Moyle & Nichols (1974) Fr'ant Dam

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Decline of the Native Fish Fauna of the Sierra Nevada Foothills, Central California

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ABSTRACT: *A survey was made of the fishes occurring in streams of the Sierra Nevada foothills above the San Joaquin Valley, California. Twenty-four species were collected, 12 native, 12 introduced. The present distributions of these fishes were compared to their pre-1900 distributions, as inferred from old records. Overall, the ranges of introduced species and rainbow trout have expanded while the ranges of native species, especially California roach, hardhead, Sacramento squawfish and Sacramento sucker, have contracted. Healthy populations of native fishes were found only in a rather narrow middle elevation band of comparatively undisturbed sections of foothill streams. The native fish populations in different foothill stream systems are now isolated from each other and are, thus, in danger of local extinction as foothill development proceeds. The study indicates that populations of native stream fishes, even if they do not contain endangered species, should be protected, to make sure that severe natural conditions, when combined with human alterations of the streams, do not destroy unique assemblages of fishes.*

INTRODUCTION

In recent years considerable attention has been paid to the many endangered freshwater fish species of the United States (Miller, 1972). Unfortunately, the emphasis on the study and preservation of endangered species may result in the neglect of declining aquatic faunas which do not include endangered species yet represent unique associations of organisms. The arid Sierra Nevada foothills on the E side of California's San Joaquin Valley contain such associations in the warm intermittent streams that are one of the most severe aquatic habitats in the huge Sacramento-San Joaquin drainage system. In the summer, many of the streams cease flowing and the aquatic organisms are crowded into stagnant pools in which water temperatures may approach that of the air (30-35 C). These streams are the last waters in the San Joaquin system that still contain mostly native organisms. They are losing this fauna rapidly as development of the foothills proceeds. The decline of the native frogs has been documented (Moyle, 1973), and studies of the macroinvertebrates and aquatic plants are in progress; this paper, therefore, will deal only with the native fishes.

The native fish fauna of the Sacramento-San Joaquin system is 75% endemic (Miller, 1958). During the past 100 or more years populations of native fishes throughout the system have been reduced, the result of habitat and water quality deterioration coupled with the introduction of exotic fishes. On the floor of the Central Valley the original populations of native fishes, reflected in the fish remains

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found in Indian middens (Schulz and Simons, 1973), have been almost completely replaced by assemblages of introduced fishes and the few native species that have managed to adapt to the changing conditions. Of the members of the original associations, some, such as the thicktail chub, *Gila crassicauda*, have become extinct or very rare. Others, such as the Sacramento perch, *Archoplites interruptus*, have become severely depleted (Fisk, 1971).

STUDY AREA

The study area was confined to the streams of the Sierra Nevada foothills between the elevations of 90 and 1100 m with a mean elevation of 401 m. At least one collection of fish was made from most of the streams accessible by road in Tulare, Fresno, Madera, Mariposa and Tuolumne counties. A few collections were also made in Stanislaus and Calavaras counties. Lack of time and funds prevented the sampling of Kern Co. at the S end of the San Joaquin Valley. A total of 167 localities was sampled, 130 between 27 July and 4 September 1970 and 37 during the summer and autumn of 1969, 1970 and 1971. Most of the streams sampled are intermittent, flowing over their entire course only when there is sufficient water from winter rains and the spring snowmelt runoff from the mountains. During the main study period, 27 July-4 September 1970, most of the streams were not flowing, except where exposed bedrock brought the small underground flow to the surface. Consequently, the fishes were confined to isolated pools. The hillsides around the streams are rocky, heavily grazed dry grasslands with a scattering of oaks (*Quercus* spp.) and, at higher elevations, digger pine (*Pinus sabiniana*).

METHODS

At each sample site as many fish as possible were collected, using 6 mm mesh seines 1 m deep and ranging in length from 3 to 9 m. The number of individuals of each species collected was recorded. Most of the fish were returned to the water, although representative samples from many localities were preserved in 10% formalin. Visual checks of the sample sites by snorkeling showed that seine collections provided a good indication of relative numbers of each species present, although lampreys (*Lampetra*), sculpins (*Cottus*) and possibly speckled dace (*Rhinichthys osculus*) [Girard]), which can burrow into the substrate, may have been inadequately sampled. At each site data were also collected on environmental variables likely to affect fish distribution (Moyle and Nichols, 1973). Collection localities for each species were plotted on maps of the study area, along with the limited pre-1900 records of Rutter (1908) and Evermann and Clark (1931). Only the distribution maps of the most abundant native and introduced species are presented in this paper. Others are available from the authors on request.

