United States Department of Agriculture

Soil Conservation Service

517 Gold Ave., SW
Room 3301
Albuquerque, NM 87102

May 22, 1989

BIOLOGY TECHNICAL NOTE NO. NM-40
190

SUBJECT: ECS - BIOLOGY - RIPARIAN PLANTING

Purpose. To distribute current information about state of the art understanding of reestablishing native riparian plants in New Mexico.

Effective Date. When received.

Filing Instructions. File in Biology Technical Note binder.

Bob McQueen

Bob G. McQueen
State Resource Conservationist

Enclosure

DIST:
AC - 1
DC - 1

PROGRESS IN THE UNDERSTANDING OF HOW TO REESTABLISH NATIVE RIPARIAN PLANTS IN NEW MEXICO[1]

Edwin A. Swenson[2]

INTRODUCTION

Most non-montane floodplains of New Mexico, both major and minor, no longer support viable native riparian plant communities. Vegetation has been destroyed by combinations of channelization, agricultural drainage, overgrazing, irrigation diversions, impoundments, and efforts to effect water salvage by the control of phreatophytes.

There has been a very large invasion by the introduced saltcedar into floodplains, washes and arroyos. Where native trees remain, they are largely older stands, and little natural reproduction is taking place because of dry soils, low precipitation, grazing pressure and drastic change in the timing, frequency and duration of out-of-bank flooding.

Efforts to reestablish native trees, shrubs, grasses and forbs, utilizing conventional techniques such as planting seedling trees and shrubs and seeding grasses have largely been unsuccessful. Plant establishment has been hampered by lowered groundwater levels, hot and dry surface soils, lack of flooding, precipitation in the 6 to 11 inch range, and competition with saltcedar.

This paper reports on the development of a dormant pole planting technique and cites the results of several operational projects. In addition, species evaluation and superior accession selections are described.

Studies are ongoing to develop methods to establish shrubs, grasses and forbs; including the use of water harvesting techniques. Finally, the objectives of a five-year interagency research program are described.

---

[1]Paper presented at the symposium: Restoration, Creation, and Management of Wetlands and Riparian Ecosystem in the American West, Denver, Colorado, November 14-16, 1988
[2]Edwin A. Swenson is the State Biologist, USDA, Soil Conservation Service, Albuquerque, New Mexico

POLE PLANTING

A previously described study (Swenson and Mullins, 1985) showed the feasibility of using large pole cuttings of Rio Grande cottonwood and black willow to restore depleted riparian stands. Poles of 2 to 3 inch basal diameter, and a height of up to 20 feet were used. Poles were cut from native stands while dormant; and again when dormancy first broke. We also studied the relationships between depth of pole butt placement and constant or fluctuating ground water levels. Depths to water of 7 to 12 feet were included in the studies.

Dormant poles set at constant water levels of 7, 8, 8 and 12 feet, had survival rates of 60, 90, 100 and 77 percent, respectively. Survival was reduced when poles were set two feet and four feet above the water table. Poles cut after breaking dormancy also had lower survival (table 1).

Poles in plots with naturally fluctuating water levels had lower survival rates (table 2) than those with constant water levels. Again, poles set above the growing season water table had lower survival; as did poles cut after breaking dormancy.

In the years following these studies, pole plantings have been made by private landowners and land managing agencies, with varied results. The El Paso District of the Bureau of Reclamation has planted 4650 poles at 13 different sites along the lower Rio Grande. Water tables varied from seasonally flooded to a constant 12 foot depth. Salinity of the soils or ground waters varied from 700 to over 4000 ppm. Survival ranged from 0 to 100 percent one year after planting, and 0 to 80 percent after four years.

The most successful plantings were on a farm field within one half mile of the Rio Grande which had a growing season water table at two to four feet, salinity of 900 ppm and pH averaging 7.6. Despite heavy competition from annual weeds, survival was 83 percent after one year and 82 percent after two.

Observations from the 13 sites indicated that reduced growth and vigor resulted from high salinity, prolonged inundation, browsing, weed competition and defoliation by grasshoppers.

The Bosque del Apache National Wildlife Refuge sustained a spring wildfire which burned 1372 acres of monotypic saltcedar and 445 acres of cottonwood, black willow and screwbean mesquite floodplain forest. These lands had historically flooded and once supported extensive native riparian communities. A fire rehabilitation plan was funded to attempt restoration of a native plant community.

Table 1.—Survival of Cuttings at Constant Groundwater Levels

Type of Cutting	Method of Controlling or Monitoring Water Table	Planting Date	Date of Measurement	Survival by Depth (ft.) of Cutting Placement: Water Table 7.3 ft.			Water Table 8.3 ft.			Water Table 11 ft.
				[1]7 ft.	5 ft.	3 ft.	[1]8 ft.	6 ft.	4 ft.	[1]11.5 ft.
				Percent						
Dormant	Lysimeter[2]	12/80	9/81	70	80	0	100	80	60	--[3]
			9/82	60	50	0	100	50	40	--
			9/83	60	50	0	90	50	30	--
Dormant	Lysimeter	12/81	9/82	--	--	--	100	40	30	--
			9/83	--	--	--	100	40	30	--
Dormant	Well[4]	1/83	9/83	--	--	--	--	--	--	77
Greenwood	Lysimeter	3/82	9/81	100	70	0	100	50	60	--
			9/82	40	50	0	100	20	20	--
			9/83	40	50	0	100	20	10	--
Greenwood	Lysimeter	3/82	9/82	--	--	--	90	50	0	--
			9/83	--	--	--	90	50	0	--

[1]Depth of planted cuttings.
[2]Ten cuttings placed within each lysimeter; water table artificially controlled at 7.3 ft. or 8.3 ft.
[3]Dashes mean no cuttings placed at the given depth.
[4]Water table level monitored by observation well; 20 cuttings placed in each area monitored by a well. Depth to constant water table averaged 11 ft.

Table 2.—Survival of Cuttings at Fluctuating Groundwater Levels

Type of Cutting	Plot Number[1]	Planting Date	Date of Measurement	Survival by Depth (ft.) of Cutting Placement: Water Table 7.5 ft. - 9.2 ft.			Water Table 7.0 ft. - 9.4 ft.		
				[2]7 ft.	5 ft.	3 ft.	[2]8 ft.	6 ft.	4 ft.
				Percent					
Dormant	2	12/80	9/81	84	24	0	--[3]	--	--
			9/82	65	20	0	--	--	--
			9/83	28	15	0	--	--	--
Dormant	3	12/81	9/82	--	--	--	80	60	35
			9/83	--	--	--	73	50	30
Greenwood	2	3/81	9/81	56	24	0	--	--	--
			9/82	55	20	0	--	--	--
			9/83	30	10	0	--	--	--
Greenwood	3	3/82	9/82	--	--	--	60	55	5
			9/83	--	--	--	60	40	5

[1]Plot 2 had five replications, five poles per treatment (dormant and greenwood), and a fluctuating water table at depths of 7.5 ft. to 9.2 ft. Plot 3 had three replictions, ten poles per treatment, and a fluctuating water table at depths of 7.0 ft. to 9.4 ft.
[2]Depth of planted cuttings.
[3]Dashes mean no poles were placed at the given depth.

The plan calls for control of saltcedar basal sprouting with herbicide followed by pole planting with Rio Grande cottonwood, black willow and hybrid poplar. After trees are established a shrub understory will be planted. In 1987 there were 2350 poles planted at sites considered representative of the burned area in an effort to determine site-specific limitations. Determinations of survival and growth were made; and a sample of poles were excavated to examine soil, groundwater and rooting characteristics. The overall first year survival of 38 percent is considered not acceptable.

Analysis of the plantings has shown that three site problems led to the poor survival. These are: 1) sites which flooded; 2) sites where the ground water dropped more than two feet during the first growing season; and 3) sites where salinities went above 3000 ppm.

We have attempted to use poles cut from Rio Grande sites in plantings made in the lower Pecos River valley. To date these have been failures, which is attributed to the much higher salinities of the soils and water in the Pecos drainage; which can exceed 6000 ppm.

Conversely, moving to higher elevations, with more constant water tables, and higher precipitation has been very successful. First year survival of over 90 percent is common.

A distillation of what has been learned, over the past five years, about site selection and establishment procedures has led to the current set of recommendations for cottonwood and black willow presented as Table 3.

TABLE 3

GUIDELINES FOR SUCCESSFUL POLE PLANTINGS

1. Determine seasonal salinities of the soil and ground water. Do not use cottonwood when salinities exceed 3000 ppm. Avoid pole planting at sites where salinities exceed 6000 ppm.

2. Select sites with sand, gravel or small cobble soils above and in the water table. Avoid sites with continuous clay or silt soils; or where lenses of clay or silt are thicker than one foot.

3. Prior to planting, measure monthly water table fluctuations for one year or preferably longer.

4. Cut poles from stands of open grown, young, rapidly growing trees, using only wood which is four years old or less. Remove side branches, leaving only the tip and next two lower side branches.

