State of California
The Resources Agency
DEPARTMENT OF FISH AND GAME
SAN JOAQUIN VALLEY – SOUTHERN SIERRA REGION

SAN JOAQUIN RIVER FISHERY AND AQUATIC RESOURCES INVENTORY

COOPERATIVE AGREEMENT 03FC203052

FINAL REPORT
SEPTEMBER 2003 – SEPTEMBER 2005

24 JANUARY 2007

Introduction

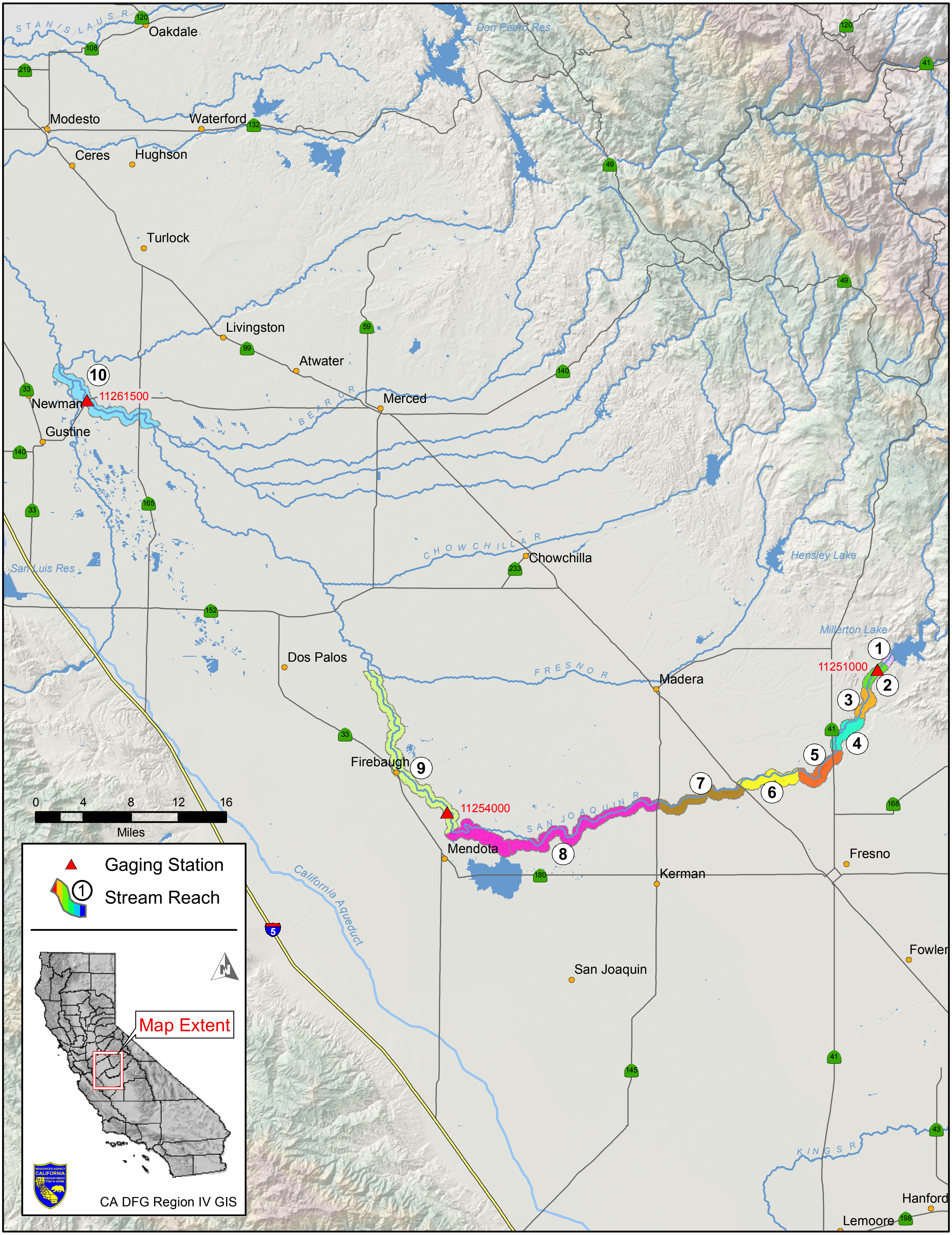
The lower San Joaquin River, between Friant Dam and the Merced River confluence, has been the subject of almost two decades of intensive controversy and planning relating to ongoing litigation between the Natural Resources Defense Council (NRDC) and the U.S. Bureau of Reclamation (USBOR). The NRDC claimed that the USBOR was not providing sufficient stream flows to maintain the historic, self-sustaining salmon runs that were present in the river before Friant Dam was built, a violation of Fish and Game Code §5937. A September 2006 settlement between the parties aims to provide sufficient flows for the return of self-sustaining salmon runs while maintaining an adequate agricultural water supply.

In planning for restoration, the San Joaquin River Riparian Habitat Restoration Program (SJRRHRP) was formed in 1997 at the request of the Friant Water User's Authority (FWUA) and the NRDC. The purpose of this program was to pursue riparian habitat restoration studies and efforts along the San Joaquin River corridor downstream of Friant Dam. The SJRRHRP is a Central Valley Project Improvement Act project and is thus co-managed by the USBOR and the U.S. Fish and Wildlife Service (USFWS). Membership in the SJRRHRP includes USBOR, USFWS, FWUA, NRDC, the Pacific Coast Federation of Fishermen's Associations, and the San Joaquin River Exchange Contractors Water Authority. Through this program several studies have investigated various aspects of the river, including the riparian vegetation (Jones and Stokes 1998, Moise and Hendrickson 2002), topography and bathymetry (Ayres Associates 1999), and streamflow and water temperature modeling (USBOR 2005). Few studies, however, have addressed the current status of the fishery and aquatic resources in the reach proposed for restoration. While several species, native and non-native, are known to have existed in the river, their current status is unknown. Jones and Stokes (1987) conducted a survey of fish in the river using gill net, beach seining, and boat electrofishing methods during a study of white bass (*Morone chrysops*) distribution. To our knowledge, no other studies have focused on inventorying the river in the study area for its current aquatic fauna. Before any changes to flows are made, for both regulatory and biological reasons, it is necessary to know what species are present, how they might be affected, and how they may potentially interact with native species targeted for restoration. This study is the first step in that process.

On September 19, 2003, we entered into a two-year, Cooperative Agreement #03FC203052 between the California Department of Fish and Game (CDFG) and the USBOR. The primary objectives of this study were to: (1) inventory and document the current fish and aquatic species and their distributions within the study area, and (2) map the aquatic macrohabitat.

Study Area

The project Study Area within the San Joaquin River was divided into 10 reaches between Friant Dam, Fresno and Madera Counties, and the Merced River confluence, Merced County (Figure 1). Each reach was studied independently as a separate unit because of variability in outflows from Friant Dam and different sampling dates for different areas on the River. In addition, the portion of the river that lies between the Sack Dam (Arroyo Canal), Fresno County, and the confluence with Bear Creek, Merced County, does not contain sufficient flows for the majority of the year and thus was not included in sampling, and the area known as Mendota Pool was not included as the goal



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was to document species in the river itself (Figure 1). The reach boundaries were designated for logistical purposes, typically corresponding to distinct landmarks that served as known access points to the river. The lengths varied from 1.10 to 23.01 miles, but most could be surveyed in a short enough time span to minimize variance in river flows from day to day sampling. The first reach was defined as substantially shorter than the other reaches due to the unusual nature of temperatures and flows coming directly from Friant Dam.

Methods

The study was divided into three broad categories of inventory, each discussed below: water conditions, habitat characterization and mapping, and biological inventory.

Water Conditions

Assessment of water conditions throughout the study area consisted of continuous monitoring of water temperature for the duration of the study at various, permanent locations, and the measurement of point samples for water temperature, turbidity, and conductivity.

For long-term, continuous monitoring of water temperatures, Stowaway Tidbit® Underwater Temperature loggers (Onset Computers) were placed in an ABS pipe protective housing and two were installed at each of 9 locations throughout the study area (see habitat Figures 8-17). The units were anchored to a suitable substrate using stainless steel cable. The protective housings were made using 1.5 inch diameter ABS pipe drilled with 0.25 inch holes to allow water to flow through the housing. A threaded coupler was affixed to one end and fitted with a galvanized steel plug that functioned as a weight and allowed access to the sensor. The other end was capped with an ABS cap. The housings were anchored in locations that would remain submerged at the lowest predicted flows during the study. The data loggers were programmed to record water temperatures hourly, and the data were downloaded once every two months, in most cases, using an optic shuttle from Onset Computers. Some loggers were inaccessible during high flows or inclement weather and were not downloaded as often, and other loggers were swept away or buried during high flows and were not recovered. After downloading, the data were imported into an Excel spreadsheet using the Onset Optic Base Station and BoxCar software. These data have been submitted to USBOR, who have analyzed them extensively (e.g., USBOR 2005); thus, they are not included in this report to avoid redundancy.

Measurements of water temperature, conductivity, and turbidity were recorded at point sample locations during the habitat characterization phase of the study and are describe in the sections below.

Flow conditions for the duration of the study are reported as mean monthly flows from three gaging stations (Figure 1): the San Joaquin River below Friant Dam (USGS Station number 11251000), near Mendota (USGS Station number 11254000), and at Fremont Ford Bridge at Highway 140 (USGS Station number 11261500). While the flows change with distance from each gage due to tributary and agricultural accretions and diversions, each station represents similar flow patterns for three sections of the river. The first station represents flow patterns from Friant Dam to Mendota Pool, where the river is dammed and diverted for agriculture. The second station represents flows from Mendota Dam, where water is released, to Sack Dam/Arroyo Canal, where water is again dammed and diverted; the third station represents flows generally from the Bear Creek confluence, where the river picks up significant accretions from tributaries and agricultural return flows, to the Merced River confluence at the end of the study area. While there is substantial distance within one such section, the general pattern of water accretions and diversions in a section are more similar than when comparing any point within one section with another point in a different section.

