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The Relative Benefits of Habitat Development and Trout Stocking

John Klingbiel
Staff Specialist

THE RELATIVE BENEFITS OF HABITAT DEVELOPMENT ON TROUT STOCKING ON WISCONSIN TROUT STREAMS

by

John Klingbiel
Bureau of Fish Management

Introduction

There is a total of 9,500 miles of identified trout streams in Wisconsin. These are divided into three classes based on the amount of natural reproduction and year-round survival of trout. Class I trout streams which have sufficient natural reproduction to use the biological carrying capacity of the stream and high year-round survival, make up 37 percent of the total stream mileage and are managed as wild trout fisheries. They are not stocked. Class II waters have limited or no reproduction, but do have good year-round survival; and make up 44 percent of the stream mileage. Class II waters must be stocked to provide satisfactory trout fishing. Class III waters have no reproduction and do not sustain trout year-round and therefore, must be stocked with legal-size trout to provide any trout fishing.

About 203,000 Wisconsin anglers making about 1,644,000 trips and harvesting 1,940,000 trout fish inland streams. This harvest is made up of 28% brown, 17% rainbow, and 55% brook trout. By 1985 we expect a statewide demand for inland trout fishing of 1,763,000 angler trips with a harvest of 2,080,000 fish. This harvest will exceed the optimum yield of Wisconsin inland trout waters by 1 percent.

Our statewide data do not reflect the patchiness of the distribution of streams and anglers, therefore; in certain cases, streams in the southern part of the state may already be overfished, while many northern streams are underfished. Overfishing tends to selectively remove larger fish resulting in a catch composed of fish averaging slightly larger than the minimum size limit and very few large fish. This provides a very low quality fishery and will result in anglers seeking waters that have a better population structure. Some small streams have very cold water and poor food resources. This results in slow growth, very few fish large enough for angling and a low quality fishery.

To many anglers, the opportunity to catch and release a wild trout may be the dominant factor leading to their continued interest in trout fishing. To others, taking a limit of hatchery-reared fish home for a fish fry is a prime incentive to continue trout fishing and fits their concept of quality fishing. To some, experiencing a sunrise or sunset on the Wolf River is sufficient to ensure their continued pursuit of trout fishing. For this reason fish managers generally are repulsed by the idea of applying simple cost/benefit analyses to fisheries programs. Each person has their own varying perception of a quality fishing experience. As managers, we must provide a broad variety of trout fishing opportunities so that each angler may select those opportunities that suit their fancy.

Basic to all trout fishing experiences is the chance to harvest or see a trout. The purpose of this report is to examine the various techniques we use to put or keep trout in Wisconsin streams and, insofar a possible, compare the relative cost and effectiveness of each technique.

Sport fish management, as presently applied, is still mostly an "art". Sound decisions are often based as much on "instinct", "intuition" or "experience" as on hard scientific facts. This heavy dependence on the "art of fish management is disconcerting but necessary because sufficient facts are seldom available. In drafing this report we have oversimplified some of the relationships between management techniques so that we can make comparative cost/benefit analyses. The risks involved in using such over-simplifications are great if they are reinterpreted out of the context of the report. In many instances a cost/benefit comparison between two different techniques is meaningless, since only one of them is amenable to cost analysis. We have also found it necessary to oversimplify our objectives so that cost/benefit analysis could be performed. For example, comparing the cost/benefit ratios of habitat development with stocking necessitates that we look at both from the same point of view. Although fish in the creel is almost always the sole objective of stocking, habitat development is often done for other reasons as well. These include increasing survival of native trout, reducing erosion and providing numerous aesthetic benefits; these are difficult to quantify.

Despite our expression of caution the following data represents some of the most comprehensive available from North America. Its weakness speaks to the need for more and better management evaluation studies. Its availability and depth demonstraties that compared with most other states our management data base is among the soundest in existence.

Method of Study

The Bureau of Fish Management staff reviewed program plans, work plans, management evaluations, investigations, research reports, published and unpublished literature, cost reports and other documents to obtain background data. Manual Codes, Handbooks, Technical Bulletins and other documents used to disseminate policy or procedures affecting trout management were also reviewed. Fish managers and researchers were queried for their opinions and insights. All these materials were viewed from the context of the Board's charge to the Department.