RESULTS

Twenty-four species of fish were collected from the study area,

12 native and 12 introduced (Table 1). Six native species collected by Rutter (1908) in the study area were not collected by us. Five of these [Sacramento blackfish, *Orthodon microlepidotus* (Ayres); splittail, *Pogonichthys macrolepidotus* (Ayres); thicktail chub, *Gila crassicauda* (Baird and Girard); tule perch, *Hysterocarpus traski* (Gibbons); and Sacramento perch, *Archoplites interruptus* (Girard)] are primarily lowland forms that reached the foothills only in the large rivers and so probably never were common in the study area. The sixth species, speckled dace, *Rhinichthys osculus* (Girard), was found by Rutter (1908) in only one locality in the study area (Kings River at Center-

TABLE 1.—Native (N) and introduced (I) fishes collected at 167 sampling sites in streams of the Sierra Nevada foothills, California, 1969-1970

Name	Origin	%*
Family Centrarchidae		
Largemouth bass, *Micropterus salmoides* (Lacepede)	I	31
Smallmouth bass, *Micropterus dolomieui* (Lacepede)	I	7
Green sunfish, *Lepomis cyanellus* (Rafinesque)	I	46
Bluegill, *Lepomis macrochirus* (Rafinesque)	I	23
Redear sunfish, *Lepomis microlophus* (Gunther)	I	2
Family Cottidae		
Prickly sculpin, *Cottus asper* (Richardson)	N	4
Riffle sculpin, *Cottus gulosus* (Girard)	N	2
Family Gasterosteidae		
Threespine stickleback, *Gasterosteus aculeatus* (Linnaeus)	N	2
Family Poecilidae		
Mosquitofish, *Gambusia affinis* (Baird and Girard)	I	26
Family Cyprinidae		
Carp, *Cyprinus carpio* (Linnaeus)	I	3
Goldfish, *Carassius auratus* (Linnaeus)	I	1
Golden shiner, *Notemigonus crysoleucas* (Mitchill)	I	8
Hitch, *Lavinia exilicauda* (Baird and Girard)	N	10
Sacramento squawfish, *Ptychocheilus grandis* (Ayres)	N	38
Hardhead, *Mylopharodon conocephalus* (Baird and Girard)	N	9
California roach, *Hesperoleucus symmetricus* (Baird and Girard)	N	32
Family Catostomidae		
Sacramento sucker, *Catostomus occidentalis* (Ayres)	N	42
Family Ictaluridae		
White catfish, *Ictalurus catus* (Linnaeus)	I	9
Brown bullhead, *Ictalurus nebulosus* (Lesueur)	I	7
Family Salmonidae		
Rainbow trout, *Salmo gairdneri* (Richardson)	N	20
Brown trout, *Salmo trutta* (Linnaeus)	I	1
Chinook salmon, *Oncorhynchus tshawytscha* (Walbaum)	N	1
Family Petromyzontidae		
Pacific lamprey, *Lampetra tridentata* (Gairdner)	N	1
Pacific brook lamprey, *Lampetra pacifica* (Vladykov)	N	1

*per cent samples in which fish occurred

12 exotic
12 native

ville), indicating it has probably never been abundant in the S Joaquin system. Other introduced species, such as black bullhea *Ictalurus melas* (Rafinesque), and threadfin shad, *Dorosoma petenei* (Gunther), that are common in reservoirs and ponds in the study ar although not found in this study may occasionally occur in footh streams.

Lampreys.—No special effort was made to collect lampreys, but single Pacific brook lamprey was collected at Friant (Kottcamp a Moyle, 1972). Anadromous Pacific lampreys were observed spawni below Friant Dam on the San Joaquin River during the spring 1969 and ammocoetes were collected in lower portions of the riv near Fresno.

