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REPORT NO. 336

A STUDY OF THE LAKES IN THE PIGEON RIVER STATE FOREST

The study of a lake or stream over a period of years provides information of value and interest which cannot be obtained except by such prolonged investigation. Until recently the lakes in the Pigeon River State Forest were relatively virgin, they were off the beaten path and, because of the paucity of fish, were probably of little interest to fishermen or to others. What changes may have taken place in these lakes during the lumbering period is not known but changes made since the lumbering days can, for the most part, still be recorded. Since several groups or individuals have been or are now, actively interested in these lakes it will be of mutual value to them to have a complete record of the changes which are being made by human agencies; those who in the future wish to study the effects of these changes will likewise find such records of value. It is the purpose of this report to indicate the stocking records, investigations, experiments, and environmental adjustments which have been made on this group of lakes to date. This record is probably not complete but includes those studies and changes of which the writer is aware.

Description of Area

The Pigeon River State Forest lies east of Vanderbilt. It is largely cut-over, rolling, sandy country, covered with second-growth timber. A map of the forest was made in 1931 by the Land Economic Survey and copies of the map are obtainable from the Department of Conservation. The roads have been changed considerably since the map was made; the names of most of the lakes are not indicated.

Dog Lake is in the northern end of the forest and Pickerel Lake is in the extreme west side of the forest, the other lakes considered in this report are all within three miles of the old Forest Headquarters site.

The Pigeon River Forest is drained by three rivers: Black, Pigeon, and Sturgeon. All three are trout streams. All flow in a general north ~~and south~~ direction.

All of the lakes in the forest which have been studied by the Institute for Fisheries Research are on state-owned land and are therefor open to public fishing. Several other lakes which are now on state land or on tax-delinquent land were not surveyed. Several small unnamed ponds, apparently too shallow to support fish life, were not inventoried. The locations of the lakes studied are as follows:

Dog Lake	T. 34, 35 N., R. 1 W.,	Sec. 35,2
Pickerel Lake	T. 32 N., R. 2 W.	Sec. 11
Hemlock Lake	T. 33 N., R. 1 W.	Sec. 34,35
Grass Lake	T. 32 N., R. 1 W.	Sec. 5
Devil's Soup Bowl	" " " " " "	" "
Hardwood Lake	" " " " " "	Sec. 11,14
Two Acre Pond	" " " " " "	Sec. 3
Lost Lake	" " " " " "	Sec. 2,3
West Lost Lake	" " " " " "	Sec. 3
Ford Lake	" " " " " "	Sec. 8
Section 4 Lake	" " " " " "	Sec. 4
North Twin Lake	" " " " " "	Sec. 10
South Twin Lake	" " " " " "	" "

Inventory

Two of the lakes, Pickerel and Round, were examined briefly by Dr. Metzelaar in 1925. Under date of August 25, 1925, ^{he} made the following comments regarding Pickerel Lake:

Vegetation - scattered bulrushes, Potamogeton. Animal life - low inshore, crayfish, big clams. Bottom - clear white sand and some marl. Temperature - 22° C. Depth - up to 11 meters sounding. Species of fish - reported to have brook trout, no pickerel, and perch and small-mouthed bass. We caught inshore 3 pumpkinseeds; 1 small-mouthed bass; numerous fingerling perch; minnows: Pfrille neogeus (fine-scaled dace) 6, Umbra limi (Mud-minnow) 2, Poeciliichthys exilis (Iowa darter) numerous. Metzelaar recommended stocking with small-mouthed bass.

Under date of August 22, 1925, he made the following comments regarding Round Lake:

Vegetation - algae. Animal life - normal. Bottom - extremely mucky, also snags. Temperature 24° C. Depth - deep. Species of fish - wall-eyed pike and pickerel reported (!!) (the exclamation points are his). Caught inshore: 1 fingerling perch; large-mouthed bass, numerous fingerlings; black bullhead (Ameiurus melas) 2; Poeciliichthys exilis (Iowa darter) 1.

Metzelaar recommended stocking with large-mouthed bass.

Round Lake was not investigated by the Institute party. Thirteen lakes (listed in Table I) were investigated by the lakes investigation crew of the Institute for Fisheries Research in the summer of 1932. Maps and the various inventory cards have been submitted for these lakes. Some of the data from the summary cards are condensed in Table No. 1.

Table 1

Data obtained from inventory of lakes in the
Pigeon River State Forest

Lake	Approximate area (acres)	Estimated app. shoal area ¹	Inlet	Outlet	Max. depth (meters)	Vegetation on shoal
Dog	181	100	none	intermittent	2.0	abundant
Grass	28.3	100	small	small	3.0	abundant
Hardwood	46.3	100	none	intermittent	3.0	common
Two Acre	1.9	100	none	none	2.3	common
Pickerel	40.6	25	springs	small	10.6	relatively rare
Ford	11.7	35	none	none	10.0	abundant
Devil's Soup Bowl	1.3	35	none	none	6.9	moderate
Hemlock	6	33	none	intermittent	19.2	abundant
Lost	4.6	15	none	none	15.8	common
West Lost	4	15	none	none	14.5	common
Section 4	3.3	15	none	none	21.9	common
North Twin	5.7	15	none	none	15.8	common
South Twin	4.3	15	none	none	12.7	common

Lake	Thermocline (meters)	Acidity or alkalinity ²		Dominate kind of bottom			Clearness-disc reading (meters)
		Surface	Bottom	Shoal	Slope	Deep	
Dog	none	alkaline (7.9)	alkaline (7.9)	peat	...	...	bottom
Grass	none	alkaline (8.2)	alkaline (7.2)	mostly peat & marl mixed	...	...	bottom
Hardwood	none	acid (5.2)	acid (5.2)	sand overlain with peat	...	...	bottom
Two Acre	none	neutral (7.0)	neutral (7.0)	peat	...	...	1.8
Pickerel	5 to bottom	alkaline (8.3)	alkaline (8.3)	marl	marl	marl	3.9
Ford	5 to bottom	alkaline (8.2)	alkaline (8.2)	sand, peat & marl	marl	peat	5.5
Devil's Soup Bowl	3 to bottom	alkaline (7.8)	alkaline (7.6)	peat & sand	peat	peat	5.1
Hemlock	4-8	alkaline (8.1)	alkaline (7.4)	peat & marl	marl	peat	4.2
Lost	4-8	alkaline (7.9)	alkaline (7.4)	marl	marl	marl & peat mixed	9.1
West Lost	3-7	alkaline (7.9)	neutral (7.0)	peat & sand margin	marl & peat	peat	5.0
Section 4	4-7	alkaline (7.9)	alkaline (7.2)	marl	marl	peat	6.8
North Twin	5-9	alkaline (7.5)	alkaline (7.4)	sand	peat	peat	4.5
South Twin	4-9	alkaline (8.1)	alkaline (7.8)	sand	peat	peat	7.5

¹ Rough estimate

² Figures in parentheses indicate pH.

All of these lakes having thermal stratification also contained dissolved oxygen in the cold water, although, in West Lost Lake and Section 4 Lake, the oxygen was almost or entirely lacking at the bottom.

Four of the lakes, Dog, Grass, Hardwood, and Two Acre, are similar in several respects: all four are quite shallow and all are warm water lakes. Lost, West Lost, North Twin, South Twin, and Section 4 Lakes are comparable in most respects; all are more or less circular "pot hole" lakes with steep banks, all are relatively deep and all show definite thermal stratification. Devil's Soup Bowl differs from these primarily in depth. Ford Lake exhibits many similar characteristics but is of a larger size and is less circular in shape. Two Acre Pond is of the "pot hole" type in shape and steepness of bank but is very shallow and is apparently well along toward extinction. Hemlock Lake is a typical "pot hole" except for the presence of an outlet. All of these lakes except Dog, Grass, Hardwood, and Pickerel appear to be of similar origin. On the basis of maximum depth the "pot holes" may be placed in four classes: 0-5 meters, Two Acre; 5-10 meters, Devil's Soup Bowl; 10-15 meters, West Lost, North Twin, South Twin, and Ford; over 15 meters, Lost, Hemlock, and Section 4. A fifth class, not of interest from a fisheries standpoint, is the temporary pot hole containing water only at times. An example of this type is found along the trail between the old headquarters and Grass Lake.

The inventory was not a complete one; food studies and fertility studies were not made. The areas determined may be somewhat inaccurate. A more thorough investigation would be desirable.

