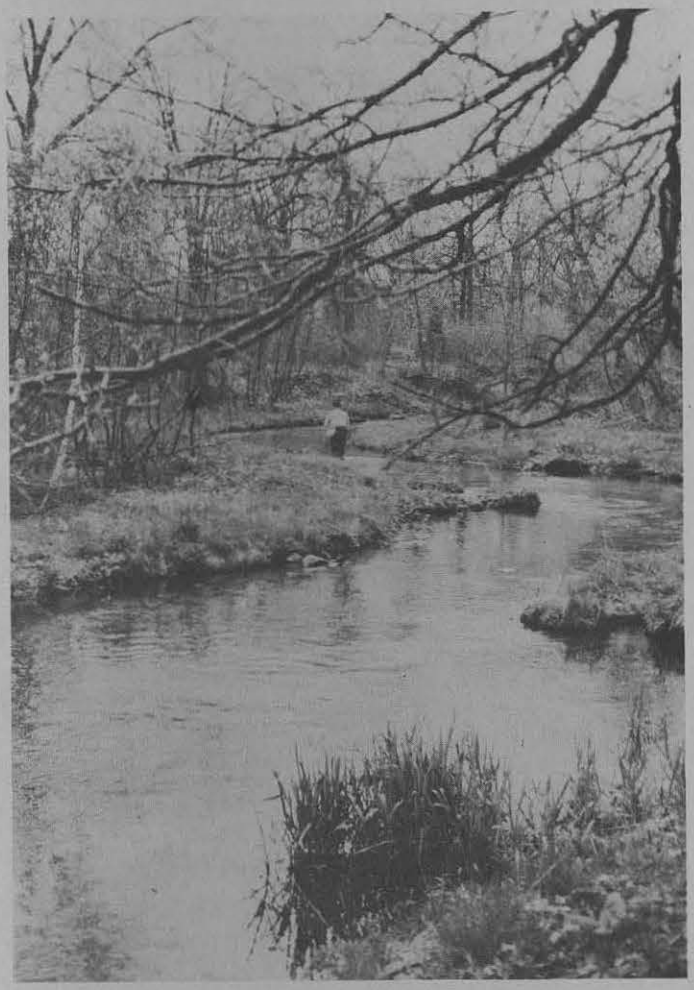

POPULATION DYNAMICS OF WILD BROWN TROUT AND ASSOCIATED SPORT FISHERIES IN FOUR CENTRAL WISCONSIN STREAMS.

Technical Bulletin No. 121
DEPARTMENT OF NATURAL RESOURCES
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COVER

An angler finds a stretch of the Mecan River to his liking in early May. The Mecan River is one of central Wisconsin's most popular brown trout streams.

ABSTRACT

Wild brown trout *(salmo trutta)* populations in four central Wisconsin streams were studied from fall 1975 through spring 1978. Population inventories were conducted each spring and fall. A partial creel census conducted throughout the 1976 and 1977 fishing seasons provided information on the associated sport fisheries on each stream.

Average spring density and biomass of brown trout in the four streams was 2,016/mile and 96 lb/acre, respectively. In the fall, the average density and biomass increased to 3,485/mile and 130 lb/acre, respectively. Roughly 37% of the spring populations and 34% of the fall populations were legal fish, i.e., 6.0 in. or more in length. Age II and III trout made up 67% and 19%, respectively, of the legal-sized fish present in the spring, while age I and II trout comprised 67% and 24%, respectively, of the legal fish present in the fall. Mean sizes of age I, II, and III trout in the spring were 4.8 in., 7.9 in., and 10.1 in., respectively. In the fall, age 0, I, II, and III trout averaged 3.8 in., 7.0 in., 9.4 in., and 11.2 in., respectively.

A mean of 398 hours/acre of fishing in 1976 resulted in an average harvest of 425 trout/mile weighing 52 lb/acre. In 1977, fishing pressure declined to an average of 376 hours/acre and the mean harvest was 320 trout/mile weighing 37 lb/acre. Age II brown trout dominated the harvest during both years. Exploitation rate was generally less than 20% of the spring populations but reached as high as 68% and 78% for ages II and III+ in individual streams. Angler harvest skewed the size and age structure in all four streams toward smaller and younger fish. Especially noticeable was the scarcity of trout larger than 10 in. or over 3 years of age when compared to the population structure in a similar but lightly fished reach of one of the study streams.

Overall effects of current minimum length (6.0 in.) and bag limit restrictions (5/day in May; 10/day from June through September) on brown trout population structure and angling quality in central Wisconsin streams are discussed. With increases in fishing pressure projected for the near future, changes to a minimum length limit of 7 in. for brown trout and a season-long bag limit of 5 brown trout/day are recommended in the southern half of Wisconsin (south of U.S. Highway 10) to insure the stability of wild brown trout stocks and to maintain and possibly improve the quality of the sport fisheries.

Population Dynamics of Wild Brown Trout and Associated Sport Fisheries in Four Central Wisconsin Streams

by
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INTRODUCTION

The most recently published classification of Wisconsin trout streams by the Department of Natural Resources (1980) lists 2,674 streams having a combined length of approximately 9,560 miles. Those streams designated as Class I constitute 37% (3,536 miles) of the total mileage. These are streams which are by definition "high quality trout water, having sufficient natural reproduction to sustain populations of wild trout at or near carrying capacity. Consequently, streams in this category require no stocking of hatchery trout."

Nearly all of these Class I streams contain wild brook trout *(Salvelinus fontinalis)* and approximately 33% (1,168 miles) contain wild brown trout *(Salmo trutta)*. Although these streams rank among the most valued of natural resources in Wisconsin, only three published reports provide quantitative data on both angler use of Class I trout streams and rates of angler exploitation (percentage of age I+ or II+ trout harvested). Such data are vital to assess present restrictions on harvest and angling quality and as baseline data to develop rational management strategies to meet anticipated future demands on the trout resource of the state.

Hunt, Brynildson, and McFadden (1962) found that exploitation of brook trout in Lawrence Creek, a central Wisconsin stream, varied from 1% to 65% during a 6-year period (1955-60) in which three different combinations of experimental fishing regulations were tested. Fishing pressure ranged from 137 to 495 hours/acre, with an average of 323 hours/acre.

Three of the important management implications derived from that study were: (1) brook trout mortality due to angling was an inverse density dependent factor, i.e., any increase in angling effort brought about a proportionately greater depletion of a sparse brook trout population than of a dense population; (2) normal statewide regulations then in effect (6 in. minimum length; bag limit of 10) would not prevent overharvest of brook trout if sufficient angling effort were applied; and (3) these regulations were providing little protection since few anglers kept brook trout smaller than 6 in. during the two fishing seasons it was legal to do so, and few anglers were skillful enough to catch 10 or more trout/trip.

In another investigation of wild brook trout populations and the sport fishery, Hunt (1979) found that exploitation in three study zones of the Little Plover River (also a Class I stream in central Wisconsin) varied from 6% to 55%. Average exploitation for all three zones during three fishing seasons was 25%. Angling effort in these zones ranged from 46 to 437 hours/acre and averaged 252 hours/acre.

Lowry (1971) did not compute exploitation of wild brown trout as part of his investigation of the benefits of trout habitat improvement in McKenzie Creek in northwestern Wisconsin, but from creel census data included in his report, we calculated that anglers removed approximately 43% of the age II and older trout during the 1963 fishing season. Angling mortality accounted for approximately 4 out of 5 age II+ trout that died during the April-October period, i.e., total mortality was 55%. Angling effort amounted to 189 hours/acre that season.

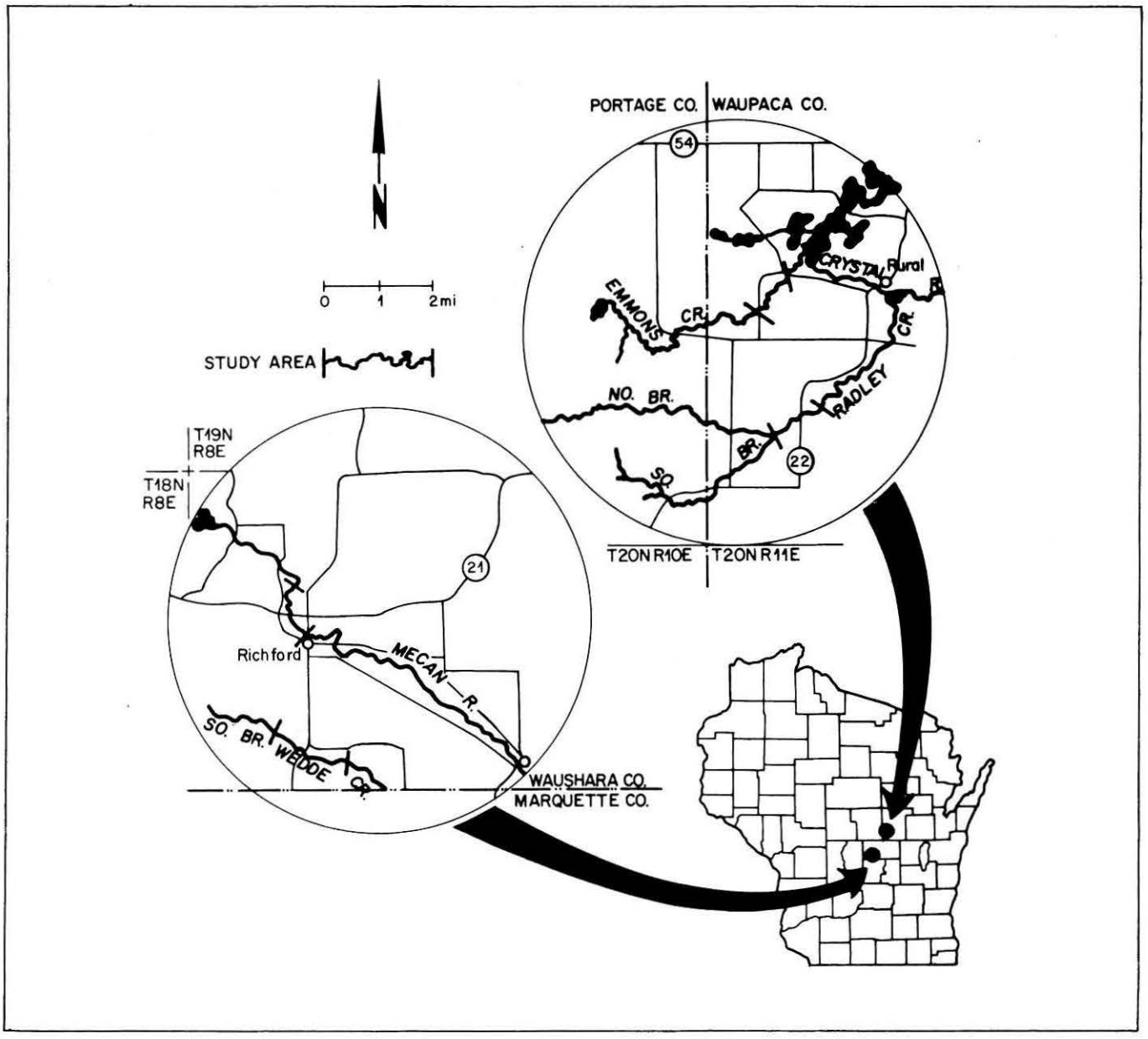
The present study was initiated on four Class I trout streams in central Wisconsin in 1975 to: (1) quantify population densities, age-specific abundance, biomass, growth, and survival rates of wild brown trout; (2) determine fishing pressure and exploitation rates, and assess the impact of the latter on the size and age structure of the brown trout populations; and (3) characterize the sport fisheries on Class I trout streams. Scarcity of such data for wild brown trout fisheries in Wisconsin was the primary reason for focusing field work on this species. Central Wisconsin was selected because a large share of the state's most popular and best quality brown trout streams are located there.

THE STUDY STREAMS

The four study streams were Emmons Creek, Radley Creek, the Mecan River, and the South Branch of Wedde Creek (Fig. 1). Emmons Creek originates from Fountain Lake in southeastern Portage County and flows 6.0 miles before entering Waupaca County's 724-acre Chain O'Lakes. Radley Creek originates 3.0 miles south of Emmons Creek and flows 11.0 miles (including South Branch) into the Crystal River near Rural. Approximately 35 miles southwest of Radley Creek, the Mecan River originates from Mecan Springs in southwestern Waushara County and flows 31 miles before emptying into the Fox River in Marquette County. The South Branch of Wedde Creek originates 4.0 miles south of the Mecan River and flows 4.9 miles before merging with the North Branch to form Wedde Creek. All of Emmons and Radley creeks, the South Branch of Wedde Creek, and the upper 6.6 miles of the Mecan River are Class I trout water. All four streams were once native brook trout streams but now support primarily brown trout. The Mecan River also contains a small but self-sustaining population of rainbow trout *(Salmo gairdneri)*.

Study zones on the four streams ranged in length from 1.1 to 1.5 miles and were easily accessible to anglers through state-owned public fishing areas. The Mecan River and Emmons Creek are the two largest streams with average widths of approximately 22

FIGURE 1. *Location of the four wild brown trout study streams in central Wisconsin and their respective study zones.*



and 19 ft, respectively, and average discharges near 22 cfs (Table 1). Radley Creek is narrower and deeper than either Emmons Creek or the Mecan River and has a 20% smaller volume. The South Branch of Wedde Creek (referred to hereafter as just "Wedde Creek") is the smallest stream, with an average discharge of 9 cfs and an average width of 12 ft. Pools more than 3.5 ft deep are uncommon in the four streams and stream gradients are less than 15 ft/mile.