Chinook salmon.—In April 1970, three small (10.5-11 cm TL chinook salmon were taken in Mill Creek, Fresno Co., near its co fluence with the Kings River (Moyle, 1970). In the previous summ an adult salmon was caught by a fishermen in the San Joaquin Riv below Friant Dam. At the present time, chinook salmon are able make it up the Kings and San Joaquin Rivers only during years exceptionally high runoff. Before construction of Friant Dam in 19 salmon used to run up both rivers into the foothill region in lar numbers (Moyle, 1970).

Rainbow trout.—Old records of rainbow trout in the study ar are few, but the trout are undoubtedly native to the upper reaches most of the streams. Where they were not, populations have becor established through stocking, and, in some of the more heavily fish streams, their populations are still maintained by stocking. Rainbo trout occurred in 20% of the samples, mostly in cool, clear, permane streams at the uppermost elevations of the study area (average elev tion, 748 m). Brown trout were occasionally found in the streams wi them.

California roach.— This small cyprinid was found in 32% of t samples, primarily in the small, intermittent tributaries (average elev tion, 458 m) to the larger streams (Fig. 1). Although they are wide distributed in the study area, they are conspicuous by their absen from the upper San Joaquin and Fresno River systems, and are rath rare in the Chowchilla River system. At one time, they were present all three streams, since C. Girard originally described California roac in 1854 from specimens collected at Fort Miller on the San Joaqu River, the present site of Millerton Lake (Rutter, 1908). Plenty suitable habitat exists for the roach in all three systems, although mo of it is now occupied by green sunfish, a predaceous species with ec logical requirements similar to the roach (Moyle and Nichols, 1973 In other streams roach were once apparently much more common lower elevations than they are today (Fig. 1).

Hardhead.—The distribution of hardhead has, apparently, alwa been somewhat spotty (Reeves, 1964); therefore, it was not surprisin to find they occurred at only 9% of the localities (Fig. 2a). Whe they occurred, however, they were abundant. In the Chowchill

