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Coldwater Fish Stocking and Native Fishes in Arizona: Past, Present, and Future

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Abstract.—Since the 1930s almost 70 million fish representing 17 nonnative species have been introduced into lakes and streams of the Little Colorado and Black river drainages in the White Mountains of east-central Arizona. The two drainages historically contained populations of native Apache trout *Oncorhynchus apache* and a native cyprinid species, Little Colorado spinedace *Lepidomeda vittata*. Both are classified as Threatened species. The declines of these fishes have resulted from stocking of nonnative species, principally rainbow trout *Oncorhynchus mykiss*, brown trout *Salmo trutta*, and brook trout *Salvelinus fontinalis*. Establishment of nonnative salmonids was facilitated in many cases by stream renovations with fish toxicants and baitfish introductions. Habitat alterations related to land management activities, principally timber harvest and livestock grazing, further affected the Apache trout and Little Colorado spinedace. Proposed changes in stocking strategies and innovative management activities will be instrumental in sustaining these two species and other native fishes of the state.

As Europeans moved west across the continental United States they brought not only personal possessions but their habits, traditions, hobbies, pets, and desire to fish for recreation and food. Water in the southwestern United States was more limited than the colonists were accustomed to, and stream discharges commonly fluctuated from flood to drought. The native fish fauna of the region was depauperate and largely comprised of smaller minnows and killifishes (Minckley 1973; Rinne and Minckley 1991).

Alteration of natural flow patterns of the arid intermountain southwestern United States began with completion of the first U. S. Bureau of Reclamation dam in Arizona in 1911 (Figure 1). Roosevelt Dam and the dams that followed in the next half century markedly altered the hydrology of this arid region (Rinne 1990a, 1994): rivers and streams that once flowed seasonally or annually in wet cycles were now either altered in quantity and quality of water or completely dried.

Water supply reservoirs provided relatively stable water bodies and regulated downstream river flows, thereby providing habitats conducive to establishment and proliferation of nonnative sport-fish species. Stocking common carp *Cyprinus carpio*, channel catfish *Ictalurus punctatus*, and black bass *Micropterus* spp. began about 1900 and has continued to the present (U.S. Fish and Wildlife Service 1979; Stephenson 1985; Rinne, 1995). Presently, Arizona's fish fauna, numbering about two dozen native species, has been doubled by nonnative fish introductions (Figure 2). Although these introductions were largely of sport species, many nonnative minnow species were introduced as forage for sport fishes and as bait for the sport-fishing industry (Miller 1952). Several species were also introduced for biological control.

In addition to warmwater species introductions to lower elevation impoundments, nonnative salmonids, principally rainbow trout *Oncorhynchus mykiss*, brown trout *Salmo trutta*, and brook trout *Salvelinus fontinalis* were introduced into upper elevation streams and reservoirs throughout the southwestern United States. Stocking activities for sport fishes in Arizona were largely under the jurisdiction and carried out by the U. S. Fish and Wildlife Service and the Arizona Game and Fish Department (Stephenson 1985). Streams in the Rocky Mountain region already were inhabited by native cutthroat trout *Oncorhynchus clarki* and subspecies (Gresswell 1988), Gila trout *O. gilae*, and Apache trout *O. apache* (Miller 1950, 1972; Rinne 1988, 1991a, 1991b). Because of spawning habits (Rinne 1985; Rinne and Minckley 1985; Rinne et al. 1986), increased competition, or predation (Rinne et al. 1981), the native trouts declined after introductions of nonnative trouts. Furthermore, native minnows and suckers also inhabiting these upper elevation montane

