3.6		6	3	9	0.6
8		7	13			20	2.8					
9			45			45	8.2					
10			6	8		14	3.6					
11			6	2		8	2.8					
12			1	3	1	5	2.3					
13												
14				2	1	3						
15				1		1	0.9					
16												
17												
18					1	1						
Total	1,846	276	86	16	3	2,227**	48.2	33	29	3	68**	1.9
Avg. size (inches)	3.4	5.6	9.2	11.8	15.1			3.8	6.7	7.5		
No./mile						3,977					121	
Legals/mile						323					38	
Avg. size legals (inches)						8.6					6.9	

*Estimate made in reach between Sweden Rd. and new Hwy. 63 only (0.6 mile).
**The standard errors for the population estimate of brown trout and brook trout are ± 322 and ± 26, respectively.

TABLE 11. *Trout population characteristics in a 1.1-mile reach (sections a and c) of Eighteen Mile Creek, July 1979.*

	Section a*						Section c*					
	Brown Trout				Brook Trout		Brown Trout				Brook Trout	
Inch	Pop. Est. by Age Group			Biomass	Pop.	Biomass	Pop. Est. by Age Group			Biomass	Pop.	Biomass
Group	I	II+	Total	(lb/acre)	Est.	(lb/acre)	I	II+	Total	(lb/acre)	Est.	(lb/acre)
3	36		36	0.5			84		84	1.1	1	
4	394		394	8.7	10	0.2	500		500	11.5	4	0.1
5	346	3	349	13.2	13	0.4	306	3	309	12.2	10	0.4
6	30	61	91	5.8	2	0.1	20	40	60	4.0	3	0.1
7		41	41	4.4				36	36	4.0		
8		24	24	3.4	1	0.1		16	16	2.3		
9		20	20	3.9	1	0.2		11	11	2.2		
10		18	18	4.6				7	7	1.9		
11		7	7	2.4				5	5	1.8		
12		8	8	3.4				6	6	2.6		
13		3	3	1.7				5	5	3.0		
14		2	2	1.4				3	3	2.2		
15		1	1	0.9				4	4	3.7		
16		1	1	1.1				3	3	3.4		
17								1	1			
Total	806	189	995**	55.4	27	1.0	910	140	1,050**	55.9	18	0.6
Avg. size (inches)	4.8	8.3					4.8	8.6				
No./mile			1,777		48				1,944		33	
Legals/mile			386		7				291		6	
Avg. size legals (inches)			8.1		7.7				8.5		6.2	

*Sweden Rd. to new Hwy. 63 (0.56 mile) is section a; old Hwy. 63 upstream (0.54 mile) is section c.
**The standard errors for the population estimates of brown trout are ± 64 and ± 60, respectively; the standard errors for the population estimates of brook trout are ± 9 and ± 9, respectively.

TABLE 12. *Trout population characteristics in a 5.3-mile reach of Eighteen Mile Creek, September 1979.*

	Brown Trout										Brook Trout				
Inch	Population Estimate by Age Group									Biomass	Pop. Est. by Age Group				Biomass
Group	0	I	II	III	IV	V	VI	VII	Total	(lb/acre)	0	I	II+	Total	(lb/acre)
1	10								10		2			2	
2	12,126								12,126	4.5	598			598	0.2
3	10,051								10,051	9.5	1,277			1,277	1.0
4	770	1,348							2,118	4.5		207		207	0.4
5	206	3,910							4,116	16.3		280		280	1.0
6		2,173	103						2,276	15.1		128	32	160	1.0
7		444	282						726	7.1			30	30	0.3
8			378	21					399	5.5			9	9	0.1
9			162	40					202	4.1			4	4	0.1
10			38	132					170	4.7			2	2	0.1
11			20	88	29				137	4.9					
12				87	37	7			131	6.2					
13				13	63	31	6		113	6.8					
14				25	38	37			100	7.5					
15					38	27	6		71	6.5					
16						37	7		44	5.0					
17						6	17		28	3.9					
18						14	3		17	2.8					
19						7	2	2	11	2.1					
20						3			3	0.5					
21							2		2	0.5					
Total	23,163	7,875	983	406	210	169	43	2	32,851*	118.0	1,877	615	77	2,569*	4.2
Avg. size (inches)	3.0	5.6	8.2	11.2	13.7	15.6	16.8	19.4			3.2	5.4	7.3		
No./mile									6,198					485	
Legals/mile									836					39	
Avg. size legals (inches)									8.1					6.8	

*The standard errors for the population estimate of brown trout and brook trout are ± 1,145 and ± 382, respectively.

TABLE 13. *Trout population characteristics in a 4.1-mile reach (sections A and C) of Eighteen Mile Creek, April 1980.*

Inch Group	Brown Trout Pop. Est. by Age Group I	II	III	III+	Total	Biomass (lb/acre)	Brook Trout Pop. Est. by Age Group I	II	III	Total	Biomass (lb/acre)
1	3				3						
2	3,502				3,502	1.4	162			162	0.1
3	5,922				5,922	6.3	537			537	0.6
4	269	294			563	1.3	176	58		234	0.5
5		684			684	3.2	12	88		100	0.3
6		325			325	2.6		41		41	0.3
7		239	60		299	3.6		17	4	21	0.2
8		10	62		72	1.3		5		5	0.1
9			44		44	1.1					
10				14	14	0.5					
11				11	11	0.5					
12				7	7*						
13				5	5*						
14				5	5*						
15				1	1*						
Total	9,696	1,552	166	43	11,457**	21.8+	887	209	4	1,100**	2.1
Avg. size (inches)	3.2	5.7	8.3	11.9			3.5	5.5	7.2		
No./mile					2,794					268	
Legals/mile					191					16	
Avg. size legals (inches)					7.4					6.8	

*Number captured on 2nd electrofishing run (none captured on 1st electrofishing run); not population estimates.

**The standard errors for the population estimate of brown trout and brook trout are ± 697 and ± 132, respectively.

with legal brown trout outnumbering legal brook trout 55 to 1 and 48 to 1, respectively.

Brown trout densities in stream sections a and c in July 1979 were 1,777/mile and 1,944/mile, respectively (Table 11). Yearlings comprised more than 80% of the populations in both stream reaches, but less than 14% of the legal fish. Age I trout averaged 4.8 inches in both stream sections. Legal trout averaged 8.1 in one reach and 8.5 inches in the other. Legal fish comprised 22% and 15% of the populations in the two stream reaches and consisted primarily of age II+ trout.

Less than 50 brook trout/mile were present in July (Table 11). Although scale samples were not acquired, most brook trout were probably age I's. Legal fish in sections a and c comprised 15% and 17% of the two populations and averaged 7.7 inches and 6.2 inches, respectively. Only 6-7 legal brook trout/mile were present.

A density of 6,683 trout/mile and a biomass of 122.2 lb/acre were found in the 5.3-mile study area on Eighteen Mile Creek in September 1979 (Table 12). The 1979 year class (age 0) accounted for 71% of the population but only 15% of the total biomass. Brown trout comprised 93% of the population and 97% of the standing stock with the remainder consisting of brook trout. Legal fish comprised only 13% of the population at a density of 875/mile. Legal brown trout outnumbered legal brook trout 21 to 1.

The brown trout population in September consisted of 6,198/mile and had a biomass of 118 lb/acre (Table 12). Eight age groups—age 0 through VII—were identified. Legal fish in age groups I-V comprised 99% of 836 legal trout/mile. Average size of the various age groups ranged from 3.0 inches for age 0 to 19.4 inches for age VII. Average size of legal trout was 8.1 inches, and the largest brown trout captured was 21 inches.

The brook trout population in September consisted of 485/mile of which only 39, or 8%, were legal (Table 12). Yearlings comprised 62% of the legal fish with the remainder being age II and older. Average size of age 0 and age I brook trout was 3.2 inches and 5.4 inches, respectively.

In April 1980, a 1.2-mile reach between new and old Hwy. 63 (section B) was eliminated from the study area on Eighteen Mile Creek (Fig. 3). Trout density in the remaining 4.1 miles of the study area was 3,062/mile and the standing stock was 23.9+ lb/acre (Table 13). Brown trout comprised 91% of both the population and biomass with the remainder consisting of brook trout. A density of 207 legal fish/mile consisted exclusively of age II and older trout. Legal brown trout outnumbered legal brook trout 12 to 1.

Brown trout density in April was 2,794/mile and 7% of the brown trout were legal size (Table 13). Yearlings comprised 85% of the spring population but were all sublegal. Only 37% of the age II's were legal, but they comprised 73% of all legal fish. Table 13 shows average lengths for various age groups. The largest brown trout captured was in the 15-inch group and was more than three years of age.

Brook trout density in April was 268/mile and the standing stock was only 2.1 lb/acre (Table 13). All yearlings and 70% of the age II's were sublegal. Legal fish averaged 6.8 inches and only 16/mile were present. Table 13 shows average sizes for the various groups. The largest brook trout captured were 2-year olds in the 8-inch group.

In mid-July 1980, the trout population was inventoried in stream sections a and c, and the two estimates were combined. No attempt was made to estimate young-of-the-year (age 0). Trout density was 2,093/mile and the standing stock was 55.3 lb/acre (Table 14). Density was 10% greater than in 1979, but the standing stock was almost identical. Brown trout comprised 96% of both the population and biomass. Approximately 17% of the population consisted of legal fish, of which 93% were brown trout. The ratio of legal brown trout to brook trout was 14 to 1.

Brown trout density and standing stock in July was 2,008/mile and 53.2 lb/acre, respectively (Table 14). Six age groups (ages 0-V) were represented; however, 95% consisted of age I's and II's. Although legal-size trout of age groups I-V were present, 62% of

TABLE 14. *Trout population characteristics in a 1.1-mile reach (section a and section c) of Eighteen Mile Creek, July 1980.**

Inch Group	Brown Trout Population Estimate by Age Group 0	I	II	III	IV	V	Total	Biomass (lb/acre)	Brook Trout Population Estimate by Age Group 0	I	II	Total	Biomass (lb/acre)
3	39	195					234	1.4					
4		888	33				921	9.9		21		21	0.3
5		662	17				679	12.0		44		44	0.8
6		68	89				157	5.0		15	7	22	0.7
7		2	90	2			94	4.9		2	4	6	0.3
8			45	5			50	3.7					
9			4	5			9	0.9					
10			5	12	2		19	2.5					
11					9		9	1.7					
12				7	7	7	14	3.2					
13					3		10	2.2					
14					7		7	2.2					
15						2	2	0.7					
16													
17						4	4	2.4					
Total	39	1,815	283	31	28	13	2,209*	53.2		82	11	93*	2.1
Avg. size (inches)		4.8	6.9	10.3	12.6	15.0				5.5	6.7		
No./mile							2,008					85	
Legals/mile							341					25	
Avg. size legals (inches)							7.8					6.5	

*The standard errors for the population estimate of brown trout and brook trout are ± 116 and ± 14, respectively.

