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THE EFFECTS OF STOCKING CATCHABLE-SIZED HATCHERY TROUT ON WILD TROUT IN THE MADISON RIVER AND O'DELL CREEK, MONTANA

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ABSTRACT

Fall wild populations of two-year-old and older brown and rainbow trout increased 159% and 868% in number and 160% and 1016% in total biomass, respectively, four years after the last catchable-sized hatchery rainbow trout was stocked in the Varney section of the Madison River. Brown trout increases peaked within two years after stocking of catchables had ceased, whereas wild rainbow trout biomass levels were still showing increases four years after the last stocking. Wild brown and rainbow trout between 10.0-17.9 inches showed the greatest increases in numbers when stocking ceased. A statistical comparison of mean winter flow rates, stocking or no stocking and total two-year-old and older wild trout biomass showed that existing flow variations had little affect on the total biomass, but stocking or no stocking had a significant correlation to total biomass levels. When catchable-sized hatchery rainbow trout were stocked for three consecutive years into a previously unstocked section of O'Dell Creek, the two-year-old and older wild brown trout population was reduced 49% in total number and biomass. Wild brown trout between 10.0-17.9 inches showed significant declines in number after stocking was initiated, whereas those smaller than 10 inches showed no significant change in numbers. In O'Dell Creek, a temporary decline in growth rates of yearling through four-year-old brown trout was measured during the first two years of catchable rainbow trout stocking. Measurable movement of wild trout marked in O'Dell Creek accelerated in lower O'Dell Creek during years of stocking. Stocking of catchable-sized hatchery rainbow trout had no detectable adverse effect on yearling brown trout numbers in either lower O'Dell Creek or the Varney section of the Madison River.

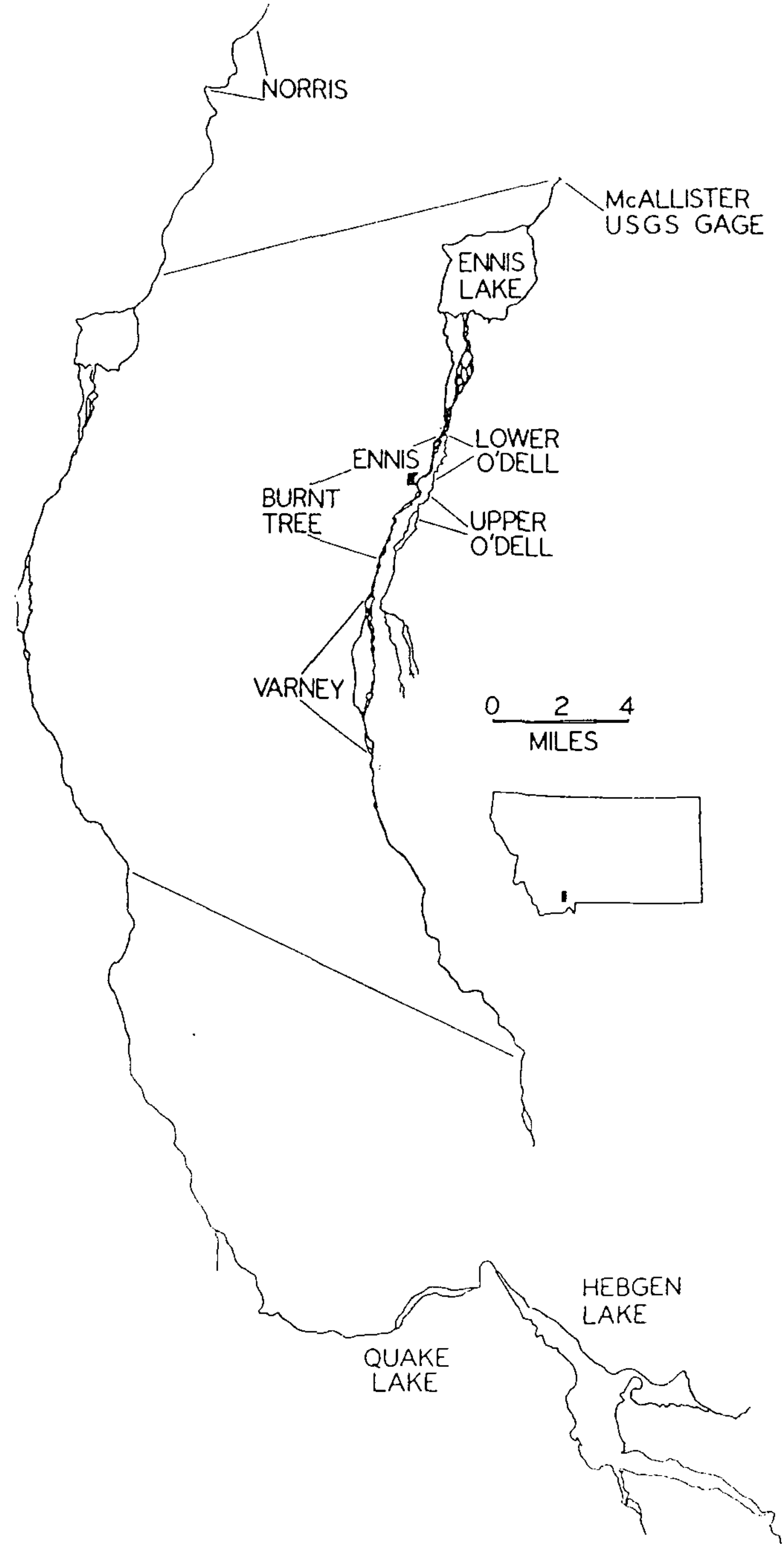
INTRODUCTION

The use of hatchery-reared catchable-sized trout to supplement existing wild stream dwelling trout has been an accepted fisheries management practice. However little concern had been given to what effect stocking had on the wild trout, although some studies did examine stresses on hatchery trout when stocked in streams having wild trout. Miller (1958) found that hatchery trout lost weight and had high initial mortality when stocked in sections of George Creek having resident wild cutthroat trout. He attributed these losses to stress from social struggles between hatchery and resident wild trout. Shetter (1974), Brynildson, et.al. (1961) and Mason, et.al. (1967) found higher survival of stocked hatchery trout in streams with the lowest wild trout numbers, suggesting detrimental social interaction with wild trout.

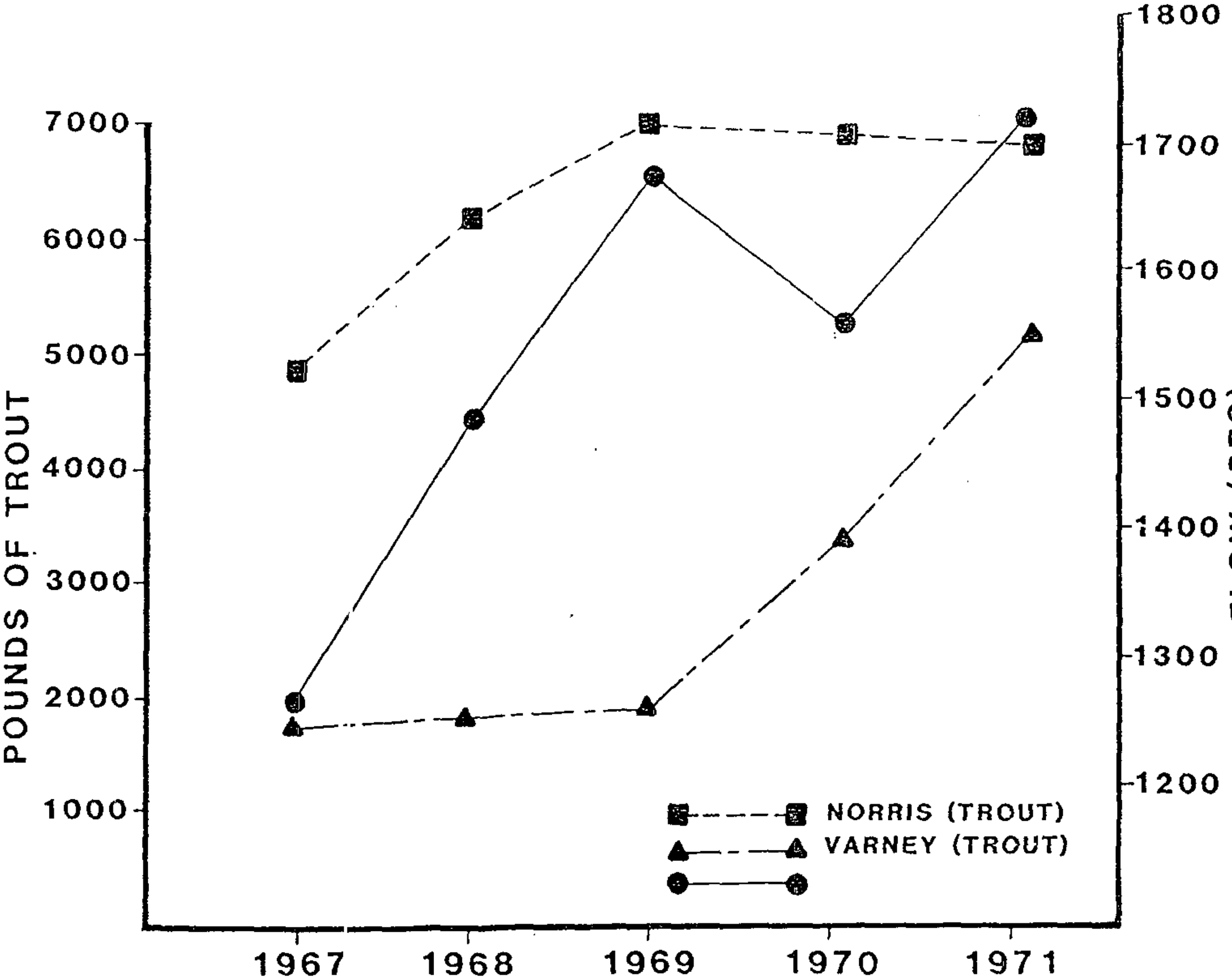
Initial studies on the Madison River (1967-69) were to determine what effect low stream flows had on wild trout populations (Vincent, 1970). Prior to 1968, the Madison River was periodically dewatered during the February-May period as a result of the filling process of Hebgen Reservoir (Figure 1). Hebgen was used to store water during the spring high water period for later use at downstream hydroelectric sites. During some years, this filling process began prior to spring high water periods resulting in a dewatered condition downstream from Hebgen Dam. In late 1967, an agreement with the local dam operator (Montana Power Company) delayed the initial filling of the reservoir until spring snow runoff was sufficient to maintain flow levels above 1,300 c.f.s. at the

