A QUESTIONNAIRE SURVEY OF FISH POND PRACTICES IN OREGON

by

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INTRODUCTION

A survey by questionnaire of fish pond owners in Oregon was conducted in 1959 to gather information on the management practices and management problems associated with fish ponds. It is a part of Oregon State University Agricultural Experiment Station Project 294: Limnology and Management of Oregon Farm Fish Ponds and Small Impoundments. This is a report of the survey.

Fish ponds have become popular in Oregon. Many governmental agencies, federal and state, have received requests for management information. The bulk of the requests undoubtedly have fallen on the U. S. Soil Conservation Service, the Federal Cooperative Extension Service, the Oregon State Game Commission, and the Fish and Game Management Department at Oregon State University.

Popularity of the fish ponds may be attributed chiefly to two reasons. First, they are a source of recreation; and second, they are a source of protein food. In Oregon, as in the rest of the United States, recreation is the primary stimulus for building fish ponds. The production of food is secondary (15, p. 233). Other benefits of fish ponds include irrigation, stock watering, and swimming.

Most of the effort in the United States to produce food fish in ponds has centered at Auburn University in Alabama. Experiments have demonstrated yields as high as 1,163 pounds of bigmouth buffalo (Ictiobus cyprinellus) per acre per year (21, p. 15). Ponds with Java tilapia (Tilapia mossambica) have yielded a maximum of 4,383.9 pounds of fish per acre in a 191-day experiment (20, p. 145). The high production of both species was made possible by heavy feeding.

In conjunction with the production of rice, farmers along the lower Mississippi River have found it economically feasible to fallow their lands by producing fish on them for two years before planting again to rice. Yields as high as 1,000 pounds of fish per acre for the 2-year period have been obtained. Principal fish grown is the bigmouth buffalo (7, p. 157-159).

Fish ponds are an important source of protein food for humans in many foreign countries. In Europe the food production is important, while in the populous countries of Asia the production of food in ponds is vital.

In Yugoslavia the annual production of carp ponds was 3,200 tons (6, p. 158). The area of carp-producing ponds was increasing. Production as high as 1,068-1,513 pounds per acre per year had been obtained. Significant quantities of fish also are produced in ponds in other European countries.

Fish ponds have been most intensively managed for food in Asia. The annual fish production in 1951 was (in tons): China, 421,300; Indonesia, 33,000; India, 59,400; Philippines, 27,500; Japan, 2,904; Malaya, 880; and Palestine, 1,320 (12, p. 132). Fish ponds are an important source of food in these heavily populated countries.

At present fish ponds are used mainly for recreation in Oregon. Most known commercial ponds are "catch out" ponds where the owners sell the recreation of catching the fish. Some of the commercial pond owners sell fry and fingerlings for the stocking of other ponds. A few sell trout to local restaurants. There are no known ponds where the fish are raised primarily for the table. In view of the soaring population of the state (and nation), the fish pond may play an important role in the production of food in future years.

As competition for recreational fishing increases in public waters in Oregon, more persons are turning to private ponds. Existing ponds which were constructed originally for irrigation, stock watering, etc., may be more fully utilized by producing fish at the same time. Thus, the pond owner's return on his investment is increased.

Whether ponds are used for recreation or for the production of food, increased productivity of fish is the ultimate goal. State and federal agencies concerned with the management of fish in farm ponds give freely of the available knowledge. Pamphlets expressly concerned with fish pond management in Oregon are available from the Oregon State Game Commission (13), and the Federal Cooperative Extension Service (9) (10). Another pamphlet concerned with the management of trout ponds in the United States, which would apply generally to trout ponds in Oregon, is available from the SCS in the U. S. Department of Agriculture (2). Other states publish information on the management of fish ponds, the principles of which may or may not apply to Oregon.

Much more information is needed, however, to manage fish ponds efficiently. Most of the research in Oregon is being done by the Agricultural Experiment Station at Oregon State University.

In order to discover the management problems which are most pressing, and to gain knowledge of the successful management practices, a field survey of a number of fish ponds was made in 1956 and 1957 (Unpublished data of Kendle and Klavano, Fish and Game Management Department, School of Agriculture, Oregon State University). The questionnaire survey was initiated in order to gain information about a greater number of ponds with the least expense.

METHODS

In November 1958, a pilot or trial questionnaire was made and sent to a few pond owners to see if the desired answers would be forthcoming. Also, copies were sent to a number of Extension Agents asking for their criticisms. Response from the pond owners was encouraging. Minor changes were necessary to make some questions more explicit. Comments of the Extension Agents were most helpful in clarifying the questions. A final form was then drafted (Figure 1).

The mailing list of fish pond owners was compiled from many sources. The Fish and Game Management Department at Oregon State University, Extension Service, Soil Conservation Service, State Game Commission, and the State Engineer all contributed to the mailing list.

The pond owners were listed alphabetically for each county. Every pond owner on the list received a questionnaire with the exception of those in Josephine County. Because of the large number (118), every other name on the Josephine County list was selected. It was assumed that the management problems and practices for the county could be obtained from half the number and would save time and expense. Those pond owners which had received the pilot questionnaires were not mailed the questionnaire in the final form.

Owner's name ______________________ Address ______________________

Town ______________________ State ______________________

How many ponds have you? ______ Please answer questionnaire regarding oldest pond.