Habitat Characterization and Mapping

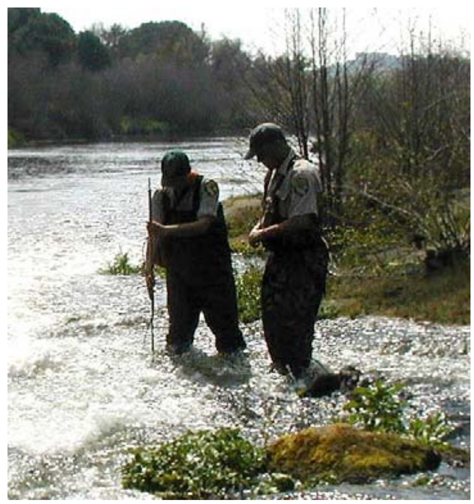
Crews of 3-8 individuals floated the river in kayaks or personal pontoon crafts, or waded in shallow habitats (Figure 2), recording measurements at each habitat unit. Habitat Units were determined following the classification system by Flosi and Reynolds (1994). A habitat unit was considered defined when its length was equal to or greater than the width of the River at that point (for mid-channel habitat units), or equal to or greater than half the width of the River at that point (for side-channel habitat units). When a defined habitat unit was encountered, the habitat type was recorded. Table 1 displays all of the potential habitat types in the classification system. At each habitat unit, a water sample was obtained 6 inches below the surface at the approximate center of the unit. Turbidity, recorded as nephelometric turbidity units (NTUs), of that sample was determined using a Lamotte® portable turbidity meter that was calibrated at the start of each sampling day using manufacturer-supplied calibration vials. The boundaries of each habitat unit were recorded using a Garmin E-Trex Global Positioning System (GPS) unit. The length of the unit was recorded and data collection locations were established at 3 equidistant points throughout the length of the unit, all at the thalweg, for all reaches except reach 3 (Figure 3). For Reach 3, data collection points were also established at the top, bottom, and 3 equidistant points throughout the length of the unit (Figure 3). In

A

B

C

D



E

Figure 2. Methods used to record habitat variables on the lower San Joaquin River, 2003-2005. Methods shown include a personal pontoon craft (A) equipped with a depth sensor (B) and a velocity meter (C); and a wading rod and velocity meter (D and E).

Table 1. List of habitat unit groups, classifications, and abbreviations used in mapping the lower San Joaquin River, 2003-2005. Habitat groups are described in Flosi and Reynolds (1994).

Habitat Group	Habitat Type	Abbreviation
Riffles/Runs	Low Gradient Riffle	LGR
	High Gradient Riffle	HGR
	Cascade	CAS
	Bedrock Sheet	BRS
	Pocket Water	POW
	Run	RUN
	Step Run	SRN
Glides	Glide	GLD
Edgewaters	Edgewater	EDW
Pools	Trench Pool	TRP
	Mid-Channel Pool	MCP
	Channel Confluence Pool	CCP
	Step Pool	STP
	Corner Pool	CRP
	Lateral Scour Pool – Log Enhanced	LSL
	Lateral Scour Pool – Root Wad Enhanced	LSR
	Lateral Scour Pool – Bedrock Formed	LSBk
	Lateral Scour Pool – Boulder Formed	LSBo
	Plunge Pool	PLP
	Secondary Channel Pool	SCP
	Backwater Pool – Boulder Formed	BPB
	Backwater Pool – Root Wad Formed	BPR
	Backwater Pool – Log Formed	BPL
	Dammed Pool	DPL
	Pool—Gravel Pit Formed	PGR
	Pool—Unknown Formation	PUNK
Other	Dry	DRY
	Culvert	CUL
	Not Surveyed	NS
	Not Surveyed due to a marsh	MAR

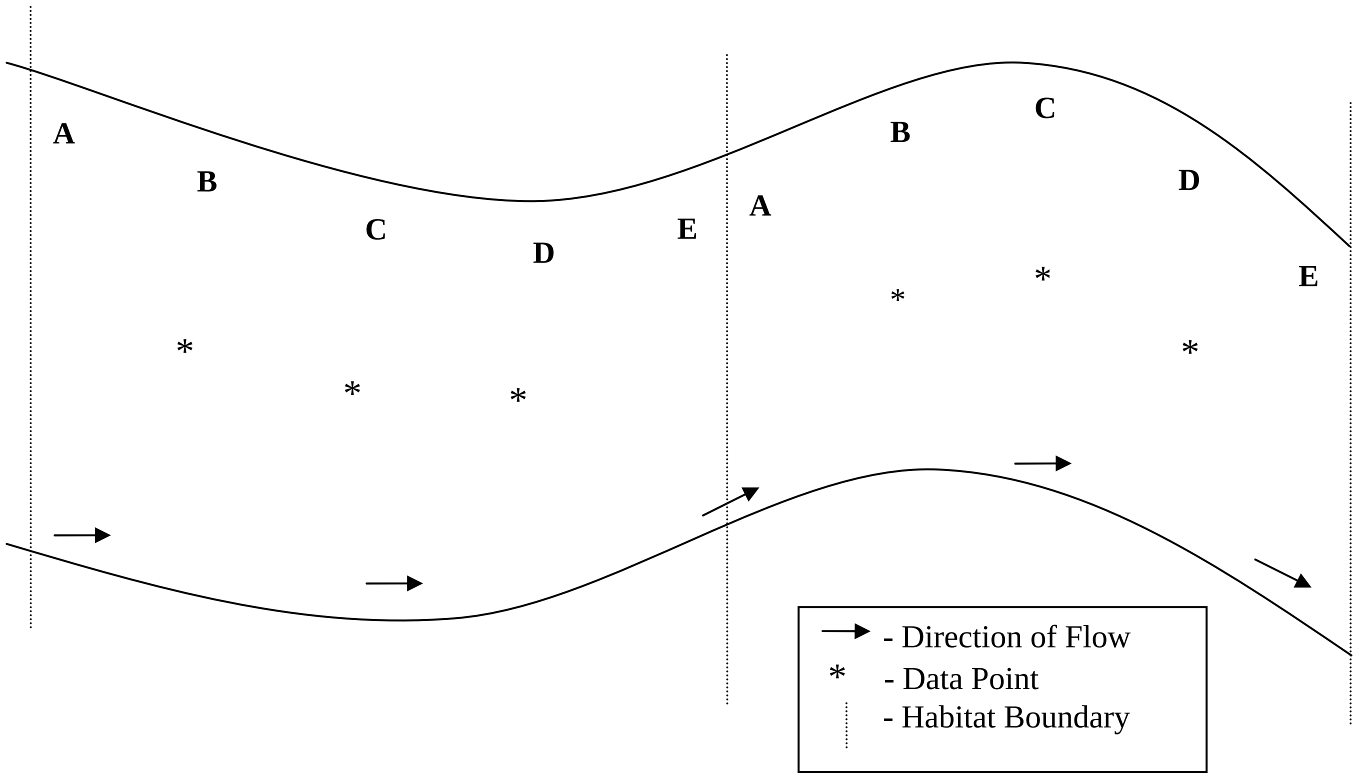


Figure 3. Schematic of the locations of data collection points within habitat units during mapping of the lower San Joaquin River, 2003-2005.

addition, for reach 3, when habitat units were longer than 8 times the average wetted width of the River, points were established every 2 wetted widths in length. This ensured a maximum spacing of points at every 2 wetted widths in length. Extremely long habitat units had more data collection points than those shorter than 8 times their average widths. Each parameter collected at data collection points was averaged for the individual habitat unit. These protocols were applied only to reach 3 because that reach was mapped first. After mapping reach 3, it was determined that a more efficient procedure was to collect data at the 3 middle points. This modification allowed for more rapid mapping, but also maintained data quality, since the boundary points (A and E) were transitional in nature and did not necessarily reflect the true values of the habitat unit.

The following data were collected at each data collection point: wetted width, depth, visual substrate characterization of dominant and co-dominant particles, and water velocity. Wetted width was determined using distance finders. Depth was recorded using a Garmin GPSmap 168 sounder attached to personal pontoon craft (Figure 2) in deep water, or using a top-setting wading rod in wadeable water (Figure 2). Substrate was visually observed when possible and the dominant and co-dominant particle size were recorded using the modified Wentworth scale (Bain 1999; Table 2). Velocity was determined by suspending a Marsh-McBirney flow meter 6 inches below the surface and recording water current in feet per second (Figure 2). In addition to the data collected at each data point, overall values for the reach were recorded for right and left bank vegetation composition and percent of reach covered. Composition was recorded as the dominant vegetation type in broad categories (trees, shrubs, grasses, and no vegetation) and the percent of the banks covered by that dominant type. The “banks” observed for

Table 2. Modified Wentworth scale (Bain 1999) used in characterizing substrate on the lower San Joaquin River, 2003-2005.

CLASS	SUBSTRATE TYPE	PARTICLE SIZE RANGE (INCHES)
A	SILT / CLAY	N/A
B	SAND	< 0.08
C	GRAVEL	0.08 – 2.5”
D	PEBBLE	2.5” – 5”
E	COBBLE	5” – 10”
F	BOULDER	>10”
G	BEDROCK	N/A
H	OTHER	N/A
UNK	UNABLE TO OBSERVE	N/A

vegetation included the area from the water’s edge to 20 feet up the bank. For each reach, the frequency of encounters and abundance of habitat type by area were reported. The 26 potential habitats were grouped into pools, runs/riffles, glides, and edgewaters (Table 1).

Biological Inventory

Habitat characterization and mapping was conducted before attempting the biological inventory phase of the study. This allowed for an attempt at targeting of limited biological sampling to various habitats in proportion to their availability; which in turn provided a more representative inventory of the river in its current state. Each of the 10 study reaches was mapped for habitat independently, to minimize the influence of variability in stream discharge on habitat mapping. Once a reach was mapped completely, it was considered “available” for biological inventory. An attempt was made to sample the most abundant habitat types, by area and by frequency encountered, within each reach. The targeted biological inventories consisted of single-pass electrofishing surveys and gill netting for fish species; and kick net surveys for macroinvertebrate sampling.

Fish Surveys. Because various fish sampling methods are inherently biased towards certain species and individuals within species (Willis and Murphy 1996), an attempt was made to incorporate several different methods to maximize the diversity of fish species detected during the study. Because of logistics, however, we determined that certain methods, such as gill netting and beach seining, were impractical. The presence of woody debris and current makes gill net sampling in lotic environments difficult and impractical (Hubert 1996). After several attempts at these methods, we determined that boat and backpack, single-pass electrofishing surveys would be the most effective sampling tool to detect the highest number of species using the limited resources available. Backpack electrofishing was employed in most riffle/run, edgewater, and glide habitats, whereas boat electrofishing was used in pool and some glide habitats. For wading, a Smith-Root model 12-B backpack electrofisher was used. One crew member wore the backpack and moved upstream, shocking the habitat unit being surveyed, while two or more netters captured fish and placed them into a 5 gallon bucket tended by another crew member. For boat surveys, a Smith-Root Model GPP 2.5 pulsator, powered by a Honda GX 160 generator, was mounted to a 16 foot, flat-bottomed boat. A boat operator moved the boat slowly along shorelines in an upstream direction, while 1-2 netters captured fish from the bow of the boat. Fish captured from either technique were measured, weighed, and released back into the river. Scales and dorsal fin clips were collected from native fish species until a total of 100 samples were obtained from each native species encountered. The scale and tissue samples were stored at the Fresno CDFG regional office. Species composition was reported for each habitat type and method used. Catch-per-unit-effort (CPUE) was used to report species occurrences for each reach and habitat type. Effort was reported as the number of seconds the electrofishing units were employed.

