This is a preprint of an article published in *Aquatic Conservation: Marine and Freshwater Ecosystems*, Vol. 17: 737-748 (2007).
http://www.interscience.wiley.com

Habitat mapping and conservation analysis to identify critical streams for Arizona's native fish

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ABSTRACT

1. Arizona's native fish species are among the most imperiled fauna in North America. Knowing the current distribution of native fish and their habitat is critical to their management and conservation, but the last detailed mapping effort was more than 30 years ago and predated computer mapping techniques.

2. Current distribution of 34 native fish species was modeled by identifying perennial stream segments for which species presence had been documented. A composite of these single-species maps displays a pattern of species richness that can inform conservation, especially when overlaid with maps of management status or invasive species.

3. The map overlays suggest that conservation priorities should include Eagle Creek, the Verde River and its tributaries, Aravaipa Canyon, the Virgin River, and Black Draw, which together hold 63% of native fish species. Of the 32 streams which support 5 or more native species, 28 have at least one non-native fish species, indicating that a more aggressive program of removing non-natives may be critical to maintaining those native populations.

4. The U.S. Forest Service and Native American tribes administer the majority of occupied stream habitat (30 and 27%, respectively). While private lands hold the third-highest amount of occupied habitat (19%), they control streams occupied by the greatest total number of native species (30). Conservationists should work more with private land owners, while also coordinating efforts with the U.S. Forest Service and North American tribes.

5. These data are publicly available (on the Internet, URL: *www.azconservation.org*) to encourage refinement and use.

KEY WORDS

Arizona; fish; conservation; distribution; GIS; land management; priority

INTRODUCTION

Of all declining native species in Arizona, fish may have suffered the biggest losses (Minckley and Deacon, 1968; Williams *et al*., 1985; Minckley and Rinne, 1991; Olden and Poff, 2005). Arizona has been ranked first among U.S. states in the proportion of native freshwater species at risk of extinction (Stein, 2002). One species, the Santa Cruz (Monkey Springs) pupfish (*Cyprinodon arcuatus*) has gone extinct due to human activities (Minckley *et al*., 2002). Of the 35 remaining native species or subspecies, 21 are federally listed as endangered, threatened, or candidate (Table 1; for this study, native refers to species found historically within Arizona).

These declines have a variety of causes. Some fish species suffered extensive habitat loss from the dewatering of at least 35% of the state's formerly perennial rivers (Minckley, 1973; Brown *et al*., 1981; Mueller and Marsh, 2002). Non-native fish, especially predatory species introduced for sport fishing, were probably responsible for reducing or eliminating the natives in many stream reaches, especially in dam-controlled streams where the natives were already stressed by habitat alteration (Marsh *et al*., 1990; Moyle and Williams, 1990; Minckley *et al*., 2003). Dams form physical barriers that fragment fish habitat, while altering stream characteristics both up- and downstream in ways that vary according to dam operations (Poff *et al*., 1997; Poff and Hart, 2002). Terrestrial activities such as agriculture, grazing, logging, mining, road construction, and urbanization can negatively affect fish by altering important instream habitat components such as flow levels, stream banks, channel characteristics, and stream substrate (Baron *et al*., 2002; Richter *et al*., 1997; Kershner *et al*., 2004).

Most of these activities are already regulated and could be better managed to reduce their impacts on native fish if information were available about current species distributions. However, the broad scope of some activities and the limited resources for restoration and protection suggest an urgent need to focus such efforts.

A useful step for conservation action is to evaluate and prioritize watersheds (Moyle and Yoshiyama, 1994; Moyle and Randall, 1998). Thus, many landscape-scale comparisons of fish habitat for conservation planning would benefit from the ability to intersect watershed condition and management with fish distribution.

Prior to this effort, data on Arizona's native fish distributions has been inadequate to support conservation planning efforts. The last detailed maps showing stream reaches were published by Minckley (1973), predating the development of digital cartography and additional habitat losses. Despite the fact that most fish populations in Arizona are distributed in a linear fashion along perennial or intermittent streams, more current fish distribution data for Arizona have identified point locations (i.e., specimen or sampling localities) or large watersheds (e.g., data available on the Internet, URL: www.peter.unmack.net/gis/fish/colorado).

This study provides the first complete analysis of native fish distribution for Arizona mapped to streams and in which species occurrences are overlain with land ownership or management. It allowed us to prioritize conservation efforts by identifying those streams with the greatest species richness, on the principle that it is most efficient to first protect streams with the most native species, then focus on extremely rare species that occur in smaller assemblages. It also allowed us to identify overlap between native and non-native species, and to identify land owners who directly or indirectly manage the habitat through use of the water, alteration of the streams, or activities in the watersheds. The authors believe that this is the most detailed and extensive mapping of fish distributions by stream length at the resolution of 1:100,000 for any state in the western USA.