Location of pond ______ miles ______________ of ______________
(direction) (town)

______ year of construction

______ greatest depth: ☐ estimated ☐ measured

______ surface acreage: ☐ estimated ☐ measured

Is pond used for irrigation? ☐ Yes ☐ No; for stock watering ☐ Yes ☐ No
Other uses of pond ______________________

Does pond contain fish? ☐ Yes ☐ No ☐ Do not know

If pond contains fish, please check those known to be present:

☐ Rainbow trout
☐ Largemouth bass
☐ Bluegill
☐ Brown bullhead (catfish)
☐ Yellow bullhead (catfish)
☐ Catfish (sp. unknown)
☐ White crappie
☐ Black crappie
☐ Crappie (sp. unknown)
☐ Cutthroat trout
☐ Eastern brook trout
☐ Pumpkinseed sunfish
☐ Silver salmon
☐ Yellow perch
☐ Goldfish
☐ Suckers
☐ Squawfish
☐ Warmouth bass

Other fish ______________________

______ year fish first stocked ______ year last stocked

Check management problems encountered:

☐ Summer or fall die-off
☐ Winter or spring die-off
☐ Rooted aquatic weeds
☐ Scum algae
☐ Shoreline plants
☐ Fish hard to catch
☐ Fish do not grow
☐ Too many small bluegills
☐ Too many small bullhead catfish

Other problems encountered ______________________

____

____

Has pond been fertilized? ☐ Yes ☐ No. type of fertilizer ☐ Organic ☐ Inorganic

Has pond weed control been attempted? ☐ Yes ☐ No

What method of control was used? ______________________

Was success ☐ good; ☐ partial, or ☐ poor

Does pond have drain ☐ Yes; ☐ No. Has pond been drained Yes ☐ No ☐ Partially ☐

Is pond fished ☐ Often ☐ Seldom ☐ Not at all

Is fishing success ☐ good ☐ fair ☐ poor

Comments (on number of fish caught, condition, size, etc.) ______________________

____

____

FIGURE 1. THE QUESTIONNAIRE USED IN THE SURVEY.

In February 1959, 688 questionnaires with a letter of explanation and a stamped, return-addressed envelope were mailed. Twenty-six questionnaires were returned because of insufficient address, leaving 662 which were delivered. Response was good, but by June 1959, a follow-up letter was necessary to encourage those who had not responded. A copy of the questionnaire was enclosed, but not an envelope. The follow-up letter brought in more questionnaires, and by September 1959, 432 (65 per cent) of those receiving questionnaires had responded.

Non-response was not measured. Those not returning the questionnaires were assumed to employ the same practices and to have the same problems as those returning the completed questionnaire.

Twenty-two of the respondents said they did not have a pond. They gave as reasons; "washed out," "sold," etc. Four hundred one of the completed questionnaires were usable. They were edited and the information entered on IBM cards to facilitate analysis.

In an earlier study at Oregon State University, questionnaires which were sent to the individual states in the United States revealed that the success of warm-water species in ponds was associated with climate (17, p. 59-65). The success of warm-water species depended upon summer water temperature (which in turn depended upon summer air temperatures). To measure any differences which might occur among the geographical sections of the state which have slightly different climates, the state was divided into six areas with generally similar climate and physiography. The division boundaries follow county lines. Figure 2 depicts the areas of the state. The number of questionnaires mailed and the number of respondents for each area are given in Table 1.

Frequency tables were obtained from the answers to the questions. Also, comparisons were made between the answers to certain questions. Statistical methods were used to test the significance of the comparisons (11, p. 390-446).

Table 1

The Number of Questionnaires and Respondents for the Areas

Area	Number of questionnaires mailed	Number of respondents
I	336	225
II	90	60
III	33	19
IV	160	102
V	23	15
VI	20	11