McAllister U.S.G.S gage. Using wild trout population estimates from the Norris and Varney study sections, the estimated total biomass of two-year-old and older wild brown and rainbow trout was compared with the mean winter flow (December 1-April 30) preceding the estimate (Figure 2). Spring estimates (April) for the Norris section show that as the mean winter flow increased from 1967 to 1969, the total pounds of wild trout increased. However, estimates of wild trout biomass from the Varney section (Sept.) showed no appreciable change. A correlation between mean winter flows and total biomass (lbs./mi.) show that mean winter flow fluctuations account for 87% (r=0.9347) of the variation in wild trout biomass in the Norris section, but only 34% (r=0.583) of the variation in biomass in the Varney section. The correlation was significant (P 0.95) for the Norris section (t=4.55), but not significant for the Varney section (t=1.25). Some factors other than flow must have been controlling wild trout biomass in the Varney section. Overharvest of larger trout by anglers was ruled out as one of the factors due to a lower (18%) angler use in the Varney section, as it had a 9 month fishing season versus a 12 month season in the Norris section during this period (Vincent, 1969). In addition, the fishing access was superior in the Norris section. One major difference was that the Varney section had been stocked annually since 1955 with catchable-sized rainbow trout, while the Norris section had received no catchables since 1960.

Prior to 1948, little annual stocking of trout raised in hatcheries occurred, as wild brown and rainbow trout were able to sustain a fishery via natural reproduction. From 1948-1954, stocking was limited to small



NORRIS
McALLISTER
USGS GAGE
ENNIS
LAKE
LOWER
O'DELL
ENNIS
BURNT
TREE
UPPER
O'DELL
VARNEY
0 2 4
MILES
HEBGEN
LAKE
QUAKE
LAKE



E Richard Vincent Figure 2

subcatchable-sized (2-5 inch) brown and rainbow trout. The first catchable-sized rainbow trout (8-12 inch) were stocked in 1955. By 1969, annual stocking had increased to an average of 1600/mi. for the 51 mile section from Quake Lake to Ennis Reservoir. Catchables were stocked monthly from April through August with some stream reaches receiving more than others due to favorable access. Stocking of the 6 mile section from Varney bridge to Burnt Tree was discontinued in 1970 and in the remaining 45 miles of the middle Madison in 1974.

This study evaluated the effect of stocking catchable-sized hatchery rainbow trout into streams supporting self-substaining wild brown and rainbow trout. Primary objectives of the study were to determine: (1) if wild trout populations were affected by stocking hatchery catchables, (2) if numbers were affected, what sizes were affected, and (3) if stocking did have adverse affects, what was the length of the recovery periods where stocking was discontinued.

Description of Study Area

Madison River

The Madison River originates in Yellowstone National Park with the junction of the Gibbon and Firehole Rivers. It enters Montana via the northwestern corner of the park and then flows 120 miles in a northerly direction before joining the Gallatin and Jefferson Rivers to form the Missouri River. Its total drainage area is approximately 2,500 square miles.

Fish native to the Madison River were cutthroat trout (Salmo clarkii), arctic grayling (Thymallus arcticus), mountain whitefish (Prosopium williamsoni), mountain sucker (Catostomus platyrhynchus), longnose sucker (Catostomus catostomus) white sucker (Catostomus commersoni), longnose dace (Rhinechthup cataractae), and mottled sculpin (Cottus bairdi). Brown trout (Salmo trutta), rainbow trout (Salmo gairdneri) and brook trout (Salvelinus fontinalis) were introduced into the Madison during the late 1800's. Utah chub (Gila atraria) was introduced into Hebgen Reservoir by fishermen in the 1930's and subsequently gained access to the Madison. Two 4-mile study sections were established on the Madison River: (1) Varney - located 41 miles downstream from Quake Lake and (2) Burnt Tree - located 1.5 miles below the lower boundary of the Varney section (Figure 2). These two study sections were located within a reach of river characterized by a braided channel with long riffles interspersed with fast runs and few pools having maximum depths of 7 feet. The average stream width was approximately 200 feet. The average stream gradient was 30 ft/mi. Woody vegetation covered much of the streambank with undercut banks in many areas providing ideal habitat for trout. The streambed consisted of large to medium-sized rocks with ample areas of smaller spawning size gravel. The average annual discharge at the McAllister USGS Gage, 9.7 miles below the end of the Burnt Tree section, was 1,400 cfs with peak flows near 5,000 cfs in June and a low flow near 1,300 cfs for the winter months of December-March (U.S.G.S., 1966-1975).

O'Dell Creek

O'Dell Creek, a tributary to the Madison River, originates near Varney bridge and then flows parallel to the river for approximately 10 miles. The primary water source is a series of springs emerging along the east side of the Madison River. It has a very sinuous riffle-pool channel which flows through the brushy Madison River floodplain. Flows are usually very stable (approximately 100cfs), except during some winter periods when ice gorging on the Madison River diverts some water into the O'Dell channel. Because of its more stable flows and lower gradient (20 ft/mi.), the streambed has a much finer substrate than the Madison River.

Fish native to O'Dell Creek are the same as those found in the Madison River. Nonnative game fish found in O'Dell Creek include brown trout, rainbow trout and brook trout. Few wild cutthroat, rainbow or brook trout reside in O'Dell Creek. The brushy undercut banks and overhanging streambank vegetation provide ideal habitat for brown trout, the predominant species.

Two study section were established on O'Dell Creek. The lower section, located 0.5 mile from the mouth, was 1.8 miles in length, while the upper section, was 1.0 miles in length. The average channel width was 25 feet for the upper section and 35 feet for the lower section with maximum depths reaching 8 feet.

Methods

Wild trout population estimates were made in the spring (April-May) and fall (September) for each study section, when possible. Wild trout were sampled from an electrofishing boat while floating through the study section. The boat contained a stationary negative electrode, a mobile positive electrode, a portable 2,500 watt AC generator with a rectifying unit, and a live box to retain captured fish. Periodically captured fish were weighed (to the nearest 0.02 lbs.), measured (to the nearest 0.1 inch), marked, and released within the study section. Fish were marked with either a partial fin clip or affixed with a numbered Floy anchor tag.

Population estimates were made using the Peterson mark-and-recapture method with the following adaptation of formula number 4 of Ricker (1958):

$$N = \frac{(m+1)\ (c+1)}{R+1} - 1 \qquad (1)$$

Where N = population estimate;

M = number of fish marked;

C = number of fish in the recapture sample; and

R = number of marked fish in the recapture sample.

Two or more "marking" and/or "recapture" trips were required where sample sizes were small and/or trout populations were large. A 7 to 14 day time interval was allowed between marking and recapture periods to allow sufficient time for marked trout to randomly mix with unmarked trout.

Estimates of total number and weight were made by summing individual estimates made for size groups selected on the basis of uniform catchability and adequate marked recaptures (minimum of four). In order to obtain specific size group estimates for size group other than those estimated above, the number per 0.5 inch was calculated for each of the initial size groups through a proportioning system using all new unmarked fish (Vincent 1971). Then appropriate 0.5 inch group estimates were summed to obtain a specific size group. This same procedure was used to make age group estimates, except each 0.5 inch group estimate was proportioned by age using a subsample of 10 aged fish scales per 0.5 inch.