METHODS

Using a Geographic Information System (GIS) approach, spatial data layers were compiled to create a more current Arizona native fish distribution database. These included digitized point localities for native fish from the Arizona Game and Fish Department's (AGFD) Heritage Data Management System, current to September 7, 2004. This information was supplemented by the SONFISHES database compiled by the late Dr. Wendell Minckley for ichthyology specimens (Fagan *et al*., 2002). Further data were obtained from U.S. Fish and Wildlife Service (Sponholtz *et al*., 2003), U.S. Forest Service, and AGFD native fish program. This study used only recent observations, those dating from 1975 or later, comprising 18,568 separate records.

The goal of the database was to associate these point occurrences with linear stream reaches that possess perennial flow. The baseline map for perennial flow was incorporated from an Arizona Land Resource Information System (ALRIS) GIS layer ("STREAMS" dated 1993). After removing constructed ditches and aqueducts, the ALRIS data layer was augmented with a small number of perennial reaches identified in a statewide riparian inventory (AGFD, 1993), current perennial stream mapping compiled by Pima County, and perennial reaches in the Galiuro Mountains mapped by The Nature Conservancy. The study included the full length of the Colorado River along the state's western border as an Arizona stream. This combined definition for the location (begin and end) of perennial flow was transferred to a selection of the National Hydrography Dataset (NHD), a GIS product from the U.S. Geological Survey. The final map of perennial flow includes thalwegs but not shorelines for lakes and reservoirs. Arizona has only three natural lakes, none of which contain native fish, and the majority of reservoirs contain only non-native fish species.

With a consultant, each perennial stream reach was attributed with each native fish species present and the total number of species found there. The attribution process was based on the proximity of each point (<1.6 km from the stream segment) and the stream name listed in each point's "locality" data field. Data points which could not be unambiguously attributed to a nearby perennial stream were excluded. Several additional classes of data were excluded because the data were not specific to stream systems or to comply with Arizona Game and Fish Department policy constraining the release of point locality data. For example, fish occurrences tied to non-linear features such as tanks, isolated springs not otherwise associated with a stream system, or vague locality descriptions for non-stream locations were excluded.

The final product was a linear “event” referencing database. In the realm of GIS, events are tabular records with spatial or temporal descriptions that can be mapped to point, line, or polygon files. In this case, reach measures were developed for each stream in the NHD subset (e.g., the headwaters of “Stream X” are measured as “0 meters”, and its downstream, along-the-thalweg confluence with “Stream Y” is at “90,000 meters”). Then, event tables were constructed for each species, such that native fish presence was described as occurring from one reach measure to another (e.g., “Fish B” occurs along “Stream X” from “12,480 meters” to “90,000 meters”). Standardized conventions were used to provide unique names for unnamed streams and multiple streams with the same name (e.g., there are 17 streams named “Ash Creek” in Arizona).

This forms a compact database with high spatial integrity. Rather than 34 separate GIS layers corresponding to the 34 native fish species, the database contains one GIS layer for hydrography to which 34 stand-alone tables are referenced. Therefore, there is no possibility that edits to species’ distributions will alter the underlying stream-channel geometry. This is important in a setting where information is accessed and edited by multiple investigators. The tables can be easily updated or augmented with other species or attributes, and can be analyzed using linear overlays with readily-available GIS tools. The tables can also be manipulated outside the GIS environment, e.g. with Microsoft Excel, without damaging their integrity as GIS data.

Finally, the perennial stream reaches were evaluated for breaks in continuity. Where breaks in stream continuity with biological significance (e.g., ephemeral reaches, dams) could be identified, attribution for a given species stopped at the break and only resumed on the next segment if there was an additional record adjacent to that segment. Since most of Arizona's lakes are human artifacts and managed for sport fishing of non-native species, every lake was assumed to be not occupied by native fish unless there was a recent record from it. For this study, it was also assumed that all perennial stream segments constitute potential fish habitat, regardless of the specific habitat preferences of particular species.

The resulting map was refined by comparison to published and unpublished reports on species distributions and habitat requirements (Minckley, 1973; Marsh *et al*., 1990, 2003; Mueller and Marsh, 2002) and to verify and refine the bounds of currently-occupied habitat.