5. Cut poles when completely dormant.

6. Soak the poles in water from the day of cutting for 10 to 14 days.

7. Auger holes to the depth of the lowest anticipated growing season water table. Cottonwood will have reduced root formation when the water table is less than 2 feet from the ground surface. Consider using black willow at high water table sites.

8. Place the poles in the augered holes the same day they are removed from the soak. Set the butt at the lowest anticipated growing season groundwater depth. Select poles of a length which provides 4 to 6 feet above the soil surface.

9. Back fill the holes carefully to avoid air pockets. The use of dry surface soil is recommended.

10. Place tree guards around poles if rodent or rabbit damage is anticipated.

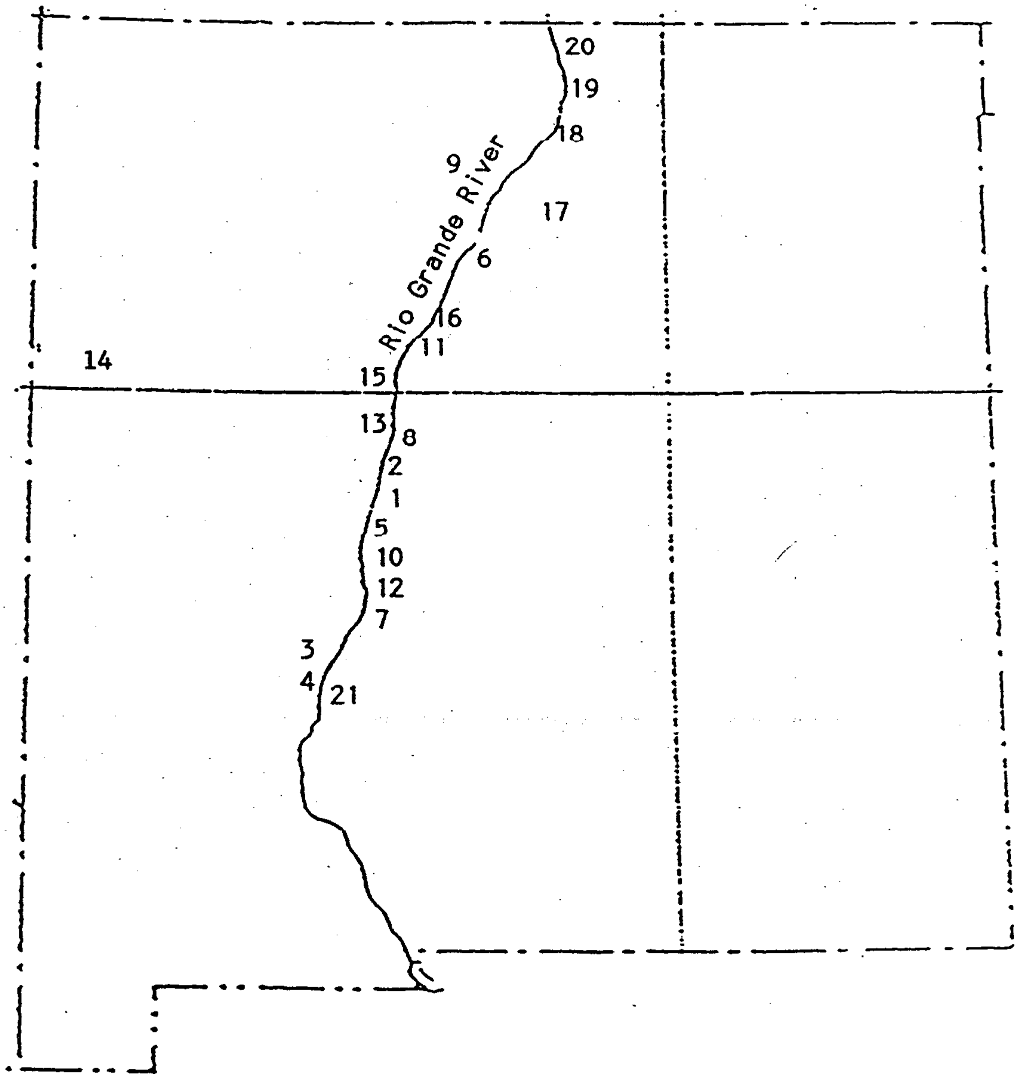
11. As buds begin to swell along the pole, usually in April or May, wipe them off the lower two-thirds of the pole.

12. Plantings must be excluded from livestock grazing for two and possibly three growing seasons. Beaver must be controlled for the full lifespan of the tree.

As we have become more comfortable with our understanding of site related limitations we began to realize the need for more uniformity within the stocks of native stands being cut for poles. It also became apparent that insufficient acreage of young, rapidly growing trees are being naturally produced along the Rio Grande to meet the demand for poles.

Starting in 1984, we began a program to evaluate native stock from the middle and upper Rio Grande in an effort to select trees with superior characteristics. Collections of six excellent specimens of cottonwood and black willow were made at each of 39 locations (figure 1). At our Los Lunas Plant Materials Center, these selections have been propagated and evaluated. Rating criteria are: 1) rooting vigor; 2) growth rate; 3) crown spread; and 4) leaf density.

FIGURE 1: Map Showing The Locations Of 21 Collection Sites Of Rio Grande Cottonwood And Black Willow in New Mexico.[1]



[1]Due to the close proximity of some sites and the scale of the Map only 21 sites were delineated.

Evaluations made at the P.M.C. and four off-center locations have resulted in our selection of four Rio Grande cottonwood and three black willow for further evaluation and increase. We are now growing these selections as sources of poles, with the first harvest to be available next winter to commercial growers.

We have also been evaluating one hybrid cottonwood and several commercially available hybrid poplars. These selections have better rooting qualities, grow faster and are more tolerant of high salinities than the Rio Grande cottonwood.

This past year we made selections of several native tree species growing in the Pecos Valley at locations of high salinity. We will propagate these selections and take rooted cuttings back to the Pecos to attempt establishment and performance evaluations.

Off-center testing of superior native accessions and hybrid strains will be expanded through 1990. Testing will be an integral part of the use of these poles in project activities of cooperating land management agencies. We desire more information about the tolerances of these selections to site specific factors; such as salinity, pH, soil temperature and moisture, and dissolved oxygen in the ground water.

UNDERSTORY PLANTS

While poles can be placed with butts in the deep moist soil of a capillary fringe, or even into a water table, the establishment of shrubs, grasses and forbs into dry riparian soils requires different techniques.

We have been experimenting with a number of species and several establishment techniques in sites such as riverside terraces, dry washes, abandoned crop fields and arroyos. These sites have very dry soils in the rooting zone, although short duration flooding or intense summer thunderstorms will temporarily wet the soils, if and when these events occur. There will usually be adequate soil moisture at a depth of three or more feet to sustain plants if they can become established.

We find that seeding of grasses, forbs or shrubs have been failures in the long term. Proper timing of the seeding with rainfall will usually bring about germination. However, the new seedlings are extremely vulnerable to drying out, drowning out, or being covered by deposited sediments.

The best results have been obtained by using rhizomes or growing individual plants in containers and putting them in the ground in late winter. Each year we decide that deeper containers are needed; 10 inch is good, but we hope to be using 18 inch soon. The critical time is June, when soil temperatures are high and soil moisture drops because there often is no rainfall. When plants survive past June, they will usually make excellent growth on the normal summer thunderstorms. In arroyo situations, it is not uncommon for summer flows to leave plantings covered with sediments of up to 6 or 8 inches in depth. Without a well established root system, these plants will die.

We are past the small, hand installed plot stage. The use of container stock and tree planting machines has mechanized operations to where 4 to 600 plants can be planted in an hour. The use of rhizomes has been very successful, as they can be planted behind a farm tractor or cat with single or double rippers. We are able to get container stock set to depths of around 12-14 inches, and rhizomes to 20 inches, depending upon soil moisture, stoniness and the horsepower of the machine.

Water harvesting is a term applied to the shaping and sealing of the soil surface so as to collect rainfall and concentrate it at a plant. We decided to try several variations, and are pleased with the results. Again, we are using rhizomes or container transplants of grasses and shrubs. However, we delay planting until the period of summer rainfall.

Sites are prepared by destroying any competing vegetation, shaping the surface into broad vee shaped ditches, applying a pre-emergent herbicide, and machine planting into the bottom of the ditch. The rainfall collection is increased by sealing the slopes of the ditch, either by compaction alone, or by spraying with a sealant emulsion, or by covering the soil with plastic film.

Plant growth has been very satisfactory in response to the added water being made available. In paired studies, both survival and growth of plants in water harvested rows are superior to adjacent normal planted rows.

As can be expected, the response of annual weed growth is also enhanced. The need for control of weeds is eliminated when a good quality, UV protected, plastic film is used to seal the slopes.

Table 4 lists those plants which have been the most successful in riparian situations.

