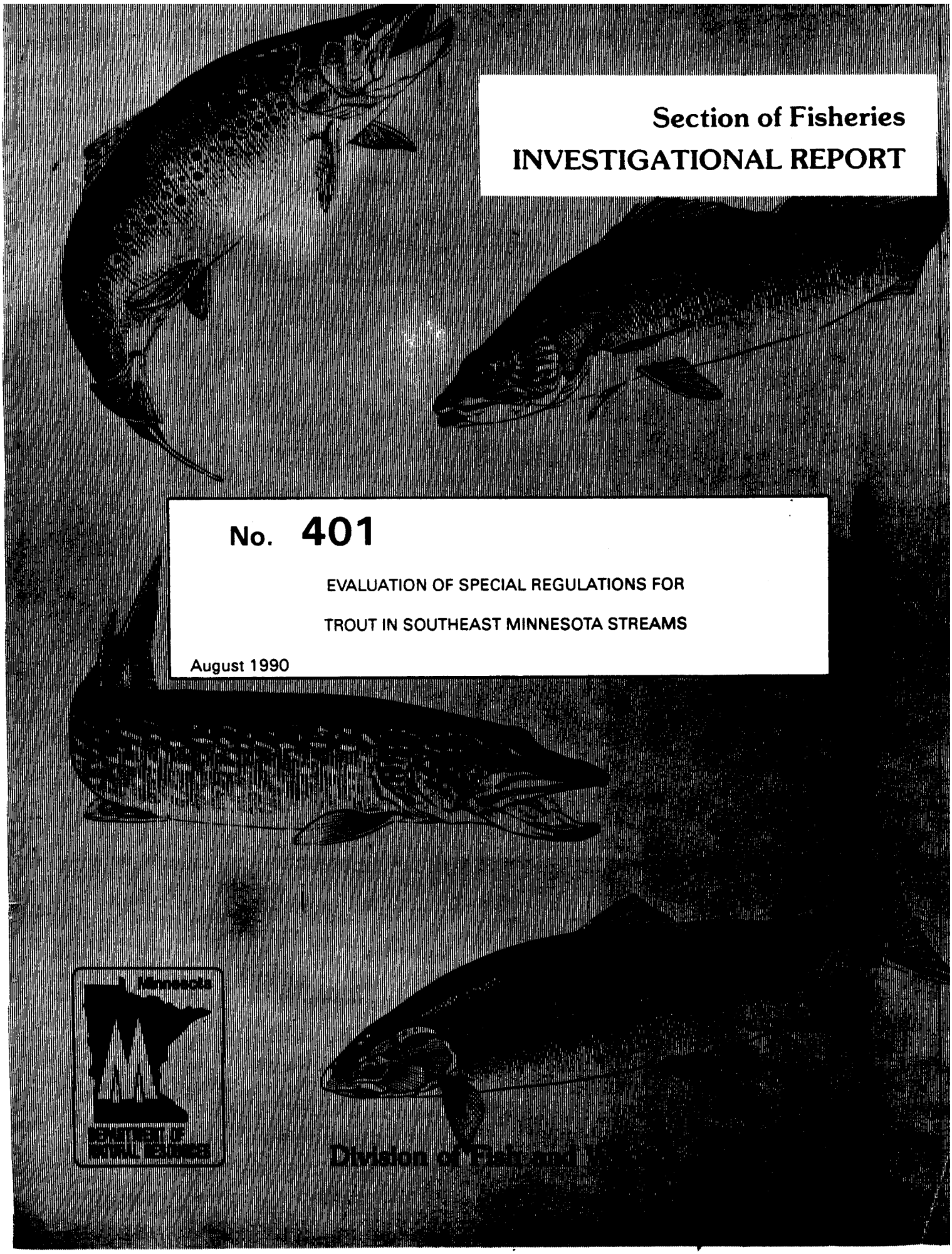

Section of Fisheries

INVESTIGATIONAL REPORT

No. 401

EVALUATION OF SPECIAL REGULATIONS FOR

TROUT IN SOUTHEAST MINNESOTA STREAMS

August 1990

Minnesota

Department of Natural Resources

Division of Fisheries

EVALUATION OF SPECIAL REGULATIONS FOR TROUT IN SOUTHEAST MINNESOTA STREAMS[1]

by

William C. Thorn
Fisheries Biologist

Minnesota Department of Natural Resources
Section of Fisheries

---

[1] This project was funded in part by the Federal Aid in Sport Fish Restoration (Dingell-Johnson) Program. Completion report, Study 221, D-J Project F-26-R Minnesota.

Abstract

Effects of special regulations upon trout populations, the fisheries, angler attitudes, and angler characteristics were evaluated on three southeastern Minnesota streams. Special regulations were selected after two years of study and were imposed on one section of each stream while normal regulations remained on a control section. Bait fishing was restricted on all experimental sections, a no-kill rule was set on Hay Creek, and a 254 mm maximum size limit was set on South Branch Whitewater River and East Beaver Creek.

Under the no-kill regulation, abundance of 200-250 mm, 251-300 mm, and 301-381 mm brown trout in Hay Creek increased. Abundance of all sizes fluctuated on South Branch Whitewater River and East Beaver Creek under the maximum size limit. Fishing pressure under special regulations decreased on East Beaver Creek and fluctuated on South Branch Whitewater River and Hay Creek. Catch and catch rates did not change on any of the three regulated stream sections. Responses were influenced by natural variation in abundance, habitat, migration, length of the evaluation period, and length of the study areas. Negative social responses to special regulations were minimal. Angling quality was influenced more by changing attitudes about importance of size and number than by biological responses to special regulations.

Introduction

Special regulations restricting harvest of stream trout have become popular with anglers and fishery managers for their potential to increase angling quality when traditional methods do not. Common objectives of special regulations are to increase angler catch rates or size of fish in the catch, two variables that influence angler satisfaction, especially where they have been reduced by increased angling pressure (Behnke 1980). Special regulations should be most successful when the rate of exploitation exceeds 50% (Behnke 1978), and when habitat is not limiting and the threat of overfishing dictates special management (Hunt 1975).

In southeastern Minnesota trout streams, harvest may exceed 50% of the preseason biomass (Thorn 1988a), suggesting special harvest restrictions could increase catch rates or fish size. In these streams habitat quality has been degraded through intensive agricultural development. Habitat improvement can increase biomass of brown trout (Salmo trutta), but associated increases in pressure and harvest may prevent catch rates from increasing (Thorn 1988a). Moreover, the habitat improvement alone was insufficient to increase abundance of larger brown trout >300 mm (Thorn, in press). Stocking trout can temporarily increase catch rates (Anderson and Nehring 1984), but few stocked trout survive the summer (Johnson 1983). Therefore, it is unlikely that present stocking programs could increase size of fish caught in southeastern Minnesota.

Not all special regulations have been successful, so individual regulations should be evaluated. Natural variation in trout abundance confounded interpretation of effects of regulations in some Michigan streams (Clark et al. 1981). Natural mortality during winter may partly negate the increased abundance of larger trout produced by reduced summer angling mortality (Clark et al. 1981). No-kill regulations may not permit complete optimization of growth and catch rates (Behnke 1980). Special regulations may increase abundance but reduce growth of trout, which in turn reduces long term success of the regulation (Barnhart and Engstrom-Heg 1984).

Species and size of trout, fishing pressure, and habitat quality will influence success of regulations in southeastern Minnesota streams. In these streams, brown trout are much more abundant than rainbow trout (Oncorhynchus mykiss) or brook trout (Salvelinus fontinalis), brown trout >300 mm are not abundant (Thorn 1988b), fishing pressure ranges from 100 h/mi to >2,000 h/mi (Minnesota DNR 1987), and habitat quality varies (Thorn 1988b).

Success of special regulations for brown trout in streams has been variable. Low vulnerability of brown trout to anglers limits their response to special regulations (Behnke 1978). Shetter (1969) concluded special regulations had little influence on brown trout in North Branch of the Au Sable River, Michigan. A special regulation on brown

trout on Race Branch, Wisconsin, increased abundance of brown trout <330 mm but not >330 mm (Hunt 1981). Special regulations for brown trout in Pennsylvania have not provided quality angling as expected (Graff and Hollender 1977). However, Anderson and Nehring (1984) demonstrated that special regulations increased abundance of brown trout >300 mm in South Platte River, Colorado. Also, brown trout have been positively influenced by special regulations in California and Colorado (Dienstadt 1980, Nehring 1980).

In streams with mixed trout populations, rainbow trout should be more influenced by special regulations than brown trout. Rainbow trout were more vulnerable than brown trout to anglers in New York (Barnhart and Engstrom-Heg 1984) and benefited more than brown trout from special regulations in Colorado (Nehring and Anderson 1984).

When angling pressure is high, importance of special regulations increases as a tool for wild trout management (Behnke 1980). For New York streams, Barnhart and Engstrom-Heg (1984) reported harvest protection for brown trout provided modest trout increases under pressure of 371-988 h/ha, and could cause dramatic increases under pressure of 988-3,706 h/ha.

Exploitation of less abundant larger trout may increase as fishing pressure increases and reduce their abundance. Nehring and Anderson (1984) reported pressure greater than 250 $h \cdot ha^{-1} \cdot yr^{-1}$ depleted stocks of rainbow trout and brown trout >300 mm, and pressure greater than 988 $h \cdot ha^{-1} \cdot yr^{-1}$

decimated rainbow trout stocks and eliminated trout >350 mm. Anderson and Nehring (1984) found protective regulations to be effective for maintaining abundance of large trout (>300 mm) under pressure of 2,900-3,700 h/ha.

Shetter (1969) suggested special regulations may increase trout production in marginal trout waters with limited recruitment and good growth. Hunt (1975) also concluded that successful special regulation fisheries would be most likely when recruitment was low or controlled (stocked) so that growth would not decrease when abundance increased. A no-kill regulation increased stocks of brown trout in two Wisconsin streams with good habitat and water quality, which were maintained by annual stocking of 125-150 mm fall fingerlings (Kerr 1982). Barnhart and Engstrom-Heg (1984) concluded that future special regulations for New York streams will likely be placed on fertile waters with limited recruitment or stocked streams with controlled recruitment. Wisconsin streams with adequate reproduction and recruitment to sustain sport fisheries (Class I) would be unlikely candidates for future special regulations (Hunt 1987).

This study examines effects of selected restrictive harvest regulations on three streams in southeastern Minnesota with differing trout populations, trout fisheries, and angler characteristics.

Study Area

Hay Creek, South Branch Whitewater River, and East

Beaver Creek are in the unglaciated driftless region of southeastern Minnesota (Fig. 1). Streams in this region form rugged valleys as they erode through limestone bedrock while draining to the Mississippi River. Land use of uplands and valley bottoms is primarily agricultural, but the valley sides are wooded. Cold springs (9 C) and groundwater seepage maintain base flows but streams are subject to flash flooding. These streams are productive and trout biomass ranged from 0 to over 300 kg/ha (Thorn 1988b). Two sections were studied in each stream; the one on which special regulations were tested was designated Section A while the control with normal regulations was designated Section B (Table 1).