Confidence intervals at the 95% were calculated for total number and weight, size groups and age groups using the following formula:

$$\text{C.I.} = \pm 2\sqrt{\text{variance}} \quad (2)$$

Total variance for total number and weight were obtained by summing variances computed for each initial group using Serber's (1973) formula:

$$\text{Variance} = \frac{(m+1)\ (m-R)\ (c+1)\ (c-R)}{(R+2)\ (R+1)^2} \quad (3)$$

When confidence intervals were desired for either a specific size or age group not covered by initial size group estimates, variances were assigned to each 0.5 inch group based on the same proportioning system used to compute number per 0.5 inch.

The student t-test was used to test the null hypotheses of no difference between the mean weight or numbers for stocked years versus unstocked years. Normal distribution were assumed in all comparisons. In no instance were t-tests used where a heterogenus variance was detected as determined by the F-test (Snedecor, 1956). All levels of significance were at the 95% level. A linear regression was used to determine correlations of mean winter flow and total two-year-old and older wild trout biomass for the Madison River and for stocking or no stocking versus total biomass. In determining stocking or no stocking correlation comparisons with total biomass arbitrary values of 300, 200 and 100 were assigned the no stocking, transitional and stocking years, respectively.

The Varney section was set up as the primary study section on the Madison River, where stocking of catchables had been continuous from 1955 through 1969. With the cessation of stocking in this section in 1970, a comparison of wild trout populations after stocking (1967-69) and no stocking (1970-76) could be made. An unscheduled stocking of catchables during the summer of 1972, somewhat altered this approach.

The Burnt Tree section was used as a field control, where stocking of catchables would continue through 1973. Any population change occurring in the Varney section after stocking ceased would be compared with population changes in the stocked Burnt Tree section to rule out or confirm that factor(s) other than stocking could have caused the change, if any occurred.

O'Dell Creek had not experienced any appreciable catchable stocking prior to this study with the last plant occurring in 1964. The lower O'Dell Creek (section) would be monitored for three years (1967-69) under a no stocking sequence followed by three consecutive years of catchable stocking (1970-72) and finally three additional years of no stocking (1973-75). Approximately 4,000-4,500 catchable-sized rainbow would be stocked in each of the stocking years. Another section (upper) would be maintained as a field control where a no stocking policy would continue (1970-74).

Each major study section was divided into smaller subsections ranging in length from 1,250-2,500 feet in order to study movement. Wild trout from each subsection were marked with a Floy anchor tag and when later recaptured, the degree of movement was determined. Recapture information was gathered either from subsequent electrofishing operations or from angler tag returns. Angler tag returns were also used to estimate a relative yearly angling pressure or harvest. It was assumed that the ratio of tags returned to the number actually caught by anglers was constant throughout the study period. Identification of hatchery trout after they had been stocked was based on the degree of eroded and deformed fins, especially the dorsal.

Since wild trout populations did not show a complete response to stocking or no stocking in one year, it was necessary to place fall trout estimates into categories based on the length of time from the last stocking or no stocking date. These categories for brown and rainbow trout were: (1) stocking years - where stocking had occurred for at least two consecutive summers prior to the estimate, (2) transition years - where the estimate had been preceded by only one summer of stocking or no stocking, and (3) no stocking years - where at least two consecutive summers of no stocking preceded the estimate. These categories were not used for spring estimates due to insufficient number of spring estimates after stocking ceased in the Madison River and for stocked years in lower O'Dell Creek.

Mean winter discharge rates (cfs) were computed using Dec. 1 - Apr. 30 discharge rates from the McAllister U.S.G.S. gage located 1.5 miles below Ennis Dam.

Results

Madison River

Brown Trout. Spring estimates of number and biomass for three-year-old and older brown trout show immediate increases following the first summer (1970) of no stocking (Table 1). By the second spring (1972) total numbers and biomass had increased 48% and 34%, respectively over the 1967-69 average. These differences between stocking and no stocking years were statistically significant.

Table 1. Comparison of spring wild brown trout estimates of number and total biomass (lbs./mile) for the Varney Study section of the Madison River between stocked and unstocked years. Confidence intervals (P greater than 0.95) are shown in parentheses. t-values greater than 2.78 show significant differences at the 95% level.

Year	II	III	IV & Older	Total three-year-old & older trout Number	Weight
Catchables stocked					
1967	a	172	89	261 (±123)	365 (±153)
1968	159	158	89	247 (± 72)	408 (±110)
1969	248	197	103	300 (±114)	417 (±147)
1970	271	121	134	255 (± 96)	377 (±108)
Average	226	162	104	266	392
No Stocking					
1971	a	200	154	354 (±137)	478 (±169)
1972	776	255	177	432 (±198)	570 (±293)
Average	776	228	166	393	524
t-value	-	2.27 n.s	3.56 sign.	4.25 sign.	3.92 sign.

[a] Insufficent recaptures to make estimate.

Fall biomass estimates of two-year-old and older brown trout also showed immediate increases following the 1970 cessation of stocking. By September, 1971, the total biomass had increased 143% from the 1967-69 average (Figure 3). Following an unscheduled stocking of catchables during the summer of 1972, the brown trout declined 24% from September 1971 to September 1972. After two additional years of no stocking (1973-74), the September 1974 brown trout biomass estimate was within 11% of the 1971 levels. Comparisons of mean number and biomass for two-year-old and older brown trout between stocked (1967-69) and unstocked years (1971 and 1974-76) show unstocked years to be 153% and 123% higher than stocked years with differences being statistically significant (Table 2). Mean number and biomass estimates for transitional years (1970, 1972 and 1973) were between mean levels for stocked and unstocked years with differences being statistically different than stocked years.

All age groups of brown trout showed increases in number when stocking of catchables ceased. When mean number and biomass estimates of two and three-year-old brown trout for stocked and unstocked years were compared

Table 2. Comparison of wild brown trout fall population estimates of number and total weight per mile for the Varney section of the Madison River between stocked and unstocked years. T-values are shown for comparisons between stocked and unstocked years with t-value greater than 2.57 significant (P greater than 0.95). Confidence intervals (P greater than 0.95) are shown in parentheses.

	Age group				Totals (two-year-old & older)	
Year	I+	II+	III+	IV & Older	Number	Weight (lbs)
Catchables stocked[a]						
1967	395	201	99	55	355 (±129)	462 (±168)
1968	1060	154	95	38	287 (± 75)	360 (± 96)
1969	788	171	102	44	317 (±117)	408 (±150)
Average	748	175	99	46	320	410
Transition						
1970	997	231	139	69	439 (±113)	616 (±158)
1972	753	386	189	95	670 (±248)	757 (±280)
1973	902	426	89	72	587 (±153)	589 (±154)
Average	884	348	139	79	565	654
No Stocking[b]						
1971	924	407	192	165	764 (±229)	996 (±298)
1974	1003	542	258	51	851 (±230)	897 (±242)
1975	1209	465	256	78	799 (±124)	815 (±126)
1976	1969	468	254	109	831 (±220)	954 (±253)
Average	1276	471	240	101	811	916
t-value	1.69 ns.	8.92 s.	7.75 s.	1.88 ns.	17.90 s.	