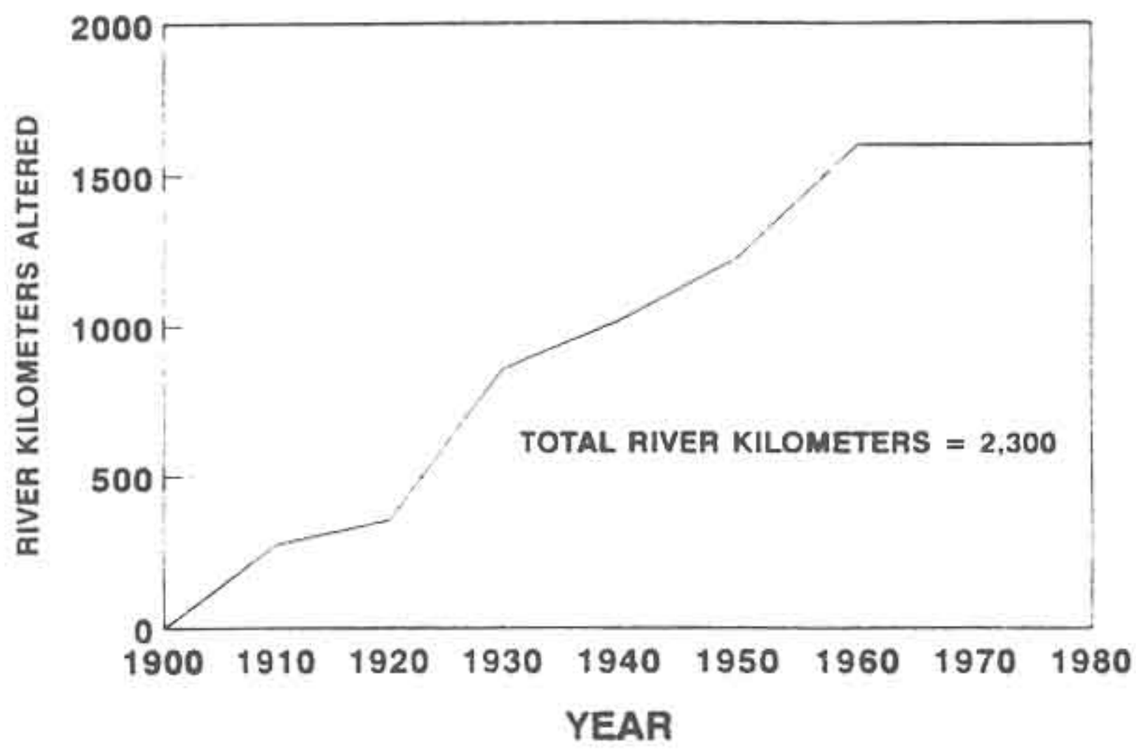

FIGURE 1.—Cumulative modification of mainstream rivers by dams in Arizona, 1900–1980.