Fish Fauna

The fish known to be present in these lakes are indicated in Table 2. The symbols (A = abundant, C = common, R = rare, Re = reported) are unsatisfactory in expressing abundance of fish because the terms used are of an indefinite nature, however, they give some idea of abundance of the several species.

Since the netting and seining operations may have been inadequate, and since fish populations change in abundance the table may not accurately or completely indicate present abundance. The table is based on the Institute's inventory, on the

stocking records, on Dr. Metzelaar's investigation (Pickerel Lake), and on the writer's observations since the inventory.

Table 2

Fish present in lakes in Pigeon River Forest

Lake	Species	Brook Trout	Brown Trout	Rainbow Trout	Northern Pike	Small-mouth Bass	Bluegills	Common Sunfish	Perch	Red-bellied Dace	Fine-scaled Dace	Northern Dace	Horned Dace	Brown Bullhead	Iowa Darter	Brook Stickleback	Fat-head Minnow	Blunt-nosed Minnow	Black-nosed Shiner	Common Shiner	Black-chin Shiner	Golden Shiner	Top Minnow	Common Sucker	Mud Minnow
Dog					C			C	C					C	C	C				C		C			
Grass		R					*			A	A	R	R		C	A		A		C				R	
Hardwood						*	*																		
Two Acre																									
Pickerel		C	*	*		C*	*	R	A		R				R										R
Ford		*	*	*					A			*				*	*								
Devil's Soup Bowl		*																C							
Hemlock		*								A			Re		C	C	C		A						
Lost		*																							
West Lost		*																A							
Section 4	1934	*							A																
	1935	?		*					?																
North Twin		*							A															R	
South Twin	1934	*							A																
	1935	?		*					R									*				*			

* = stocked (Includes stocking to November 15, 1935)

✓ The scientific names of these species are as follows: Brook Trout, Salvelinus fontinalis; Brown Trout, Salmo fario; Rainbow Trout, Salmo irideus; Northern Pike, Esox lucius; Small-mouthed Bass, Aplites salmoides; Bluegill, Helioperca macrochira; Common Sunfish, Eupomatis gibbosus; Perch, Perca flavescens; Red-bellied Dace, Chrosomus eos; Fine-scaled Dace, Pfrittle neogaea; Northern Dace, Margariscus margarita nachtriebi; Horned Dace, Semotilus atromaculatus atromaculatus; Brown Bullhead, Ameiurus nebulosus; Iowa Darter, Poecilichthys exilis; Brook Stickleback, Eucalia inconstans; Fat-head Minnow, Pimipheles promelas; Blunt-nosed Minnow, Hyborhynchus notatus; Black-nosed Shiner, Notropis heterolepis; Common Shiner, Notropis cornutus frontalis; Black-chinned Shiner, Notropis heterodon; Golden Shiner, Notemigonus crysoleucas auratus; Top Minnow, Fundulus diaphanus menona; Common Sucker, Catostomus commersonii; Mud Minnow, Umbra limi.

Table 2 shows a rather interesting distribution of fish in these lakes. Whether fish were transplanted in lumbering days is not known; recent stocking records appear to be complete.

Dog Lake appears to have a more or less warm-water lake fauna. It is connected by a small outlet with a trout stream but apparently the stream fishes have not become established in the lake. Grass Lake, on the other other hand, contains largely fish which are also found in streams. This lake appears to have originated, or at least to have been enlarged, by beaver activities.

Hardwood Lake appeared devoid of all fish life. Two Acre Pond also was apparently without fish.

Pickerel Lake contained an abundance of small Perch and a limited number of Small-mouthed Bass and Sunfish, species which might be expected in a marl lake of this type. Forage fish were almost completely absent. The trout probably entered through the outlet which connects the lake with the Sturgeon River.

Ford Lake, Section 4 Lake, North Twin Lake, and South Twin Lake contained only Perch (except that North Twin also had a limited population of common Suckers). Lost, West Lost, Devil's Soup Bowl, and Hemlock Lakes contained no perch but all appeared to have a relatively large supply of minnows; the three land-locked lakes containing only fathead minnows while Hemlock Lake contained, in addition, a number of other forms.

Three of the lakes now containing trout may have also contained them originally because of connections with trout streams; Pickerel Lake and Grass Lake obviously contained trout before the recent stocking; it is possible that trout were also originally present in Hemlock Lake.

Removal and Stocking

South Twin Lake was netted in the summer of 1934 and was poisoned in September of the same year. A record of the fish removal appears elsewhere in this report.

Ford Lake was netted in 1934 and about 10 gallons of small perch were removed. North Twin Lake and Section 4 Lake were also netted in 1934, and Section 4 Lake was poisoned in September, 1935. Records of the fish removed appear elsewhere.

Any netting or seining in the other lakes was merely to determine the kind of fish present and was too meager to noticeably affect the fish supply. Stocking records for recent years appear to be complete. In reply to a letter addressed ^{to} him recently, William Horsell, Superintendent of the Forest replies (in part):

"Mr. Wm. Green, Hillman, planted Lost Lake in I think 1927, but I do not know the number of fish he put in it. I planted 200 fingerling trout in Hemlock Lake in 1927. West Lost Lake was not planted until Mr. Lincoln planted it."

The fish referred to in the first sentence are Brook Trout.

In reply to an inquiry regarding recent stocking of lakes in the Pigeon River Forest, Mr. Guy Lincoln, District Superintendent of Fisheries Operations, State Fish Hatchery, Oden, writes (Sept. 30, 1935):

"Following is a list of various fish plants made in lakes of the Pigeon River Forest Reserve:

1. Devils Soup Bowl
1933 - 5,000 Brook trout 5 mos old
1934 - 500 " " 6 " "
2. Ford Lake
1933 - 500 Brook trout 8 mos old
1934 - 6,000 " " 6 " "
600 Brown trout 8 mos old
600 Rainbow " yearlings
1935 - 300 " " adults 3 yrs. old
3. Lake Four
1933 - 300 Brook trout 8 mos old
4. Lost Lake
1933 - 5,000 Brook trout 5 mos old
500 " " 8 " "
1934 - 6,000 " " 6 " "
1935 - 5,000 " " 5 " "
5. West Lost Lake
1934 - 6,000 Brook trout 6 mos old
1935 - 4,000 " " 5 mos old
6. Twin Lake
1933 - 1,300 Brook trout 8 mos old
5,000 " " 5 " "
7. South Twin Lake
1933 - 5,000 Brook trout 5 mos old
1,500 " " 8 " "

8.	Hardwood Lake		
	1933 - 7,500 Bluegills	4 mos old	
	250 SM Bass	4 " "	
9.	Round Lake		
	1933 - 7,500 Bluegills	4 mos old	
	500 SM Bass	3 " "	
	1934 - 2,000 Bluegills	4 " "	
10.	Hemlock Lake		
	1933 - 5,000 Brook trout	5 mos old	
	1934 -10,000 " "	5 " "	
	1935 - 5,000 " "	5 " "	
11.	Lake of the Woods		
	1933 - 500 Brook trout	8 mos old	
12.	Lantz Lake		
	1933 - 800 LM Bass	3 mos old	
	500 SM Bass	4 mos old	
13.	Osman Lake		
	1933 - 5,000 Bluegills	4 mos old	
	1934 - 450 SM Bass	4 " "	
	500 Bluegills	4 " "	
14.	Pickeral Lake		
	1934 - 7,000 Brook trout	6 mos old	
	600 Brown "	8 " "	
	600 Rainbow "	Yearlings	
	500 SM Bass	4 mos old	
	3,000 Bluegills	4 mos old	
	1935 - 500 Brook trout	7 " "	
15.	Grass Lake		
	1934 - 4,000 Bluegills	4 mos old.	

"The number of fish planted in 1935 as listed above includes all plants made to date, but does not include plants which may be made later."