Goal of the Study

Assess and compare the cost and relative benefits of stocking streams and improving habitat in order to determine the appropriate levels and methods of use for each of these practices.

Comparisons are made of the costs needed to produce additional fish to the creel and additional mileage of stream producing satisfactory trout angling. Also considered are additional benefits which cannot be fully evaluated or quantified such as improved water quality, erosion control, aesthetics and changes in wildlife species.

The only aspects of trout management considered here have to do with streams. Only trout stocking and habitat improvement are addressed. Other management practices as well as the management of inland trout lakes and the Great Lakes have been omitted.

Prerequisites for Effective Use

The benefits derived from each management practice depend upon the characteristics of individual streams and the number of anglers that can potentially use the area. Benefits from either practice range from negligible to a maximum carrying capacity depending upon the effectiveness of the practice in the specific instance.

Trout Stocking - Only streams having insufficient natural reproduction are stocked. The lower the wild population, the greater the potential benefits from stocking. Because of public access requirements, stocking is usually done only on navigable streams and no closer than 1/4 mile from streambanks posted against trespass. Streams where legal sized trout are stocked must have suitable conditions only from the time of stocking, usually April, until most of the fish are caught by anglers. This period usually lasts only two months after the season opening.

Stocking of sublegal sized fingerling trout is most successful where there are stable amounts of good quality water throughout the year. Adequate living space, cover, a minimal amount of predation and little competition from other fish are desirable. High angler use also increases benefits.

Habitat Improvement - This practice can be applied only on public lands or those under easement or lease which provide public access and the right to improve habitat. Because there are a number of different techniques of habitat improvement, conditions that optimize benefits are somewhat variable. Those streams respond best which have only one factor limiting the expansion of the trout population. Stable flows, good quality water and moderate gradient are necessary to maximize benefits. The presence of a wild trout population along with minimal competition and predation from other fish species also enhance chances of success. Sufficient numbers of anglers must be available to harvest the increased trout population if maximum benefits are to occur, although there cannot be an overharvest which would result in a shortage of spawning fish. Over-fishing occurs most readily in brook trout populations.

Description of Alternatives

Although stocking and habitat improvement are usually done on different sections of streams, they are occasionally used in combination on the same portion of stream when neither can produce totally satisfactory results independently.

Stocking - There are basically two sizes of trout stocked in streams, fingerling and legal sized (6"+).

Fingerling are stocked either in early summer or in fall. These are small fish which are expected to utilize the natural food produced in the stream and grow considerably before they are caught in later years. This is called put-grow-and-take stocking.

Legal-sized fish are stocked just before the season opening or during the season so that they can be caught as soon as possible after stocking. Significant growth is not expected, although in a few places considerable numbers of fish survive and grow to be caught in following years.

Habitat Improvement - There are a number of methods used to improve stream habitat. Although the method applied depends upon the specific objective and the condition of the existing habitat, usually a combination of methods are used on each stream.

Fencing is used to keep cattle out of the stream and off the banks in order to control erosion. When cattle are excluded, brush can become abundant and must be removed. Fenced cattle watering areas and stream

crossings are provided.

Brushing is done where woody vegetation (alder, red osier, etc.) is very dense along streambanks. Dense vegetation promotes silt traps caused by root encroachment and dead branches falling into the stream. Removal usually extends about 30 feet from each bank. Stumps are chemically treated to prevent regrowth. Brushing increases light penetration to the stream which in turn promotes the production of fish food organisms. The stream becomes deeper and more stable substrate is usually exposed. Angling is easier because a meadow type environment develops.

Wing deflectors and bank covers narrow the stream channel, increase water depth and provide cover. They also expose more solid substrate which may increase food production and occasionally encourage spawning. Temperature regimes are improved by narrowing and deepening stream channels.

Half logs provide cover, resulting in increased trout survival. They can be used as a single method or in combination with other improvement methods.

Stabilization of eroded banks is most often done by riprapping with rock, although other methods are sometimes used. This reduces erosion and accompanying silt deposits. Riprapping sometimes provides cover for fish thereby increasing survival.

