FISH COMMUNITY STRUCTURE IN THE VERDE RIVER, ARIZONA, 1974–1997

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The Verde River flows more than 300 km from its headwaters in Big Chino Wash on the Prescott National Forest to its confluence with the Salt River near Phoenix (Figure 1). The upper 60 km of river corridor above Sycamore Creek is relatively undisturbed by humans. This quasi-pristine reach (Reach I, Figure 1) contains no flow-altering dams or major diversions. The reach from Sycamore Creek downstream through the Camp Verde area (Reach II) sustains municipalities, mining, groundwater pumping, diversions, recreational activity, and livestock grazing (Rinne et al. in press). Below Beasley Flat to the confluence with the Salt River, two major mainstream dams, Horseshoe and Bartlett, effect marked changes in the natural hydrograph of the Verde (Figure 1). The river contains one of the few remaining native fish communities in Arizona (Stefferud and Rinne 1995); however, nonnative species of fishes, introduced primarily for sport fishing, also exist throughout the river.

The primary objective of this paper is to delineate fish community structure throughout the Verde River by (a) evaluating and defining relative native and nonnative fish communities of four arbitrarily designated reaches; (b) defining the native fish component of the fish communities at these four predesignated reaches over two decades; (c) relating historic stocking and museum collections of nonnative species to fish community structure; and (d) suggesting factors that appear to be important in cumulative legislation of observed changes in fish community structure that need further evaluation.

Data and Me

Fish data comprise a combination of U.S. Forest Service (Rocky Mountain Research Station) surveys over the past 4 years, and Arizona Game and Fish Department databases and collections over the past two decades. Because sampling in the four designated reaches is not comparable through all years, no statistical analyses were performed. Electrofishing with backpack units and from canoes combined with seining and trammel netting were used to capture fish. Data were stratified and categorized for analyses into four major predesignated reaches of river (Figure 1). Linear position in the watershed, presence of stream gages, and conceivable human-induced impacts on the river were used in combination as designation criteria. In the event of multiple fish data sets (i.e. Arizona Game and Fish, or Game and Fish and Forest Service) within a sample year, data are combined. Data are presented as percentages of native and nonnative fish species and successive downstream changes in distribution of individual native species. The total fish database comprised more than 150,000 individuals collected throughout the entire 300 km of the Verde River over the past two decades. Data on historic stocking with nonnative sport fishes into stock tanks and lakes on the watershed and streams tributary to the Verde and mainstream reservoirs were abstracted from Pringle (1996, unpublished). Fish databases (based on museum depositions of nonnative fishes) on file at Arizona State University for the Gila River Basin were used to supplement and further document temporal-spatial collections.

Fishery Management Practices

Stocking of sport fishes commenced about six decades ago in Bartlett Reservoir on the mainstream Verde, and in tributary streams, lakes and reservoirs on the watershed. More than a dozen nonnative, primarily sport fishes were stocked in the Verde Basin. More than 850 stocking events in reservoirs and almost 4500 in streams have occurred in the past six decades, mostly in tributaries to the Verde (Rinne et al. in press). Both cold-water salmonid species and warm-water Ictalurids and Centrarchids have been stocked. The majority of stocks in tributary streams constituted three species of trout: rainbow, brown, and brook trout. In Bartlett Reservoir, almost three million channel cat-