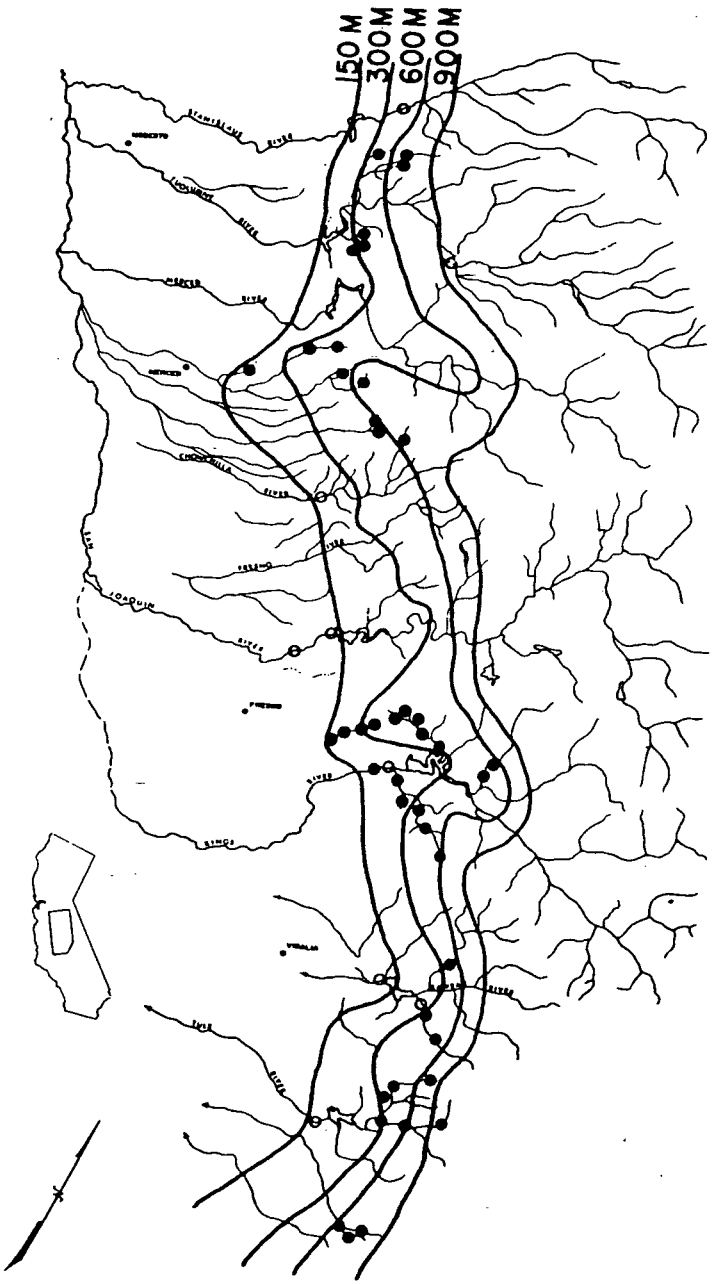

Fig. 1.—Map of the study area, showing the pre-1900 (open circles) and 1969-1970 (solid dots) locality records for California roach in the San Joaquin foothills

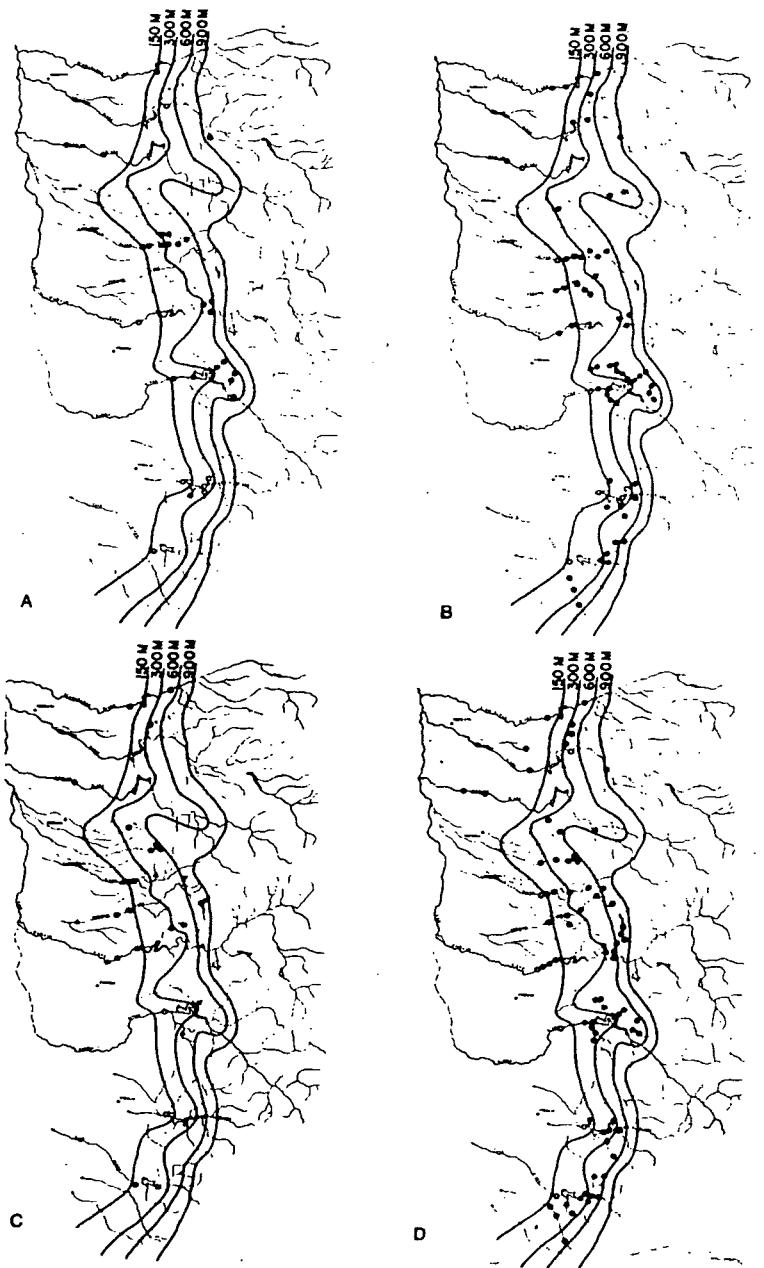

Fig. 2.—Pre-1900 (open circles) and 1969-1970 (solid dots) locality record for native fishes in the San Joaquin foothills: (a) hardhead; (b) Sacrament squawfish; (c) hitch; and (d) Sacramento suckers. Triangles in map C repre sent 1969-1970 records for golden shiner (introduced)