Beaver dam removal is essential. Habitat destruction caused by beaver dams is the most serious trout stream management problem in Wisconsin. Beaver populations have been increasing statewide and currently are very high.

Transects flown in Marinette, Oconto and Florence Counties in 1979, show that there was one beaver dam for every 1.2 miles of trout stream. These counties contain 1230 miles of trout stream, about 13% of the state total. Although the major problems exist in the northern half of the state, southern Wisconsin streams are also plagued by beaver.

Removal of beaver dams in extremely important on most trout streams where signigicant natural reproduction occurs, where heavy silt loads exist or where warming of the water can be detrimental. The effect of beaver dams varies according to the characteristics of the stream and individual beaver pond. Dams increase deposition of silt, warm the water, inhibit the migration of trout and occasionally completely destroy spawning areas. In addition to dam removal, it is also necessary to remove the beaver in order to prevent rebuilding of the dam.

Benefits and Costs

Both benefits and costs for stocking and habitat improvement vary widely. Some types of benefits such as the number of fish caught can be easily compared, but there are many other benefits, particularly aesthetic aspects, which cannot be adequately evaluated nor be compared in quantitative terms.

Stocking - There are two main benefits of stocking: (1) additional fish caught by anglers, and (2) additional miles of stream furnishing successful trout fishing. Although survival of fall stocked fingerling is extremely low in many streams, under proper conditions it is estimated that 50% survive to the following spring. Variability in the percent of stocked

legal-sized fish that are caught by anglers depends mostly upon the number of fishermen present immediately after stocking. Some variability in harvest rate can also be expected between trout species. It is estimated that on a statewide basis 50% of the legal-sized fish stocked are caught by anglers.

Since only those streams with substandard trout populations should be stocked, virtually all the miles of stream stocked can be considered additional miles suitable for improved trout fishing. However, stocked populations can furnish satisfactory angling for only one to two months because of reductions in trout numbers. Some angling takes place throughout the remainder of the season, but catch rates are usually low. Good Class I streams furnish satisfactory angling throughout the season.

Costs of stocking vary with the size of the fish stocked, the species and the distance transported from the hatchery. In general, a stocked legal-sized trout costs 29 cents each and a fall fingerling costs 18.8 cents.

Habitat Improvement - Many types of benefits can accrue from habitat improvement. Some are directly comparable to those from stocking, namely (1) additional fish caught by anglers, and (2) additional miles of stream furnishing satisfactory trout fishing. Other benefits also include such things as changes of wildlife populations, improvement in water quality, increased fishability and better aesthetics. The benefit to the fish population and therefore to the angler, is based on the maximum population of legal-sized trout that the average Wisconsin stream is capable of producing. Habitat improvement is usually most

effective in the better Class II streams and Class I streams where the carrying capacity for legal-sized fish can be increased and natural reproduction provides the recruits needed to fill the niche provided. The type of habitat improvement necessary is considered only in the cost analyses because the type of improvement depends upon the particular factors which limit the number of legal-sized fish. Improvements used to increase spawning or fingerling survival are also used in the final analyses to increase numbers of legal-sized trout.

Although fish populations and harvest are usually expressed in terms of number or pounds per acre, in the case of stream improvement it must be expressed as number or pounds per mile because surface acreage is often drastically changed by improvement practices. Following habitat improvement, spring populations of legal-sized trout increased as much as 1076 fish per mile in Lawrence Creek (Hunt 1966). In addition to these are the increased number of smaller fish recruited into the legal size group during the angling season. In most streams these include all the yearling fish. Increases in sublegal-sized yearling fish have been as great as 1404 per mile in spring in Lawrence Creek (Hunt 1966). The range of increase found in spring populations of yearling fish and older is 58 (Lowry 1971) to 2480 per mile (Hunt 1966). It may normally be assumed that the more intensive and, therefore, expensive the habitat improvement, the better the results. Although the best response was found in Lawrence Creek where intensive work was done, the least response was found in McKenzie Creek where a medium level of effort was expended. Improvements

there included installation of deflectors, bank covers and bank stabilization using rock riprap. The use of 1/2 logs as a single improvement device increased populations 1729 per mile in the West Branch White River (Hunt 1978). After brushing, populations on Spring Creek increased 962 per mile (Hunt 1978).