Total alkalinities ($CaCO_3$) within the study zones ranged from 131 to 186 ppm, conductivities ranged from 276 to 356 mhos/cm^2 (Table 2), and pH ranged from 7.5 to 8.2. Stream temperatures from mid-June through mid-September ranged from the low 50's to the low 60's F in Emmons and Radley creeks with maximum temperatures rarely attaining 65 F (Fig. 10). Temperatures were similar in Wedde Creek with the exception that maximum temperatures were commonly in the mid-60's. The Mecan River was the warmest of the four streams with summer temperatures reaching the mid-70's F. Portions of all four streams remain ice free even during severe winters. Minimum winter temperatures generally hovered between 33 and 34 F on all but the Mecan River, where they approached 32 F.

Some trout habitat improvement work had been done in the study zones of all the study streams except Emmons Creek prior to this investigation. Substrates consisted primarily of fine sand with gravel riffles occurring frequently in Emmons Creek and the Mecan River and occasionally in Radley and Wedde creeks. Aquatic vegetation ranged from sparse in Emmons Creek, Radley Creek, and the Mecan River to moderately abundant in Wedde Creek and consisted primarily of watercress *(Nasturtium officinale)* and water buttercup (*Ranunculus* sp.). The food base for trout consisted primarily of aquatic and terrestrial invertebrates.

Most of the nontrout fishes were mottled sculpin *(Cottus bairdi)* and brook stickleback *(Culaea inconstans)* but neither fish was particularly abundant. A sparse crayfish population was also present in the Mecan River.

TABLE 1. *Physical characteristics of the four central Wisconsin brown trout study streams measured within their respective study zones.*

Stream	Study Zone Length (miles)	Surface Area (acres)	Average Width (ft)	Average Depth (ft)	Average Discharge (cfs)
Emmons Creek	1.3	3.1	18.9	1.1	21.8
Radley Creek	1.5	3.1	16.7	1.2	17.0
South Branch Wedde Creek	1.1	1.6	12.3	1.1	8.8
Mecan River	1.4	3.7	21.5	0.9	21.6

TABLE 2. *Chemical parameters determined from quarterly water samples from four central Wisconsin brown trout streams in 1976-77.*

Parameter*	Emmons Creek	Mecan River	S. Br. Wedde Creek	Radley Creek
pH	7.9-8.2	7.6-8.0	7.6-7.9	7.5-8.0
Conductivity	320-355	330-356	276-319	288-339
Alkalinity	161-186	160-170	131-147	135-157
N (tot)	1.88-2.47	1.93-2.13	1.48-2.79	2.24-2.33
P (tot)	0.03-0.07	0.01-0.08	0.03-0.05	<0.01-0.05
Ca	36-40	26-42	25-35	33-40
Mg	23-28	24-28	19-24	21-24
Na	2-8	<1-7	<1-18	<1-26
K	<0.5-1.6	0.5-1.4	<0.5-1.4	<0.5-3.4
Fe	<0.09-0.40	<0.09-0.55	0.13-0.19	<0.09-0.14
Mn	<0.03-0.14	<0.03-0.05	<0.03-0.06	<0.03-0.06
SO_4	5-8	5-8	4-9	6-9
Cl	2-4	2-4	2-4	3-4
Turbidity	0.05-2.0	1.0-7.0	0.06-2.5	0.03-6.0

*Measurements are mg/l except for the following parameters: pH: units; conductivity: micromhos/cm^2 at 25 C; alkalinity: mg/l $CaCO_3$; and turbidity: FTU.

METHODS

TROUT POPULATION DYNAMICS

Double-run electrofishing surveys of trout populations in the four study zones were made each spring (late April-early May) and fall (late September-early October) beginning in fall 1975 and terminating in spring 1978. A small electrofishing boat equipped with a 220-volt DC generator (1 negative and 3 positive electrodes) was used to capture fish. Trout captured on the first electrofishing survey were measured to the nearest 0.1 in., weighed to the nearest gram, given a temporary (partial) fin clip and released. Trout captured on the second electrofishing run were examined for fin clips, measured to the nearest 0.1-in. or 0.5-in., and released. Samples of the fingerlings (age 0) captured each fall were weighed and measured. The remainder collected were tallied and apportioned to inch groups based upon the samples measured. Numbers of trout/inch group were estimated using the Bailey modification of the Petersen mark-recapture formula (Ricker 1958).

All fingerlings captured each fall were given permanent (total) fin clips to help establish known-age segments of the trout populations. Scale samples were also taken to help determine age structures of the populations. In the spring of 1976, scales were taken from a random sample of 250 trout and from all trout over 12.0 in. in each stream except Wedde Creek. In Wedde Creek, scales were taken from trout 6.0-7.4 in., 9.0-11.9 in., and all trout over 12.0 in. These intervals appeared to be those in which most overlap of age groups occurred. In the fall of 1976, scales were taken from trout in the 5.0-in. group in each stream to clarify the percentage of age 0 and age I fish in this interval of age overlap. Additional scales were taken from trout between 8.0 and 10.0 in. that lacked a permanent year class fin clip and from almost all trout larger than 10.0 in. In the spring of 1977, age I and II trout could be identified by their corresponding year class marks. Scales were, therefore, taken only from unmarked trout larger than 9.0 in. No scale samples were collected in the fall of 1977. Age 0 and age I trout were determined by constructing length frequency tables of the 4.0-in. and 5.0-in. groups. Older age groups were determined from known-age (fin-clipped) trout. In the spring of 1978, scales were taken from unmarked trout larger than 11.0 in. in Emmons and Wedde creeks and from trout larger than 12.0 in. in the Mecan River and Radley Creek.

Trout within each inch group were stratified into age categories depending upon the frequency distribution of fin clips (year class marks) and verifications of the age of unmarked trout by scale readings. Average length and weight of each inch group were used to determine the average length and total biomass of each age group as well as the total biomass of each population.

Age-specific survival rates of trout in each study zone were based on changes in the numbers of trout of each year class during a specified time interval. Survival rates were probably influenced by volitional movement of trout as well as by losses from natural or angling mortality.

Production (P) is the growth in weight by all trout of a given age group during a specified time interval, including growth by trout of that age which died during the interval. Production by several age groups of the 1975 and 1976 year classes was calculated as the products of their average biomass ($\bar{B}$) and their instantaneous rates of growth (G) (Ricker 1968).

TROUT SPORT FISHERIES

In Waupaca and Waushara counties, Wisconsin's general trout seasons in 1976 and 1977 opened the first Saturday in May and extended through September. A bag limit of 5 trout/day in May and 10 trout/day from June through September was in effect during this study with a minimum legal length limit of 6.0 in.

The sport fishery on each study stream was studied in 1976 and 1977 by means of a partial creel census conducted throughout the respective fishing seasons. Preliminary investigations in 1975 on three of the four study streams suggested that 50% of the fishing pressure occurred on weekends and holidays with the remainder occurring on weekdays. Census effort was, therefore, stratified so that 50% occurred on weekends and holidays and 50% occurred on weekdays. Census clerks normally worked one of two 8-hour shifts, i.e., 5:30 a.m. to 1:30 p.m. or 1:30 p.m. to 9:30 p.m. each census day, and averaged 40 hours/week on each stream. Double shifts, i.e., 16-hour days, were conducted on opening weekend to achieve as nearly as possible a complete census. Thereafter, census days and 8-hour shifts were selected randomly. This still resulted in some 16-hour workdays, especially on weekends. On Emmons Creek and Radley Creek, the census was conducted on 105 days of the 153-day season in 1976 and included all weekend days and holidays (46) plus 59 weekdays. Nine fewer days (4 weekend days and 5 weekdays) were censused on the Mecan River and Wedde Creek because the fishing season was terminated on 17 September by special order of the DNR Secretary. Outdoor activity was banned in 9 central Wisconsin counties due to drought and extreme fire danger. Waupaca County was not included; thus the fishing season on Emmons and Radley creeks was not affected.

In 1977, the census was conducted on 91 days of the 147-day season—40 weekend days and holidays and 51 weekdays.

The census consisted of two main parts: estimates of fishing pressure and catch statistics. Most anglers parked their cars in designated parking areas on each stream, and estimates of fishing pressure were made by tallying all cars at these points at approximately 2-hour intervals between 6:30 a.m. and 8:30 p.m. Vehicles not parked in designated parking areas but that obviously belonged to anglers were also tallied. Car counts usually took 15 min. Between counts, anglers were interviewed for information concerning the number in their party, their residence, the length of time fished, fishing methods, and the nature of their catch. Most anglers were interviewed as they returned to their cars in order to gather as much information from completed trips as possible. All creeled trout were measured to the nearest 0.25-in. and examined for age-specific fin clips. Unclipped trout were scale sampled.

Fishing pressure was estimated on a monthly basis during each fishing season. Monthly totals were summed to achieve a season estimate. Data collected for each day type, i.e., weekend and holiday vs weekday, were treated separately each month and separate estimates were computed. A 15 1/2-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. Day length each month varied with the time intervals represented by the 6:30 a.m. and 8:30 p.m. car counts. These were determined by the earliest angler on the stream and the last angler leaving the stream, respectively. All other car counts represented 2.0-hour time intervals.

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

$$\left[\sum_{i=1}^{n=8} (\bar{C}_i\bar{T}_i)\right] (A_{wd})\,(WD) + \left[\sum_{i=1}^{n=8} (\bar{C}_i\bar{T}_i)\right] (A_{wed})\,(WED)$$

where n = number of car counts possible/day

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

$\bar{T}_i$ = the time interval represented by each car count, usually 2 hours

A = mean number of anglers/car on weekdays (wd) or weekend days plus holidays (wed)

WD = number of weekdays in the month

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

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

where $OWED$ = number of days in opening weekend.

In 1977, riparian landowners on Radley Creek and the Mecan River were issued a "fisherman's log" to record fishing effort and size, number, and species of trout caught by relatives, friends, etc. Vehicles present on these riparian properties were not included in the 2-hour counts on census days. Pertinent data recorded by the riparian landowners were added to the estimated values from the census to achieve monthly and season totals.

RESULTS

TROUT POPULATIONS*

Standing Stocks

Spring 1976-78

The average spring density of age I and older brown trout ranged from 1,270/mile in the Mecan River to 2,500/mile in Emmons Creek (Table 3). The average density in the four streams as a whole during the 3-year period was 2,020/mile. Average standing stock ranged from 59 lb/acre in the Mecan River to 114 lb/acre in Radley Creek, with a composite average in all four streams of 96 lb/acre. These brown trout densities and standing stocks are generally greater than those found in northern Wisconsin streams (Frankenberger 1968; Mason and Wegner 1970; Lowry 1971; Thuemler 1976); but, although numerical densities are higher, standing stocks in weight are lower than in Class I streams of southern Wisconsin (Brynildson and Mason 1975; C. L. Brynildson, pers. comm.).

Relatively few trout in the 5.5- to 6.4-in. range were present in the spring in any of the study streams. This interval proved to be a natural break between age I and age II+ fish at this time of year, with most yearlings being less than the minimum legal length of 6.0 in. Yearlings were numerically dominant each spring in all streams; their minimum average was 61% in Emmons Creek and their maximum average, 77% in Wedde Creek (Table 4). Average size of yearling stocks in April ranged from 4.6 in. in both Emmons and Radley creeks to 5.2 in. in the Mecan River. Average yearling densities ranged from 860/mile in the Mecan River to over 1,500/mile in the other streams. Lowry (1971) found 61% of the spring population of brown trout in McKenzie Creek in northwestern Wisconsin consisted of yearlings which averaged 4.6 in. However, trout densities in McKenzie Creek were generally less than half those observed in this study.

The average percentage of the spring populations consisting of age II's ranged from 18% in Wedde Creek to 29% in Emmons Creek (Table 4). Average densities ranged from 311/mile in the Mecan River to 703/mile in Emmons Creek, while the average size of the 2-year-olds ranged from 7.3 in. in Emmons Creek to 8.6 in. in the Mecan River. Age III's accounted for averages of 5-9% of the spring populations, and their average densities ranged from 80/mile in the Mecan River to 216/mile in Emmons Creek. Average size ranged from 9.6 in. in Emmons Creek to 10.7 in. in the Mecan

*Native brook trout were captured occasionally in each of the streams but were unimportant in terms of numbers or standing stock. Rainbow trout, captured only in the Mecan River, were of greater importance than brook trout but were still insignificant relative to the brown trout population present. Only brown trout are discussed in this report.

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"Brushy" and "meadow" sections of Radley Creek provide a variety of habitat for trout as well as a choice of recreational experience for the angler.

River. Although 5- and 6-year-old trout were identified through scale analysis, an average of 2% or less of the spring populations in the four streams consisted of trout 4 or more years old. The average densities of trout 4 years old and older ranged from 8/mile in Wedde Creek to 35/mile in Emmons Creek.

Legal-sized trout (≥6.0 in.) made up 29-44% of the spring populations in the study streams and represented from 68 to 81% of the average standing stocks (Table 3). Average densities ranged from 512/mile in the Mecan River to 923/mile in Emmons Creek, and their average size ranged from 7.8 in. in Wedde Creek to 8.6 in. in the Mecan River.

Most legal-sized trout present in the spring were age II's and III's (Table 5). Two-year-olds had averages ranging from 62 to 72% of the legal populations, while age III averages ranged from 17 to 23%. Generally less than 5% of the legal trout were either yearlings or age IV+'s. The exception occurred in the spring of 1976, when legal yearlings comprised over 40% of the legal trout present in both Wedde Creek and the Mecan River. The average size and density of yearlings in these two streams were greater in the spring of 1976 than in any other year of study; there was thus an unusually high percentage of legal fish in spring 1976.