TABLE 4

Container Grown Plants and Rhizomes
Which Perform Well as Understory in Riparian Zones

GRASSES

Common reed - rhizomes
Giant reed - rhizomes
Reed canarygrass - plants or rhizomes
Garrison meadow foxtail - plants
Critana thickspike wheatgrass - plants
Western wheatgrass - plants
Atlantic coastal panicgrass - plants
Sand bluestem - plants
Giant sacaton - plants
Giant sand reed - plants

SHRUBS

Coyote willow
New Mexico olive
Russian olive
Fourwing saltbush
Streamco purple-osier willow

FIVE YEAR PROGRAM

The New Mexico Department of Game and Fish, Bureau of Reclamation, Fish and Wildlife Service, Bureau of Land Management, and Corps of Engineers have agreed to jointly support research on riparian plants by the Soil Conservation Service.

The research objectives are: "1) expand the number of native riparian plant species for comparative testing, selection, and development of propagation and establishment techniques; and 2) accelerate the release of selected plants to seed growers and nurserymen to get them into commercial production and available for use in riparian revegetation programs."

The group has developed lists of plants which they need (table 5) and estimates of timetables and numbers of plants. The lists are formidable, and probably exceed the resources available to accomplish them.

TABLE 5

Priority List of Native Riparian Plants
for Commercial Production

Screwbean mesquite	Buckthorn
Velvet ash	Netleaf hackberry
Coyote willow	Giant reed
Wolfberry	Rio Grande cottonwood
New Mexico elder	Black willow
Little walnut	Peachleaf willow
Western soapberry	Currant

Plants now Available for Release

4 selections of Desert willow
2 selections of Russian olive
New Mexico olive
Chokecherry
Fourwing saltbush

Many of the plants native to the riparian zones of the lower elevations in New Mexico are commercially not available. Propagation techniques are unknown for many of the species, but information is available for some families. Plant growers cannot be expected to perform the studies and field trials necessary to learn how to grow these plants. However, under ongoing plant release programs, the seed or stock source, and the know-how, when available, will be made available to growers.

It is expected that specific plants needed for cooperating member agencies' project needs will be obtained by contract with private producers.

We intend to expand the collection and evaluation of plants in search of superior ecotypes. Our philosophy is to make available a broad genetic base and wide selection of plant species which are adapted to the highly varied riparian conditions of New Mexico.

LITERATURE CITED

Swenson, E. A., C. L. Mullins. 1985. Revegetating Riparian Trees in Southwestern Floodplains. Pages 135-138. In Riparian Ecosystems and Their Management: Reconciling Conflicting Uses. First North American Conference, Tucson, Arizona.

1989

MANAGEMENT GUIDE

WARMWATER

FISH PONDS

IN

ARIZONA

Prepared by

Donald W. Welch
Biologist
Soil Conservation Service

For the following Southern Arizona Natural Resource Conservation Districts:

Eloy	Redington
East Maricopa County	San Pedro
Florence-Coolidge	Wellton-Mohawk Valley
Gila Bend	West Pinal
Hereford	Whitewater Draw
Pima	Winkelman

and the

Arizona Chapter of the Soil Conservation Society of America.

Appreciation is expressed to David Patterson, Ivan Lines, Ron Schultz and John York for their work on this pamphlet.

Special appreciation is expressed to the Oklahoma Department of Wildlife Conservation which provided the line drawings by Wallace Hughes.

FORWARD

This booklet was written as a basic guide for anyone interested in managing warmwater ponds for recreational fishing in Arizona.

The Soil Conservation Service (SCS) has long encouraged the use of privately owned ponds for fish production for recreational or commercial purposes. However, knowledge of pond management in Arizona has lagged behind that in other parts of the country, especially the South and the Midwest. In recent years, interest in private ponds has grown as a result of increasing demand for fishing. SCS, as well as colleges and universities, is now providing information for better management of Arizona warmwater ponds.

Warmwater fishponds are those with water temperatures consistently above 70° during the summer. Warmwater species such as bass, and channel catfish do best when summer water temperatures are around 80 to 85° F. Most ponds in Arizona, below an elevation of 4,500 feet, are suited to warmwater fish production.

THE IMPORTANCE OF FISHPONDS

The demand by the American public for suitable fishing waters is increasing each year. The U.S. Bureau of Sport Fisheries and Wildlife reported that the number of anglers in the United States is increasing at a greater rate than the population. However, many waters no longer produce fish as they did in the past. Pollution, urban development, poor fishery management and other man-related activities have degraded aquatic habitats. Meeting the increasing angling demands is a major challenge. Two ways in which new demands can be met are 1) developing new waters and 2) better management of existing waters.

Warmwater fishponds will play an important role in absorbing increasing fishing pressure. Their small size makes them suitable for intensive management, and, acre for acre, they are more productive than larger lakes or reservoirs. Although a small pond is capable of providing only a few man-days of fishing, the large number of these ponds makes them an important fishery resource.

In Arizona, more than 2,000 private ponds and small reservoirs have been constructed during the past 30 years. Some stock water ponds and small, short-term irrigation reservoirs do not hold water all year and are not suitable for fish production. The majority, however, are suitable, and many have been stocked with fish.

The aquatic environment in smalls ponds is a complex system. While the general principles are known, they are not commonly understood. Many microscopic plants and animals exist in a single drop of water. In ponds, they interact with each other in the production of fish and the growth of aquatic plants. This booklet provides pond owners with a fundamental background of management procedures to more fully realize the fishing potential of their ponds.

Commercial fish farming is another subject. While there is a place for commercial fishponds in Arizona, this booklet will not deal with that subject.

REQUIREMENTS FOR A SUCCESSFUL POND

There are three basic requirements that must be met if pond management is to be successful.

1. ***Pond Construction:*** Proper construction is of fundamenta importance to successful fish production. A pond with excessive shallow areas (less than 3 feet deep) can rapidly become a weed-choked marsh with low potential for fishing. If a pond's water level will not be maintained by a supplemetal water source such as irrigation drainage or well water, the pond should be deep enough to withstand evaporation and last through the dry Arizona summer.

2. ***Stocking:*** The pond should be stocked with suitable fish species that will provide satisfactory angling, utilize the pond's natural foods, and successfully reproduce so that sustained sport fishing yields will result. Details of stocking will be discussed later in the text.

3. ***Owner Interest:*** Warmwater ponds have considerable potential as a recreational resource. The factor limiting maximum realization of the pond fishery resource is not a lack of technical know-how. It is the tendency of pond owners to neglect the necessary management. Unless the owner is willing to treat the pond as a "water pasture" and is prepared to manage it, the pond is unlikely to provide successful fishing. Although fishing is not usually the primary concern of most Arizona pond owners, fish production can be compatible with such uses as irrigation and stock watering. Many successful ponds in the state attest to this fact.

WATER SUPPLY

Perhaps the single most underestimated factor affecting the fish-pond owner is evaporation. The net annual evaporation rate ranges from about eight feet in Southwest Arizona to 6½ to 7 feet in the higher elevations. This means that the owner of a one acre pond in Yuma will need about 2.6 million gallons of water just to replace that lost to the atmosphere. The same pond owner on Mount Lemmon may need only about 2.1 million gallons to offset evaporation.

It quickly becomes obvious that to be adequate, a water supply must replace evaporation as well as seepage losses, and to provide a source of exchange water to keep the pond fresh. The amount of exchange water needed will vary from site to site depending on the conditions. A starting point would be to increase the amount needed to replace losses by about one percent.

There are four basic sources of water which can be used to supply a fishpond. Each source has its own benefits and problems.

Watershed Runoff is one of the least expensive water sources generally available for fishponds. In the Arizona desert however, runoff is extremely unpredictable.

Fishponds constructed to use watershed runoff should be sufficiently deep to survive drought periods and should include sediment detention structures. Other problems associated with watershed runoff include the possibility of contamination by pesticides; herbicides; high concentrations of organic matter, such as livestock wastes; and trash fish, fish diseases and parasites from upstream waters.

Streams can provide an abundance of high quality water for a sportfish pond. Flowing streams have the same likelihood of contamination as watershed runoff. The wild trash fish and disease contamination potential is greater for streams than watershed runoff. Diversions and flow control structures can be a problem with flowing streams.

Diversions and flow control structures must be designed to provide ample water to the pond while passing flood flows downstream without damage.

Springs are the most desirable sources of water since the water is freeflowing. Some problems with spring water are that it is typically low in dissolved oxygen and high in carbon dioxide. These problems can usually be corrected by aeration.

Springs can also be highly mineralized. The water should be analyzed before use in a fishpond.

Some springs also contain wild fish and potential fish diseases. The wild fish should be classified to assure that they are not a rare species.

Wells are a fine source of water for sportfish ponds. As with springs, they are characteristically short of dissolved oxygen and high in carbon dioxide and aeration may be necessary.

It is possible that well water may be highly mineralized and a water analysis should be performed.