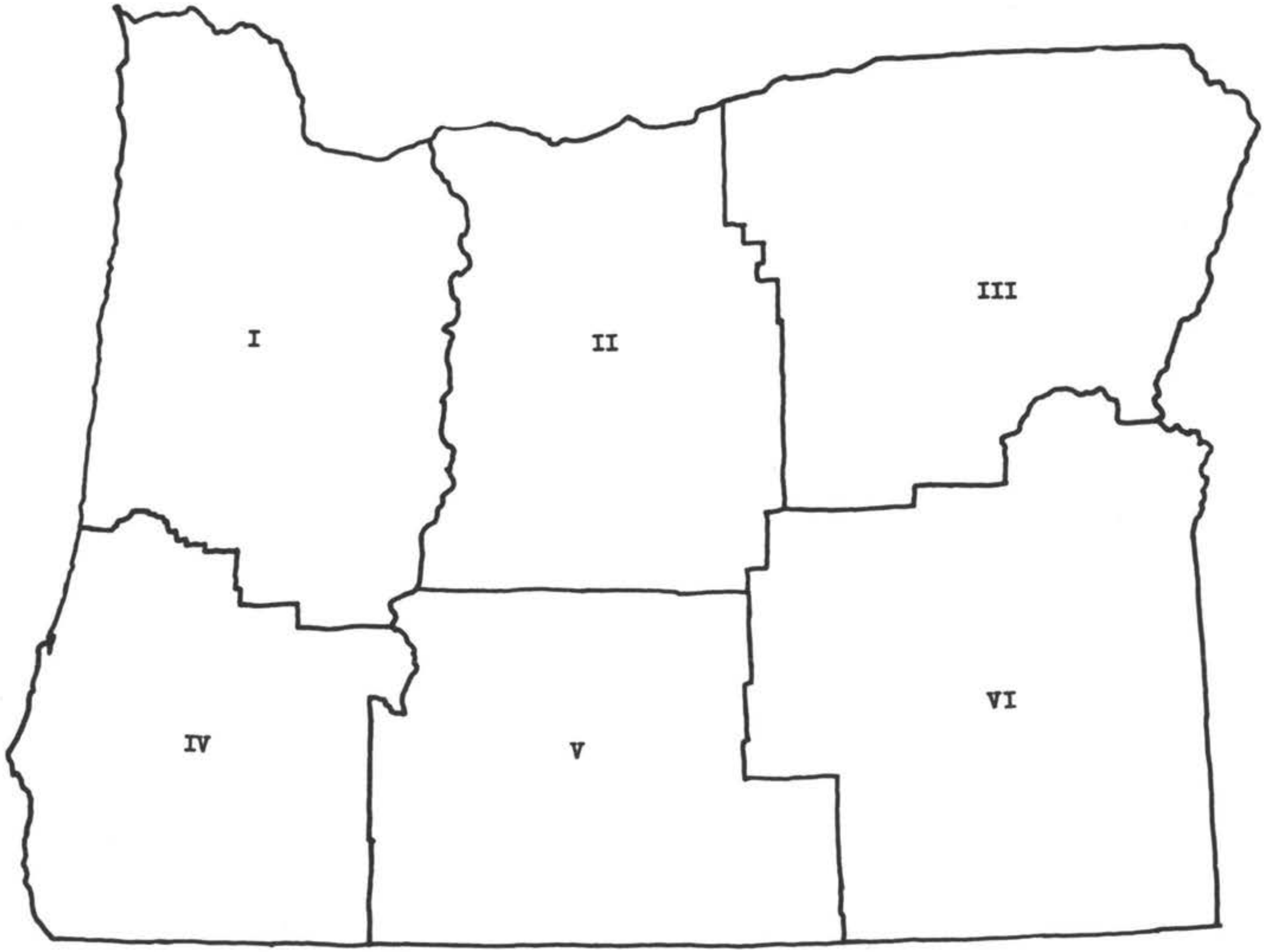

FIGURE 2. OUTLINE DRAWING OF OREGON SHOWING AREAS.

RESPONSE TO QUESTIONS

The response to the questions on the questionnaire is reported in the following text.

General

Of the 382 respondents to the question, "How many ponds have you?" 69 per cent had one pond, 16 per cent had two, and 8 per cent had three. The remaining 7 per cent had four ponds or more. One per cent said they had more than 10 ponds.

Only 21 per cent of 354 respondents said their ponds had been constructed prior to 1950. The large percentage being constructed in the last ten years attests to the recent rise in popularity.

More than 78 per cent of 384 respondents reported the greatest depth of their ponds was less than 15 feet. Nine per cent said they had less than 5 feet maximal depth.

Most of the ponds are small. Fifty-four per cent of the 362 respondents said their ponds were less than 1 acre in surface area. Only 13 per cent said their ponds were 5 acres or more in size. Three ponds were reported to be 100 acres or more in area. The largest, 1,000 acres, was near Burns in Harney County.

Uses of Ponds

Fish ponds are put to uses other than rearing fish. More than half of the respondents reported using their fish ponds for irrigation and/or stock watering.

Uses of the ponds, in addition to producing fish, are listed in Table 2.

Table 2

Additional uses of Fish Ponds in Oregon

Use	Frequency
Irrigation	189
Stock watering	171
Swimming	31
Recreation	16
Waterfowl	7
Boating	6
Water skiing	4
Aesthetic value	4
Fire protection	3
Ornamental landscaping	2
Log pond	2
Duck hunting	2
Settling basin	2
Erosion control	1
Picnic area	1
Domestic	1

Species Present

Of the 401 pond owners, 76 per cent said their ponds presently contained fish. Table 3 shows the species present and their frequency of occurrence. Rainbow trout was the most prevalent species, followed by largemouth bass, bluegill, catfish (all species), and cutthroat trout. Bullfrogs (Rana) headed the list of other species with a frequency of seven. Also listed once or twice in "Other species" were channel catfish (Ictalurus punctatus), smallmouth bass (Micropterus dolomieui), brown trout (Salmo trutta), stickleback (Gasterosteus aculeatus), sturgeon (Acipenser), tui chub (Siphateles bicolor), and carp (Cyprinus carpio). A single mention was made of trout, "minnows," "chub," "hybrid trout," Kamloops, and "trash fish."

Table 3

Species of Fish Reported in Oregon Ponds

Species	Frequency
Rainbow trout (Salmo gairdneri)	187
Largemouth bass (Micropterus salmoides)	88
Bluegill (Lepomis macrochirus)	84
Cutthroat trout (Salmo clarki)	35
Catfish (species unknown) (Ictalurus)	34
Yellow bullhead (catfish) (Ictalurus natalis)	18
Brown bullhead (catfish) (Ictalurus nebulosus)	10
Crappie (species unknown) (Pomoxis)	11
Black crappie (Pomoxis nigromaculatus)	6
White crappie (Pomoxis annularis)	5
Yellow perch (Perca flavescens)	9
Eastern brook trout (Salvelinus fontinalis)	8
Coho (silver) salmon (Oncorhynchus kisutch)	7
Goldfish (Carassius auratus)	6
Suckers (Catostomus)	5
Pumpkinseed sunfish (Lepomis gibbosus)	3
Warmouth bass (Chaenobryttus gulosus)	3
Squawfish (Ptychocheilus)	2
Other species	27

Sixty per cent of 281 respondents reported first stocking their ponds in 1955 or later. Of 192 respondents, 85 per cent reported stocking their ponds for the last time in 1955 or later.