The average density of trout larger than 10 in. present in the spring ranged from 54/mile in Wedde Creek to 127/mile in Radley Creek; 10+-in. trout comprised from less than 3% of the spring populations in Wedde Creek to 8% of the populations in the Mecan River (Table 6). The average density of trout at least 12 in. in length ranged from 7/mile in Wedde Creek to 23/mile in Radley Creek. Such trout made up roughly 1% of the spring populations. A 19-in. trout in Wedde Creek and a 17-in. fish in Emmons Creek (both captured in 1976) were the two largest brown trout captured in the spring during the 3-year study.

Fall 1975-77

The average fall density of brown trout (age 0 and older) ranged from 2,950/mile in the Mecan River to 4,710/mile in Wedde Creek (Table 7). The average fall density in the study streams as a whole was 3,480/mile, an increase of 1,460/mile from the spring mean. Most of this increase was due to the addition of the new class (age 0's) into the population estimates in each stream. Average standing stocks ranged from 74 lb/acre in the Mecan River to 163 lb/acre in Wedde Creek, with an overall average of 130 lb/acre. The last figure represented an increase of 34 lb/acre since the spring, the result of the addition of age 0's into the populations, trout growth, and immigration of mature trout into the study areas in preparation for spawning in October and November.

The 5.0-5.9 in. interval was the area of overlap between age 0 and age I fish in the fall; relatively few trout were in this size range. The average percentage of the fall populations consisting of age 0 fish ranged from 45% in Emmons Creek to 77% in Wedde Creek* (Table 8). Average densities ranged from 1,400/mile in Emmons Creek to 3,640/mile in Wedde Creek. Legal-sized fingerlings (age 0) were rare. Average size of age 0's for the 3-year period was almost identical in all streams, while year-to-year differences within streams varied as much as 0.6-in. Average yearling densities in the fall ranged from 676/mile in the Mecan River to 1,132/mile in Emmons Creek. Age I's comprised an average of 20-36% of the fall populations. Their mean length ranged from 6.8 in. in both Emmons and Wedde creeks to 7.2 in. in the Mecan River.

The average percentage of the fall populations comprised by age II's ranged from 4% in Wedde Creek to 16% in Emmons Creek (Table 8). Average densities of 2-year-old fish ranged from 162/mile in the Mecan River to 496/mile in Emmons Creek, and their average size ranged from 8.8 in. in Emmons Creek to 9.8 in. in the Mecan River. The average density of brown trout at least 3 years of age ranged from 51/mile in Wedde Creek to 188/mile in Emmons Creek. This age group accounted for only 1-6% of the fall populations. Distinction between the age III and age IV+ components of the fall population in each stream was possible in only one of the three years due to high percentages of regenerated scales in samples taken from the larger trout. Densities of age IV+ trout are presented in Table 8 but have been incorporated into the statistics presented under age III+. The oldest trout verified by scale analysis was a 7-year-old fish captured in the Mecan River.

Legal brown trout represented 20-50% of the average fall populations and from 67 to 89% of the average standing stocks in weight in the study

*Age 0 was the only age group determined in the fall of 1975 and in three of the four streams comprised the highest percentage of the fall populations of any year of the study. The average percentages of age I's, II's, and III+'s presented in Table 8 are therefore higher than their corresponding values for the 1975-77 period would have been had they been able to be determined in 1975.

TABLE 3. *Brown trout population characteristics in four central Wisconsin trout streams in the spring, 1976-78.*

Stream	Average Density (No./mile)	Average Biomass (lb/acre)	Legal Trout* Average Density (No./mile)	Legal Trout* Average Biomass (lb/acre)	Legal Trout* Average Percent of Population	Legal Trout* Average Percent of Biomass	Legal Trout* Average Size (in.)
Emmons Creek	2,500	100	923	79	39	79	8.0
Radley Creek	2,320	114	824	91	35	80	8.4
South Branch Wedde Creek	1,990	112	608	78	29	68	7.8
Mecan River	1,270	59	512	47	44	81	8.6
Grand Average	2,020	96	717	74	37	77	8.2

*≥6.0 in.

TABLE 4. *Density (no./mile), percent composition, and average length (in.) by age class of brown trout in four central Wisconsin streams, spring 1976-78.*

		Age Class I			Age Class II			Age Class III			Age Class IV+	
Stream	Year	No./mile	Percent	In.	No./mile	Percent	In.	No./mile	Percent	In.	No./mile	Percent
Emmons Creek	1976	1,400	60	4.5	727	31	7.6	211	9	10.4	12	<1
	1977	2,180	67	4.5	753	23	7.3	290	9	9.4	37	1
	1978	1,040	56	4.7	628	34	7.1	148	8	8.9	55	3
Avg.		1,540	61	4.6	703	29	7.3	216	9	9.6	35	2
Radley Creek	1976	1,640	73	4.4	456	20	7.9	139	6	10.5	6	<1
	1977	1,250	67	4.7	503	27	7.8	109	6	10.3	15	<1
	1978	1,680	59	4.7	800	28	7.7	307	11	9.8	61	2
Avg.		1,520	66	4.6	586	25	7.8	185	8	10.2	27	1
South Branch Wedde Creek	1976	2,370	81	5.3	396	14	8.6	147	5	10.2	9	<1
	1977	1,180	77	4.3	303	20	7.4	51	3	9.9	6	<1
	1978	1,090	73	4.6	305	20	7.3	88	6	9.1	9	<1
Avg.		1,550	77	4.7	335	18	7.8	95	5	9.7	8	<1
Mecan River	1976	1,150	76	5.5	296	20	9.1	50	3	11.7	17	1
	1977	1,140	71	4.8	349	22	8.3	104	6	10.5	5	<1
	1978	300	43	5.3	287	41	8.3	87	12	10.0	24	3
Avg.		860	63	5.2	311	28	8.6	80	7	10.7	15	2

TABLE 5. *Age composition (percent of total) of legal-sized brown trout (≥ 6.0 in.) in four central Wisconsin trout streams in the spring, 1976-78.**

Stream	Year	Age Class I	Age Class II	Age Class III	Age Class IV+
Emmons Creek	1976	3	74	22	1
	1977	2	68	27	3
	1978	1	73	19	7
Avg.		2	72	23	4
Radley Creek	1976	9	68	22	1
	1977	3	78	17	2
	1978	2	67	26	5
Avg.		5	71	21	3
South Branch Wedde Creek	1976	47	38	14	1
	1977	2	82	14	2
	1978	2	74	22	2
Avg.		17	65	17	2
Mecan River	1976	42	47	8	3
	1977	3	74	22	1
	1978	8	66	20	6
Avg.		18	62	17	3

*Age-specific densities of the spring populations are presented in Table 31.

streams (Table 7). Average densities ranged from 772/mile in Wedde Creek to 1,550/mile in Emmons Creek and their average size ranged from 7.8 in. in Wedde Creek to 8.2 in. in the other streams. A composite average density of 1,100/mile represented an increase of 383/mile since the spring. This increase was due primarily to growth and recruitment of age I's into the legal size range.

The majority of legal-sized trout present in the fall were age I's and II's (Table 9). Even though not all yearlings had reached legal size by fall, those which had comprised averages of 56-75% of the legal trout present in the study streams. Age II's accounted for 19%-31% of the legal fish present, while age III+'s represented from 5% to 12%.

The average density of trout larger than 10 in. present in the fall ranged from 94/mile in Wedde Creek to 219/mile in Emmons Creek and comprised from less than 3% to 7% of the fall populations, respectively (Table 10). Overall, there was an average increase of 59/mile since the spring. Trout over

12 in. comprised an average of 1% of the fall populations, just as they had in the spring. This was equivalent to 36/mile and an average increase of 21/mile since the spring, however.

The most significant increases in trout over 10 in. and 12 in. between spring and fall occurred in Emmons and Radley creeks. These streams showed an accumulative average increase of 87/mile over 10 in. and 31/mile over 12 in. Comparable increases in Wedde Creek and the Mecan River averaged 31/mile and 12/mile, respectively. Thuemler (1976) noted significant movement of adult brown trout into the upper reaches of Sidney Creek in northeastern Wisconsin between spring and fall and concluded that much of it was due to the preferred spawning habitat found there. An obvious movement of larger, mature trout into the study zones of Emmons and Radley creeks was observed during this study in late September through early October and was also considered to be related to the onset of spawning activities. Mass immigration was not observed in either Wedde Creek or the Mecan River. Some immigration occurred, however, as evidenced by the presence of a few trout as large as 18-21 in. which were not present in the spring. The largest brown trout captured in the fall was a 23-in. specimen from Emmons Creek.

Growth

Most brown trout hatch and emerge in central Wisconsin in late February and early March. Brown (1946; 1951) found that brown trout fry average 0.9-in. when they reach the "swim-up" stage and begin feeding. Assuming this is also the case in central Wisconsin, growth increments of brown trout during their first 7-8 months after reaching the swim-up stage averaged 2.9 in. in three of the streams and 3.0 in. in the other (Table 11). Within-stream differences in average summer growth of age 0's ranged from 0.2-in. to 0.4-in. during the study period. The summer of best growth varied from stream to stream.

Mean size of fall fingerlings when plotted against fingerling density in the fall indicated an inverse relation between growth and density in the Mecan River and suggested a similar relation in Radley Creek and possibly in Wedde Creek (Fig. 2). Fingerling growth appeared to be independent of density in Emmons Creek at least over the narrow range of densities observed. An inverse relation between fingerling growth and density has been observed in other Wisconsin brown trout

TABLE 6. *Density (no./mile) and percent composition by size class of brown trout in four central Wisconsin trout streams in the spring, 1976-78.*

		Size Class (in.)													
		<6		6-7		8-9		10-11		12-13		14-15		16+	
Stream	Year	No./mile	Percent	No./mile	Percent	No./mile	Percent	No./mile	Percent	No./mile	Percent	No./mile	Percent	No./mile	
Emmons Creek	1976	1,390	59	466	20	354	15	128	5	14	1	2	<1	1	
	1977	2,190	67	628	19	325	10	105	3	13	<1	2	<1		
	1978	1,140	61	463	25	231	12	34	2	5	<1	1	<1		
Avg.		1,570	62	519	21	303	12	89	3	11	<1	2	<1		
Radley Creek	1976	1,600	71	290	13	243	11	90	4	19	1	1	<1		
	1977	1,230	65	318	17	234	12	71	4	23	1	3	<1		
	1978	1,670	59	503	18	505	18	151	5	21	1	1	<1	1	
Avg.		1,500	65	370	16	327	14	104	4	21	1	2	<1		
South Branch Wedde Creek	1976	1,850	63	609	21	354	12	98	3	8	<1	1	<1	1	
	1977	1,190	77	218	14	107	7	25	2	6	<1	1	<1		
	1978	1,100	74	235	16	138	9	18	1	1	<1	2	<1		
Avg.		1,380	71	354	17	200	9	47	2	5	<1	2	<1		
Mecan River	1976	882	58	299	20	199	13	97	6	27	2	6	<1		
	1977	1,120	71	135	8	253	16	66	4	11	1	4	<1	1	
	1978	263	38	141	20	215	31	71	10	6	1	2	<1		
Avg.		760	56	192	16	222	20	78	7	15	1	4	<1		

TABLE 7. *Brown trout population characteristics in four central Wisconsin trout streams in the fall, 1975-77.*

Stream	Average Density (No./mile)	Average Biomass (lb/acre)	Legal Trout* Average Density (No./mile)	Legal Trout* Average Biomass (lb/acre)	Legal Trout* Average Percent of Population	Legal Trout* Average Percent of Biomass	Legal Trout* Average Size (in.)
Emmons Creek	3,110	151	1,550	134	50	89	8.2
Radley Creek	3,160	133	1,130	111	36	83	8.2
South Branch Wedde Creek	4,710	163	955	112	20	67	7.8
Mecan River	2,950	74	772	56	30	77	8.2
Grand Average	3,480	130	1,100	103	34	79	8.1

*≥ 6.0 in.

TABLE 8. *Density (no./mile), percent composition, and average length (in.) by age class of brown trout in four central Wisconsin streams, fall, 1975-77.*

		Age Class													
		0*			I			II			III+**			IV+	
Stream	Year	No./mile	%	In.	No./mile	%	In.	No./mile	%	In.	No./mile	%	In.	No./mile	%
Emmons Creek	1975	1,520	51	3.7	(1,490 Age I+)										
	1976	1,720	52	3.9	1,010	31	6.9	446	13	8.9	121	4			
	1977	958	32	3.8	1,260	42	6.6	546	18	8.7	243	8	10.2	11	
Avg.		1,400	45	3.8	1,130	36	6.8	496	16	8.8	188	6			
Radley Creek	1975	2,380	72	3.5	(927 Age I+)										
	1976	1,710	60	4.1	777	27	7.3	306	11	10.0	46	2	12.5	19	1
	1977	1,720	52	3.7	1,080	33	6.7	425	13	9.2	75	2	11.1	21	1
Avg.		1,940	61	3.8	930	30	7.0	366	12	9.6	81	2	11.8		
South Branch Wedde Creek	1975	3,160	83	3.9	(638 Age I+)										
	1976	5,510	76	3.5	1,360	19	7.0	272	4	9.7	71	1			
	1977	2,250	72	3.9	687	22	6.5	158	5	8.6	24	1	10.8	6	1
Avg.		3,640	77	3.8	1,020	20	6.8	215	4	9.2	51	1			
Mecan River	1975	3,070	84	3.7	(602 Age I+)										
	1976	2,630	74	3.9	730	21	7.4	146	4	10.1	25	1			
	1977	784	47	4.0	622	37	7.0	177	11	9.4	66	4	11.2	12	
Avg.		2,160	68	3.9	676	29	7.2	162	8	9.8	52	2			

*Age 0 was the only age group determined in the fall of 1975 and in three of the four streams comprised the highest percentage of the fall populations of any year of the study. The average percentages of age I's, II's, and III+'s presented are therefore higher than these length values for the 1975-77 interim would have been had they been able to be determined in 1975.