TABLE 15. *Trout population characteristics in a 4.1-mile reach of Eighteen Mile Creek, September 1980.*

Inch Group	Brown Trout Population Estimate by Age Group 0	I	II	III	IV	V	VI	Total	Biomass (lb/acre)	Brook Trout Population Estimate by Age Group 0	I	II	Total	Biomass (lb/acre)
4	487	1,622						2,109	5.6	*	147		147	0.4
5		3,172						3,172	15.3		319		319	1.4
6		1,710						1,710	13.4		177		177	1.3
7		586	84					670	8.4		24	5	29	0.3
8		103	233					336	6.2			8	8	0.1
9			148	15				163	4.1			1	1	
10			42	50				92	3.0					
11			7	42	21			70	3.4					
12				41	41	8		90	5.4					
13				14	51	23		88	6.7					
14				18	49	22		89	8.3					
15				3	18	16		37	4.1					
16				7		21		28	3.7					
17					11			11	1.8					
18					5			5	1.0					
19					4	4		8	1.9					
20							5	5	1.4					
21							1	1	0.3					
Total	487	7,193	514	190	200	94	6	8,684**	94.0		667	14	681**	3.5
Avg. size (inches)		5.8	8.7	11.3	13.9	14.8	20.6				5.6	8.0		
No./mile								2,118					166	
Legals/mile								830					52	
Avg. size legals (inches)								8.0					6.6	

*A few 4-inch brook trout are age 0's.

**The standard errors for the population estimate of brown trout and brook trout are ± 165 and ± 82, respectively.

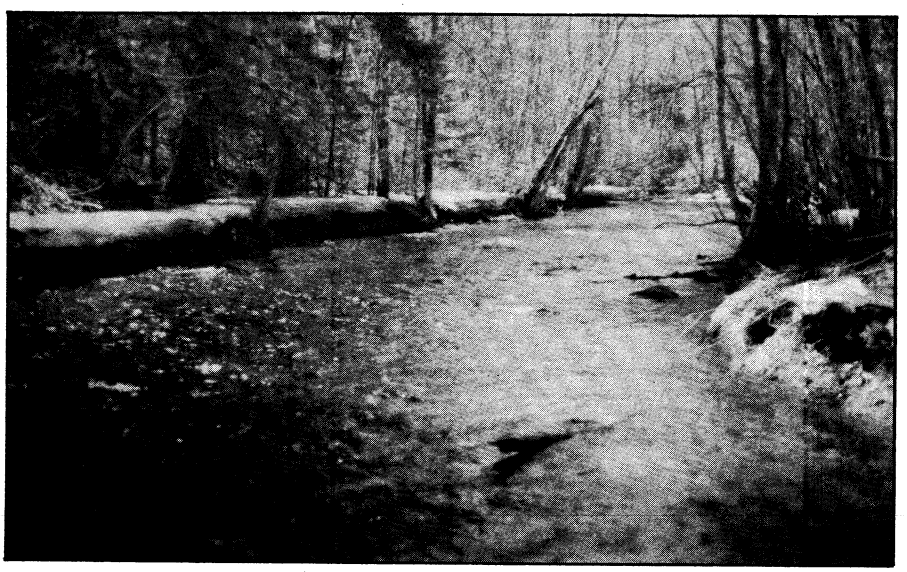
the legal fish were age II's. There were 341 legal fish/mile present and these fish averaged 7.8 inches. The oldest and largest brown trout captured were in the 17-inch group.

Brook trout were again a minor component of the trout population in July with a density of 85/mile and a biomass of 2.1 lb/acre (Table 14). Approximately 88% of the population and 61% of the legal fish were yearlings. The remainder were age II's. Legal brook trout averaged 6.5 inches and only 25/mile were present.

Estimates of age 0 trout were not attempted in the fall in Eighteen Mile Creek, although some were present in the 4-inch group (Table 15). Density and biomass of trout in September 1980 were 2,284/mile and 97.5 lb/acre, respectively. Brown trout were again dominant, comprising 93% of the population and 96% of the biomass. The density of legal fish had increased more than 4 times since April and included 882/mile. The ratio of legal brown trout to brook trout was 16 to 1.

A brown trout population of 2,118/mile with a biomass of 94 lb/acre was present in September (Table 15). Age groups 0-VI were represented. The density of legal fish was 830/mile and included age groups I-VI. Legal brown trout averaged 8.0 inches and the largest fish captured was 21.7 inches and weighed 3.6 lb.

Only 166 brook trout/mile were present in the fall in Eighteen Mile Creek (Table 15). Standing stock was only 3.5 lb/acre. Age groups 0, I, and II were represented but yearlings comprised 98% of the population. Legal brook trout averaged 6.6 inches and were primarily yearlings. The largest fish captured was 9.8 inches and weighed 0.4 lb.



These 1¼-ft thick ice shelves remaining in May indicate the harsh overwintering conditions for trout in Eighteen Mile Creek.

GROWTH

Most trout in northern Wisconsin hatch in late March and early April. Brown trout fry average 0.9 inch when they reach the "swim-up" stage and begin feeding (Brown 1946, 1951). Hollender (1981) found recently emerged brook trout fry in two Pennsylvania streams averaged 0.9 inch (22.5 mm) in March. Miller (1970) reported a mean length of almost 1.0 inch (24.3 mm) for brook trout fry collected in mid-March from Lawrence Creek, Wisconsin. Assuming a mean length of 0.9 inch for recently emerged brown and brook trout in northern Wisconsin, growth of both species during their first 6-7 months in Beaver Creek averaged 2.8 inches (Tables 16, 17). Corresponding growth of brown trout and brook trout in Eighteen Mile Creek was 2.1 inches and 2.3 inches, respectively.

Growth of fingerling brown trout over their first winter was slow in both streams, averaging only 0.2 inch (Table 16). Corresponding growth of fingerling brook trout was better, averaging 0.9 inch in Beaver Creek and 0.3 inch in Eighteen Mile Creek (Table 17). Because of their more rapid growth over winter, yearling brook trout were larger than yearling brown trout in both streams in the spring; both species were larger in Beaver Creek than in Eighteen Mile Creek.

Summer growth of age I brown trout averaged 3.4 inches in Beaver Creek and 2.4 inches in Eighteen Mile Creek (Table 16). Most yearlings in Beaver Creek attained the minimum legal size of 6 inches sometime during the summer, but this was not the case in Eighteen Mile Creek. Age I brown trout averaged 7.0 inches by fall in Beaver Creek, but only 5.7 inches in Eighteen Mile Creek.

Summer growth of yearling brook trout was slower than their brown trout counterparts (Table 17). Summer growth of age I brook trout averaged 2.6 inches in Beaver Creek and 1.6 inches in Eighteen Mile Creek. Age I brook trout were smaller than their brown trout counterparts by fall because of slower summer growth. Yearling brook trout averaged 6.8 inches in Beaver Creek and 5.4 inches in Eighteen Mile Creek. Most yearling brook trout were legal only in Beaver Creek.

Growth of brown trout during their second winter was nil in Beaver Creek and averaged only 0.1 in Eighteen Mile Creek (Table 16). Overwinter growth of yearling brook trout could not be determined in Beaver Creek due to an inability to separate age II and age III+ fish. Yearling brook trout grew an average of 0.1 inch in Eighteen Mile Creek overwinter.

Summer growth of age II brown trout averaged 4.0 inches in Beaver Creek and 2.8 inches in Eighteen Mile Creek (Table 16). Summer growth of age II brook trout was 1.2 inches in Beaver Creek and could not be determined in Eighteen Mile Creek. Two-year-old brown trout in Beaver Creek averaged 10.3 inches in the fall. This was 2.2 inches larger than their brook trout counterparts and 1.9 inches larger than age II brown trout in Eighteen Mile Creek.

Overwinter growth of age II brown trout in both streams was negligible and could not be determined for age II brook trout (Table 16). An apparent overwinter decline of 1.3 inches in the average brown trout size in Beaver Creek was due either to inaccurate aging of fish or to the movement of larger age II's into the study area in the fall and their subsequent movement back out prior to the spring population inventory.

Summer growth of age III brown trout averaged 4.8 inches in Beaver Creek and 2.5 inches in Eighteen Mile Creek (Table 16). Corresponding growth of brook trout was only 0.7 inch in Beaver Creek and could not be determined in Eighteen Mile Creek due to the absence of age III's in the fall. Age III brown trout averaged 13.9 inches in Beaver Creek in the fall. This was 3.8 inches larger than age III brook trout in the same stream and 2.7 inches larger than age III brown trout in Eighteen Mile Creek.

In summary, the growth of age 0 brook trout in Beaver Creek and Eighteen Mile Creek was faster than the growth of age 0 brown trout. However, subsequent growth of brown trout exceeded the growth of brook trout in both streams. Although average size of age I brook trout in the spring was

TABLE 16. *Growth increments and average length of brown trout in the two study streams (units in inches).*

Stream	Age Group 0 Fall	I Spring	I Fall	II Spring	II Fall	III Spring	III Fall
North Branch Beaver Creek							
1979	(2.7)* 3.6	3.4	(3.5) 6.9	5.8	(4.5)10.3	9.3	(4.3) 13.6
1980	(2.8) 3.7	(0.2) 3.8	(3.4) 7.2	(-0.1) 6.8	(3.6)10.4	(-1.3) 9.0	(5.2) 14.2
Avg.	(2.8) 3.6	3.6	(3.4) 7.0	6.3	(4.0)10.3	9.2	(4.8) 13.9
Eighteen Mile Creek							
1979	(2.1) 3.0	3.4	(2.2) 5.6	5.6	(2.6)8.2	9.2	(2.0) 11.2
1980		(0.2) 3.2	(2.6) 5.8	(0.1)5.7	(3.0)8.7	(0.1)8.3	(3.0) 11.3
Avg.		3.3	(2.4) 5.7	5.6	(2.8)8.4	8.8	(2.5) 11.2

*Growth increments are shown in parentheses.

TABLE 17. *Growth increments and average length of brook trout in the two study streams (units in inches).*

Stream	Age Group 0 Fall	I Spring	I Fall	II Spring	II Fall	III Spring	III Fall
North Branch Beaver Creek							
1979	(2.9)* 3.8	3.6	(2.7) 6.3	6.6	(1.2) 7.8	9.1	(0.7) 9.8
1980	(2.7) 3.6	(0.9) 4.7	(2.5) 7.2	7.2	8.4		
Avg.	(2.8) 3.7	4.2	(2.6) 6.8	6.9	8.1		
Eighteen Mile Creek							
1979	(2.3) 3.2	3.8	(1.6) 5.4	6.7		7.5	
1980		(0.3) 3.5	5.6	(0.1)5.5		7.2	
Avg.		3.6	5.5	5.8		7.4	

*Growth increments are shown in parentheses.

greater than that of age I brown trout, age I brown trout in the fall were larger than age I brook trout, and brown trout retained a size advantage throughout the remainder of their lives in both streams. Growth of both species was faster in Beaver Creek than in Eighteen Mile Creek, resulting in a larger average size at all ages. Most trout in Beaver Creek reached the minimum legal size of 6 inches as yearlings, but in Eighteen Mile Creek most trout did not become legal until age II.