In both sections of Hay Creek, habitat had been improved for trout. Habitat in pastured Section A was improved in 1978-79 by riprapping eroded banks and by adding artificial overhead bank covers for trout (Thorn 1988a). Section B, 0.1 km downstream from Section A and bordered by 15-20 m of woody vegetation, was improved in 1980 by removal of streambank woody vegetation so streambanks could be sloped, riprapped, and seeded at selected locations (Thorn, in press). Section A has been managed for wild brown trout since 1982. Section B was stocked with 219 fall fingerling brown trout/km and 109 spring yearlings throughout the study. Other fish species present in Hay Creek were blacknose dace (Rhinichthys atratulus), white sucker (Catostomus commersoni), and brook stickleback (Culea inconstans).

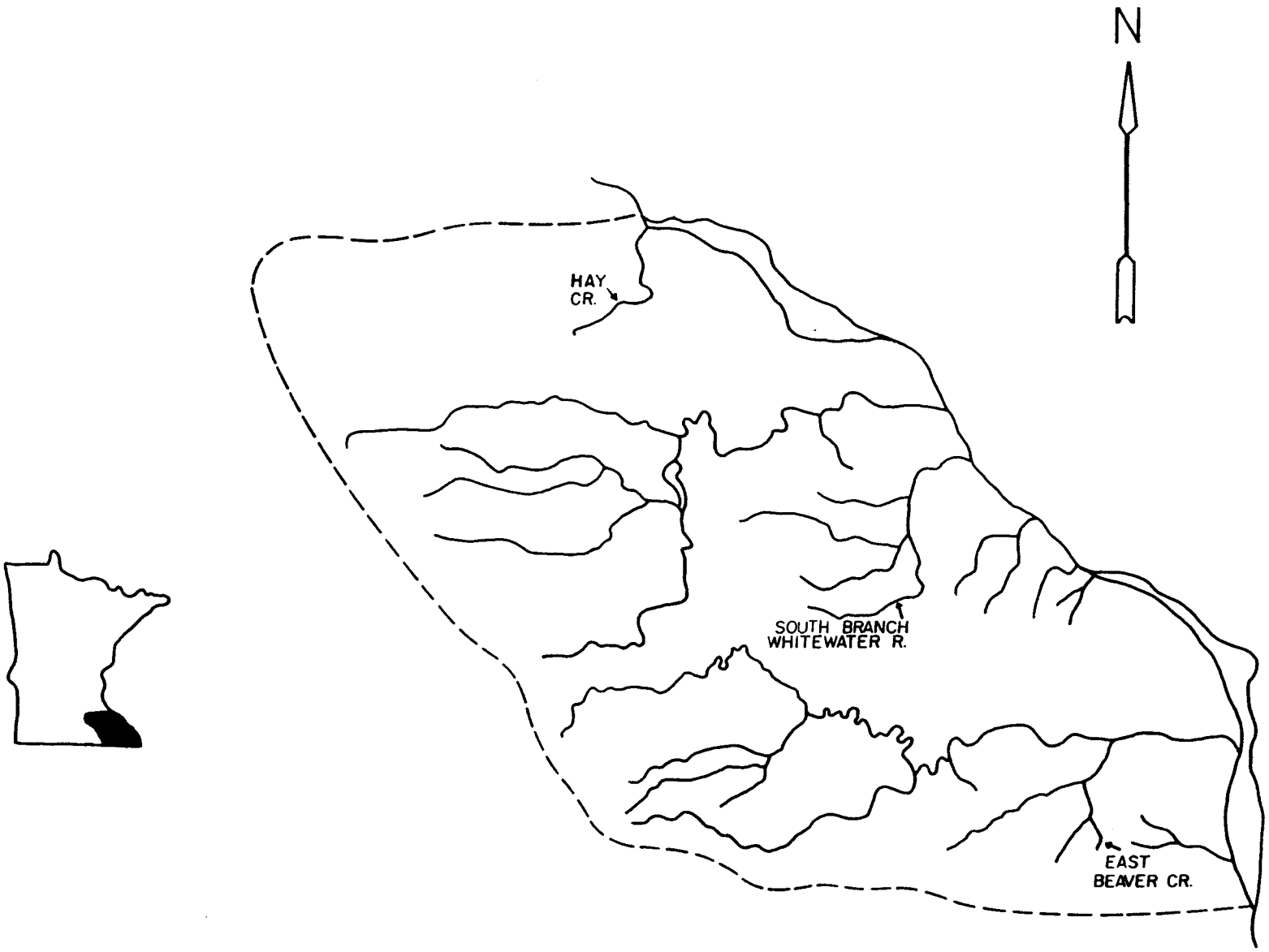

Figure 1. Study streams in southeast Minnesota.

Table 1. Length, width, and area of special regulation (A) and control (B) sections of Hay Creek, South Branch Whitewater River, and East Beaver Creek.

Section	Hay Creek		South Branch Whitewater River		East Beaver Creek	
	A	B	A	B	A	B
Length (km)	1.10	0.78	1.57	1.61	0.82	0.83
Width (m)	5.6	6.5	10.6	10.7	5.7	6.4
Area (ha)	0.62	0.51	1.67	1.72	0.47	0.53

South Branch Whitewater River is the largest study stream (Table 1). Section A is within a Department of Natural Resources Wildlife Management Area and the flood plain is wooded. Section B, immediately upstream of Section A, is a privately owned pasture and camping area. Trout cover in both sections consists of instream woody debris and deep water (>60 cm). The trout population consists of wild brown trout, stocked brown trout (625 spring yearlings/km), and stocked rainbow trout (1,250 fall fingerlings/km). Other common species were blacknose dace, longnose dace (Rhinichthys cataractae), white sucker, and brook stickleback.

East Beaver Creek is within the boundaries of Beaver Valley State Park. Flood plain of the study sections is wooded and undeveloped. Section A begins at the stream mouth and Section B is immediately upstream of Section A.

Habitat in both sections was improved for trout in 1971 by the addition of bank cover devices and riprap. East Beaver Creek is managed for wild brown trout. Other fish species in were blacknose dace, white sucker, slimy sculpin (Cottus cognatus), and brook stickleback.

Methods

Sections A and B were studied for at least two years under normal regulations before special regulations were selected and imposed. Section A of each stream then received a special regulation for three years. Section B was studied as a reference section with normal regulations. Normal regulations were a daily limit of five of which three could be >406 mm and no restriction on terminal tackle. The trout angling season began the second Saturday in April and ended 30 September.

Trout populations were sampled by electrofishing before and near the end of the fishing season. Population estimates were made by the adjusted Chapman mark and recapture method (Ricker 1975) for age-0 and for five size groups of adults (older than age-0 but <200 mm, 200-250 mm, 251-300 mm, 301-380 mm, and 381-500 mm). Mean population estimates were compared before and after implementation of the regulation with t-tests. Trout were measured and a sample was weighed to calculate length-weight relationships. Ages of trout were determined from scales. Growth increments were calculated before regulation and after three years of regulation by backcalculating length at each

annulus. Biologists estimated potential trout abundance for South Branch Whitewater River under special regulations with the Delphi Technique (Zuboy 1981).

Angler effort and success were estimated by a random instantaneous count of anglers and from angler interviews. Separate creel survey estimates were made for opening weekend and for weekdays and weekends during April-June and July-September. Daily fishing hours were from one hour before sunrise (1000 on opening day) until 2300. The period between sunset and 2300 h was not sampled because few anglers fished after sunset (personal observations during F-26-R, Study 218). Mean creel estimates were compared before and after implementation of special regulations with t-tests.

Angler attitudes were surveyed by methods described by Weithman and Anderson (1978). Anglers were asked to rate, on a scale from 1 (most important) to 5 (least important), importance of kind, of size, and of number of fish caught; enjoyment of catching more than one species (diversity) and of catching and releasing fish; importance of brown trout, rainbow trout, and brook trout; and importance of individual harvested trout. Standard t-tests and orthogonal contrasts with Bonferroni control (Wilkinson 1988) tested differences in angler attitudes before and after regulation. These ratings were also used to calculate overall fishing quality (Q) (Weithman and Katti 1979).

Anglers were also asked questions to characterize the

fishery. Anglers were asked if they belonged to an organized angling group, and their hometown and method of angling. Local anglers lived within 20 km of the stream, metro anglers were from the seven county Minneapolis-St. Paul metropolitan area, other SE MN anglers were from ten counties in southeastern Minnesota excluding locals, other MN anglers were from remaining Minnesota counties, and non-residents were from other states. Methods of angling were bait, artificials (other than artificial flies), flies (artificial), and mixed (combination of some type of artificial and bait). Data calculated as a percent, was normalized by an arcsine transformation before statistical testing of before and after means.

Results

Hay Creek

The fishery of Section A of Hay Creek under normal regulations was characterized by high fishing pressure (average of 2,091 h/ha, Appendix Table 1), moderate individual success (mean catch rate of 0.49 fish/h, Appendix Table 10), and a mean exploitation rate of 55% of the preseason population. The trout population was characterized by variable recruitment (30-1,035 age-0/km; Appendix Table 2), and low preseason abundance of trout >300 mm (mean of 33/km, Appendix Table 6).

Catch rate and abundance of brown trout >300 mm in Section A were disappointing because habitat had been improved. Increased fishing pressure after habitat

improvement prevented an increase of the catch rate (Thorn 1988a) and of abundance of trout >300 mm (Thorn in press). A successful catch and release fishery on nearby Race Branch, Wisconsin, sustained a catch rate >1.0/h (Hunt 1981). Therefore a no-kill, artificial bait only, restriction was placed on Section A for the 1985-87 fishing seasons to increase the mean catch rate to 1.0/h and increase abundance of trout >300mm.

Trout Population Characteristics--Mean abundance of adult brown trout and biomass (excluding age-0) increased in Section A after harvest was restricted but did not change in Section B under normal regulations (Table 2). In Section A mean spring and fall abundance of adults, 200-250 mm, 251-300 mm, and 301-381 mm trout increased after the no-kill regulation was imposed as did biomass. In Section B with normal regulations, no changes occurred during these time periods for total abundance, for abundance in any size group, or for biomass. Mean abundance of age-0 or trout older than age-0 but <200 mm did not increase in either section.

The no-kill regulation reduced the mean summer mortality rate of brown trout in Section A but not the mean winter mortality rate (Table 2). Mean summer mortality rate in Section A during regulation (31%) was significantly less than in Section B with normal regulations (75%) ($t = -3.775$, $P < 0.05$). Mean winter mortality rates in Sections A (17%) and B (+2%) were not significantly different during

Table 2. Mean abundance (number/km), biomass (kg/ha, excluding age-0), and rates of mortality (%) of brown trout in Hay Creek before and after a no-kill regulation was placed on Section A. Normal regulations were in effect on Section A before regulation and on Section B for all study years. Asterisks indicate significance at P <0.05* or P <0.01**.