STATE FISH HATCHERY
Oden, Michigan

1935

REPORT OF FISH PLANTED IN PIGEON RIVER STATE FOREST
LAKES

<u>Name of Lake</u>	<u>No. of Fish</u>	<u>Kind of Fish</u>	<u>Age</u>	<u>Weight</u>
Hemlock L.	5,000	Brook trout	5 mos.	22 $\frac{1}{2}$
Osmun L.	200	S.M. Bass	4 "	$\frac{1}{2}$
	1,000	Bluegills	4 "	1 $\frac{1}{2}$
Lance L.	15,000	Perch	fing.	90
	1,000	Bluegills	4 mos.	1 $\frac{1}{2}$
Lost L.	5,000	Brook trout	5 mos.	22 $\frac{1}{2}$
W. Lost L.	4,000	" "	5 "	18
Ford L.	300	Rainbow trout	Adults	300
Lake Four	150	" "	"	150
Twin L.	100	" "	"	75
Pickerel L.	1,500	Bluegills	4 mos.	2 $\frac{1}{4}$
	500	Brook trout	6 mos.	7 $\frac{1}{2}$
	100	Rainbow trout	Adults	75
	400	Brook trout	"	300
Grass L.	1,000	Bluegills	4 mos.	1 $\frac{1}{2}$
Round L.	1,000	S.M. Bass	4 mos.	2
	500	Bluegills	4 "	3/4
	<u>36,750</u>			<u>1,070$\frac{1}{2}$</u>

Note: This includes all stocking in these lakes
for 1935.

In addition to the stocking above, several plants of minnows were made:

Approximately 15,500 minnows were planted in Ford Lake in the summer of 1934 by R. G. Janes and the writer. These consisted chiefly of northern dace but fat-head minnows and several other species were included in the plant. The minnows were taken from above an old beaver dam near the old headquarters.

Approximately 5,000 blunt-nosed minnows and a few dozen top minnows were planted in South Twin Lake in late August, 1935 by the same party. These were seined from Tomahawk Lake, Presque Isle Forest.

Survival from Stocking

It is impossible, of course, to give any definite figures on the percentage of survival, however, some indication of the success of some of the plantings may be made. Unless some of the stocking is followed by a study of the effectiveness, the benefits to be derived from planting must necessarily be questioned.

It has been noted that the four lakes mentioned below contained only minnows prior to stocking:

Lost Lake. Stocked with brook trout. Results of stocking excellent.

See creel census.

West Lost Lake. Stocked with brook trout. Results of stocking excellent.

See creel census.

Hemlock Lake. Stocked with brook trout. Results of stocking excellent.

See creel census.

Devil's Soup Bowl. Stocked with brook trout. No creel census records

but according to reports the stocking was successful.

The four lakes mentioned below each contained an abundance of perch when stocked with trout. In several of the lakes the perch were obviously stunted, growth was relatively slow in all of them.

South Twin Lake. Stocked with brook trout. Survival relatively poor.

Fish partially removed by poisoning; lake recently restocked with Rainbow Trout.

Section 4 Lake. Stocked with brook trout. Survival relatively poor.

Fish partially removed by poisoning; lake recently restocked with Rainbow Trout.

Ford Lake. Stocked with brook trout. Survival relatively poor. Recently stocked with adult trout. No information on survival from stocking in 1934 and 1935.

North Twin. Stocked with brook trout. Survival relatively poor.

It appears that in these four lakes which were overrun with perch, the brook trout were not able to compete successfully. These four lakes are similar in most respects to the four previously mentioned lakes. As indicated elsewhere in this report, two of these lakes were restocked with trout (rainbow) after the perch had been largely removed, one was stocked with adult trout of several species without removal of perch; the fourth was fertilized.

Pickerel Lake. Pickerel Lake has been stocked with trout and also with bass and bluegills. Some information regarding the plants should be available later.

Hardwood Lake. Planted with bluegills and small-mouthed bass. Stocking apparently entirely unsuccessful.

Survival from recent stocking on the above mentioned lakes and from stocking on several of the other lakes cannot be discussed because of inadequate information.

Natural Reproduction

It is obvious that the perch are quite capable of maintaining themselves in the lakes in which they are now present.

Conditions for reproduction of bass and bluegills in Grass Lake appear suitable; with improvements (completed and proposed) they should also be suitable for bass and bluegills in Pickerel Lake.

It is doubtful whether the trout will reproduce successfully in reasonable numbers if at all in any of the lakes. It was reported that young trout were seen in Lost Lake last summer. This lake contains gravel, as does Section 4 Lake and it is possible that some natural reproduction occurs here, however, such reproduction would probably be quite limited and the desired population must be maintained by stocking.

Stocking Recommendations

The following stocking recommendations were submitted in the fall of 1935:

Recommendations for the stocking of several Pigeon

River Forest lakes

South Twin Lake. This lake was poisoned last year. Apparently a few perch still remain but most of them were killed. A few weeks ago 6000 blunt-nosed minnows were planted in the lake. It is recommended that this lake be stocked with approximately 300 legal sized rainbow trout. It is further recommended that these be carefully counted and that the exact number be recorded. It has been indicated that trout in these lakes do not "bite" well during the latter part of the season. This may be due to depletion or to some inherent characteristic of the trout. It is anticipated that a careful creel census will be conducted on this lake, and, if the fish have been counted, the reason for the poorer fishing late in the season can be determined.

Section 4 Lake. This lake was recently poisoned. It has been suggested that grayling might do well in the lake. If several hundred grayling are available these might well be planted as an experiment. If not available, it is recommended that this lake be stocked with approximately 300 legal sized brown trout, carefully counted as for South Twin Lake, and counted for the same reason.

North Twin Lake. This lake now contains some trout and many perch. It is recommended that the lake be stocked with approximately 200 legal-sized rainbow trout carefully counted.

It appears especially desirable that the above 3 lakes be stocked as suggested because of the valuable information which may be obtained from the stocking and the subsequent checking. The creel census on these lakes will indicate which species is best suited to the lakes and will indicate the reason for a decline in the fishing in late summer.

Lost Lake, West Lost Lake, Hemlock Lake and Devil's Soup Bowl, should be stocked as previously with brook trout. Hemlock Lake is reported to have produced poorer fishing this season than last and a rather liberal planting of fish appears desirable in this lake. Food in Hemlock Lake is abundant. If available, legal-sized fish might well be planted.

Pickereel Lake should be stocked with Smallmouthed Bass, while Grass Lake should have a liberal planting of Largemouthed Bass and Bluegills.

Mr. J. E. Schwerdt, Superintendent of Camp Vanderbilt, SP-15, indicates that he will be able to transport the trout from the hatchery to the lakes.

Submitted by R. W. Eschmeyer

Creel Census

For three of these lakes definite information regarding the fishing for 1935 is now available. The lakes were checked from daylight to dark for the entire fishing season and the data presented below represent fully 95% of the fishing on these lakes during the "open" season. The creel census was taken by the Pigeon River C.C.C. camp. One man was stationed on Hemlock Lake, while another man checked the fishing on Lost and West Lost lakes. Since these lakes are small and close together, two men are able to take the census on the three lakes without difficulty.

Lost Lake Creel Census

The following tables represent an analysis of the fishing and fish catch on Lost Lake for the trout fishing season (May 1st to Sept. 2, 1935).

Table 3

Monthly analysis of fishing

	May	June	July	August	Total or Average	Per Acre
Number of fisherman days	155	56	114	62	387	84
Number of fishermen taking no fish	90	30	88	40	248	...
Number of hours fished	605.5	155.25	204.5	156.5	1157.75	251.7
Number of legal fish taken ¹	206	78	93	84	461	100.2
Fish per fisherman	1.3	1.4	.82	1.4	1.2	...
Fish per hour	.34	.50	.39	.54	.4	...
Average size of legal fish (inches)	8.8	8.8	8.8	9.2	8.9	...
Number of undersized fish ²	99	30	12	24	165	36

¹ All fish caught were brook trout

² Undersized fish not included in above calculations

Table 4

Size frequency and weight of catch

Size (inches)	7	7 $\frac{1}{4}$	7 $\frac{1}{2}$	7 $\frac{3}{4}$	8 $\frac{1}{4}$	8 $\frac{1}{2}$	8 $\frac{3}{4}$	9	9 $\frac{1}{4}$	9 $\frac{1}{2}$	10	10 $\frac{1}{2}$	11	12	13	22	
No. (May)	4		9	7	59		15	3	71		5	27		3		2	1
No. (June)		3	2		15		21	6	15	3		10	2		1		
No. (July)				3	24	6	7		38			15					
No. (Aug.)					1		8		47		17	4		7			
No. (total) ^{2/4}	4	3	11	10	99	6	51	9	171	3	22	56	2	10	1	2	1
Estimated wt. per fish ^{3/} (lbs.)	.141	.156	.174	.192	.211	.231	.252	.276	.300	.325	.353	.411	.476	.548	.711	.904	4.379
Total wt. (lbs.)	.56	.47	1.91	1.92	20.89	1.39	12.85	2.48	51.30	.97	7.77	23.02	.95	5.48	.71	1.81	4.38

^{1/} The number of fish measuring even inches is not in proper proportion with the number having fractional measurements. Obviously measurements on many of the fish were probably not correct to more than the nearest half inch.