[a]Estimates were preceded by two or more years of stocking

[b]Estimates were preceded by two or more years of no stocking

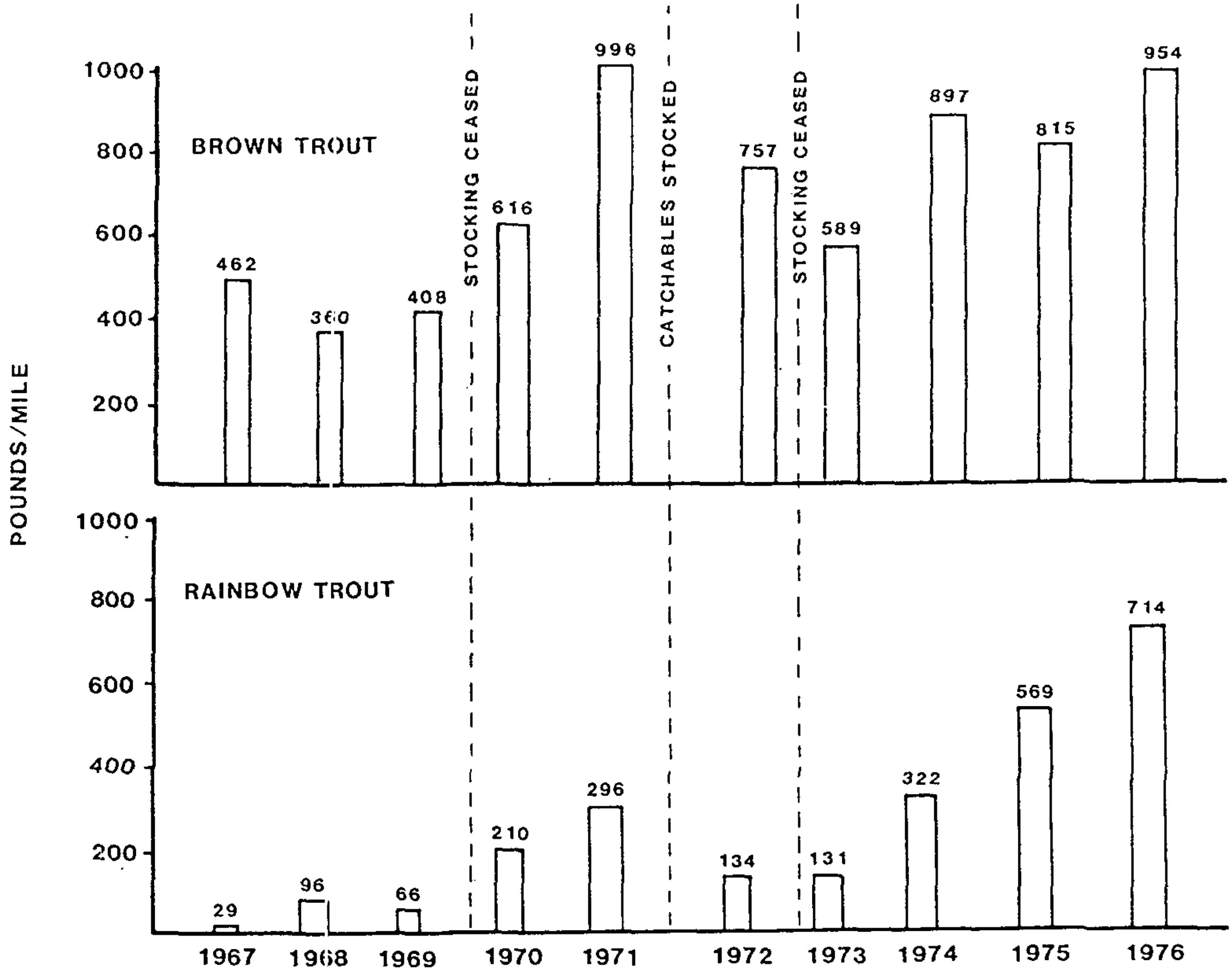
statistical significant increases of 169% and 142%, respectively, were shown. Four-year-old and older brown trout also showed a large increase (120%) in mean number, although differences were not statistically significant. Mean fall yearling numbers were 71% higher during unstocked years, but differences were not statistically different.

To determine whether certain sizes of brown trout were more affected by stocking, fall estimates of number were separated into three size categories (Table 3). The mean number of 10.0-17.9 inch brown trout increased 141% from the stocked to unstocked years with differences being significant. Those smaller than 10.0 inches showed a 79% increase in mean number from stocked to unstocked years, but difference was not significant.

Table 3. Comparison of numbers estimated per mile (fall) for various size groups of wild brown and rainbow trout between stocking and no stocking years for the Varney section of the Madison River. Transitional years' data not included. T-values greater than 2.57 significant at P greater than 0.95.

	Size Group (inches)				
	5.0 - 9.9[a]	10 - 17.9		18.0 & larger	
Year	Brown trout	Brown trout	Rainbow Trout	Brown trout	Rainbow trout
Catchable stocking					
1967	381	328	32	40	1
1968	1019	303	96	25	2
1969	776	300	67	29	5
Average	725	310	65	31	3
No stocking[b]					
1971	925	669	262	93	16
1974	1040	791	417	19	7
1975	1256	730	714	18	4
1976	1962	795	552	37	20
Average	1296	746	486	42	12
t-value	1.89	9.30*	2.82*	0.54	

[a]No estimates for rainbow due to insufficient sample sizes.
[b]Includes only those estimates which are preceded by at least 2 summers no stocking
[c]Asterisk = significant difference



POUNDS/MILE
BROWN TROUT
462
360
408
616
996
757
589
897
815
954
STOCKING CEASED
CATCHABLES STOCKED
STOCKING CEASED
RAINBOW TROUT
29
96
66
210
296
134
131
322
569
714
1000
800
600
400
200
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976

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A comparison of two-year-old and older brown trout biomass estimates between the Varney and Burnt Tree sections for the 1971-73 period showed that the mean biomass estimate for the Varney section was 65% higher than for the Burnt Tree section, although not statistically significant due to a heterogensus F-value (Table 4). The Varney section consisted of two transitional years and one unstocked year, while the Burnt Tree estimates were an average of three stocked years. When the mean biomass estimate for three stocking years from the Varney section (1967-69) was compared with the mean biomass estimate for three stocking years from the Burnt Tree section (1971-73), the difference 15% was not statistically significant. The first fall estimate made after stocking ceased in the Burnt Tree section (1974) showed a 74% increase over the 1971-73 stocking years mean biomass.

Wild Rainbow Trout. Following the cessation of catchable stocking in 1970, there was an immediate increase in the fall population of two-year-old and older wild rainbow trout (Figure 3). By September 1971, the rainbow biomass had increased 363% over the 1967-69 stocking years' average. Following the unscheduled summer 1972 stocking of catchables, the biomass estimate decreased 55% from September 1971, although estimates were higher than the 1967-69 stocking years' average. After another two years of no stocking, the 1974 rainbow biomass estimate again reached September 1971 levels. By 1976, after four consecutive years of no stocking, the total biomass had increased 1016% from the mean for the 1967-69 stocking years.

Table 4. Comparison of two-year-old and older brown trout biomass (lbs/mi) between the Varney and Burnt Tree sections of the Madison River. Confidence intervals (P greater than 0.95) are shown in parentheses.

Year	Varney	Year	Burnt Tree	Year	Varney	
Catchable stocking						
1967	462 (±168)	1971	448	1971	996 (±298)	no stocking
1968	360 (± 96)	1972	405	1972	756 (±280)	transition
1969	408 (±150)	1973	565	1973	589 (±154)	transition
Average	410		473		780	

Comparisons of age groups between stocked and unstocked years show yearling numbers increased 474%, two-year-olds 640% and three-years-old and older 942% from 1967-69 stocked year means (Table 5). These differences were not statistically evaluated due to heterogensus variances. Comparisons of total two-year-old and older wild rainbow

trout mean number and biomass between stocked and unstocked years show unstocked years to be 733% and 642% higher, respectively, with differences statistically significant.

Fall rainbow trout population estimates were also separated into two size groups to determine if there was a size related response to stocking (Table 3). Both the 10.0-17.9 inch and 18.0 inch and larger size groups showed large increases in number after stocking ceased. The mean number of 18 inch and larger rainbow trout increased 300% after stocking ceased. There were significant statistical differences in the 10.0-17.9 inch

Table 5. Comparison of wild rainbow trout fall population estimates of number and total weight per mile for the Varney section of the Madison River between stocked and unstocked years. T-values are shown for comparisons between stocked and unstocked years with t-value greater than 2.57 significant (P greater than 0.95). Confidence intervals (P greater than 0.95) are shown in parentheses.

	Age group			Totals (two-year-old & older)	
Year	I+	II+	III & Older	Number	Biomass (lbs)
Catchables stocked[a]					
1967	82	30	5	35 (± 22)	29 (± 18)
1968	a	64	28	92 (± 65)	96 (± 68)
1969	a	32	25	57 (± 40)	66 (± 47)
Average	82	42	19	61	64
Transition					
1970	217	186	45	231 (± 95)	210 (±104)
1972	a	26	79	105 (± 43)	135 (± 58)
1973	644	74	40	114 (± 47)	131 (±108)
Average	431	95	55	150	159
No Stocking					
1971	a	184	97	281 (±104)	296 (±104)
1974	622	389	45	434 (±166)	322 (±107)
1975	350	471	256	727 (±174)	569 (±136)
1976	440	198	393	591 (±269)	714 (±325)
Average	471	311	198	508	475
t-value	-	-	-	3.00*	2.64*

[a] No estimates due to insufficient sample size
[b] Asterisk = significant difference