		Section A		Section B	
		Before	After	Before	After
Abundance					
All adults	Spring	591	1,576*	1,626	1,712
	Fall	205	707**	244	421
Age-0	Fall	440	1,543	448	1,272
Adults					
<200 mm	Spring	360	820	1,192	1,114
	Fall	1	41	7	17
200-250 mm	Spring	71	387**	534	306
	Fall	55	355**	92	241
251-300 mm	Spring	56	236*	137	221
	Fall	64	180*	93	102
301-380 mm	Spring	29	127**	57	69
	Fall	24	120*	45	59
381-500 mm	Spring	4	6	2	3
	Fall	5	6	12	2
Biomass	Spring	101.3	345.4**	271.6	272.4
	Fall	92.5	251.3**	101.2	117.8
Mortality	Summer	63	31*		75
	Winter	15	17	+84	+2

regulation of Section A ($t = 0.500$, $P > 0.05$).

Annual growth increments of brown trout did not change in Sections A or B after three years of no-kill regulation on Section A (Table 3). Increments from Sections A and B in 1988 did not differ significantly ($P > 0.05$).

Table 3. Mean and standard error (SE) for annual growth increments (mm) of brown trout in Hay Creek, South Branch Whitewater River, and East Beaver Creek before and after a no-kill regulation was placed on Section A. Normal regulations were in effect on Section A before regulation and on Section B for all study years. Asterisks indicate significant changes at P <0.05* or P <0.01**.

	Year of growth							
	1		2		3		4	
Section	Mean	SE	Mean	SE	Mean	SE	Mean	SE
				Hay Creek				
A & B - Before	139	2.9	84	8.2	72	8.3		
A - After	146	2.4	86	3.4	62	3.8		
B - After	143	2.6	93	4.1	59	12.5		
				South Branch Whitewater River				
A & B - Before	149	2.5	99	3.1	78	5.2	64	4.1
A - After	143	2.1	99	2.9	80	4.2	54	6.1
B - After	148	2.4	108*	2.9	78	4.8	46*	4.3
				East Beaver Creek				
A & B - Before	138	2.9	91	3.6	91	7.1	57	6.6
A - After	140	2.0	90	2.5	69**	3.3	52	4.6
B - After	149**	2.2	91	2.7	64**	3.7	46	5.6

Fishery Characteristics--Mean fishing pressure fluctuated on Section A under the no-kill regulation and increased on Section B with normal regulations (Table 4). Estimated pressure on Section A declined from a mean of 2,010 h/ha under normal regulations to 1,166 h/ha the first year with the no-kill regulation and increased to 2,192 h/ha in the third year (Appendix Table 1). Mean harvest rate and mean number harvested under the no-kill regulation in

Table 4. Estimated fishing pressure (hr/km); catch, release, and harvest rates (fish/hr); estimated number of trout caught, released, and harvested (fish/km); overall fishing quality (Q); and rates of exploitation (%) for Hay Creek before and after a special regulation was placed on Section A. Normal regulations were in effect on Section A before regulation and on Section B for all study years. Asterisks indicate significant changes at P <0.05* or P <0.01**.

	Section A		Section B	
	Before	After	Before	After
Hr/ha	2,091	1,751	1,422	2,690
Fish/hr caught	0.48	1.11	0.69	0.79
Fish/hr released	0.30	1.11	0.46	0.51
Fish/hr harvested	0.18	<0.01**	0.23	0.23
Fish/km caught	500	1,283	530	1,485
Fish/km released	254	1,287	338	916
Fish/km harvested	248	11**	194	472*
Q	0.09	0.15	0.10	0.07
Exploitation	55	1*		33

Section A decreased. Mean harvest increased on Section B with normal regulations. Mean overall fishing quality (Q) did not increase on Section A under the no-kill regulation or on unregulated Section B. The no-kill regulation nearly eliminated angling mortality of brown trout in Section A. Under normal regulations on Sections A and B the rate of exploitation ranged from 15-72% and averaged 47% (Appendix Table 18).

Angler Characteristics--A greater proportion of anglers fishing Section A belonged to an organized angling group under the no-kill regulation than fished Sections A or B with normal regulations (Table 5). Under normal regulations fewer than 10% of anglers belonged to an organized angling group. On Section A during regulation a mean of 35% of anglers were members of an organized angling group, and the percentage increased each year of the regulation (Appendix Table 13).

Hay Creek was a popular fishing stream for anglers from the Twin Cities Metropolitan area (Table 5). Mean percent of Metro anglers increased in Section A under the regulation, but not in Section B with normal regulations.

Bait fishing was the most common method under normal regulations and fly fishing was the most popular method under the no-kill regulation (Table 5). Angling methods did not change on Section B under normal regulations. A decrease in use of bait from a mean of 54% to a mean of 1% (illegal anglers) on Section A is suggested ($P < 0.10$).

Anglers fishing under normal regulations rated importance of size and of kind of fish caught and enjoyment of catching more than one species and of catching and releasing fish similar and all were rated more important than number of fish caught (Table 6). Anglers fishing Section A under special regulations rated enjoyment of catching and releasing fish and importance of kind more important than size, number, or catching more than one

Table 5. Anglers belonging to an organized angling group (%), origin of anglers (%), and method of angling (%) in Sections A and B of Hay Creek before and after a special regulation was placed on Section A. Normal regulations were in effect on Section A before regulation and on Section B for the entire study. Asterisks indicate significant changes at P <0.05* or P <0.01** after arcsine transformation of percentages.

	Section A		Section B	
	Before	After	Before	After
% belonging to an organized angling group	9[a]	35	5[a]	6
Origin of angler (%)				
Metro	41	58*	41	55
Local	26	14	31	19
SE MN	29	20	26	19
Other MN	3	7	2	6
Non-resident	2	1	1	1
Method of angling (%)				
Bait	59	1	71	61
Artificial	6	4	8	10
Flies	15	83**	6	10
Mixed	21	1	17	19

[a] One year before regulation.

species. Importance of catch and release fishing on Section A increased after regulation, and the importance of size and enjoyment of catching more than one species decreased. On Section B during regulation of Section A, importance of kind decreased and importance of number increased.

Anglers fishing Section A preferred brown trout to rainbow trout and brook trout under both regulations (Table 7). On Section B with normal regulations, brown

Table 6. Multiple comparison tests of mean angler ratings for importance/enjoyment of kind, of size, of number, of catching more than one species (DIV), and of catching and releasing fish (C&R) on Sections A and B of Hay Creek, South Branch Whitewater River, and East Beaver Creek before and after a special regulation was placed on Section A. Underlining indicates no significant difference (P >0.05 with Bonferroni control) among values. Asterisks indicate significant change (T-test; P <0.05* or P <0.01**) for the rating after the regulation was placed on Section A.

Section					
			Hay Creek		
A - Before	C&R 2.34	Kind 2.54	Size 2.56	Div 2.61	Number 3.00
A - After	C&R 1.65*	Kind 2.50	Size 2.83**	Div 2.83**	Number 2.96
B - Before	Kind 2.49	C&R 2.57	Div 2.66	Size 2.67	Number 3.25
B - After	C&R 2.42	Div 2.59	Size 2.66	Kind 2.70*	Number 3.08*
			South Branch Whitewater River		
A - Before	C&R 2.27	Kind 2.53	Size 2.63	Div 2.91	Number 3.13
A - After	C&R 1.80**	Div 2.51**	Kind 2.74*	Size 2.80*	Number 2.88**
B - Before	C&R 2.29	Kind 2.49	Size 2.61	Div 2.88	Number 3.22
B - After	C&R 2.34	Div 2.52**	Size 2.54	Kind 2.92**	Number 3.11

Table 6. Cont.

Section					
	East Beaver Creek				
A - Before	Div	Kind	C&R	Size	Number
	2.23	2.31	2.42	2.53	3.15
A - After	C&R	Kind	Size	Div	Number
	1.83**	2.54	2.61	2.96**	2.96
B - Before	C&R	Kind	Div	Size	Number
	2.11	2.36	2.50	2.64	3.20
B - After	C&R	Size	Kind	Div	Number
	2.12	2.72	2.82**	2.88	3.09

trout and brook trout were rated more important than rainbow trout.

South Branch Whitewater River

Under normal fishing regulations on South Branch Whitewater River trout abundance appeared to be more influenced by angling than by habitat. High fishing pressure (average 1,175 h/ha during 1981-1984, F-26-R files) produced a large average size harvested (mean length for 1981-84 ranged from 259-288 mm, F-26-R files) indicating a substantial harvest of trout >300 mm. Preseason abundance of brown trout >300 mm was 54-65/km under normal regulations (Appendix Table 7), but carrying capacity for this size was estimated by the Delphi Technique to be 208/km.

Table 7. Multiple comparison tests of mean angler ratings for importance of brown trout (BNT), rainbow trout (RBT), and brook trout (BKT) for Sections A and B of Hay Creek, South Branch Whitewater River, and East Beaver Creek before and after a special regulation was placed on Section A. Normal regulations were in effect on Section A before regulation and Section B for all study years. Underline indicates no significant difference (P >0.05 with Bonferroni control) between variables. Asterisks indicate significant changes in ratings at P <0.05* or P <0.01** after implementation of special regulations on Section A.

Section			
		Hay Creek	
A - Before	BNT 1.70	RBT 1.95	BKT 1.98
A - After	BNT 1.94**	BKT 2.38**	RBT 2.62**
B - Before	BNT 1.74	BKT 1.83	RBT 2.11
B - After	BNT 2.26**	BKT 2.37**	RBT 2.52**
		South Branch Whitewater River	
A - Before	BNT 1.98	BKT 2.22	RBT 2.33
A - After	BNT 1.89	RBT 2.22	BKT 2.43*
B - Before	BNT 2.02	RBT 2.31	BKT 2.40
B - After	BNT 1.84*	RBT 2.32	BKT 2.36

Table 7. Cont.

Section	East Beaver Creek		
	BNT	BKT	RBT
A - Before	1.55	1.75	2.13
	BNT	BKT	RBT
A - After	1.90**	2.18**	2.47
	BNT	BKT	RBT
B - Before	1.67	1.80	1.97
	BNT	BKT	RBT
B - After	2.15**	2.41**	2.62**

Rainbow trout stocked in fall survived and grew to provide an early season fishery the next year for 175-250 mm trout, but few survived the summer to a larger size (Thorn 1984). If angling mortality during the first summer was reduced, potential for survival to larger and more desirable sizes would be increased.

A special regulation permitting a maximum size limit of 254 mm and fishing with artificial baits only was placed on Section A for three years (1985-1987). Objectives were to increase abundance of brown trout >300 mm and of rainbow trout >250 mm.

Trout Population Characteristics--Abundance and biomass of brown trout and rainbow trout did not increase in Section

A or Section B after harvest was restricted on Section A (Tables 8 and 9). A greater abundance of rainbow trout >250 mm was suggested for Section A with special regulations than for Section B with normal regulations.

Mean summer mortality rate of brown trout decreased in Section A under the special regulations but not in Section B with normal regulations (Table 8). Mean winter mortality rate in Sections A and B fluctuated ($P > 0.05$). Mean summer mortality rate of rainbow trout did not change in Sections A or B during regulation of Section A ($P > 0.05$) (Table 9). Mean winter mortality rate of rainbow trout could not be estimated because of very low fall abundance.

Growth increments of brown trout in Section A did not change after three years with restricted harvest (Table 3). Growth increments for two of four years in Section B with normal regulations were larger in 1988 after regulation of Section A than in 1984.