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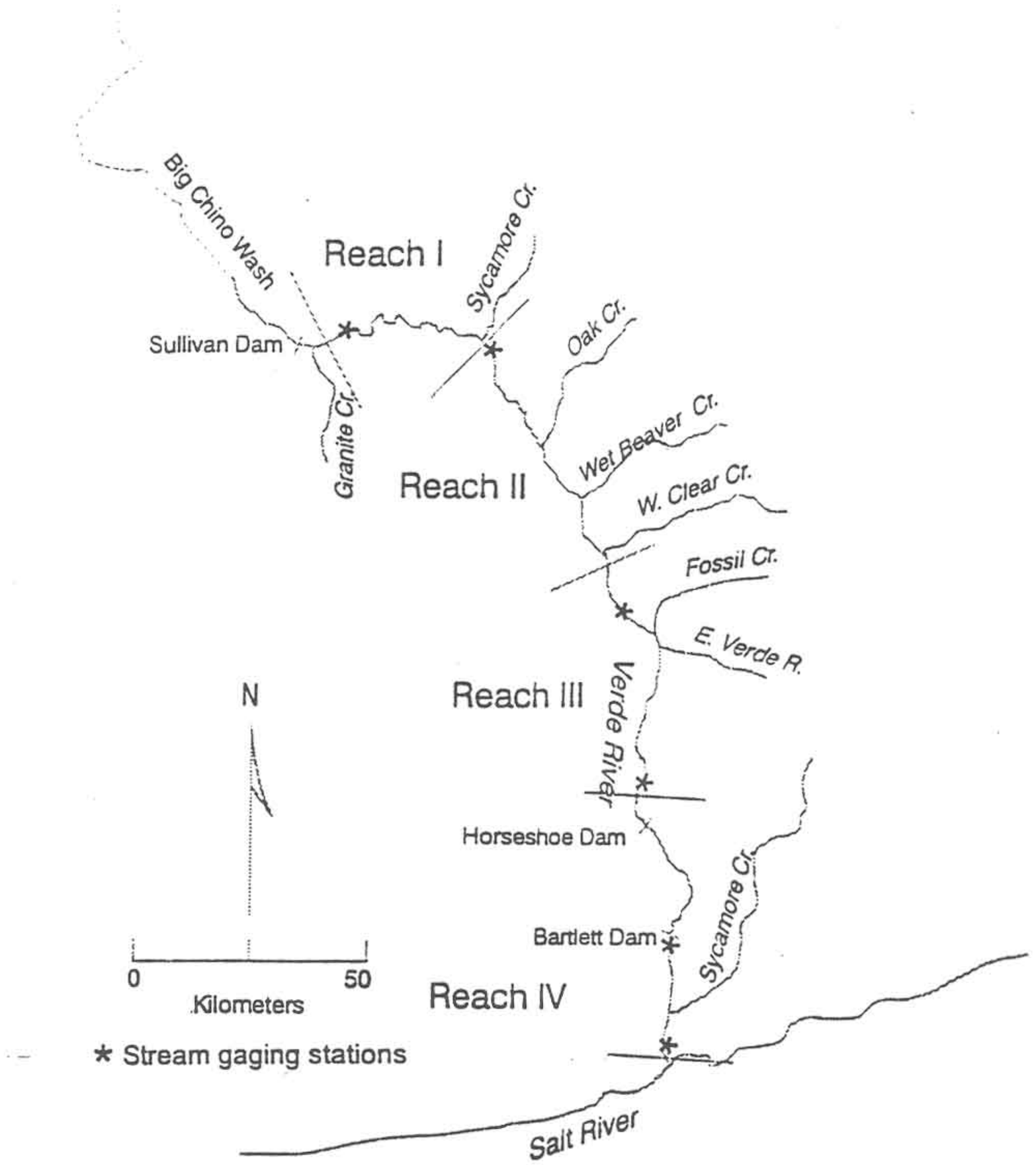

Figure 1. The Verde River, showing the extent of Reaches I–IV, and locations of stream gaging stations.

fish, largemouth bass, and sunfish species were stocked in aggregate over a 40-year period.

Museum collections of nonnative fishes parallel the history of stocking in the Verde Basin. Before 1950 all five records of nonnative fishes were from two tributaries of the Verde: Oak and Wet Beaver creeks. Between 1950 and 1964, collection records of nonnatives doubled; however, 6 of the 11 records also appeared in the mainstream Verde during this period. The period 1965–1979 resulted in a four-fold increase in occurrence of nonnatives in collections. Again, 59 percent were from tributary streams. Records of nonnatives between 1980 and 1995 were slightly reduced (41 to 37) from that of the previous 15-year period; however, this reduction more likely reflects a lack of preservation of specimens for museum deposition than actual reduction in numbers of nonnatives (personal communication, Peter Unmack, Arizona State University). Similar to previous periods, records are evenly distributed between the mainstream and the tributaries.

Fish Community Composition

The comparative composition of the fish community in the four arbitrarily designated reaches (Figure 1) of the Verde River are shown in Figures 2 and 3. Results of data are presented for both overall sampling at successive reaches of river beginning with the most upstream reach (Figure 2) and individual reach for the entire period of analyses (Figure 3).