^{2/} Since each sheet indicated the average size of the fish taken, the distribution as listed here is not correct. However, it approaches the actual size distribution.

^{3/} To convert production into pounds, the condition factor used was 1.45. This was found by L. A. Woodbury (unpublished) as average for brook trout in seven lakes in Glacier National Park. The average condition of the trout in Lost Lake was probably not less than 1.45, so the estimate of weight given here appears to be a relatively conservative one. Mr. Woodbury provided a table by which his measurements could be expressed in inches and pounds.

Census and length-weight computations indicate that Lost Lake produced 461 legal trout having a total weight of 138.86 pounds, or a per acre production of 100.2 trout (average length 8.9 inches) weighing 30.2 pounds. This is obviously an exceptionally large production. Further census will indicate whether or not trout may continue to be taken from the lake in such large quantities. Judging from general observations, it appears that the minnow supply has been maintained despite the large trout population; other food organisms may or may not have diminished.

About two-thirds of the fishermen took no fish and the average fisherman caught only a little over one trout each. Were the per acre production not considered, it might be concluded that fish production in Lost Lake was relatively poor*; it is apparent that the lake was overfished.

A check of the number using various methods indicates the following: Casting 44, trolling 5, still fishing 346. Ten fishermen used two methods in the day's fishing; the others used only one.

Table 5 shows the extent to which the various baits were used and the effectiveness of the several baits. It includes only those records which indicated one bait for the day's fishing.

* Average catch per hour for trout waters in Otsego County (according to the general census, Report 282) was 1.08 in 1933 and 1.43 for the period 1928-32. The average catch for Lost Lake (1935) was .4 fish per hour.

Table 5

Effectiveness of baits used

Bait	Number using bait	Number of hours bait was used	Number fish caught	Fish per hour	Average size of fish
Insects	33	59	25	.42	8.5
Art. Fly	21	42 $\frac{1}{2}$	26	.61	8.4
Minnows	117	495 $\frac{3}{4}$	219	.44	9.1
Worms	78	193 $\frac{1}{4}$	113	.58	8.7
Spinner	4	5 $\frac{1}{4}$	1	.19	11
Plug	1	1 $\frac{1}{2}$	..	..	..

The table indicates that fly fishing produced the most trout per hour, while the bait most used (minnows) produced the largest (average) fish (spinner excepted).

A check of the residences of the anglers who fished Lost Lake indicates that the lake attracted fishermen from a large number of localities. The list of towns, and number of fishermen from each community follows: Local (includes approximately a 20 mile radius, the towns of Wolverine, Afton, Onaway, Tower, Vanderbilt and Indian River) 136, Ann Arbor 3, Bay City 3, Battle Creek 3, Boyne City 14, Conway 1, Cheboygan 6, Charlevoix 1, Detroit 34, Dearborn 2, E. Lansing 1, Flint 3, Gaylord 11, Grand Rapids 4, Jones 1, Jackson 8, Kalamazoo 5, Lansing 7, Mullet Lake 1, Midland 16, Mt. Clemens 2, Mt. Pleasant 4, Monroe 1, Muskegon 2, North Star 4, Newaygo 1, Owosso 3, Oden 2, Petosky 41, Pontiac 2, Saginaw 12, Three Rivers 1, Topinabee 9, Wyandotte 3, Waloon Lake 2, Ypsilanti 4, and Vicksburg 2. Non-residents: Ohio 5, Indiana 4, Illinois 4, and Pennsylvania 2.

West Lost Lake Creel Census

Table 6

Monthly analysis of fishing¹

	May	June	July	August	Total or Ave.	Per Acre
Number of fisherman days	95	35	26	8	164	41
Number of fishermen taking no fish	54	23	19	7	103	
Number of hours fished	376	106 $\frac{3}{4}$	78	21 $\frac{1}{2}$	582 $\frac{1}{4}$	145 $\frac{1}{2}$
Number of legal fish taken	161	23	14	1	199	50
Fish per fisherman	1.7	.66	.53	.13	1.2	
Fish per hour	.43	.22	.18	.05	.34	
Ave. size of legal fish (inches)	10.2	9.8	11.7	13.0	10.5	
Number of undersized fish	14	1	7	0	22	5.5

¹ Comments under tables 3, 4, and 5 apply also here.

Table 7

Size frequency and weight of catch¹

Size (inches)	7½	8	8¼	8½	9	9½	10	10½	11	11½	12	13	13½	17
No. (May)	5	14	4	10	28		20		42	6	31	1		
No. (June)		1		1	10	5			3		1	2		
No. (July)							6		2		2		3	1
No. (Aug.)												1		
No. (Total)	5	15	4	11	38	5	26		47	6	34	4	3	1
Estimated wt. per fish (lbs.)	.174	.211	.231	.252	.300	.353	.411		.548	.626	.711	.904	1.012	2.021
Total wt. (lbs.)	.87	3.17	.92	2.77	11.40	1.77	10.69		25.76	3.76	24.17	3.62	3.04	2.02

✓ Comments under tables 3, 4, and 5 apply also here.

It will be noted that there was a constant decline in fishing and in the per hour catch as the season progressed. Whether this is due to depletion or to seasonal variation in the feeding habits or other activities of the fish cannot now be determined. West Lost Lake produced fewer fish, both in number and poundage, than did Lost Lake, but the fish taken from West Lost were of a considerably larger average size. West Lost Lake produced a total catch of 199 trout (average length 10.5 inches) weighing 93.96 pounds, or a per acre catch of 50 fish averaging 23.5 pounds. Although lower than the production on Lost Lake, this was, nevertheless, an excellent per acre production of trout.

Eighteen fishermen used casting as a method, while one trolled and 146 still fished (one fisherman used two methods).

Effectiveness of the several kinds of bait used is shown in Table 8. Records showing use of more than one kind of bait during the day's fishing were not used in these determinations.

Table 8

Effectiveness of baits used

Bait	Number using bait	Number of hours bait was used	Number fish caught	Fish per hour	Average size of fish
Insects	2	5	3	.60	13.5
Art. Fly	12	36	36	1.0	8.7
Minnows	45	227 $\frac{3}{4}$	102	.45	10.9
Worms	68	206 $\frac{3}{4}$	54	.26	10.0
Spinner	4	7 $\frac{1}{2}$	..	..	..

It will be noted that artificial flies produced the most fish per hour, also the smallest fish. The bait most used (worms) was not the most effective.

The residences given by the fishermen are as follows: Local (within approximately 20 mile radius) 62, Au Gres 1, Cheboygan 3, Detroit 11, Dearborn 1, Gaylord 11, Jackson 3, Lansing 22, Mackinaw 1, Muskegon 3, Oden 2, Perry 1, Petoskey 18, Pontiac 5, Romeo 4, Royal Oak 2, St. Johns 2, Traverse City 3, Topinabee 4.

Hemlock Lake Creel Census

Table 9

Monthly analysis of fishing

	May	June	July	August	Total or Average	Per Acre
Number of fisherman days	123	37	44	8	212	35
Number of fishermen taking no legal trout	72	21	27	4	89	
Number of hours fished	373	116 $\frac{1}{2}$	110	22 $\frac{1}{2}$	622	104
Number of legal trout taken ^{1/}	143	15	40	17	215	36
Fish per fisherman	1.2	.4	.9	2.1	1.0	
Fish per hour	.38	.13	.36	.76	.35	
Ave. size of legal trout (inches)	8.2	7.7	7.8	8.5	8.1	
Number of undersized trout	277	45	22	0	344	57

^{1/} Eleven horned dace were also caught. They are not included in these calculations.

According to reports, fishing on Hemlock Lake in 1935 was decidedly poorer than in 1934.

The writer's experiences on this lake are in accord with these reports, i.e. he found

fishing to be good in this lake in 1934. It will be noted, however, that a large number of undersized fish were taken in 1935. These fish were, for the most part, only an inch or less below the legal limit. It is predicted that the Hemlock Lake fish catch in 1936 will be very good, much better than the 1935 catch. It will be noted that the proportion between legal and undersized fish changed decidedly as the season progressed; apparently many of those which had been just below legal size in May had grown sufficiently to be above 7 inches in length later in the season.