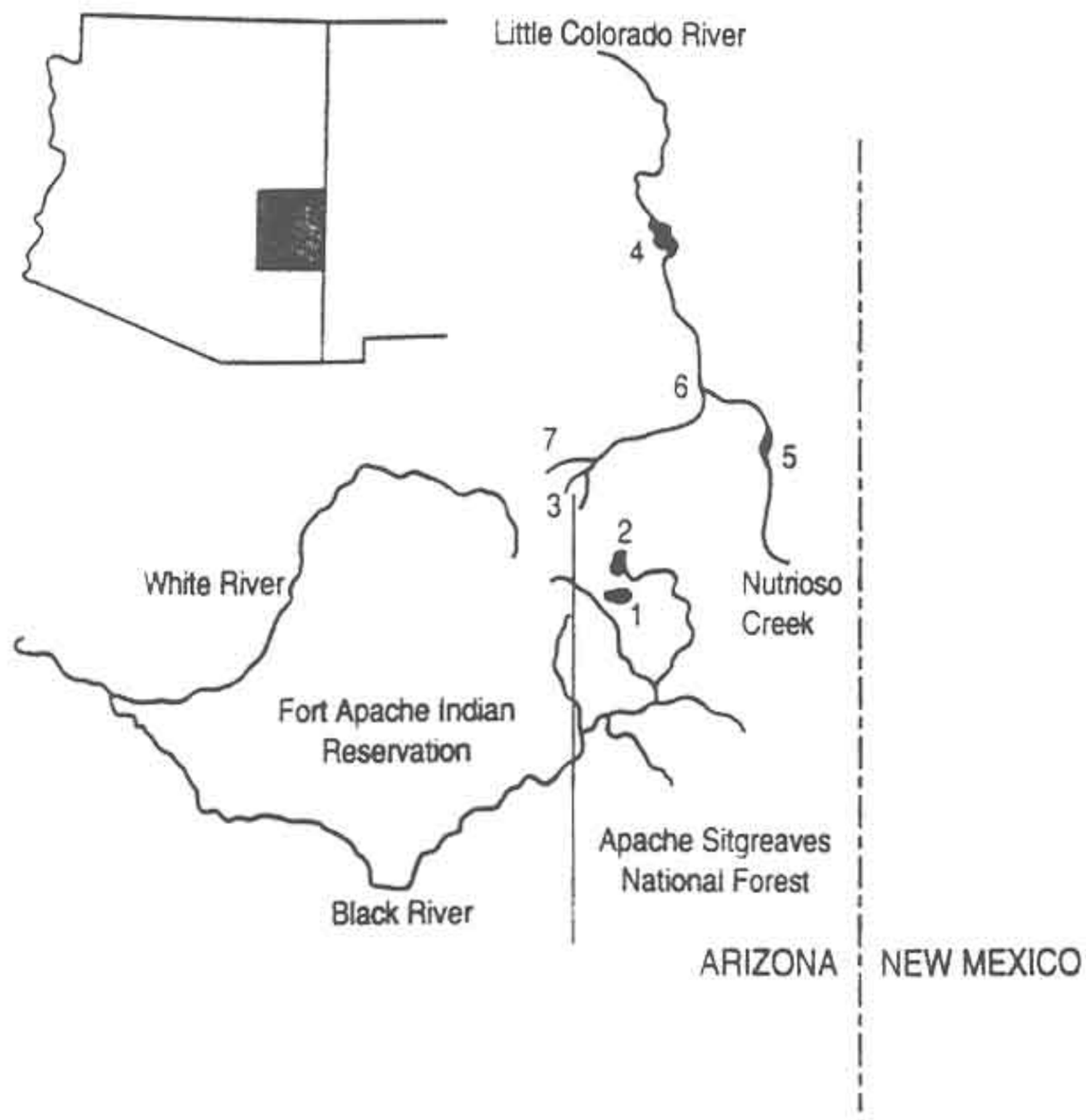

FIGURE 3.—The Little Colorado and Black river drainages in the White Mountains, Arizona. Lakes and reservoirs are (1) Big Lake, (2) Crescent Lake, (3) Lee Valley Reservoir, (4) Lyman Lake, (5) Nelson Reservoir, (6) Becker Lake, and (7) Colter Reservoir.

streams (Minckley 1973; Rinne and Minckley 1991; Rinne and Medina, in press) were affected through predation by the nonnative salmonids (Blinn et al. 1993). In addition to the widespread introductions of nonnative salmonids stocked from hatcheries, management activities including fish eradications were common practice to enhance survival of nonnative salmonids (Rinne and Turner 1991).

In this paper we discuss (1) coldwater stockings of principally salmonid species in the White Mountains of east-central Arizona, (2) management activities and regulations attendant to sport-fishery management, and (3) changes in agency philosophy to restore native fishes.

Stocking History

Since the 1930s over 61 million nonnative sport fishes have been introduced into lakes in the Little Colorado and Black river drainages (Figure 3; Table 1). In addition, about 8 million nonnative sport fish were introduced to these two rivers and their tributaries (Tables 2 and 3). Combining lake and stream introductions, almost 41 million hatchery-cultured nonnatives were stocked into the Black River system and 28 million individuals were stocked into all water bodies in the Little Colorado River system. In addition to sport fishes, fathead minnows, tadpoles, and crayfish were introduced as bait in lake environments. Stockings consisted predominantly of rainbow trout (60%), followed by cutthroat trout (12%), brook trout (7%), and brown trout (3%).