Management Problems

Scum algae (probably *Aphanizomenon flos-aquae* or *Oedogonium*) was the most frequently reported management problem. Rooted aquatics (*Elodea*, *Potamogeton*, etc.) was second. Table 4 presents the frequency with which pond owners indicated the management problems.

Poachers headed the list of "Other problems" in frequency, with fifteen reports. Neighboring children were blamed especially for the unlicensed harvest of fish. Additional predators named were kingfishers (*Megaceryle alcyon*) and herons (*Ardea herodias*), with frequencies of twelve and nine, respectively. Other animals indicated one to four times as problems--probably because of competition--were roughskin newt (*Taricha granulosa*), frogs, goldfish, and lampreys (*Lampetra*). Crayfish and muskrats (*Ondatra zibethica*) were blamed for making holes in the earthen dams by nine pond owners. Diseases and/or parasites were indicated as problems by only seven owners. Pollution from silt was named by six pond owners as a problem. Ten owners reported their ponds would not hold water.

Table 4

Management Problems Reported for Oregon Fish Ponds

Management Problems	Frequency
Scum algae	111
Rooted aquatic weeds	87
Fish hard to catch	58
Shoreline plants	40
Summer or fall die-off	32
Too many small bluegills	24
Fish do not grow	21
Winter or spring die-off	18
Too many small bullhead catfish	16
Other problems encountered	84

Management Attempts

Fifty-two per cent of those ponds having a drain had been at least partially drained. The use of the drain in the fish pond may be indicative of management attempts by the owner.

Of 356 respondents to the question, "Has pond been fertilized" 53 replied, "Yes"; 44 of them indicated the type of fertilizer used. Thirteen added organic and 31 inorganic fertilizer.

Fifty-four of the respondents said they had attempted weed control. More than half (30) reported partial or poor success. Three pond owners indicated that geese controlled their weed problem.

Fishing Intensity and Success

Thirty-one per cent of 324 respondents reported their ponds were fished often. Forty-four per cent said their ponds were fished seldom, and 25 per cent said their ponds were fished not at all.

Fishing success was reported good by 43 per cent, fair by 34 per cent, and poor by 23 per cent of the 250 respondents to the question.

ANALYSIS OF ANSWERS TO QUESTIONS

In order to learn more about the management practices and problems of pond owners, the answers to some questions were compared with the answers to others. For example, the species present in a pond might have some effect on the fishing success. To test this hypothesis the species composition and fishing success was compared by area.

Species Composition and Fishing Success

A series of tests was made to determine the best species group, in terms of fishing success, for Oregon fish ponds. Because of the diverse fish populations present, the ponds were divided into three broad groups; trout (cold-water species) only, warm-water species only, and trout and warm-water species combined. The fact that a pond contained non-game species (suckers, goldfish, etc.) in addition to the species groups being examined, was ignored. The ponds in this category were few in number and would not materially bias the result.

Trout proved to be the better species group in terms of fishing success in Area I. The hypothesis that there was no difference between species groups was rejected by a chi-square test of independence (Appendix Table 1). A similar test showed trout to be the species group providing the better fishing success (Appendix Table 2).

In Area II, the hypothesis that there was no difference in fishing success between ponds with trout only and those ponds containing warm-water species was accepted (Appendix Table 3). In Area IV, a chi-square test of independence showed no difference in fishing success by species groups (Appendix Table 4). There were not enough respondents to test the effect of species composition on fishing success for each of the other areas. The hypothetical frequencies were not great enough to make a valid chi-square test of independence (11, p. 438). Therefore, Areas III, V, and VI were combined and put to the chi-square test of independence (Appendix Table 5). There was no indication that species composition influenced fishing success.

In a slightly different approach to determine the best species for ponds, the species group present in ponds of owners marking the management problem "Fish hard to catch" was compared with the species group present in ponds of those leaving it blank. When examining each area individually, only in Area I were there enough respondents for a valid test. The results of the chi-square test of independence showed there was no difference among species groups when related to "Fish hard to catch" (Appendix Table 6).

The hypothesis that there was no association between species groups and "Fish hard to catch" was tested for the combined areas by a chi-square test of independence (Appendix Table 7). The hypothesis was accepted, indicating no difference among species groups.

Management Problems and Pond Characteristics

For Area I, a chi-square test of independence was made to determine whether the management problem "Summer or fall die-off" was associated with greatest pond depth (Appendix Table 8). The hypothesis that there was no association was accepted.

There was an insufficient number of respondents from each of the other areas to test an association of the management problem "Summer or fall die-off" to greatest pond depth. Therefore a chi-square test of independence was made for all areas combined (Appendix Table 9). The null hypothesis was accepted, indicating no association.

For the areas combined, a chi-square test of independence was made to determine whether the management problem "Winter or spring die-off" was associated with greatest pond depth (Appendix Table 10). The null hypothesis was rejected. Ponds having a greatest depth of 10 feet or less had a significantly higher incidence of winter or spring die-off than did ponds having the greatest depth more than 10 feet.

A chi-square test of independence was made, for the areas combined, to discover whether the use of fertilizer was a factor in summer or fall die-off (Appendix Table 11). The hypothesis that the use of fertilizer had no influence was accepted.

A similar test for the areas combined to see whether the use of fertilizer was associated with winter or spring die-off could not be made because one of the hypothetical frequencies was less than 5 (11, p. 412).