Table 10

Size frequency and weight of catch^{1/}

Inches	7	7 $\frac{1}{4}$	7 $\frac{1}{2}$	7 $\frac{3}{4}$	8	8 $\frac{1}{2}$	9	9 $\frac{1}{2}$	10
No. (May)	12	1	28	2	40	10	47	2	1
No. (June)	4	3			6		2		
No. (July)	6		15		15		4		
No. (Aug.)					2	15			
No. (Total)	22	4	43	2	63	25	53	2	1
per fish Estimated ^{total} wt. (lb.)	3.10	.62	7.48	.38	13.29	6.30	15.90	.71	.41

^{1/} Comments made under table 4 apply also here

Hemlock Lake produced a total of 215 legal trout having a total weight of 48.2 pounds, and an average length of 8.1 inches. The per-acre production was 36 legal trout, weighing a total of 8.03 pounds.

Table 11

Effectiveness of baits used^{1/}

Bait	Number using bait	Number of hours bait was used	Number fish caught	Fish per hour	Average size of fish
Insects	13	34 $\frac{1}{2}$	20	.58	8.1
Art. Fly	12	30 $\frac{1}{2}$	9	.30	7.4
Minnows	16	62 $\frac{3}{4}$	18	.29	8.1
Worms	122	343 $\frac{1}{2}$	122	.33	8.0
Spinner	5	9 $\frac{1}{4}$	1	.11	7.5

^{1/} Data taken from those records where only one kind of bait was used in the day's fishing.

The methods used on Hemlock Lake and the number of blanks listing each are: casting 21, trolling 12, stillfishing 196 (Three fishermen used two methods in one day's fishing).

Growth Rate

Brook Trout

The trout were not checked for growth rate and any determination of their rate of growth must be made by using the stocking records. It is hoped that, in the future, growth studies of the trout may be made. Comments regarding growth of the trout in several of the lakes follow:

Lost Lake. Two hundred fingerling trout were planted by Mr. Horsell in 1927. On August 1st, 1931 an "Institute" party, in surveying the lake, took 5 trout 10-15 inches long. In 1934 a fisherman caught a 23 $\frac{1}{2}$ inch trout in this lake, and in 1935 a 22 inch trout was taken; all of these fish were probably from the 1927 plant of fingerlings. The next plant was in 1933. The 1935 catch was probably largely fish planted in 1933 and 1934. Nine inch trout were the dominant group in this catch.

West Lost Lake. So far as can be ascertained the first plant in West Lost Lake was in 1934 when the lake was stocked with 6,000 brook trout (6 months old). If this is correct the fish showed an excellent growth since, for in 1935 those caught averaged about 10 $\frac{1}{2}$ inches long; many were 11 and 12 inch fish.

Hemlock Lake. Hemlock Lake was probably stocked in 1927, perhaps with fingerlings. An "Institute" party took six trout from this lake in the summer of 1931, ranging in length from $15\frac{1}{2}$ to 20 inches. These probably were fish planted in (approximately) 1927. The lake produced well in 1934. The fish taken then (those caught by the writer averaged almost 9 inches long) were probably of the 1933 stocking, while those caught in 1935 were probably of the 1933 and 1934 stocking; the large number of undersized fish (6 - $6\frac{1}{2}$ inches long) probably having been planted in 1934.

Devil's Soup Bowl. This lake was stocked with 5-month-old trout in 1933. It was reported in 1934 that during that season a considerable number of 8 to 9 inch trout were taken from this small lake. No data for 1935 are available.

It appears that, in the four lakes mentioned, the trout made excellent growth. The fishes from these lakes appeared to be in good condition, much heavier and deeper in body than those taken in the neighboring streams.

When a species is introduced into a body of water previously barren or when a body of water is newly impounded, it has been found in many cases that the fish do exceptionally well for a few years but that, after that period, the fishing conditions fail to be maintained. It will be interesting to note whether or not the production in these lakes will hold up (even with repeated stocking) over a period of years; also to attempt to determine the reason for the decline should it occur.

Hemlock and Lost Lake have now been fished heavily for two seasons; West Lost Lake was fished some in 1934 and fished heavily in 1935; Devil's Soup Bowl was fished to some extent both years but the degree of intensity is not known.

Pickerel Lake. When examined in 1932 by an "Institute" party a net set in Pickerel Lake produced one 19-inch brook trout and 13 brook trout ranging in length from 9 to 12 inches. So far as known the lake had not been stocked, and the trout probably had entered Pickerel Lake through the outlet connecting it with the Sturgeon River. The 19-inch trout was very narrow and had an unusually large head, apparently it was more or less "starved". The other fish appeared to be normal in proportion and condition.

Scale samples were taken from these fish and it may be possible to determine their age and relative rate of growth. However, since it is not known at what age the fish may have entered the lake, such data would not be especially significant. Since trout can migrate into or out of this lake, the rate of growth of the trout planted recently probably cannot be determined later with assurance unless it be found that because of beaver dams or for other reasons migration into the lake is unlikely to occur at present.

Ford Lake. Ford Lake was first stocked with brook trout in 1933 (500 8-month-old fish). This lake was netted in the summer of 1934 for perch and some trout were taken with the perch (ratio about 1 trout per 90 perch). These trout which had been planted as 8-month-old fish in 1933 now were approximately 6-7 inches long.

Section 4 Lake. This lake was stocked in 1933 with 300 8-month-old brook trout and was not stocked again until the fall of 1935, following reduction in perch population by poisoning. The lake was netted for perch on August 14 and 15, 1934. Thirty-nine perch and 3 brook trout were taken by nets. The brook trout had an average length of about 6-7 inches.

North Twin Lake. North Twin Lake was netted for perch in August 1934. It had been stocked with trout in 1933 (1300 brook trout, 8-month-old and 5000 brook trout 5-month-old). Nets produced 278 perch and 41 trout. The trout had an average length of about 6 inches. It has been reported that in 1935 this lake produced some fair-sized trout (9 inches long) also some fair-sized perch (see section on fertilizing).

South Twin Lake. This lake was stocked with 5000 brook trout, 5 months old and 1500 brook trout 8 months old in 1933. Netting in August, 1934 produced 263 perch and 21 trout. Apparently very few trout remained unless during the poisoning in September they sank to the bottom in deep water. (See perch). The fish taken had an average size of about 6 1/8 inches.

The last four lakes mentioned differed from the other four pothole lakes in that they contained an abundance of perch while the first four mentioned contained no perch. Since the eight lakes are quite similar in most respects and since the growth of trout was poor in those four containing perch, it may be safely assumed that the perch were

responsible for the poor growth of the trout. The perch were doing very poorly also and food was undoubtedly scarce in most of these lakes. The poor survival of the trout is probably due also to the presence of the large number of perch; most of the trout probably died of starvation or were eaten by the larger perch.

Perch

For several of the lakes a large amount of data regarding the growth of perch is (or will be) available, for several others few perch were collected and these were discarded. It was obvious that the perch were slow-growing in the five lakes which contained an abundance of them.

Pickereel Lake. A small number of perch were taken from this lake in the summer of 1934. Age determination was not made on these fish but their condition and shape indicated that they were stunted. They probably compared in growth with those taken from the other lakes.

North Twin Lake. The perch netted from this lake in 1934 were discarded. These likewise were in poor condition and their growth was probably similar to the growth of perch in the other lakes.

South Twin Lake. Some perch were netted in August, 1934, and the population was poisoned on the following month. The fish which were found floating during the several days following the poisoning or which were found in shallow water were saved for later study. Approximately 30 gallons of fish were removed. A net-set (over night) a few weeks later produced no fish, but one live perch was seen at that time. It was reported that a few were seen here in 1935. Evidently the poisoning did not kill the entire population; however, it is believed that only a small percentage survived. Unfortunately some of the fish sank in deep water and were not recovered, so an estimate cannot be made of the total population. Since a large portion of the population was available and since the fish were taken by means which appeared not to be selective, also since the population was an extremely stunted and interesting one, it was considered desirable that they be studied more or less in detail. This study has been completed and is shown in detail in

Report No. 334. Some of the findings are given, briefly, below. The actual poisoning operations will not be discussed.