River system they were the dominant fish numerically. They have become established in Kerckoff and Redinger reservoirs in the upper San Joaquin River, although more typically they are abundant in reservoirs only for the first few years after impoundment (Reeves, 1964). Hardhead were found in the larger undisturbed streams of the study area, characterized by deep pools and clear water, at an average elevation of 320 m. They were abundant at much lower elevations in the past.

Sacramento squawfish.—Although widely distributed throughout the study area, squawfish were uncommon at low elevations where they once occurred in large numbers. During the study, they were most abundant in the larger intermittent and permanent streams at elevations from 200 to 500 m (Fig. 2b).

Hitch.—Hitch are sluggish water cyprinids that survive today mostly as a minor element of the Valley floor fish fauna (Turner and Kelley, 1966) and in large numbers in some reservoirs. They once enjoyed a wide distribution in the larger streams of the study area but now occur only as scattered populations (Fig. 2c). They are the most abundant fish in the middle portions of the Fresno River, Madera Co.

Golden shiner.—Despite their status as a legal bait minnow in California, golden shiners were uncommon in study area streams (Fig. 2c), although they are abundant in many of the reservoirs. At most localities where they were found only a few individuals were collected, suggesting that they were recent escapees from ponds, reservoirs or bait buckets.

Carp.—Carp were surprisingly uncommon in study area streams. They were found only near large reservoirs in which they were abundant.

Sacramento sucker.—This was the most widely distributed native fish species in the study area (Fig. 2d), occurring in 42% of the samples. Most suckers sampled were juveniles, indicating that small foothill streams serve as nursery areas while the adults live in larger streams and reservoirs. Sacramento suckers were most abundant in clear, permanent streams at an average elevation of 371 m. They were uncommon at low elevation localities where they were once found in large numbers.

Catfishes.—Both brown bullheads and white catfish are present in the main rivers and reservoirs of the study area but were uncommon in the smaller streams. They were represented in our collections mostly by occasional individuals taken at low elevation localities dominated by other introduced fishes.

Mosquitofish.—Originally introduced into the study area for mosquito control, mosquitofish were found, usually in large numbers, at 34% of the sample sites (Fig. 3a). They were characteristically found in sections of stream that had been disturbed by humans, in association with other introduced fishes.

Threespine stickleback.—Although common in canals in the Fresno area, sticklebacks were found in the study area only in back-