The primary disadvantage of well water is the pumping. If power is available, pumping costs will need to be considered. When power is not available, a windmill will probably be necessary.

SITE SELECTION

Several aspects of site selection are nearly as important as water availability. While flooding potential and soils are probably most important, other factors should be considered.

Flooding Potential. The most important consideration is locating a pond so that it will not fail or wash out due to flooding.

Floods can wash trash fish into the pond during high flows or wash established sportfish populations out.

In some cases when it is necessary to locate a pond in a floodprone area it can be designed to reduce or eliminate problems.

Soils are extremely important in selecting a site for a fish pond. Sandy soils or sand lenses in alluvial soils will probably not hold water. Clay or clay loam soils are best for building ponds, since they do seal best.

If it is necessary to build a pond where sand in the soil could be a problem, the pond should be over excavated, then backfilled with a clay layer, wetted and compacted. Several types of liners can also be used.

Pollution can cause fish kills or render fish unsuitable for consumption. Fishponds should be located well away from septic system leach fields, animal feed lots and other sources of organic or chemical pollution.

General. The fishpond should be located to simplify water delivery. Future management problems can be reduced if the pond can be located to allow complete draining by gravity through a pipe outlet.

A pond site can also be selected to simplify construction and reduce costs. It can be constructed in a natural depression or a dam can be constructed across a narrow place in a swale to reduce the amount of earth movement required.

CONSTRUCTION

Size will be determined pretty much by individual needs, available area, amount of water available, and the suitability of the landscape. The smaller the pond, the fewer the fish it will produce.

Shape or shoreline configuration will be a matter of personal preference. It can be based on ground elevation contours to reduce construction costs. An irregular shoreline normally has a more pleasing natural appearance.

Design Considerations. The ideal fishpond would have many of the same design considerations as a swimming pool. It would have steep sides, a shallow end (3 to 4 feet), a deep end (8 to 12 feet), a drain, and a pressure aeration system.

Steep sides help control and contain aquatic plant growth. The shallow end provides better fish habitat and spawning areas than deep water. The deep end provides an area to hold the fish when drawing the pond down for plant control and other pond maintenance. It also provides an area for concentrating fish for management purposes, including seining.

The drain, preferably a gravity outlet, is the most efficient method of dropping water levels for maintaining the pond and managing the fish. Draining the pond is the most efficient method of pond renovation to eliminate unwanted fish or aquatic plants.

A pressure aeration system is used for water quality control. It can be used to supply additional oxygen during periods of oxygen stress and to reduce high levels of carbon dioxide, hydrogen sulfide, and nitrogen compounds when needed.

Often, due to site limitations or financial considerations, one or more of these features must be eliminated from the plan. This should not preclude pond construction. It should be realized, however, that with each deleted feature, good pond management becomes progressively more difficult.

Further information can be found in Agricultural Handbook No. 590, PONDS, PLANNING, DESIGN, CONSTRUCTION.

NEW POND TREATMENT

Newly constructed ponds with fresh well water are relatively sterile. The pond should be fertilized to stimulate natural biologic growth prior to stocking fish.

Fertilizer stimulates the growth of minute plants called phytoplankton, which are the starting point for the "food chain" in the pond. These are then eaten by minute animals called zooplankton, which are in turn eaten by insect larvae, which are eaten by small fish, then large fish.

The minute plants, or phytoplankton, causes the green color in the water. Their abundance in the water can be measured in terms of water clarity or light penetration. In otherwise clear water (not muddy), a white disc or shiny disc (Secchi disc) will disappear from view at some depth in the pond indicating the abundance of phytoplankton.

A device to measure light penetration can easily be made by nailing a one pound coffee can lid to a stick about three feet long. The stick should be marked at 16 and 20 inches from the lid.

A new pond should be fertilized after filling, with about 25 pounds of commercial 16-20-0 fertilizer per surface acre. Fertilizer can be applied in a number of ways including sprinkling the granules from the bank. When applied on the pond bottom, however, the fertilizer has a tendency to become tied up in the soil, and is released to rooted aquatic weeds more readily than to minute suspended plants.

The easiest way to apply fertilizer is to put it on a floating 4 foot by 4 foot piece of 3/8″ plywood. This will assure that the fertilizer is dissolved directly in the water.

For ponds filled in the fall or winter, fertilizer applications should be delayed until early spring.

Within a week or two of the first application, the water should start to green up. Further fertilizer applications should be made at two to three week intervals until the phytoplankton densities reach a point that the light measuring disc goes out of sight between the 16 and 20 inch marks on the stick. At this point, fertilizer applications can be adjusted to maintain the 16 to 20 inch reading.

For established ponds the fertilizer program should begin in the spring when the afternoon surface temperature of the pond regularly reaches 60°F or higher. Phytoplankton blooms will usually not occur until the surface temperature reaches at least 70°F. When fertilizer is added, the density of the phytoplankton usually increases rapidly, and care must be exercised to avoid over-fertilization. If a white object disappears at a depth of less than about 16 inches, too much fertilizer has been added. Such a condition is not usually critical and is only temporary but indicates a waste of materials.

Occasionally, highly fertile or over-fertilized ponds can develop a "pea soup" condition that is objectionable and potentially dangerous. Under such a condition, the dissolved oxygen in the pond is consumed by the plants at night. This is especially critical in hot summer months when oxygen concentrations are lower due to high temperatures. The combination of factors frequently cause serious fish kills.

Excessive plankton blooms and the possible oxygen deficiency that often occurs as a consequence can be corrected by aeration. This can be done by adding fresh oxygenated water, or inducing circulation with aeration equipment, or by the use of a recirculating pump well in advance of oxygen deficiencies.

The pond owner can easily learn to adjust the application rate according to the needs of the individual pond. In some cases several applications may be required the first summer to maintain a satisfactory bloom. It usually requires fewer applications in subsequent years.

STOCKING THE POND

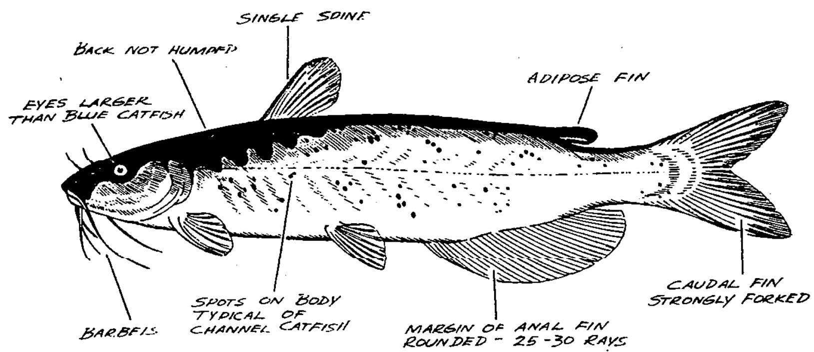
Many species of warm water fish can survive and reproduce in Arizona warm-water ponds. Only a few of these, however, provide good, easily manageable angling year after year.

It should be remembered that the Arizona Game and Fish Department requires a permit to transport and/or stock any aquatic species. The nearest regional office of that department should be consulted prior to stocking any waters in Arizona.

SPECIES RECOMMENDED FOR STOCKING

There are few species combinations that do well, providing an easily manageable and reasonably productive sport fishery. Channel catfish and largemouth bass stocked together or separately are the most popular species in Arizona. Both species are well adapted to small warm-water ponds below about 4,500 feet in elevation.

CHANNEL CATFISH



The channel catfish (*Ictalurus punctatus*) is one of the most popular game fish. This catfish regularly reaches 5 pounds in size, and occasionally larger. The Arizona inland waters record is 31 pounds 10 oz. Channel catfish are native to most drainages east of the Continental Divide, but not in Arizona. They have been introduced to most drainages in Arizona as a sport and food fish.

Habitat Needs

Water: The channel cat does best in highly fertile waters and will tolerate moderately muddy water. For best growth and activity, a water temperature beween 70 and 80°F is best. Feeding and growth rates are reduced at temperatures below 70°F. Waters having a salinity under 5,000 ppm and waters with a pH between 6.0 and 9.5 are best.

This catfish normally spawns in the spring when the daytime water temperature is between 70° and 80°F probably in May or June. The female lays up to 3000 eggs per pound of body weight. The eggs hatch in 5 to 10 days at temperatures between 70-80°F.

Food: The channel catfish is omniverous. About 50% of its diet is plant material. The remaining 50% consists of animal material (crayfish, tadpoles, worms, etc.) either alive or dead. Highly fertile waters produce sufficient food for normal catfish populations. They can also be fed a prepared pelleted food either supplementally or as a full diet.