A total of 3615 fish were used for age determination, and 503 fish were counted lying on the bottom in the lake in water 7 feet deep or less by Trautman and Eschmeyer after they had finished collecting the dead fish. There is reason to believe that more dead fish were lying on the bottom in water too deep to permit their being seen. The perch population of this lake was in excess of 4118 fish, consequently it approached (and probably exceeded) a population of 1000 fish per acre. Only two brook trout were taken.

Age determination of these slow growing fish was difficult, especially determination of the males in the III and IV year classes. It is possible that some of those in the IV class were really 3 years old and vice versa. Table 12 shows the age distribution. The Roman numerals refer to the winter marks, for example fish in the II group were two winters old. Since the fish were taken in the fall, they were actually one growing season older (so far as growth is concerned, they were one year older) than the numerals indicate.

The poisoned fish were collected at three different times, lot 1 on September 20, lot 2 on September 20, and lot 3 on September 21. Lot 4 includes the fish netted and dynamited previous to the poisoning.

Table 12

Age distribution of perch removed from
South Twin Lake, fall of 1934

Winter marks	0	I	II	III	IV	V	VI?	VII or VIII?
Females (1530)								
Lot 1	2	27	607	24	66	13		2
Lot 2			284	4	31	3		
Lot 3			320	6	31	2	1	
Lot 4		1	27	65	13			1
Total	2	28	1238	99	141	18	1	3
Males (2085)								
Lot 1	1	45	638	132	11			
Lot 2		3	497	59	32			
Lot 3		10	361	108	42			
Lot 4		13	40	84	9			
Total	1	71	1536	383	94			
Total (both sexes)	3	99	2774	482	235	18	1	3

The age determinations indicate several interesting conditions:

1. One year class, II (3 summer old), included 76.7% of all the fish.
2. There were almost no fish in the 0 group (1 summer old) and very few in the I group (two summers old).
3. The ratio between males and females was approximately 4 to 3.
4. Males dominated the I, II and III groups but the number of females exceeded the number of males in the IV group.
5. Females lived longer than the males; only a small number of the males were 4 winters old while some females were well over 4 years old.

These data will be further discussed later.

Growth rate is indicated in Table 13.

Table 13

Growth rate of perch in South Twin Lake
based on 3615 specimens, recorded in
millimeters and grams, standard length used

Year Class	0	I	II	III	IV	V	VI?	VII or VIII?
Average standard length								
Females	44	80.4	87.1	125.0	134.2	169.1	274.0	282.0
Males	43	89.0	84.8	116.0	121.1	...	...	...
Average weight in grams								
Females	2.7	7.7	9.6	30.2	35.3	76.5	445.5	443.3
Males	2.2	11.3	9.7	21.7	25.0	...	...	...

In the next table these figures are altered to read in more commonly used terms, viz. total length in inches and weight in ounces. The total lengths of the entire population were not considered in arriving at the total length figures; a number of specimens of average standard length were checked for total length and the figures given were arrived at on this basis, consequently the figures for total length represent a close approximation rather than the exact figures. The weight figures are exact.

Table 14

Growth rate of perch in South Twin Lake
based on 3615 specimens, recorded in approximate
total length in inches and weight in ounces

Year Class	0	I	II	III	IV	V	VI?	VII or VIII?
Average length (inches)								
Females	2.1	3.8	4.14	5.91	6.30	7.88	12.49	13.83
Males	2.0	4.2 ¹	4.02	5.48	5.71	...	...	...
Average weight (ounces)								
Females	.09	.27	.34	1.07	1.25	2.70	15.73	15.65
Males	.08	.40	.37	.77	.89	...	...	...

¹ A number of the one year old males grew unusually fast, considerably raising the average. A majority of this age group were comparable with the females of the same group in length and weight.

It will be noted that the females grew much more rapidly than did the males (after the first year), however both sexes grew quite slowly. The III group (4 summers old) of females were, on the average, below legal size while the IV group (5 summers old) averaged above legal size. The females older than five summers were of good size but were very few in number.

A few of the males reached legal size but the oldest (5 summers old) did not average 6 inches in length. The males were, with a few exceptions, of no benefit whatsoever, from an angling viewpoint. The question naturally rises "What becomes of the older fish?" Since this lake was fished little or none it is obvious that the bigger fish were not caught out.

A study of the perch suggests that:

1. A majority of the fish (almost all of them) die of starvation.
2. A majority of the females and nearly all of the males die (of starvation) before they reach legal size.
3. The two chief food items appear to be insect larvae (which are small) and perch.
4. Most of the fish do not grow rapidly enough to make the change in food from insect larvae to the dominant perch population (slightly over four inches long), they apparently are too large to subsist on the small insect larvae but not large enough to eat the four-inch perch, consequently food on which they might subsist is virtually absent.
5. The fish which had reached sufficient size to eat the 4-inch perch grew very well and were in excellent condition, those which were unable to make the change were in very poor condition.
6. Many of the fish which were of legal length were hardly edible, they were literally "skin and bones".
7. The heads were unusually large; Jordan's Manual lists head in body as $3 \frac{1}{4}$ while these fish had an average "head in body" of less than 3. In the fish of poor condition the scales were partially resorbed and the sex organs were quite small, probably also partially resorbed.

8. The O and I groups may have been very poorly represented because of predation on the part of the older fish.
9. There is probably a definite cycle in these populations; it is possible that most fish of the dominant group (II⁴) would have died of starvation the next winter and that a large production of young (another dominant group) would have resulted in 1935. This group would have been able to survive since larger predatory perch would have been few. It is believed that a dominant group dies of starvation, at about 3 or 4 years of age and that another dominant group may then appear (enough survive to produce the next crop). The dominant group is never of legal size. This belief cannot be verified in the case of South Twin Lake. A reply from William Horsell, Forest Superintendent, (January 2, 1935) to an inquiry regarding perch fishing in this lake tends to lend support to this belief:

"In regard to your letter of December 18th, 1934 about fishing in South Twin Lake:

"South Twin Lake has been fished very little in the last 11 years and the fish taken out of it have been small, 6 inches or under."

Section 4 Lake. This lake was poisoned by Hazzard and Eschmeyer in September, 1935, and about 20 gallons of perch were removed. Perch were still dying two days after poisoning, and it is probable that more fish floated to the surface later. Whether or not all fish were killed was not determined. These fish have not yet been examined, but growth rate determinations were made on a relatively small number, sufficient to indicate that the perch grew considerably more rapidly than those in South Twin Lake, the growth, however, was by no means phenomenal. It is anticipated that this population will be studied in detail and that they will be reported on at a later date. Large perch (over 8 or 9 inches) were very few. However, since the smaller fish died first and since fish were still dying when the dead fish were removed from the surface, it is possible that large fish were present and that they had not yet died. It is doubtful, however, that a reasonably large number of fish over 9 inches long were present.

Ford Lake. About 1000 perch were netted from this lake in the summer of 1934. The entire lot has not yet been examined but a study of the scales of a few of these fish indicates that the rate of growth was not fast. Fish over 8 inches long were not taken (with few exceptions) although the nets used contained a variety of meshes. It is anticipated that this lot of perch will be reported on at a later date.

There is sufficient evidence to indicate that the perch in the five lakes mentioned above grew slowly. There is reason to believe that conditions similar to those found in South Twin Lake also prevailed in the other lakes, though in some lakes in a less extreme degree. The fact that the perch in these lakes had previously attracted very few fishermen indicates that, from a fishing standpoint, they were of little value.

One point which has not been previously mentioned is the fact that the perch in several of these lakes were heavily parasitized either with the small black "specks" (Strigeid larvae), or with cysts in the flesh (Clinostomum marginatum). Trout which were recovered in these lakes showed neither form of parasitism. The perch in both South Twin Lake and Ford Lake showed heavy infection of these parasites, those taken from North Twin Lake showed little or none.

Management of Populations

It was obvious that some kind of environmental change was necessary if those lakes containing perch or only minnows were to be an asset to fishermen. It was also desirable that trout be established, if possible, to relieve some of the fishing on the Pigeon. The first step in managing the four pot holes containing only minnows was an easy one; the mere planting of trout has, thus far, been sufficient to obtain excellent production from these lakes.

The lakes containing perch presented more of a problem, obviously some change needed to be made. There appeared to be several alternatives:

1. Stocking with trout. Since the perch were stunted and since it appeared that lack of food was responsible for the stunting, it was questionable whether stocking with trout would be very successful. However, stocking with trout would help indicate

whether the trout could survive in these lakes, whether they could compete with the perch and whether they would be susceptible to the parasitism which was so pronounced in the perch in several lakes.