Through a series of intersections, the fish distribution map was compared to GIS layers for surface management (ALRIS "LAND" dated 01/2001), and dams (National Inventory of Dams, dated 02/2005). Through visual inspection, it was also compared to point data for non-native fish species in the SONFISHES database (Fagan *et al*., 2002).

RESULTS

This effort produced a native fish event database and an updated map of perennial streams for Arizona that can be used for analysis, planning, and map creation on a variety of scales, based on total species richness or the presence of individual species (Figure 1,

Table 1). This is publicly available (data available on the Internet, URL: *www.azconservation.org*) to encourage refinement and use.

The combination of these data sets shows that Arizona contains 8,514 km of perennial streams, of which 5,990 km (70%) contain native fish. These include 217 unique streams. Five of those streams are tributaries to river systems in Mexico while the remainder are part of the Colorado River system. Federally protected fish species occupy 3,369 km, 40% of the total.

Patterns of species richness suggest several priorities for conservation management. These include Eagle Creek, the Verde River and some of its tributaries (East Verde River, Fossil, Oak, and West Clear Creeks), Aravaipa Canyon, Virgin River, and Black Draw (Table 2). Each of these systems supports six or more native fish species, and together they hold populations of 22 of Arizona’s native fish species. Black Draw is among the tributaries to Mexican river systems, and contains all the Arizona species that are not native to the Colorado River system. A triage approach to native fish conservation suggests that efforts should focus on these streams, along with the small set of other streams which support the remaining species.

Among those high-richness streams, all but four of the shortest streams also have exotic fish species (Table 2). The documented richness of non-native fish ranges up to 28 species in the Salt River, more than 5 times the current native richness in that stream.

Arizona has at least 95 dams on perennial streams, ranging from 2-182 m in height. Of the 32 streams which support 5 or more native fish species, 7 have at least one dam (Table 2). Dam presence and native species richness were both correlated with longer stream length (regression ANOVA, $p<0.001$ for both, $r^2=0.24$ and 0.22 respectively, excluding the Colorado River).

Comparing the results with land management status produced several insights. Streams controlled by private land owners collectively harbor 30 out of the 35 native fish species (Figure 2), and represent the third-highest total length of occupied and potential habitat (19 and 16% of the state totals, respectively; Figure 3). The U.S. Forest Service and tribal lands contain the greatest amount of fish habitat, both occupied (30 and 27%, respectively) and potential (32 and 30%), but rank fourth and fifth in species richness (Figure 2). Looking at just those streams with five or more native fish species present, the Forest Service has more than double the stream length of this species-rich habitat than either tribal or private lands.

To test the utility of this data set for fine-scale analysis, conditions were examined along the stream with the highest species richness, Eagle Creek. It has nine native fish species, one of which was reintroduced, along with recent records for nine exotic fish species. Intensive sampling has found that the distribution of natives was not consistent along the stream's length (Marsh *et al*., 1990). The stream has perennial flow for approximately 94 km, but nine species are known from the upper 30 km of that, while eight of those species are in the middle 9 km, and seven of those species in the lower 55 km. Species diversity and relative abundance of native fish were inversely correlated with those of non-native fish, with the biggest differences observed above and below a diversion dam (Marsh *et al*., 1990). Analysis of the GIS data shows private land owners control almost half of the stream's length, with most of the remainder split between the

Apache-Sitgreaves National Forest and the San Carlos Indian Reservation. However, a stream’s quality and quantity is strongly affected by the watershed that supplies it, and for Eagle Creek, private land makes up only 4% of the 172,000-ha watershed. In contrast, more than half of the watershed is within the reservation, making it clear that Eagle Creek can be maintained for biodiversity only if our conservation strategies engage with reservation land managers (Figure 4).

DISCUSSION

Arizona has an active program to manage and conserve native fishes, and several independent groups vigorously advocate for fish conservation efforts, but a complex legal and administrative environment has created barriers to success. The Arizona Game and Fish Department is mandated to manage the state’s wildlife yet controls very little of the land or water that constitutes wildlife habitat. Several other state and federal agencies, along with several Native American tribes, collectively control 82% of the state’s land surface and thus affect conditions in most of the aquatic habitat. A wide array of private, municipal, and other parties own rights to the water in the state’s streams and the groundwater supporting those surface flows, all within a legal framework that does not require maintenance of surface flows for aquatic organisms. As Arizona’s population grows, development of land and demand for water will also grow, predictably increasing the challenges for native fish conservation.