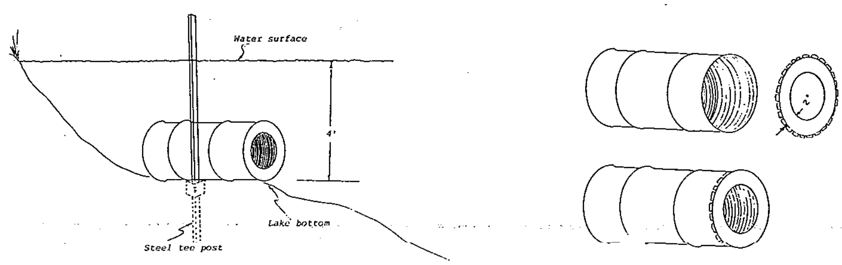
Stocking Rates

Proper stocking of channel catfish with fathead minnows normally produces good fishing within one to two years. Several stocking techniques can be used with good results.

Brood fish. Stock the pond with a dozen brood fish (sexually mature fish) per acre in the late winter. They will then spawn in the spring.

Fingerling. Fingerling catfish (two to four inch fish) should be stocked at 50 to 100 per surface acre depending on the fertility of the pond. The fingerling will normally begin to spawn the second or third spring after stocking.

Spawning. Channel catfish will not spawn reliably without a spawning device. A ten gallon milk can or other 10 to 30 gallon can will work. When using a 120 pound grease can (approximately 14″ diameter, 28″ length), remove lid, clean well, cut a 10″ hole in the center of the lid, leaving a 2″ lip all around and replace the lid. Place the can in the pond, on its side, level in 3 to 4 feet of water, facing away from or parallel to the bank, and tie to a tee fence post as an anchor and marker (see diagrams). Install two or three cans per acre and space at 20 feet or more along bank.



Stocking with forage fish. Fathead minnows should be stocked at a rate of about 1000 per surface acre. They should be stocked as early in the spring as possible and allowed to spawn.

Should there not be sufficient time to allow the spawn of these forage fish, they should be stocked at a rate of several thousand per surface acre prior to the stocking of catfish.

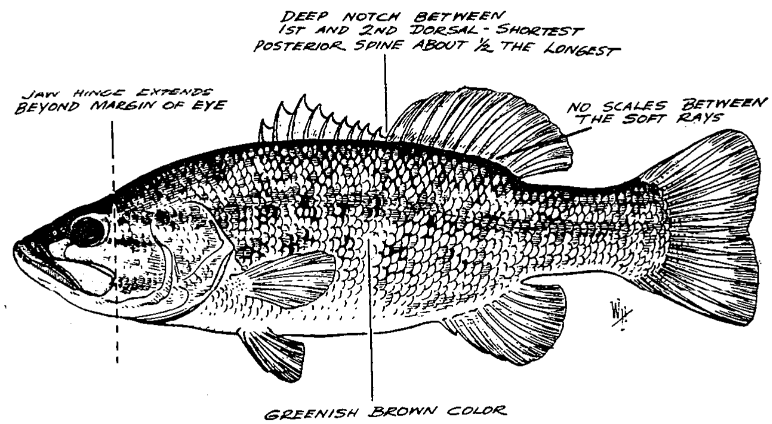
Stocking of catfish with other fish is not generally advised. Bullhead catfish, bluegills or other sunfish normally over-populate. This results in numerous, very small, unusable fish.

Related Items

Fishing should not be done until the catfish have spawned. In mid to late summer pull a small seine through the water to see if small catfish (1-2″) can be found. For best results, carefully return the brood fish to the pond for two years.

Over population is common after each spawn. Remove the spawning devices and store. Remove smaller fish until growth rate exceeds one inch per month during the summer months. Start eating the catfish as soon as they reach a usable size (over 8″).
Under population. Eventually the catch rate will fall below your liking. Reinstall spawning devices and permit another spawn.

LARGEMOUTH BASS



The largemouth bass *(Micropterus salmoides)* regularly exceeds 3 pounds in size. The Arizona inland waters record is 14 pounds, 2 ounces. Largemouth bass are native to most drainages east of the Continental Divide. They have been introduced into warm water drainages in Arizona because of their extreme popularity. Largemouth bass are not true bass. They are in the sunfish family with other sunfishes, crappies, etc.

Habitat Needs

Water: The largemouth bass does best in non-turbid, highly fertile, non-flowing waters. For best growth and activity, water temperature above 80°F is needed. It is reported that they become very inactive in waters having temperatures below 50°F, and digestion of food was slow at water temperatures below 65°F. Waters having a salinity over 5,000 ppm are unsuitable, and waters with a pH between 6.0 and 9.5 are best.

This bass normally spawns in the spring when the daytime water temperature is between 60° and 68°F. This usually occurs in April and May. The female lays something over 1000 eggs, depending on her size. The eggs hatch in 2 to 5 days at 60° - 68°F.
Food: The largemouth bass eats a wide variety of food, mainly small fish, insects, and insect larvae. It also eats crawfish, tadpoles, worms and frogs when they are available. Highly fertile waters are necessary to produce an abundance of food for the bass.

Stocking Rates

Proper stocking of bass ponds with mosquitofish and fathead minnows normally produces good fishing within one year. Several stocking techniques are used with good results.

Brood fish. Stock the pond with a dozen brood bass per surface acre in the late winter. They will then spawn in the spring.

Fingerling. These should be stocked at 50 to 100 per surface acre depending on the fertility of the pond. Fingerlings will normally begin to spawn the second spring after stocking.

Stocking with forage fish. Fathead minnows should be stocked at a rate of about 1000 per surface acre. They should be stocked as early in the spring as possible and allowed to spawn.

When the fathead minnows have spawned, the pond should be stocked with mosquitofish at a rate of about 1000 per surface acre. The mosquitofish should then be allowed to reproduce.

Should there not be sufficient time to allow the spawn of forage fish, they should be stocked at a rate of several thousand per surface acre prior to the stocking of bass.

Stocking of bass with other fish is not generally advised. Bullhead catfish, bluegills or other sunfish normally over-populate. This results in numerous, very small, unusable fish.

Related Items

Fishing should not be done in a newly stocked pond until the bass have spawned. In mid to late summer, pull a small seine through the water to see if small bass fingerlings (1-2″) are to be found. The bass should be fished lightly the first year, even though a spawn has occurred. For best results, carefully return the brood fish to the pond for two years.

Overpopulation. Bass managed according to this guide may tend to become overpopulated and stunted. As this happens, the average size fish taken becomes smaller. One solution is to increase the fishing pressure, taking greater numbers of smaller pan size fish and returning large fish to the pond. The average size fish taken will gradually increase. Another solution is to seine to remove some smaller fish, and return larger fish to the pond.

CHANNEL CATFISH AND LARGEMOUTH BASS

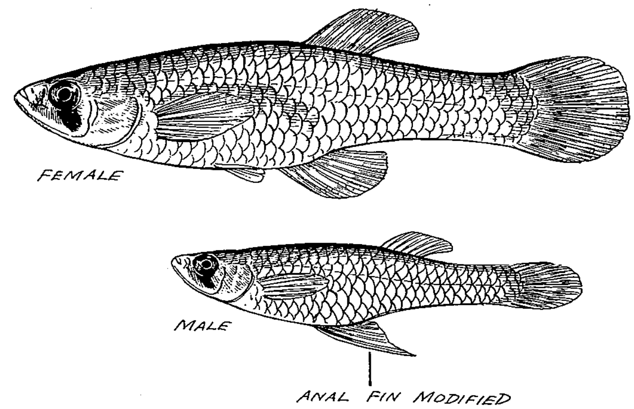
Channel catfish and largemouth bass when stocked together can produce an excellent sportfish pond. When stocking these fish together, catfish populations must be established first according to the previous guidelines.

When the offspring from the first catfish spawn reach six to eight inches in length, the catfish spawning devices can be removed. The catfish must be at least six inches long, or they will be eaten by brood bass.

Bass can be stocked at this time and their populations established according to the guidelines for largemouth bass.

The catfish will not successfully produce young again. They will be eaten by the bass. When the catfish populations are depleted they will have to be restocked as six to eight inch fish.

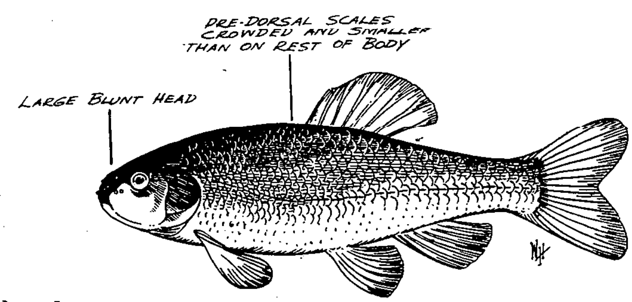
MOSQUITOFISH



Gambusia

The mosquitofish, a small fish which produces its young alive, is found in most ponds in the state. It is stocked in new waters to control mosquito larvae. It serves primarily as forage for small bass and for mosquito control.