Fishery Characteristics--Mean fishing pressure did not change on Sections A or B when harvest was restricted on Section A (Table 10). On regulated Section A, mean harvest rate of brown trout and rainbow trout decreased and mean harvest of brown trout decreased. Also on regulated Section A, an increase in mean number of rainbow trout caught and released and a decrease in mean harvest of rainbow trout were suggested ($P < 0.10$). On Section B under normal regulations mean catch of rainbow trout increased during regulation of Section A.

Table 8. Mean abundance (number/km), biomass (kg/ha, excluding age-0), and rates of mortality (%) of brown trout in South Branch Whitewater River before and after a 254 mm maximum size limit was placed on Section A. Normal regulations were in effect on Section A before regulation and on Section B for all study years. Asterisks indicate significance at P <0.05* or P <0.01**.

		Section A		Section B	
		Before	After	Before	After
Abundance					
All adults	Spring	343	730	218	576
	Fall	360	253	291	179
Age-0	Fall	187		794	333
Adults					
200 mm	Spring	85	479	32	263
	Fall	4	0	0	0
200-250	Spring	104	38	50	73
	Fall	94	65	73	34
251-300	Spring	95	118	81	126
	Fall	82	101	54	72
301-380	Spring	46	85	40	100
	Fall	44	72	27	57
381-500	Spring	14	11	16	14
	Fall	11	16	11	16
Biomass	Spring	59.8	84.7	47.4	89.6
	Fall	50.5	61.2	33.9	47.0
Mortality	Summer	55	30*	41	28
	Winter	14	18	39	+26

Mean overall fishing quality (Q) increased on Section A under special regulations, but not on Section B with normal regulations during the same time periods.

Mean rate of exploitation for brown trout in Section A decreased under special regulations (Table 10). Mean

Table 9. Mean abundance (number/km), biomass (kg/ha, excluding age-0), and rates of mortality (%) of rainbow trout in South Branch Whitewater River before and after a 254 mm maximum size limit was placed on Section A. Normal regulations were in effect on Section A before regulation and on Section B for all study years. Asterisks indicate significance at P <0.05* or P <0.01**.

		Section A		Section B	
		Before	After	Before	After
Abundance					
All adults	Spring	301	597	253	602
	Fall	4	48	5	5
Age-0	Fall	0	0	0	0
Adults					
< 200 mm	Spring	233	324	147	165
	Fall	0	0	0	0
200-250 mm	Spring	67	245	106	423
	Fall	2	10	4	0
251-300 mm	Spring	1	17	2	3
	Fall	1	29	1	5
301-380 mm	Spring	0	11	0	7
	Fall	1	9	0	0
381-500 mm	Spring	0	0	0	0
	Fall	0	0	0	0
Biomass	Spring	0.4	10.6	0.6	1.1
	Fall	17.4	53.1	20.1	54.9
Mortality	Summer	99	94	97	99
	Winter				

exploitation rate of brown trout in Section B under normal regulations and of rainbow trout under both regulations did not change.

Angler Characteristics--More anglers belonging to an organized angling group appeared to fish Section A under

Table 10. Estimated fishing pressure (hr/km); catch, release, and harvest rates for brown trout (BNT) and rainbow trout (RBT) (fish/km); and overall fishing quality (Q); and rates of exploitation (%) for South Branch Whitewater River before and after a special regulation was placed on Section A. Normal regulations were in effect on Section A before regulation and on Section B for all study years. Asterisks indicate significant changes at P <0.05* or P <0.01**.

	Section A		Section B	
	Before	After	Before	After
Hr/ha	1,137	1,218	1,204	1,398
BNT/hr caught	0.67	0.50	0.44	0.42
BNT/hr released	0.41	0.45	0.19	0.23
BNT/hr harvested	0.26	0.03*	0.24	0.20
RBT/hr caught	0.52	0.70	0.57	0.61
RBT/hr released	0.37	0.23	0.38	0.40
RBT/hr harvested	0.14	0.04*	0.20	0.22
BNT/km caught	766	678	544	583
BNT/km released	462	635	231	335
BNT/km harvested	306	43**	309	250
RBT/km caught	670	1,203	738	1,086*
RBT/km released	446	1,113	488	738
RBT/km harvested	195	87	242	351
Q	0.15	0.27*	0.15	0.22
Exploitation				
BNT	48	4**	63	59
RBT	34	23	130	71

special regulations than Section B under normal regulations (Table 11). Many anglers had fished both sections, starting in regulated Section A and continuing into adjacent Section B with normal regulations. During this study, 47-81% of the

Table 11. Anglers belonging to an organized angling group, origin of anglers, and method of angling in Sections A and B of South Branch Whitewater River before and after a special regulation was placed on Section A. Normal regulations were in effect on Section A before regulation and on Section B for the entire study. Asterisks indicate significant changes at P <0.05* or P <0.01** after arcsine transformation of percentages.

	Section A		Section B	
	Before	After	Before	After
% belonging to an organized angling group	18[a]	41	4[a]	15
Origin of angler (%)				
Metro	18	37	10	13
Local	5	2	5	7
SE MN	67	54	76	74
Other MN	5	3	5	4
Non-resident	5	4	3	3
Method of angling (%)				
Bait	57	4*	68	58
Artificial	8	16	7	11
Flies	22	79*	18	21
Mixed	13	1*	8	9

[a] Data for one year before regulation.

anglers on Sections A and B were from southeastern Minnesota (Appendix Table 14). An increase in anglers from Twin Cities Metropolitan area fishing regulated Section A is suggested.

Bait fishing was the most common method of angling under normal regulations and fly fishing was most popular under special regulations (Table 11). On Section A during

regulation, use of bait decreased and the use of flies increased. Fishing methods on Section B with normal regulations did not change during regulation of Section A.

Angler ratings for all importance/enjoyment attributes changed under special regulations (Table 6). On Section B under normal regulations during regulation of Section A two ratings changed.

Anglers fishing Sections A and B before and after regulation of Section A rated brown trout more important than rainbow trout or brook trout (Table 7).

East Beaver Creek

Fishing pressure on East Beaver Creek under normal regulations (Appendix Table 1) indicated potential for success with special regulations, but exploitation (Appendix Table 18) and abundance (Appendix Table 5) did not. Angling appeared to be influencing abundance of brown trout >300 mm in Section A. Mean preseason abundance of trout >300 mm was less in Section A (127/km) than in Section B (153/km) ($t = -8.510$, $P < 0.05$), and mean size of harvest was larger in Section A (304 mm) than in Section B (288 mm) ($t = 2.386$, $P < 0.05$). Also mean catch rates under normal regulations were less than 1.0/h.

A maximum size limit of 254 mm and fishing with artificial baits only regulation was placed on Section A during 1986-88 to increase abundance of trout >300 mm to that of Section B and to increase the mean catch rate to 1.0/h.

Fish Population Characteristics--Abundance and biomass of brown trout fluctuated in Section A under special regulations and in Section B with normal regulations (Table 12).

Mean summer mortality rate of brown trout did not decrease under special regulations, and mean rates under special regulations (50%) and under normal regulations (47%) did not differ significantly ($t = 0.693$, $P > 0.05$) (Table 12). Mean winter mortality rate did not change in Section A or B when special regulations were applied to Section A.

No changes in growth were attributed to special regulations on Section A (Table 3).

Fishery Characteristics--Mean fishing pressure declined on Section A under special regulations, but did not change on Section B with normal regulations (Table 13). An increase in mean release rate and decrease in mean harvest rate on Section A under special regulations is suggested ($P < 0.10$). Mean harvest in Section A decreased under special regulations. Mean overall fishing quality (Q) increased on Section B with normal regulations during regulation of Section A but did not change on Section A under special regulations. However the largest Q, trip quality (TQ), and percentage of successful anglers (SA) recorded during the study were on Section A in the third year of regulation (Appendix Table 12).

Mean rate of exploitation decreased in Section A

Table 12. Mean abundance (number/km), biomass (kg/ha, excluding age-0), and rates of mortality (%) of brown trout in East Beaver Creek before and after a no-kill regulation was placed on Section A. Normal regulations were in effect on Section A before regulation and on Section B for all study years. Asterisks indicate significance at P <0.05* or P <0.01**.

		Section A		Section B	
		Before	After	Before	After
Abundance					
All adults	Spring	874	1,385	1,048	1,311
	Fall	360	673	625	720
Age-0	Fall	625	1,290	851	1,671
Adults					
<200 mm	Spring	408	950	384	680
	Fall	34	169	40	174
200-250 mm	Spring	107	166	195	213
	Fall	124	222	258	206
251-300 mm	Spring	232	160	316	246
	Fall	116	146	185	194
301-380 mm	Spring	114	103	142	170
	Fall	81	127	139	141
381-500 mm	Spring	13	6	11	1
	Fall	6	9	4	5
Biomass	Spring	278.3	246.8	305.9	285.4
	Fall	169.1	267.6	243.5	247.3
Mortality	Summer	61	50	47	38
	Winter	8	28	32	45

under special regulations, but not in Section B under normal regulations (Table 13).

Angler Characteristics--The percentage of anglers belonging to an organized angling group increased on Sections A and B after special regulations were placed on

Table 13. Estimated fishing pressure (hr/km); catch, release, and harvest rates (fish/hr); estimated number of trout caught, released, and harvested (fish/km); overall fishing quality (Q); and rate of exploitation (%) for East Beaver Creek before and after a special regulation was placed on Section A. Normal regulations were in effect on Section A before regulation and on Section B for all study years. Asterisks indicate significant changes at P <0.05* or P <0.01**.

	Section A		Section B	
	Before	After	Before	After
Hr/ha	1,662	769**	1,080	764
Fish/hr caught	0.84	1.12	0.64	0.72
Fish/hr released	0.57	1.09	0.43	0.60
Fish/hr harvested	0.37	0.03	0.21	0.11
Fish/km caught	724	494	411	384
Fish/km released	396	475	229	322
Fish/km harvested	303	19*	181	58
Q	0.22	0.24	0.08	0.18*
Exploitation	34	2*	16	5

Section A (Table 14).

The origin of anglers fishing East Beaver Creek changed more on Section A under special regulations than on Section B with normal regulations (Table 14). Significant changes occurred in four of five angler origin categories on Section A and in two of five on Section B. Anglers from Twin Cities Metropolitan area were attracted to East Beaver Creek. Local anglers were few and were most frequently encountered in Section A when it had normal regulations.

After special regulations were placed on Section A, the

Table 14. Anglers belonging to an organized angling group, origin of anglers, and method of angling in Sections A and B of East Beaver Creek before and after special regulation was placed on Section A. Normal regulations were in effect on Section A before regulation and on Section B for the entire study. Asterisks indicate significant changes at P <0.05* or P <0.01** after arcsine transformation of percentages.

	Section A		Section B	
	Before	After	Before	After
% belonging to an organized angling group	13	25*	11	23*
Origin of angler (%)				
Metro	31	52**	50	53
Local	18	6*	4	2
SE MN	43	29*	37	25*
Other MN	7	3	6	10
Non-resident	1	10*	3	10*
Method of angling (%)				
Bait	58	3	50	29
Artificial	6	30	13	18
Flies	15	64**	20	40*
Mixed	21	3	17	13

most popular method of fishing changed on both sections from bait to artificial flies (Table 14).