Our analyses suggest several priorities for conservation efforts. A focus on streams which still retain high species richness of native species should maximize the impact of protection or restoration efforts. Statewide, National Forest managers, Native American tribes, and private land owners control most of the perennial streams and thus are leading candidates for cooperative conservation efforts. On a local scale, the most important partners may vary according to the needs of a site. In the case of Eagle Creek, management efforts that focus on instream water management would likely emphasize working with private land owners, while efforts to improve watershed condition should focus on tribal and Forest Service managers.

Although there are many possible approaches to prioritizing conservation action for aquatic biodiversity, fish species richness will likely always play a role, especially when native fish persistence is rampantly threatened as it is in Arizona. The spatial distribution of fish species richness has been used in projects such as The Nature Conservancy’s “Critical Watersheds” of the continental U.S., which used fish and mussel distributions for a rarity-weighted richness index of small watersheds (Master *et al*., 1998), and the IUCN “Freshwater Biodiversity Assessment Programme” which suggested prioritization based on richness of species endemic to a biogeographic area, among other criteria (Darwall and Vié, 2005). Within Arizona, the U.S. Fish and Wildlife Service has begun an effort to prioritize watersheds for conservation using an index of biotic integrity which includes fish species richness as one of several metrics (P. Sponholtz, personal communication).

An early version of the fish data described here was used in an analysis of terrestrial and aquatic conservation priorities within the Apache Highlands region, a 12-million ha area that includes 25% of Arizona and parts of 3 adjacent states. The linear fish distributions were combined with point localities for 202 other species of animals and plants, polygons representing 26 ecological systems, and a continuous overlay representing threats to ecosystem viability. Using representation goals for all species and systems, a network of essential conservation areas was identified which now directs much of The Nature Conservancy's work in the region. Those areas were further prioritized using several criteria which included target species richness and representation (Marshall *et al*., 2004).

The leading threat to native fish in the western U.S. is the influence of introduced fish species (Richter *et al*., 1997). Of the 48 conterminous states in the U.S., Arizona's current fish fauna has the highest proportion (66%) of non-native species (Rahel, 2000; F.J. Rahel, pers. comm.), with approximately 68 non-native species (Arizona Game and Fish Dept. unpubl. data). New species are still being introduced and the distribution of non-native fish in Arizona appears to be still expanding (Unmack and Fagan, 2004; Olden and Poff, 2005). The susceptibility of watersheds to invasion by non-native fish species can be predicted by spatial analyses of anthropogenic influences such as urban development, water diversions, and agriculture, and has been shown to correlate with the distribution of native fish species richness (Moyle and Williams, 1990; Rathert *et al*., 1999; Marchetti *et al*., 2004).

The wide distribution of non-native fish species suggests that those few streams which are currently free of exotics, such as Dix Creek and Hot Springs Canyon, should be managed to prevent any introductions. It also indicates that a more aggressive program of removing exotic fish from high-richness streams may be critical. One approach might be to use the types of mapped data produced here to select streams for aggressive removal of non-native species, and to select streams that are appropriate to maintain for sport fishing of non-natives. This would be in accord with current plans by the Arizona Game and Fish Department to identify stream-by-stream management zones that favor either native or sport fish (AGFD, 2005). A useful example was the recent treatment of Fossil Creek, where native fish were removed, non-natives poisoned, and the natives returned to the stream (Weedman *et al*., 2005).

Habitat fragmentation poses another threat, and has been shown to correlate with local extirpations (Fagan *et al*., 2002, 2005). Dams are especially problematic, as they change flow rates, temperature, flood characteristics, sediment transport, and other aquatic habitat qualities (Poff *et al*., 1997; Pringle *et al*., 2000; Poff and Hart, 2002). The ability to analyze fish species distributions relative to the locations of dams has value for planning and prioritizing conservation efforts such as removal or changing operations of dams (Richter *et al*., 2003; Poff *et al*., 2003).

While reservoirs above large dams in Arizona are commonly stocked with non-native sport fish, small dams can have beneficial effects by acting as barriers to natural dispersal of non-natives into upstream reaches (e.g., Marsh *et al*., 1990). Given the ongoing risk of unauthorized species introductions (Ludwig and Leitch, 1996), dams may also serve as useful boundaries for intensive management efforts such as removal of non-natives. Incorporation of non-native fish distributions into this data set would aid the identification of such stream reaches.

A distribution map such as this must be regularly updated to be most useful, and for this reason the data are publicly available. Biologists are invited to recommend additions or deletions to this map to correct errors or document recent changes in distribution. Increasingly government agencies and conservation groups are developing public databases that detail the distribution of species or natural communities at a variety of spatial scales (e.g., Lehner and Döll, 2004). In the long term, we expect these data sets will be valuable for both planning and evaluating the success of conservation efforts by all parties.