Invertebrate Sampling. Kick net surveys were utilized to obtain a cursorary view of the macroinvertebrate composition within each reach. After habitats were mapped for a reach, one to three habitat types were sampled: one to represent the dominant habitat type, by frequency encountered, for that reach, one riffle/run, if it was available for the reach, to represent a "high diversity" site for the reach, and for Reach 1 an edgewater was also sampled. If riffles were the dominant habitat type, then an additional riffle or run was sampled. The collection, preparation, and laboratory identification methods for samples from kick net surveys followed those described by Harrington and Born (1999), with the exception that only three individual samples made up the single composite sample collected from each habitat unit. Date of sample, habitat type, and dominate substrate class (Table 2) were recorded for each survey. The most specific taxonomic group identified was species, but most groups were identified to the class or order level. The objective was to document groups of invertebrates occurring within each reach at one point in time. Limited resources did not allow for any quantitative assessment, specific identifications, or for any claim of absence of species or groups.

Results

Water Conditions

Monthly mean flows ranged from 85 cubic feet per second (cfs) near Mendota in January 2004 to 5051 cfs below Friant Dam in May 2005 (Figure 4). Tables 3 and 4 show the range of flow conditions during habitat sampling and biological sampling periods, respectively, for each reach.

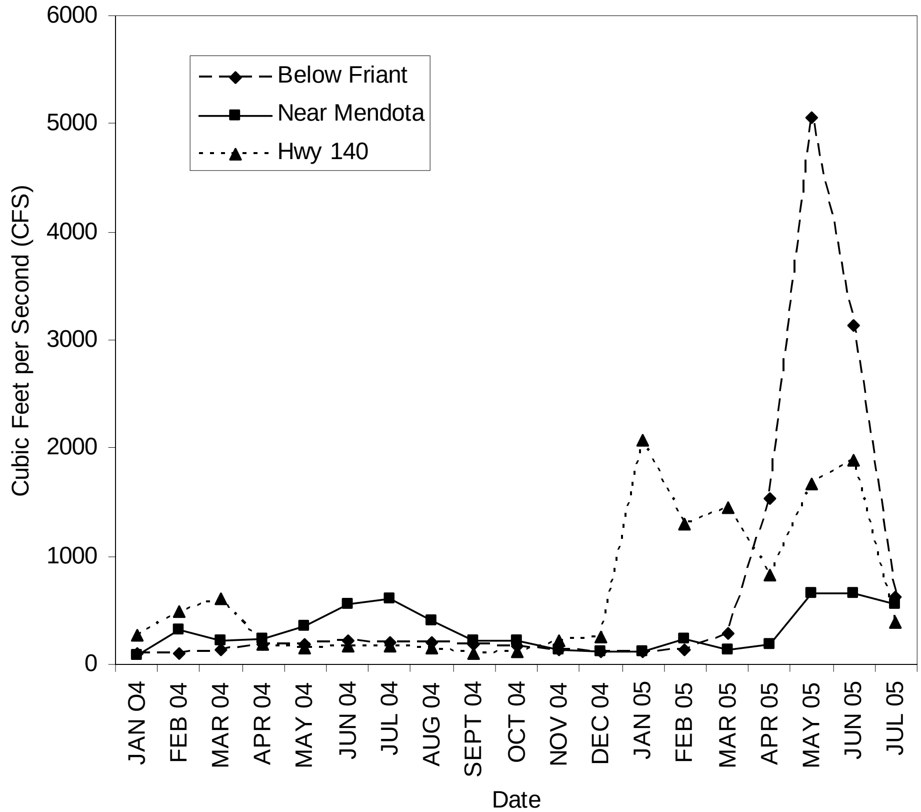


FIGURE 4. San Joaquin River mean monthly flows from three gauging stations from January 2004 to July 2005.

Table 3. Sampling periods, number of days of habitat sampling, and range of flows during sampling on the lower San Joaquin River, 2003-2005.

Reach	Sampling Period	No. Days	Minimum[1]	Maximum[1]	CDEC Gage I.D.[2]
1	April 2004	1	149	149	SJF
2	March – April 2004	5	149	191	SJF
3	January – March 2004	13	113	161	SJF
4	March – April 2004	12	115	250	SJF
5	April – July 2004	8	186	244	SJF
6	April – July 2004	13	194	244	SJF
7	August – October 2004	5	161	206	DNB
8	December 2004 – February 2005	8	128	154	DNB
9	June 2005	2	122	2720	MEN
10	April – June 2005	6	412	839	FFB

[1] Minimum and maximum mean daily flows encountered on sampling days reported in cubic feet per second.
[2] CDEC = California Data Exchange Center; Gages used to obtain flows on the San Joaquin River include near Friant Dam (SJF), Donny Bridge (DNB), Mendota (MEN), and Highway 140/Fremont Ford Bridge (FFB).

Table 4. Sampling dates, types, and range of flows during fish and macroinvertebrate sampling on the lower San Joaquin River, 2003-2005.

Reach	Sampling Type	Habitat Type	Date	Water Temperature (^{0}C)	Mean Daily Flow[1]	CDEC Gage I.D.[2]
1	FBT	GLD	3/4/05	11.0	140	SJF
	FBT	MCP	3/4/05	11.0	140	SJF
2	FBP	SRN	3/10/05	11.0	111	SJF
3	FBP	EDW	10/22/04	--	159	SJF
	FBP	EDW	3/18/05	11.5	103	SJF
	FBP	RUN	3/18/05	11.5	103	SJF
4	FBP	SRN	10/29/04	--	114	SJF
	FBP	BPB	10/29/04	--	114	SJF
	FBP	GLD	1/14/05	8.6	60	SJF
5	FBP	RUN	11/4/04	12.0	124	SJF
	FBP	EDW	11/5/04	12.0	137	SJF
	FBP	RUN	11/5/04	13.0	137	SJF
	FBP	EDW	11/5/04	13.0	137	SJF
	FBP	GLD	11/5/04	--	137	SJF
	FBP	RUN	11/5/04	13.0	137	SJF
	FBT	PGRV	5/24/05	--	8470	SJF
	FBT	PGRV	5/26/05	12.0	8750	SJF
	FBT	EDW	6/8/05	13.0	4270	SJF
	FBT	PGRV	6/8/05	13.0	4270	SJF
	FBT	GLD	6/8/05	13.0	4270	SJF
6	FBP	LGR	7/8/04	24.5	195	SJF
	FBP	EDW	7/8/04	26.0	195	SJF
	FBT	PGRV	10/13/04	--	174	SJF
	FBT	PGRV	10/13/04	--	174	SJF
	FBP	EDW	11/12/04	17.0	130	SJF
	FBP	EDW	11/12/04	14.0	130	SJF
	FBP	RUN	11/12/04	14.0	130	SJF
	FBP	RUN	11/12/04	14.0	130	SJF
	FBT	GLD	2/8/05	--	118	SJF
	FGL	MCP	2/10/05	9.0	113	SJF
	FBP	RUN	2/10/05	9.0	113	SJF
	FBT	GLD	2/10/05	9.0	113	SJF
	FGL	MCP	2/10/05	9.0	113	SJF
7	FBP	RUN	2/9/05	--	117	DNB
	FBP	EDW	2/9/05	--	117	DNB
	FBP	RUN	2/9/05	--	117	DNB
	FBP	GLD	2/9/05	--	117	DNB
	FBP	EDW	2/9/05	--	117	DNB

(continued on following page.)

Table 4. Continued.

Reach	Sampling Type	Habitat Type	Date	Water Temperature (^{0}C)	Mean Daily Flow[1]	CDEC Gage I.D.[2]
7	FBT	PGRV	3/1/05	16.0	177	DNB
8	FBT	MCP	4/5/05		1286	DNB
	FBP	EDW	4/6/05	12.5	1190	DNB
	FBP	GLD	4/6/05	12.5	1190	DNB
9	FBT	MCP	7/11/05		464	MEN
	FBT	EDW	7/11/05		464	MEN
	FBT	GLD	7/11/05		464	MEN
10	FBT	GLD	3/29/05	16.5	2640	FFB
	FBT	GLD	3/30/05	15.0	2570	FFB
	FBT	MCP	6/29/05		1130	FFB
	FBT	GLD	6/29/05		1130	FFB
	FBT	EDW	6/29/05		1130	FFB
	FBT	GLD	6/30/05		1050	FFB
	FBT	EDW	6/30/05		1050	FFB
	FBT	MCP	6/30/05		1050	FFB

[1] Minimum and maximum mean daily flows encountered on sampling days reported in cubic feet per second.
[2] CDEC = California Data Exchange Center; Gages used to obtain flows on the San Joaquin River include near Friant Dam (SJF), Donny Bridge (DNB), Mendota (MEN), and Highway 140/Fremont Ford Bridge (FFB).

Water temperature data acquired by the permanent temperature loggers has been reported partially by USBOR (2005) and is being analyzed extensively by USBOR.

Habitat Characterization and Mapping

A total of 845 habitat units were mapped during the study across 103.96 river miles (Table 5). While discharge fluctuations were within 200 cfs for Reaches 1-8, Reaches 9 and 10 experienced fluctuations in discharge that we considered significant enough to preclude including these reaches in habitat comparisons (Table 3). Glides dominated the area mapped for the upper four reaches and were replaced by pools for the next four reaches (Figure 5). The four habitat groups were generally well-distributed in frequency encountered, although riffles and runs were scarce or non-existent in the more downstream reaches (Figure 6). Table 5 summarizes the characteristics of habitats throughout the study area. Turbidity measurements are summarized in Figure 7. Figures 8-17 show the habitat groupings mapped by reach.

Biological Inventory

Fish Surveys. Fifty-two fish surveys were conducted in separate habitat units (Table 4). Boat and backpack electrofishing methods were conducted at 25 sites each, whereas gill netting was only conducted two times (Table 4). Figures 18 and 19 display the amount of effort expended during electrofishing surveys for each reach. While the number of species detected increased with distance downstream, the composition of fish assemblages shifted from native species to non-native species (Figure 20). Most native species were absent downstream of Reach 4, with the exception of Sacramento suckers and lampreys (Figures 21-30). Most lampreys detected were ammocoetes and were not

Table 5. Characteristics of habitats mapped and level of effort for habitat sampling on the lower San Joaquin River, 2003-2005.