MOVEMENT

On both streams, a dramatic reduction in trout numbers and a significant skewing of the population to smaller fish occurred between single-run preliminary electrofishing surveys in the fall of 1978 and the population inventories in the spring of 1979. These changes suggested extensive overwinter movements of larger trout out of the study areas or severe overwinter mortality in both Beaver Creek and Eighteen Mile Creek. Longtime residents and anglers contacted along both streams in April 1979 indicated that larger brown trout are normally absent in the spring but move up into the streams throughout the summer and fall. To document this migration, sections of the study areas were inventoried in the spring, summer, and fall.

The population of age I+ brown trout in section b_1 on Beaver Creek increased more than 5 fold from April to July 1979 (Table 18). An increase of more than 4 fold was evident between April and October. Age I and II trout were responsible for most of the population increase, with almost 20 times the spring population of yearlings present in the fall and more than twice the spring population of age II's. Only 5 brook trout were captured in April, but more than 10 times that number were present in July, which indicated a significant increase in the population (Table 19). Just like the brown trout population, brook trout declined between July and October. However, the fall brook trout population was still more than 8 times the number captured in the spring.

Trout populations within the entire study area on Beaver Creek showed trends similar to those exhibited in section b_1. The density of age I+ brown trout increased 32% between spring and fall and the fall density of age I+ brook trout was more than 3 times the spring density (Tables 5, 6). Age I was, however, the only age group in each population which showed increases. Fall density of age I brown trout was almost twice the spring density, and fall density of age I brook trout was almost 7 times the spring density.

Although the density of age II+ brown trout declined between spring and fall in 1979 in Beaver Creek, the density of trout 10 inches or more increased 104% and trout 12 inches or more increased 188%. These two facts seem incongruent, but the average summer growth of age II, III, IV, and V brown trout was 4.5 inches, 4.3 inches, 3.5 inches, and 2.7 inches, respectively (Tables 5 and 6). Such rapid growth could explain the increase in larger trout between spring and fall but is unrealistic within the study area. Instead, it is possible that a contingent of age II+ wild brown trout migrate downstream to larger, more productive water where summer growth is accelerated. Subsequent movement upstream occurs in response to sexual maturity and the search for spawning sites in the fall. In support of this theory, a 1974 stream survey conducted 3-4 miles downstream in Beaver Creek found no evidence of natural reproduction (Meyers and Thuemler 1976). The majority of native trout found in this survey (53/mile) were age II's and III's recruited from upstream spawning areas.

Another possible explanation for both the increase in larger trout between spring and fall and the very rapid growth rates in the older age groups is a movement of domestic brown trout up into the study area. Hatchery trout are stocked as spring yearlings in Beaver Creek about 2 miles below the study area. These hatchery trout are larger than their

TABLE 18. *Age and size structure of the brown trout population in the North Branch of Beaver Creek (section b_1) during spring, summer, and fall, 1979.*

Inch Group	April Population Estimate by Age Group I	II	III	IV+	Total	July Total	October Population Estimate by Age Group I	II	III	IV+	Total
3	2				2						
4	3	2			5		7				7
5		1			1	30	2				2
6		8			8	40	8				8
7		3	2		5	20	46				46
8						18	22	4			26
9			2		2	16	9	10			19
10			3	2	5	5	3	10			13
11			1	1	2	19		4	2	1	7
12				2	2	6		2	3		5
13				1	1	9		1	2	1	4
14						6			2		2
15						5					
16						5			1	2	3
17				1	1					1	1
18						1				2	2
19										1	1
22						1					
Total	5	14	8	7	34*	181*	97	31	10	8	146*

*Standard errors for totals in April, July, and October are ± 4, ± 17, and ± 14, respectively.

TABLE 19. *Size class structure of the brook trout population in section b_1 of North Branch of Beaver Creek during spring, summer, and fall, 1979.*

Inch Group	April Number Captured*	July Pop. Est.	October Pop. Est.
3	1		
4			10
5		10	8
6		12	9
7	1	15	9
8	1	9	
9		2	4
10	2	2	1
11		1	
Total	5	51**	41

*Population estimate not possible in April.
**Standard errors for the July and October totals are ± 5 and ± 8, respectively.

wild trout counterparts when stocked and subsequently continue to grow faster. Movement of surviving age II+ trout into the study area could likely occur in the search for spawning sites.

In 1980, the study area on Beaver Creek was reduced from 3.4 miles to 1.2 miles (segment B, Fig. 2). The population of age I+ brown trout increased 46% from April to July and by 69% from April to October (Tables 7, 8, 9). The yearling population more than doubled from April to July and showed the largest increase of any age group. Brown trout in all age groups (I-IV+) increased from 26% to 550% between April and October.

Similar to the spring of 1979, too few brook trout were captured in April 1980 to make a population estimate. The mid-summer population was more than 5 times the number captured in April and again indicated a real increase in the brook trout population (Tables 7, 8). Between July and October, the population of age I+ brook trout declined, primarily as a result of a 52% decline in the yearling cohort. Age II+ brook trout actually increased 58% between July and October (Tables 8, 9).

Movement of trout into the Eighteen Mile Creek study area occurred between spring and fall of 1979, but was more confined to the larger, older age groups of brown trout than in the case of Beaver Creek. In section a, the July population of age I+ brown trout was less than half of the April population and showed only a slight increase by late September (Tables 10, 11, 20). While densities of ages I, II, and III brown trout declined 53%, 57%, and 44%, respectively, between spring and fall, densities of age IV and V+ increased 50% and 733%, respectively. Associated with the increase in the older age groups between spring and fall was a corresponding increase in the number of large trout. In the fall, density of brown trout 10 inches or more was 166/mile, or 3 times the density in the spring. Density of trout 12 inches or more was 107/mile, 6 times greater than in the spring. Increases in the brook trout population which indicated potential movement into the study area were confined primarily to age I's. Brook trout density increased from 121/mile in the spring to 141/mile in the fall. Yearling density more than doubled between spring and fall while density of age II+ declined 75%.

In 1980, movement of larger, older brown trout into sections a and c (total 1.1 mile) on Eighteen Mile Creek was indicated throughout the summer. A population of 105/mile of age III+ trout in September was more than 3 times the corresponding population present in April (Table 21). Age I and age II brown trout declined 39% and 53%, respectively, during this period. Age groups III, IV, V, and VI all increased between July and September, increasing the number of larger trout significantly. Density of brown trout 12 inches or greater increased from 11/mile to 77/mile during this period (Table 22).

Changes in the trout population structure in the entire study zone of Eighteen Mile Creek between spring and fall substantiated the movement of older, larger brown trout into reaches a and c throughout the summer. Density of age III+ trout increased from 41/mile in April to 120/mile in September (Tables 13, 15). Brown trout 10 inches or more increased from 10/mile to 128/mile between spring and fall, while trout 12 inches or more increased from 4/mile to 88/mile in the same period. Brook trout populations comprised between 7% and 8% of the spring and fall trout populations in 1980, but there was no evidence of substantial movement into the study area. In fact, all age groups declined between spring and fall.

Attempts to document the chronology and direction of trout movement within the study zone on the two study streams failed to indicate any substantial movement of age 0's, age I's, or age II's. Of 809 brown trout marked as age 0's or age I's and subsequently recaptured as age 0's, I's, or II's in Beaver Creek, 90% were recaptured in the same reach in which they had been marked, 6% were found downstream, and 3% were recaptured upstream (Table 23). Of 100 brook trout recaptured, 84% had not moved, 8% were found upstream, and 8% were captured downstream. Although substantial increases in age I fish occurred in Beaver Creek between spring and fall, no evidence of movement of age I trout marked in the study area was apparent. Alternatives explaining these increases include migration or movement of young fish into the study area between spring and fall and/or poor population estimates.

In Eighteen Mile Creek, of 5,210 brown trout previously marked as age 0's or age I's and subsequently recap-

TABLE 20. *Trout population characteristics in a 0.6-mile reach (section a) of Eighteen Mile Creek, September 1979.*

Inch Group	Brown Trout Pop. Est. by Age Group I	II	III	IV	V	VI	Total	Brook Trout Pop. Est. by Age Group I	II+	Total
4	123						123	16		16
5	480						480	48		48
6	221	11					232	7	2	9
7	50	32					82		2	2
8		55	3				58		2	2
9		15	4				19		2	2
10		4	15				19			
11		2	9	3			14			
12			14	6	1		21			
13			1	6	3	1	11			
14			2	3	3		8			
15				5	4	1	10			
16					2	1	3			
17				1	1	2	4			
18					1		1			
19					1	1	2			
Total	874	119	48	24	16	6	1,087	71	8	79
No./mile	1,561	212	86	43	29	11	1,941	127	14	141

TABLE 21. *Age structure of brown trout populations in a 1.1-mile reach (sections a and c) of Eighteen Mile Creek during spring, summer, and fall, 1980.*

Age Group	April	July	September
0		39	153
I	3,179	1,815	1,932
II	257	283	123
III	35	31	42
IV		28	51
V		13	18
VI			4
Total	3,471	2,209	2,322

TABLE 22. *Brown trout population characteristics in a 1.1-mile reach of Eighteen Mile Creek during spring, summer, and fall, 1980 (sections a and c).*

Inch Group	April Pop. Est.	April Biomass (lb/acre)	July Pop. Est.	July Biomass (lb/acre)	September Pop. Est.	September Biomass (lb/acre)
2	1,241	1.9				
3	1,869	7.5	234	1.4		
4	144	1.2	921	9.9	663	6.7
5	116	2.1	679	12.0	847	15.5
6	53	1.6	157	5.0	436	12.9
7	15	0.7	94	4.9	126	6.0
8	3	0.2	50	3.7	95	6.7
9	9	0.9	9	0.9	33	3.2
10	1	0.1	19	2.5	19	2.4
11	8	1.4	9	1.7	18	3.3
12	4		14	3.2	18	4.1
13	3		10	2.7	23	6.6
14	5		7	2.2	23	8.2
15			2	0.7	9	3.8
16					2	1.0
17			4	2.4	4	2.4
18					2	1.5
19						
20					4	4.1
Total	3,471*	17.6	2,209*	53.2	2,322*	88.4
No./mile	3,155		2,008		2,111	
Legals/mile	92		341		738	

*Standard errors for totals in April, July, and September are ± 387, ± 116, and ± 104, respectively.

tured as age I's or age II's, 96% had remained stationary, 2% were found upstream, and 2% had moved downstream (Table 24). All marked brook trout subsequently recaptured were found in the same reach of stream in which they had been marked. While seasonal movements of the older, larger trout in both Beaver Creek and Eighteen Mile Creek may occur, there is no evidence of significant movement prior to their third fall of life.

Three age III brown trout and 1 age II brown trout previously marked within the study area on Eighteen Mile Creek were captured in April 1981 during a 300-m electrofishing survey approximately 3/4 mile below the study area (halfway between the study area and the stream mouth). Few trout, none of which were marked, were recaptured in a 300-m stream section electrofished immediately upstream from the stream mouth.