It is estimated that 30% of the spring trout population which are yearlings and older will be harvested. Using the population increases stated previously, this means that the increase of harvest from intensive habitat improvement can be expected to range from 17 to 744 per mile and probably averages 500 per mile under good conditions. Inexpensive improvement methods such as 1/2 logs and brushing can be expected to yield a harvest of as much as 520 and 290 fish per mile, respectively, over that of the stream in its original condition.

Intensive habitat development can also produce additional fishable stream miles with acceptable trout populations as a result of improving water temperatures or increasing movement of trout into adjacent areas because of higher populations in the improved portions. For purposes of this report, it is assumed that there is a 20% increase of trout stream mileage; for every one mile of intensive stream improvement, there is .2 miles of additional trout stream available, for a total of 1.2 miles per mile of stream improved. No additional miles accrue from 1/2 log installation.

Equally important, in the opinion of some trout anglers, are a number of benefits which are much more difficult to evaluate or quantify. Some anglers place a great deal of value on the catching of wild trout rather than

hatchery fish. Coloration, fighting quality and the psychological aspects of nature are factors influencing those values. The average size of the fish caught generally increases somewhat making them more attractive to anglers.

Changes in habitat type and vegetative cover are also viewed as important benefits even when they are divorced from their effects on the fish population. Areas having wild vegetation are greatly preferred over intensively pastured and eroded fields, and many anglers would rather have grassy meadows than alder thickets along streams. With these changes in vegetative cover come changes in bird and wildlife populations. The value of these changes are as diverse as the species impacted.

Benefits to the water supply often accrue after habitat development. Although improvements can be documented in terms of more stable temperatures and flows, or reduced silt load or turbidity, they are extremely difficult to evaluate quantitatively. Some of these water quality changes may even be measured partially in terms of dollars, as in the case of reduced flood damage, but in all cases aesthetic and other psychological and sociological values are at least as important as the economic values.

Habitat improvement done in Class II streams sometimes reduces the number of stocked trout needed. Improvement in fishability also results, thereby increasing the enjoyment and use by anglers.

Although costs for habitat improvement vary with existing habitat conditions and types of improvement necessary, it is estimated that the average intensive improvement program costs about $29,000 per mile. A project costing this much may include .? miles of fencing, .5 mile of brushing

and 40% of the stream length having deflectors or bank covers. Stream width is not usually a major factor in costs because improvement is based upon stream length.

Maintenance costs of various types of habitat improvement vary according to the type of improvement and the specific conditions. Fence maintenance is estimated to cost about $25/mile/year, although those located in river bottoms which are frequently flooded require considerably more maintenance. Periodic beaver and beaver dam removal is necessary in many locations. Dam removal costs a $70.91/dam as estimated in a recent large scale project but no cost analysis is available for preventing dam building. Some improvement techniques, such as brushing and 1/2 logs are relatively new, so their life and maintenance requirements are uncertain. Deflectors and bank covers need little maintenance if water levels are stable and quality materials are used. In some locations large rock is scarce and substitute materials requiring more maintenance have been used.

Maintenance on the ideal project site would be negligible. However, it is estimated that most existing projects require annual maintenance which costs about 1% of the development cost. New techniques in habitat improvement tend to minimize this need. In most cases, when using deflectors and bank covers, the more intensive the development, the less that maintenance is necessary.

Comparisons of Benefits and Costs

Because of the extremely wide variations in costs of habitat improvement

from project to project as well as variations in benefits, some examples are given to form a basis for cost/benefit analysis.

Additional fish creeled - If intensive habitat improvement is assumed to cost $29,000 per mile for initial development, 1% of development cost per year is needed for maintenance, the improvement has a life of 50 years and 500 additional fish will be creeled annually, each additional trout creeled will cost $1.74.

Benefits from the brushing projects which have been evaluated indicate much more favorable cost effectiveness. If the development costs $3,600, lasts for 100 years with $120 annual maintenance, and 290 additional fish are harvested annually, each fish costs $.541.

Still greater cost effectiveness is evident using 1/2 logs. If development costs $2,880 and it lasts for 100 years with no maintenance and 520 additional fish are harvested annually, each fish costs $.055.