	Reach Number									
	1	2	3	4	5	6	7	8	9	10
Length (miles)	1.10	2.92	5.68	7.80	13.24	11.90	10.64	8.45	23.01	19.22
Total No. Habitat Units	11	24	71	128	140	131	116	114	19	91
No. Different Habitats	5	8	12	14	10	10	11	8	4	7
Total Area (acres)	11.6	46.4	66.2	77.6	227.7	326.15	98.62	90.61	301.51	217.05
Mean Area/Habitat Unit	1.05	1.72	0.92	0.61	1.63	2.49	0.85	0.79	15.87	2.39
(Standard Deviation)	(0.96)	(4.57)	(2.40)	(1.02)	(5.03)	(18.56)	(1.21)	(1.91)	(46.49)	(5.71)
No. Field Sampling Days	1	3	12	12	13	10	8	8	2	6
No. Miles/Sampling Day	1.10	0.97	0.47	0.65	1.02	1.19	1.33	1.06	11.51	3.20

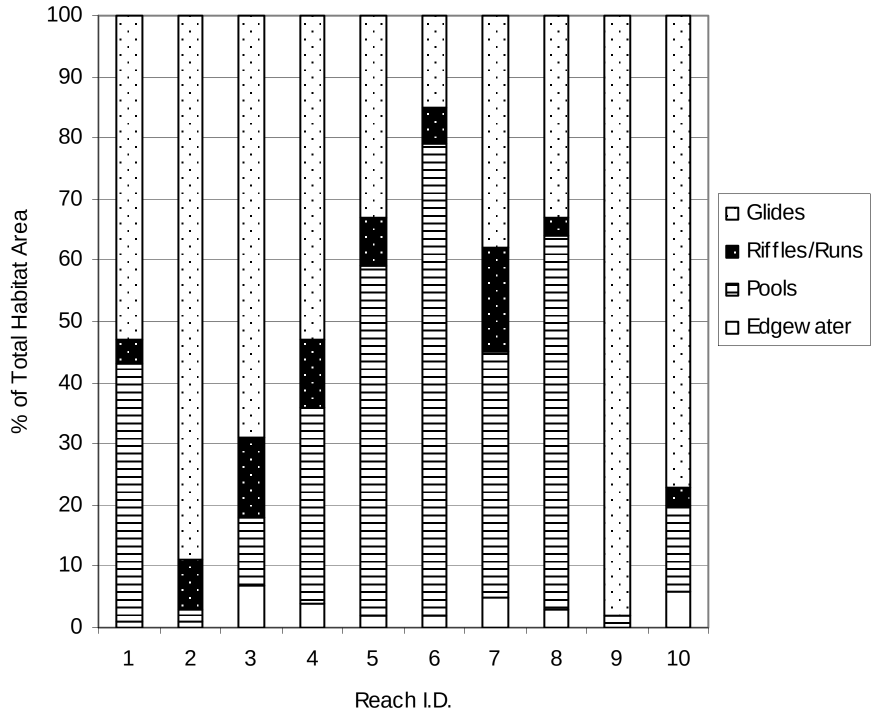


FIGURE 5. Habitat abundance by area for all habitats mapped in Reaches 1-10 on the lower San Joaquin River, 2003-2005.

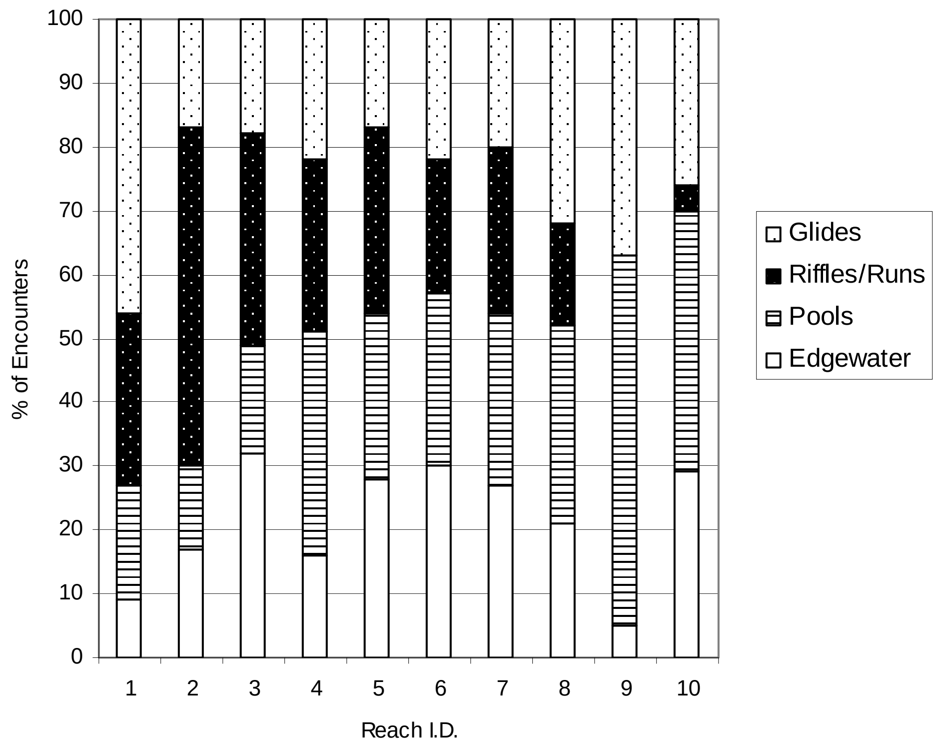


FIGURE 6. Frequency of encounters of various habitat types for all habitats mapped in Reaches 1-10 on the lower San Joaquin River, 2003-2005.

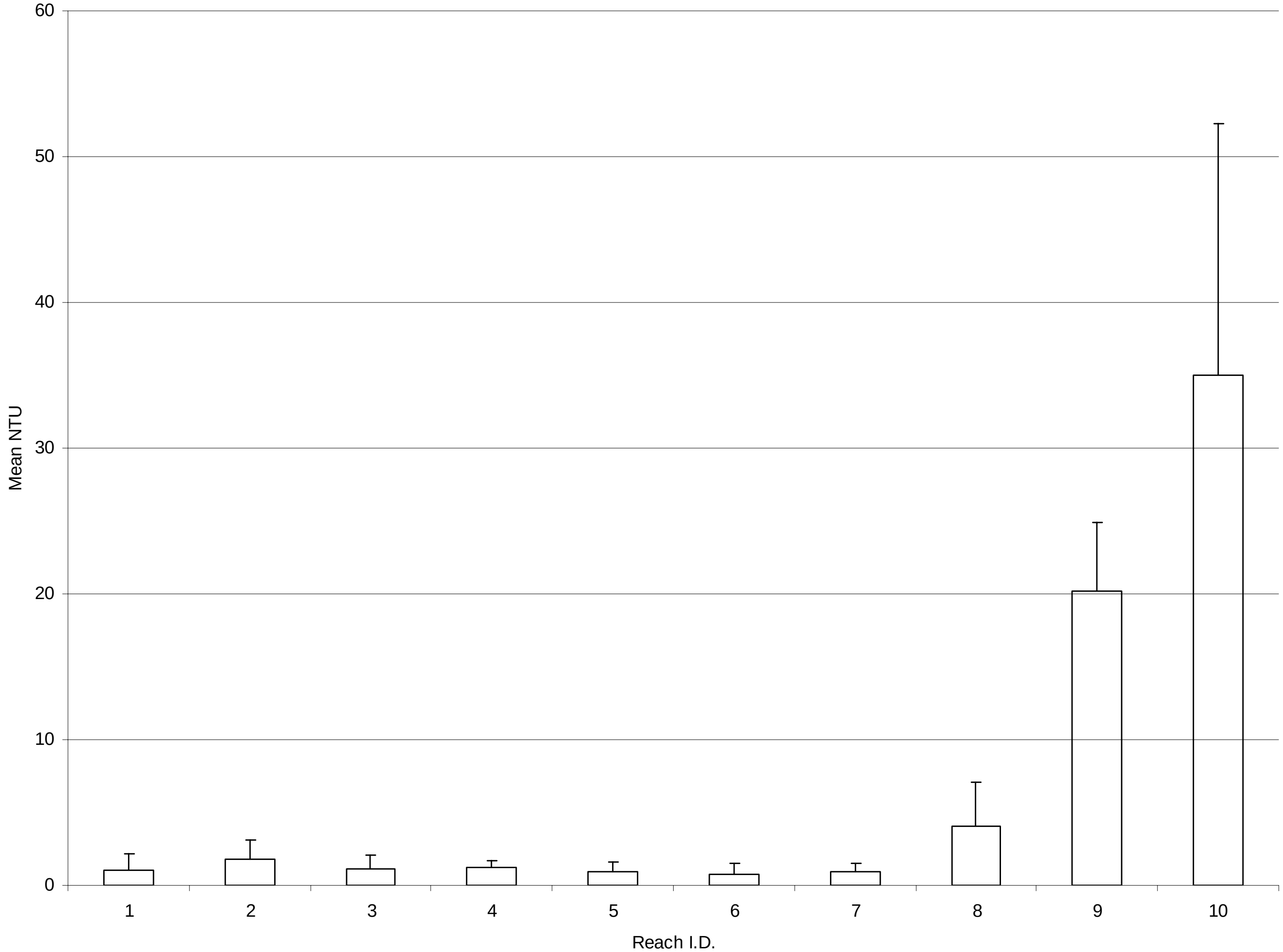


FIGURE 7. Mean turbidity (NTU) across all habitats for Reaches 1-10 on the lower San Joaquin River, 2003-2005.