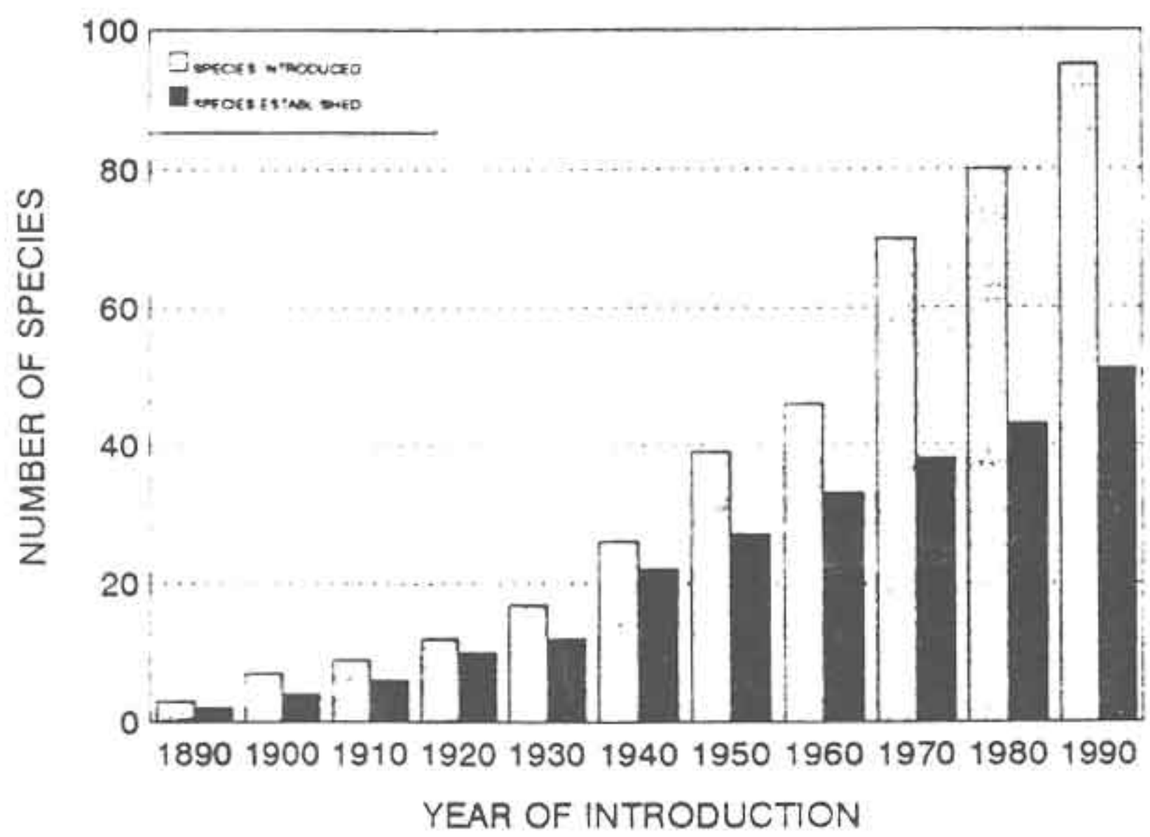

FIGURE 2.—Nonnative fish species introduced and established in Arizona, 1890–1990.

Effects of Introductions

The Little Colorado and Black river drainages are part of the historic range of Apache trout and Little Colorado spinedace *Lepidomeda vittata*. These two native species are currently listed as Threatened under the Endangered Species Act of 1973 (16 U.S.C.A. §§ 1531 to 1544). The Apache trout ranged throughout the headwaters of the Black, White, and Little Colorado rivers (Minckley 1973; Rinne 1985). Rinne and Minckley (1985), based on morphometric evidence, documented that pure populations of the native Apache trout occurred in streams where rainbow trout were not

TABLE 1.—Nonnative fishes stocked into White Mountain lakes, Arizona, 1930–1991.

Lake and year	Species	Number of stocking events	Number stocked
Becker			
1937	Largemouth bass[a]	1	510
1979–1982	Fathead minnow[b]	2	750
1985	Brook trout	1	10,000
1978–1988	Brown trout	14	121,700
1979–1987	Cutthroat trout	6	135,100
Big			
1940–1970	Arctic grayling[c]	33	3,941,000
1936–1991	Brook trout	41	1,532,000
1942	Brown trout	1	400
1940–1991	Cutthroat trout	61	6,604,000
1936–1939	Native cutthroat trout[d]	7	178,000
1936–1991	Rainbow trout	234	11,434,356
1968	Tadpole[e]	1	575
Colter			
1973–1982	Brook trout	2	15,000
1952–1975	Brown trout	4	16,600
1953–1978	Rainbow trout	12	87,560
Concho			
1977–1991	Brook trout	22	619,000
1971	Crayfish	1	325
1980–1991	Cutthroat trout	7	245,300
1957	Rainbow trout	123	4,213,000
Crescent			
1973–1991	Brook trout	31	1,008,000
1945–1953	Cutthroat trout	7	482,000
1940–1991	Rainbow trout	141	3,837,000
Lee Valley			
1965–1991	Arctic grayling[c]	11	107,500
1953–1985	Brook trout	28	356,300
1955–1991	Rainbow trout	4	50,800
Luna			
1943–1991	Brook trout	19	502,200
1935–1979	Brown trout	5	126,900
1952–1990	Cutthroat trout	10	316,400
1958–1964	Kokanee[i]	2	156,100
1937–1938	Native cutthroat trout[d]	4	154,100
1937–1991	Rainbow trout	222	7,084,251
1986	Tadpole[e]	1	2,700
Lyman			
1978	Black crappie[g]	1	20,000
1935–1976	Bluegill[h]	4	6,993
1953–1968	Brown trout	8	219,000
1965–1991	Channel catfish	24	1,678,000
1952–1966	Cutthroat trout	4	369,000
1978	Fathead minnow[b]	1	40,000
1935–1991	Largemouth bass[a]	8	40,500
1967–1973	Northern pike[i]	8	303,100
1952–1991	Rainbow trout	89	3,184,000
1979	Redear sunfish[j]	1	15,000
1967	Tadpole[e]	1	5,000
1959	Threadfin shad[k]	1	750
1973–1984	Walleye[i]	6	3,250,000
1979	Yellow perch[m]	1	100,000
Nelson			
1977–1991	Brook trout	18	450,400
1978–1991	Brown trout	10	73,100
1975	Channel catfish	1	10,000
1987–1991	Cutthroat trout	10	208,300
1958–1991	Rainbow trout	106	3,312,000
1968–1969	Tadpole[e]	2	9,500

(Continued on next page)

TABLE 1.—Continued.