The cost and percent of stocked fish creeled varies greatly. If 50 percent of the legal-sized trout are creeled, each one costs $.58. If 25 percent of stocked fall fingerling are creeled, each costs $.752.

With these costs and projected results, 1/2 logs are the most cost effective method of increasing the trout catch when instream cover for legal-sized trout is the principle limiting factor. It is essential that adequate natural reproduction is available, otherwise the beneficial result will be drastically reduced since 1/2 logs simply provide protection for existing fish.

The cost effectiveness of brushing and legal-sized trout stocking are fairly similar although brushing is slightly better.

Intensive habitat improvement is least cost effective in increasing the harvest. Even if the results were doubled (1000 fish per year instead of 500), the cost would still be $.87 each or about 50% higher than with brushing or legal trout stocking. Likewise if the life of the project is 25 years instead of 50, the cost would be $2.90 per fish or about 5 times as much as brushing or legal trout stocking. In many situations, however, it may be the only effective habitat improvement technique.

Additional Mileage of Fishable Trout Stream - Intensive habitat improvement or brushing is assumed to produce .2 miles of additional trout water per mile of improvement. With a 50-year life, a $29,000 development cost per mile and 1% annual maintenance cost, each additional mile of trout stream costs $4,350 for each angling season.

Streams which are stocked do not have natural populations large enough to furnish satisfactory angling, however, about 50% of the Class II streams have enough reproduction to furnish substandard angling - fewer fish need to be stocked in those streams. In order to harvest 500 fish per mile which is the number considered produced by intensive stream improvement, 1000 legal-sized fish must be stocked in the spring or 2000 fingerling the previous fall. Using these stocking rates, stocking legal-sized trout in spring costs $290 per mile and fall fingerling stocking $376 per mile. Usually stocking provides satisfactory angling for only two months after stocking. Habitat improvement provides satisfactory angling for the entire 5-month angling season. Good angling for the

entire season resulting from legal-sized stocking would require 2½ times as much stocking as currently and costs $725/mile. It is extremely doubtful that stocking of fall fingerling could produce satisfactory angling throughout the entire season. If 2½ times as many fish were stocked the harvest would be considerably greater than the 500 used as a base. If the same number of fish were stocked at intervals during the season, the percent harvested would be reduced but the fish would be larger. No costs are available for this type of stocking.

Brushing is the most cost effective method of producing additional miles of trout stream for angling; $156 per mile per year. Stocking of legal trout is second best costing $725 per mile per year but still far better than intensive habitat improvement at $4,350 per mile per year.

Other Benefits - Various types of habitat improvement produce a number of other kinds of benefits; these are difficult to evaluate or quantify. Stocking generally produces none of these. These types of benefits, especially those related to aesthetics, are valued very highly by some anglers, and in fact are thought by some to be more important than additional fish in the creel or additional miles of trout stream angling. Habitat improvement is often done in streams where stocking must continue in order to obtain satisfactory angling. Where fingerling are stocked, the addition of cover often increases the number surviving to catchable size. In some cases where natural populations do not increase substantially the other types of benefits may justify the expenditures.

Table 1. Comparative Benefits of Stocking and Various Types of Habitat Improvement

	Stocking	Habitat Improvement		
		Intensive	Brushing	1/2 logs
Measurable Benefits:				
$/each additional fish harvested	Spring legals $.58 Fall Fingerling $.752	$1.74	.541	.055
$/each additional mile of trout stream/season	$725	$4350	156	N/A
Unmeasurable Benefits:				
Wildlife - Birds	0	+ or -	+ or -	0
Beaver	0	-	-	0
Waterfowl	0	+ or -	+	0
Water Quality	0	+	0	0
Erosion Control	0 or -	+	0	0
Aesthetics	0 or -	+	+ or -	0

Conclusions

1. Costs and benefits vary widely with stocking and the various types of habitat improvement.

2. Of those methods evaluated, the installation of 1/2 logs is the most cost effective method of increasing the anglers catch in streams with adequate trout reproduction.

3. Of those methods evaluated, brushing is the most cost effective method of increasing the miles of fishable trout water in streams with adequate trout populations. It is also slightly more effective than stocking in increasing the angler harvest.