**Average length of age III trout is presented whenever a density of age IV+ trout is given. However, average density and percentages of age III+ trout include age IV+ trout.

TABLE 9. *Percent age composition of legal-sized brown trout (≥ 6.0 in.) present in four central Wisconsin trout streams in the fall, 1975-77.**

Stream	Year	Age Class I	Age Class II	Age Class III+
Emmons Creek	1976	61	31	8
	1977	54	31	15
Avg.		56	31	12
Radley Creek	1976	66	28	6
	1977	63	30	7
Avg.		64	29	6
South Branch Wedde Creek	1976	78	17	5
	1977	72	23	5
Avg.		75	20	5
Mecan River	1976	81	16	3
	1977	69	22	9
Avg.		75	19	6

*Age-specific densities of the fall populations (including age 0) are presented in Table 31.

streams by Lowry (1971) and Brynildson and Mason (1975).

Average growth of brown trout over their first winter ranged from 0.7-in. in Radley Creek to 1.3 in. in the Mecan River (Table 11). Overwinter growth of fingerlings was more rapid in the Mecan River and Wedde Creek, the two most southerly streams, and resulted in significantly larger spring yearlings in the Mecan River and slightly larger yearlings in Wedde Creek than in Emmons and Radley creeks.

Average summer growth of yearlings ranged from 1.9 to 2.7 in. with the most rapid growth occurring in Radley and Emmons creeks (Table 11). The average size of yearlings in the fall was still larger in the Mecan River than in the three other streams. The average yearling in both Radley and Emmons creeks was now larger than the average yearling in Wedde Creek, however. The average annual growth increment from fall to fall for age 0-I ranged from 2.6 to 3.8 in., with a composite average of 3.2 in.*

Brown trout growth during their second winter ranged from an average of 0.4-in. to 1.1 in. (Table 11). Growth was most rapid in the Mecan River followed by that in Radley, Wedde, and Emmons creeks. Summer growth of age II's followed the same pattern as age I's, i.e., more rapid in Emmons and Radley creeks than in Wedde Creek and the Mecan River.** Summer growth ranged from 1.1 to 1.4 in., with a composite average of 1.3 in. Average size of 2-year-olds in the fall was greater in the Mecan River and Radley Creek than in Wedde and Emmons creeks. The average annual growth increment from fall to fall for age I-II

*Computed only on the 1975 and 1976 year classes for which complete information is available.

**Computed only on the 1975 year class for which complete information is available.

TABLE 10. *Density (no./mile) and percent composition by size class of brown trout in four central Wisconsin trout streams in the fall, 1975-77.*

Stream	Year	Size Class (in.) <6		6-7		8-9		10-11		12-13		14-15		16+	
Emmons Creek	1975	1,570	52	806	27	378	12	172	6	52	2	30	1	7	<1
	1976	1,830	56	882	27	409	12	126	4	35	1	7	<1	2	<1
	1977	1,280	41	1,050	34	459	15	188	6	27	1	4	<1	5	<1
Avg.		1,560	50	912	29	415	13	162	5	38	1	14	1	5	<1
Radley Creek	1975	2,430	73	489	15	253	8	104	3	27	1	6	<1	0	0
	1976	1,760	61	557	20	316	11	174	6	36	1	10	<1	8	<1
	1977	1,930	58	854	26	359	11	149	4	30	1	3	<1	3	<1
Avg.		2,040	64	633	20	309	10	142	4	31	1	6	<1	3	<1
South Branch Wedde Creek	1975	3,180	84	369	10	180	5	63	2	7	<1	1	<1	0	0
	1976	5,650	78	1,040	14	350	5	149	2	20	<1	4	<1	1	<1
	1977	2,450	78	509	16	130	4	30	1	7	<1	2	<1	0	0
Avg.		3,760	80	639	13	220	5	81	2	11	<1	2	<1	<1	<1
Mecan River	1975	3,070	84	305	8	203	6	48	1	20	1	8	<1	3	<1
	1976	2,640	75	543	15	242	7	76	2	18	1	7	<1	4	<1
	1977	830	50	521	31	182	11	99	6	18	1	6	<1	5	<1
Avg.		2,180	70	456	18	209	8	74	3	22	1	7	<1	4	<1

ranged from 1.6 to 2.0 in., with a composite average of 1.8 in.

Average growth of brown trout during their third winter ranged from 0.2-in. to 0.6-in., with a composite average of 0.5-in. (Table 11). With the exception of an average overwinter growth of 0.2-in. in Emmons Creek, there was little difference in the average overwinter growth of 2-year-olds in the study streams. Total growth of the 1975 year class during 38 months of life averaged from 7.9 in. in Emmons Creek to 9.1 in. in the Mecan River, with an accumulative average of 8.6 in. or 0.23-in./month in all streams.

In summary, there was little difference in the average growth of brown trout during their first summer. Thereafter, overwinter growth tended to be greater in the Mecan River and Wedde Creek, while summer growth was faster in Emmons and Radley creeks. Overall, trout growth was most rapid in the Mecan River, resulting in larger-sized trout at any given age. In Wedde Creek trout growth during their first 14 months was slightly faster than in Radley Creek and resulted in slightly larger spring yearlings. Subsequent growth was more rapid in Radley Creek, however, and resulted in larger trout throughout the remainder of their lives. The slowest growth of trout occurred in Emmons Creek and with few exceptions resulted in smaller trout at any given age. Only growth of some age 0 stocks appeared to be density dependent.

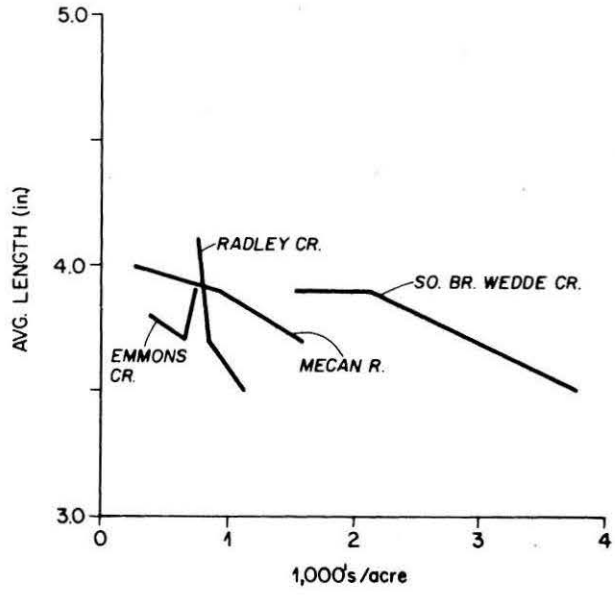


FIGURE 2. *Mean size vs density of fall fingerling (age 0) brown trout in four central Wisconsin trout streams.*

Survival

Overwinter survival of all age groups of brown trout was generally better in Emmons and Radley creeks than in Wedde Creek and the Mecan River (Table 12). Average overwinter survival of age 0's ranged from 40% in the Mecan River to 107% in Emmons Creek. Overwinter survival in excess of 100% occurred in 2 of the 3 years of study on Emmons Creek and indicated an extensive immigration of fall fingerlings or spring yearlings into the study area between the fall and spring population inventories. This was not too surprising, since a segment of the trout population in Emmons Creek is known to be anadromous, i.e., living in the stream for 1 or 2 summers, then migrating downstream to Long Lake where they mature and subsequently return to Emmons Creek to spawn. Mature trout moving into Emmons Creek each fall are readily discernible from stream trout by their silvery color, firmer flesh, and slimmer appearance.

Average overwinter survival of age 0's in Radley Creek was 82% and compared favorably with an overwinter survival of 79% in McKenzie Creek in northwestern Wisconsin (Lowry

TABLE 11. *Average length (in.) and growth increments (in parentheses) of brown trout in four central Wisconsin trout streams.*

		Age Group					
		0	I		II		III
Stream	Year	Fall	Spring	Fall	Spring	Fall	Spring
Emmons Creek	1975	(2.8) 3.7					
	1976	(3.0) 3.9	(0.8) 4.5	(2.4) 6.9			
	1977	(2.9) 3.8	(0.6) 4.5	(2.1) 6.6	(0.4) 7.3	(1.4)8.7	
	1978		(0.9) 4.7		(0.5) 7.1		(0.2) 8.9
Avg.		(2.9) 3.8	(0.8) 4.6	(2.2) 6.8	(0.4) 7.2	(1.4) 8.7	(0.2) 8.9
Radley Creek	1975	(2.8) 3.7					
	1976	(3.2) 4.1	(0.7) 4.4	(3.1) 7.3			
	1977	(2.8) 3.7	(0.5) 4.6	(2.1) 6.7	(0.5) 7.8	(1.4) 9.2	
	1978		(1.0) 4.7		(1.0) 7.7		(0.6) 9.8
Avg.		(2.9) 3.8	(0.7) 4.6	(2.7) 7.0	(0.8) 7.8	(1.4) 9.2	(0.6) 9.8
South Branch Wedde Creek	1975	(3.0) 3.9					
	1976	(2.6) 3.5	(1.4) 5.3	(1.7) 7.0			
	1977	(3.0) 3.9	(0.8) 4.3	(2.1) 6.4	(0.4) 7.4	(1.2) 8.6	
	1978		(0.7) 4.6		(0.9) 7.3		(0.5) 9.1
Avg.		(2.9) 3.8	(1.0) 4.7	(1.9) 6.7	(0.6) 7.4	(1.2) 8.6	(0.5) 9.1
Mecan River	1975	(2.8) 3.7					
	1976	(3.0) 3.9	(1.8) 5.5	(1.9) 7.4			
	1977	(3.1) 4.0	(0.9) 4.8	(2.2) 7.0	(0.9) 8.3	(1.1) 9.4	
	1978		(1.2) 5.2		(1.3) 8.3		(0.6) 10.0
Avg.		(3.0) 3.9	(1.3) 5.2	(2.0) 7.2	(1.1) 8.3	(1.1) 9.4	(0.6) 10.0
Composite Avg.		(2.9) 3.8	(1.0) 4.8	(2.2) 6.9	(0.7) 7.6	(1.3) 9.0	(0.5) 9.4

TABLE 12. *Overwinter survival (percent) of brown trout in four central Wisconsin trout streams.*

		Age Group		
Stream	Year	0	I	II
Emmons Creek	1975-76	93		
	1976-77	120	68	57
	1977-78	109	50	27
Avg.		107	59	42
Radley Creek	1975-76	69		
	1976-77	80	69	38
	1977-78	98	74	72
Avg.		82	72	55
South Branch Wedde Creek	1975-76	75		
	1976-77	22	22	19
	1977-78	48	44	56
Avg.		48	33	37
Mecan River	1975-76	38		
	1976-77	43	48	71
	1977-78	38	46	49
Avg.		40	47	60

TABLE 13. *Annual survival (percent) of brown trout in four central Wisconsin trout streams (spring to spring).*

		Age Groups	
Stream	Year	I-II	II-III
Emmons Creek	1976-77	49	35
	1977-78	29	20
Avg.		39	28
Radley Creek	1976-77	33	26
	1977-78	64	61
Avg.		48	44
South Branch Wedde Creek	1976-77	13	13
	1977-78	26	29
Avg.		19	21
Mecan River	1976-77	30	35
	1977-78	25	25
Avg.		28	30

1971). In contrast, average overwinter survival in both Wedde Creek and the Mecan River was less than 50% (Table 12).

Mean overwinter survival of age I brown trout ranged from 33% in Wedde Creek to 72% in Radley Creek (Table 12). Corresponding figures for age II trout ranged from 37% in Wedde Creek to 60% in the Mecan River. Lowry (1971) found overwinter survival of yearlings in McKenzie Creek averged 82% and overwinter survival of age II's was 66%.

Annual survival of age I and age II trout ranged from 13% to 64% and from 13% to 61%, respectively (Table 13). The lowest annual survival rate of both age groups, 13%, occurred in Wedde Creek between the spring of 1976 and the spring of 1977. Two successive large year classes (1975 and 1976) were responsible for trout densities reaching more than 7,200/mile in Wedde Creek in the fall of 1976. This exceptionally high density in conjunction with low stream flows resulting from severe drought conditions in 1976 and 1977 contributed to overwinter mortalities exceeding 77% in all age groups. Lower-than-normal stream flows as a result of the 1976-77 drought had no detectable effect upon either overwinter or annual survival in the three other streams, where densities of trout were lower.

Average annual survival of age I brown trout in the individual streams ranged from 19% to 48% (Table 13). Corresponding average annual survival of age II's ranged from 21% to 44%. Annual survival of both age groups was

TABLE 14. *Production (lb/acre) of brown trout in four central Wisconsin trout streams from fall 1975 through spring 1978 (months of life in parentheses).*

		Age Intervals						
Stream	Time Frame	0-1 (8-14)	I (15-19)	I-II (20-26)	II (27-31)	I-III (32-38)	III (39-43)	Totals
Emmons Creek	Fall to spr. 1975-76	8						8
	Spr. to fall 1976		43		20			63
	Fall to spr. 1976-77	7		11		9		27
	Spr. to fall 1977		42		21		4	67
	Fall to spr. 1977-78	6		13		5		24
	Year class totals			62		88		
Radley Creek	Fall to spr. 1975-76	7						7
	Spr. to fall 1976		56		31			87
	Fall to spr. 1976-77	8		17		6		31
	Spr. to fall 1977		39		16		3	58
	Fall to spr. 1977-78	15		30		11		56
	Year class totals			77		107		
South Branch Wedde Creek	Fall to spr. 1975-76	55						55
	Spr. to fall 1976		69		12			81
	Fall to spr. 1976-77	25		22		5		52
	Spr. to fall 1977		39		11		2	52
	Fall to spr. 1977-78	15		16		4		35
	Year class totals			80		162		
Mecan River	Fall to spr. 1975-76	26						26
	Spr. to fall 1976		21		3			24
	Fall to spr. 1976-77	9		16		4		29
	Spr. to fall 1977		23		7		3	33
	Fall to spr. 1977-78	5		15		4		24
	Year class totals			47		74		

generally higher in Emmons and Radley creeks than in Wedde Creek and the Mecan River.