For the areas combined, the management problem "Rooted aquatic weeds" was compared to greatest pond depth to see if there was a relationship (Appendix Table 12). The hypothesis was accepted, indicating no association.

The size of the ponds was compared to the management problem "Scum algae" for the areas combined (Appendix Table 13). The hypothesis that there was no association was rejected. The ponds of less than 1 acre in area had a higher incidence of scum algae than did ponds 1 acre or greater in area.

The hypothesis was made that the owners of smaller ponds, because of the higher shoreline-to-area ratio, might have a higher incidence of checking the management problem "Shoreline plants" (Table 14, Appendix). For the areas combined, a chi-square test of independence showed no relationship between pond size and the frequency with which the management problem "Shoreline plants" was checked.

Management Practices and their Success

A chi-square test of independence was made to determine whether the addition of fertilizer improved fishing success (Appendix Table 15). The hypothesis was accepted that there was no difference in fishing success between ponds which received fertilizer and those which did not (areas combined). There were not enough respondents to determine whether fishing success was influenced by type of fertilizer, organic or inorganic. A comparison of weed control methods--physical removal and chemical treatment--and weed control success was made for the areas combined (Appendix Table 16). The hypothesis that there was no difference in the effectiveness of the methods was accepted.

Eighty-one respondents said their ponds were fished "Not at all". Of the number, 30 ponds did not contain fish. In the 51 that contained fish, 28 had been stocked for the first time in 1957 or later and had not been tested. Three contained non-game species--goldfish, stickleback, and "trash fish." The remaining 20 did not fish their ponds for unexplained reasons.

DISCUSSION AND CONCLUSIONS

Number of Fish Ponds

From the number of ponds per owner and the number of names on the mailing list, a rough estimate of the number of fish ponds in Oregon may be made. The mean number of ponds per owner (1.67) times the number of names on the mailing list (762) equals 1,270 fish ponds. The estimate is believed to be minimal because it is known that all fish pond owners were not included in the mailing list.

Mr. Andrew Landforce, Wildlife Management Specialist for the Extension Service, Oregon State University, in personal communications, stated that the estimated number of privately owned impoundments in Oregon is approximately 13,000. This figure would include stock-watering ponds, backyard pools, reservoirs, log ponds, and farm fish ponds and others. A separate estimate of the number of fish ponds was not available.

Most of the estimated 13,000 ponds are used strictly for irrigation and/or stock watering and for various uses other than fish production. Many of these are potential fish ponds as well. Often, ponds will produce fish without interfering with the primary use, thus increasing the owner's return on his investment.

Eighty per cent of the ponds surveyed had been constructed since 1950. The reasons for the recent increase are many. The economic prosperity which has prevailed since World War II probably has had more influence than any other factor. People have had more time and money for recreation. And what better way to relax than at one's own fish pond?

The Federal Government has encouraged pond construction by sharing in the cost of ponds to conserve agricultural water or to provide water necessary for the conservation of soil resources. The Soil Conservation Service helps by providing technical assistance in the form of engineering, soil studies, etc. The Agricultural Conservation Program then shares the construction cost up to 50 per cent of the total, but not exceeding $1,500 for a single project for an individual. Under a manager-type pooling agreement, ACP will pay up to 50 per cent, but not exceeding $10,000, for a project (24, p. 10). Exact specifications for projects and the rate of cost sharing may be obtained from the ACP county committee for the county in which the pond is to be located.

Species Present

The numerous species of fish reported in the ponds is somewhat surprising in view of the fact that only three species--largemouth bass, bluegill, and rainbow trout--are recommended by the agencies concerned with fish pond management in Oregon. The other species may not have been placed in the ponds, but may have gained entrance because of improper screening or because of flooding.

Fishing Intensity

Generally speaking, the fish ponds are not fished enough. Only 31 per cent reported fishing the ponds intensively. The low fishing intensity indicates that the pond owners are not efficiently harvesting the crops of fish. It has been demonstrated that trout should be fished upon heavily as soon as they are large enough to eat (3, p. 18-20) (2, p. 6-7).

The reason for the intensive angling as soon as the fish have reached an acceptable size is this:

> "The total poundage of fish present in a pond at any given time is the net result of two opposing forces: (1) the death rate, which reduces total poundage, and (2) growth, which increases the poundage. In a population of fish all the same age, the total weight of the population increases when the poundage being added by growth exceeds the poundage being lost by reduction in numbers. When the effect of death rate over-balances that of growth, a net decrease in total poundage results." (3, 12-13)

In a theoretical case of two ponds of equal size and each stocked with trout fingerlings in the fall, Pond No. 1 was fished the first and second summer, while Pond No. 2

was not fished until the second summer (when the fish were larger). While there were more large trout taken from Pond No. 2, the total yield from Pond No. 1 was 205 trout weighing 75 pounds; and the total yield from Pond No. 2 was 70 trout weighing 50 pounds (3, p. 18-20).

In the foregoing argument, the discussion has been concerned with trout. However, similar principles are involved in the management of warm-water fishes. In order to obtain the maximum yield of bass, bluegill, or other warm-water species, the populations must be heavily cropped by angling or other means as soon as the fish reach an acceptable size; say, 5 inches for bluegill and 8 inches for bass.

Species Groups and Fishing Success

In the analysis of the data, two methods were used to determine which species group, trout or warm-water species, was superior in terms of fishing success. The first method was a "Fishing success" X "Species group" comparison. The second method was a "Fish hard to catch" X "Species group" comparison. For the state as a whole, the two approaches of determining the best species group are in agreement. But for Area I, the results of the two methods are at odds.