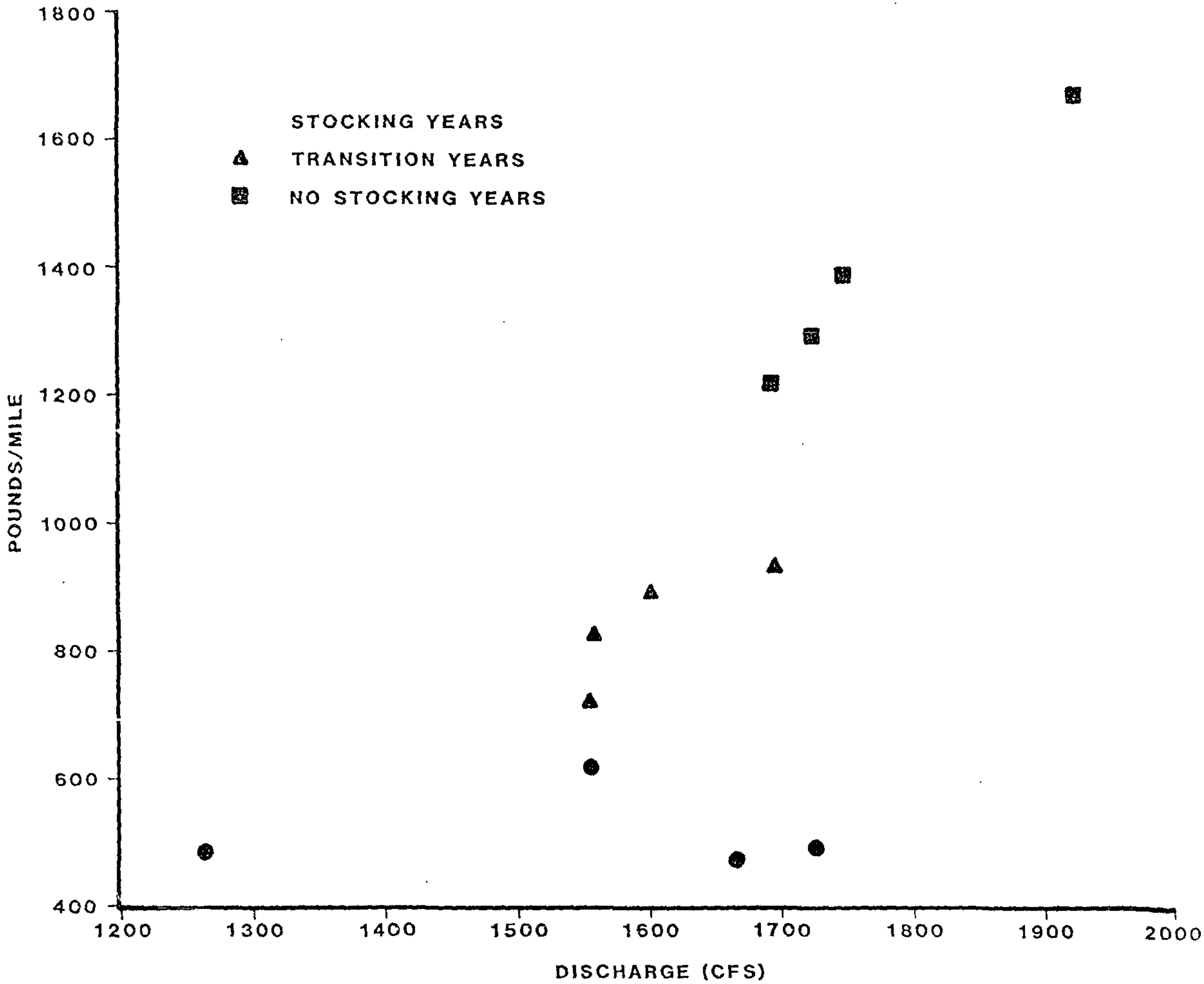
group, but due to heterogensus variances no statistical list was run. The first fall estimate of two-year-old and older wild rainbow trout following the cessation of stocking in the Burnt Tree section showed a 317% increase in numbers and a 145% increase in biomass from the mean for the 1971-73 stocking years.

Population estimates of hatchery catchables in the Varney section were made each fall during stocking years to evaluate their survival rates. These estimates in number range from 32/mi in 1972 to 151/mi in 1969.

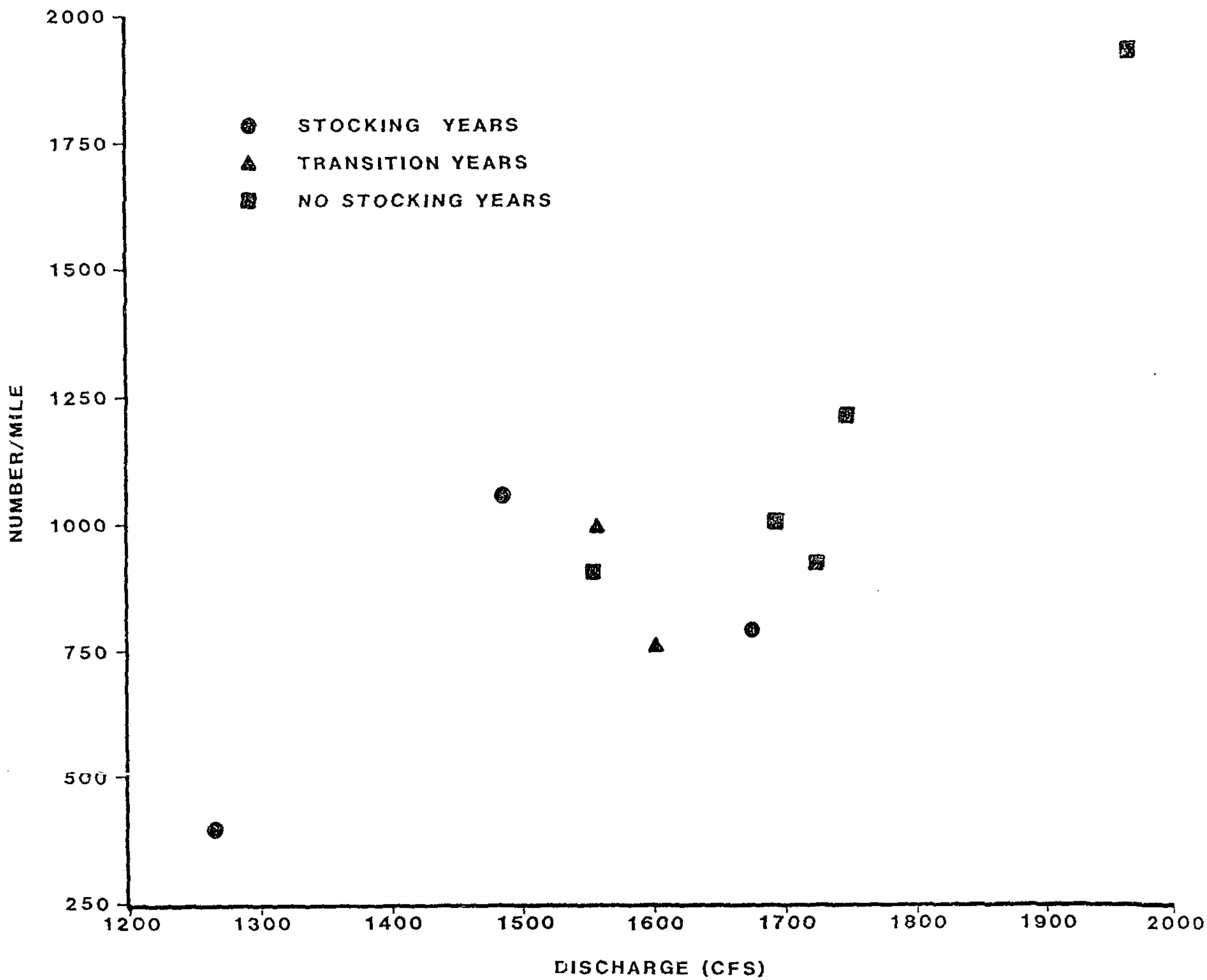
Assuming an annual stocking rate of 1,600/mi, summer survival averaged 6%. The average biomass estimate for these surviving hatchery trout was 41 lbs/mi. Spring electrofishing produced too few hatchery trout to make estimates, indicating an extremely low annual survival rate. During the unstocked years of 1970, 71 and 73, a few hatchery trout were found in the lower Varney section due to movement up from the stocked Burnt Tree section. Estimates of number and biomass of hatchery trout in the Burnt Tree section averaged 128/mi and 91 lbs/mi, respectively for 1971, 72 and 73.

Comparisons of flow rates and wild trout populations.

To determine if changes in the wild two-year-old and older brown and rainbow trout population for the two Madison River study sections were the result of yearly fluctuations in the mean winter flow rate or from the stocking of catchables, comparisons were made between mean winter flow levels (September 1967-76) and biomass estimates (Figure 4). The linear regression showed no significant correlation between flow rate and biomass (r=0.538, t-value=1.24). If biomass estimates from stocking years were removed from the analysis, a significant correlation (r=0.740, t-value=2.69) between mean winter flows and fall wild trout biomass levels was found, as higher mean winter flows resulted in higher fall wild brown and rainbow trout biomass levels. When fall biomass estimates from stocking years, transition years and no stocking years were compared a significant correlation between stocking and fall wild trout biomass levels was calculated (r=0.953 with t-value=9.32).



STOCKING YEARS
TRANSITION YEARS
NO STOCKING YEARS
POUNDS/MILE
1800
1600
1400
1200
1000
800
600
400
1200
1300
1400
1500
1600
1700
1800
1900
2000
DISCHARGE (CFS)


NUMBER/MILE
2000
1750
1500
1250
1000
750
500
250
STOCKING YEARS
TRANSITION YEARS
NO STOCKING YEARS
1200
1300
1400
1500
1600
1700
1800
1900
2000
DISCHARGE (CFS)

To determine if variations in abundance of fall yearling brown trout for the Varney section were related to levels of mean winter flow or to stocking of catchables, a linear regression was calculated (Figure 5). A significant correlation (r=0.677 with t-value=2.61) was shown between yearling brown trout abundance and mean winter flows, with higher mean winter flows resulting in higher yearling numbers. No significant correlation (r=0.583 with t-value=2.04) was noted between stocking and yearling numbers.