FATHEAD MINNOWS

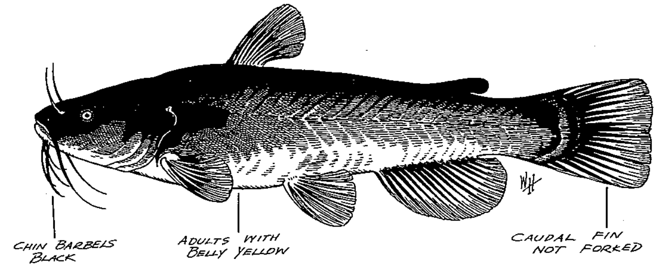


The fathead minnow inhabits slow moving streams and ponds with abundant vegetation. It feeds on dead animal and plant material picked up off the pond bottom. It spawns between April and September when water temperatures are above 55°F. It lays up to 12,000 eggs per spawn and may spawn up to 12 times per summer. Since it reaches 3½ inches in length, it provides good forage for larger bass.

SPECIES *NOT* RECOMMENDED FOR STOCKING

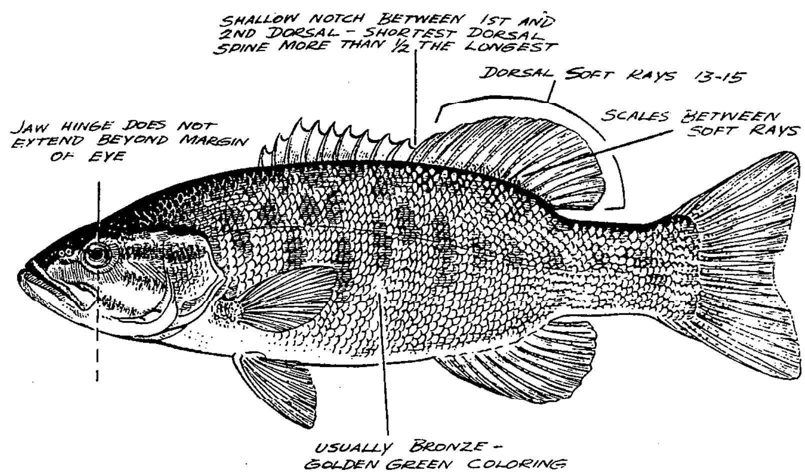
Several species of fish found in Arizona ponds and streams should be avoided in stocking a pond. Some of these are desireable sportfish to some fishermen. They are not recommended for stocking because they require intensive management to produce a productive fishery. Most pond owners do not have sufficient control over their ponds to provide the intensity of management needed. Without this management most of these species will overpopulate producing an abundance of stunted fish.

BULLHEADS



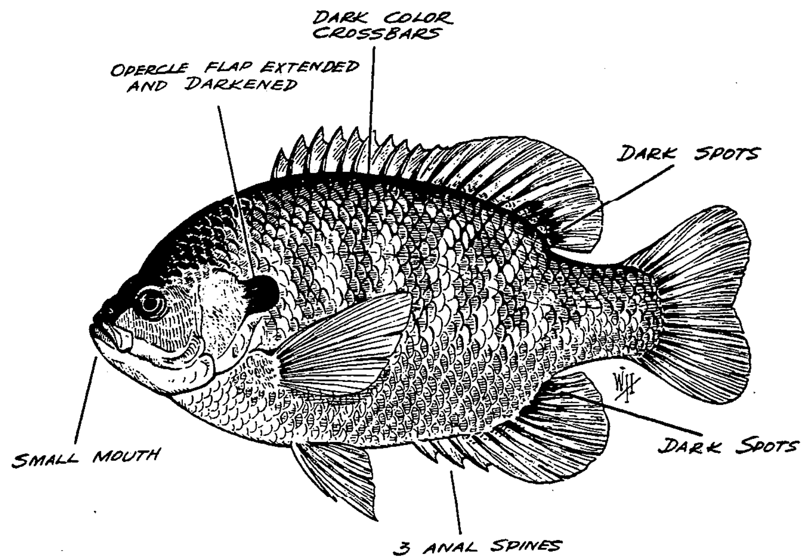
Bullheads (yellow, brown and black) are closely related to the channel catfish, and do well in most Arizona ponds. They do not grow as large as the channel catfish, but they will normally reproduce in ponds. However, under conditions of heavy bass predation, they have been known to disappear. When not subjected to some bass predation they tend to over-populate. They can be caught with a variety of baits. Since bullhead catfish are difficult to manage, it is not recommended that they be stocked in small ponds.

SMALLMOUTH BASS



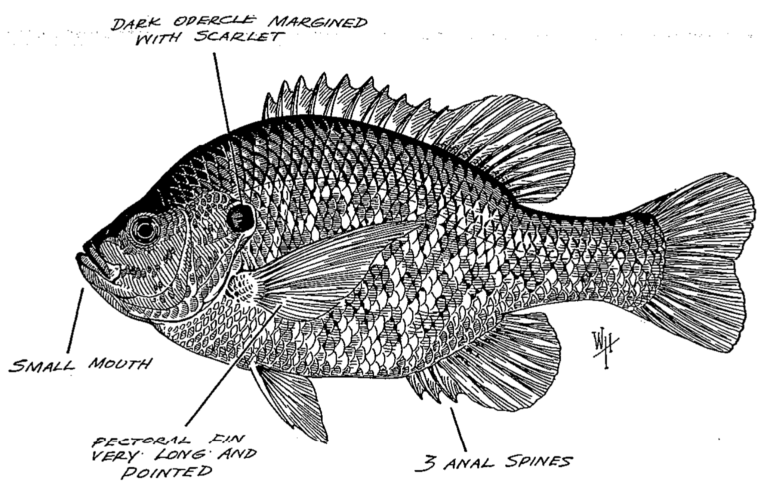
The smallmouth bass, a smaller relative of the largemouth bass, is typically found in clear, warm streams and rivers. It does occur in a few ponds in the state. Smallmouth bass are most likely to be successful in a pond if they are the only species present, the pond is clear with a rocky bottom and vegetation is not excessive.

BLUEGILL SUNFISH



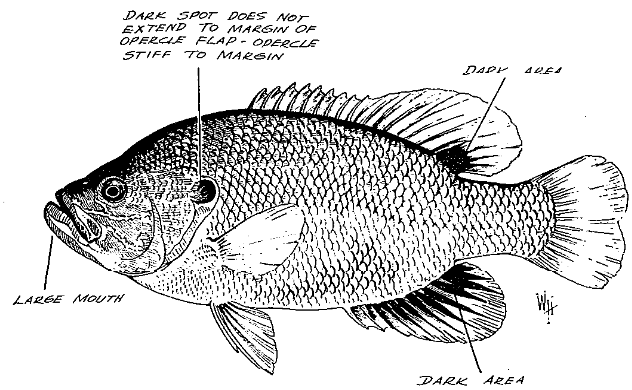
Bluegill sunfish are related to the largemouth bass and have been historically stocked with bass as forage. Bluegills reproduce in abundance, rapidly overpopulating small ponds. They then consume most of the eggs and young of other species, limiting or eliminating their successful reproduction.

RED-EAR SUNFISH



The red-ear sunfish ("shellcracker"), a close relative of the bluegill, is frequently stocked instead of, or along with, the bluegill in bass ponds. The red-ear does not spawn as intensively as the bluegill and thus does not have as much tendency to overpopulate and stunt, even in weedy ponds. The red-ear may not provide the bass with as much forage as the bluegill. Red-ear feed mainly on aquatic insects and snails. Red-ear grow faster than bluegill and commonly weigh over one pound.

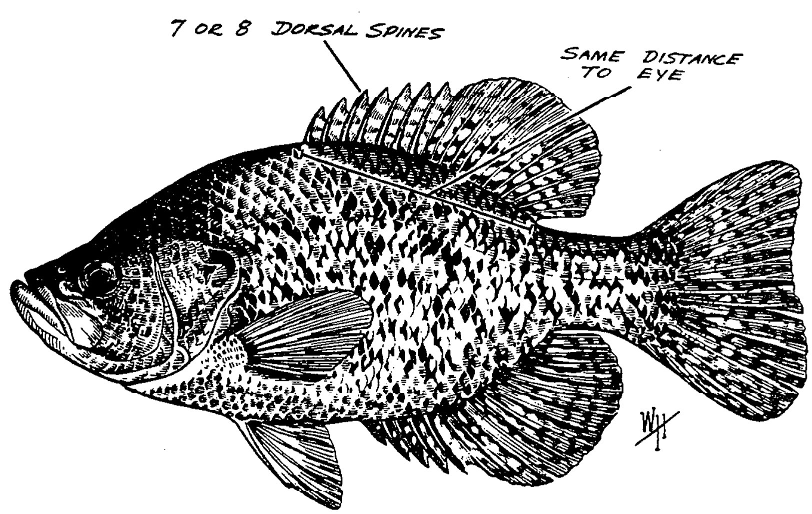
GREEN SUNFISH



Green Sunfish

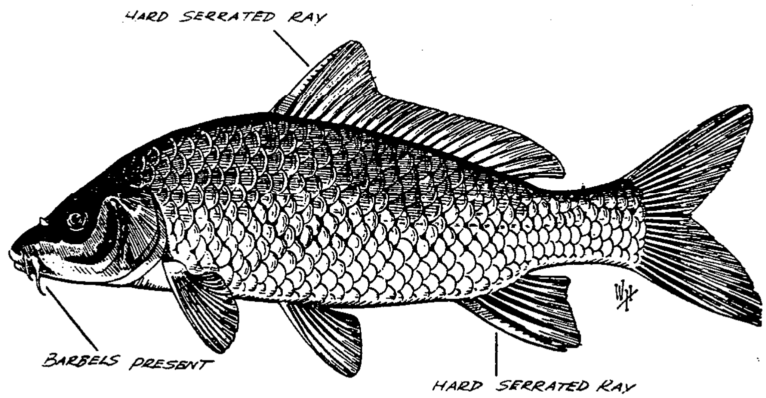
The green sunfish is not recommended because of its tendency to overpopulate and because it spawns at nearly the same time as bass. They are competitors for food with the young bass.