Lake and year	Species	Number of stocking events	Number stocked
Showlow			
1969	Arctic grayling[c]	1	5,000
1982–1989	Brook trout	5	138,700
1986	Bluegill[h]	1	3,000
1977–1991	Brown trout	21	391,100
1976–1991	Channel catfish	19	149,700
1972	Cutthroat trout	1	15,000
1960	Kokanee[f]	1	20,000
1969–1970	Northern pike[i]	3	125,000
1954–1991	Rainbow trout	386	3,918,000
Total			61,399,570

[a]*Micropterus salmoides*; [b]*Pimephales promelas*; [c]*Thymallus arcticus*; [d]black spotted mountain cutthroat trout and Wyoming native cutthroat trout *Oncorhynchus clarki* subsp.; [e]*Rana* spp.; [f]lacustrine sockeye salmon *Oncorhynchus nerka*; [g]*Pomoxis nigromaculatus*; [h]*Lepomis macrochirus*; [i]*Esox lucius*; [j]*Lepomis microlophus*; [k]*Dorosoma petenense*; [l]*Stizostedion vitreum*; [m]*Perca flavescens*.

stocked on a sustained basis. Rainbow trout introduced into waters of the Black River drainage (Tables 1 and 2) have negatively affected the Apache trout through hybridization (Miller 1972; Rinne 1985; Rinne et al. 1986). In addition, the extensive introductions of brook and brown trouts reduced Apache trout distribution and abundance through competition for food and habitat (Rinne et al. 1981).

The Little Colorado spinedace occurred throughout the Little Colorado River drainage (Miller 1963; Minckley and Carufel 1967). Distribution and abundance of this species are now greatly reduced (Miller 1963; Minckley and Carufel 1967; Minckley 1984). Rainbow trout prey on Little Colorado spinedace, and Little Colorado spinedace abundance is inversely related to rainbow and brook trout abundance (Blinn et al. 1993).

The effects of other introduced sport and bait fishes that are abundant in waters now occupied by the Little Colorado spinedace in streams in the White Mountains are unknown. Interbasin transfers of bait species and a lack of consideration for the recipient drainage and its fauna is a national and international problem (Litvak and Mandrak 1993). The baitfish industry has had considerable influence in the lower Colorado River (Miller 1952). Bullfrog tadpoles, for example, are opportunistic in feeding habits (Clarkson and Devos 1986) and could negatively affect fry and larvae of native and juvenile fishes. The movement of introduced minnows, crayfish, and frogs from one habitat to another by anglers, although illegal, continues today.

Fishery management activities to ensure the success of nonnative sport fishes also impacted the native ichthyofauna. In the 1950s and 1960s management activities for salmonid sport fisheries in upper elevation montane streams involved extensive removal of native fish with toxicants. In most cases, these fishes were minnows and suckers, some of which are now Rare, Threatened, or Endangered species. Earliest records are from the 1950s when toxaphene was used to eradicate fish from Lyman and Becker lakes (Hemphill 1954). Effects of the toxicant downstream in the Little Colorado River were not measured. However, the Little Colorado spinedace was noted as part of the kill in that eradication activity. Because 23 km of stream treated on the Little Colorado River between Springerville and Lyman Lake were prime Little Colorado spinedace habitat, the effect on Little Colorado spinedace probably was significant.

Reports in the 1960s referred to most stream renovation activities as "minor stream habitat manipulations of a developmental nature" (Bruce 1961). Stream renovations with rotenone were extensive in the state of Arizona in the early 1960s; Rinne and Turner (1991) reported 135 km treated with fish toxicants during 1958–1968. More recent efforts have been designed to remove nonnative sport salmonids and reintroduce the Apache trout—a native, and potential, sport species (Table 4). Often, however, other species such as speckled dace *Rhinichthys osculus* and desert sucker *Catostomus clarki* were natural components of the native fish community in these montane streams and were adversely affected. Restoration of natural fish communities was incomplete at best.

Land Management

By the 1930s, as sport-fish management was being initiated in the White Mountains, these lands already had sustained extensive timber harvesting and livestock grazing for a quarter of a century or more. Maximum timber harvest was the primary objective of multiple use management. Effects of logging on

TABLE 2.—Nonnative fishes stocked in streams in the historic range of Apache trout in the Apache Sitgreaves National Forest, White Mountains, Arizona, 1920–1991.