For Area I, the "Species group" X "Fishing success" comparison indicated that trout were superior, while the

"Species group" X "Fish hard to catch" method showed no difference. The "Species group" X "Fishing success" is believed to be the more realistic measure because it involves positive answers on the part of the respondents. That is, only those which indicated fishing success as good, fair or poor were considered.

In the "Fish hard to catch" X "Species group" comparison, the negative or blanks were judged as not having the problem. The latter method is believed to be less sensitive as a measure of the better species group. For example, the "Fish hard to catch" X "Species group" test would not measure the undesirability of a stunted population. A pond owner, although able to catch fish readily, may have judged the fishing success as poor because of the stunted fish.

Only in Area I were trout found to be a better species group than warm-water fishes in terms of fishing success. The reason for the apparently better success of warm-water species in regions other than Area I may be the slightly warmer water in summer caused by warmer air temperature. The mean summer air temperature of the Willamette Valley where the bulk of the fish ponds in Area I were found was 64.4° F. In Area IV (Southern Oregon), the mean summer air temperature was 67.8° F. In Area II (Central Oregon) the mean summer air temperature was 68.3° F. (17, p. 80-81).

The available food supply appears to be more critical than climate for growth of largemouth bass, bluegill, and rainbow trout in Oregon fish ponds (8, p. 25). For a given food supply, however, it is logical to assume that climate would influence the growth of trout (cold-water fishes) and warm-water fishes. An analysis of the growth rates of largemouth bass and bluegill from different areas of the state support the hypothesis. The growth rate of largemouth bass and bluegill in Area I (Northwestern Oregon) was less than that in Area II (Central Oregon) and in Areas IV and V (Southern Oregon) (8, p. 15). Cooler summer temperatures in Area I probably accounted in part for the decreased growth rate.

The growth rate of rainbow trout was found to be faster in Area I (Western Oregon) than in Area II (Central Oregon) (8, p. 17). Again, this may be a result of cooler summer temperatures in Area I.

Another factor which may have led to the poorer fishing success for warm-water species in Area I may be the time of bluegill spawning (5, p. 11). In Area I (Willamette Valley), bluegill usually spawn in June. In Area II (Central Oregon) at least, and possibly in the other areas, bluegill do not spawn until late summer. The delay in time of spawning is caused by the cool nights which cool the water in the shallows where spawning occurs. The time of bass spawning is about the same for all sections of the state (June). In Area I, the bluegill hatch before the young bass are large enough to prey on them, but in Area II the young bass are large enough by late summer to feed on the newly-hatched bluegill. The heavy cropping of the young bluegill would tend to prevent over-population of the ponds, which may be reflected in better fishing success.

Management Problems

The reason for the greater incidence of winter or spring die-off in the shallower ponds may have been caused by ice-cover. The decomposition of the greater number of aquatic plants usually present in shallow ponds would have a high biochemical oxygen demand, leaving little or none for fish respiration. Deeper ponds having fewer aquatic plants would be less likely to be devoid of oxygen.

There was a higher incidence of the management problem "Scum algae" on smaller ponds than on larger ponds. The cause may have been the absence of wind action on the surface of the small ponds. The larger the pond, the greater the opportunity for wind to sweep algae from the surface.

The roughskin newt was named as a problem by some pond owners--and probably for good reason. There is evidence that they compete with fish for the available food organisms in ponds. The standing crop of newts in three ponds in the Willamette Valley was found to be 244.9, 78.3, and 76.1 pounds per acre, respectively. An examination of the stomach contents of several newts indicated that they were feeding primarily on aquatic insect larvae and were, therefore, competing with pond fishes for food (4, p. 19). Newts are rarely utilized as food by pond fishes (or other animals) because of poisonous glands in the skin (16, p. 133).

Crayfish were mentioned as a problem--being blamed for burrowing in the earthen dams. Probably, this conclusion is in error. The crayfish found in Oregon (Pacifasticus) belongs to the non-burrowing subfamily, Astacinae. The burrowing form, subfamily Cambarinae, is found east of the Rocky Mountains. However, two members of Cambarinae, Procambarus clarki and Orconectes virilis, have been introduced into California and have become established (18, p. 29). No Cambarinae have been found in Oregon.

In all probability the holes in the dams were made by some other animal such as moles (Scapanus; Neurotrichus gibbsi), gophers (Thomomys) or muskrats. Crayfish may have occupied some of the holes as a refuge, thus confusing the observer.

Crayfish are considered an asset in fish ponds by many persons. They are readily taken for food by trout and bass. In streams, they enter the food chain by converting terrestrial leaf material, aquatic plants, and aquatic insects into crayfish flesh.[1] The food habits of crayfish in ponds are probably similar to those in streams.

Crayfish, too, may contribute as the end product to the pond owner. They are considered a delicacy boiled, either with or without spices.

The Use of Fertilizer

The addition of fertilizer to ponds was not reflected in better fishing success. This does not mean that fertilizer will not improve angling in some ponds, only that no relationship existed among the respondents to the questionnaire. The reason(s) that no relationship was evident may have been: (1) insufficient fertilizer was added, (2) the nutrients limiting production may have been absent also from the fertilizer, and/or (3) the addition of fertilizer may have caused a heavy plankton bloom which decreased visibility and discouraged fishing.