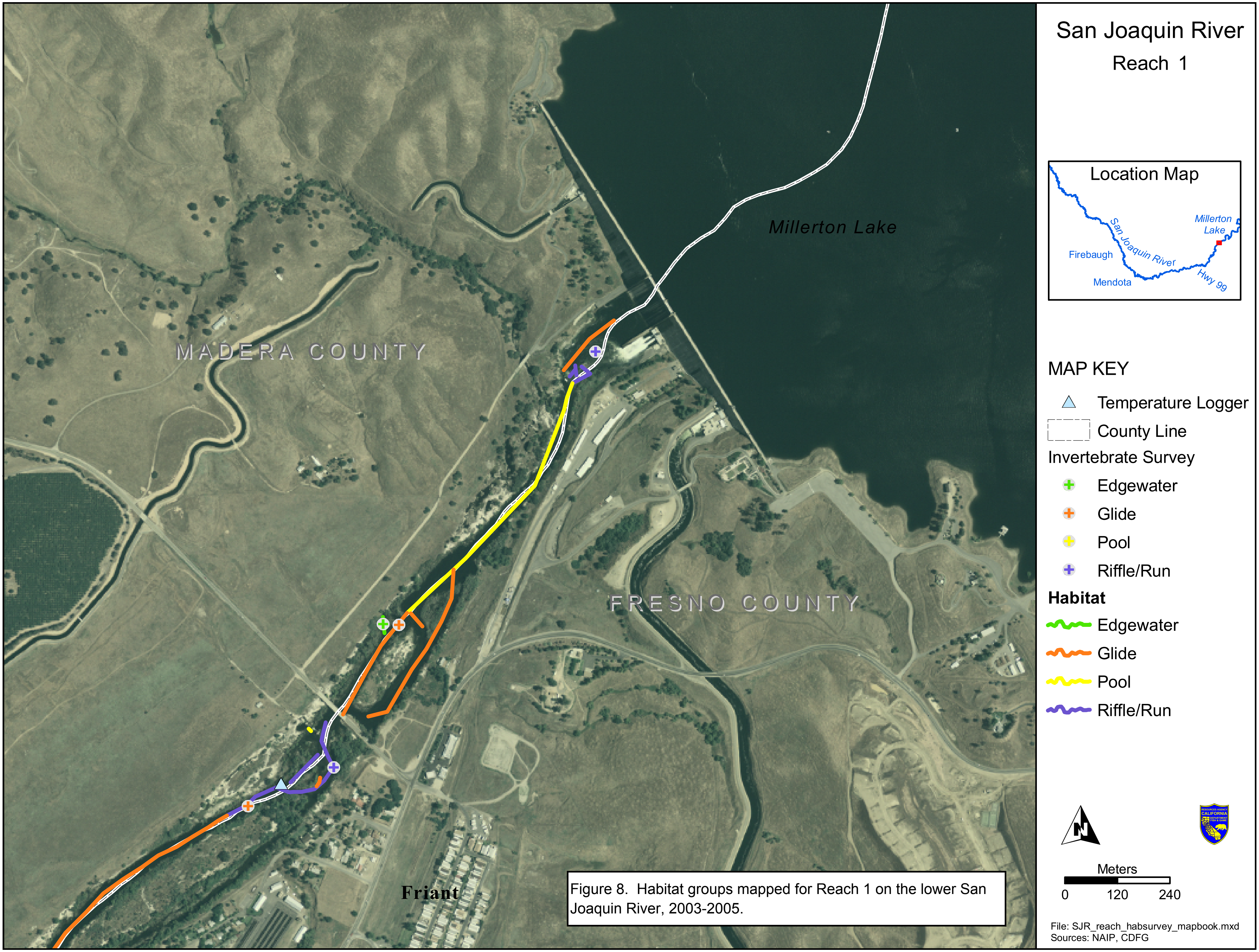


Figure 8. Habitat groups mapped for Reach 1 on the lower San Joaquin River, 2003-2005.

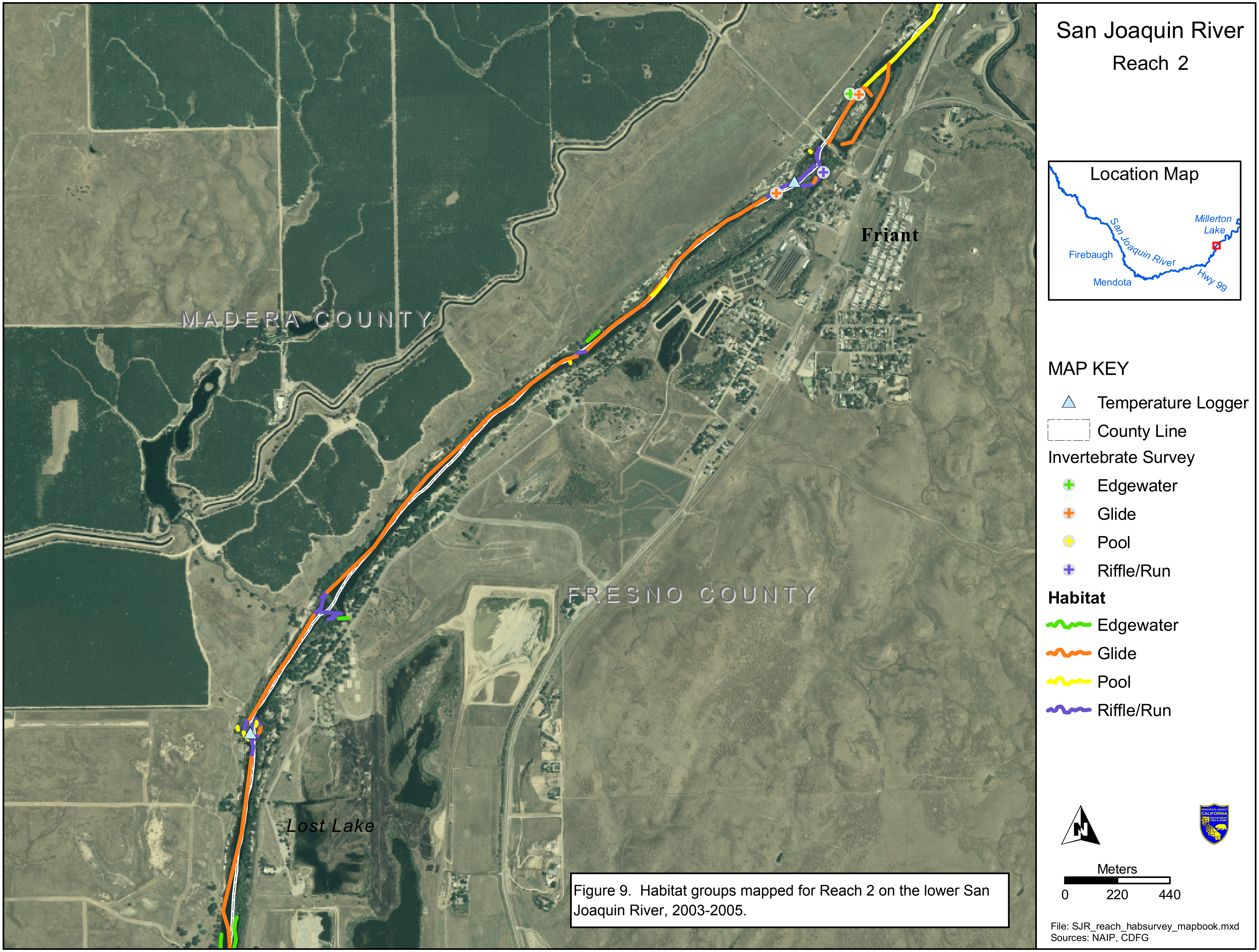


Figure 9. Habitat groups mapped for Reach 2 on the lower San Joaquin River, 2003-2005.

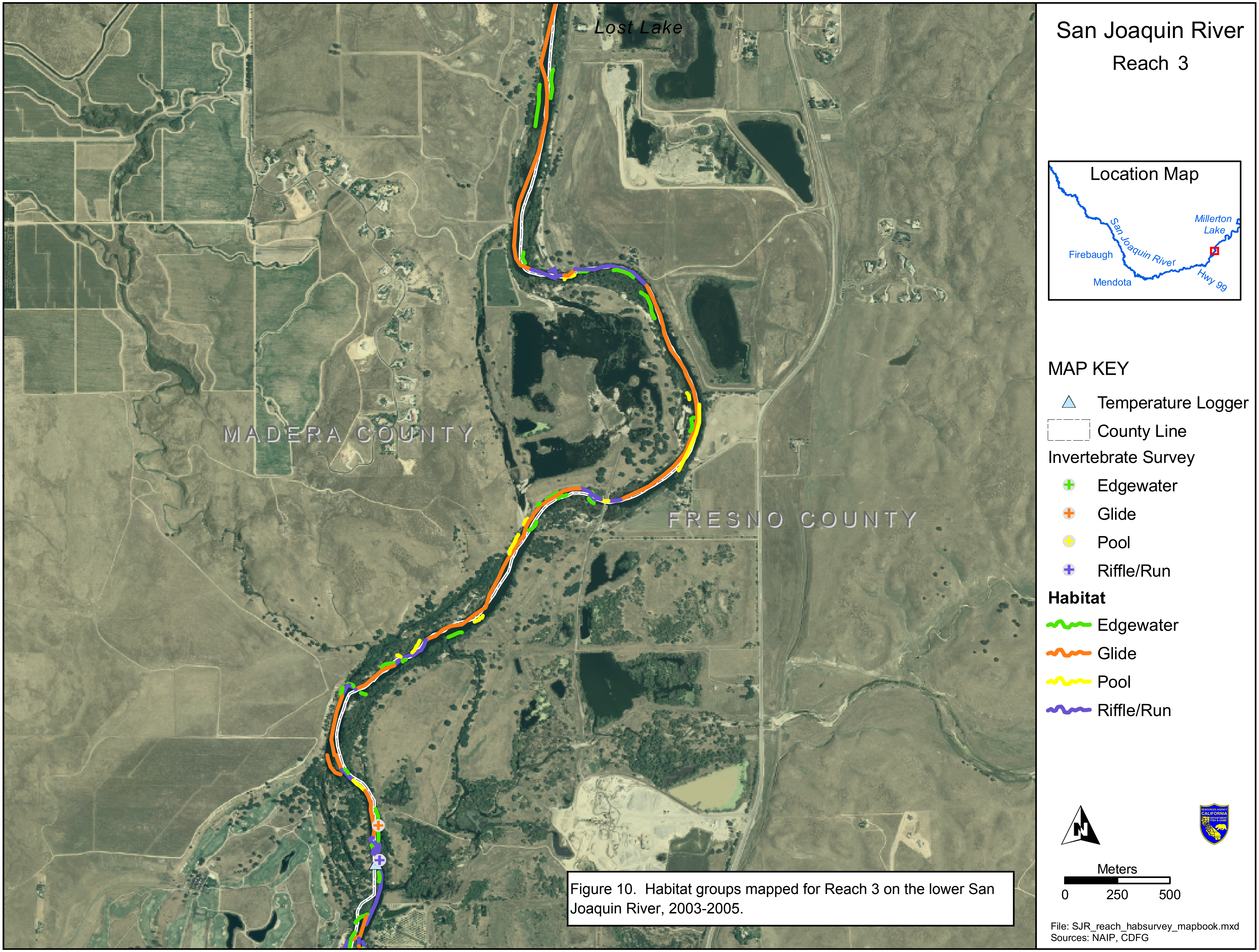


Figure 10. Habitat groups mapped for Reach 3 on the lower San Joaquin River, 2003-2005.