Stream and year	Species	Number of stocking events	Number stocked
Bear Wallow Creek			
1920–1933	Native cutthroat trout[a]	4	9,400
1933	Brook trout	1	6,400
1935–1954	Rainbow trout	2	2,300
Beaver Creek			
1939–1953	Rainbow trout	2	6,700
1933–1977	Brown trout	2	6,500
Black River			
1959–1981	Brown trout	3	6,981
1938–1981	Rainbow trout	50	45,430
East Fork Black River			
1969	Arctic grayling	1	10,000
1933–1940	Brook trout	6	48,620
1935–1977	Brown trout	50	286,267
1933–1937	Native cutthroat trout[a]	5	57,760
1933–1991	Rainbow trout	692	1,427,350
North Fork Black River			
1969	Arctic grayling	2	10,000
1933–1963	Brook trout	2	30,500
1938–1959	Brown trout	11	48,515
1936–1986	Rainbow trout	174	143,541
West Fork Black River			
1970	Arctic grayling	1	5,100
1935–1937	Brook trout	3	50,400
1938–1981	Brown trout	20	76,149
1938	Native cutthroat trout[a]	2	6,100
1934–1991	Rainbow trout	705	573,130
Boggy and Centerfire Creeks			
1941–1975	Brown trout	3	5,000
1937	Native cutthroat trout[a]	2	2,688
1938–1948	Rainbow trout	3	4,838
Conklin Creek			
1933	Brook trout	1	5,400
1933	Native cutthroat trout[a]	1	5,400
Fish Creek			
1933	Brook and cutthroat trout	1	900
1954	Brown trout	1	1,000
1935–1952	Rainbow trout	6	26,620
Wildcat Creek			
1966–1975	Rainbow trout	2	2,600
Willow Creek			
1933	Brook trout	1	6,400
1933	Native cutthroat trout[a]	1	6,400
Total			2,924,389

[a]Black spotted mountain cutthroat trout and Wyoming native cutthroat trout.

riparian vegetation and instream habitat for the Apache trout and Little Colorado spinedace were not considered. Trees were cut adjacent to stream channels, and logging roads became as numerous as the streams themselves. These roads frequently crossed and recrossed the streams and increased sediment in stream channels. These effects are typical of how forest management practices affect the aquatic environment (Lynch et al. 1977; Rinne 1990b; Rinne and Medina, in press).

An essential component of sustaining and enhancing native fishes is ownership of stream habitat (Rinne 1994, 1995). Most of the watersheds of the two river drainages in the White Mountains is under

TABLE 3.—Nonnative fishes stocked into streams historically containing Little Colorado spinedace in the White Mountains, Arizona, 1930–1991.

Stream and year	Species	Number of stocking events	Number stocked
Colter Creek			
1933	Brook trout	1	3,800
1933	Native cutthroat trout[a]	1	3,800
1936–1963	Rainbow trout	5	19,500
1936	Brown trout	1	300
Little Colorado River			
1975	Brook trout	1	500
1975	Channel catfish	1	10,000
1969–1975	Rainbow trout	3	2,550
Upper Little Colorado River			
1968–1975	Brook trout	2	6,000
1933–1966	Brown trout	63	593,200
1973	Coho salmon[b]	1	1,800
1937	Native cutthroat trout[a]	1	11,200
1933–1991	Rainbow trout	1,100	1,906,700
East Fork Little Colorado River			
1935	Brook trout	1	2,500
1940–1958	Brown trout	5	21,850
1933	Native cutthroat trout[a]	1	14,000
1937–1989	Rainbow trout	96	111,013
South Fork Little Colorado River			
1938–1975	Brown trout	5	33,200
1938	Native cutthroat trout[a]	1	2,500
1937–1991	Rainbow trout	510	266,750
West Fork Little Colorado River			
1935–1937	Brook trout	2	29,264
1946–1973	Brown trout	17	59,394
1973	Coho salmon[b]	1	480
1933	Native cutthroat trout[a]	1	44,000
1936–1991	Rainbow trout	879	975,428
Nutrioso Creek			
1937	Rainbow trout	1	2,400
1935	Brown trout	1	6,100
Paddy Creek			
1935	Brook trout	1	500
1933	Native cutthroat trout[a]	1	7,000
1936–1947	Rainbow trout	4	20,060
Silver Creek			
1983	Brook trout	1	1,000
1934–1963	Brown trout	18	194,830
1969–1983	Channel catfish	4	10,600
1937–1991	Rainbow trout	297	533,123
Total			4,895,342

[a]Black spotted mountain cutthroat trout and Wyoming native cutthroat trout.
[b]*Oncorhynchus kisutch.*

U.S. Forest Service jurisdiction. However, native fish species such as Apache trout and Little Colorado spinedace have fragmented distributions. Frequently, critical stream reaches are necessary for their survival. For this reason, a 2.4-km reach of Nutrioso Creek immediately upstream of Nelson Reservoir (Figure 3), critical habitat for Little Colorado spinedace, was acquired by the U.S. Forest Service in a land exchange in 1993. Also in 1993, the Arizona Game and Fish Department (Department) acquired 3.2 km of the Little Colorado River immediately north of Springerville, Arizona, and the watershed for Rudd Creek, a 3-km tributary of Nutrioso Creek (Figure 3). The latter acquisition will secure habitat for both the Apache trout and Little Colorado spinedace.