ACKNOWLEDGEMENTS

This mapping benefited from reviews by Rob Bettaso, Doug Duncan, Dave Gori, and Peter Unmack. Additional information and advice was provided by Dana Backer, Gita Bodner, Julia Fonseca, Mary Gleason, Jeanmarie Haney, Bruce Higgins, Peter Karieva, Rob Marshall, Bill Radke, Peter Reinthal, Stacey Solie, Pam Sponholtz, and Jeremy Voeltz. Howard Ward conducted the initial attribution process. The Arizona Department of Environmental Quality provided the enhanced NHD base map.

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Table 1. Arizona's native fish and their habitat. Taxonomy follows Nelson *et al.* (2004). Total perennial stream habitat covers 8,514 km. ESA status refers to designations under the U.S. Endangered Species Act. "Extirpated" refers to a species historically present in the state, now absent here but still present elsewhere. "Extinct" refers to a species historically present in the state, now globally absent. Last column is count of unique streams.

Scientific name	Common name	ESA status	Total occupied habitat (km)	Portion of total stream habitat (%)	Number of streams
Agosia chrysogaster	longfin dace		2,523	29.6	94
Campostoma ornatum	Mexican stoneroller		15	0.2	2
Catostomus bernardini	Yaqui sucker		Extirpated	0.0	0
Catostomus clarkii	desert sucker		2,961	34.8	87
Catostomus d. discobolus	bluehead sucker		838	9.8	20
Catostomus d. yarrowi	Zuni bluehead sucker	Candidate	39	0.5	2
Catostomus insignis	Sonora sucker		2,074	24.4	56
Catostomus latipinnis	flannelmouth sucker		704	8.3	7
Catostomus sp.	Little Colorado sucker		454	5.3	12
Cyprinella formosa	beautiful shiner	Threatened	4	0.0	1
Cyprinodon arcuatus	Santa Cruz pupfish		Extinct	0.0	0
Cyprinodon eremus	Sonoyta pupfish	Endangered	0.3	0.0	1
Cyprinodon macularius	desert pupfish	Endangered	33	0.4	4
Elops affinis	machete		70	0.8	1
Gila cypha	humpback chub	Endangered	497	5.8	2
Gila ditaenia	Sonora chub	Threatened	15	0.2	2
Gila elegans	bonytail chub	Endangered	490	5.8	2
Gila intermedia	Gila chub	Endangered	439	5.2	29
Gila nigra	headwater chub		59	0.7	3
Gila purpurea	Yaqui chub	Endangered	19	0.2	4
Gila robusta	roundtail chub		1,841	21.6	38
Gila seminuda	Virgin chub	Endangered	32	0.4	1
Ictalurus pricei	Yaqui catfish	Threatened	4	0.0	1
Lepidomeda mollispinis	Virgin spinedace		32	0.4	1
Lepidomeda vittata	Little Colorado spinedace	Threatened	425	5.0	10
Meda fulgida	spikedace	Threatened	294	3.5	5
Mugil cephalus	striped mullet		88	1.0	2
Oncorhynchus gilae apache	Apache trout	Threatened	847	9.9	52
Oncorhynchus gilae gilae	Gila trout	Endangered	12	0.1	2
Plagopterus argentissimus	woundfin	Endangered	32	0.4	1
Poeciliopsis occidentalis occidentalis	Gila topminnow	Endangered	261	3.1	20
Poeciliopsis occidentalis sonoriensis	Yaqui topminnow	Endangered	4	0.0	2
Ptychocheilus lucius	Colorado pikeminnow	Endangered	194	2.3	1
Rhinichthys (=Tiaroga) cobitis	loach minnow	Threatened	295	3.5	10
Rhinichthys osculus	speckled dace		3,429	40.3	110
Xyrauchen texanus	razorback sucker	Endangered	999	11.7	9

Table 2. Arizona streams with five or more native fish species. Total native species richness includes reintroduced native species, with the number of reintroduced natives shown in parentheses.