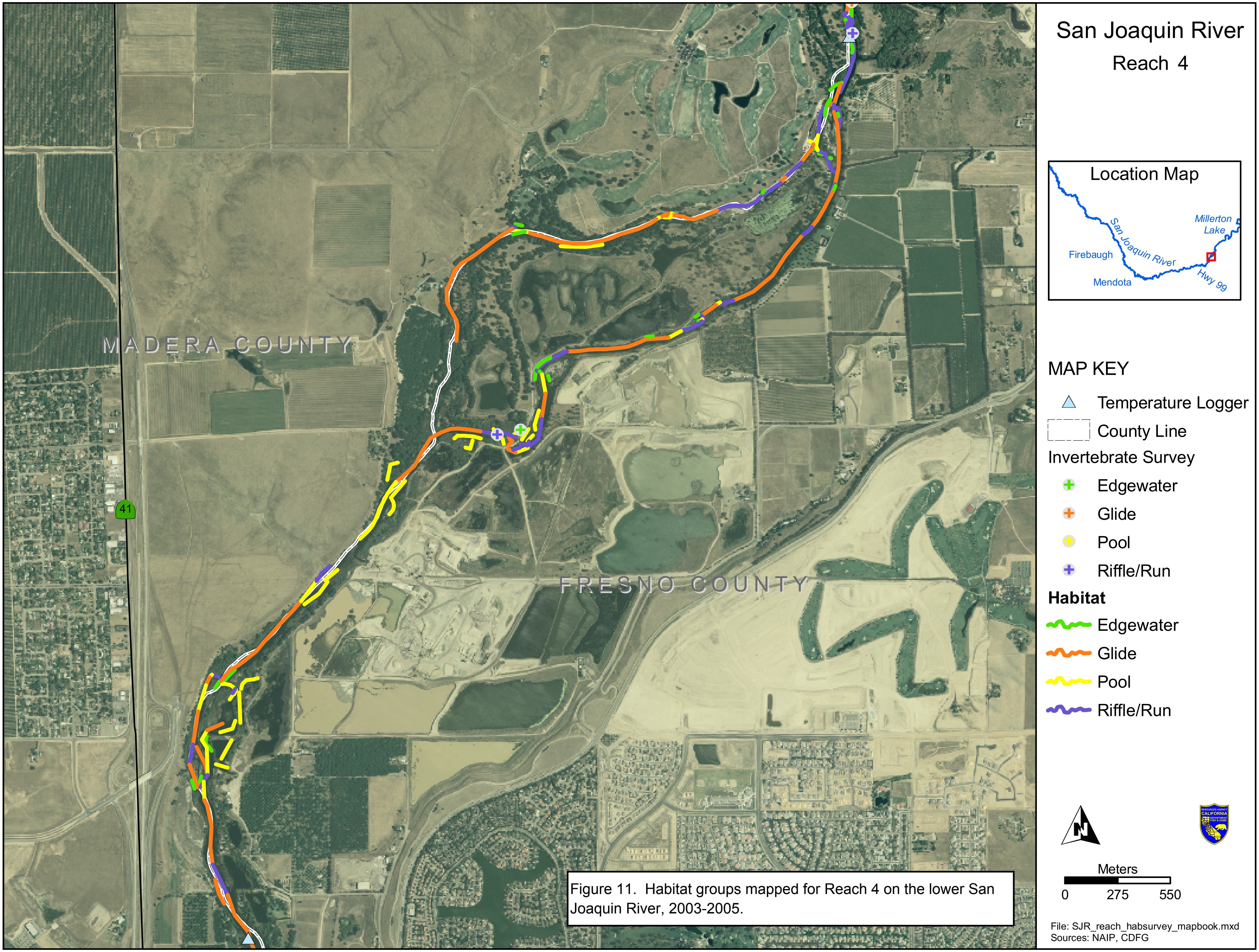


Figure 11. Habitat groups mapped for Reach 4 on the lower San Joaquin River, 2003-2005.

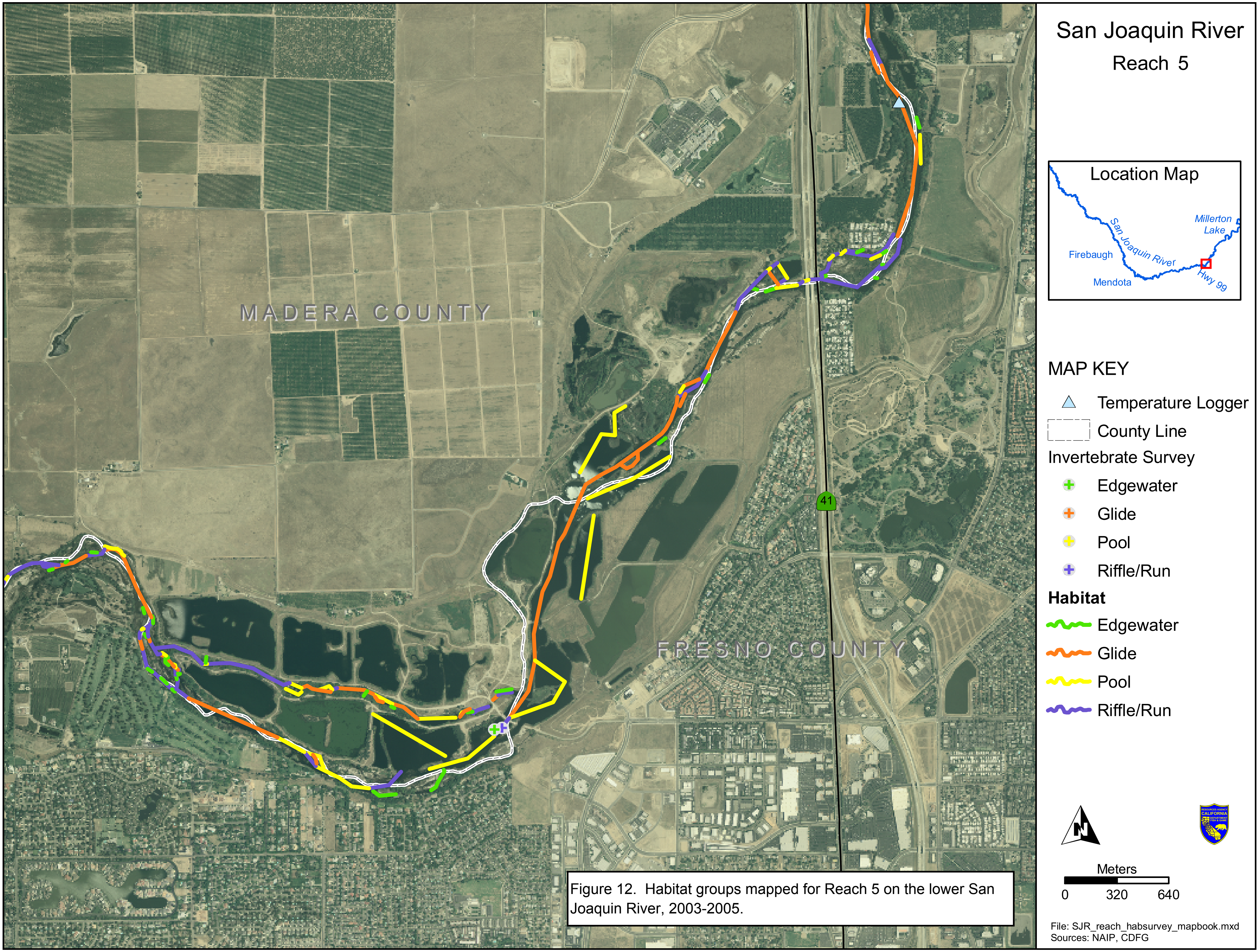


Figure 12. Habitat groups mapped for Reach 5 on the lower San Joaquin River, 2003-2005.

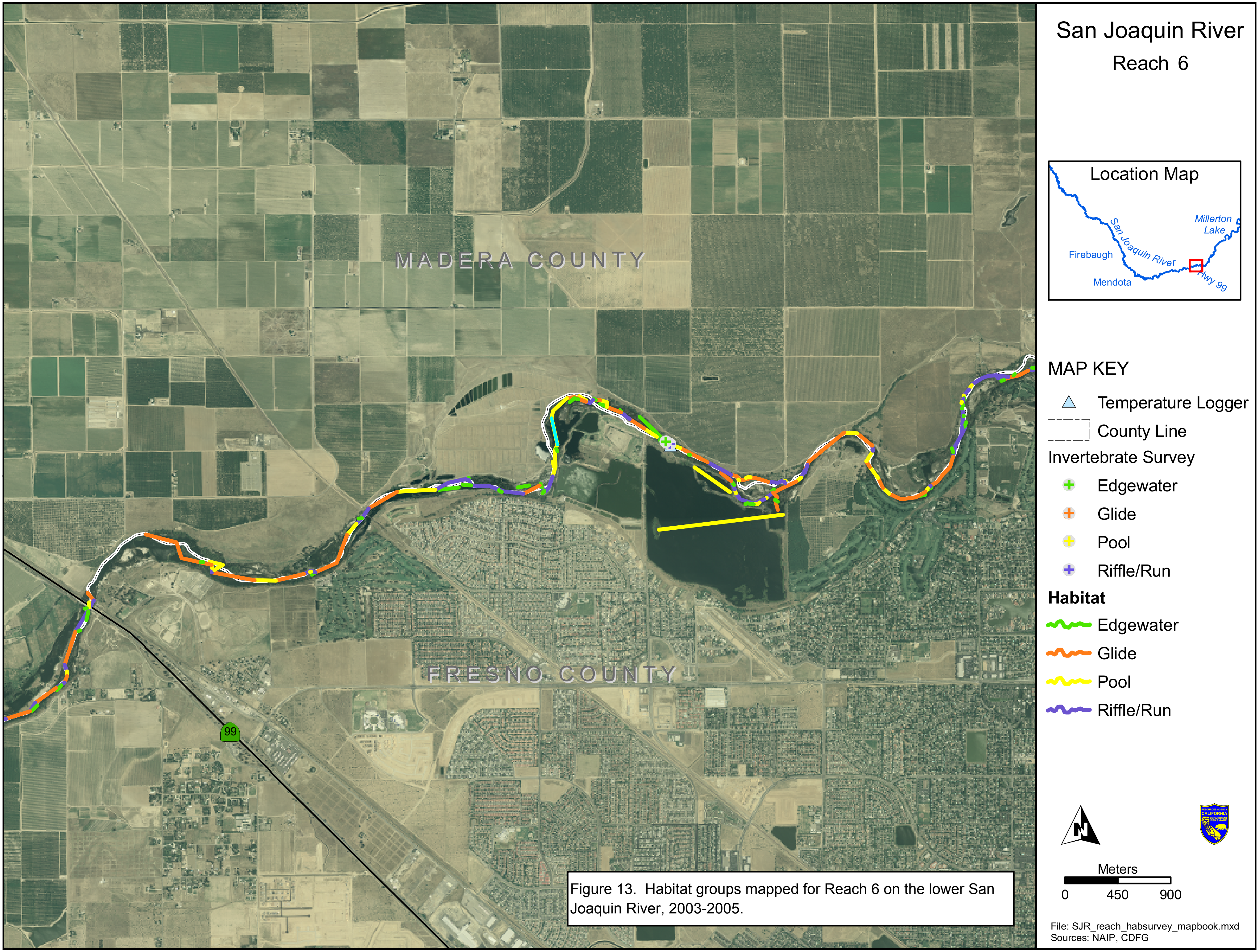


Figure 13. Habitat groups mapped for Reach 6 on the lower San Joaquin River, 2003-2005.