CRAPPIES



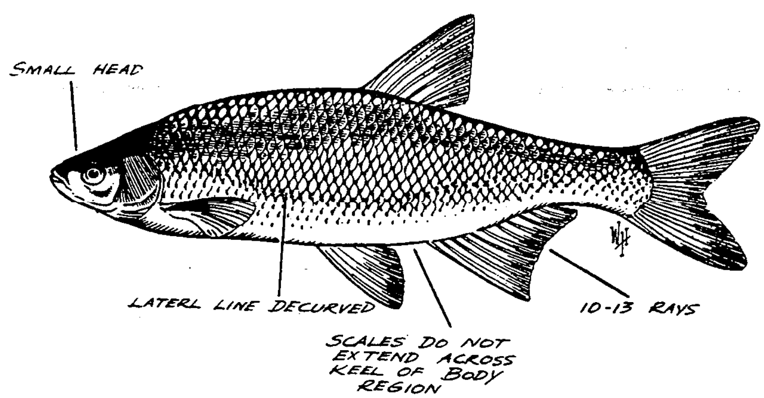
Black and white crappies, while excellent pan-fish in larger lakes and reservoirs, are difficult to manage in small ponds. They tend to overpopulate and compete with bass and other sunfish, throwing this combination out of balance.

CARP



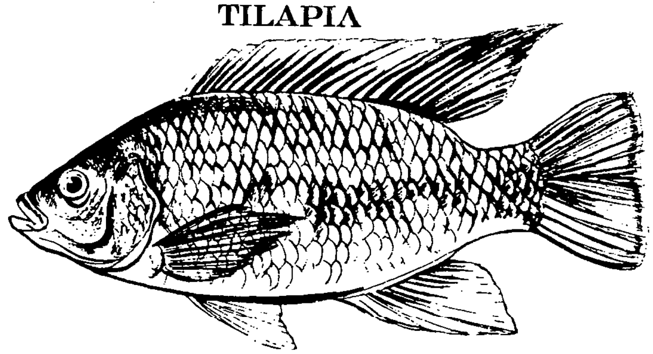
The carp is a nuisance fish because it roils the bottom and may compete for food and space with other game fish in the pond. Under certain conditions it can be used to control submersed weeds. The common goldfish, a relative of the carp, should also be avoided.

GOLDEN SHINER



The golden shiner, which is the common bait minnow in Arizona, is of questionable value in warm-water ponds. While it may provide the bass with good forage, it is usually too small for hook and line fishing. In weedy ponds it has a tendency to overpopulate and become a nuisance

TILAPIA



Tilapia inhabit warm, heavily vegetated ponds, shallow lakes and streams. They eat vegetation, algae and a few insects. Tilapia spawn any time the temperature is above 68°F, and grow to about 3 pounds. They are mouth brooders, therefore, the young are well protected from predation and tend to overpopulate. They can be of value in vegetation control, but will not survive prolonged temperatures below 55°F.

AQUATIC WEED CONTROL

Probably the most troublesome management problem of Arizona fish ponds is aquatic vegetation. While sparse to moderate growths of vegetation may be desirable because they may provide habitat for aquatic insects and other pond life, excessive growths are undesirable because they discourage angling. They can cause oxygen depletion when they die and decay. They use up nutrients, and they decrease the lifespan of the pond by the build-up and accumulation of organic matter (eutrophication).

There are 4 main categories of vegetation in ponds: 1) ALGAE, which includes a) *planktonic algae* (phytoplankton), tiny microscopic plants which give the water a greenish cloudiness or "bloom"; b) *filamentous algae,* long thin, thread-like strands often forming unsightly surface scums (see figure at right); and c) more highly developed forms such as Chara, which grow up from the bottom; 2) SUBMERSED PLANTS, which are rooted in the bottom and occasionally reach the surface of the water—they include elodea, sego pondweed, coontail, milfoil, and water lilies; 3) EMERGENT PLANTS, rooted in the pond bottom or along shorelines, extending well above the water surface—examples are cattails, bulrushes (tules), and arrowheads; 4) FLOATING PLANTS, such as duckweed and water hyacinth, float on the water's surface and are not rooted in the bottom.

A properly constructed pond with moderately steep slopes and adequate depth is not likely to have serious weed problems.

A poorly constructed pond with extensive shallow areas (less than 3 feet deep) represents excellent habitat for a variety of aquatic plants. As long as suitable habitat for aquatic weeds exists, any control method will be temporary. The best remedy for a weedy pond is renovation involving draining, deepening, and steepening the sides. Overhanging vegetation around the pond's edge should be removed. When vegetation, such as leaves, falls into the water and decays, it stimulates undesirable growths of filamentous algae.

If modifying the pond bottom is not feasible, the pond owner should consider the alternative approaches to weed control discussed below. These five methods are: 1) mechanical control, 2) fall drawdown, 3) chemical control, 4) fertilization and 5) biological control.

MECHANICAL CONTROL - This involves cutting or pulling the weeds. If the weeds are removed a few at a time as they appear, and before they become well established, the work will be minimal. For established weed beds, submersed weeds can be removed by dragging a steel cable or a heavy chain across the pond bottom. For larger ponds, mechanical cutting devices that are mounted on boats are commercially available but are quite expensive.

FALL DRAWDOWN - A proven way to control rooted vegetation in ponds that have depths of more than 10 feet is the fall drawdown, where the water level can be substantially lowered in October—down to about 40 percent of the pond's capacity. This drawdown exposes the shallow areas of the pond where rooted vegetation will be exposed to the bright autumn sun. The vegetation is soon killed and dried out. It is also advisable to disc, rake, or better yet, scrape the exposed pond bottom at this time. The pond will be rapidly refilled by the winter rains which usually arrive in November. This annual treatment helps control emergent weeds as well.

CHEMICAL CONTROL - In recent years, much attention has been given to the chemical control of aquatic vegetation. Several aquatic herbicides are on the market. The main advantages of chemical control are that application is fast, requires minimum labor, and produces quick results. Its disadvantages are that it can be expensive, repeated applications are usually necessary, and extreme caution is needed during application. Decomposing plant material can cause serious oxygen depletion. The nearest Regional Office of the Arizona Game and Fish Department should be contacted prior to the use of any chemical that is toxic to fish.

FERTILIZATION - Submersed weeds require sunlight in order to germinate and grow. Thus, it is possible to prevent or discourage the growth of submersed weeds in most properly constructed ponds by adding fertilizer which stimulates the growth of phytoplankton. This in turn acts as a light filter and shades out the weeds. The addition of fertilizer will usually increase the production of fish.

If weeds are to be controlled, an adequate amount of basic plant nutrients must be in solution during the normal summer growing season. Refer to the earlier section of this report on new pond treatment.

It is much easier to prevent submersed weeds from developing in a new pond with fertilization than it is to control a heavy infestation after it has developed. In the latter case, it may be desirable to use mechanical control methods in conjunction with a fertilization program to attain control, or to use chemical treatments to obtain initial control and prevent the weeds from coming back with a fertilizer program. Fertilizer is not effective in shallow areas along the shoreline where the water is less than three feet deep. Supplemental chemical or mechanical control methods may be needed in these areas.

Obviously, the effective use of fertilizer in pond management requires close attention. A single application, without the proper follow-up applications, is useless and a waste of time and materials. Pond fertilization should not be attempted if more than 10 percent of the surface is less than 3 feet deep. However, well-planned and properly-executed fertilizer programs, in most cases, will control submersed weeds, cost less than conventional chemical control, and increase fish production.

BIOLOGICAL CONTROL - There is much interest in biological controls, although their use has not proven to be a panacea for pond owners. Crayfish have been used effectively in some trout lakes in Arizona to control submersed weeds. Carp can control sego pondweed, but create very turbid water in doing so. Tilapia, which have become established in drain ditches in Arizona, have been used in Hawaii for aquatic weed control but cannot tolerate cold water (less than 55°).