Production

Production is the growth in weight by all trout of a given age group during a specified time interval, including the growth of trout which died during the interval. Production of age 0 brown trout during their first 7 months of life and of age III+ trout beyond their 43rd month of life could not be determined because of insufficient population and growth data. Allen (1951) found that approximately 95% of the estimated total production of a year class of brown trout occurred during their first 2 years, while Hunt (1966) found a corresponding value of 88% by brook trout. It is therefore recognized that the unknown production occurring during the initial 7 months of life in this study could represent a significant proportion of the total production of an individual age group. In contrast, the unknown production by age III+ brown trout can be assumed to be relatively insignificant because of their low numbers and slower growth rates.

Production by the 1975 year class from their 8th through 38th months of life ranged from 74 lb/acre in the Mecan River to 162 lb/acre in Wedde Creek (Table 14). With the exception of the Mecan River, the greatest amount of fish flesh was produced during their second summer of life as age I's. Production during this 5-month interval ranged from 21 lb/acre in the Mecan River to 69 lb/acre in Wedde Creek and represented 28% to 52% of the total production measured, respectively. The highest production by the 1975 year class in the Mecan River occurred over their first winter during the initial period of measurement.

Production by the 1976 year class from their 8th through 26th months of life ranged from 47 lb/acre in the Mecan River to 80 lb/acre in Wedde Creek (Table 14). The greatest production occurred during their second summer of life in all streams. During this 5-month interval, from 23 lb/acre in the Mecan River to 42 lb/acre in Emmons Creek were produced and represented 49% to 68%, respectively, of the totals measured during the 18 months of study.

In the absence of an estimate of summer production by age 0's, the summer production by age I's dominated the summer production by all age groups in all streams during both years of the study (Table 14). During the summer of 1977 when estimates for three age clases were made, production by yearling trout comprised 62% to 75% of the total production.

THE SPORT FISHERIES

Fishing Pressure

Estimated fishing pressure in 1976 on the four central Wisconsin streams in the study ranged from 324 hours/acre on Radley Creek to 534 hours/acre on Wedde Creek (Table 15). Average pressure on all streams was 398 hours/acre and was equivalent to 3.1 angler trips/mile/day throughout the fishing season. Wedde Creek and the Mecan River received an average of 42% more fishing than Emmons and Radley creeks even though the fishing season closed 3 weeks earler on these two streams due to severe drought and hazardous fire conditions in Waushara County.

In 1977, the fishing pressure was more equitably distributed among the streams, ranging from 322 hours/acre on Wedde Creek to 376 hours/acre on the Mecan River (Table 15). Average pressure on all streams was 347 hours/acre and was equivalent to 2.8 angler trips/mile/day. This represented a 13% decline in the average pressure from 1976, in large part due to a 40% decline in the pressure on Wedde Creek. A 6% decline in pressure occurred on the Mecan River, while pressure on Emmons and Radley creeks showed modest increases of 6% and 4%, respectively. Average fishing pressure on the individual streams during the 2-year period were substantially higher on Wedde Creek and the Mecan River than on Emmons and Radley creeks.

The typical distribution of fishing pressure on Wisconsin trout streams, i.e., heavy pressure associated with the opening of the fishing season, was evident in 1976 (Fig. 3). An average of 44% of the season pressure occurred during the first month (May) of the 5-month fishing season, and an average of 60% had occurred by the end of June. A similar but less extreme pattern of fishing pressure was evident in 1977 (Fig. 4), when an average of 33% of the pressure occurred in May while an average of 54% had occurred by the end of June.

The distribution of fishing pressure by day type during both the 1976 and 1977 fishing seasons adhered closely to preliminary information gathered in 1975 which indicated that 50% of the pressure occurred on weekends and holidays and 50% on weekdays.

For the study streams as a whole, 50% of the total season pressure in 1976 was exerted on weekends and holidays and 50% on weekdays (Table 16). In 1977, an average of 47% of the season pressure occurred on weekends and holidays and 53% on weekdays. If we consider the streams individually, Emmons Creek received slightly more pressure on weekends and holidays than on weekdays during both years of study. The reverse was true on Radley and Wedde creeks which received more pressure on weekdays during both 1976 and 1977. On the Mecan River more fishing pressure was exerted on weekends and holidays in 1976 and on weekdays in 1977.

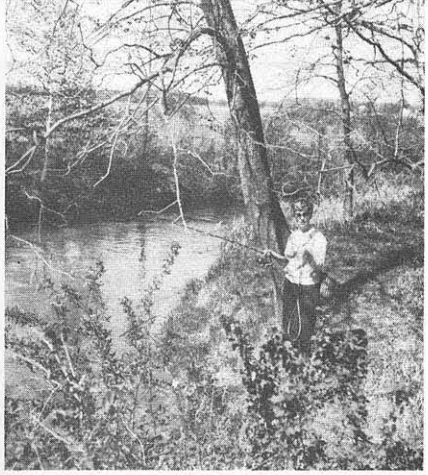
The daily distribution of fishing pressure* during the two fishing seasons indicated that most anglers fished during the morning and early afternoon between 7:30 a.m. and 1:30 p.m. This was true both on weekdays and on weekends and holidays on all four streams. Although late evening fishing is often associated with brown trout fisheries, the lightest pressure observed in this study occurred after 7:30 p.m. and before 7:30 a.m. during the last and first 2-hour census periods, respectively.

Harvest

Estimated angler harvest of brown trout during the 1976 fishing season ranged from 347/mile in Emmons Creek to 573/mile in Wedde Creek and averaged 425/mile for all streams (Table 17). The total weight of fish creeled averaged 52 lb/acre and ranged from 35 lb/acre for the Mecan River to 91 lb/acre from Wedde Creek. The

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

Opening morning of the statewide trout fishing season on the Mecan River. Angler use on opening weekend averages 70 trips/mile/day on central Wisconsin trout streams, but averages 3 trips/mile/day throughout the entire 5-month fishing season.



Females comprise approximately 6% of the anglers fishing wild brown trout streams in central Wisconsin. Here one plies the waters of Emmons Creek in mid-May.

average size of creeled trout ranged from 8.7 in. in Radley Creek to 9.3 in. in the Mecan River and averaged 9.0 inches from all streams.

Trout less than 10 in. in length comprised 65% to 79% of the total harvest from individual streams in 1976 and averaged 74% (Table 18). Most of these trout were in the 8- or 9-inch groups. An average of 22% of the trout creeled were from 10 to 11.9 in. in length and an average of only 4% were longer than 12 in. More large trout were taken from the Mecan River than from any of the other streams.

Angler harvest during the 1976 trout season consisted primarily of age II's (Table 19). Age structure of the monthly harvest varied considerably but was generally dominated by age II's during May, June, and July (Fig. 5; Append. Table 29). Yearlings became more important than age II's in July in Wedde Creek and the Mecan River, and comprised the bulk of the harvest from all streams during August. Age II's again dominated the harvest in September. Three-year-old and older trout were important in the creel (comprising at least 10% of the harvest) only during May and June.

In 1977, estimated harvest of brown trout ranged from 267/mile in Wedde Creek to 373/mile in Emmons Creek and averaged 320/mile for all four streams (Table 17). The total weight creeled averaged 37 lb/acre and ranged from 32 lb/acre in Emmons Creek to 46 lb/acre in Wedde Creek. Both the number and biomass of trout creeled were 29% less than in 1976. Significant declines in the legal populations present in the Mecan River and Wedde Creek as well as in the amount of fishing pressure exerted on these two streams were responsible for the overall decline in trout harvest. Average size of creeled trout ranged from 8.5 in. in Emmons Creek to 9.5 in. in the Mecan River and averaged 8.9 in. The only notable change in the average size of creeled trout was a 0.4-in. decline in Emmons Creek as compared with the 1976 harvest data.

FIGURE 3. *Accumulated fishing pressure exerted on four central Wisconsin brown trout streams during the 1976 fishing season.*

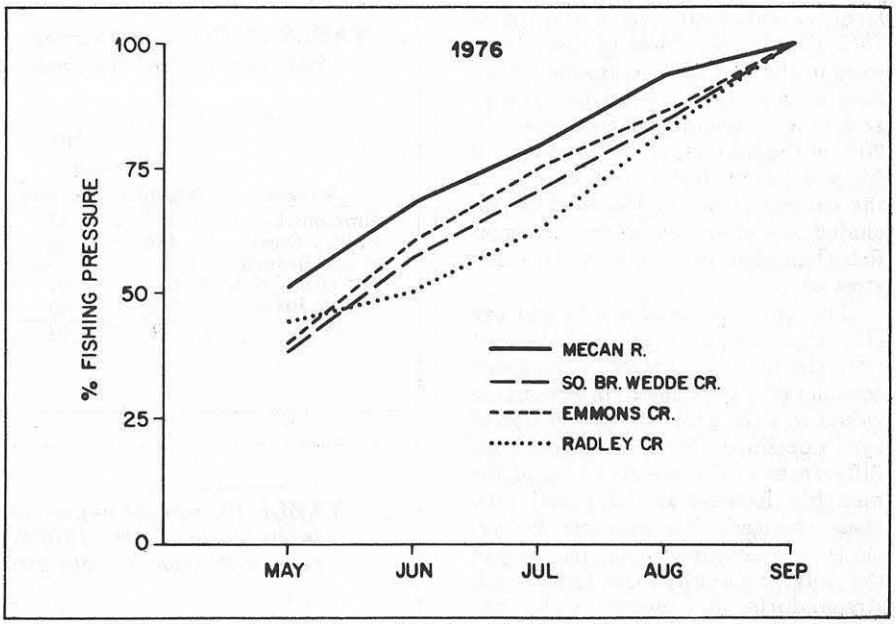


FIGURE 4. *Accumulated fishing pressure exerted on four central Wisconsin brown trout streams during the 1977 fishing season.*

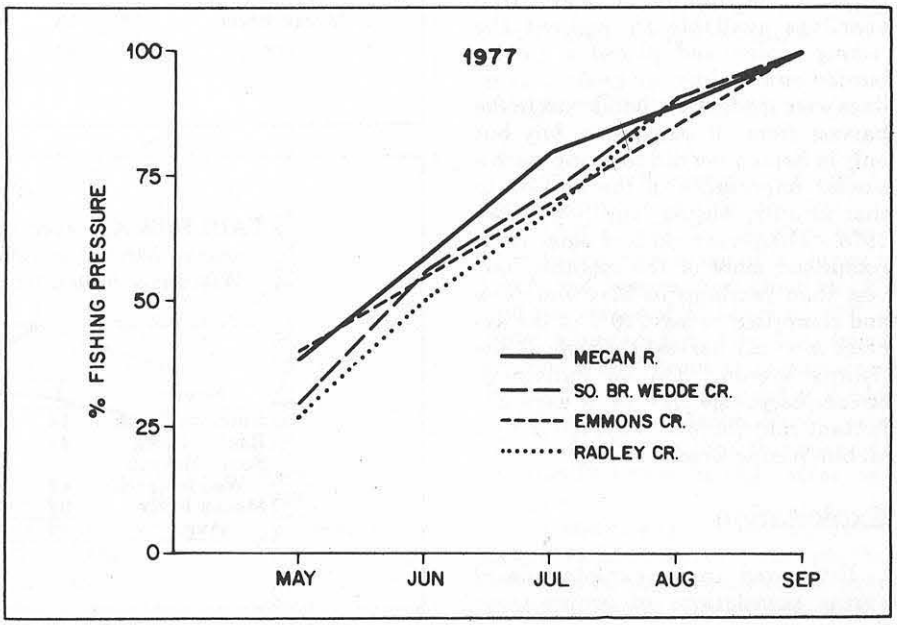


TABLE 15. *Estimated fishing pressure (hours/acre) on four central Wisconsin brown trout streams, 1976-77.*

Stream	1976	1977	1976-77 Avg.
Emmons Creek	333	354	344
Radley Creek	324	337	331
South Branch Wedde Creek	534	322	428
Mecan River	400	376	388

TABLE 16. *Percent distribution of fishing pressure by weekdays vs weekends plus holidays during 2 fishing seasons on four central Wisconsin brown trout streams (opening weekend excluded).*

	Weekends and Holidays		Weekdays	
Stream	1976	1977	1976	1977
Emmons Creek	57	56	43	44
Radley Creek	47	44	53	56
South Branch Wedde Creek	42	49	58	51
Mecan River	55	41	45	59
Avg.	50	47	50	53

Trout less than 10 in. long comprised 65%-84% of the total harvest from individual streams and averaged 75% (Table 18). Most of these trout were in the 8- and 9-in. groups just as they were in 1976. Trout between 10 and 11.9 in. comprised an average of 20% of the harvest, while an average of 5% was longer than 12 in. As in 1976, the harvest from the Mecan River included a higher percentage of larger fish than that from any of the other streams.