There is no doubt that the correct addition of nutrients will increase the productivity of ponds. Experiments in Alabama have demonstrated increased productivity and fishing success by adding fertilizer (23, p. 20) (22, p. 247-248).

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[1] Mason, John C., Graduate student, Department of Fish and Game Management, Oregon State University, Corvallis. Personal interview. (April 1962).

A questionnaire survey of the fish and game agencies of the then 48 states of the U. S. revealed that fertilization was recommended by half (17, p. 24). These were mostly Southern, Eastern and Mid-western states, and the species involved were largemouth bass and bluegill.

Other researchers have found the fertilization of fish ponds to be unwarranted. A study in Michigan showed the yield of three fertilized ponds to be slightly greater than the yield of three unfertilized ponds, but the increased production was not worth the cost (1, p. 18). The addition of fertilizer did not result in a plankton bloom where higher aquatic plants were present.

In New York, the use of fertilizer for fish ponds is questioned. The results are unpredictable. Although the addition of fertilizer appears to improve the growth of trout, it also may cause "summer kill" by depletion of dissolved oxygen (19, p. 281).

At Oregon State University, experiments have demonstrated that the addition of nitrogen and phosphorus to newly-constructed ponds resulted in increased productivity of plankton organisms 25 to 50 times that of the unfertilized control pond, as indicated by photosynthetic rates (14, p. 45). A complementary study of the same ponds showed the production of bluegills to be increased 4 to 12 times by the addition of the fertilizer (4, p. 48).

The regular application of commercial fertilizer to the OSU experimental ponds near Soap Creek has effectively controlled the growth of rooted aquatic weeds for the past four summer seasons by causing plankton blooms which decrease the amount of light.

To summarize, the benefits of the judicious application of fertilizer are twofold. First, production of fish is increased. Second, rooted aquatic weeds can be controlled. The disadvantages of adding fertilizer to fish ponds are several. First, unless the fish population in the pond is heavily cropped, the addition of fertilizer is not warranted. Second, unless fertilizer is added early in the spring and continued throughout the summer at a rate to maintain a plankton bloom, the nutrients may stimulate a lush growth of filamentous algae or rooted aquatic weeds which would choke the pond. Third, the decomposition of large numbers of plankton organisms may deplete the dissolved oxygen to the point where fish are killed. The latter point is especially important for trout ponds because trout are not as tolerant of depressed dissolved oxygen as warm-water fishes.

Because of the difficulties that may arise and because the increased production usually is not harvested, the addition of nutrients to fish ponds in Oregon is not recommended (9, p. 6) (10, p. 6) (13, p. 4).

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APPENDIX

APPENDIX TABLE 1

Species Composition and Fishing Success of Fish Ponds of Respondents from Area I

Species Group	Fishing Success			
	Good	Fair	Poor	Total
Trout only	40	25	7	72
Trout and warm-water species	9	8	9	26
Warm-water species only	7	12	12	31
Totals	56	45	28	129

Hypothesis: There was no difference in fishing success by species group.

X^2 = 17.15 with 4 degrees of freedom. The value is significant at the 5 per cent level, indicating that fishing success was not equal among the species groups.

APPENDIX TABLE 2

Species Composition and Fishing Success of Fish Ponds of Area I Respondents

Species Group	Fishing Success		
	Good or Fair	Poor	Total
Trout only	65	7	72
Trout and/or warm-water species	36	21	57
Total	101	28	129

Hypothesis: There was no difference in fishing success between ponds with trout only and ponds with warm-water species.

X^2 = 13.77 with 1 degree of freedom. The value is significant at the 5 per cent level, indicating that fishing success was better in ponds with trout only.

APPENDIX TABLE 3

Species Composition and Fishing Success for Fish Ponds of Respondents in Area II

Species Group	Fishing Success		
	Good	Fair or poor	Total
Trout only	4	8	12
Trout and/or warm-water species	8	7	15
Totals	12	15	27

Hypothesis: There was no difference in fishing success between ponds with trout only and ponds with warm-water species.

$X^2 = 1.08$ with 1 degree of freedom. The value is not significant at the 5 per cent level, indicating no difference in fishing success.

APPENDIX TABLE 4

Species Composition and Fishing Success of Fish Ponds of Area IV Respondents

Species Group	Fishing Success		
	Good or fair	Poor	Total
Trout only	30	5	35
Warm-water species present	18	7	25
Totals	48	12	60

Hypothesis: There was no difference in fishing success between ponds with trout only and ponds containing warm-water species.

X^2 = 1.71 with 1 degree of freedom. The value is not significant at the 5 per cent level, indicating no difference in fishing success.

APPENDIX TABLE 5

Fishing Success and Species Composition of Fish Ponds of Respondents of Areas III, V and VI

Species Group	Fishing Success		
	Good	Fair or Poor	Total
Trout only	11	5	16
Warm-water species present	4	7	11
Totals	15	12	27

Hypothesis: There was no difference in fishing success between ponds with trout only and ponds containing warm-water species.

X^2 = 2.77 with 1 degree of freedom. The value is not significant at the 5 per cent level, indicating no difference in fishing success.

APPENDIX TABLE 6

Species Composition and the Management Problem "Fish hard to catch" for Fish Ponds of Area I Respondents

Species Group	Fish hard to catch		
	Yes	Blank	Total
Trout only	8	91	99
Trout and warm-water species	6	25	31
Warm-water species only	8	32	40
Totals	22	148	170

Hypothesis: There was no difference among species groups in the frequency of reporting the management problem, "Fish hard to catch."