Considering all years of sampling, native species dominated the fish community only in Reach I (Figure 2). Combined, native species generally drop to 25 percent or less of the fish community in Reaches II and III, before plummeting to 10 percent or less in Reach IV. Years of exceptions for

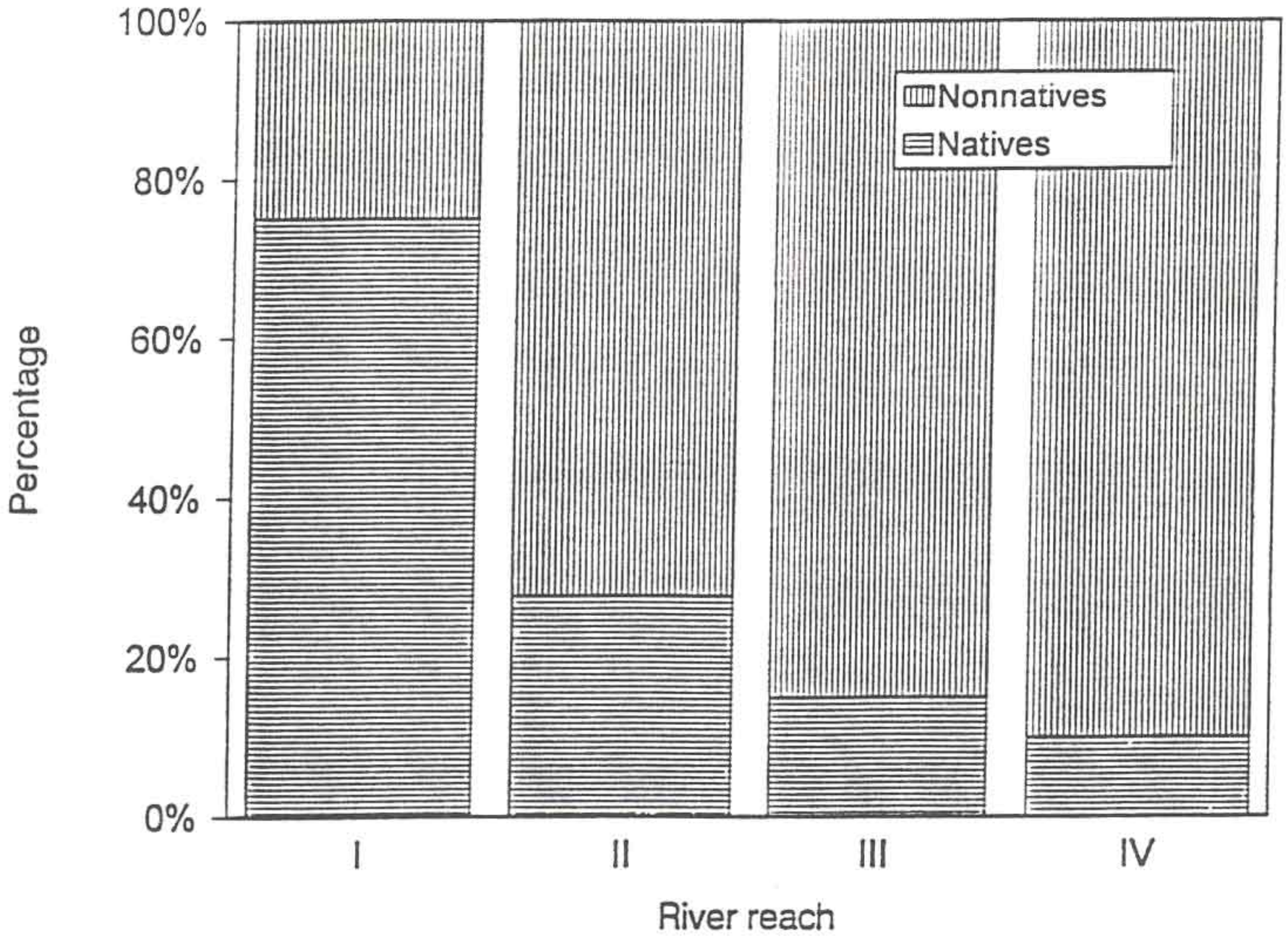

Figure 2. Relative abundance of native and nonnative fishes by reach during period of sampling.