The proportions of age II and age III+ trout in the total 1977 harvest from the four study streams increased considerably over their corresponding values in 1976 while the proportion of age I's declined (Table 19). Significant differences in the age structure of the monthly harvest in 1977 reflected these changes. For example, 2-year-old trout accounted for the majority of the angler-caught fish from each stream during all 5 months of the fishing season (Fig. 6; Append. Table 30). One reason for this was that yearlings in Wedde Creek and the Mecan River averaged 0.8-in. smaller in the spring of 1977 than in the spring of 1976. This reduced the number of legal-sized yearlings available throughout the fishing season and placed a greater burden on the older age groups. Yearlings were moderately important in the harvest from all streams in July but only in September did they approach a similar importance in the harvest to that in July, August, and September 1976. Three-year-old and older trout comprised more of the monthly harvest than yearlings in May and June and comprised at least 10% of the average monthly harvest throughout the fishing season. On an individual stream basis, age III+ trout were important contributors to the harvest on all but Wedde Creek.

TABLE 17. *Estimated harvest and average size of brown trout creeled from four central Wisconsin trout streams during 1976 and 1977.*

	1976			1977		
	Harvest		Avg. Size	Harvest		Avg. Size
Stream	No./mile	Lb/acre	(in.)	No./mile	Lb/acre	(in.)
Emmons Creek	347	37	8.9	373	32	8.5
Radley Creek	420	46	8.7	282	32	8.8
South Branch Wedde Creek	573	91	8.9	267	46	8.8
Mecan River	359	35	9.3	358	39	9.5
Avg.	425	52	9.0	320	37	8.9

TABLE 18. *Percent angler harvest of brown trout by size intervals during the 1976 and 1977 fishing seasons on four central Wisconsin trout streams.*

	Size Interval (in.)							
	6-7		8-9		10-11		≥12	
Stream	1976	1977	1976	1977	1976	1977	1976	1977
Emmons Creek	23	40	53	39	21	19	3	2
Radley Creek	36	31	39	42	23	21	1	6
South Branch Wedde Creek	27	20	52	64	20	15	2	1
Mecan River	33	13	32	52	24	25	10	10
Avg.	30	26	44	49	22	20	4	5

TABLE 19. *Age-specific composition (percent) of the season harvest in 1976 and 1977 on four central Wisconsin brown trout streams.*

	1976 Age			1977 Age		
Stream	I	II	III+	I	II	III+
Emmons Creek	14	72	14	24	56	20
Radley Creek	41	55	4	21	61	18
South Branch Wedde Creek	46	48	7	19	76	5
Mecan River	36	54	10	14	62	24
Avg.	34	57	9	20	64	17

Exploitation

Estimated angler exploitation of spring populations of brown trout

TABLE 20. *Percent angler exploitation by age group in four central Wisconsin brown trout streams during the 1976 and 1977 fishing seasons (exploitation of age II+ in parentheses).*

	1976				1977			
	Age				Age			
Stream	I	II	III+	Total	I	II	III+	Total
Emmons Creek	4	35(31)	21	15	4	28(26)	23	11
Radley Creek	10	50(41)	13	19	5	34(35)	40	15
South Branch Wedde Creek	11	69(56)	24	20	4	67(60)	22	17
Mecan River	11	65(63)	56	24	4	64(67)	78	22
Avg.	9	55(48)	28	20	4	48(47)	41	16

TABLE 21. *Harvest rate (trout/hour) during the 1976 and 1977 fishing seasons on four central Wisconsin brown trout streams.*

Stream	1976	1977
Emmons Creek	0.5	0.4
Radley Creek	0.4	0.5
South Branch Wedde Creek	0.7	0.5
Mecan River	0.6	0.6
Avg.	0.6	0.5

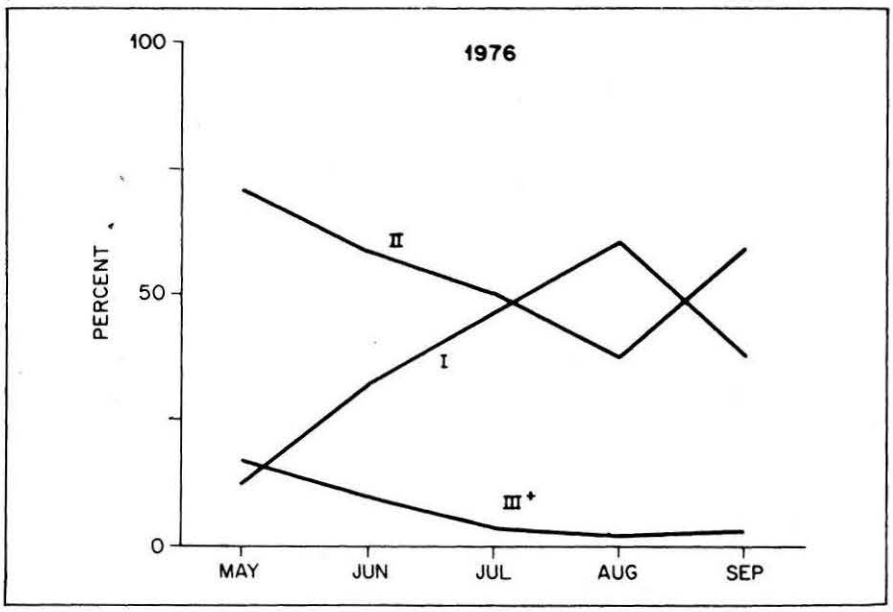


FIGURE 5. *Average age composition (%) of the monthly harvest of brown trout from four central Wisconsin trout streams in 1976.*

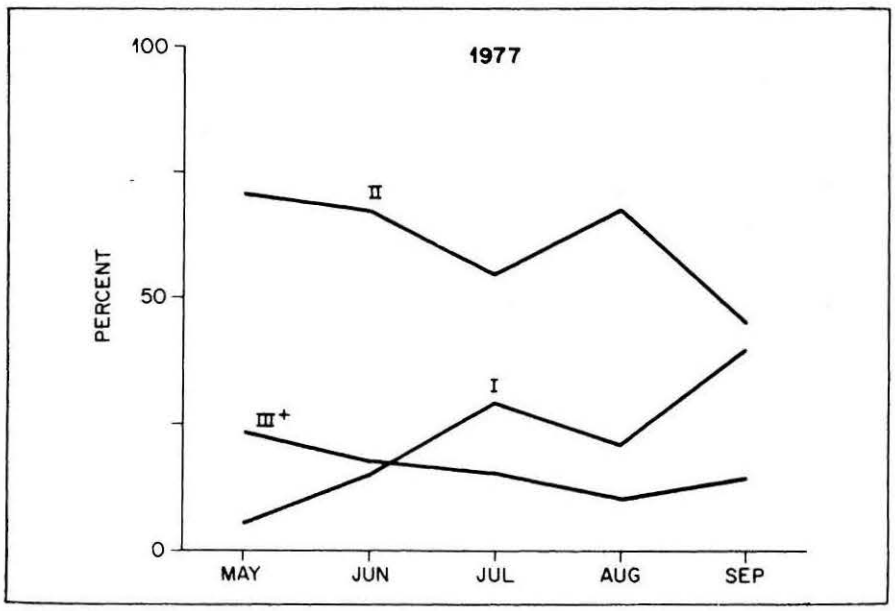


FIGURE 6. *Average age composition (%) of the monthly harvest of brown trout from four central Wisconsin trout streams in 1977.*

ranged from 15% to 24% in 1976, with an average of 20% (Table 20). Exploitation of age I, age II, and age III+ trout averaged 9%, 55%, and 28%, respectively. Exploitation of all age groups was highest at Wedde Creek and the Mecan River, the two streams with the highest angler use.

In 1977, angler exploitation ranged from 11% to 22% and averaged 16% (Table 20). Exploitation of age I, age II, and age III+ trout averaged 4%, 48%, and 41%, respectively. Much higher exploitation of age II trout occurred at Wedde Creek and the Mecan River than at Emmons and Radley creeks, and exploitation of age III+ trout in the Mecan River was noticeably higher than in the other three streams.

Exploitation of age I trout declined in 1977 because fewer legal yearlings were available for harvest, especially during the first half of the trout season when most fishing occurred. The decline in availability of legal yearlings resulted not only in greater harvest but also in higher exploitation of age III+'s in 1977 in all of the study streams except Wedde Creek. Legal yearlings thus serve as a buffer to the exploitation of the older age groups.

Angler Characteristics

Harvest rate averaged 0.6 and 0.5 trout/hour during 1976 and 1977, respectively (Table 21). Anglers, therefore, fished an average of 1.7 hours to catch and keep a legal trout in 1976 and an average of 2.0 hours in 1977. In general, anglers fished 0.6-hour longer to creel a legal trout at Emmons and Radley creeks than they did at Wedde Creek and the Mecan River, even though densities of legal fish were substantially lower in the latter two streams.

Successful anglers, i.e., those who caught at least 1 trout/trip, whether creeled or released, comprised an average of 41% of the anglers interviewed

TABLE 22. *Percentage of anglers interviewed who caught at least 1 brown trout while fishing in one of four central Wisconsin trout streams during 1976 or 1977 (percentage capturing and keeping at least 1 legal brown trout is shown in parentheses).*

Stream	1976		1977	
Emmons Creek	47	(39)	33	(27)
Radley Creek	36	(27)	41	(33)
South Branch Wedde Creek	50	(45)	48	(39)
Mecan River	30	(24)	53	(44)
Avg.	41	(34)	44	(36)

TABLE 23. *Frequency of bag sizes of brown trout creeled from four central Wisconsin trout streams in 1976 and 1977 (data in parentheses represent changes if brook and rainbow trout are included).*

No. Trout Creeled	Emmons Creek		Radley Creek		South Branch Wedde Creek		Mecan River	
	1976	1977	1976	1977	1976	1977	1976	1977
0	106	185	88(87)	125(123)	83(75)	60	179(172)	139(136)
1	19	27	14(13)	21(22)	16(19)	18	25(28)	23(21)
2	11	20	8	15(13)	13(15)	7	9(11)	7(10)
3	10	7	3(5)	5(7)	5(7)	7(5)	7(6)	9
4	4	8	1	6	2(1)	3(4)	2	6(8)
5	6	4	2	0(1)	4(6)	3	2(4)	1
Limits in May*	4	1	1		2(4)	2	1(2)	0
6	0	1	1	1	2	0(1)	0	0
7	1	2	0	2	6(4)	0	1	0
8	0	0	0	1	3(1)	1	1	1
9	2	0	2	0	2(3)	0	0	0
10	1	1	0	0	1(4)	0	0(1)	0
Total Anglers	160	255	119	176	137	99	226	186

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

TABLE 24. *Percentage of anglers traveling various distances (one-way) to fish four central Wisconsin brown trout streams.*

Stream	Miles <25	Miles 26-50	Miles >50	Out of State	No. Interviews
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

TABLE 25. *Duration (hours) of the average fishing trip on four central Wisconsin trout streams in 1976 and 1977.*

Stream	1976	1977	Average
Emmons Creek	1.7	1.6	1.6
Radley Creek	1.6	1.7	1.6
South Branch Wedde Creek	2.3	1.7	2.0
Mecan River	2.0	2.1	2.0
Avg.	1.9	1.8	

TABLE 26. *Duration (hours) of the average fishing trip according to the distance traveled (one-way) to reach one of four central Wisconsin brown trout streams.*

Stream	Year	Distance Traveled (Miles) <25	25-49	>50	>50(Nonresident)
Emmons Creek	1976	1.8	2.3	1.7	0.7
	1977	1.6	1.9	1.3	2.4
Radley Creek	1976	1.7	1.7	1.7	2.0
	1977	2.1	1.5	1.3	1.7
South Branch Wedde Creek	1976	2.3	2.5	2.3	2.6
	1977	1.7	2.2	1.5	1.1
Mecan River	1976	2.0	2.3	2.2	1.4
	1977	0.7	1.7	2.2	2.7

TABLE 27. *Percentage of anglers using various baits while fishing for brown trout in four central Wisconsin trout streams.*

Stream	Worms 1976	Worms 1977	Spinners 1976	Spinners 1977	Flies 1976	Flies 1977	Other 1976	Other 1977	Combination* 1976	Combination* 1977
Emmons Creek	49	60	18	15	9	7	1	2	23	14
Radley Creek	63	55	14	17	10	9	0	3	12	16
South Branch Wedde Creek	61	70	14	13	15	9	2	0	9	6
Mecan River	70	58	10	14	13	14	0	0	7	12
Avg.	61	61	14	15	12	10	1	1	13	12

*Essentially all anglers using one or more baits/trip selected worms as one choice.

in 1976 and 44% of those interviewed in 1977 (Table 22). If success is defined as capturing and keeping at least 1 legal trout/trip, then averages of only 34% and 36% of the anglers interviewed were successful in 1976 and 1977, respectively.

Limit catches of 5 brown trout/day in May were recorded infrequently, and limit catches of 10 trout/day from June through September were rare (Table 23). An average of 92% of the successful anglers (anglers catching and keeping at least 1 trout/trip) caught 1-5 brown trout/trip, while an average of 8% caught 6-10/trip. Considering all anglers, an average of 70% caught nothing, 27% creeled 1-5 brown trout, and only 3% creeled 6-10 brown trout.

The sport fisheries on Emmons and Radley creeks were of a more localized nature than those on Wedde Creek and the Mecan River. During the 1976 and 1977 fishing seasons, an average of 36% and 24%, respectively, of the anglers interviewed on Radley and Emmons creeks lived within a 25-mile radius of the streams (Table 24). Corresponding figures for Wedde Creek and the Mecan River were 12% and 11%, respectively. The Mecan River is one of the largest and most popular trout streams in central Wisconsin* and because of its reputation attracts anglers from greater distances. Wedde Creek, because of its close proximity to the Mecan River, no doubt receives some "spillover" of anglers who come primarily to fish the Mecan River and secondarily to fish streams nearby.