The rather substantial declines in age I and age II trout observed in Eighteen Mile Creek cannot be explained by migration or movement out of the study area. Natural mortality must be assumed as the culprit.

THE SPORT FISHERIES

Fishing Pressure

Estimated fishing pressure in 1979 was 75 hours/acre on Beaver Creek and 47 hours/acre on Eighteen Mile Creek. During the 149-day fishing season, 53 trips/mile were made at Beaver Creek and 70 trips/mile were made to

TABLE 23. *Chronology and direction of trout movement within the study area on the North Branch of Beaver Creek.*

Date	Downstream Age Groups			Stationary Age Groups			Upstream Age Groups		
	0	I	II	0	I	II	0	I	II
Apr 1979*			2 Bn		6 Bn	22 Bn		1 Bn	
			1 Bk			2 Bk			
Jul 1979		1 Bn**	3 Bn		6 Bn				
Oct 1979		2 Bn	4 Bn	3 Bn	255 Bn	151 Bn		7 Bn	
				1 Bk	25 Bk	2 Bk		2 Bk	
Apr 1980		1 Bn	7 Bn		29 Bn	29 Bn		1 Bn	
		1 Bk	1 Bk		8 Bk	3 Bk			
Jul 1980		10 Bn	7 Bn		49 Bn	36 Bn		3 Bn	1 Bn
		3 Bk			21 Bk	7 Bk		3 Bk	1 Bk
Oct 1980	1 Bn	4 Bn	10 Bn		98 Bn	47 Bn		12 Bn	1 Bn
		2 Bk			14 Bk	1 Bk		1 Bk	1 Bk
Total	1 Bn	18 Bn	33 Bn	3 Bn	433 Bn	285 Bn		24 Bn	2 Bn
		6 Bk	2 Bk	1 Bk	68 Bk	15 Bk		6 Bk	2 Bk

*Age I and age II trout recorded here were trout marked during the initial single-run electrofishing survey made in September 1978.
**Bn = brown trout; Bk = brook trout.

TABLE 24. *Chronology and direction of trout movement within the study area on Eighteen Mile Creek.*

Date	Downstream Age Groups		Stationary Age Groups		Upstream Age Groups		Age Unknown
	I	II	I	II	I	II	
Apr 1979							
Jul 1979			253 Bn		9 Bn		4 Bn
Sep 1979	11 Bn**		1,155 Bn		37 Bn		5 Bn
			41 Bk				
Apr 1980	7 Bn	2 Bn	475 Bn			5 Bn	
Jul 1980	10 Bn	13 Bn	375 Bn	101 Bn		2 Bn	
			3 Bk	5 Bk			
Sep 1980	22 Bn	28 Bn	1,849 Bn	495 Bn	3 Bn	15 Bn	1 Bn
			27 Bk	3 Bk			
Total	50 Bn	43 Bn	4,107 Bn	929 Bn	49 Bn	22 Bn	10 Bn
			71 Bk	8 Bk			

*Recaptures from a cohort of 103 brown trout and 5 brook trout captured and marked on 6 June 1979 in a 0.3-mile reach below Taylor Rd.
**Bn = brown trout; Bk = brook trout.

Eighteen Mile Creek. Anglers fished an average of 2.6 hours/trip on Beaver Creek, but only 1.8 hours/trip on Eighteen Mile Creek.

In 1980, characteristics of the sport fishery on Beaver Creek were not determined. Fishing pressure on Eighteen Mile Creek, however, was 31 hours/acre and represented a 34% decline from 1979. Approximately 35 trips/mile were made to the stream during the 151-day fishing season and each trip averaged 2.4 hours.

The heaviest fishing pressure on wild brown trout streams in central Wisconsin occurs in May during the first month of the trout fishing season (Avery and Hunt 1981). Contrary to this pattern, only 13% of the season pressure occurred in May 1979 on Beaver Creek, while 64% occurred during June and August (Fig. 4). A pattern similar to that in central Wisconsin occurred at Eighteen Mile Creek in 1979, with 33% of the pressure exerted in May and 53% occurring by the end of June. In 1980, only 15% of the season pressure on Eighteen Mile Creek occurred in May, but 53% had again occurred by the end of June.

In 1979, fishing pressure on Beaver Creek was almost equally divided between weekdays and weekends plus holidays (47% vs 53%). The 1979 creel census schedule on both streams assumed that 50% of the pressure would occur within each day type category. On Eighteen Mile Creek, however, 58% of the estimated fishing pressure occurred on weekdays and 42% occurred on weekends plus holidays. The census schedule was adjusted accordingly for the 1980 fishing season on Eighteen Mile Creek, but anglers then fished 48% of the time on weekdays and 52% on weekends plus holidays.

During the 1979 fishing season, the daily distribution of fishing pressure* failed to show any preference for fishing in morning, afternoon, or evening on weekends and holidays at either Beaver Creek or Eighteen Mile Creek. Weekday anglers on both streams did, however, begin fishing later in the morning than weekend anglers (8:30 a.m. vs 6:30 a.m.). Several anglers stayed after 8:30 p.m. on Beaver Creek, but none stayed on Eighteen Mile Creek after 7:30 p.m.

In 1980, anglers fishing on weekends or holidays on Eighteen Mile Creek were encountered between 9:30 a.m. and 6:30 p.m. Anglers fishing during the week were encountered between 7:30 a.m. and 7:30 p.m. No preference

*Based on the average number of vehicles present at each 2-hour car count.

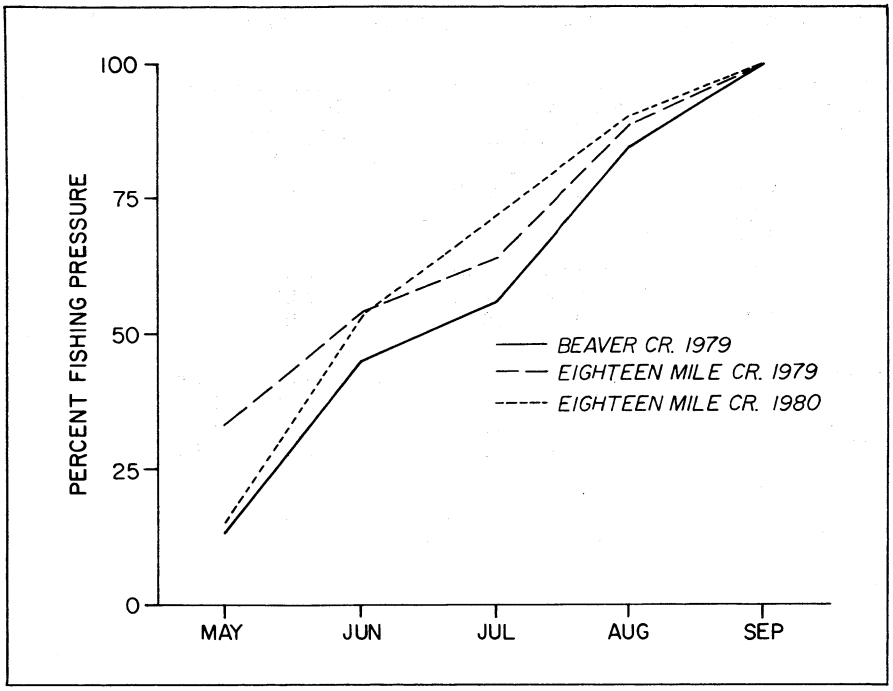


FIGURE 4. Accumulated fishing pressure exerted on the two study streams during the 1979 and 1980 fishing seasons.

This deep-bodied, 24-inch brown trout was the largest fish captured in Beaver Creek. Such trout are rare, moving into the study area in the fall from areas further downstream.

for morning or afternoon fishing was apparent.

Harvest

Estimated harvest from Beaver Creek in 1979 was 90 trout/mile and 13.4 lb/acre (Table 25). Although primarily a brown trout stream, only 37% of the number and 54% of the biomass harvested consisted of brown trout. Brook trout comprised 56% of the number and 41% of the biomass harvested. Domestic rainbow trout (*Salmo gairdneri*) comprised the remaining 7% of the harvest and 5% of the biomass. These rainbow trout were age II fish which had escaped in the spring from a private hatchery near the mouth of the only significant tributary to Beaver Creek within the study area (Fig. 2). Average size of creeled brown trout was 10.5 inches, while brook trout and rainbow trout averaged 8.7 inches and 8.2 inches, respectively.

Anglers creeled an estimated 94 trout/mile and 9 lb/acre in 1979 from Eighteen Mile Creek (Table 25). Brown trout comprised 72% of the numerical harvest and 80% of the biomass creeled, while brook trout comprised the remaining 28% and 20%, respectively. Creeled brown trout averaged 9.5 inches, while brook trout averaged 8.2 inches.

An estimated 49 trout/mile weighing 4.6 lb/acre were creeled from Eighteen Mile Creek in 1980 (Table 25). Brown trout comprised 84% of the number and 96% of the biomass harvested, while brook trout comprised the remaining 16% and 4%, respectively. The total harvest represented a 47% decline in number and 44% decline in weight from 1979. The 34% decline in fishing pressure was at least partially responsible. Average size of creeled brown trout and brook trout was 9.6 inches and 7.6 inches, respectively.

In 1979, 40% of the brown trout harvested, 83% of the brook trout creeled, and all rainbow trout taken from Beaver Creek were less than 10 inches (Table 26). Most brook and rainbow trout were in the 8- or 9-inch groups. Sixty percent of the brown trout were at least 10 inches and 20% were 12 inches or more.

An average of 59% of the angler-caught brown trout and 95% of the brook trout creeled from Eighteen Mile Creek during 1979 and 1980 were less than 10 inches (Table 26). Most brown trout were in the 8- or 9-inch groups, while the greatest number of brook trout were in the 6- or 7-inch groups. An average of 26% of the brown trout harvested during the two years were 10-11.9 inches and 15% were at least 12 inches. An average of 2% of the brook trout creeled were also at least 12 inches.

Approximately 78% of the brown trout harvested from Beaver Creek in 1979 were at least 3 years old, while the remaining 28% were age II's (Table 27). Although 14% of the brook trout creeled were age I's, the remaining 86% were divided equally between age II's and age III's.

Average age of brown trout creeled from Eighteen Mile Creek in 1979 and 1980 was 8% age I's, 42% age II's, 34% age III's, and 16% age IV+'s (Table 27). Over 80% of the brook trout harvested were age II's, with relatively few yearlings and age III's being caught.