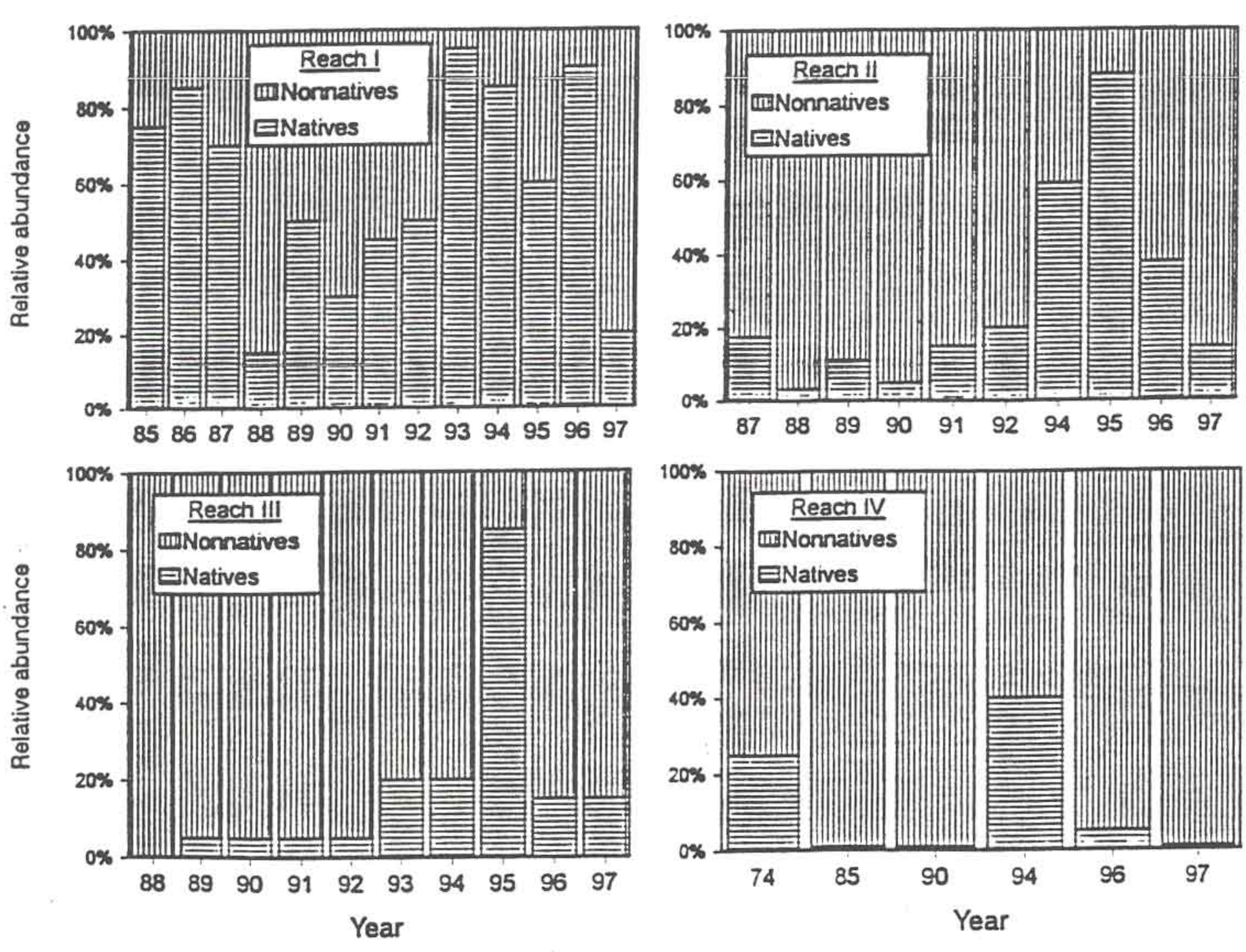

Figure 3. Relative abundance of native and nonnative fishes by reach and by year of sampling.

Reaches III and IV occurred in 1994–1995 and 1974 (respectively) when natives comprised 40–90 percent of the fish community (Figure 3). In general, based on relative abundance, native species successively decrease downstream whereas nonnatives increase (Figure 2).