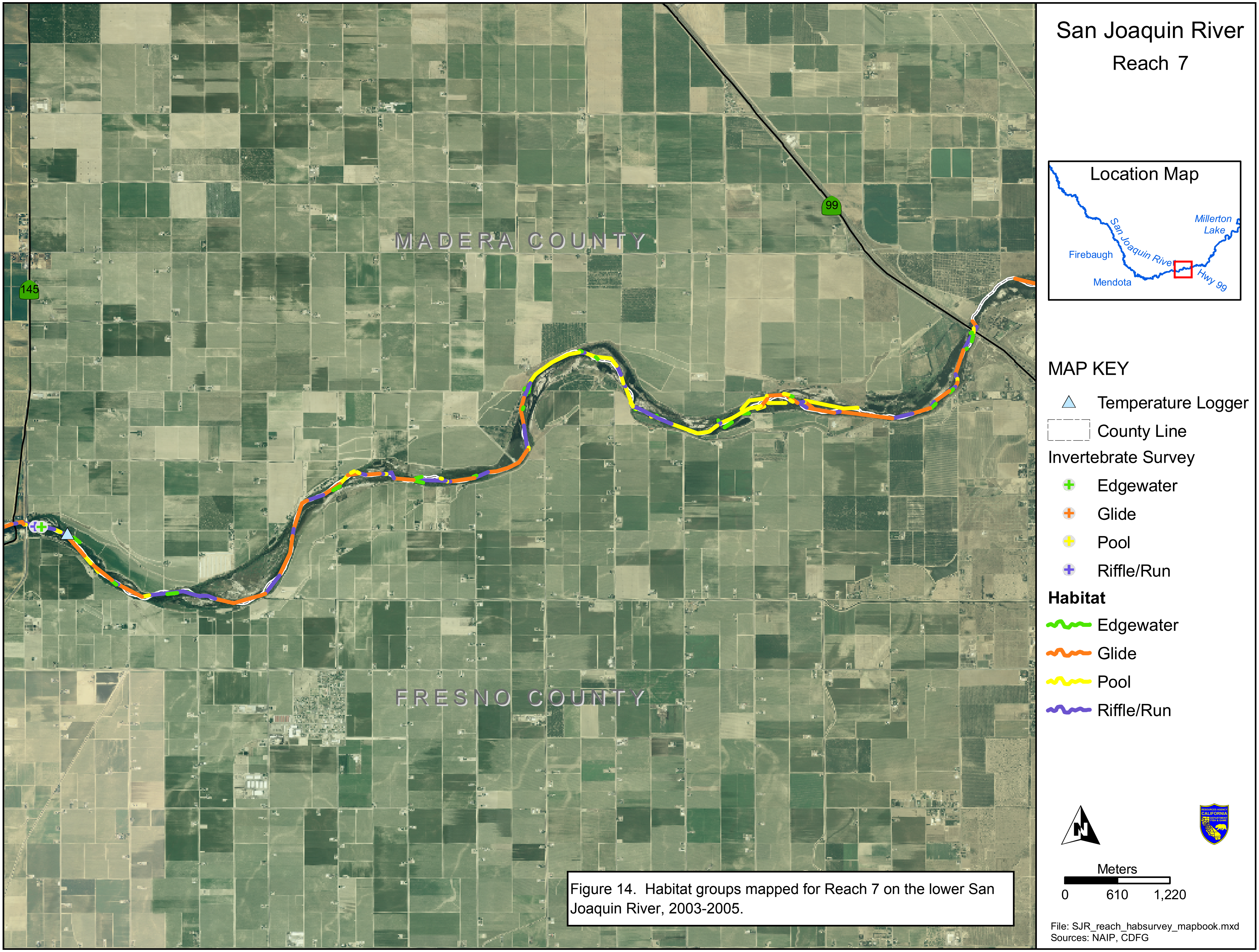


Figure 14. Habitat groups mapped for Reach 7 on the lower San Joaquin River, 2003-2005.

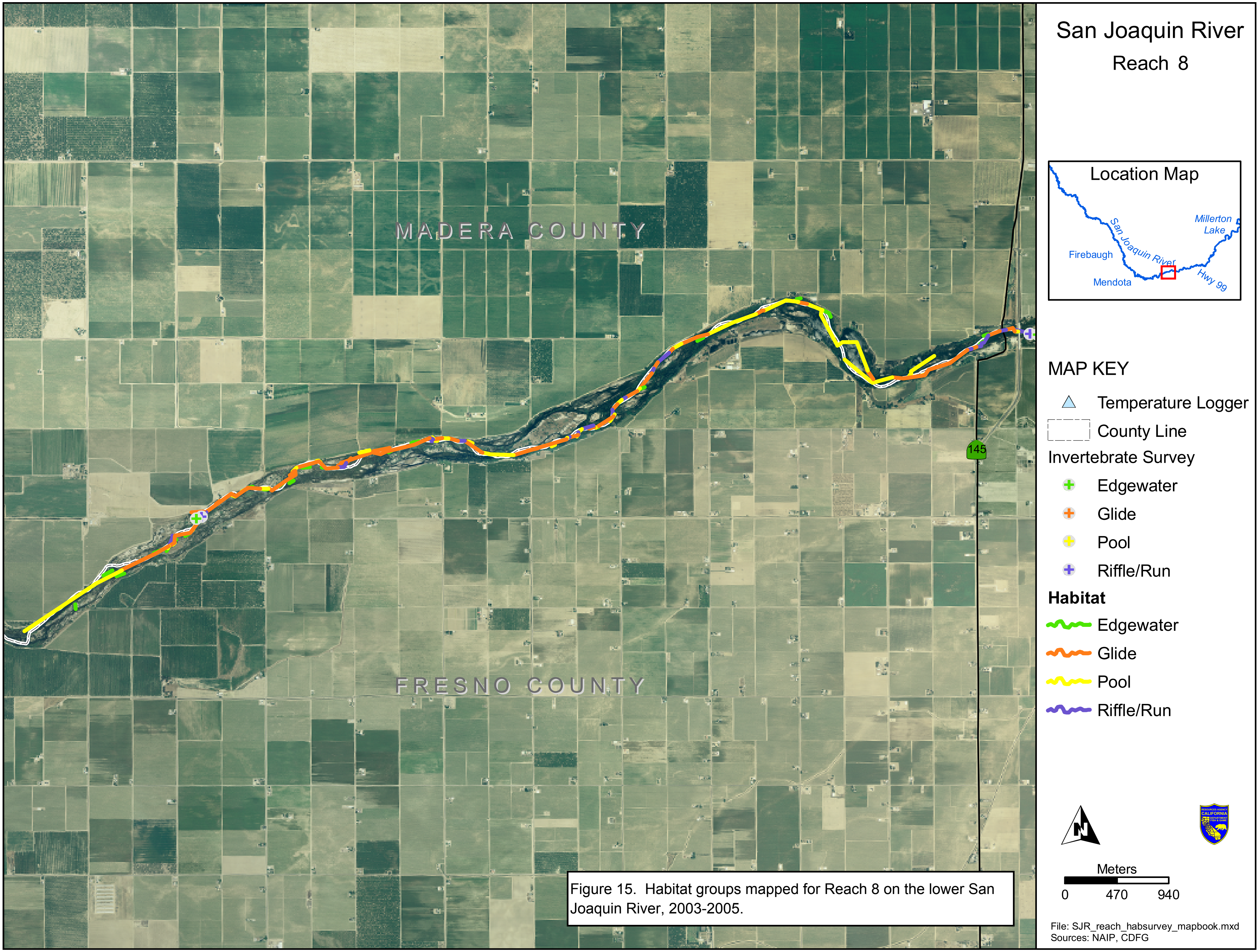


Figure 15. Habitat groups mapped for Reach 8 on the lower San Joaquin River, 2003-2005.