4. Stocking of legal-sized fish is a cost effective method of increasing the angler's catch as well as the miles of fishable trout stream where natural reproduction is inadequate.

5. Intensive habitat improvement is not very cost effective in increasing angling harvest or providing additional miles of stream for trout fishing. It provides a great many other diverse benefits which are not produced by other methods. These include aesthetic and psychological benefits as well as general habitat enhancement. In some cases, if habitat quality is to be improved, there may be no more cost effective alternative.

6. Habitat improvement designed to maximize wild populations is possible on about 3,800 miles of stream (50% of Class I and 50% of Class II streams). Currently only a small fraction of this is under public land control which would permit improvement.

7. Stocking can produce satisfactory trout fishing in about 4,900 miles of stream (75% of Class II and all Class III streams). Most of this mileage can be stocked; relatively little is posted against trespass.

8. The evaluation of benefits which are largely aesthetic is an important factor in determining the mileage of waters on which intensive habitat improvement can be utilized in a practical manner.

9. Beaver dam removal and prevention is extremely important to improve and protect habitat.

Recommendations

1. Both habitat improvement and trout stocking in streams are effective management measures when used correctly in suitable locations. Objectives, costs and expected benefits must be carefully assessed when either activities are proposed for a specific stream.

2. The type of habitat improvement used should be chosen very carefully in order to accomplish the objective most economically. The use of brush removal and/or 1/2 logs should be favored above other habitat management measures whenever applicable because of their relatively low cost and great potential benefits.

3. Extensive use of costly methods of habitat improvement should not be conducted on very small streams because of the limited number of fish that can be produced and the limited amount of angling that can be supported.

4. Unless exceptional overwinter survival of fall stocked fingerling exceeds 65% streams should be stocked with legal-sized trout in spring instead of with fingerling in the fall.

5. Unless there are serious local prejudices, legal-sized brook or rainbow trout are preferred over brown trout for stocking because they are more catchable.

6. Accurate cost records should be obtained for various types of habitat improvement.

7. Benefits from various types of habitat improvement should be documented on more streams and differences in the responses of brook, brown and rainbow trout should be evaluated.

8. Results and costs of stocking legal-sized fish before the season opening should be compared to periodic stocking during the season.

9. Beaver control must be emphasized to preserve good habitat and restore that already damaged by dams.

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Appendix

Trout Stocking Costs

The following steps were used for computing the cost of different size trout *

1. State costs for stream trout - 1975-76 - $1.493/lb production + $.289/lb distribution = $1.782/lb. (presented at Natural Resources Board meeting November 1976).

2. % Production by size group in weight

3.5 - 4.5"	3%
6 - 7"	18%
8 - 9"	79%

3. Wis. Trout Growers Association cost quotation - January 22, 1976.

3.5 - 4.5"	$120/1000
6 - 7"	$275/1000
8 - 9	$425/1000

4. Assume purchase of 10,000 lb at same % as production.

Size Group	% of Production	No./lb	No. lb.	No. Fish	Cost of Size Group	% of Total Cost
3.5 - 4.5	3	40	300	12,000	$ 1,440	6.7
6 - 7	18	10	1,800	18,000	4,950	23
8 - 9	79	4.5	7,900	35,550	15,108.75	70.3
			10,000	65,550	21,498.75	

5. Use state costs in #1 above and % cost of size groups in commercial quote.

Size Group	% of Total Cost	State Cost for 10,000lb. All sizes	Cost of Size Group	No. of Fish	$/Fish	$/Fish Excluding Overhead
3.5 - 4.5	6.7	17,820	$ 1,193.94	12,000	$.099	.082
6 - 7	23	17,820	4,098.60	18,000	.228	.188
8 - 9	70.3	17,820	12,527.46	35,550	.352	.290

*All state figures except last column of table in step 5 include 17.6% overhead for central administration.