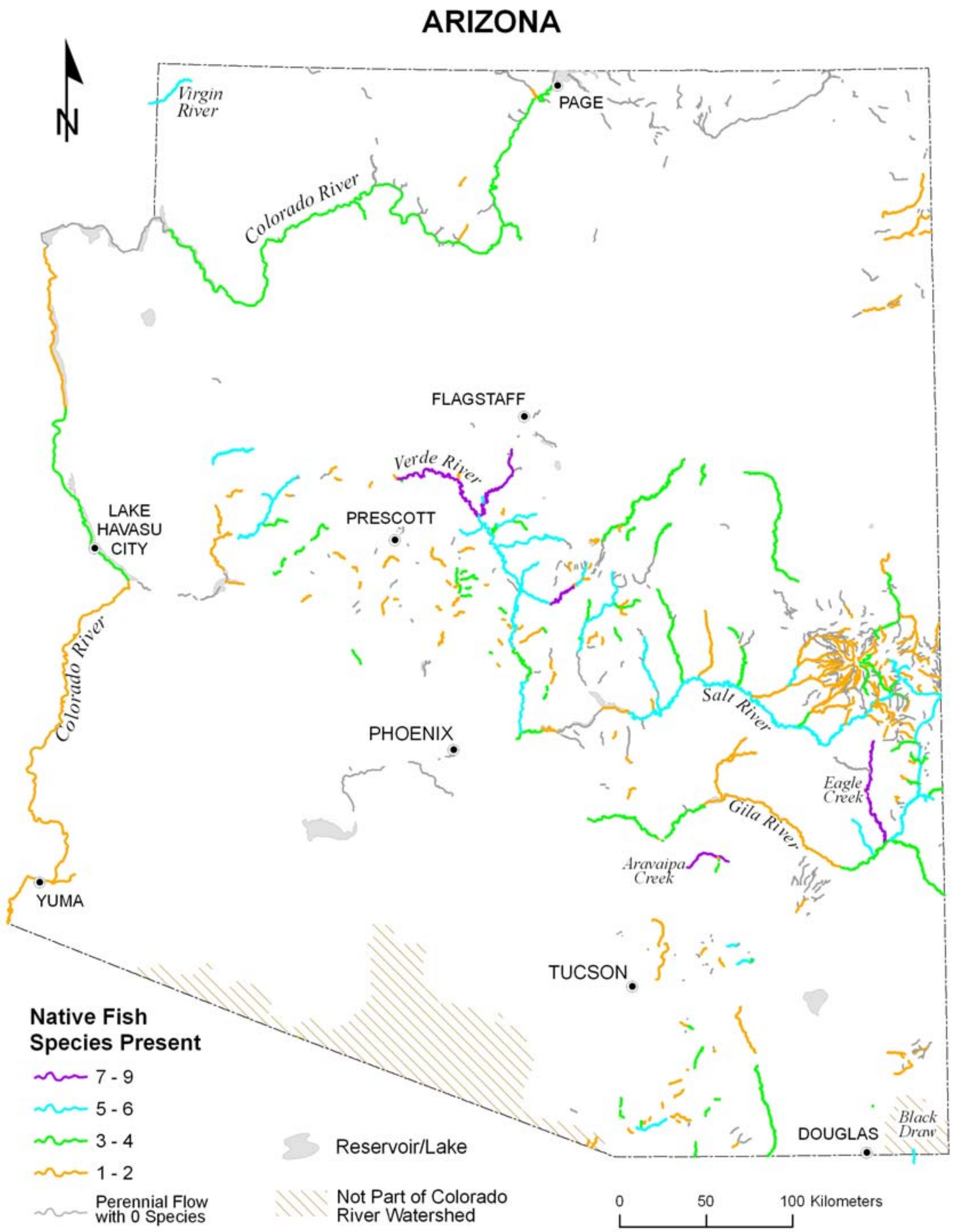
Stream Name	Native fish species		Exotic fish species	Perennial length (km)	% length with full set of native species	Dams
Eagle Creek	9	(1)	9	94	32	
Verde River	8	(2)	21	308	20	2
Aravaipa Creek	7		8	36	100	
Fossil Creek	7	(1)	4	25	100	2
Oak Creek	7		14	81	100	
Black Draw	6	(2)	3	4	100	
Blue River	6		5	79	68	
Cherry Creek	6	(1)	8	65	13	
East Verde River	6	(1)	7	84	44	
Virgin River	6		6	32	100	
West Clear Creek	6		4	59	100	
Bass Canyon	5		1	3	100	
Black River	5		3	183	100	
Boneyard Creek	5		1	10	100	
Bonita Creek	5		7	30	100	
Burro Creek	5		6	85	85	1
Campbell Blue Creek	5		3	32	100	
Dix Creek	5		0	3	100	
Dutch Blue Creek	5		0	3	27	
East Fork Black River	5		1	37	78	
Francis Creek	5		1	9	100	
Harden Cienega Creek	5		3	3	100	
Hot Springs Canyon	5		0	10	99	
Left Prong Dix Creek	5		0	1	100	
North Fork White River	5		3	84	20	1
Redfield Canyon	5		2	9	100	
Salt River	5		28	250	60	5
San Francisco River	5		7	88	68	1
Sonoita Creek	5		10	31	74	1
Spring Creek	5		2	5	100	
Tonto Creek	5		11	96	74	
Trout Creek	5		2	40	100	