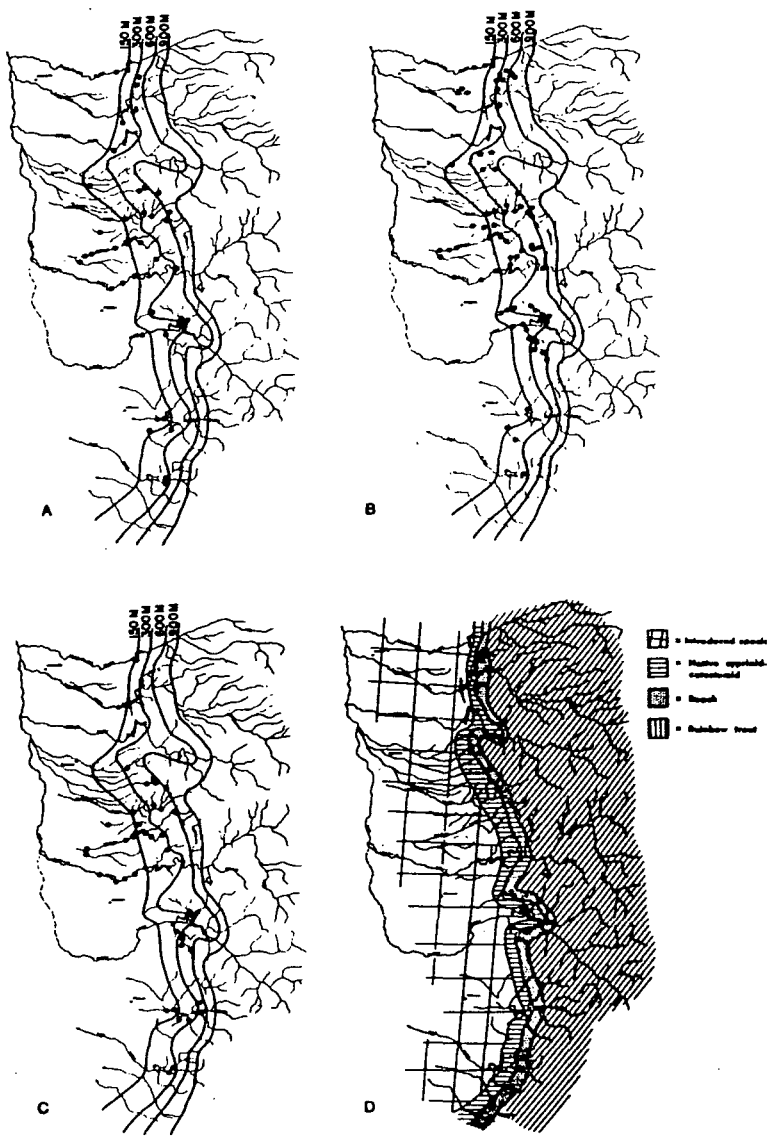

Fig. 3.—1969-1970 locality records for (a) mosquito fish; (b) green sunfi and (c) largemouth bass (solid dots) and smallmouth bass (triangles) in San Joaquin foothills. Map D shows the distribution of fish associations,–ba on 1969-1970 locality records. In D, crosshatched lines = Introduced spec Horizontal lines = Native Cyprinid-Catostomid, Dots = Roach, Slan lines = Rainbow trout. The distributions of the Native Cyprinid-Catosto and California Roach Associations overlap

waters of the San Joaquin and Kings rivers, at low elevations.

Sculpins.—The two species of sculpins were probably more abundant than our records indicate, especially in streams at higher elevations, since they are difficult to capture by seine. Prickly sculpins are common in reservoirs of the study area and were abundant at low elevation localities in the Kings, San Joaquin and Merced rivers (Kottcamp and Moyle, 1972). Riffle sculpins were found only in tributaries to the Kings River above Pine Flat Reservoir and in the Merced River. The two species were collected together in the Merced River below LaGrange Dam.

Redear sunfish.—Only occasional individuals of redear sunfish, presumably escapees from ponds and reservoirs, were taken in the study area. A population is established, however, in the San Joaquin River near Herndon.

Green sunfish.—In their native Midwest, green sunfish are adapted to intermittent streams (Cross, 1967), so it is not surprising that they were the most widely distributed fish in the study area (Fig. 3b). Although individuals were frequently collected in areas dominated by squawfish and hardheads, they were abundant only where the streams had been impounded or otherwise disturbed by man. When they were abundant in small, intermittent streams, California roach were usually absent.

Smallmouth bass.—Smallmouth bass were uncommon in our samples because they occurred mostly in the reservoirs and large rivers (Fig. 3c). However, populations have become established in a few intermittent streams with large, deep pools.

Largemouth bass and bluegill.—Although widely distributed throughout the study area (Fig. 3c), these two species occurred together mostly in pondlike situations either near reservoirs or in stretches of stream extensively modified by human activities.

Associations.—Moyle and Nichols (1973) found that the fishes could be grouped into four associations of species, each association occurring in a distinct habitat area: (1) the Introduced Fishes Association, in low elevation waters, (2) the Native Cyprinid-Catostomid Association in larger streams at intermediate altitudes, (3) the California Roach Association, in small tributary streams at intermediate elevations, and (4) the Rainbow Trout Association in high altitude streams (Fig. 3d). The Introduced Fishes Association occurred mostly in disturbed areas and its species composition varied from place to place. Usually, there were two or more species of centrarchid, mosquito fish and one or more species of catfish or cyprinid at each locality. The Native Cyprinid-Catostomid Association, dominated by squawfish, hardhead and Sacramento sucker, was confined to a narrow altitudinal band in the foothills, as was the California Roach Association (Fig. 3d). The latter association was dominated numerically by California roach, so it was absent from the upper San Joaquin and Fresno rivers. The Rainbow Trout Association, dominated by rainbow trout, is maintained by poisoning and stocking programs in some lower elevation streams that normally would support the Native Cyprinid-Catostomid Association.