Habitat Improvement Costs

The cost of intensive habitat improvement as given in the text was computed in the following manner:

fencing	-	.2 miles @ $,2880/mile	=	$ 456
deflectors	-	covers - 2112 ft @ $1,050/ft	=	22,176
brushing	-	.5 mile @ $3,000/mile	=	1,500
				24,132
fringe benefits and Bureau overhead @ 20%				4,826
				$28,958

Table 1 shows the general cost and use of the various types of habitat improvement:

All habitat costs were compiled in the field and include rental, material, travel expenses and Department salaries. In some cases additional labor from various federal and state programs was used. When possible the estimated value of this labor was included. Because no overhead or fringe benefits were included it was necessary to add 20% when making cost comparisons with stocking. Stocking costs include these costs.

The following are habitat costs taken from individual projects or averaged from a number of projects in an administrative unit:

Fencing -

Development - $2881 per mile

Maintenance - $47.18 per mile (Eau Claire Area Report 1975).

Cattle-Machinery Crossings -

Development - $858 each (Eau Claire Area Report 1975).

Maintenance - $400/crossing every 5 years (Calhoun pers. comm.).
$ 80/crossing every 2 years (Galla pers. comm.).

Deflectors and Bank Covers -

Development - $11.96/foot (Tally pers. comm.).
$10.50/foot (Galla pers. comm.).

Maintenance - $180 to $220/year per mile (White 1972).

Use - 40% of stream length - Rullands Coulee Creek (Tally pers. comm.).

Devices cover 60% of stream length - Spaulding Creek (Galla pers. comm.).

Brush Removal -

Development - $450 - $500/acre or $3005/mile (Hunt pers. comm.).
$700/mile - Tank Cr. (Simonson pers. comm.)

Use - 90% of Streambank - Spaulding Creek (Galla pers. comm.).

Half Logs -

Development - $9.00 each (Galla pers. comm.).
$6.00-$7.00 for material and 1/2 man-hours each (Hunt pers. comm.)

Use - 120/800 yards - West Branch White River (Hunt pers. comm.).
60/330 yards - Emmons (Hunt pers. comm.).
15/1255 feet - Spaulding Co. (Galla pers. comm.).

Intensive Development -

Development - $26,000/mile in 1963 - Lawrence Cr. (Hunt pers. omm.).
$13,200/mile in 1955 - Split Rock River (Hunt pers. comm.)
$ 8,300/mile in 1960 - Bohemian Valley Cr. (Hunt pers. comm.).
$23,040/mile in 1971 - Mac Intire Cr. (Thuemler pers. comm.). (excludes some equipment costs)
$28,000/mile proposed in 1978 - KC Cr. (Thuemler pers. comm.).
$20,000/mile in 1960 - 62 - Big Roche a Cri Cr. (White 1975)

Maintenance - $200/mile/yr in 1960 - 62 (1 % of development cost) Big Roche a Cri Cr. (White 1975)

Life - 100 years (White 1975)

Beaver Dam Removal

Removal - $70.91/dam in 1979-80 - Marinette Area (Thuemler pers. comm.)

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TABLE I

Approximate Habitat Improvement Costs & Use

Type of Improvement	Development Cost*	Annual Maintenance Cost	Life	Range of Use per Stream mile
Fencing	$2,880/mile	$25/mile	30 yrs.	.2 - 1.8 miles
Cattle crossings	$860 each	$40 each	30 yrs.	0 - 3 crossings
Wing deflectors & Bank Covers	$10.50/lin.ft.	$300/mile	50 yrs.	2640 - 3170 ft.
Bank Stabilization	$12/lin.ft.	0	100 yrs.	0-500 ft.
Half logs	$12 each	0	100 yrs.	150 - 300 half logs
Brushing	$3000/mile (both banks)	$120/mile	100 yrs.	0 - .9 miles

* Costs do not include employee fringe benefits and administrative overhead which are figured at 20% and included in cost-benefit analysis.