Before regulation of Section A, importance to anglers of kind and size of fish caught and enjoyment of catching more than one species and of catching and releasing fish were rated similar, and all were rated more important than number of fish caught (Table 6). Under special regulations enjoyment of catching and releasing fish was most important, kind and size were intermediately important, and number of

fish caught and enjoyment of catching more than one species were least important.

Before regulation of Section A, anglers under normal regulations rated brown trout and brook trout more important than rainbow trout (Table 7). On Section A under special regulations ratings for the three species did not differ.

Discussion

Responses to special regulations differed, achieving many objectives in Hay Creek and few in South Branch Whitewater River and East Beaver. Responses appeared most influenced by natural variation in abundance, exploitation, habitat, migration, and length of study sections. Changes in angler attitudes and angling pressure on control and regulation sections complicated analysis, and suggested additional objectives for special regulations should be considered. In addition, the relatively short evaluation period limited statistical treatment of special regulations.

Stream trout populations fluctuate (Platts and Nelson 1988) and habitat quality (cover) and stream flow may be the most important stream characteristics causing variation in abundance (Hall and Knight 1981). This study and Anderson (1983) showed that abundance and year class strength of brown trout in southeastern Minnesota streams fluctuate widely. In this three-year study of special regulations natural variation in abundance influenced catch rates for brown trout more than did response of populations to special regulations. Some study objectives that were met could be

attributed to population fluctuations. Mean catch rates >1.0/h in Hay Creek and East Beaver Creek during regulation could not be statistically attributed to the regulations, but annual catch rates >1.0/h were not recorded on these two streams under normal regulations.

Exploitation influenced trout abundance when habitat was not limiting. Under special regulations exploitation decreased on all three streams. However, summer mortality decreased on two streams and abundance increased on one stream. On Hay Creek under normal regulations, exploitation kept abundance below carrying capacity. When exploitation and summer mortality were reduced under special regulations abundance increased as habitat was available. On South Branch Whitewater River under special regulations, exploitation and summer mortality decreased indicating that habitat was limiting and that trout protected from harvest moved out of the study area. On East Beaver Creek under special regulations, summer mortality did not decrease with exploitation indicating that abundance was at carrying capacity and was limited by natural mortality.

Exploitation must be about 50% under normal regulations to decrease summer mortality and increase abundance under special regulations. Summer mortality was reduced by special regulations on Hay Creek and South Branch Whitewater River with exploitation rates of 55% and 48%. Summer mortality was not reduced on East Beaver Creek with an exploitation rate of 34%. Hunt (1985) concluded that

long-term exploitation rates >40% were excessive in a southwestern Wisconsin stream.

Abundance of larger brown trout (301-380 mm) was limited by exploitation under normal regulations in Hay Creek but not in East Beaver Creek. Abundance of this size was similar in Hay Creek under special regulations and in East Beaver Creek under normal regulations. In South Branch Whitewater River where habitat had not been improved, abundance did not increase after three years of harvest protection and was less than in the other two streams.

Habitat was also influential in determining abundance of brown trout >380 mm, which was not influenced by special regulations. Behnke (1987) explained that each stream environment has a terminal age or size beyond which abundance of older or larger trout cannot be increased. The terminal size is determined by fish energetics and optimal foraging theory. As trout increase in size they prefer larger prey and will move to find habitat with the preferred prey size. In this study habitat for brown trout >380 mm and for preferred sizes of prey was lacking since abundance of this size did not increase when harvest was restricted for three years.

Habitat improvement projects have increased cover and trout abundance (Thorn 1988a), but apparently have not improved the cover required by large trout. Trophy brown trout (>432 mm) in South Branch Au Sable River, Michigan preferred water velocities <10cm/sec, depths between 46 and

60 cm, areas of cover, and areas with silt substrate (Clapp 1988). During winter, trout need cover to position themselves under and pool depth for reduced velocity (Cunjak and Power 1987). In southeastern Minnesota streams flow may be limiting deep water needed by large trout during winter. Cunjak and Power (1986) found that an annual discharge of 0.0679 m^3/sec in a tributary stream in Ontario precluded use during winter by larger trout that overwintered in deeper pools of the main river with a winter discharge of 2.24 m^3/sec. Winter discharge was <0.25 m^3/sec in Hay Creek and East Beaver Creek and <1.3 m^3/sec in South Branch Whitewater River.

Migration of fish could influence expectations and results on stream lengths used in this study. Thorn (1988a) showed that brown trout moved into enhanced habitat and that fishing pressure increased after habitat improvement. Harvest of these immigrants could inflate exploitation rates under normal regulations. Larger trout may have moved out of the study areas. Clapp (1988) found that brown trout >432 mm had an average range of movement of 5 km in summer and of 12 km in winter. Regulations to increase abundance of trout <350 mm on shorter stream lengths may be successful (Klein 1974), but regulations to increase larger trout abundance and catch rates may have to be placed on longer stream lengths than used in this study.

Angling pressure under a special regulation commonly declines initially but then increases to levels equal to or

greater than before the regulation was imposed (Hunt 1981, Barnhart and Engstrom-Heg 1984). In the present study this pattern was noted on Hay Creek and may be occurring on East Beaver Creek. Nehring and Anderson (1984) reported that a minimum of 3-5 years were needed to evaluate special regulations in Colorado. The three years of this study were insufficient to rigorously evaluate effects of a management practice upon a fluctuating population. Also, since the rate of exploitation was negatively correlated with preseason abundance ($r^2 = 0.39$, $P < 0.01$) and natural abundance was relatively high during this study, a longer study period would have better evaluated effects of special regulations under different levels of abundance and exploitation.

Stream productivity did not limit effectiveness of special regulations in southeastern Minnesota streams as it may have elsewhere. Abundance can increase when angling mortality is reduced without decreasing growth (i.e. Hay Creek). Clark et al. (1980) concluded that changes in fishing regulations that significantly changed abundance did not significantly affect growth rates of trout in streams. In New York (Barnhart and Engstrom-Heg 1984) and in Wisconsin (Hunt 1987), however, future special regulations will probably be restricted to streams with limited or stocked recruitment so that growth does not decrease as abundance increases.

Based on criteria of Hunt (1977) and Behnke (1978), an

increase in abundance of brown trout under South Branch Whitewater River from special regulations was expected. Natural recruitment was low (average of 187 age-0/km), growth potential appeared good, exploitation under normal regulations was 48%, and habitat appeared adequate for more brown trout >300 mm. Apparently the Delphi habitat evaluation was wrong and trout not harvested had to move out of the study area.

Catch rates >1.0/h for naturally fluctuating wild brown trout populations under normal regulations in southeastern Minnesota streams may not be maintained in the long term without releasing some of the fish caught. Catch rates under normal regulations ranged from 0.34-0.95/h and averaged 0.63/h, with a voluntary release fishery that ranged from 32-87% of the trout caught and averaged 61%. The mean harvest rate of 0.23/h on Section B of Hay Creek under normal regulations appeared to be prohibiting recruitment of brown trout >300 mm into enhanced habitat.

Habitat and movement, rather than the angling mortality, limited rainbow trout abundance under the 254 mm maximum size limit in South Branch Whitewater River. An increase in abundance of rainbow trout >254 mm was expected because the exploitation rate under normal regulations was high (88%) and rainbow trout fisheries in other brown trout/rainbow trout populations have been improved by special regulations (Barnhart and Engstrom-Heg 1984, Nehring and Anderson 1984). However, exploitation and summer

mortality did not decrease under the special regulations and abundance did not increase. Hunt (1981) also reported little success in increasing abundance of rainbow trout >330 mm with a special regulation in Race Branch, Wisconsin. Thorn (1984) reported that high natural mortality of rainbow trout in South Branch Whitewater River was due to seasonally receding water levels, which reduced depth in faster, open water preferred by rainbow trout, and exposed trout to avian predators. A reduction in total mortality under special regulations may have been obscured by movement of larger rainbow trout. Downstream from the study area where no rainbow trout were stocked, the rainbow trout harvest in 1988 was 152/km and 36% were >300 mm (Hayes 1989).

Fisheries administrators often fear special regulations will negatively impact a majority of anglers on a stream. The concern in this study was over potential displacement of local bait anglers who would not change methods, and their replacement by a smaller number of fly fishermen, often members of an organized angling club, or from Twin Cities Metropolitan area. Under normal regulations, local anglers were not a majority, few anglers belonged to an organized angling group, and a majority fished with bait. Under special regulations origins of the angler changed only on one stream, anglers belonging to an organized angling group were not a majority, and a large majority fished with artificial flies. A meaningful negative impact on angling use did not occur under special regulations.

Simplicity of a no-kill regulation makes it the most appropriate regulation to increase abundance and catch of larger brown trout in southeastern Minnesota streams when habitat is available. A maximum size limit would also protect larger trout, yet this study and Clark (1981) indicate abundance, growth, and mortality would not change due to increased abundance of larger trout. Also, Clark (1981) concluded that catch of trout >406 mm decreased as maximum size limit increased from 178 to 305 mm, and increased most under a no-kill regulation. The slot limit, an alternative regulation, would only produce a small increase in catch of trophy trout without causing a large decrease in total catch (Jensen 1981).

Criteria recommended by Hunt (1987) for successful special regulations for brown trout in Wisconsin were not completely applicable to this study. Public access and physical stream characteristics and water quality were common criteria in both states. East Beaver Creek, with a dense, wooded canopy, did not appear to be an easy stream to fish with artificial flies, yet fly fishing pressure increased (Tables 13 and 14). Apparently importance of catch and release fishing and trout abundance were more important than fishability and anglers adapted fishing methods to the stream. Lack of importance for recruitment for successful special regulations in southeastern Minnesota has been discussed. As in Wisconsin special regulation fisheries attracted nonlocal anglers.

Angling quality was determined more by changing attitudes about importance of size and number caught (catch rates) than by biological responses to regulations. Common objectives of special regulations are to increase catch rates by increasing abundance or by recycling fish, and to increase average size of fish caught. Under normal regulations number of fish caught was the least important variable and the other four variables were similarly rated. Under special regulations importance of catching and releasing fish increased and was the most important of the five variables, importance of the other four variables varied among streams, importance of size decreased on two streams, and importance of number caught increased on one stream. Other objectives such as expanding fishing opportunities to diverse angler interests or extending seasons are increasing in importance. In Michigan stream trout anglers ranked four non-biological variables as more important than number or size of fish caught (Fenske 1983).