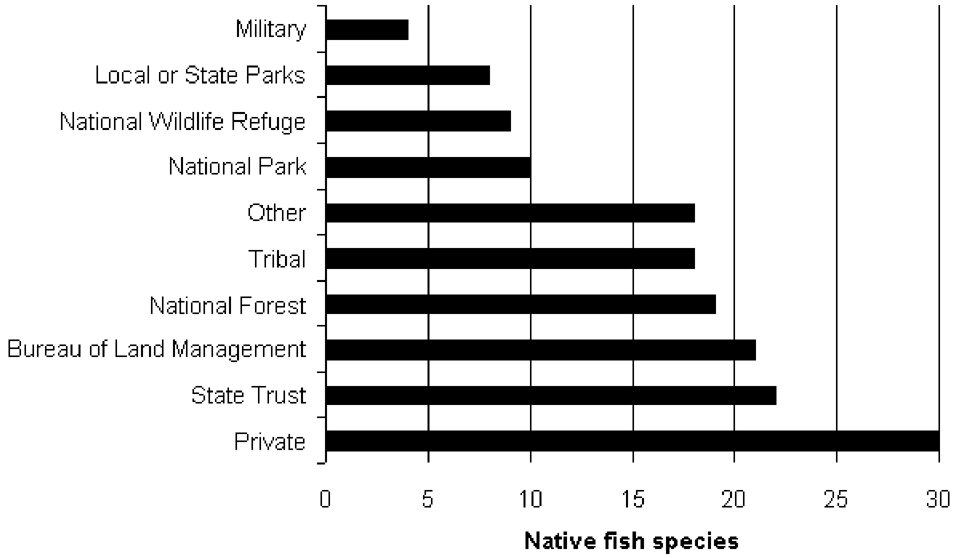
Figure 1. Native fish species richness in Arizona's perennial streams. Values include reintroduced populations of native species. Gaps in stream continuity represent intermittent or ephemeral reaches. Lakes are shown with fish attribution only for lines following the thalwegs through them. Most of Arizona drains into the Colorado River, but its southern edge includes small portions of 3 Mexican river basins: Sonoyta, Asuncion, and Bavispe (from west to east).

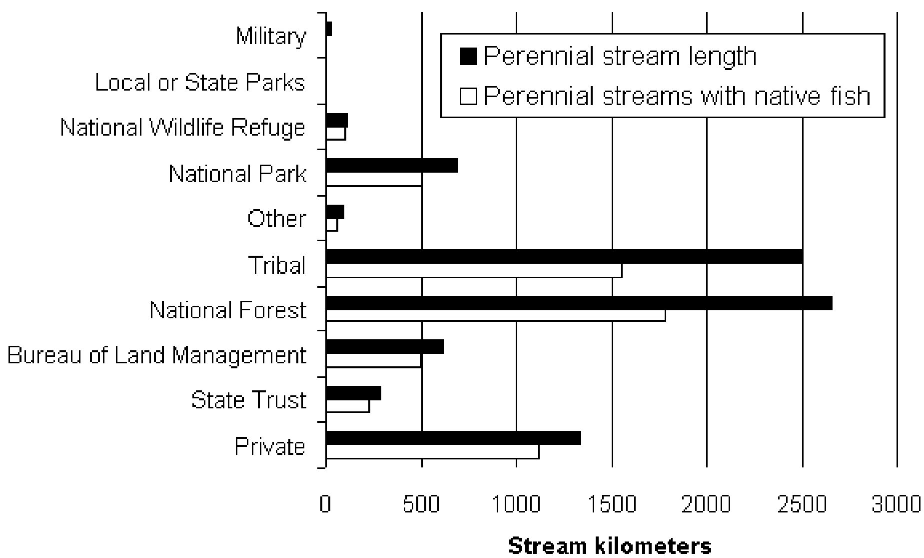
Figure 2. Total native fish species by manager for Arizona. Sum is based on all species occurrences statewide for each land management class.