The duration of the average fishing trip** during the two fishing seasons averaged 1.6 hours on Emmons and Radley creeks and 2.0 hours on Wedde Creek and the Mecan River (Table 25). Logically, one would expect that anglers traveling farther to fish would likely stay longer to make their trip worthwhile. This relationship was apparent for anglers traveling less than 25 miles vs those traveling more than 25 miles but could not be extrapolated further (Table 26).

Worms were by far the most popular bait used by trout anglers during this study (Table 27). An average of 61% of the anglers used them exclusively, and another 12-13% used them in conjunction with one or more other baits. Spinner-type baits were the second choice, used by 14-15% of the anglers interviewed. Only 10-12% of the anglers used artificial flies.

*Historically the Mecan River is known for its "fly hatches" and for producing large brown trout in its lower reaches.

**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.

DISCUSSION AND MANAGEMENT CONSIDERATIONS

Assessing the managerial significance of the 11-24% exploitation rates of brown trout populations in the four central Wisconsin streams in this study is hampered by both the scarcity of comparable data on other wild trout populations in Wisconsin and the absence of any published information on size and age structure of unfished trout populations in the state. In an analysis of population dynamics of several species of oceanic fishes having 12-15 age groups, Ricker (1963) concluded that annual exploitation (commercial harvest) of only 5% was sufficient in a few years to cause major reductions in the relative weight and abundance of the older age groups. Although these stocks were not being exploited by sport fishing, it seems reasonable to infer that if such were the case, angling quality would also be diminished by such seemingly insignificant exploitation, even if there were no change in total catch.

Exploitation rates of brown trout in the four study streams were all considerably lower than the rates Hunt et al. (1962) and Hunt (1979) calculated for wild brook trout in two streams located within 25 miles of one of our study streams. Exploitation data from those two studies that are most comparable to data presented here—with the same season length and the same length and bag limit restrictions—show 32% exploitation of brook trout in Lawrence Creek (1955 season) and 25% exploitation of brook trout in Little Plover River (1970, 1972, and 1976 season avg) vs 18% exploitation on the average for brown trout in the Mecan River and Emmons, Radley, and Wedde creeks (1976-77).

The only other quantitative index of exploitation of wild trout populations in Wisconsin is that for brown trout in McKenzie Creek (Lowry 1971). Exploitation of age II+ brown trout in that stream was similar to the 2-year average for trout in these age groups in our study streams (43% vs 48%). Use of the 48% average for all four streams masks, however, an important difference in exploitation of these older age groups among study streams. In the Mecan River and Wedde Creek age II+ exploitation was nearly double the rate calculated for Emmons and Radley creeks, the two more lightly fished streams (62% vs 34%; Table 19).

Exploitation (angling mortality), if high enough, can reduce the spawning stock density to such a low level that natural recruitment, i.e., year class strength, is reduced and becomes insufficient to maintain the population. Most female brown trout in central Wisconsin do not mature until after their third summer of growth (at age II) and until they reach a minimum size of about 8.0 in. (Avery unpubl.). Year class strength (density) of age 0's in the fall was plotted against the density of mature trout present the previous fall just prior to the spawning season (Fig. 7). No relationship was evident. Thus, the levels of exploitation occurring in the four streams during 1976-77 were not seriously affecting natural recruitment.

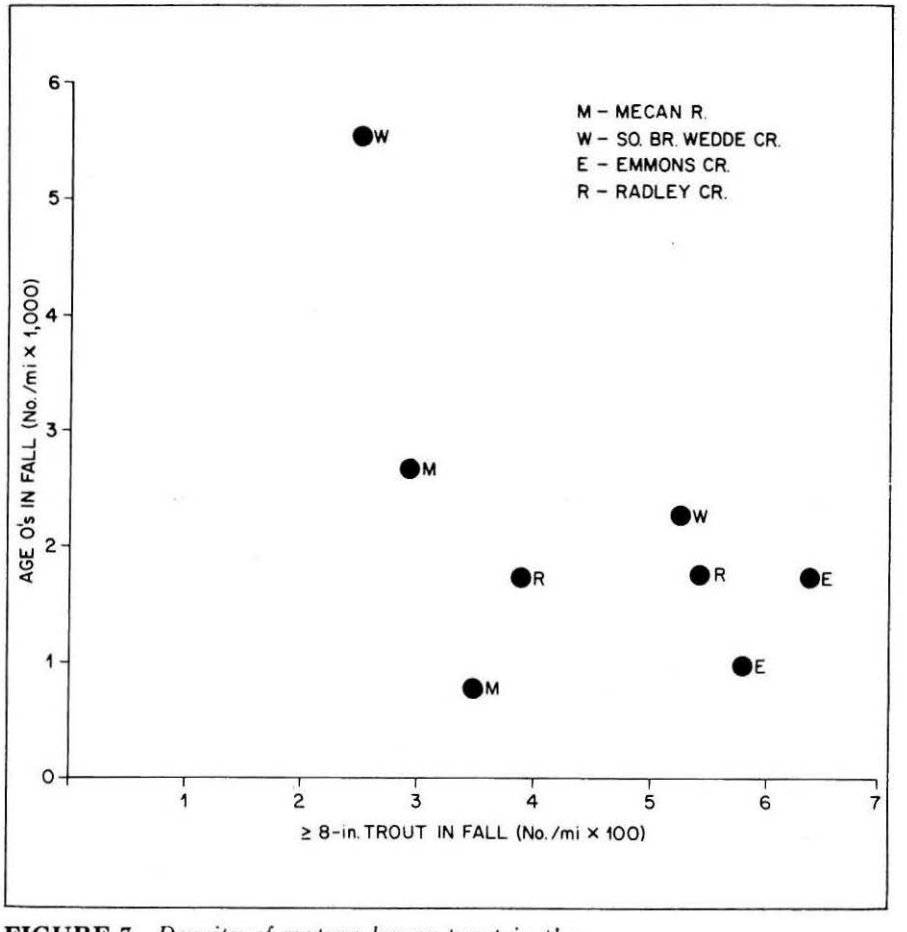


FIGURE 7. *Density of mature brown trout in the fall vs year class strength the following fall in four central Wisconsin trout streams.*

Exploitation of age II+ brown trout proved to be inversely related to the initial stock density, while the relationship of exploitation of age II+ brown trout to angling effort was ambiguous (Figs. 8 and 9). The first relationship is similar in principle to that documented by Hunt et al. (1962) for a brook trout fishery and by Snow (1978) for a northern pike *(Esox lucius)* fishery. Both of the latter investigators, however, found exploitation was also directly dependent upon the amount of angling effort. The relatively narrow range of angling intensity observed in our study (7 of 8 measurements of angling intensity were between 322 and 400 hours/acre) is probably responsible for the absence of a clear relationship between exploitation and angling effort in the four brown trout fisheries. Thus, while both Hunt et al. (1962) and Snow (1978) concluded that an increase in angling intensity caused a proportionately greater depletion of sparse fish populations than of dense populations, our data did not identify a similar relationship in the brown trout fisheries in our study streams.

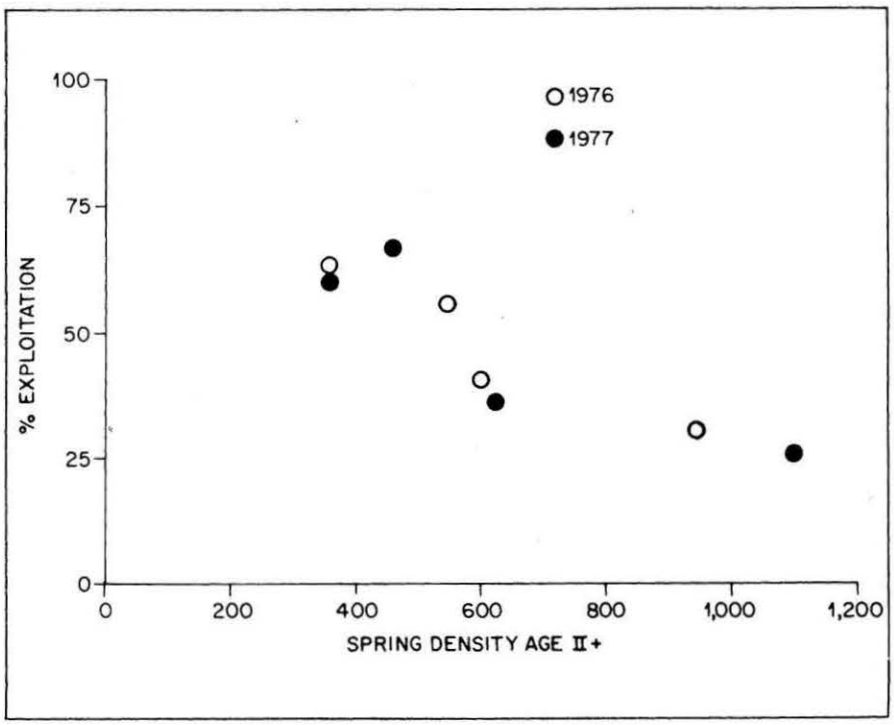


FIGURE 8. *Exploitation vs spring density of age II+ brown trout in four central Wisconsin trout streams during 1976 and 1977.*

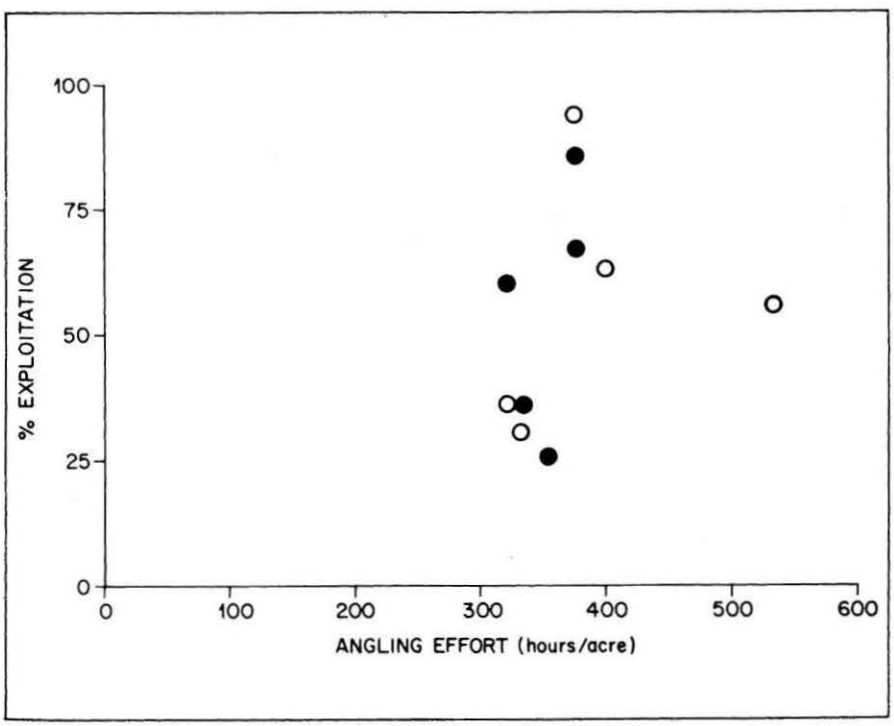


FIGURE 9. *Exploitation vs angling effort in four central Wisconsin trout streams during 1976 and 1977.*

In the spring of 1980 a fortuitous opportunity arose to acquire a quantitative assessment of a brown trout population in a portion of Wedde Creek that for many years had been lightly fished in comparison with other trout streams in the area. In 1979 the Wisconsin DNR purchased privately owned land along a 0.63-mile section of the stream located about 0.75-mile below our study zone. The former private landowner did little trout fishing and actively discouraged public use of the stream. It is likely, therefore, that annual angler use was less than 50 hours/acre.

In April 1980, about a month before the trout fishing season, this newly acquired reach of Wedde Creek was electrofished to inventory its brown trout population. A 0.27-mile portion of the study zone was also electrofished to obtain an updated estimate of its brown trout stock. Results of these two inventories provided strong additional evidence to conclude that levels of angler exploitation we observed during 1976-77 are sufficient to markedly skew size and age composition of wild brown trout populations toward smaller, younger individuals in central Wisconsin streams and as a consequence to reduce angling quality. Total population density in the lightly fished sector of Wedde Creek was excellent (2,830/mile) in April 1980, better than that present in the portion of our upstream study zone on the same date but within the range of spring densities observed in the entire study zone during 1976-78. However, in comparison with the concurrent situation in the study zone, the lightly fished portion of Wedde Creek held nearly twice the density of legal-sized trout (6 in. or longer), 3 times the density of 10-in. or larger trout, and 4.5 times as many trout over 12 in. long (Table 28). In comparison with the average values for the entire study zone during 1976-78, population structure in the lightly fished sector of Wedde Creek was even more impressive—over twice as many legal trout, 5 times as many over 10 in., and nearly 10 times as many over 12 in.

TABLE 28. *Size composition of brown trout populations in a lightly fished portion of the South Branch Wedde Creek compared with similar population structure found in the heavily fished upstream study zone.*

Stream Segment	Date	Total	Density (No./Mile) ≥6 in.	≥10 in.	≥12 in.	≥14 in.	≥16 in.
Lightly fished zone	Apr 80	2,830	1,252	278	67	10	2
Reference sector of study zone	Apr 80	2,519	674	96	15	0	0
Study zone*	Apr 76-78	1,989 (1,496-2,925)**	608	54	7	2	1

*Mean spring densities, 1976-78.
**Range of spring densities during 1976-78.