TABLE II

Trout Population Increases Following Habitat Improvement

	Species	Size or Age	Time of Year	Number Increased per Mile	Before Improvement Number per Mile	After Improvement Number per Mile	Location	Reference
Intensive Improvement	Brook	over 6 in.	April	1076	562	1638	Lawrence Co.	Hunt 1966
	Brook	I+	"	2480	1746	4226	" "	"
	Brook	I+	"	396	860	1256	Big Roche-a-Cri	White 1972?
	Brook	I+	Sept.	172	396	568	" " "	"
	Brook	I+	Fall	48	22	70	Split Rock R.	Hale 1969
	Brook	Over 6 in.	Spring	18			Big Roche-a-Cri	White 1975
	Brook/Brown	Over 6 in.	Fall	740	910	1649	Plover R.	anonymous 1978
	Brook/Brown	I+	July	51*	352*	403*	MacIntire Cr.	Thuemler-pers.comm.
Moderate Improvement	Brown	I+	April	58	822	880	McKenzie Cr.	Lowry 1971
	Brown	I+	Sept.	100	356	456	"	"
Half logs	Brown	I+	April	1729	1754	3483	W.Br.White R.	Hunt 1978
	Brown	Legal	April	629	403	1032	" "	"
Brushing	Brook	I+	April	962	2335	3297	Spring Cr.	Hunt 1978
	Brook	Legal	April	384	813	1197	" "	"
	Brook	Legal	Sept.	387*	574*	961*	McCann Cr.	Hunt - pers. comm.

*number/acre

TABLE III

% of Stocked Fish Creeled

Species	Size Stocked	Month Stocked	Estimated % of catch Observed	% of Stocked fgl: Observed Catch	% of Stocked fgl: Estimated Total Catch	% of Stocked Fish Present in Spring: Observed Catch	% of Stocked Fish Present in Spring: Estimated Total Catch	Stream	Reference
Brown	fgl	Oct.	60	6	11	10	18	Big Roche-a-Cri	White 1959 c
	fgl	Sept.	80%-May/June	15	18-May/June	34	41-May/June	Black Earth Cr.	Brynildson - Christenson 1961
	fgl	Sept.	80%-May/June	21	25-May/June	43	52-May/June	Mount Vernon Cr.	" "
	yrl	March	80			42	50	Mt.Vernon & Bl.Earth Cr.	Brynildson & Snow 1957a
	yrl	March	80			18	22	" "	
	yrl	May	80			44	55	McKenzie Cr.	White, Brynildson & Skowronski 1958
	yrl	March	80			2	3	Mt. Vernon Cr.	Brynildson & Christenson 1961
	yrl	Spring	60			17	28	Big Roche-a-Cri	White 1959c
	yrl	Spring					63	E.Br.Eau Claire R.	Johnson 1977
	yrl	Spring					33	Plover R.	Johnson 1977
	yrl	May					23	N.Br.Beaver	Meyers & Thuemler 1976
	fgl & yrl	Sept.			29.4		68.7	Watson Cr., Minn.	Hale - Smith 1955
	yrl	Spr. & Sum.					33	Pigeon R.	Cooper 1953
Brook	fgl	Fall	60	17	28	40	67	Big Roche-a-Cri	White 1959a
	fgl	Fall	60	14	23	32	53	" "	White 1959c
	fgl	Fall	60	18	30	36	60	" "	"
	fgl	Sept.	70-May/June	8	11	50	71	Mt. Vernon Cr.	White 1960
	7-13"	Dec.					28	Deerskin R.	Schneberger & Williamson 1943
	7-13"	May					82	" "	"
	yrl	Spring					43	Big Roche-a-Cri	White et al 1958
	yrl	Spring					55	Sabin Pond	Christenson 1955b
	yrl	June					70 in 3wks,	Bear Bk. N.H.	Hoover & Johnson 1938
	yrl	Spr.& Sum.					43	Pigeon R.	Cooper 1953
	yrl	Spring					66	E.Br. Eau Claire R.	Johnson 1977
	yrl	Spring					57	Plover R.	"
	yrl	Apr.-July					79	W.Br. Split Rock Cr.Min.	Hale 1952
	yrl	May-July					35	" " "	Hale 1969
	fgl	Fall					52.6	Seas Br.	Avery - pers. com.
Rainbow	7-15	May					30	Deerskin R.	Schneberger & Williamson 1943
	7-15	Dec.					48	" "	Schneberger & Williamson 1943
	fgl	Sept.	90	28	31	54	60	Black Earth Cr.	White 1960
	yrl	March	80			34	43	Mt. Vernon Cr.	Brynildson & Snow 1957a
	yrl	March	80			47	59	Black Earth Cr.	"