Mortality

Annual mortality of two year old and older wild brown trout were similar between stocked and unstocked years, 55% and 58%, respectively. But during transitional periods following cessation of stocking or initation of stocking, mortality rates deviate from the norm. After stocking ceased the average annual mortality was 33% versus 70% following the 1972 stocking. Summer mortality rates were average 43% for the stocking years versus less than 20% for non stocked years. Winter mortality rates for yearling brown trout was highest following stocking years (68%) and lowest for years of nonstocking.

Movement

No comparisons were made for differential movement rates between stocked and unstocked years. To determine if movement could explain some of the changes in the Varney study section wild trout population, tag returns from electrofishing were used. A total of 25% of the brown trout and 29%

of the rainbow trout sampled moved distances greater than 2,000 feet. From these recaptured tagged trout only 7% of the brown trout and 8% of the rainbow trout moved distances greater than 1.5 miles. No substantial directional movement was detected with 45% of the tag returns showing upstream movement and 55% downstream. Hatchery rainbow trout, which were either stocked in the lower one mile or upper 0.5 mile of the Varney section dispersed throughout the Varney study appearing in all subsections.

Angling Pressure

Although angling pressure was not directly measured for the study section, some information on angler use is available. Vincent (1969) estimated use for the 51 miles of the Madison River between Quake and Ennis Lakes averaged 680 angler days per mile in 1969. A statewide survey estimated angling pressure for this reach to be 953 angler days per mile for 1975. This represents an average annual increase in angling pressure of 4.5% resulting in more angling pressure present in unstocked years than in stocked years. Using angler returned fish tags from three-year-old and older trout as an indicator of relative harvest between study years, there was a decline in the tag return rate from 12% for the stocking years (1967-69) to 8% for the unstocked years 1970-71 for brown trout and a 15% to 11% drop for rainbow trout, respectively.

O'Dell Creek

Brown Trout

Little change was noted in the fall 1970, two-year-old and older biomass brown trout biomass estimate following the June-July, 1970, stocking of 4,000 catchable-sized rainbow trout (Figure 6). However biomass estimates made the following spring (1971) showed a decrease of 39% from the 1967-70 no stocking average. With continued catchable stocking in 1971, further declines were found with the spring 1972 biomass estimate being 57% below the 1967-70 average. Although continued stocking occurred in 1972, further declines were not measured, in fact, the spring 1973 biomass estimate returned to levels found in 1971. After stocking ceased in 1973, the spring 1974 biomass estimate returned to the prestocking average of 332 found for the 1967-70 period.

Comparison of spring two-year-old and older brown trout biomass estimates between stocked and unstocked years show the mean unstocked years biomass to be 42% higher than stocked years (significant t-value 3.79). No significant difference was found for total numbers of two-year-old and older brown trout, although there was a 27% reduction in mean numbers for the stocked years (Table 6). Spring yearling numbers were not significantly different between stocked and unstocked years, although numbers were 12% higher for stocked years. Only three-year-old brown trout showed a significant (47%) decline in mean numbers during the stocking years; although two and four year old mean numbers declined 15% and 23%, respectively.

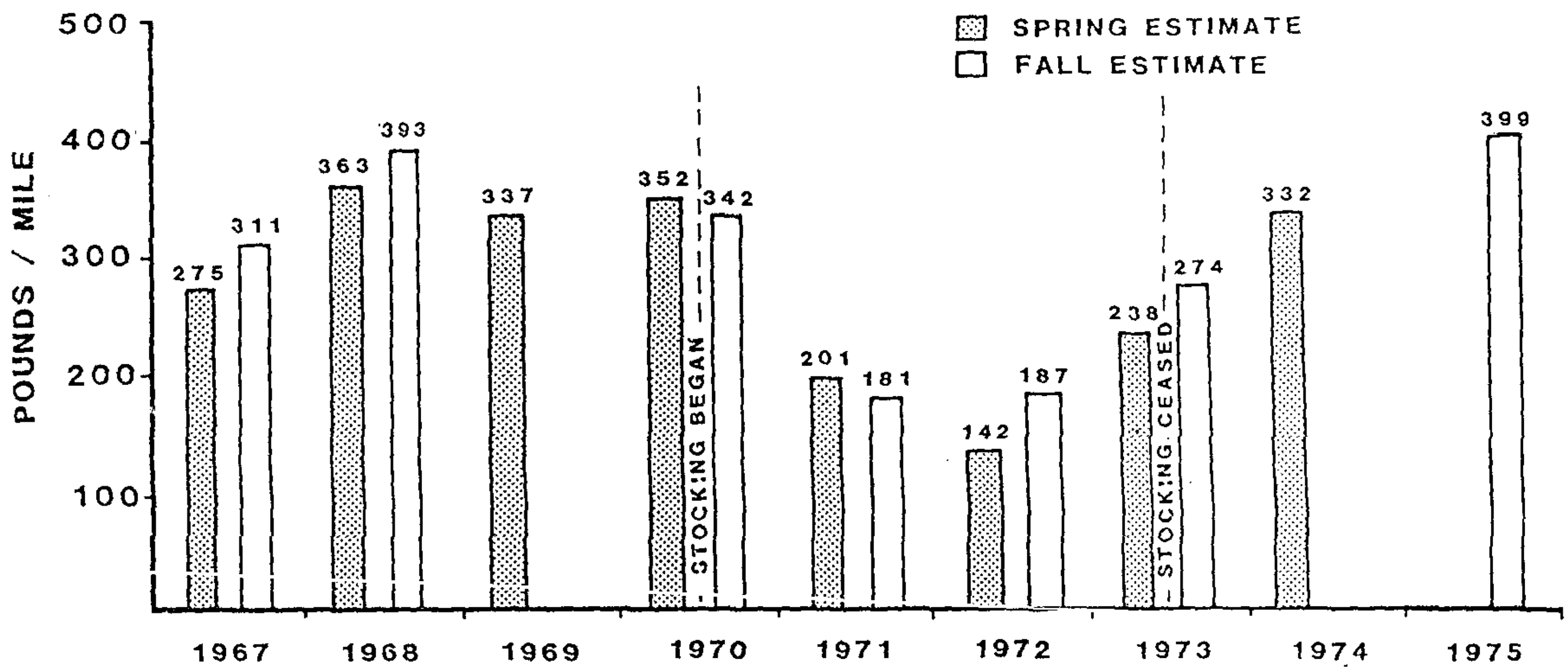

POUNDS / MILE
500
400
300
200
100
SPRING ESTIMATE
FALL ESTIMATE
275
311
363
393
337
352
342
201
181
142
187
238
274
332
399
STOCKING BEGAN
STOCKING CEASED
1967
1968
1969
1970
1971
1972
1973
1974
1975

Table 6. Comparison of spring wild brown trout population estimates by number and total weight per mile between stocked and unstocked years for the lower study section on O'Dell Creek. Confidence intervals (P greater than 0.95) are shown in parentheses. t-values greater than 2.45 significant P greater than 0.95.

Year	Age group I	II	III	IV & Older	Totals (two-year-old & Older) Number	Weight (lbs.)
No Stocking						
1967	669	311	112	34	457 (± 76)	275 (± 46)
1968	652	339	148	48	535 (± 76)	363 (± 51)
1969	660	323	135	44	502 (± 70)	337 (± 50)
1970	1116	322	193	52	567 (± 73)	352 (± 45)
1974	1008	402	153	58	613 (±104)	332 (± 56)
Average	821	339	148	47	535	332
Catchables Stocked						
1971	857	244	99	40	383 (± 84)	201 (± 44)
1972	773	188	61	31	280 (± 43)	142 (± 22)
1973	1128	431	75	37	543 (± 60)	238 (± 27)
Average	919	288	78	36	402	194
t-value	0.63 ns.	0.88 ns.	3.60 sign	1.93 ns.	2.01 ns.	4.79 sign.

Spring brown trout numbers were separated into three size groups to determine if certain sizes were more affected by stocking than others (Table 7). Those smaller than 10 inches showed no significant difference between stocked and unstocked years with the mean stocking year average being 13% higher. The mean number for the 10.0-17.9 inch group showed a significant decrease of 47% from unstocked to stocked years. While the mean number of 18.0 inch and larger brown trout declined 78% from unstocked to stocked years, although the difference was not statistically significant.

Table 7. Comparison of mean spring estimates of number/mi. for three size groups of wild brown trout between stocking and no stocking years for the lower O'Dell Creek study section. t-values greater than 2.45 significant (P greater than 0.95). Transitional year 1971 included in stocking category.