We believe these striking differences are largely due to differences in exploitation rather than reflections of differing trout-carrying capacity. Although no measure was made of pools and hiding cover for trout in the lightly fished area of Wedde Creek, it was subjectively obvious that it had much less of both than did the upstream study zone where intensive habitat improvement had been instituted, improvement similar to that quantified by Hunt (1971) and designed specifically to enhance these two components of trout habitat.

Although more conjectural than the relationship just discussed (the impact of exploitation on population structure), the 1980 data from lower Wedde Creek also helps to support the supposition that central Wisconsin Class I streams, like those in this study, would not be wisely managed as trophy trout waters. Application of very restrictive regulations on any of the four study zones would likely result in the stockpiling of more trout in the 10-15 in. range, but even the lightly fished portion of Wedde Creek did not support a population that would be compatible with a trophy trout fishery. The largest trout captured was only 17 in. and density of trout over 14 in. was only 10/mile. The goals of such a management strategy are more likely to be met when applied to larger Class I or Class II streams which have more prey species of fishes and larger invertebrates present for larger trout to feed on.

What, then, is the best management strategy for the majority of brown trout streams in central Wisconsin? It could be argued that in view of their popularity with anglers now, existing regulations must be providing adequate protection and acceptable quality. Perhaps no changes are needed despite a likely trend of gradually increasing angler use (Wisconsin Department of Natural Resources 1979). If, however, minimum length limit and bag limit regulations are meant to have some protective benefit, the present regulations are providing even less protection for brown trout in our study streams than did the same regulations for brook trout in Lawrence Creek (Hunt et al. 1962). Only 8% of the brown trout creeled from the streams under study were less than 7 in. and only 3 of 1,367 anglers (0.02%) interviewed at the end of their fishing trips kept 10 trout. During May, when the bag limit was 5/day, about 2% of the anglers made limit catches. These brown trout fisheries are essentially being regulated in name only by the present length limit and bag limit restrictions, especially during the last four months of the season when the bag limit is liberalized to 10/day.

Unless present length and bag limit regulations are changed, therefore, the predicted increase in angling pressure will inevitably accelerate undesirable exploitation of brown trout populations in central Wisconsin. Hardest hit will be the age II+ stocks. Sufficient spawning stock to maintain population abundance may not be a problem in the foreseeable future (if habitat quality can be preserved or enhanced), even if regulations are not made more protective, but quality of the fishery will continue to deteriorate in terms of average size of catch. Year class strength will also become more and more dependent upon one or two of the youngest age groups of spawners, a situation that eventually tends to produce less stable recruitment and more variable fishing quality.

As immediate modest revisions of present regulations, we propose from the biological viewpoint that the minimum length limit for brown trout be increased to 7 in. and the bag limit be set at 5 brown trout/day throughout the season for Class I trout streams south of U.S. Highway 10. These changes should help to reduce total harvest by at least 15% based on creel census data from the four streams under study, increase the average size of trout creeled, increase the proportion of limit catches, provide better fishing quality throughout the season, and enhance stability of spawning stocks and the recruitment process by increasing survival of many adult trout by at least one fishing season.

SUMMARY

1. This study on portions of four central Wisconsin Class I trout streams was initiated to gather quantitative baseline data pertinent to improving the management of wild brown trout *(Salmo trutta)* and the sport fisheries they sustain. Emphasis was placed on: (1) quantifying age-specific abundance, biomass, and growth and survival rates of brown trout stocks in the study zones; (2) assessing the impact of angler exploitation rates on these representative stocks; and (3) characterizing the angler clientele that utilize these streams.
2. Spring and fall inventories of the trout populations were conducted to obtain relevant vital statistics for three successive years (fall 1975-spring 1978). Stratified partial creel census operations were conducted throughout 2 fishing seasons (1976-77).
3. Average spring density of brown trout (age I+) ranged from 1,270/mile to 2,500/mile in the four streams, with an average density of 2,020/mile for all four streams. Mean standing stock ranged from 59 lb/acre to 114 lb/acre, with an overall average for the four streams of 96 lb/acre. Legal trout ($\geq$6.0 in.) comprised 37% of the average spring population and 77% of the average spring biomass. Most legal trout were in the 7-9 in. groups. Mean density of trout larger than 10 in. ranged from 54 to 127/mile in the individual streams. Mean density of trout larger than 12 in. was 16/mile in the four streams.
4. Average age composition of spring populations was 67% age I, 25% age II, 7% age III, and 1% age IV+. Age II and III trout comprised 67% and 19%, respectively, of the legal fish present. Mean lengths of age I, II, and III trout were 4.8 in., 7.9 in., and 10.1 in., respectively.
5. Average fall density (including age 0) ranged from 2,950/mile to 4,710/mile in individual streams, with an average density of 3,480/mile for all four streams. Mean standing stock ranged from 74 lb/acre to 163 lb/acre, with an overall average for all four streams of 130 lb/acre. Legal trout accounted for 34% of the average fall population and 79% of the biomass. Most legal trout were in the 6-8 in. groups. Mean density of trout longer than 10 in. ranged from 94 to 219/mile in individual streams. Mean density of trout longer than 12 in. was 36/mile in the four streams.
6. Ages 0, I, II, and III+ comprised 58%, 29%, 10%, and 3%, respectively, of the average fall population. Age I and II trout comprised 67% and 24% of the legal fish present. Mean lengths of age 0, I, II, and III trout were 3.8 in., 7.0 in., 9.4 in., and 11.2 in., respectively.
7. Growth increments of brown trout during the first 38 months of life ranged from 8.0 to 9.1 in. in the four streams, with an overall average of 8.6 in. Growth rate was 0.23-in./month. Mean lengths of age I, II, and III trout in the spring were 4.8 in., 7.9 in., and 10.1 in., respectively. Average size of age 0 trout in the fall was 3.8 in. Growth of age 0's in three of the four streams was inversely related to density. Mean overwinter survival of age 0 in the four streams was 57%. Mean annual survival (spring to spring) of age I to age II was 34%, and of age II to age III, only 31%.
8. Fishing effort on the four streams averaged 398 hours/acre in 1976 and 376 hours/acre in 1977. Such effort is equivalent to about 3 trips/stream mile/day throughout the fishing season. Anglers harvested an average of 425 trout/mile weighing 52 lb/acre in 1976. Harvest in 1977 averaged 320/mile and 37 lb/acre. Age II dominated the harvest in both years. Mean size of trout creeled was 8.9 in. Exploitation rate was generally less than 20% of the spring populations, but exploitation of ages II and III+ reached as high as 69% and 78%, respectively, in individual streams. Catch rates fluctuated around 0.5/hour on all streams. Anglers traveling more than 50 miles one way accounted for 24-56% of those interviewed. Worms were the preferred bait of over 70% of the anglers interviewed, followed by spin lures and flies.
9. Although angler harvest removed only 20% or less of the spring populations, on the average, such harvest was sufficient to skew the size and age structure in all four streams toward smaller and younger fish. Especially noticeable was the scarcity of trout larger than 10 in. or over 3 years of age when compared with the population in a reach of stream where fishing pressure and harvest were much less. Natural reproduction is currently sufficient to sustain these populations at their present abundance. However, projected increases in fishing pressure in the near future should be countered with more restrictive length limit and bag limit regulations. We recommend that to maintain brown trout fisheries in central Wisconsin streams at their present level, or to improve them despite increased angling use, the minimum length limit for brown trout should be increased to 7 in. and the daily bag limit should be changed to 5 throughout the season. These regulatory changes would help to: (1) prevent exploitation from increasing or even reduce it; (2) increase the average size of trout creeled; (3) increase the proportion of limit catches; (4) provide better fishing quality throughout the season; and (5) enhance the stability of spawning stocks and the recruitment process by increasing survival of adult trout.

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APPENDIX

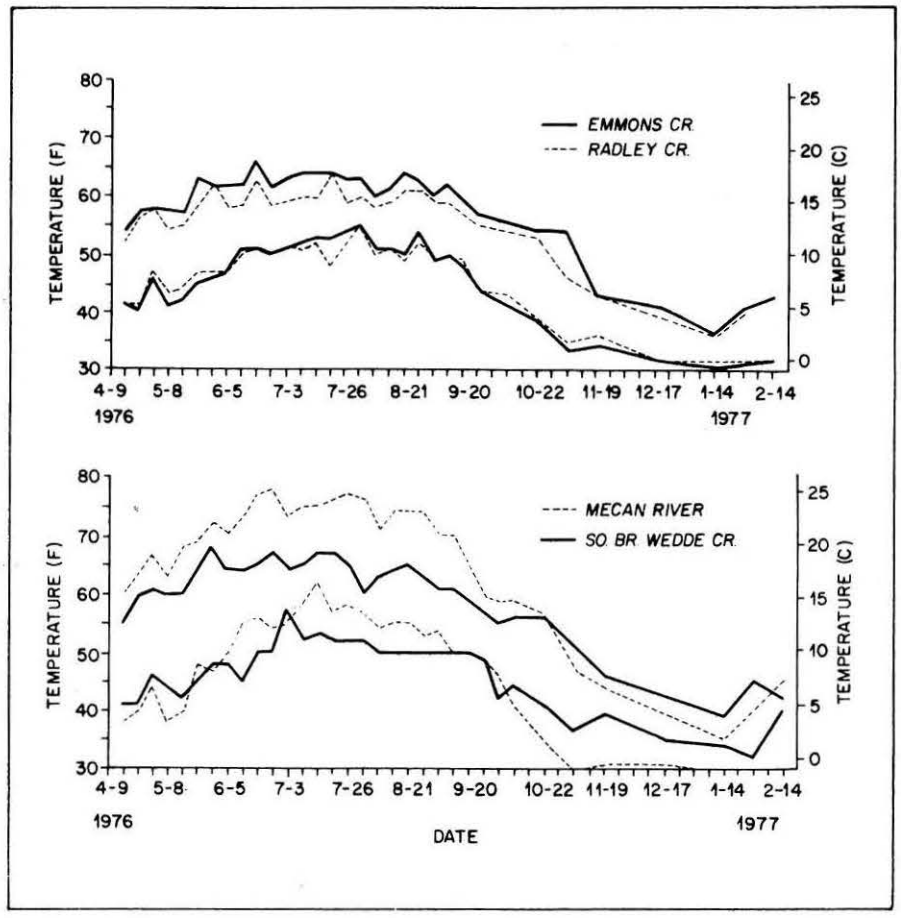

FIGURE 10. *Weekly and bimonthly maximum and minimum water temperatures of four central Wisconsin brown trout streams in 1976 and 1977.*

TABLE 29. *Percent age composition of the monthly harvest of brown trout in four central Wisconsin trout streams in 1976.*

	May			Jun			Jul			Aug			Sep		
Stream	I	II	III+	I	II	III+	I	II	III+	I	II	III+	I	II	III+
Emmons Creek	2	73	25	12	76	12	21	69	10	52	48	—	—	100	—
Radley Creek	25	68	7	—	—	—	33	67	—	63	37	—	37	54	9
South Branch Wedde Creek	14	67	19	27	66	7	60	36	4	71	26	3	47	50	3
Mecan River	7	76	17	57	33	10	71	29	—	55	40	5	68	32	—
Avg.	12	71	17	32	58	10	46	50	4	60	38	2	38	59	3

TABLE 30. *Percent age composition of the monthly harvest of brown trout in four central Wisconsin trout streams in 1977.*

	May			Jun			Jul			Aug			Sep		
Stream	I	II	III+	I	II	III+	I	II	III+	I	II	III+	I	II	III+
Emmons Creek	—	58	42	16	56	28	68	32	—	24	66	10	34	54	12
Radley Creek	6	66	28	29	55	16	16	51	33	21	73	6	42	42	16
South Branch Wedde Creek	12	81	7	8	84	8	28	72	—	20	80	—	52	48	—
Mecan River	4	81	15	6	76	18	4	67	29	22	53	25	30	40	30
Avg.	6	71	23	15	68	17	29	55	16	22	68	10	40	46	14

TABLE 31. *Spring and fall densities (no./mile) of brown trout by age class in four central Wisconsin trout streams, fall 1975 through spring 1978.*

		Spring				Fall				
		Age Group				Age Group				
Stream	Year	I	II	III	IV+	0	I	II	III	IV+
Emmons Creek	1975					1,520				
	1976	1,400	727	211	12	1,720	1,010	446	121	
	1977	2,180	753	290	37	958	1,260	546	243	11
	1978	1,040	628	148	55					
Avg.		1,540	703	216	35	1,400	1,140	496	188	
Radley Creek	1975					2,380				
	1976	1,640	456	139	6	1,710	777	306	46	19
	1977	1,250	503	109	15	1,720	1,080	425	75	21
	1978	1,680	800	307	61					
Avg.		1,520	586	185	27	1,940	928	366	81	
South Branch Wedde Creek	1975					3,160				
	1976	2,370	396	147	9	5,510	1,360	272	71	
	1977	1,180	303	51	6	2,250	687	158	24	6
	1978	1,090	305	88	9					
Avg.		1,550	335	95	8	3,640	1,020	215	51	
Mecan River	1975					3,070				
	1976	1,150	296	50	17	2,630	730	146	25	
	1977	1,140	349	104	5	784	622	177	66	12
	1978	300	287	87	24					
Avg.		863	311	80	15	2,160	676	162	52	

ENGLISH-METRIC MEASURES AND WEIGHTS EQUIVALENTS.

1 in. = 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 sq in.
1 g = 0.035 oz
1 liter = 33.83 oz

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