CLEARING MUDDY PONDS

Muddy water is undesirable in a pond because it shades out sunlight needed by microsocopic plants, hinders feeding by the fish, makes fish harder to catch, and makes the pond unattractive. Muddiness may be due to poor watershed management, resulting in excessive silt in the runoff water which enters the pond. It can also be caused by cattle wading in the pond or by the presence of muskrats and carp.

Good watershed management, fencing out cattle, and control of muskrats and carp may solve the problem of a muddy pond. In some cases muddiness may persist, even though none of the above-mentioned factors are contributing to the problem. This muddiness is due to minute clay particles which tend to remain in suspension. There are three different treatments which will cause these suspensions to settle out and subsequently clear the water, and none will harm the fish. Periodic treatments may be necessary.

1. Spread powdered gypsum over the water at the rate of 12 lbs. per 1,000 cubic feet of water (500 lbs. per acre-foot)
2. Apply 50 lbs. of superphosphate fertilizer and 100 lbs. of cottonseed meal per surface acre. Do not use this treatment during the hot summer months, as it may result in oxygen depletion.
3. Scatter loose green hay or dry straw in the water. Use 7 to 10 bales for each surface acre. Do not use this treatment during summer months, as it may result in oxygen depletion.

FISH PARASITES AND DISEASES

Fish in general, harbor a variety of parasites. A fish in nature without some kind of parasite is rare. Numerous kinds of parasites, such as yellow grubs, tapeworms, anchorworms, and nematodes are commonly found in bass and other pond fish.

Generally, parasites do not represent a serious problem in ponds. Since most occur in the viscera of fish, they are discarded when the fish are cleaned. Those that occur in muscle tissue and skin are killed when the fish is cooked and represent no danger to man.

When heavy parasite infestations occur, it is usually because the fish are stressed or weakened from some other cause, such as low concentrations of dissolved oxygen, high water temperature, or when fish are crowded. In ponds, the fish are usually not crowded and parasites are less likely to become a problem. Generally, it is not feasible to control them in ponds. Certain fish parasites are hosted temporarily by snails before infecting fish. Since redear sunfish feed on snails, they may serve to reduce the incidence of these particular parasites (such as the yellow grub).

Fish diseases are not common in warm-water ponds, but they represent no threat to man and rarely cause serious fishkills. Diseased fish are usually sluggish and may have sores, swelling, or lesions on the body. Fishkills that result from disease outbreaks are likely to occur when the fish are weakened or stressed such as in early spring after overwintering, or during periods of high water temperature and/or low dissolved oxygen.

If a disease occurs resulting in death of many fish, it should be reported to the nearest SCS biologist. Unfortunately, fish diseases in ponds are usually difficult to control and will probably have to run their course. Although heavy mortality may occur, there will usually be enough surviving fish to reproduce and rapidly return the pond to its carrying capacity.

EVALUATING THE CONDITION OF THE FISH POPULATION

The pond owner must be aware of the condition of fish populations in the pond so that measures can be taken to maintain or return the pond to a suitable conditon. Examination of the angler's catch is probably the best and easiest way to determine the conditon of the population of sport fish. Are the fish of each species too small, too numerous, too few, or not in good condition? This will give some idea of what must be done to manage these species.

This technique has some disadvantages. It will not provide information on the condition of forage species. More often than not, the owner does not have perfect control over fishermen, so that he will not have a good knowledge of exactly what the anglers are catching.

Shoreline seining or netting is an alternative and/or supplemental method of sampling. This is done by seining along the shoreline with a minnow seine during mid-summer. This is an effective method of sampling forage fish as well as the current year's spawn of sportfish.

FISH POPULATION MANAGEMENT
HARVESTING THE FISH

Fishing is an important aspect of fishpond management. As fish are removed, more food is made available to the remaining fish. The remaining fish will then reproduce, replacing those that are removed.

Fish ponds can be over fished, depleting the numbers of some or all species. Most privately owned fishponds in Arizona, however, are not over fished, or under fished, they are under managed.

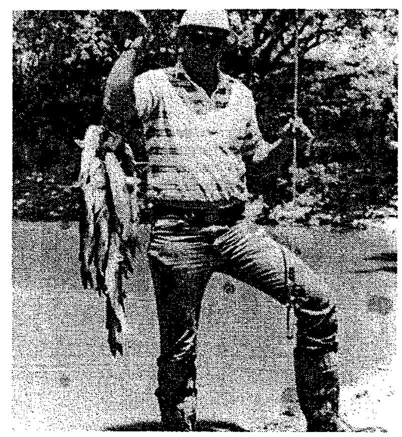
Problems generally are related to the lack of control the owner has on fishing pressure.

Catfish ponds, bass ponds, and catfish-bass ponds are the most easily manageable ponds. Basic guidelines for managing these ponds are outlined in the stocking section of this report. The primary problem with these ponds is uncontrolled fishermen taking the large fish which the owner has returned to the pond to control the numbers of small fish.

Most farm pond management problems arise in ponds stocked with multiple species. These include any or all of those species listed previously as *not recommended for stocking.*

If any of these not-recommended species are stocked in a new pond with bass, it is imperative that no more than 25 pounds of bass be harvested per acre per year. Most ponds cannot be controlled that closely.

When sampling shows that populations of fish other than bass (and minnows) consist primarily of abundant 3 to 4 inch fish, the population is probably out of balance. This is especially true if few bass are in the sample and are of older age groups.



Several management treatments or a combination of treatments can be used to remedy the situation.

The most effective treatment is to completely eradicate the existing fish population and restock with bass, channel catfish, or bass with catfish. Eradication can be accomplished best by draining the pond. The alternative is chemical treatment with chlorine, or fish toxicants such as rotenone or antimycin. The Arizona Game and Fish Department should be consulted prior to treatment.

Another alternative is to thin the populations of undesirable fish by seining, trapping or spot treatment with fish toxicants. This treatment can be reasonably effective if bass remain in the population.

If few or no bass remain in the population, it will be necessary to stock several large bass back into the pond after controlling the population of undesirable fish. It will probably be necessary to harvest NO bass and continue to control other fish populations until a bass spawn is verified and a balanced population is achieved.

It will then be necessary to assure a bass harvest of no more than 25 pounds per acre per year to maintain this balance.

FISHKILLS AND THEIR PREVENTION

The most common cause of fishkills in farm ponds in Arizona is oxygen depletion. Oxygen deficiencies are most likely to occur during the summer when water temperatures are highest. There are several contributing factors which can lead to a fishkill as a result of high temperatures: 1) water holds decreasing amounts of oxygen as the temperature rises, 2) fish require more oxygen at higher temperatures since their metabolic rate increases with temperature, 3) bacterial decomposition, which also requires oxygen, increases with temperature. Since photosynthesis (which produces oxygen) stops at night, and respiration (which uses oxygen) proceeds at night, oxygen shortage will be most acute at dawn. Fish gasping for air at the surface at this time of day is a sure sign of oxygen shortage in the water. (Note: small, simple to operate, portable water chemistry kits for testing oxygen level in the water are available commercially).

The pond owner can best take measures to prevent fishkills by not permitting conditions to occur which lead to oxygen depletion. Shallow, weedfilled ponds are likely places for oxygen shortages to occur, as are ponds which have inflowing water containing organic pollutants, such as drainage from cattle pastures. When signs of oxygen shortage occur, the oxygen level of the water can be raised by importing fresh water or aerated well water, or by utilizing portable aerators and re-circulating pumps. These are available commercially. The application of 50 to 100 pounds of superphospate per acre broadcast over the pond surface is also an emergency measure.

Another cause of fish kills may be the accidental introduction of pesticides into the pond. Surface runoff from treated fields may cause a fishkill; livestock sprayed with insecticide wading in a pond may also produce a fishkill. Extreme caution must be exercised when using any pesticide near ponds.

KEEPING RECORDS

It is important that records be kept of the pond harvest. The owner should have people who fish the pond record numbers and sizes of the fish they catch, along with the time spent by each person fishing on each trip. This information can be conveniently recorded on a 3x5 card. These data will provide the basis for the owner to evaluate the condition of his fish population, as well as a record of the total harvest. Records of other pond management activities, such as fertilization, should also be kept.

SAMPLE FARM POND RECORD CARD:

POND ______________________________

Name and Address ______________________________

____

Type of Fishing Gear Used ______________________________

Length of Time Fished (Draw a line through the hours fished)

AM: 12 Midnight..1..2..3..4..5..6..7..8..9..10..11..12 Noon

PM: 12 Noon..1..2..3..4..5..6..7..8..9..10..11..12 Midnight

LENGTHS OF FISHES CAUGHT	
SPECIES	LENGTHS
Bass	
Bluegill	
Redear Sunfish	
NOTE: Circle the lengths of any fish returned to the water.	

Such records are your fishpond "bank account" ledger and should prove invaluable. Don't neglect them.

HAPPY FISHING!