Exploitation

Data on angler exploitation of the spring trout populations in both Beaver Creek and Eighteen Mile Creek are considered invalid and will not be dis-

TABLE 25. *Estimated harvest and average trout size creeled from the study streams during 1979 and 1980.*

		1979			1980		
		Harvest		Avg. Size	Harvest		Avg. Size
Stream	Species	(no./mile)	(lb/acre)	(inches)	(no./mile)	(lb/acre)	(inches)
North Branch Beaver Creek	Brown	33	7.2	10.5			
	Brook	50	5.5	8.7			
	Rainbow	7	0.7	8.2			
Total		90	13.4				
Eighteen Mile Creek	Brown	68	7.2	9.5	41	4.2	9.6
	Brook	26	1.8	8.2	8	0.4	7.6
Total		94	9.0		49	4.6	

TABLE 26. *Percent angler trout harvest by size intervals during the 1979 and 1980 fishing seasons on the two study streams.*

			Size interval (inches)			
Stream	Year	Species	6-7	8-9	10-11	12+
North Branch Beaver Creek	1979	Brown		40	40	20
		Brook	38	45	17	
		Rainbow	20	80		
Eighteen Mile Creek	1979	Brown	24	35	23	18
		Brook	40	55		5
Eighteen Mile Creek	1980	Brown	29	29	29	12
		Brook	70	30		

TABLE 27. *Age-specific composition of the season harvest in 1979 and 1980 on the two study streams (units in percent).*

		1979				1980				
		Age				Age				
Stream	Species	I	II	III	IV+	I	II	III	IV	V
North Branch Beaver Creek	Brown		22	56	22					
	Brook	14	43	43						
	Rainbow		100							
Eighteen Mile Creek	Brown	12	43	32	12	4	40	36	16	4
	Brook		82	18		11	82	7		

cussed because of the extensive increase in legal trout populations between spring and fall. Much of this increase is due to the movement of larger trout into the study area of both streams throughout the angling season.

Angler Characteristics

Harvest rates averaged 0.9 trout/hour in 1979 on Beaver Creek and 0.7 trout/hour on Eighteen Mile Creek. Anglers, therefore, fished an average of 1.1 hours to catch and keep a legal trout from Beaver Creek in 1979. The corresponding time to catch a legal trout from Eighteen Mile Creek was 1.4 hours. In 1980, the harvest rate dropped to 0.5 trout/hour on Eighteen Mile Creek, requiring 2.1 hours to catch a legal trout.

Anglers who caught at least one legal trout/trip, whether creeled or released, comprised 39% of the anglers interviewed on Beaver Creek in 1979 and 54% of the anglers interviewed on Eighteen Mile Creek during both 1979 and 1980. Successful anglers on Beaver Creek in 1979 all kept at least 1 fish, while 5 successful anglers on Eighteen Mile Creek during both 1970 and 1980 kept none.

No limit catches of 5 brown trout/day in May were recorded at either stream in 1979 or 1980 (Table 28). Limit catches of 10 trout/day from June through September occurred twice at Beaver Creek in 1979 and once at Eighteen Mile Creek in 1980. In all three instances, at least 9 of the 10 trout captured were brook trout. An average of 78% of the successful anglers caught 1-5 trout/trip, while only 28% caught 6-10 trout/trip.

In 1979, 23 of 30 anglers interviewed on Beaver Creek had finished fishing and 59 of 70 anglers interviewed on Eighteen Mile Creek had finished fishing. The most brown trout creeled by any angler for a completed trip on Beaver Creek was 3, while one angler on Eighteen Mile Creek creeled 7. In 1980, 35 of 58 anglers interviewed on Eighteen Mile Creek were finished fishing. Three brown trout was the most taken per trip. Although brown trout far outnumbered brook trout in both streams, 2 anglers captured 9 brook trout from Beaver Creek in 1979 and 2 anglers caught 8 or more brook trout per trip from Eighteen Mile Creek in 1980.

The sport fishery of Beaver Creek was more localized than the fishery of Eighteen Mile Creek. In 1979, 75% of the anglers fishing Beaver Creek lived within a 25-mile radius, and only 11% traveled more than 50 miles (Table 29). An average of 37% of the anglers fishing Eighteen Mile Creek in 1979 and 1980 lived within a 25-mile radius, while an average of 56% came farther than 50 miles. No nonresidents were encountered on Beaver Creek in 1979, but an average of 20%—or 1 out

of every 5 anglers interviewed on Eighteen Mile Creek during the 1979 and 1980 fishing seasons—were nonresidents.

Male anglers comprised 91% (143 of 156) of all anglers interviewed (Table 30). Sixty-seven percent of the males were 16-64 years of age, while 21% were under 16 and 12% were 65 or older. Although the sample size was small, 92% of the women were 16-64 years of age and the remaining 8% were under 16.

The duration of the average fishing trip* was 2.6 hours on Beaver Creek in 1979 and 2.1 hours for the 1979 and 1980 seasons combined on Eighteen Mile Creek. One would expect the anglers traveling farther to stay longer. This relationship was evident on both streams for anglers traveling less than 25 miles vs those traveling more than 25 miles (Table 31). However, trip duration for anglers traveling more than 50 miles was less than for those traveling between 25 and 49 miles. Many anglers who traveled more than 50 miles were staying with friends, renting a cottage, or staying at a vacation home nearby. Fishing was probably not their primary interest, which combined with the fact that they were locally based, may explain the shorter length of their fishing trip.

Worms were by far the most popular bait choice by anglers on both streams in this study (Table 32). Seventy-six percent of the anglers used them exclusively, and another 8% used them in conjunction with other baits. Of the remaining anglers, 10% used spinner-type baits, and 6% used artificial flies, grasshoppers, minnows, etc.

Sleek, beautifully colored brown trout such as these 17-inch and 20-inch specimens move into Eighteen Mile Creek throughout the summer and are prime targets for September anglers.

*A fishing trip was the total length of time an angler spent in the study area in active pursuit of fish. If an angler left the stream and returned on the same day, this constituted a new trip.

TABLE 28. *Frequency of bag sizes for trout creeled from the two study streams in 1979 and 1980.*

Bag Size	Beaver Creek, 1979				Eighteen Mile Creek, 1979			Eighteen Mile Creek, 1980		
	Bag Size Frequency	No. Trout/Species Brown	Brook	Rainbow	Bag Size Frequency	No. Trout/Species Brown	Brook	Bag Size Frequency	No. Trout/Species Brown	Brook
0	16				33			21		
1	1	1			8	5	3	4	2	2
2	1	2			9	13	5	5	8	2
3	3	5	4		3	4	5	3	8	1
4	0				3	11	1	0		
5	0				2	8	2	0		
Limits in May*	0				0			0		
6	1	3	3		1	4	2	0		
7	0				0			0		
8	1		3	5	0			1		8
9	0				1	7	2	0		
10	2	2	18		0			1		10
Total Anglers	25				61			35		

*Bag limit was 5/day in May and 10/day from 1 June through 30 September.

TABLE 29. *Percentage of anglers traveling various distances to fish the two study streams.*

Stream	Miles (one way) ≤25	26-50	>50	Out of State	Number Interviewed
North Branch Beaver Creek (1979)	75	14	11	0	28
Eighteen Mile Creek (1979)	50	10	40	16	70
Eighteen Mile Creek (1980)	24	4	72	22	58

TABLE 30. *Sex and age of anglers at the two study streams.*

Stream	Number Interviewed	Sex Males (%)	Females (%)	Age Males (%) <16	16-64	>64	Females (%) <16	16-64	>64
North Branch Beaver Creek (1979)	30	93	7	15	67	18		100	
Eighteen Mile Creek (1979)	70	83	17	31	60	9	25	75	
Eighteen Mile Creek (1980)	58	98	2	16	75	9		100	
Avg.		91	9	21	67	12	8	92	

TABLE 31. *Duration of the average fishing trip in relation to the distance traveled to reach the two study streams (units in hours).*

Miles (one way)	North Branch Beaver Creek 1979	Eighteen Mile Creek 1979	1980
≤25	2.0	1.6	2.1
26-50	4.5	2.5	2.8
>50	2.8	1.8	2.5
>50 (nonresident)		1.6	2.2

TABLE 32. *Percentage of anglers using various baits while fishing for trout in the two study streams.*

Bait	North Branch Beaver Creek 1979	Eighteen Mile Creek 1979	1980
Worms	83	74	72
Spinners	3	14	12
Flies	3	0	5
Other	7	2	0
Combination	3	10	10

COMPARISONS WITH OTHER WISCONSIN BROWN TROUT STREAMS

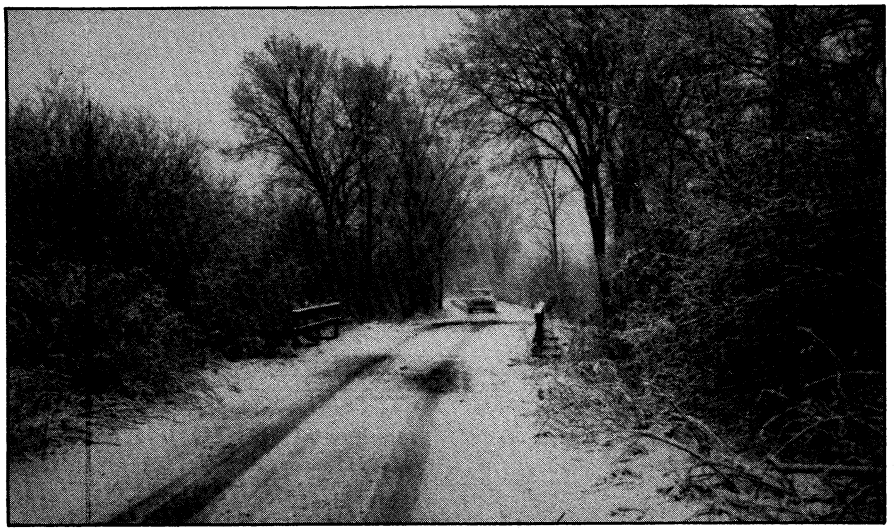
BROWN TROUT POPULATION CHARACTERISTICS

Spring and fall population densities of brown trout in the study zone of Beaver Creek were lower than in Eighteen Mile Creek and lower than the published values for nine other Class I trout streams throughout the northern two-thirds of Wisconsin (Table 33). Gravel substrates necessary for natural reproduction of brown trout are scarce in Beaver Creek. On the other hand, Eighteen Mile Creek has abundant gravel substrates and the highest spring and second highest fall population density of the 11 streams listed. If age 0's in Eighteen Mile Creek were included in the fall estimate, then the fall population density would also be the highest of the 11 streams recorded.

Relatively few legal trout (6 inches or more) were present in either Beaver Creek or Eighteen Mile Creek in the spring. Average densities of 118/mile in Beaver Creek and 256/mile in Eighteen Mile Creek are well below the range of 511-924/mile found in four central Wisconsin streams studied by Avery and Hunt (1981).