Year	Size group (inches) 3.5-9.9	10.0-17.9	18.0 & Larger
No Stocking			
1967	784	331	11
1968	778	384	15
1969	810	343	9
1970	1273	391	9
1974	1215	405	1
Average	972	371	9
Catchables Stocked			
1971	1053	184	2
1972	903	140	2
1973	1341	262	3
Average	1099	195	2
t-value	0.72	4.34*	1.67

[a] Asterisk - significant difference

Mean fall estimates of two-year-old and older brown trout during stocking years decreased 52% in number and 50% in biomass when compared to the means from the unstocked years (Table 8). Using unstocked, transitional and stocked years data, a linear regression analysis showed a significant correlation between stocking of catchables and the decline of wild trout biomass levels (r=0.9055, with t-value=4.77). When mean numbers for various age groups were compared, the two, three and four-year-old and older age groups declined 57%, 56%, and 7%, respectively, from unstocked years, but differences were not statistically significant using a t-test. Yearling numbers averaged 12% lower during stocking years, although difference was not statistically significant (t=0.31).

Wild brown trout population estimates made in the upper section were used as field control data and were compared with estimates made in the lower section (Table 9). Comparisons of mean two-year-old and older brown trout biomass estimates during unstocked years between the upper and lower sections show no significant differences either in the spring or fall period (t-value=0.43 and 0.043, respectively). When mean spring biomass estimates from the unstocked upper section (1970-74) were compared with the stocked lower section (1971-73), the stocked lower section had a significantly lower biomass (45%) estimate (t=4.26). A similar comparison of mean fall biomass estimates between the unstocked upper section (1970-72) and the stocked lower section (1971-72) show a 50% lower mean biomass estimate, although difference was not statistically significant (t=2.59)

Table 8. Comparison of mean fall wild brown trout estimates by total number and biomass per mile between stocked and unstocked years for the lower O'Dell Creek study section. Confidence intervals (P greater than 0.95) are shown in parentheses.

Year	Age Group				Totals (two-year-old & older	
	I	II	III	IV & Older	Number	Weight (lbs.)
No Stocking						
1967	427	228	69	32	329 (± 99)	311 (± 59)
1968	450	271	107	43	421 (± 82)	393 (± 69)
1969[a]	-	-	119	22	-	-
1975	837	277	144	80	501 (± 94)	399 (± 75)
Average	571	259	110	44	417	368
Transition						
1970	698	214	133	39	386 (±123)	342 (± 53)
1973	521	229	57	49	335 (± 59)	274 (± 67)
Average	610	222	95	44	361	308
Catchables stocked						
1971	496	78	61	46	185 (± 42)	181 (± 31)
1972	499	143	35	36	214 (± 57)	187 (± 41)
Average	498	111	48	41	200	184

[a] Due to poor sample size, estimates were not made.

Table 9. Comparison of mean wild brown trout estimates of total biomass (lbs) per mile between unstocked and stocked years for the upper and lower O'Dell Creek study sections. Confidence intervals (P greater than 0.95) are shown in parentheses.

	Upper section	Lower Section		
Year	No stocking	Catchables stocked	Year	No stocking
		Spring (April)		
1970	367 (± 21)	-	1967	275 (± 46)
1971	345 (± 44)	201 (± 28)	1968	363 (± 51)
1972	262 (± 32)	142 (± 14)	1969	337 (± 50)
1973	354 (± 43)	238 (± 17)	1970	352 (± 29)
1974	423 (± 31)	-	1974	332 (± 36)
	350	194		332
		Fall (September)		
1970	412 (± 44)	-	1967	311 (± 38)
1971	398 (± 61)	181 (± 20)	1968	393 (± 44)
1972	285 (± 43)	187 (± 26)	1975	399 (± 84)
	365	184		368

Rainbow Trout

No population estimates were made for wild rainbow trout in either the upper or lower sections due to extremely low numbers. Fall estimates of hatchery rainbow trout in the lower section made after the first two summers (June-July) of stocking averaged 198/mi weighing 104 lbs./mi, while the third fall estimate (1972) showed 58/mi weighing 60 lbs/mi. Small numbers of hatchery rainbows were captured in the upper section during electrofishing, probably coming from sites in the lower section.

Growth

Mean annual growth of all age groups, yearling through four-year-olds, decreased during the stocking years from levels found in the no stocking years (Table 10). No significant change was found in the summer growth rate for any age group.

Table 10. Comparison of average summer (April - September) and winter growth of yearling through four year old wild brown trout between stocked and unstocked years for lower O'Dell Creek. Growth shown as changes in length (inches) t greater than 2.57 significant P greater than 0.95.

	Age Group			
Time Period	I	II	III	IV
No Stocking				
Summer	2.8	1.4	1.3	1.2
Winter	1.5	1.9	1.6	0.6
Annual	4.3	3.3	2.9	1.8
Stocked				
Summer	3.1	1.4	1.2	1.0
Winter	0.9	1.3	1.1	0.4
Annual	4.0	2.7	2.3	1.4
t-values (S)[a]	0.94 ns.	0.00 ns.	0.23 ns.	0.38 ns.
t-values (W)[b]	3.52 sign.	2.64 sign.	0.75 ns.	0.63 ns.

[a] Comparisons of summer growth between stocked and unstocked years.
[b] Comparisons of winter growth between stocked and unstocked years.

During the winter growth period, all age groups examined showed a decline in growth rate during stocking years with yearlings and two-year-olds showing statistically significant declines. The net result of this lowered winter growth rate was a reduction in the average spring size of all age groups older than yearlings with two, three and four-year-olds averaging 1.0, 1.2 and 2.0 inches smaller than found in the no stocking years. No significant change in the average size of spring yearlings was found between stocked and unstocked years.

Mortality

Comparison of annual mortality rates between prestocking and the first two stocking years showed an increase from 58% during no stocking years to an average of 76%. When the wild brown trout population stabilized at a lower level, the annual mortality rate lowered to a rate similar to prestocking years (60%) even though stocking of catchables continued. Stocking of catchables tended to elevate the summer mortality of two-year-old and older brown trout from an average of 25% during prestocking years to 42% for the first two stocking years.

Movement

Based on electrofishing returns of tagged trout, the rate of movement within O'Dell Creek did accelerate during the stocking years. The number of brown trout moving more than 1,320 feet increased from an average of 2% in no stocking years to 10% in stocking years. Those brown trout showing detectable, but less than 1,320 feet of movement, increased from 19% in unstocked years to 33% in stocked years. Angler tag returns showed an average of one tagged O'Dell Creek wild trout was caught in the Madison River in unstocked years versus an average of 12 per year during stocked years. Tag returns were based on only fish tagged during spring electrofishing with an average of 240 being tagged in unstocked years and 215 in stocked years.

Angling Pressure

Although there were no direct measurements of angling pressure during the period of study, mail surveys from 1968 and 1975 estimated 56 angler days/mile in 1968 and 69/mile in 1975. Fish tag return rates from the lower section also confirm this low angler use, as the return rate averaged 8% for unstocked years and 6% for stocked years.

DISCUSSION

Populations of wild brown and rainbow trout declined significantly in numbers and total weight following the introduction of hatchery-reared catchable-sized rainbow trout. The degree of decline varied with the wild species, with the stream being stocked and with the number of consecutive years catchables were stocked. Other investigations have also shown decreases in wild fish populations in streams when hatchery fish were stocked. Bachman (1982) found that when hatchery trout were stocked into a section of Spruce Creek, Pa., wild brown trout numbers decreased below any perviously measured level. Thuember (1955) found that the number of wild brook trout nearly doubled in the North Branch of the Pike River and K.C. Creek, Wisc., when stocking of hatchery brook trout ceased. Snow (1974) reported that when hatchery northern pike were stocked in Murphy's Flow, where wild northern pike populations existed, wild pike numbers decreased, especially the number of pike exceeding 26.0 inches, which declined 76%. McMullin (1982) found that seven years after rainbow trout stocking had been discontinued in the Melrose section of the Big Hole River, MT., wild brown and rainbow numbers had increased 83% and 325%, respectively.

In Big Springs Creek, Idaho, Petrosky (1984) concluded that experimental stocking rates of 2.7 - 5.4 catchables per meter had little effect on the number of wild rainbow trout present. However further analysis of the population data showed increased summer mortality of wild rainbow trout with increased catchable-sized hatchery rainbow trout stocking rates. This resulted in a decline in the fall numbers of two year old and older wild rainbow trout with the degree of decline relative to the stocking rate.

Total trout biomass probably is the best indicator of "carrying capacity" for any particular section of a stream. Two major physical factors which can alter "carrying capacities" in Montana streams are variations in streambank habitat and water flow volumes. During the period of study little noticeable changes were noted in the condition of streambank habitat in either of the Madison River or O'Dell Creek study section, but some variation in stream flow was measured in the Madison River. Nelson and Vincent (1978) found that total wild trout biomass (lbs/mile) in the Gallatin River, MT., was higher in those sections which experienced the least summer (July-September) dewatering from irrigation withdrawals.