Brook trout were planted. Subsequent study indicates that the trout can live in these lakes, that they appear not to be parasitized as are the perch but that the trout cannot grow at a satisfactory rate in the lakes with a dense perch population. It also appears that a relatively large proportion do not survive.

2. Stocking with predatory species. It might be possible to hold the perch population in check by stocking with bass or pike.

However, the pothole lakes are quite small and should the predators be successful in materially reducing the perch population, they in turn would probably develop into a stunted population, providing conditions similar to those which previously prevailed except that another species would be present. Increasing the bass supply in Pickerel Lake has been recommended, introduction of bass or pike in the small potholes was not considered advisable except that stocking with a number of bass of one sex (to prevent reproduction) might have been beneficial.

3. Fertilizing. Fertilizing to increase the food supply might provide rapid growth. However, the perch, being quite prolific, would probably increase sufficiently to again "upset" the balance and the result would be, as previously, stunted perch, the difference being one of concentration of perch. The change in North Twin (Production of fair sized trout and perch in the summer of 1935) may be attributed to the rather heavy fertilizing of this lake with phosphate in the summer of 1934. Since no other environmental changes were made (except the removal of a few fish by netting) other than the fertilizing it appears that the fertilizing was probably responsible for the change. Excessive fertilizing might eventually render such lakes unfit for trout. It will be interesting to check the growth rate and the catch of fish from this lake for the next several years.

4. Stocking with minnows. If it be assumed that South Twin Lake contained 1000 fish per acre (a conservative estimate), the lake contained about 4300 fish. If each ate one minnow per day, the fish would have consumed 1,569,500 minnows annually. It would be difficult to get the minnows established because of the unfavorable balance between fish and food and the stocking of minnows in sufficient quantities to maintain the perch (on minnows) would hardly be feasible.

5. Removal of a considerable portion of the population. This rather important step in the management of certain types of lakes is not yet fully appreciated. The removal of fish of desirable species to increase the supply of (sizeable) fish of that species appears, at first thought, contradictory. Since the perch in these lakes are apparently feeding on or near the bottom in deeper water they are seldom seen. Without making a thorough study of the lakes, the suggestion for improving the perch fishing in these lakes would be the usual one, "stock with more perch", all of which would tend only if carried out, to make conditions worse.

Partial removal might be effected by netting but such removal would be both costly and of temporary help. Partial removal might also be effected by encouraging fishing for perch provided the fishermen be also encouraged to kill all fish caught regardless of size. There is a legal size limit on perch. Catching of legal-sized fish would tend to reduce the few predators present, and therefore be detrimental while removal of "undersized" fish would be beneficial. This should indicate that size limits applying to a species over a large area, while they are probably beneficial in some waters, are injurious in others.

6. Removal of all perch. On two of the lakes removal of all perch and subsequent stocking with other species appeared best since the perch were heavily parasitized in the two lakes and any efforts to improve conditions would probably not rid the perch of the parasitism. Of the two lakes in which the perch were heavily parasitized (Ford and South Twin) one (South Twin) was poisoned. Not all of the perch were removed. From a point of view of management it is probably unfortunate that the killing was not entirely successful; for experimentation it is fortunate that a few fish remained.

It will be possible to check changes in growth rate and to determine the amount of time needed for these fish to multiply to a point where the balance between fish and food will again be upset. Section 4 Lake was also poisoned. Whether or not all fish were killed must be determined later.

In brief, management of the perch in these lakes (either completed or contemplated) includes:

1. North Twin, fertilizing.
2. South Twin, poisoning (with subsequent stocking).
3. Section 4, poisoning (with subsequent stocking).
4. Pickerel, encouragement of bass by stocking, shelter improvement and improvement of spawning conditions, fertilizing.
5. Ford, stocking with large fish (poisoning now considered advisable).

In two of the lakes stocking with bass is considered desirable. The two lakes, Pickerel and Grass are entirely different from each other in type, Grass is shallow and weedy while Pickerel is fairly deep and contains very little vegetation. Grass Lake appears well suited for Large-mouthed Bass. Food is present in relative abundance and spawning conditions appear to be favorable. An increase in depth would probably be desirable, otherwise no environmental changes seem to be necessary. The lake now contains no bass. Pickerel Lake is suited for Small-mouthed Bass and contains a limited number of them at present. Spawning and shelter conditions have been improved. Stocking is considered desirable.

Grass Lake appears suitable for bluegills. This is the only lake of the group considered here where stocking with bluegills is considered desirable.

It is possible that the stocking of a lake with both trout and bass is not desirable. However, these two species are probably segregated in summer, the bass in the warmer layer and the trout in the lower colder strata. In winter, when the two species are not segregated the bass are more or less inactive. It may well be that the two species will do well in the same lake; at any rate, it is believed that both should be encouraged as an experiment in Pickerel Lake. Creel census should help indicate, in time, whether or not it is wise to encourage both species in this lake.

Trout probably need to be planted annually in the lakes in this area since conditions are not suitable for natural reproduction, the warm water species should eventually be maintained without stocking unless fishing is unusually heavy.

The proper number of trout to be planted annually cannot at present be determined. Had growth rate studies of a number of trout from each lake been made annually, it would have been possible, in time, to indicate whether the number to be stocked should be an increase or a decrease over the previous year. It is anticipated that the growth of the fish will be checked and that definite information regarding the desirable intensity of the "plant" will eventually be available.

Environmental Improvement

A. Completed. North Twin Lake was fertilized by the writer in 1934. Plankton samples were taken in this lake (also in South Twin, as a check) several times weekly, before and after the fertilizing. It is certain that the plankton increased with fertilizing but the extent of increase is not yet known. It is anticipated that this experiment will be reported on in detail later.

Erosion on West Lost Lake, caused by water running from a fire line was checked in 1934 by placing brush in the gully and by willow planting.

Brush shelters and bass spawning beds were placed in Pickerel Lake by Camp Pigeon-River (C.C.C.). The number of each was not ascertained.

Rafts and a few boats were made available, chiefly by men from Camp Pigeon River, for fishing on several of the pot-hole lakes.

A dam to raise the water in Grass Lake was partially completed (by Camp Pigeon River).

B. Contemplated. Recently the area including most of these lakes has been placed under the supervision (so far as E.C.W. work is concerned) of the National Parks Division. A new C.C.C. camp, Camp Vanderbilt, has been installed near Pickerel Lake. The camp superintendent, Mr. J. B. Schwerdt, requested, from the "Institute" suggestions for the further improvement of these lakes. Possible improvements were discussed by Mr. Schwerdt and the writer. It is anticipated that the area will be developed as

an attraction for tourists, consequently, that fishing in the future will be much more intensive than it is at present. With this probability in mind, the writer made a number of improvement suggestions, most of which are contained in a letter addressed to Mr. Schwerdt (September 25, 1935):

"In accordance with your suggestion relative to the improvement and management of the several Pigeon River Forest lakes, I am submitting recommendations which, if carried out, should materially improve the fishing conditions on these lakes. We have investigated these lakes rather thoroughly, have made some environmental changes, and recognize the need for further improvement and management. We are very much interested in these lakes and welcome the opportunity to cooperate rather closely with you in their further development.

"You will note that we have stressed the development of trout fishing in these lakes. Trout have been emphasized because of the feeling that the development of these lakes as trout lakes would attract some of the fishermen from the Pigeon which, in some sections at least, has been very heavily fished.

"Creel census returns for Lost, West Lost and Hemlock lakes are not yet available but present tabulations indicate that Lost Lake produced in excess of 80 brook trout per acre (av. length 8.8 inches). This number may approach 100 fish per acre when all returns for the season are available. This production is almost unbelievably high and indicates that these lakes respond well to management.

"In the recommendations which follow we indicate the work which appears desirable; whether or not all of it is feasible remains for you to decide. We strongly recommend that you include Lost Lake and Hemlock Lake in your program even though both lie just a few feet outside the area in which you are especially interested. Specific recommendations follow:

1. Hardwood Lake. This is an acid, bog lake, and is not well suited for fish life. We are informed that several attempts have been made to establish bluegills. It appears that these were unsuccessful. We suggest that, from a fisheries standpoint, this lake be ignored.

2. Two-acre Pond. This little pond is quite shallow and apparently is unsuited for fish life. It is suggested that this pond also be ignored.