Average standing stocks of 19 lb/acre in Beaver Creek and 35 lb/acre in Eighteen Mile Creek in the spring are generally well below the standing stocks of brown trout reported in other Class I trout streams in Wisconsin. Avery and Hunt (1981) found a range of 59 to 114 lb/acre in four central Wisconsin streams and Hunt (1979) recorded an average of 102 lb/acre in Lunch Creek, another central Wisconsin stream. The standing stock of brown trout in the Kinnickinnic River, located in western Wisconsin, averaged 154 lb/acre (Frankenberger 1968). Schram (1978) found 105 lb/acre of brown trout in the South Branch of the White River, a stream in the same watershed as Eighteen Mile Creek. McKenzie Creek, another stream in northwestern Wisconsin, supports an average spring biomass of 51 lb/acre (Lowry 1971), and Thuemler (1976) found 14 lb/acre in Sidney Creek in northeastern Wisconsin. The trout population in the latter stream is more nearly divided between brown trout and brook trout than in any of the

Age structures of spring populations of brown trout in Beaver Creek and Eighteen Mile Creek differ significantly from those in four central Wisconsin streams (Table 34). Beaver Creek had a substantially lower percentage of yearlings and a higher percentage of older age groups than central Wisconsin streams. Eighteen Mile Creek was the opposite, with a significantly higher percentage of yearlings and a lower percentage of older age groups.



Opening day of the trout fishing season at the lower bridge on Eighteen Mile Creek (May 1979).

Densities of legal brown trout increased more than threefold in Beaver Creek and Eighteen Mile Creek between spring and fall. Fall densities averaged 376/mile in Beaver Creek and 833/mile in Eighteen Mile Creek. Increases in the density of legal trout between spring and fall in four central Wisconsin streams ranged from 51% to 68%. Fall densities in these streams ranged from 722 to 1,550/mile with an average of 1,110/mile.

One of the most striking increases between spring and fall occurred in brown trout 12 inches or more. Average spring density was 11/mile in both Beaver Creek and Eighteen Mile Creek. This increased to 61/mile in Beaver Creek and 93/mile in Eighteen Mile Creek in the fall. Corresponding densities of trout 12 inches or more in four streams in central Wisconsin ranged from 7 to 23/mile in the spring and from 14 to 57/mile in the fall.

Along with an increase in density and standing stock of larger brown trout in Beaver Creek and Eighteen Mile Creek between spring and fall was an increase in the density of age III+ trout (Table 35). Average densities of age III+ trout declined between spring and fall in the four central Wisconsin streams cited previously as well as in McKenzie Creek in northwestern Wisconsin.

An average biomass of 80 lb/acre in Beaver Creek and more than 106 lb/acre in Eighteen Mile Creek was present in the fall. These standing stocks compare favorably to standing stocks of 46 to 115 lb/acre in three other northern Wisconsin streams and are generally between 50% and 80% of the fall biomass in five central Wisconsin streams (Table 33).

SPORT FISHERY CHARACTERISTICS

The sport fisheries of central Wisconsin streams have several different characteristics than the two northern Wisconsin streams in this study. Average fishing pressure on four central Wisconsin streams ranged from 331 to 428 hours/acre (Avery and Hunt 1981). These compare to only 75 hours/acre on Beaver Creek and a 2-year average of 39 hours/acre on Eighteen Mile Creek.

Although most fishing pressure on the central Wisconsin streams was during May and June (the first two months of the fishing season), greatest fishing pressure on Beaver Creek and Eighteen Mile Creek was during June and August. Late spring runoff and more unfavorable weather conditions in northern Wisconsin are, in part, responsible for less fishing pressure in the spring. For example, on 4 May 1979, opening day of the trout fishing season, a storm dumped 3-4 inches of snow on

Eighteen Mile Creek and a cold drizzle fell on Beaver Creek. No precipitation was reported in central Wisconsin.

Another factor influencing fishing pressure was the local angler's intimate knowledge of the streams. An angler on Beaver Creek in late May 1979 said earthworms were always abundant in the stream in May, which meant he rarely fished the stream until later because the trout weren't hungry.* In June 1979, a longtime angler and landowner on Beaver Creek stated that most of his serious fishing was in August, because over the years he had learned that most larger brown trout weren't present until then.

Fishing pressure by day type on Beaver Creek and Eighteen Mile Creek, as well as on the central Wisconsin streams mentioned earlier, was essentially the same. Anglers exerted half the total season pressure on weekends and holidays and half on weekdays.

Brown trout captured in Beaver Creek and Eighteen Mile Creek were larger and older than trout captured in central Wisconsin streams. Creeled trout in Beaver Creek averaged 10.5 inches and 78% were age III+, while trout from Eighteen Mile Creek averaged 9.6 inches and 50% were age III+. Average brown trout creeled from central Wisconsin streams were 8.9 inches and only 13% averaged age III+ (Avery and Hunt 1981).

Angler success was similar on both northern and central Wisconsin trout streams. About 41% of the anglers caught at least 1 trout/trip on central Wisconsin streams vs 39% on the two northern Wisconsin streams in this study. A harvest rate of 0.9 trout/hour on Beaver Creek was higher than the 0.5-0.6 trout/hour on central Wisconsin streams. Brook trout and a few domestic rainbow trout were present in Beaver Creek and, because of their greater vulnerability to the angler, were probably responsible for the higher catch rate. Average harvest rate on Eighteen Mile Creek was 0.6 trout/hour, similar to that on central Wisconsin streams.

The sport fishery on Beaver Creek was more of a local nature than the fishery on Eighteen Mile Creek or on any of the four central Wisconsin streams (Avery and Hunt 1981). For example, 75% of the anglers on Beaver Creek lived within a 25-mile radius as opposed to a maximum of 36% who lived within a 25-mile radius of any one of the streams in central Wisconsin (Table 36).

Local anglers were not as prevalent on Eighteen Mile Creek. Fifty-six percent of the anglers came from more than 50 miles away, including 19% from out of state. This was similar to the residency of anglers on the South Branch of the Wedde Creek and on the Mecan River in central Wisconsin (Table 36).

Anglers primarily used worms as bait on both central and northern Wisconsin streams. About 84% of the anglers in this study used worms vs an average of 74% of the anglers on central Wisconsin streams.

Anglers fishing Beaver Creek and Eighteen Mile Creek tended to fish longer per trip than their counterparts on central Wisconsin streams. The average trip on Beaver Creek and Eighteen Mile Creek was 2.6 hours and 2.1 hours, respectively. The average fishing trip on two central Wisconsin streams was 2.0 hours, while anglers fished an average of only 1.6 hours on two others (Avery and Hunt 1981). Relatively easy access points, more frequent access points, greater angling pressure (competition for fishing sites), and the presence of many other excellent brown trout streams nearby may explain the shorter fishing trip on central Wisconsin streams.

*Tremendous numbers of earthworms were observed in Beaver Creek in early May during the spring electrofishing surveys.

TABLE 33. *Average density and biomass of brown trout in Class I trout streams in central and northern Wisconsin.*

Stream	County	Region	Spring Density (no./mile)	Spring Biomass (lb/acre)	Fall Density (no./mile)	Fall Biomass (lb/acre)
North Branch Beaver Creek	Marinette	NE	303	19	842	80
Eighteen Mile Creek	Bayfield	NW	3,386	35	4,158*	106+
McKenzie Creek	Polk	NW	1,076	51	1,342	46
South Branch White River	Bayfield	NW	1,627	105		
Kinnickinnic River	St. Croix	W	1,030	154	1,239	115
Sidney Creek	Marinette	NE	1,094	14	2,911	49
Lunch Creek	Waushara	C	1,740	102	1,584	155
Emmons Creek	Waupaca	C	2,500	100	3,110	151
Radley Creek	Waupaca	C	2,320	114	3,160	133
South Branch Wedde Creek	Waushara	C	1,990	112	4,710	163
Mecan River	Waushara	C	1,270	59	2,950	74

*Excludes most age 0's in 1980 from the estimated average density and their biomass in 1979 and 1980.

TABLE 34. *Average age of brown trout populations in the spring in Class I trout streams in central and northern Wisconsin, by percent in each age group.*

Stream	Age I	II	III	IV+
North Branch Beaver Creek	48	36	10	6
Eighteen Mile Creek	84	13	3*	
Emmons Creek	61	29	9	1
Radley Creek	66	25	8	1
South Branch Wedde Creek	77	18	5	<1
Mecan River	63	28	7	2

*Age III+.

TABLE 35. *Density of age III+ brown trout present in Class I trout streams in central and northern Wisconsin.*

Stream	Spring (no./mile)	Fall (no./mile)
North Branch Beaver Creek	57	67
Eighteen Mile Creek	119	214
Emmons Creek	286	188
Radley Creek	239	81
South Branch Wedde Creek	111	51
Mecan River	110	52
McKenzie Creek	130	49

TABLE 36. *Percentage of anglers traveling various distances to fish wild brown trout streams in central and northern Wisconsin.*

Stream	Miles (one way) ≤25	26-50	>50	Out of State	Number Interviewed
North Branch Beaver Creek	75	14	11	0	28
Eighteen Mile Creek	37	7	37	19	128
Emmons Creek	24	50	24	2	328
Radley Creek	36	28	33	3	255
South Branch Wedde Creek	12	33	49	6	207
Mecan River	11	22	56	10	409

MANAGEMENT CONSIDERATIONS

The brown trout populations in Beaver Creek and Eighteen Mile Creek both showed extensive seasonal movements of larger, older fish into and out of the study areas. Movement was downstream, presumably sometime between November and April, followed by a gradual movement upstream throughout the summer and fall. These movements are of much greater magnitude and of much greater importance as a management factor compared to brown trout populations studied in central Wisconsin streams.

Two brown trout marked in Eighteen Mile Creek were captured 4-5 miles below the study area, in the White River near the town of Mason, 11 months after completion of this study (Steven Schram, DNR Fish Manager, pers. comm.). Eighteen months after this study, another trout marked in Eighteen Mile Creek was captured about 15 miles from the study area near Sutherland's bridge in the White River. Meyers and Thuemler (1976) alluded to similar long-distance downstream movements of brown trout in Beaver Creek.

If such movements are common in northern Wisconsin trout streams, perhaps as a response to severity of winter ice formations, stream management strategies should be developed with more emphasis on a stream system approach rather than on a stream-by-stream approach. More intensive investigations of annual trout movements in northern Wisconsin stream systems are recommended to clarify this potentially important management concept.

More studies are also needed to clarify the impact of angler harvest on larger, main stream reaches where older age groups may be temporarily concentrated. High exploitation of these older and larger fish could ultimately affect trout populations in the entire stream system if recruitment is dependent on significant numbers of these fish surviving through the fishing season and dispersing to tributaries to spawn.

An excellent watershed for studying movement and exploitation is the White River in Bayfield and Ashland counties. It has more than 45 miles of trout water (excluding tributaries), is known throughout the state for producing large brown trout in excess of 15 inches, and is probably the most popular trout stream in this region of Wisconsin. However, the river lacks sufficient natural reproduction to attain its carrying capacity in the lower two-thirds of the trout water (Class II* trout water). This important fishery zone must depend on recruitment from the Class I headwater reaches and/or from Eighteen Mile Creek and other tributaries.