The Weithman and Anderson (1978) fishing quality index combines size and number of fish caught in calculating Q, overall fishing quality. Q may not accurately measure increased fishing quality resulting from fisheries management on southeastern Minnesota streams. On Hay Creek under special regulations, total abundance and abundance of brown trout >300 mm increased and importance of catch and release fishing increased, but Q did not change because importance of size and diversity decreased. On South Branch

Whitewater River under special regulations, abundance did not increase but Q increased because importance of catch and release fishing, number and diversity and percent of anglers successful ($t = -3.016$, $P < 0.10$, Appendix Table 12) increased even though importance of kind decreased. On East Beaver Creek, abundance did not change under either regulation but Q increased under normal regulations because percent of anglers successful increased ($t = -2.574$, $P < 0.10$, Appendix Table 12) even though importance of kind decreased. However, Q may suggest reduced angling quality. On Section B of Hay Creek abundance and pressure increased under normal regulations after habitat improvement (Thorn, in press), but Q decreased significantly ($r^2 = 0.75$, $P < 0.10$) during five years of this study because of changes over time in the five importance/enjoyment variables determining Trip Quality (Appendix Table 12). Fishing quality on South Branch Whitewater River appeared to be enhanced by the rainbow trout fishery. Trout abundance or importance of rainbow trout did not increase there under special regulations, but importance of catching more than one species increased, importance of kind decreased, and Q increased. Thus Q may aid managers in comparing streams on a relative index rather than a fixed index or in determining the length of trout to satisfy anglers in different streams (S. Hirsch, Minn. Dept. Nat. Res., personal communication 1988).

Management Implications

Special regulations can increase abundance of brown trout 200-381 mm in southeastern Minnesota streams if habitat is available. Abundance of wild brown trout >381 mm may be limited by trout energetics and regulations will not increase their abundance. Special regulations may prevent a decrease in abundance of brown trout >300 mm under intense angling pressure.

To increase abundance of brown trout >381 mm, their habitat requirements and those of preferred prey sizes must be determined and incorporated into habitat improvement projects. Then special regulations may be applied to maintain the desired density.

Special regulations on southeastern Minnesota streams should be applied to longer stream lengths than in this study. Regulations to increase abundance of trout >381 mm should be applied to a minimum stream length of 5 km when habitat is available. Regulations to increase abundance of trout <381 mm may be applied to a minimum length of 1 km. Regulations to protect low trout populations can be applied to any length as necessary.

Special regulations on southeastern Minnesota streams should be evaluated for a longer period of time (five years) because of fluctuating abundance and sociological angler use characteristics.

Rate of exploitation should exceed 50% of the preseason population under a normal regulation before a special

regulation is imposed. Then special regulations can reduce summer mortality to increase abundance when habitat is available.

Special regulations may increase survival and abundance of larger rainbow trout when habitat is available, however, few streams in southeastern Minnesota will provide a quality rainbow trout fishery because of poor quality habitat. Also lack of importance for rainbow trout by anglers probably will limit future rainbow trout management.

Special regulations may be the only management with unlimited fishing to provide a long term catch rate of 1.0/h for wild brown trout.

Catch and release fishing was important to anglers under all regulations and negative social implications of special regulations were minimal. Expansion of specialized fishing opportunities with special regulations should be considered.

Weithman and Katti's (1979) Q did not adequately measure changes in fishing quality due to special regulations. Sociological attitudes not included in Weithman and Anderson's (1978) fishing quality indices, appear to be determining angling quality and should be investigated.

The Department of Natural Resources should establish agency credibility and public trust for special regulations by developing an authoritative spokesperson, respected by angling groups (Behnke 1987).

Literature Cited

Anderson, D.W. 1983. Factors affecting brown trout reproduction in southeastern Minnesota streams. Minnesota Department of Natural Resources, Division of Fish and Wildlife, Section of Fisheries Investigational Report No. 376: 36 pp.

Anderson, R.M., and R.B. Nehring. 1984. Effects of a catch-and-release regulation on a wild trout population in Colorado and the acceptance by anglers. North American Journal of Fisheries Management 4:257-265.

Barnhart, G.A., and R. Engstrom-Heg. 1984. A symposium of some New York experiences with catch and release management of wild salmonids. Pages 91-101 in F. Richardson and R.H. Hamre, eds. Wild Trout II Proceedings of the Symposium. Trout Unlimited, Inc.

Behnke, R.J. 1978. Use of native trout in special regulations fisheries. Pages 45-57 in K. Hashagen, ed. Proceedings of a National Symposium on Wild Trout Management. California Trout, Inc., San Francisco.

Behnke, R.J. 1980. Special regulations; historical perspective. Pages 58-63 in R. Whaley, ed. Proceedings of the 15th Annual Meeting Colorado-Wyoming Chapter. American Fisheries Society.

Behnke, R.J. 1987. Catch-and-release - The last word. Pages 291-299 in R.A. Barnhart and T.D. Roelofs, eds. Proceedings of Catch-and-Release Fishing, A Decade of Experience. Humboldt State University, Arcata, California.

Clapp, D.F. Movement, habitat use, and daily activity patterns of trophy brown trout in the South Branch of the Au Sable River, Michigan. Michigan Department of Natural Resources, Fisheries Research Report No. 1907: 60 pp.

Clark, R.D. Jr., G.R. Alexander, and H. Gowing. 1980. Mathematical description of trout-stream fisheries. Transactions of the American Fisheries Society 109:587-602.

Clark, R.D. Jr. 1981. Analysis of "quality fishing" regulations through mathematical simulation of a brown trout fishery. Michigan Department of Natural Resources, Fisheries Research Report No. 1985: 33 pp.

Clark, R.D., Jr., G.R. Alexander, and H. Gowing. 1981. A history and evaluation of regulations for brook trout and brown trout in Michigan streams. North American Journal of Fisheries Management 1:1-14.

Cunjak, R.A. and G. Power. 1986. Winter habitat utilization by stream resident brook trout (Salvelinus fontinalis) and brown trout (Salmo trutta). Canadian Journal of Fisheries Aquatic Science 43:1970-1981.

Cunjak, R.A., and G. Power. 1987. Cover use by stream-resident trout in winter: a field experiment. North American Journal of Fisheries Management 7:539-544.

Dienstadt, J.M. 1980. Catch-and-release angling in California wild trout streams. Pages 119-124 in R.A. Barnhart and T.D. Roelofs, eds. Proceedings of a National Symposium on Catch and Release Fishing. Humboldt State University, Arcata, California.

Fenske, J.L. 1983. Attitudes and attitudes of anglers who fish for trout in Michigan. Michigan Department of Natural Resources, Fisheries Research Reprt No. 1916: 52 pp.

Graff, D.R. and B.A. Hollender. Catch-and-release fishing--the Pennsylvania experience. Pages 137-150 in R.A. Barnhart and T.D. Roelofs, eds. Proceedings of a National Symposium on Catch and Release Fishing. Humboldt State University, Arcata, California.

Hall, D.H., and N.J. Knight. 1981. Natural variation in abundance of salmonid populations in streams and its implications for design of impact studies. Oregon Agricultural Experiment Station. Technical Report Paper 5608, Corvallis. 4 pp.

Hayes, M. 1989. Progress Report: Evaluation of special regulations for a winter trout season on the South and Middle Branches of the Whitewater River. Minnesota Department of Natural Resources, Division of Fish and Wildlife F-29-R Report: 32 pp.

Hunt, R.L. 1975. Angling regulations in relation to wild trout management. Pages 66-73 in W. King, ed. Proceedings of the Wild Trout Management Symposium. Trout Unlimited, Inc.

Hunt, R.L. 1981. A successful application of catch and release regulations on a Wisconsin trout stream. Wisconsin Department of Natural Resources, Technical Bulletin No. 119: 30 pp.

Hunt, R.L. 1985. Results and trout management implications of a 9-month creel census on Timber Coulee Creek in 1984. Wisconsin Department of Natural Resources, Bureau of Research Report 135: 23 pp.

Hunt, R.L. 1987. Characteristics of three catch-and-release fisheries and six normal-regulation fisheries for brown trout in Wisconsin. Pages 33-48 in R.A. Barnhart and T.D. Roelofs, eds. Proceedings of Catch and Release Fishing, A Decade of Experience. Humboldt State University, Arcata, California.

Jensen, A.L. 1981. Optimum size limits for trout fisheries. Canadian Journal of Fisheries Aquatic Science 38:657-661.

Johnson, M. 1983. An evaluation of stream trout stocking in Langlade, Lincoln and Marathon counties. Wisconsin Department of Natural Resources, Bureau of Fish Management Report No. 114: 7 pp.

Kerr, R.A. 1982. A five-year study of brown trout populations and angling success in the Castle Rock Creek fish for fun area, Grant County, Wisconsin. Wisconsin Department of Natural Resources, Fisheries Management Report 111: 13 pp.

Klein, W.D. 1974. Special regulations and elimination of stocking: influence on fishermen and the trout population at the Cache la Poudre River, Colorado. Colorado Department of Natural Resources, Division of Wildlife, Technical Publication No. 30: 57 pp.

Minnesota DNR. 1987. Stream Trout. Minnesota Department of Natural Resources, Division of Fish and Wildlife. Long Range Plan. 12 pp.

Nehring, R.B. 1980. Special regulations evaluations in Colorado. Pages 84-94 in R. Whaley, ed. Proceedings of the 15th Annual Meeting Colorado-Wyoming Chapter. American Fisheries Society.

Nehring, R.B., and R. Anderson. 1984. Catch and release management in Colorado - what works? How, when, where, why? Pages 109-112 in F. Richardson and R.H. Hamre, eds. Wild Trout III Proceedings of the Symposium. Trout Unlimited, Inc.

Platts, W.S., and R.L. Nelson. 1988. Fluctuations in trout populations and their implications for land-use evaluation. North American Journal of Fisheries Management 8: 333-345.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada 191: 382 pp.

Shetter, D.S. 1969. The effect of certain angling regulations on stream trout populations. Pages 333-353 in T.G. Northcote, ed. Symposium on Salmon and Trout in Streams. University of British Columbia, Institute of Fisheries, Vancouver, Canada.

Thorn, W.C. 1984. Evaluation of fall stocked rainbow trout fingerlings in southeastern Minnesota streams. Minnesota Department of Natural Resources, Division of Fish and Wildlife, Section of Fisheries Management Report No. 27: 24 pp.

Thorn, W.C. 1988a. Evaluation of habitat improvement for brown trout in agriculturally damaged streams of southeastern Minnesota. Minnesota Department of Natural Resources, Division of Fish and Wildlife, Section of Fisheries Investigational Report No. 394: 32 pp.

Thorn, W.C. 1988b. Brown trout use in southeastern Minnesota and its relationship to habitat improvement. Minnesota Department of Natural Resources, Division of Fish and Wildlife, Section of Fisheries Investigational Report No. 395: 28 pp.

Thorn, W.C. (in press). Effects of habitat improvement and a special regulation on a brown trout population in Proceedings of a Brown Trout Workshop, Biology and Management.

Weithman, S.A., and R.O. Anderson. 1978. A method of evaluating fishing quality. Fisheries 3:6-10.

Weithman, S.A., and S.K. Katti. 1979. Testing of fishing quality indices. Transactions of the American Fisheries Society 108:320-325.

Wilkinson, L. 1988. SYSTAT: The System for Statistics. Evanston, Illinois: Systat, Inc. 1988.

Zuboy, J.R. 1981. A new tool for fisheries managers: the Delphi technique. North American Journal of Fisheries Management 1:55-59.