TABLE 4.—Stream renovations conducted and proposed in the Black and Little Colorado river drainages, Apache Sitgreaves National Forest, Arizona, to reestablish Apache trout.

Stream	Year	Stream length treated (km)	Target species removed
	Completed to Date		
Bear Wallow Creek	1981	18.0	Rainbow and hybrid trouts
Lee Valley Creek	1982	4.8	Brook trout
	1987	4.8	Brook trout
Home Creek	1987	11.3	Rainbow trout
Wildcat Creek	1988	6.5	Rainbow trout
Hayground Creek	1989	6.5	Brown trout
Total		47.1[a]	
	Proposed		
West Fork Black River		8.0	Brown trout
Thompson Creek		3.2	Brown trout
Burro Creek		9.6	Brown trout
Stinky Creek		3.8	Brown and hybrid trouts
Snake Creek		7.2	Brown and hybrid trouts
Bear Wallow Creek		18.0	Rainbow and hybrid trouts
Total		49.8	

[a]Represents net kilometers: Lee Valley was treated twice.

Domestic livestock grazing had its inception even earlier than the timber industry. In the late 1800s cattle grazing was unrestricted on the White Mountain landscape prior to its designation as U.S. Forest Service land. Lack of regulation led to overstocking of the rangeland, which resulted in degradation of ground cover across watersheds and increased sediment delivery to stream channels. In addition, livestock congregated in stream bottoms during hot, dry periods and negatively affected riparian vegetation.

By the time of the Taylor Grazing Act of 1934 (43 U.S.C.A. §§ 315 et. seq.) in the 1930s, the Multiple Use and Sustained Yield Act of 1960 (16 U.S.C.A. §§ 528 to 531), and the environmental legislation in the late 1960s and early 1970s, much of the impact to these two native fishes and their habitats had occurred (Rinne and Medina, in press). Almost a century of land use and more than half a century of extensive sport-fish management had brought these two fishes to the brink of extinction.

In summary, the combination of extensive nonnative sport-fish introductions into waters of the Black and Little Colorado river drainages accompanied by stream renovations with fish toxicants, baitfish introductions, and devastating land management activities has negatively affected the Apache trout and Little Colorado spinedace and their habitats.

Management Strategies

Current Activities

Trout angling is a large component of the overall sportfishing industry in Arizona (Persons 1990). Over 130,000 anglers prefer to fish for trouts and most of this activity is on mountain lakes and reservoirs (Persons 1990). Today, trout fishing in Arizona is the result of more than 60 years of hatchery development and introduction of trouts into streams and lakes in the wild (Stephenson 1985). In 1988, over 5 million trout were stocked into Arizona waters by state and federal hatcheries (Arizona Game and Fish Department 1990) at a cost of US$1.2 million. Any significant changes in management that will reduce trout fishing opportunities must be approached with caution. Changes will have economical, political, and social implications for both the Department and the state of Arizona. Currently, 380,000 anglers spend $57–79 on an average fishing trip and contribute $355–561 million into the Arizona economy annually (Anonymous 1992).

Indeed, from the 1930s to the early 1980s the fisheries program in Arizona was insensitive to native fish management. The Department now recognizes the need to manage for both sport and native fishes in Arizona. The Department must be innovative in managing both coldwater sport fisheries and native, nongame species (Cain 1993).

Currently, fisheries managers are at the crossroads of opportunity to commence positive, innovative, and aggressive management activities to sustain native fishes in Arizona. Socially and politically, the climate is more favorable than in the past. Department fishing license sales have decreased gradually since 1986. Almost two-thirds of Arizona residents believe that every effort should be made to manage native fishes—even if it means restricting stocking of sport fishes such as trout (Behavior Research Center, Inc., Phoenix, Arizona, 1992). In addition, 26% of Arizona anglers think we should do everything we can to preserve native fish (Anonymous 1992). The Department has recognized not only the responsibility but the opportunity to effect important management measures that will enhance both native fish ranges and populations.

Some changes have already taken place. By Department policy enacted in 1982, no additional

nonnative species will be stocked into the waters of the state. Furthermore, no additional species (native or nonnative) will be transplanted into a watershed or range where it currently does not exist. Also, baitfish regulations keep anglers from transporting baitfish between lakes and from one area of the state to another, and baitfish are not allowed as a legal method of take in over half of the state.

Native fishes were included in the Department's sport-fish management program beginning in 1984. However, to date, only the Apache trout has received considerable attention. Plans are now underway to establish and maintain lake fisheries for the Apache trout in addition to those already in existence in Bear Canyon Lake, Lee Valley Reservoir, and Becker Lake.