In the Madison River, the low flow period usually was during the winter period (December 1-April 30), as summer flow reductions due to irrigation withdrawals was not significant. During the early part of this study period (1967-71) another study section on the Madison River (Norris section) showed that as the winter flow levels increased, the two-year-old and older wild brown and rainbow trout biomass increased, whereas the wild trout biomass in the Varney section, where stocking occurred, did not increase under the same flow regimes. Further comparisons of winter flow rates and wild trout populations (lbs/mi) were made using data from both the Varney and Burnt Tree sections. Both sections had similar habitat conditions, such as braided channels, brushy banks and stream gradient. Both experienced similar flow regimes and total water volumes. Although minor differences in habitat may alter the relative number of certain size groups, total biomass (lbs/mile) should be quite similar. No significant correlation was found between mean winter flows and estimated total fall two-year-old and older brown and rainbow trout biomass during the 1967-76 period, when data from both stocked and unstocked years was used. When stocking years data was removed from the analysis, increases in mean winter flows resulted in a significant increase in total wild trout biomass. If only data from stocked years was used, no appreciable change in biomass was noted under any observed winter flow level. This data shows that under the observed fluctuations in winter flow level, the total two-year-old and older wild trout biomass levels were being significantly lowered by the stocking of catchable-sized rainbow trout and levels could not be increased even with more favorable winter flows. To further illustrate how significantly wild trout biomass levels were being controlled by stocking, comparisons between stocking, transitional and no stocking years showed that 90% of the variation in biomass levels could be explained by stocking or no stocking.

O'Dell Creek usually had a very stable flow regime since its primary water source was springs, although an occasional substained cold weather period during the winter months could cause severe ice gorging in the nearby Madison River, diverting large amounts of river water into O'Dell Creek above the two study areas. This severe winter flooding occurred only once during the period of study, the winter of 1971-72. The following spring (1972) wild two-year-old and older brown trout estimates in both study sections showed a decline over previous spring estimates. In the unstocked upper section the brown trout biomass was 30% below the mean for the 1970, 71, 73 and 74 estimates when normal winter flow conditions prevailed. In the lower section, the severe winter flow condition for the 1971-72 winter occurred during the catchable stocking years. The spring 1972 brown trout biomass estimate was 36% lower than the mean for the 1971 and 1973 normal winter flow years for stocking years, showing severe habitat problems could further reduce biomass levels. With exception of the 1971-72 severe winter flows, the wild brown trout populations remained somewhat stable in the upper section during the period of study, fluctuating only 14% and 2% from the mean for the spring and fall, respectively. In the lower section, wild brown trout biomass estimates made during no stocking years fluctuated 17% from the mean for spring estimates and 16% for fall estimates. Using estimates from both the upper and lower sections of O'Dell Creek, a linear regression test showed that either stocking or no stocking accounted for 72% of the variation found in the biomass estimates.

The actual mechanism(s) which cause declines in wild fish numbers when hatchery fish are stocked is not totally understood, but disruption of existing social behavior may be a major factor. A number of investigators have observed a relatively stable social structure in wild trout populations with such structure based on the size of the fish. Jenkins (1969) found adult brown and rainbow trout showed aggressive behavior between individuals at drift feeding sites. These aggressive interactions were relatively stable in wild trout with aggressive actions being minimized by the ranking of trout according to size. Newman (1956) also observed aggressive social interaction between wild rainbow trout during feeding. Bachman (1982) suggested that since significant social interaction occurred during feeding, the number of available feeding sites may determine the carrying capacity of a stream. If this is true, any significant disruption of the stable social hierarchy may lead to stresses which could significantly reduce the stream's natural carrying capacity.

Some investigators have studied what changes occur in resident wild populations when alien animals are introduced. McLaren (1979) found that hatchery-reared trout, when placed in a semi-natural stream environment were more active, fed more frequently and exhibited greater agonistic behavior than their wild counterparts. Bachman (1982) found stocked hatchery brown trout disrupted the stable social structure which existed in the wild trout populations prior to stocking, engaging in frequent long agonistic encounters with the wild trout resulting in some wild trout becoming exhausted. Butler (1975) suggested that imposing hatchery trout upon wild trout resulted in similar condition to Selye's (1973) general adaptation syndrome, in which animals placed in high density situations, suffer physiological changes resulting in the death of the individual. Davis (1949) found that when alien rats were introduced into stable rat populations, the native rats neither increased nor remained stable, but actually decreased due to the stresses of accelerated social turmoil and competition.

The stocking of hatchery fish probably induces stress on the wild trout through disruption of the stable social structure through abnormal interactions with wild trout and possibly causing a temporary overpopulation situation. These stresses eventually lead to large losses of the stocked trout and high losses of wild trout. These stresses on wild trout appear as increased mortality, decrease in growth rates, greater vulnerability to angling and increased movement.

Stocking of hatchery rainbow trout in this study did alter existing natural mortality rates of wild trout. With the cessation of stocking in the Varney section of the Madison River in 1970, the annual mortality of two-year-olds and older wild trout decreased dramatically and then rising in subsequent years as suppressed wild populations increased. In the lower O'Dell Creek section, the annual mortality increased during the first two year of stocking. When population abundance of brown trout decreased to levels in equilibrium with existing stocking levels, mortality rates lowered to prestocking levels. Petrosky (1984) also found an increase in the summer mortality rates of two year old and older wild rainbow trout when catchable sized hatchery rainbow trout were stocked with the rate being the highest in sections receiving the highest stocking rate. Yearling brown trout winter mortality rates were exceptionally high in both O'Dell Creek and the Madison River during stocking years. In the Madison River, these high winter losses averaged 67% for the 1967-70 stocking years versus 16% for the unstocked winter of 1971-72. In the lower O'Dell Creek section the winter mortality rates for stocked years was 47% versus 24% for the unstocked years. In the

Madison River the yearling brown trout winter mortality rates was high, even though this section had been stocked since 1954. The reason yearling brown trout winter losses continue to maintain high levels is that brown trout below this size have not yet been adversely affected by stocking, as they may not directly compete with either adult wild trout or hatchery trout until their second winter. Fall yearling brown trout numbers do not show any relationship to stocking or no stocking in this study. In the Varney section of the Madison River fall yearling numbers increase with increased winter flow rates. Yearling rainbow trout numbers are significantly lower during stocking years, which indicates rainbow trout maybe adversely effected by stocking at even earlier age than brown trout.

In lower O'Dell Creek, annual growth rates of all ages of brown trout decreased when stocking was initiated. This decrease in growth primarily was evident during the winter period (September-April), similar to the mortality rate increases. This decrease in growth, which reduced the average size of two-year-old and older aged brown trout was another indicator of a population under stress.

Stresses resulting from stocking may also cause wild trout to be more susceptible to being caught by anglers. McLaren (1979) found that the introduction of hatchery trout tended to increase the activity of wild trout and altering their activity patterns to coincide with those of hatchery trout. This may explain Butler and Borgeson (1965) findings that show wild brown and rainbow trout had increased catchability during periods of stocking. During stocking years in the Madison River, angler returned fish tags was 40% higher than in unstocked years for the larger three-year-old and older wild trout, even though angler use was less than in unstocked years. This phenomenon did not occur in lower O'Dell Creek, as angling pressure was extremely low. While an interesting phenomenon, angling does not explain the high losses of wild trout, but merely points out the stressed condition of the wild trout.

Rainbow trout showed a more substantial decline in total numbers and biomass than brown trout, when catchable-sized rainbow trout are stocked. After four consecutive years of no stocking, two-year-old and older brown trout increased 162% in number and 133% in total biomass compared to 809% and 1016% in number and biomass, respectively for wild rainbow trout. Since wild rainbow trout showed larger declines under stocking, their recovery time was much longer than brown trout. In the Madison River, wild rainbow trout biomass was still increasing four years after stocking ceased, while brown trout peaked after two years. McMullian (1982) also found the wild brown trout recovery rate to be faster than that of wild rainbow trout in the Big Hole River, Mt.

The practice of stocking catchable-sized hatchery trout into most self-sustaining wild trout streams has some serious implications. The stocking of catchables can reduce the number of wild trout available to anglers, can be an expensive program for wildlife agencies and may cause some genetic alteration of the wild stocks. Kruger and Menzel (1978) found that long-term stocking of hatchery brook trout in nine brook trout streams in Wisconsin altered certain alleles in wild brook trout. Correlations were noted between the number of years a stream was stocked and the degree of genetic alteration. In these cases, changes in genetics were not attributed to interbreeding, but selection of wild brook trout compatible with the hatchery brood trout in that environment. These genetic alterations may cause rare long-term problems to wild trout than the direct losses described in this study. While use of catchables in self-sustaining wild trout fishery should be avoided, there are some more desirable uses in other waters such as lakes, ponds and streams where no natural reproduction is possible and angler use is high enough to quickly remove hatchery trout. In these put-and-take fisheries, there would be no serious impact on a wild fisheries with high angler harvest rates making economics more favorable and no chance of genetic degradation of wild trout strains. Management of self-sustaining wild trout streams would be better directed to maintaining or enhancing riparian habitat, maintaining adequate water flows and when necessary using specific angling regulations.

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