Appendix Table 1. Fishing pressure for Sections A and B of Hay Creek, South Branch Whitewater River, and East Beaver Creek. An R designates estimate made under special regulations.

	Hr/ha		Hr/km	
	A	B	A	B
		Hay Creek		
1983	2,276	1,033	1,283	676
1984	1,905	1,811	1,054	1,184
1985	1,166 R	2,973	657 R	1,944
1986	1,895 R	2,364	1,068 R	1,546
1987	2,192 R	2,733	1,235 R	1,787
		South Branch Whitewater River		
1983	1,272	1,272	1,332	1,332
1984	1,002	1,135	1,069	1,211
1985	1,355 R	1,565	1,441 R	1,671
1986	1,005 R	1,271	1,069 R	1,358
1987	1,295 R	1,359	1,377 R	1,452
		East Beaver Creek		
1984	1,729	1,221	991	780
1985	1,594	938	913	598
1986	721 R	841	413 R	537
1987	581 R	832	333 R	531
1988	1,006 R	619	577 R	395

Appendix Table 2. Estimated abundance of age-0 brown trout in the fall in Sections A and B of Hay Creek, South Branch Whitewater River, and East Beaver Creek. An R designates estimate made under special regulations.

	Age-0/km			
	A		B	
		Hay Creek		
1980	30			
1981	232		490	
1982	363		152	
1983	130		44	
1984	1,035		1,104	
1985	177	R	267	
1986	1,652	R	1,842	
1987	2,801	R	1,706	
		South Branch Whitewater River		
1980	5			
1981	396			
1982	195			
1983	192			
1984	145		205	
1985	124	R	37	
1986	--		--	
1987	1,464	R	629	
		East Beaver Creek		
1984	863		1,063	
1985	387		639	
1986	1,090	R	2,071	
1987	1,771	R	1,769	
1988	1,010	R	1,172	

Appendix Table 3. Estimated abundance (number/km) and biomass (kg/ha) of brown trout (age-0 not included) in Sections A and B of Hay Creek. An R designates estimate made under special regulations.

	Abundance		Biomass	
	A	B	A	B
Spring				
1980	946	1,013	78.2	130.4
1981	366		87.9	
1982	311		79.2	
1983	691		104.8	
1984	338	352	105.1	137.9
1985	894	3,513	152.7	546.6
1986	934 R	719	295.0 R	208.7
1987	1,370 R	1,677	342.7 R	285.3
1988	2,424 R	2,740	398.4 R	323.1
Fall				
1980	423		144.2	
1981	147	194	58.1	73.1
1982	88	229	94.9	100.1
1983	241	267	99.4	110.1
1984	124	287	66.1	121.3
1985	803 R	556	267.6 R	133.4
1986	566 R	202	268.3 R	86.4
1987	753 R	506	218.0 R	133.2

Appendix Table 4. Estimated abundance and biomass of brown trout and rainbow trout (age-0 not included) in Sections A and B of South Branch Whitewater River. An R designates estimate made under special regulations.

	Abundance (no/km)		Biomass (kg/ha)	
	A	B	A	B
		Brown trout		
Spring				
1983	322	322	47.7	47.7
1984	308	252	61.7	56.5
1985	378	183	57.9	38.3
1986	288 R	251	63.2 R	68.6
1987	341 R	360	61.4 R	80.1
1988	1,561 R	1,118	129.5 R	120.2
Fall				
1983	145	145	25.3	25.3
1984	323	184	75.6	42.4
1985	271 R	187	61.2 R	45.4
1987	234 R	170	61.2 R	48.5
		Rainbow trout		
Spring				
1983	1,476	1,476	62.5	62.5
1984	283	99	9.1	4.6
1985	318	406	25.7	35.5
1986	422 R	642	34.1 R	51.7
1987	893 R	470	70.9 R	42.2
1988	475 R	695	54.3 R	70.9
Fall				
1983	4	4	0.4	0.4
1984	4	6	0.3	0.8
1985	9 R	0	1.8 R	0.0
1987	87 R	10	19.3 R	2.1

Appendix Table 5. Estimated abundance and biomass of brown trout (age-0 not included) in Sections A and B of East Beaver Creek. An R designates estimate made under special regulations.

	Abundance (no/km)		Biomass (kg/ha)	
	A	B	A	B
Spring				
1984	889	1,106	351.7	378.8
1985	947	1,208	222.7	252.1
1986	787	831	260.4	286.8
1987	1,210 R	1,225	226.7 R	327.2
1988	1,910 R	1,550	314.8 R	306.5
1989	1,035 R	1,157	199.0 R	222.5
Fall				
1984	392	467	184.0	211.1
1985	327	783	154.2	275.9
1986	323 R	614	169.1 R	267.6
1987	698 R	715	231.7 R	217.8
1988	999 R	830	402.1 R	256.6

Appendix Table 6. Estimated abundance (number/km) of brown trout (excluding age-0) by size groups in Sections A and B of Hay Creek. An R designates estimate made under special regulations.

	<200 mm		Stock 200-250 mm		Quality 251-300 mm		Preferred 301-380 mm		Memorable 381-500 mm	
	A	B	A	B	A	B	A	B	A	B
Spring										
1981	148		176		41		0		0	
1982	201		32		57		21		0	
1983	607		4		33		42		4	
1984	182	131	14	13	91	108	41	75	10	25
1985	663	2,252	128	1,054	57	165	39	38	7	4
1986	291 R	181	209 R	162	352 R	337	75 R	40	8 R	0
1987	552 R	1,100	533 R	375	124 R	88	155 R	113	6 R	0
1988	1,618 R	2,060	420 R	380	232 R	238	151 R	54	3 R	0
Fall										
1981	4	11	52	83	69	63	20	31	0	6
1982	0	--	12	--	48	--	22	--	5	--
1983	0	10	114	98	95	73	22	69	10	17
1984	0	0	43	96	44	144	31	35	5	12
1985	29 R	0	456 R	354	251 R	179	53 R	23	12 R	0
1986	0 R	4	228 R	65	147 R	54	190 R	73	0 R	6
1987	95 R	48	382 R	304	141 R	73	118 R	81	5 R	0

Appendix Table 7. Estimated abundance (no/km) of brown trout by size groups (excluding age-0) in Sections A and B of South Branch Whitewater River. An R designates estimate made under special regulations.

	<200 mm		200-250 mm		251-300 mm		301-380 mm		381-500 mm	
	A	B	A	B	A	B	A	B	A	B
Spring										
1984	0	0	136	87	118	109	41	41	13	15
1985	169	64	71	12	73	52	50	39	15	16
1986	78 R	0	0 R	26	121 R	152	75 R	54	14 R	19
1987	90 R	99	51 R	43	127 R	86	56 R	108	17 R	24
1988	1,268 R	689	63 R	150	105 R	140	123 R	139	2 R	0
Fall										
1983	0	0	84	84	40	40	15	15	6	6
1984	8	0	103	62	124	67	73	39	15	16
1985	0 R	0	78 R	43	121 R	84	62 R	42	10 R	18
1987	0 R	0	52 R	25	80 R	59	81 R	72	21 R	14

Appendix Table 8. Estimated abundance (number/km) of rainbow trout (excluding age-0) by size groups in Sections A and B of South Branch Whitewater River. An R designates estimate made under special regulations.

	≤200mmm		200-250 mm		251-300 mm		301-380 mm		381-500 mm	
	A	B	A	B	A	B	A	B	A	B
Spring										
1984	281	99	0	0	2	0	0	0	0	0
1985	184	194	134	212	0	0	0	0	0	0
1986	228 R	255	194 R	377	0 R	10	0 R	0	0 R	0
1987	664 R	241	184 R	218	31 R	0	14 R	11	0 R	0
1988	80 R	0	356 R	675	20 R	10	19 R	10	0 R	0
Fall										
1983	0	0	4	4	0	0	0	0	0	0
1984	0	0	0	4	2	2	2	0	0	0
1985	0 R	0	2 R	0	7 R	0	0 R	0	0 R	0
1987	0 R	0	18 R	0	51 R	10	18 R	0	0 R	0

Appendix Table 9. Estimated abundance (number/km) of brown trout (age-0 not included) on Sections A and B of East Beaver Creek. An R designates estimate made under special regulations.

	<200 mm		200-250 mm		251-300 mm		301-380 mm		381-500 mm	
	A	B	A	B	A	B	A	B	A	B
Spring										
1984	211	227	207	277	332	443	118	140	21	19
1985	640	708	37	118	152	234	111	140	7	8
1986	373	217	77	190	213	272	113	146	11	6
1987	917 R	614	63 R	119	96 R	278	130 R	214	4 R	0
1988	1,359 R	913	241 R	246	205 R	225	94 R	166	11 R	0
1989	574 R	512	196 R	275	178 R	236	84 R	131	3 R	3
Fall										
1984	34	18	117	124	145	164	90	153	6	8
1985	34	61	130	392	87	206	71	124	5	0
1986	39 R	82	124 R	154	66 R	201	88 R	171	6 R	6
1987	195 R	205	237 R	228	168 R	147	98 R	135	0 R	0
1988	273 R	235	305 R	236	204 R	235	195 R	116	22 R	8

Appendix Table 10. Catch, release, and harvest rates (fish/hr) for trout in Sections A and B of Hay Creek, South Branch Whitewater River, and East Beaver Creek. An R designates estimate made under special regulations.

	Catch rate		Release rate		Harvest rate	
	A	B	A	B	A	B
			Hay Creek - Brown trout			
1983	0.40	0.57	0.25	0.38	0.15	0.19
1984	0.56	0.81	0.35	0.54	0.21	0.27
1985	0.71 R	0.55	0.71 R	0.42	<0.01 R	0.14
1986	0.85 R	0.86	0.85 R	0.53	0.00 R	0.32
1987	1.78 R	0.95	1.78 R	0.57	0.01 R	0.23
			South Branch Whitewater River - Brown trout			
1983	0.48	0.48	0.25	0.25	0.23	0.23
1984	0.86	0.39	0.57	0.13	0.29	0.25
1985	0.47 R	0.38	0.38 R	0.22	0.06 R	0.15
1986	0.33 R	0.55	0.31 R	0.29	0.02 R	0.27
1987	0.69 R	0.34	0.66 R	0.17	<0.01 R	0.17
			South Branch Whitewater River - Rainbow trout			
1983	0.50	0.50	0.33	0.33	0.17	0.17
1984	0.54	0.64	0.40	0.42	0.11	0.22
1985	0.54 R	0.45	0.47 R	0.30	0.05 R	0.16
1986	0.52 R	0.63	0.46 R	0.45	0.06 R	0.21
1987	1.03 R	0.74	1.01 R	0.44	0.01 R	0.30
			East Beaver Creek - Brown trout			
1984	1.11	0.78	0.74	0.40	0.54	0.37
1985	0.57	0.50	0.39	0.46	0.19	0.04
1986	0.95 R	0.90	0.92 R	0.80	0.04 R	0.10
1987	1.02 R	0.64	1.01 R	0.60	0.01 R	0.03
1988	1.38 R	0.62	1.35 R	0.39	0.04 R	0.19

Appendix Table 11. Estimated number (number/km) of trout caught, released, and harvested for Sections A and B of Hay Creek, South Branch Whitewater River, and East Beaver Creek. An R designates estimate made under special regulations.