Reach I—Above Sycamore Creek. Based on 13 years of data, natives were more abundant than nonnatives 8 of the 13 years for which samples were available. Between 1985 and 1987 native species comprised 70–85 percent of the fish community (Figure 3). In 1988, the native fish community dropped dramatically to less than 20 percent and remained less abundant than nonnatives until 1993 following significant spring flooding. Native species continued to decline in the fish community until 1997 when nonnative species markedly dominated.

Reach II—Sycamore Creek to Beasley Flats. By comparison, natives only exceeded nonnatives in 2 of 10 sample years in this reach. Similar to Reach I, natives were more abundant in 1994 and 1995.

Reach III—Beasley Flat to Horseshoe Reservoir. Ten sample years were available for analyses. Native species predominated in the fish community only once, in 1995 (Figure 3). The same pattern of relative community composition appeared as noted for Reaches I and II. That is, natives were relatively lower in numbers than nonnatives in 1988–1994. Generally, native species comprised a very small portion of the fish community in this reach of river.

Reach IV—Below Bartlett Reservoir: In this lowermost reach nonnatives always predominated (Figure 3). Following 1993 flooding, native species did comprise nearly half of the fish community in 1994, but were very low to absent in other sample years. Unfortunately, data were lacking for 1995 following a second period of winter flooding (Stefferud and Rinne 1995). Native species, however, quickly become a very small component of the fish community by 1996–1997 (Figure 3).

Native Fish Distributions

The two native suckers, Sonoran (*Catostomus insignis*) and desert (*C. clarki*), persisted in all sample reaches over the two decades of sampling, although they were collected only half the time in Reach IV (Table 1). By comparison, roundtail chubs (*Gila robusta*) were taken during only half the sample years in Reach III and were absent in all 6 years of sampling in Reach IV. Longfin dace (*Agosia chrysogaster*) occurred in all reaches but were present in only a third to a fifth of sample years in reaches III and IV. In a marked contrast, speckled dace (*Rhinichthys osculus*) was absent in Reaches III and IV during all years of sampling and occurred in only 1 of 10 years in Reach II. The threatened spikedace (*Meda fulgida*) was most limited in temporal-spatial distribution, occurring only in Reach I.

Table 1. Occurrence of Native Fishes in Annual Samples at Respective Reaches in the Verde River, 1974–1997

Species	Reach I	Reach II	Reach III	Reach IV
Sonora sucker	13/13	10/10	10/10	3/6
Desert sucker	13/13	9/10	5/10	3/6
Roundtail chub	13/13	10/10	5/10	0/6
Longfin dace	12/13	7/10	2/10	2/6
Speckled dace	11/13	1/10	0/10	0/6
Spikedace	10/13	0/10	0/10	0/6

Discussion and Conclusions

Based on a substantial database, over a considerable (two-decade) time period, it appears there is a distinct gradient from upstream to downstream in the ratio of native to nonnative species. In Reach I, native species have predominated in the fish community for the past 15 years. In contrast, commencing in Reach II and escalating successively in Reaches III and IV, nonnative fishes predominate. On a species-specific basis, the two suckers occur in all reaches, the chub in all but Reach IV. Two of the smaller size species, speckled dace and spikedace, may be much more sensitive and vulnerable to changes in hydrograph and the increase in and predominance of nonnative species. Longfin dace persisted in Reaches III and IV and spikedace occurred only in Reach I of the river. Longfin dace was collected only in 1995 (Reach III) and 1996 (Reach IV). The occurrence of longfin dace in the two lower, nonnative-predominated reaches may reflect their input into the mainstream Verde by flooding of tributary streams in the mid 1990s.

Changes in native fish populations in the Verde River appear to mirror human-induced changes in river systems on a regional basis. That is, with construction of reservoirs followed by introduction of nonnative, predatory sport fish, native species began to decline (Rinne 1991, 1994, 1995; Rinne and Minckley 1991). Prior to 1950, the Verde watershed was agrarian in nature and human population was small. Riparian areas were largely pristine and intact, affected mostly by livestock grazing in river corridors. Stocking of nonnative species began in the 1930s and escalated with com-

pletion of dams on the Verde. After 1950, transportation systems and affordable electricity rates resulting from hydropower generation on many of these same reservoirs encouraged and effected urbanization and human population growth.