DISCUSSION

Comparison of past and present distributional records shows that the San Joaquin foothill fish fauna has changed dramatically in many areas in recent years as native fishes are gradually replaced by introduced species. Perhaps the best illustration of the changes that have occurred is provided by the collections made from the San Joaquin River at Friant by Rutter (1908) in 1898, by Needham and Hanson (1935) in 1934, by Dill (1946) in the early 1940's, and by Moyle and Nichols in 1970 (Table 2). The 1898 collection indicates that the area originally had a fish fauna transitional between that of the Valley floor and that of the foothills. As the river became progressively modified, especially by the construction of dams upstream, the fish fauna changed. By 1934 a number of introduced fish species were present along with the native fishes. By the early 1940's the number of introduced species had increased, but many of the native species were still present as well. By 1970 the river immediately below Friant

TABLE 2.—Fishes present in the San Joaquin River at Friant during 1898, 1934, and 1970. (?) indicates the species was not recorded but probably present, (X) the species was present, and (—) the species was absent. Names followed by (*) are introduced species.

Species	Rutter 1898	Needham and Hanson 1934	Dill 1940–41	Present study 1970
Pacific lamprey	?	?	X	X
Pacific brook lamprey	?	?	X	X
Rainbow trout	?	X	X	X
Brown trout*	—	X	X	X
Chinook salmon	X	X	X	—
Sacramento blackfish	?	X	X	—
Hitch	X	X	X	—
Hardhead	X	X	X	—
Splittail	X	—	—	—
California roach	X	X	X	—
Sacramento squawfish	X	X	X	—
Carp*	—	X	X	X
Sacramento sucker	X	X	X	X
Brown bullhead*	—	—	X	X
Mosquitofish*	—	—	X	X
Tule perch	X	X	X	—
Prickly sculpin	?	?	X	X
Threespine stickleback	X	X	X	X
Green sunfish*	—	—	X	X
Bluegill*	—	X	X	X
Smallmouth bass*	—	—	X	X
Largemouth bass*	—	—	X	X
Per cent native species	100	77	62	40
ex	0	4	8	7
	9/9	14/19	13/21	6/13

Dam, completed in 1942, was dominated by planted rainbow trout, prickly sculpins, threespine sticklebacks and mosquitofish. Further downstream, the fish fauna was dominated by carp, centrarchids and catfishes.

Healthy populations of native fishes occur only in a rather restricted region of comparatively undisturbed sections of foothill streams. This region is likely to become even more restricted as further disruption of the streams occurs and introduced fishes move into more areas. Most of the habitat differences that now exist between the Introduced Fishes Association and the Native Cyprinid-Catostomid Association can be related to changes in the streams due to human activity, especially impoundment, reduced stream flows and siltation (Moyle and Nichols, 1973). As the recreational development of the foothills increases, and with it the demand for more fishing, the tendency to manage streams for game fishes is likely to further contribute to the restriction of habitat for native minnows and suckers.

Still another problem is that the populations of native fishes in each stream are now isolated from other such populations by extensively altered lowland stretches of stream, occupied by introduced fishes. Such isolation may lead to local extinctions of native fish populations during years of severe drought, with no way to renew populations when stream flows return. This has already happened to California roach in the upper San Joaquin and Fresno rivers, where they have been replaced by green sunfish. It is unlikely that habitat deterioration was the main reason roach disappeared, since suitable areas for them still exist in the systems and, in the absence of green sunfish, roach will live in disturbed environments. During the study roach were collected several times in the sewage outfalls of small foothill towns.

It is evident that populations of native fishes now seemingly widespread should be watched closely, especially following periods when severe natural conditions stress populations already affected by human activity. If their decline continues, efforts should be made to set aside suitable sections of streams and manage them for native fishes. Certainly, consideration for the native fish fauna, whether or not it contains endangered species, should be part of environmental impact statements for any developments. Additional studies to evaluate the status of native fishes in river systems throughout the state are needed.

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