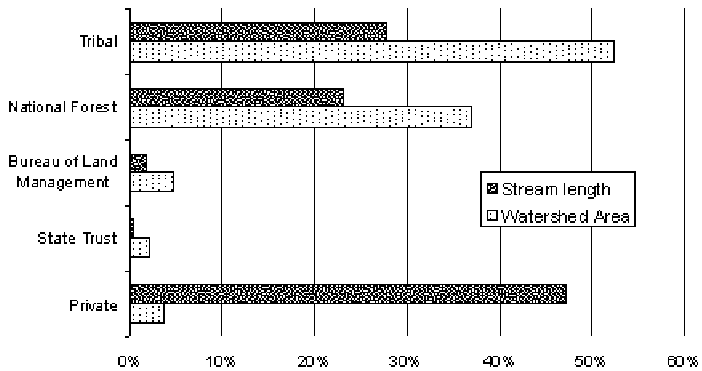
Figure 3. Native fish habitat by manager for Arizona. Large differences in stream length shown with and without native fish for tribal and national forest lands may reflect lack of data due to undersampling of tribal lands or headwaters streams.

Figure 4. Native fish habitat management around Eagle Creek. Values show proportion of total stream length and of the watershed surface area. Almost half of the stream length is managed by private land owners, but tribal and federal lands comprise most of the watershed. Thus, the appropriate partners for conservation action may vary according to the issues being addressed.


ARIZONA
N
Virgin River
PAGE
Colorado River
FLAGSTAFF
Verde River
LAKE HAVASU CITY
PRESCOTT
Colorado River
Salt River
PHOENIX
Eagle Creek
Gila River
Aravaipa Creek
YUMA
TUCSON
DOUGLAS
Black Draw
Native Fish Species Present
7 - 9
5 - 6
3 - 4
1 - 2
Perennial Flow with 0 Species
Reservoir/Lake
Not Part of Colorado River Watershed
0
50
100 Kilometers


Military
Local or State Parks
National Wildlife Refuge
National Park
Other
Tribal
National Forest
Bureau of Land Management
State Trust
Private
0
5
10
15
20
25
30
Native fish species


Military
Local or State Parks
National Wildlife Refuge
National Park
Other
Tribal
National Forest
Bureau of Land Management
State Trust
Private
Perennial stream length
Perennial streams with native fish
0
500
1000
1500
2000
2500
3000
Stream kilometers


Tribal
National Forest
Bureau of Land Management
State Trust
Private
Stream length
Watershed Area
0%
10%
20%
30%
40%
50%
60%

Appendix 1. Native fish species present in highest-richness streams. Stream order matches Table 2. Species acronyms are comprised of the first four letters of each genus and specific epithet, as listed in Table 1.

Stream name	Native fish species	Agoschry	Camporna	Catoclar	Catoinsi	Catolati	Cyprform	Gilainte	Gilanigr	Gilapurp	Gilarobu	Gilasemi	Ictapric	Lepimoll	Medafulg	Oncoapac	Plagarge	Poecocci	Poecsono	Ptycluci	Rhincobi	Rhinoscu	Xyratexa
Eagle Creek	9	X		X	X			X			X				X						X	X	X
Verde River	8	X		X	X						X				X					X		X	X
Aravaipa Creek	7	X		X	X						X				X						X	X	
Fossil Creek	7	X		X	X				X													X	X
Oak Creek	7	X		X	X			X			X							X				X	
Black Draw	6	X	X				X			X			X						X				
Blue River	6	X		X	X																X	X	X
Cherry Creek	6	X		X	X						X											X	X
East Verde River	6	X		X	X						X											X	X
Virgin River	6			X		X						X		X			X					X	
West Clear Creek	6	X		X	X						X					X						X	
Bass Canyon	5	X		X	X			X														X	
Black River	5			X	X						X					X						X	
Boneyard Creek	5			X	X											X					X	X	
Bonita Creek	5	X		X	X			X														X	
Burro Creek	5	X		X	X						X											X	
Campbell Blue Creek	5	X		X	X																X	X	
Dix Creek	5	X		X	X			X														X	
Dutch Blue Creek	5	X		X	X																X	X	
East Fork Black River	5			X	X											X					X	X	
Francis Creek	5	X		X	X						X											X	
Harden Cienega Creek	5	X		X	X			X														X	
Hot Springs Canyon	5	X		X	X			X														X	
Left Prong Dix Creek	5	X		X	X			X														X	
North Fork White River	5			X	X						X										X	X	
Redfield Canyon	5	X		X	X			X														X	
Salt River	5	X		X	X						X											X	
San Francisco River	5	X		X	X																X	X	
Sonoita Creek	5	X		X	X													X				X	
Spring Creek	5	X		X	X			X														X	
Tonto Creek	5	X		X	X						X											X	
Trout Creek	5	X		X	X						X											X	