Although extensive movement of brown trout in both Beaver Creek and Eighteen Mile Creek prevented age-specific determinations of angler exploitation, there is no reason to believe that current harvest levels from either stream are inhibiting normal age and size structures. Furthermore, since Eighteen Mile Creek and Beaver Creek were selected because of their easy access and popularity among anglers, it appears unlikely that brown trout populations in other Class I northern streams (having poorer access and being less well known) are being seriously affected by current fishing pressures. Such is no longer the case in central Wisconsin streams, where angler exploitation rates of 16%-20% have substantially reduced the densities of fish greater than 10 inches and age III+, and have made recruitment strongly dependent upon one or two of the youngest age groups of spawners (Avery and Hunt 1981). Present management emphasis for brown trout streams in northern Wisconsin, therefore, should continue to stress preservation and enhancement of trout habitat quality. No major revisions of harvest regulations seem to be needed in the immediate future.

The need for a regulatory change to species-specific bag limits or size limits to protect wild brook trout in northern Wisconsin appears to warrant further investigation. Native brook trout in Beaver Creek comprised only 18% of all legal trout in the spring of 1979, but they accounted for 55% of the angler harvest. In Eighteen Mile Creek, brook trout comprised 8% of the legal trout in the spring of both 1979 and 1980, yet accounted for 28% and 16% of the angler harvest, respectively. The greater vulnerability of brook trout compared to brown trout is well known to many trout anglers and has been indicated in other studies (Shetter 1950, Cooper 1952). The importance of this phenomenon in this study is its occurrence at fishing pressures as light as 31 hours/acre (Eighteen Mile Creek, 1980). Although good population survey work is available on many wild brook trout streams in northern Wisconsin, there are no studies of brook trout popula-

*Class II streams by definition have some natural reproduction but not enough to use the available food and space. Such streams show good survival and carryover of adult trout, often producing fish of better-than-average size. Stocking is sometimes necessary to maintain a desirable sport fishery (Wis. DNR 1980).

tion dynamics and associated angler exploitation rates to help guide management decisions. Such a study on Class I brook trout streams in northern Wisconsin is needed.

Perhaps the most important value of the current study in terms of management is its quantitative baseline information on dynamics of wild brown trout populations in northern Wisconsin and the fisheries they support. Such information was heretofore unavailable and now provides a bench mark to which documented changes in population structures and sport fisheries can be referenced.

SUMMARY

1. This two-year study of two northern Class I trout streams was begun to gather data on wild brown trout populations and their sport fisheries in a region where growing seasons are shorter, winters are more severe, streams are less productive, and fishing pressures are less intense than in central and southern Wisconsin. Comparison of these data from northern Wisconsin with those data from central Wisconsin streams has permitted assessment of the relative impact of angler exploitation on the fish stocks. Because both streams in this study had resident populations of brook trout, population data for that species are also included in the report.

2. Spring, summer, and fall inventories of the trout populations in the North Branch of Beaver Creek in northeast Wisconsin and in Eighteen Mile Creek in northwest Wisconsin were conducted to gather vital statistics during 1979 and 1980. A stratified, partial creel census was conducted throughout the fishing season on both streams in 1979 and on Eighteen Mile Creek in 1980.

3. Average spring density and biomass of age I+ trout (brown and brook trout) in Beaver Creek were 346/mile and 21.4 lb/acre, respectively (Table 37). Corresponding figures in the fall for age I+ trout were 1,174/mile and 91.0 lb/acre. In the spring, brown trout outnumbered brook trout more than 4 to 1 and comprised 89.6% of all legal trout (6 inches or longer). In the fall, brown trout were more than twice as abundant as brook trout and were 80.8% of all legal fish.

   Most legal brown trout in the spring (85%) were age II and III and most legal brook trout (62%) were age II. All age I trout were sublegal. Average lengths of age I, II, and III brown trout were 3.6 inches,

TABLE 37. *Trout population characteristics in the Beaver Creek study area.**

Characteristic	Brown Trout	Brook Trout	Combined
Avg. Population Density			
Spring	303/mile	63/mile**	346/mile[1]
Fall	842/mile	332/mile	1,174/mile
Biomass			
Spring	19.2 lb/acre	3.4 lb/acre**	21.4 lb/acre[1]
Fall	80.2 lb/acre	10.8 lb/acre	91 lb/acre
Avg. Length by Age Group			
Spring			
I	3.6 inches	4.2 inches	
II	6.3 inches	6.9 inches	
III	9.2 inches		
Fall			
0	3.6 inches	3.7 inches	
I	7.0 inches	6.8 inches	
II	10.4 inches	8.1 inches	
III	13.9 inches	10.8 inches	
% Legal Size			
Spring	43%	51%**	
Fall	48%	29%	
% of Legal Trout, by Age			
Spring			
II	59%	62%	
III	26%	31%	
IV+	15%	6%	
Fall			
I	60%	70%	
II	27%	23%	
III+	13%	7%	
Largest Captured	24.8 inches	10.0 inches	
Oldest Age Group	VII	VI	
Avg. Pop. Density of Trout			
≥10 inches (brown and brook)			
Spring			32/mile
Fall			19/mile
≥12 inches (brown and brook)			
Spring			11/mile
Fall			65/mile

*In 1979, the study area was a 3.4-mile stretch, but in 1980 this was reduced to a 1.2-mile stretch.
**1979 data only. Estimate could not be made in 1980.
[1]Includes 1980 data for brook trout captured.

6.3 inches, and 9.2 inches, respectively (Table 37). Age I and II brook trout averaged 4.2 inches and 6.9 inches, respectively. In the fall, age I and II trout comprised most of the legal brown and brook trout populations. Average lengths of age I and II brown trout were 7.0 inches and 10.4 inches, respectively. Age I and II brook trout averaged 6.8 and 8.1 inches, respectively.

Average spring density of trout 10 inches or larger in Beaver Creek was 32/mile, while trout 12 inches or larger averaged 11/mile. In the fall, average density of trout 10 inches or larger was 119/mile, while fish 12 inches or larger averaged 65/mile. A 24.8-inch brown trout and a 16.1-inch brook trout were the largest fish captured. Age VII brown trout and age IV+ brook trout were the oldest age groups identified.

4. Average spring density and biomass of age I+ trout in Eighteen Mile Creek were 3,580/mile and 37.0 lb/acre, respectively (Table 38). In the fall, average density of age I+ trout was 2,062/mile and average biomass was 100.4 lb/acre. Brown trout outnumbered brook trout more than 20 to 1 in the spring and comprised 90.9% of all legal trout. In the fall, age I+ brown trout outnumbered age I+ brook trout 13 to 1 and comprised 94.8% of all legal trout.

   In the spring, most legal brown trout (92%) were age II or III, and most legal brook trout (90%) were age II. All age I trout were sublegal. Average lengths of age I, II, and III brown trout were 3.3 inches, 5.6 inches, and 8.8 inches, respectively. Age I and II brook trout averaged 3.6 inches and 6.1 inches, respectively (Table 38). In the fall, most of the legal brown trout (84%) were age I and II, and most legal brook trout (78%) were age I. Age I and II brown trout averaged 5.7 inches and 8.4 inches, respectively, while age I brook trout averaged 5.5 inches.

   Average spring density of trout 10 inches or larger in Eighteen Mile Creek was 34/mile, but trout 12 inches or larger averaged only 11/mile. In the fall, average density of fish 10 inches or larger was 142/mile, while density of trout 12 inches or larger averaged 93/mile. A 21.7-inch brown trout and a brook trout in the 10-inch group were the largest fish captured. The oldest brown trout and brook trout recorded were in age groups VII and VI, respectively.

5. Age 0 brook trout in both study areas grew faster than age 0 brown trout, and average size of age I brook trout in the spring was greater than that of age I brown trout. However, subsequent growth of brown trout exceeded the growth of brook trout in both streams. By the fall, age I brown trout were larger than age I brook trout, and they remained larger for the rest of their lives in both streams. Growth of both species was faster in Beaver Creek than in Eighteen Mile Creek and resulted in a larger average size at all ages. Most trout in Beaver Creek reached the minimum legal size of 6 inches as yearlings, but in Eighteen Mile Creek, most trout did not become legal until age II.

6. Movement of trout into the study areas was significant throughout the summer and fall. In Beaver Creek, much of the movement was of age I trout and brown trout larger than 10 inches, resulting in increases in their respective populations between spring and fall. Trout movement in Eighteen Mile Creek was confined primarily to age III+ brown trout and brown trout larger than 10 inches, and was responsible for substantial increases in their populations by fall. Overwinter movement of trout out of the study areas resulted in spring populations with few age III+ trout and few trout larger than 10 inches.

7. Fishing effort at Beaver Creek in 1979 was 75 hours/acre (53 trips/mile) and resulted in a harvest of 90 trout/mile weighing 13.4 lb/acre (Table 39). Although Beaver Creek is primarily a brown trout stream, brook trout comprised 55% of the number and 41% of the biomass harvested. Sixty percent of the brown trout creeled were 10 inches or longer. Average size of creeled brown trout was 10.5 inches, while brook trout averaged 8.7 inches. Most brown trout harvested (78%) were age III+, while most brook trout harvested (86%) were age II+.

   Fishing effort at Eighteen Mile Creek was 47 hours/acre (70 trips/mile) in 1979, but declined to 31 hours/acre (35 trips/mile) in 1980. Anglers creeled 94 trout/mile weighing 9.0 lb/acre in 1979 and 49 trout/mile weighing 4.6 lb/acre in 1980. Brown trout comprised an average of 78% of the total harvest and 88% of the total biomass taken during the two years. Age II's and III's comprised most of the brown trout harvest (75%), while age II's accounted for most of the brook trout creeled (82%). Average size of creeled brown trout was 9.5 inches in 1979 and 9.6 inches in 1980.

   Average size of brook trout harvested in 1979 and 1980 was 8.2 inches and 7.6 inches, respectively.

   Anglers who caught at least one legal trout/trip, whether creeled or released, comprised 39% of the anglers interviewed on Beaver Creek and 54% of the anglers contacted on Eighteen Mile Creek. Harvest rate in 1979 was 0.9 trout/hour on Beaver Creek and 0.7 trout/hour on Eighteen Mile Creek. In 1980, anglers creeled 0.5 trout/hour from Eighteen Mile Creek. Most anglers on Beaver Creek lived within a 25-mile radius, while most anglers on Eighteen Mile Creek came more than 50 miles. Over 75% of the anglers interviewed on both streams preferred worms for bait.

8. Spring and fall population densities of trout in Beaver Creek were lower than in nine other Class I trout streams throughout Wisconsin. Spring and fall population densities in Eighteen Mile Creek, however, were among the highest documented. Spring standing stocks in Beaver Creek and Eighteen Mile Creek were generally below the standing stocks present in other Class I trout streams. In the fall, however, standing stocks compared favorably with those present in other northern Wisconsin trout streams. Fishing pressure on both study streams was much lighter than on central Wisconsin trout streams, and angler harvest consisted of larger and older trout.

9. More intensive investigation of the annual trout movement in northern Wisconsin streams is recommended to further substantiate the importance of management on a stream system approach rather than management on a stream-by-stream approach. No major revision of harvest regulations is needed in the immediate future to protect northern Wisconsin brown trout stocks. Management should continue to stress preservation and enhancement of habitat quality. This study indicated that compared to brown trout, brook trout are more vulnerable to angler harvest, a finding that merits further documentation.