	Trout caught		Trout released		Trout harvested	
	A	B	A	B	A	B
			Hay Creek - Brown trout			
1983	569	396	316	262	253	134
1984	432	663	191	414	242	253
1985	745 R	1,698	725 R	937	20 R	521
1986	945 R	935	945 R	533	0 R	398
1987	2,157 R	1,822	2,144 R	1,279	13 R	496
			South Branch Whitewater River - Brown trout			
1983	608	608	307	307	135	135
1984	923	480	617	154	164	212
1985	761 R	711	694 R	448	43 R	139
1986	429 R	651	381 R	353	35 R	185
1987	843 R	386	829 R	204	17 R	94
			South Branch Whitewater River - Rainbow trout			
1983	777	777	534	534	243	243
1984	526	698	346	442	147	241
1985	1,189 R	1,045	1,070 R	776	111 R	281
1986	941 R	1,185	842 R	853	99 R	334
1987	1,478 R	1,027	1,428 R	584	52 R	439
			East Beaver Creek - Brown trout			
1984	928	558	496	242	379	314
1985	520	264	296	216	226	48
1986	343 R	500	328 R	437	13 R	61
1987	451 R	375	446 R	314	5 R	58
1988	689 R	276	650 R	214	39 R	54

[a] Wild brown trout.

Appendix Table 12. Mean $\log_{10}$ trip quality (TQ) of successful anglers, percentage of successful anglers (% SA), and overall fishing quality (Q) for Sections A and B of Hay Creek, South Branch Whitewater River, and East Beaver Creek, before and after harvest was restricted in Section A. An R designates estimate made under special regulations.

	Mean $\log_{10}$ TQ		%SA		Q	
	A	B	A	B	A	B
			Hay Creek			
1983	0.44	0.72	9	14	0.04	0.10
1984	0.51	0.51	27	17	0.14	0.09
1985	0.52 R	0.38	18 R	23	0.09 R	0.09
1986	0.68 R	0.46	31 R	16	0.21 R	0.07
1987	0.42 R	0.33	33 R	13	0.14 R	0.04
			South Branch Whitewater River			
1983	0.53	0.53	28	28	0.12	0.12
1984	0.54	0.47	31	36	0.17	0.17
1985	0.70 R	0.53	36 R	27	0.25 R	0.14
1986	0.66 R	0.57	45 R	57	0.30 R	0.32
1987	0.56 R	0.61	46 R	32	0.26 R	0.20
			East Beaver Creek			
1984	0.60	0.41	34	20	0.20	0.08
1985	0.52	0.38	24	20	0.24	0.08
1986	0.56 R	0.80	38 R	37	0.21 R	0.22
1987	0.57 R	0.56	35 R	25	0.20 R	0.14
1988	0.78 R	0.54	42 R	35	0.32 R	0.19

Appendix Table 13. Percentage of anglers that belonged to an organized angling group on Sections A and B of Hay Creek, South Branch Whitewater River, and East Beaver Creek. An R designates sample taken under special regulations. Sample size is in parentheses.

	Hay Creek		South Branch Whitewater River		East Beaver Creek	
	A	B	A	B	A	B
1984	9(162)	5(161)	18(174)	4(208)	14(60)	11(61)
1985	19(53)R	6(142)	43(113)R	15(163)	12(72)	11(46)
1986	38(142)R	4(175)	42(153)R	15(167)	24(50)R	26(76)
1987	49(150)R	7(143)	37(154)R	15(164)	21(66)R	25(76)
1988					30(91)R	18(99)

Appendix Table 14. Origin of anglers (%) fishing Sections A and B of Hay Creek, South Branch Whitewater River, and East Beaver Creek. An R designates sample taken under special regulations.

	Sample Size		Metro		Local		SE MN		Other MN		Non-resident	
	A	B	A	B	A	B	A	B	A	B	A	B
Hay Creek												
1983	111	162	44	44	32	32	21	21	1	1	2	2
1984	162	161	38	37	20	30	36	30	4	3	2	0
1985	53 R	142	53 R	44	21 R	27	17 R	20	9 R	6	0 R	2
1986	142 R	175	58 R	57	6 R	12	25 R	23	8 R	6	2 R	2
1987	150 R	143	63 R	63	15 R	17	17 R	13	3 R	7	2 R	0
South Branch Whitewater River												
1983	185	185	10	10	4	4	70	70	8	8	8	8
1984	174	208	26	10	5	6	64	81	2	1	3	2
1985	113 R	163	27 R	7	2 R	7	61 R	81	6 R	1	4 R	4
1986	153 R	167	40 R	15	0 R	7	54 R	68	3 R	5	3 R	5
1987	154 R	164	45 R	16	3 R	6	47 R	72	1 R	5	4 R	1
East Beaver Creek												
1984	60	61	27	49	20	5	38	35	13	8	2	3
1985	77	46	34	50	17	4	47	39	2	4	0	2
1986	50 R	76	48 R	57	8 R	3	30 R	24	0 R	8	14 R	8
1987	66 R	76	53 R	49	8 R	0	31 R	24	0 R	18	8 R	9
1988	91 R	99	53 R	54	2 R	2	26 R	29	10 R	3	9 R	12

Appendix Table 15. Method of angling by anglers (%) on Sections A and B of Hay Creek, South Branch Whitewater River, and East Beaver Creek, 1983-88. An R designates sample taken under special regulations.

	Sample Size		Bait		Artificial Flies		Mixed	
	A	B	A	B	A	B	A	B
				Hay Creek				
1983	111	162	52	72	4	8	17	7	27	14
1984	162	161	65	69	8	7	13	5	14	19
1985	53 R	142	4 R	61	9 R	13	83 R	5	4 R	20
1986	140 R	173	0 R	58	20 R	8	80 R	13	0 R	21
1987	150 R	143	0 R	63	14 R	9	86 R	12	0 R	16
				South Branch Whitewater River				
1983	185	185	57	57	4	4	27	27	12	12
1984	174	208	57	78	13	10	16	9	14	3
1985	93 R	143	8 R	61	16 R	13	76 R	16	0 R	10
1986	155 R	171	3 R	53	16 R	9	79 R	29	2 R	9
1987	154 R	164	2 R	60	16 R	12	80 R	19	1 R	9
				East Beaver Creek				
1984	60	61	49	50	16	18	23	18	12	14
1875	77	46	50	50	13	9	14	22	7	19
1986	50 R	76	6 R	35	30 R	12	62 R	36	2 R	17
1987	66 R	76	0 R	26	35 R	21	64 R	36	1 R	17
1988	91 R	99	1 R	26	22 R	21	73 R	47	2 R	5

Appendix Table 16. Importance of size, number, and kind of fish caught and enjoyment of catching more than one kind (diversity) and of catching and releasing fish (C&R) to anglers on Sections A and B of Hay Creek, South Branch Whitewater River, and East Beaver Creek (1 = very important, 5 - very unimportant). An R designates sample taken under special regulations.

	Size		Number		Kind		Diversity		C&R	
	A	B	A	B	A	B	A	B	A	B
					Hay Creek					
1983	2.5	2.8	2.8	3.3	2.4	2.7	2.6	2.8	2.2	2.5
1984	2.6	2.5	3.1	3.2	2.7	2.3	2.6	2.5	2.5	2.7
1985	2.9 R	2.5	3.3 R	3.0	2.4 R	2.4	2.8 R	2.4	1.9 R	2.4
1986	2.8 R	2.7	3.0 R	3.1	2.5 R	2.8	2.7 R	2.7	1.6 R	2.4
1987	2.9 R	2.8	2.9 R	3.0	2.5 R	2.8	3.0 R	2.5	1.6 R	2.4
					South Branch Whitewater River					
1983	2.7	2.7	3.1	3.1	2.4	2.4	2.9	2.9	2.3	2.3
1984	2.5	2.4	3.1	3.3	2.6	2.6	2.8	2.8	2.2	2.2
1985	2.8 R	2.7	2.7 R	3.1	2.8 R	3.1	1.4 R	1.9	1.8 R	2.5
1986	2.9 R	2.4	2.9 R	3.2	2.7 R	2.7	2.6 R	2.9	1.6 R	2.3
1987	2.7 R	2.5	2.9 R	2.9	2.7 R	3.1	2.7 R	2.6	1.8 R	2.2
					East Beaver Creek					
1984	2.6	2.6	3.3	3.3	2.3	2.2	3.0	3.0	2.5	2.2
1985	2.5	2.7	3.0	3.1	2.4	2.6	1.6	1.8	2.4	2.0
1986	2.5 R	2.9	2.8 R	3.3	2.4 R	2.8	2.6 R	2.8	2.0 R	2.2
1987	2.7 R	2.8	3.1 R	3.1	2.3 R	2.8	3.0 R	2.7	1.6 R	2.1
1988	2.5 R	2.4	2.8 R	2.7	2.8 R	2.9	3.2 R	3.2	1.9 R	2.1

Appendix Table 17. Importance of catching brown trout, rainbow trout, and brook trout to anglers on Sections A and B of Hay Creek, South Branch Whitewater River, and East Beaver Creek (1 = very important, 5 = very unimportant). An R designates sample taken under special regulations.

	Brown trout		Rainbow trout		Brook trout	
	A	B	A	B	A	B
			Hay Creek			
1983	1.7	1.8	2.0	2.1	2.0	1.8
1984	1.7	1.7	1.9	2.1	2.0	1.9
1985	2.5 R	2.6	2.5 R	3.0	2.4 R	2.9
1986	1.7 R	2.2	2.6 R	2.3	2.5 R	2.3
1987	2.0 R	2.1	2.6 R	2.4	2.3 R	2.0
			South Branch Whitewater River			
1983	2.1	2.1	2.3	2.3	2.3	2.3
1984	1.8	1.9	2.0	2.3	1.9	2.3
1985	1.7 R	1.5	2.1 R	2.0	2.2 R	2.0
1986	1.8 R	1.9	2.3 R	2.5	2.4 R	2.6
1987	2.0 R	2.2	2.5 R	2.4	2.5 R	2.7
			East Beaver Creek			
1984	1.6	1.7	2.1	2.1	1.8	1.9
1985	1.5	1.6	2.2	1.7	1.7	1.7
1986	1.6 R	1.7	2.4 R	2.4	2.0 R	2.4
1987	2.1 R	2.2	2.6 R	2.6	1.9 R	2.1
1988	2.0 R	2.8	2.5 R	2.9	2.3 R	2.7

ACKNOWLEDGMENTS

Many individuals provided assistance during this study. D. Pitman and P. Wingate supervised initiation and administration of the project. Members of the Fisheries Research Unit, Lake City Management Area, Park Rapids Management Area, and Central Staff provided electrofishing assistance. Numerous clerks and members of the Fisheries Research Unit conducted the creel census. J. Hirsch and J. Wiechman did the age and growth and angler attitude analysis. C. Anderson assisted with statistical analysis and the final report. B. Dohrn provided word processing assistance.

Edited by:

D.E. Woods, Fisheries Research Manager

C.S. Anderson, Coldwater Fisheries Research Supervisor