3. Devil's Soup Bowl. Bluegills were recommended for this lake but trout were planted several years ago, and apparently the planting was successful. The lake should be stocked again with brook trout. It is considered desirable that steps be installed here to prevent erosion and that a raft be built (or the raft now present be enlarged), to accommodate the fishermen. Creel census recommended.

4. Grass Lake. This is a shallow lake and is not suited for trout. It is recommended that this lake be stocked with Largemouthed Bass and bluegills. It is now rich in food and vegetation and contains some gravel for spawning. No environmental improvement appears necessary. From our point of view an increase in depth would be desirable. If the installation of a dam is feasible and if other interests do not object, it appears desirable that a dam be installed provided the lake level can be raised several feet or more. Creel census

recommended when and if adult fish are present. One man could take the census on this and the above mentioned lake. Several boats might well be provided for the public and a path should be made to the lake which would permit access without contact with the poison ivy which is rather abundant on the side where the lake is usually approached.

5. Section 4 Lake. This lake was poisoned a few days ago to remove the perch which were small and were parasitized. It should now be stocked with legal-sized fish (see copy of letter enclosed). Some erosion has been caused by the beaver which were abundant in this lake. This erosion was not injurious and since it washed some gravel into the lake it may have been slightly beneficial. It appears, however, that fishermen will, in time, cause harmful erosion. It is recommended that a series of steps be made to the water and that the steep slopes be planted with vegetation which will prevent erosion in areas where erosion may be expected. Several boats might well be provided for fishing.

Creel census should be taken on this lake and should be taken carefully and completely. The fish planted should be carefully counted. It appears that in late summer the trout do not "bite" well in these lakes. This may be due to some inherent characteristic of the trout or to depletion, probably to the latter. A careful counting of the fish planted and a subsequent census will indicate the actual reason for the decline and will indicate also what management is desirable.

6. Pickerel Lake. This clear marl lake is one of the finest in the forest, also one in most need of improvement. Since the lake will probably be fished heavily after the public camp ground has been provided the lake should have considerable attention. It has now been provided with gravel for bass spawning and with brush shelters. The food problem is perhaps the most serious one. It is recommended that

a. The lake be subjected to a creel census during the entire fishing season.

b. The lake be fertilized with super-phosphate. This can be conveniently distributed by floating several (3 or 4) burlap bags filled with the phosphate so that the bags are in the water just below the surface. The fertilizer dissolves rather slowly and the bags should be refilled every few weeks. Two tons might well be added although one ton would probably help considerably if the cost of several tons were considered prohibitive.

c. The lake be raised a foot by placing a dam in the outlet. This would flood some of the adjacent flats, would tend to warm the water slightly and to increase the food.

d. The lake be stocked with Smallmouthed Bass and with brook trout. It appears, in this case, that both might do well in the same lake, even though as a rule, it is not considered advisable to stock a lake with both warm-water and cold-water fish.

e. The perch situation be carefully checked. An increase in game fish, coupled with more intensive fishing and with food increase may render it unnecessary to reduce the number of small perch which in the past has been excessive. If it can be conveniently done, some of the perch might well be seined out.

f. "Rich" soil be placed on portions of the shoal.

g. Added bass spawning beds and brush shelters be provided if more bass are planted and if there appears to be a need for more spawning grounds and for more shelter.

h. Aquatic vegetation be encouraged by transplanting from some other lake. Kind of vegetation and suitable locations for planting can best be discussed at some subsequent personal interview.

i. Boats for fishing be provided.

j. Minnows be planted (under close supervision).

7. Ford Lake. Ford Lake contains an abundance of stunted perch and a few trout. The trout were planted but have apparently not been able to compete successfully with the large perch population. If I recall correctly the perch were parasitized. About 1000 perch were netted out last year. This is a fair-sized lake and at present is not an asset (from a fishing standpoint). It appears that the perch in this lake might best be poisoned and that trout be planted later. Because of the size of the lake, the poison needed would cost about \$150. It appears that this amount of money would be well spent. We do not recommend the use of this poison by persons not familiar with its use, but would be glad to cooperate should funds be available for purchasing the poison. It is recommended that the poisoning of this lake be carefully considered and that the present population be examined before proceeding, when and if funds for poisoning are made available.

Should the lake be poisoned, it should be planted with legal-sized trout and subjected to creel census. (See comments on creel census for Section 4 Lake).

8. North Twin Lake. This lake was fertilized last year and some of the perch were removed by netting. This year, for the first time, to our knowledge it has been producing both perch and trout of fair size. Creel census, steps to the lake to prevent erosion and the provision of several boats is recommended. More trout should be planted. A little more fertilizing (500 lbs. of super-phosphate) is recommended.

9. South Twin Lake. This lake was poisoned last year and minnows were recently planted. It should be stocked with legal-sized trout and subjected to a careful census (see comments on census for Section 4 Lake). One man could take care of the census on the two Twin lakes. Steps might well be provided and several boats or rafts might well be made available to the fishermen. Plantings of suitable vegetation should be made on both Twin lakes to prevent erosion.

10. Mud Lake. This lake was not examined by the Institute. Apparently it is still on private property, although the taxes are reported to be delinquent. It is recommended that this lake be given no consideration unless or until the adjoining land, or a considerable portion of it, becomes state property.

11. Lost Lake. Lost Lake is now producing trout quite satisfactorily. It is recommended that steps be provided, that several boats or rafts be made available, that present erosion be checked and future erosion be prevented. Creel census recommended.

12. West Lost Lake. Same as for Lost Lake. One man could take census on both lakes.

13. Hemlock Lake. Same as for Lost Lake. This lake, and the two mentioned above are now excellent trout lakes. It is necessary, of course, that these be stocked regularly since little or no natural reproduction is anticipated.

Pigeon River. The writer has been interested primarily in lakes and does not feel competent to make recommendations for improvement of the river. He fully realizes, however, the benefits which might be obtained from a creel census on portions of the river and strongly recommends the taking of such a census.

Creel census. Creel census is of great value in fisheries management and stocking programs. It requires virtually no equipment or material and calls for relatively few man days. If possible creel census should be taken on all the lakes where fishing is sufficiently intensive to justify it. Blanks can be obtained from the Fish Division, Department of Conservation. As in the past, the Institute would like to receive the data and tabulate them. The results would of course be made available to the parties interested in them.

Surveys. If time permits and if suitable equipment is available, it is recommended that the lakes be resurveyed, i.e. the area of water be accurately determined. This could be done in a very few days. The lakes were surveyed with a telescopic alidade, many of them were surveyed while the writer was not present, and it is felt that some of the areas may be slightly incorrect. Since these lakes are of especial interest and are being used considerably for experimental work, a careful resurvey of the areas is considered desirable. A planimeter can be made available for determining the areas after the lakes have been surveyed.

Other improvements. Construction of shelters, wells, small camp sites, etc. on some of the lakes would appear to be desirable. However, such work is more or less outside our field of interest and no recommendations are made regarding them.

Previous work. It is hoped that a report on all previous work of an experimental, investigative or improvement nature will be made available (by us) in a few months. Such report would indicate what has been done on these lakes to date. It appears desirable that the record of all work on this interesting set of lakes be kept complete.

Cooperation. As has been previously indicated, the Institute for Fisheries Research is especially interested in this group of lakes and you may be assured that the Institute will be glad to cooperate with you in every way possible in any work you may undertake on these lakes."

Mr. Schwerdt (also Mr. Howard, wildlife inspector, from the regional office) has exhibited a definite interest in these lakes, also has indicated a desire to have the Institute cooperate with him in their further development. It appears probable that, within the next few years a considerable number of environmental adjustments will be made, also that a complete creel census will be maintained to help indicate effects of those adjustments and to help in determining a future management policy.

General Discussion

It might easily be felt that these lakes have been given, and are being given, more attention than their size and importance justifies. However, it is believed that much can be learned regarding the relative value of present management methods by subjecting a group of lakes to such management; also, much that is learned from study and experimentation on these lakes will be applicable or of value in work on

other lakes. It is believed, therefore, that these lakes should continue to receive considerable attention. It is also believed that, to provide the greatest benefit from this work, a record should be kept of all activities which are of interest in the management of these lakes. It is hoped that the Institute will be informed of any stocking, environmental adjustments, or other changes which are made, that the Institute may keep on record a complete account of these changes for its own use and for the use of other interested agencies.

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