TABLE 38. *Trout population characteristics in the Eighteen Mile Creek study area.**

Characteristic	Brown Trout	Brook Trout	Combined
Avg. Population Density			
Spring	3,386/mile	194/mile	3,580/mile
Fall	1,914/mile**	148/mile**	2,062/mile
Biomass			
Spring	35 lb/acre	2.0 lb/acre	37.0 lb/acre
Fall	97.2 lb/acre**	3.2 lb/acre**	100.4 lb/acre
Avg. Length by Age Group			
Spring			
I	3.3 inches	3.6 inches	
II	5.6 inches	6.1 inches	
III	8.8 inches	7.4 inches	
Fall			
0	3.0 inches	3.2 inches	
I	5.7 inches	5.5 inches	
II	8.4 inches	7.6 inches (age II+)	
III	11.2 inches		
% Legal Size			
Spring	7%	18%	
Fall	44%**	31%**	
% of Legal Trout, by Age			
Spring			
II	58%	90%	
III	34%	10%	
IV+	8%		
Fall			
I	65%	78%	
II	19%	23% (age II+)	
III+	12%		
Largest Captured	21.7 inches	16.1 inches	
Oldest Age Group	VII	IV+	
Avg. Pop. Density of Trout			
≥10 inches (brown and brook)			
Spring			34/mile
Fall			142/mile
≥12 inches (brown and brook)			
Spring			11/mile
Fall			93/mile

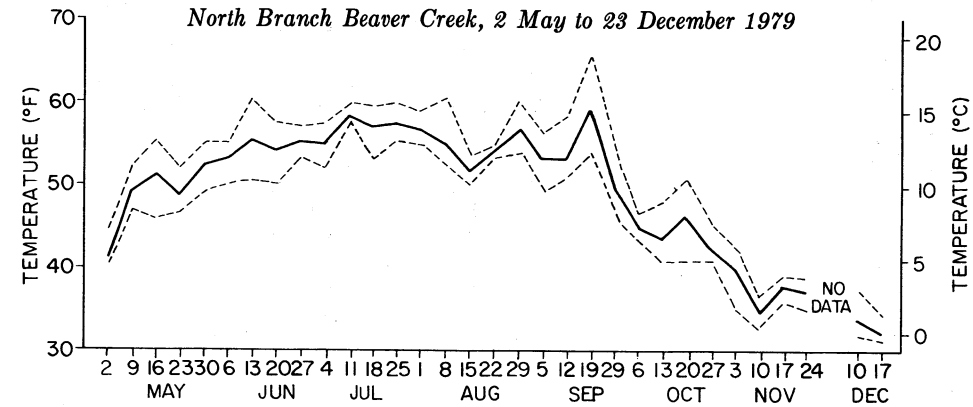
*In 1979, the study area was a 5.3-mile stretch, but in 1980 this was reduced to a 4.1-mile stretch.
**Excluding age 0's.

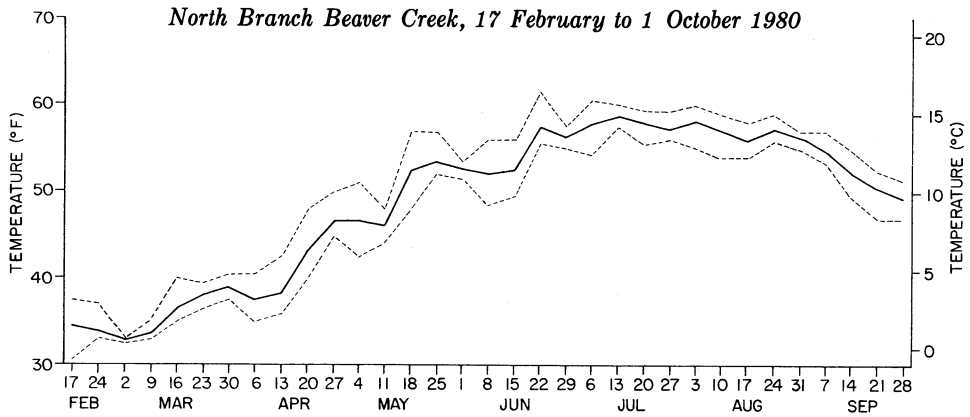
TABLE 39. *Trout fishing pressure and harvest characteristics on the two study streams, 1979 and 1980.*

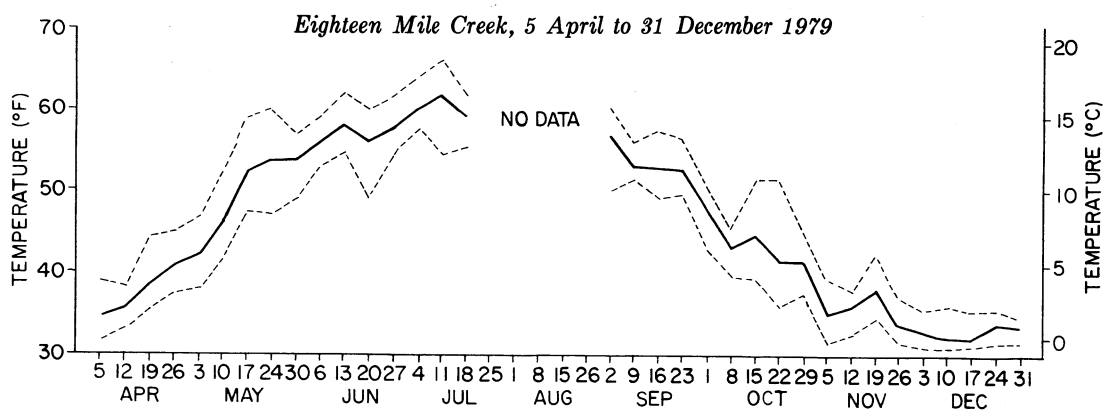
Stream	Fishing Pressure (hour/acre)	Harvest (no./mile)	Avg. Weight (lb/acre)	Average Size		Percent Harvest		
				Brook	Brown	Brown	Brook	Rainbow*
North Branch Beaver Creek								
1979	75	90	13.4	10.5	8.7	37	55	8
Eighteen Mile Creek								
1979	47	94	9.0	9.5	8.2	72	28	
1980	31	49	4.6	9.6	7.6	84	16	

*Escaped from private trout hatchery.

APPENDIX







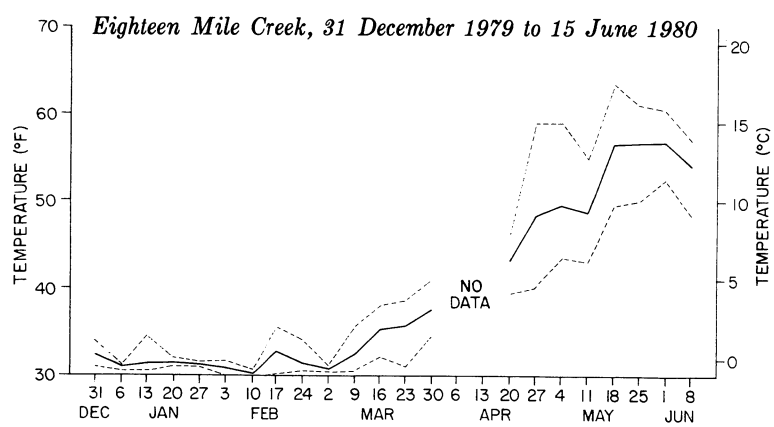


 FIGURE 5. Weekly minimum, mean, and maximum temperatures of the two study streams.

LITERATURE CITED

AVERY, E. L. AND R. L. HUNT
1981. Population dynamics of wild brown trout and associated sport fisheries in four central Wisconsin streams. Wis. Dep. Nat. Resour. Tech. Bull. No. 121. 26 pp.

BROWN, M. E.
1946. The growth of brown trout (*Salmo trutta* Linn.). I. Factors influencing the growth of trout fry. J. Exp. Biol. 22:118-29.

1951. The growth of brown trout (*Salmo trutta* Linn.). IV. The effect of food and temperature on the survival and growth of fry. J. Exp. Biol. 28:73-91.

COOPER, E. L.
1952. Rate of exploitation of wild eastern brook trout and brown trout populations in the Pigeon River, Otsego County, Michigan. Trans. Am. Fish. Soc. 81:224-34.

FRANKENBERGER, L.
1968. Effects of habitat management on trout in a portion of the Kinnickinnic River, St. Croix County, Wisconsin. Wis. Dep. Nat. Resour. Fish Manage. Rep. No. 22. 14 pp.

HOLLENDER, B. A.
1981. Embryo survival, substrate composition, and dissolved oxygen in redds of wild brook trout. Univ. Wis., Stevens Point, MS Thesis. 87 pp.

HUNT, R. L.
1979. Removal of woody streambank vegetation to improve trout habitat. Wis. Dep. Nat. Resour. Tech. Bull. No. 115. 36 pp.

LOWRY, G. R.
1971. Effect of habitat alteration on brown trout in McKenzie Creek, Wisconsin. Wis. Dep. Nat. Resour. Res. Rep. No. 70. 27 pp.

MEYERS, L. S. AND T. F. THUEMLER
1976. Creel census on the Lower North Branch Beaver Creek, 1975. Wis. Dep. Nat. Resour. Fish Manage. Rep. No. 89. 14 pp.

MILLER, J. M.
1970. An analysis of the distribution of young-of-the-year brook trout, *Salvelinus fontinalis* (Mitchell), in Lawrence Creek, Wisconsin. Univ. Wis., Madison, PhD Thesis. 118 pp.

RICKER, W. E.
1958. Handbook of computations for biological statistics of fish populations. Fish Res. Board Can. Bull. No. 119. 300 pp.

SCHRAM, S. T.
1978. Stream survey—South Fork White River, Bayfield County. Wis. Dep. Nat. Resour., Brule Area Fish. Work Unit, Brule. 31 pp.

SHETTER, D. S.
1950. The relationship between the legal-size trout population and the catch by anglers in portions of two Michigan trout streams. Mich. Acad. Sci., Arts, and Lett. 24(148):98-107.

THUEMLER, T. F.
1976. Trout populations in Sidney Creek, Marinette County, Wisconsin. Wis. Dep. Nat. Resour. Fish Manage. Rep. No. 85. 14 pp.

WISCONSIN DEPARTMENT OF NATURAL RESOURCES
1980. Wisconsin trout streams. Publ. 6-3600(80). Madison, Wis. 67 pp.

ENGLISH-METRIC MEASURE AND WEIGHT EQUIVALENTS

1 inch = 2.54 cm
1 ft = 30.48 cm or 0.3048 m
1 mile = 1.609 km
1 cfs = 0.028 cms
1 acre = 0.405 ha or 4.047 m^2
1 oz = 31.103 g
1 lb = 0.373 kg
1 cm^2 = 0.155 inch ^{2}
1 g = 0.035 oz
1 liter = 33.83 oz

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