X^2 = 4.98 with 2 degrees of freedom; the value is not significant at the 5 per cent level, indicating no difference among species groups.

APPENDIX TABLE 7

Species Composition and the Management Problem "Fish hard to catch" for Fish Ponds of Respondents (areas combined)

Species Group	Fish hard to catch		
	Yes	Blank	Total
Trout only	23	144	167
Trout and warm-water species	9	35	44
Warm-water species only	21	72	93
Totals	53	251	304

Hypothesis: There was no difference among species groups in the frequency with which pond owners checked the management problem, "Fish hard to catch."

X^2 = 3.59 with 2 degrees of freedom. The value is <u>not significant</u> at the 5 per cent level, indicating <u>no difference among</u> species groups.

APPENDIX TABLE 8

Greatest Depth of Pond and the Management Problem "Summer or fall die-off" for Fish Ponds of Area I Respondents

Greatest Pond Depth	Summer or fall die-off		
	Yes	Blank	Total
10 feet or less	7	93	100
Greater than 10 feet	9	60	69
Total	16	153	169

Hypothesis: The management problem, "Summer or fall die-off" was not associated with greatest pond depth.

X^2 = 1.74 with 1 degree of freedom. The value is not significant at the 5 per cent level, indicating no association.

APPENDIX TABLE 9

Greatest Pond Depth and the Management Problem "Summer or fall die-off" for Fish Ponds of Respondents (areas combined)

Greatest Pond Depth	Summer or fall die-off		
	Yes	Blank	Total
10 feet or less	14	171	185
Greater than 10 feet	14	104	118
Totals	28	275	303

Hypothesis: The management problem, "Summer or fall die-off", was not associated with greatest pond depth.

X^2 = 1.59 with 1 degree of freedom. The value is not significant at the 5 per cent level, indicating no association.

APPENDIX TABLE 10

Greatest Pond Depth and the Management Problem "Winter or spring die-off" of Fish Ponds of Respondents (areas combined)

Greatest Pond Depth	Winter or spring die-off		
	Yes	Blank	Total
10 feet or less	13	171	184
Greater than 10 feet	2	117	119
Totals	15	288	303

Hypothesis: The management problem, "Winter or spring die-off", was not associated with greatest pond depth.

$X^2 = 4.45$ with 1 degree of freedom. The value is significant at the 5 per cent level, indicating that winter or spring die-off was most prevalent in ponds where the greatest depth was 10 feet or less.

APPENDIX TABLE 11

The Management Problem "Summer or fall die-off" and the Use of Fertilizer in Fish Ponds of Respondents (areas combined)

Used fertilizer?	Summer or fall die-off		
	Yes	Blank	Total
Yes	6	47	53
No	23	227	250
Totals	29	274	303

Hypothesis: The management problem, "Summer or fall die-off", was not associated with the use of fertilizer.

X^2 = 0.23 with 1 degree of freedom. The value is <u>not significant</u> at the 5 per cent level, indicating no association.

APPENDIX TABLE 12

The Management Problem "Rooted aquatic weeds" and Greatest Pond Depth for Fish Ponds of Respondents (areas combined)

Greatest Pond Depth	Rooted aquatic weeds		
	Yes	Blank	Total
10 feet or less	49	196	245
Greater than 10 feet	30	109	139
Totals	79	305	384

Hypothesis: The management problem, "Rooted aquatic weeds", was not associated with greatest pond depth.

$X^2 = 0.14$ with 1 degree of freedom. The value is not significant at the 5 per cent level, indicating no association.

APPENDIX TABLE 13

The Management Problem "Scum algae" and the Size of Ponds of Respondents (areas combined)

Surface Area	Scum algae		
	Yes	Blank	Total
Less than 1 acre	59	135	194
1 acre or more	32	136	168
Totals	91	271	362

Hypothesis: The management problem, "Scum algae", was not associated with surface area.

X^2 = 6.18 with 1 degree of freedom. The value is <u>significant</u> at the 5 per cent level, indicating that <u>ponds with a surface area of less than 1 acre had a higher incidence of scum algae than did the larger ponds.</u>

APPENDIX TABLE 14

The Management Problem "Shoreline plants" and the Size of Ponds of Respondents (areas combined)

Surface Area	Shoreline plants		
	Yes	Blank	Total
Less than 1 acre	21	171	192
1 acre or more	20	150	170
Totals	41	321	362

Hypothesis: The management problem, "Shoreline plants", and surface area were not associated.

$X^2 = 0.06$ with 1 degree of freedom. The value is not significant at the 5 per cent level, indicating no association.

APPENDIX TABLE 15

Fishing Success and the Use of Fertilizer in Fish Ponds of Respondents (areas combined)

Used fertilizer?	Fishing success			
	Good	Fair	Poor	Total
Yes	14	15	14	43
Blank	78	60	34	172
Totals	92	75	48	215

Hypothesis: Fishing success and the use of fertilizer were not associated.

X^2 = 3.84 with 2 degrees of freedom. The value is <u>not significant</u> at the 5 per cent level, indicating no association.

APPENDIX TABLE 16

Weed Control Success and Weed Control Method Used in Fish Ponds of Respondents (areas combined)

Weed Control Method	Weed control Success		
	Good	Partial or Poor	Total
Physical	9	17	26
Chemical	12	12	24
Totals	21	29	50

Hypothesis: Weed control success was not associated with weed control method.

X^2 = 0.12 with 1 degree of freedom. The value is not significant at the 5 per cent level, indicating no association.