Because of changes in the fish community structure in Reach II, which has a natural flow regime, yet sustains increased human influence, additional factors that may successively and cumulatively affect fish community structure in the Verde River need examination.

River Hydrograph

Based on peak hydrographs and fish community structure, the Verde River becomes increasingly and cumulatively altered in hydrograph (Rinne et al. in press) and fish community structure (Figure 2) as one progresses downstream. The native fish community is inversely related to these increases and the nonnative component parallels them. Floods can have a marked influence on relative abundance of native and nonnative fishes (Stefferud and Rinne 1995; Rinne and Stefferud 1996). During the period of our analyses, significant floods occurred in the mid 1960s, early 1970s and 1980s, and mid 1990s (Stefferud and Rinne 1995). In 1994–1995, parallel increases in peak hydrograph and relative proportion of natives occurred in all reaches, even the nonnative-predominated Reaches II–IV.

Fish community structure is altered by successive downstream cumulative hydrologic changes resulting from human-induced impacts as well as natural flow regimes characterized by periodic floods. That is, native species comprise an increasingly smaller component of the total fish community as one proceeds downriver with accompanying alteration of quantity and perhaps quality of water in time and space. As a result, native species basically become absent in the lowermost reach of river below the two major reservoirs. Nevertheless, even in these markedly altered reaches, native species increase in response to flood events. Nonnative species respond inversely, by both dominating the fish community in lower reaches and becoming reduced, although briefly, in response to significant flooding.

Groundwater mining or pumping is greatest in the Middle Verde Valley or Reach II (Rinne et al. in press), and fish community structure favors nonnative species in this reach. Further, hundreds of diversions or stock tanks on the watershed (Sponholtz et al. 1997) must cumulatively affect the Verde hydrograph (Rinne et al. in press) and most probably fish community composition. More specific information on potential livestock grazing impacts to the river corridor, its riparian area, and ultimately the fish community is needed.

The presence of agriculture in the river flood plain and diversions and wells, again mostly in Reach II, must be evaluated relative to fish community structure. Probably the most significant lack of information is that of water quality. Information on suspended sediment and basic nutrient content of the Verde in the respective river reaches needs evaluation. Numerous diversions in Reach II not only reduce flows, but also can increase suspended sediment upon return flow to the mainstream river. Reduced flow and increased suspended sediment combined with potential warming of water and nutrient input may become more limiting to native fish species, more than to more tolerant, nonnative species such as catfish and carp. Accordingly, the number of native species decreases as nonnative species density increases.

Human Populations

Historic human populations along the middle Verde corridor approximated five individuals per square mile (Peter Pilas, U.S. Forest Service, Coconino National Forest, Flagstaff, unpublished manuscript). Currently, human population densities are 20 times those of historic times (Rinne et al. in press). Human population growth increased 135 percent in the Verde watershed between 1980 and 1994 and is expected to increase by that same percentage over the next four decades. More significantly, almost half this increase in population is sustained by the Middle Verde Valley—Reach II in our study.

The marked growth in human population, in turn, brought about an increased demand for sport fish stocking. Stocking of nonnative, sport species has been ongoing for more than six decades in the Verde drainage. During that time, more than a dozen species and 15 million individual nonnative sport fishes were stocked. Predatory species such as catfishes, bass, and sunfish comprised a majority of introduced species—museum records reflect this impact. Prior to 1950 only five records of nonnative fishes are known for the Verde River. Four of these were from tributaries in Reach II. During the next 15 years (1951–1964), collection records for nonnatives doubled. More than half were in the mainstream, and records expanded downstream to the Salt River. Over the next 15 years (1965–1979) a four-fold increase in collections of

nonnatives occurred; half were in the mainstream. This pattern of collection of nonnatives has continued to the present. Further, it must be emphasized that these occurrences are based on museum records, and additional collections were made, but not preserved and deposited in museums.

Summary and Conclusions

The fish community of the Verde River changes from upstream to downstream. These changes are reflected in both the ratio of native to nonnative components and linear species-specific changes. Changes in the river hydrograph and apparent undefined anthropogenic impacts appeared related to the observed changes in fish community structure. We suggest and recommend a more detailed analysis and definition of these relationships. Such information is prerequisite for effective management of the Verde River and sustainability of the native fish community.

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