In contrast to the 1960s, the current objective of stream renovations is to remove nonnative salmonids and reestablish or enhance native trouts (Minckley and Brooks 1985; Rinne and Turner 1991). Within the historic range of Apache trout, for example, stream renovation projects to remove rainbow, brown, and hybrid trouts and reintroduce Apache trout are ongoing (Table 4). Apache trout are raised in hatcheries or salvaged from wild populations for reintroduction. All stocked fish are first generation progeny of cultured stock of pure strain Apache trout from the type locality, East Fork of the White River. In addition, nonnative salmonids are not stocked into streams containing Apache trout populations. However, the mainstream Black and Little Colorado rivers and Silver Creek were stocked with nonnative trouts as recently as 1991 (Tables 2 and 3).

Future Opportunities

Put-and-take fisheries for Apache trout will be developed on the mainstream Little Colorado and Black rivers where rainbow trout are currently stocked. The Department, the U.S. Forest Service, and Trout Unlimited have initiated a program to enhance the Apache trout on the West Fork of the Black River (U.S. Forest Service 1993). This project encompasses about 29 km of the mainstream West Fork of the Black River and an additional 30 km of tributary streams; management activities include special fishing regulations, habitat improvement including instream and streambank structures, willow plantings, road closures, and vegetation management via fencing and grazing strategy alteration. Stream renovations involving habitat enhancement and removal of nonnative species with fish toxicants will be major components of this project (Table 4). This project alone will increase the stream kilometers reclaimed for Apache trout on the Black River drainage by almost 50%. With additional renovations of Snake and Bear Wallow creeks, current stream kilometers reclaimed for Apache trout will be doubled.

It has been relatively easy to conduct stream renovations that replace nonnative trouts with Apache trout. This native trout has sportfishing potential, and efforts to restore it are accepted by the public. However, implementing future stream renovations and removing nonnative sport species (trouts) and reestablishing a native, nonsport species will be both more controversial and less easily implemented. Adoption of the same course of action to reestablish the Little Colorado spinedace, which has no recreational value, will be the true test of public support for native fish management in these two montane river systems and in Arizona in general.

Native fish management is long overdue in Arizona. New approaches will be phased into the current coldwater sport-fish management program throughout the state. Several different strategies will be used to introduce native fishes and yet maintain sportfishing opportunities for nonnative trouts. Key watersheds and drainages will be designated specifically for the management of native fishes. In addition, native fish management will be integrated into some existing sport-fish populations to provide sustainability of both. Often, this will involve placement of natives upstream from habitats occupied by nonnative fishes and separation by either natural or artificial barriers (Rinne and Turner 1991). Land acquisitions will more readily facilitate designation of these waters as special management areas for the Apache trout, the Little Colorado spinedace, and other native species.

Many montane streams have been impounded for irrigation or recreation purposes. An alternative to spatial separation of nonnative and native species may be strain or special species management. Here, strains or species that will not have the same competitive effect, will not reproduce, or that are less piscivorous will be used for sport-fish management. Certain strains of rainbow trout or genetically altered rainbow trout, Arctic grayling, and kokanee will be utilized in the new management strategy.

The basic philosophy for stocking coldwater species for sportfishing will no longer be dictated by angler demands (e.g., size and diversity of stock) but rather by the probable effect on the native

species. To accomplish this, we need to realign the thinking of our many constituents through education. Both Department and private avenues of educating the public will be needed to attain success in this area. The Apache trout, and perhaps the Gila trout, will be used in the future for coldwater sportfishing. Rinne (1988) suggested that promotion of the Apache and Gila trouts for sportfishing will aid in their long-term sustainability through angler affiliation with the species.

Timely and effective management of native species in the state will reduce the probability of loss of native fishes and will prevent listing as Endangered species. Endangered status can limit management alternatives and curtail or eliminate recreational sportfishing.

Conclusions

Management of native fishes and sport fishes in Arizona is at the crossroads. The challenge to institutionalize management and conservation activities for native fishes is great. Changes in the Department in both the philosophy of management for native fishes and actual activities on the ground have occurred. An ecosystem or watershed approach to managing riparian-stream areas that provide fish habitat will be equally important and essential in sustaining changes in fisheries management.

It took many years to bring about the decline of native fishes because of past management philosophy; it will also require some time to reverse this trend and reach the goal of native fish sustainability. However, time is a precious commodity and may be short for species such as the Little Colorado spinedace. Achieving the goal of a compatible nonnative and native fisheries program will require both immediate and novel sport-fish-native-fish management and proper stewardship of the habitats these native species will require to perpetuate themselves.

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