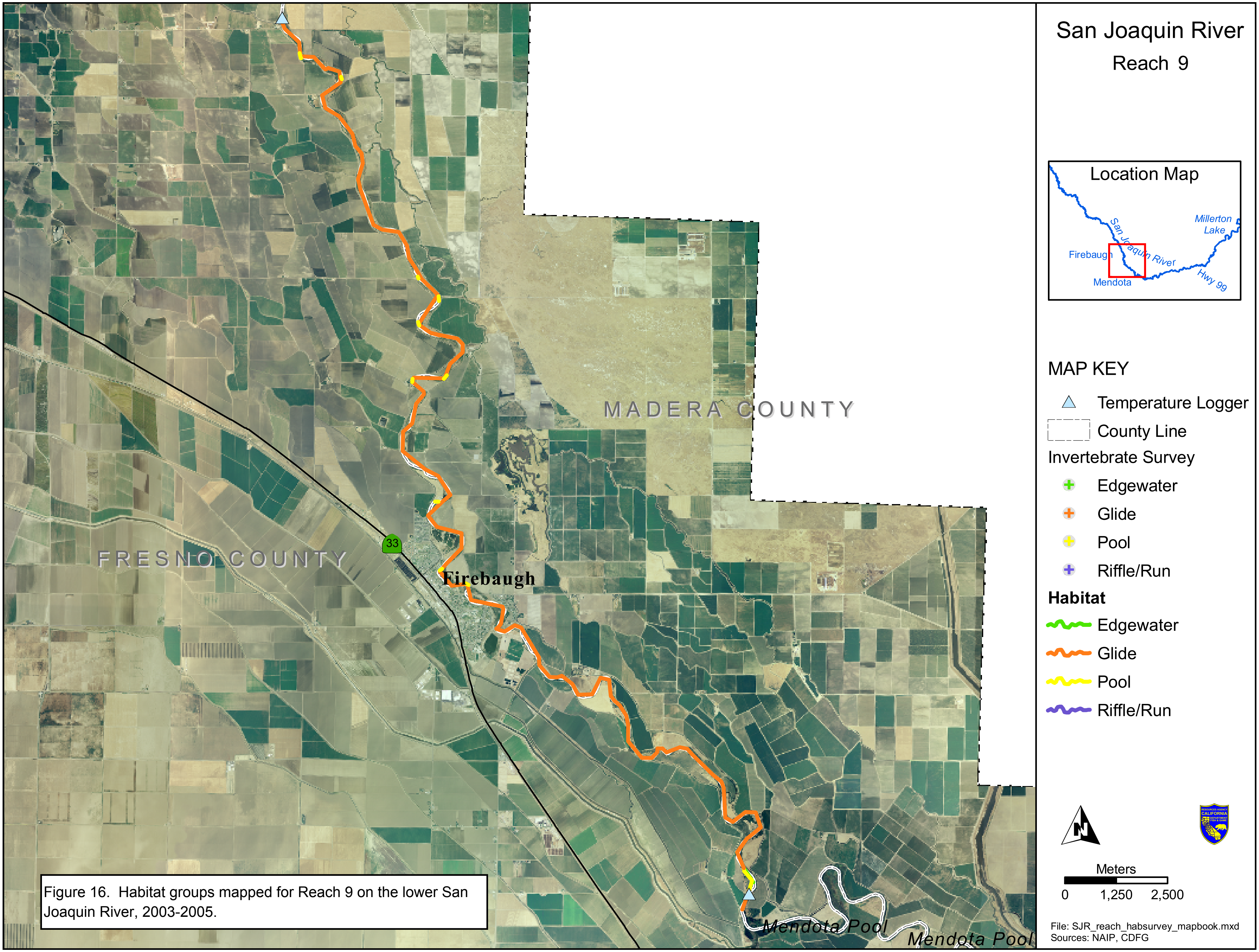


Figure 16. Habitat groups mapped for Reach 9 on the lower San Joaquin River, 2003-2005.

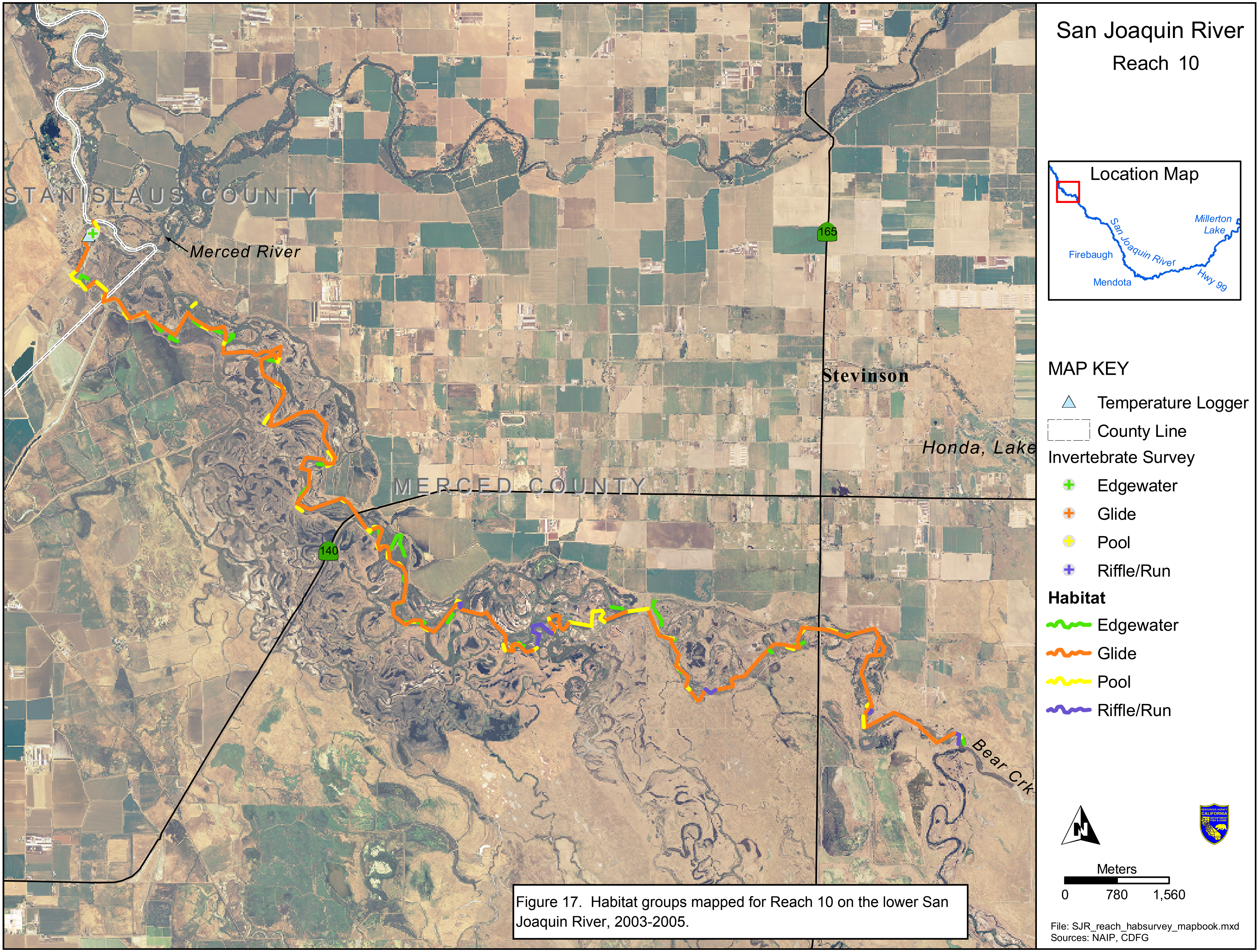


Figure 17. Habitat groups mapped for Reach 10 on the lower San Joaquin River, 2003-2005.

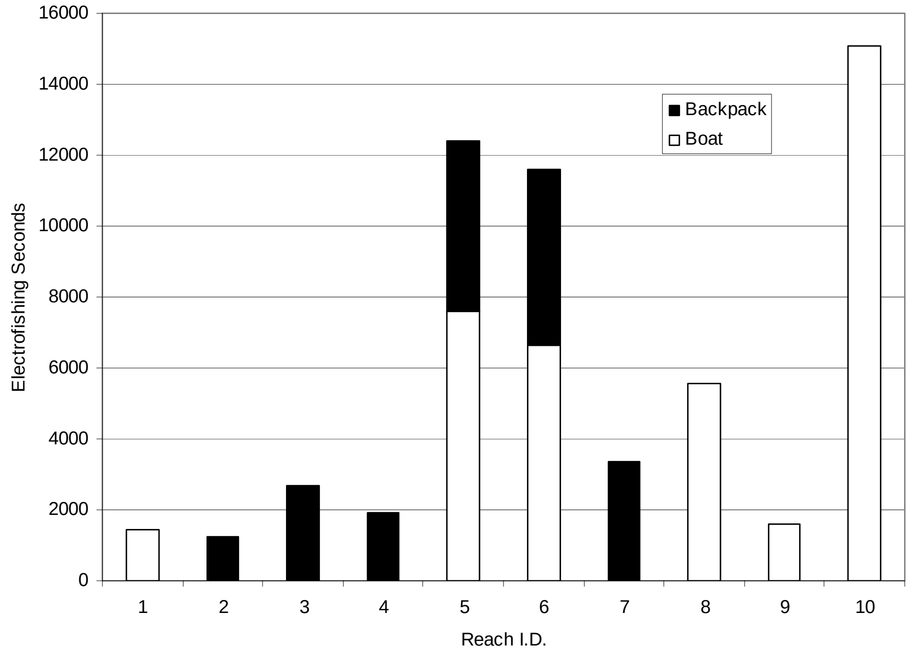


FIGURE 18. Amount of effort expended towards boat and backpack electrofishing surveys during biological sampling on the lower San Joaquin River, 2003-2005.

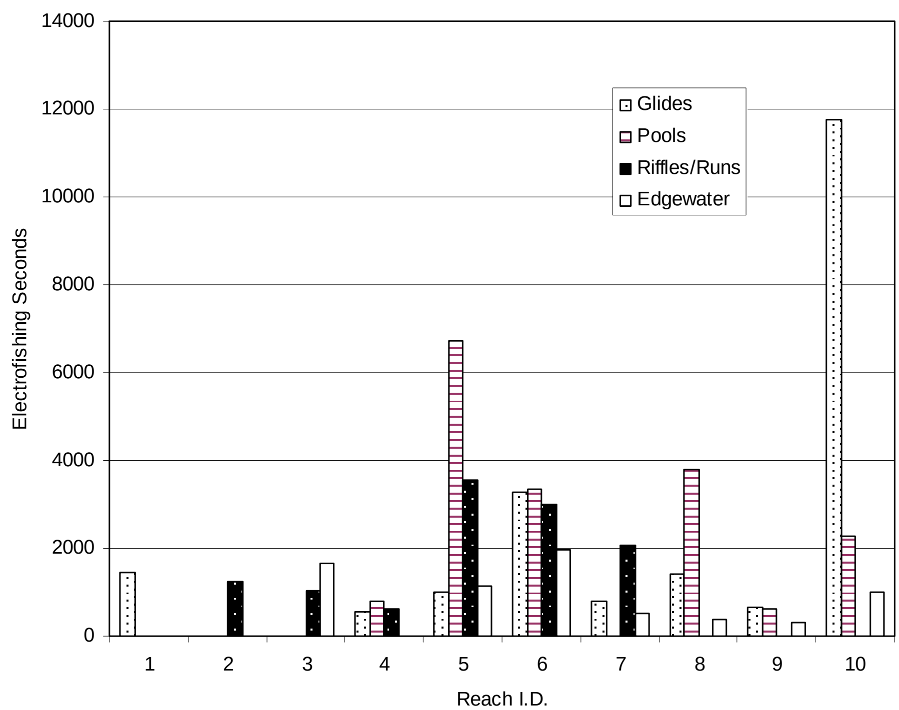


FIGURE 19. Amount of effort expended towards various habitat types for all electrofishing methods during biological sampling on the lower San Joaquin River, 2003-2005.

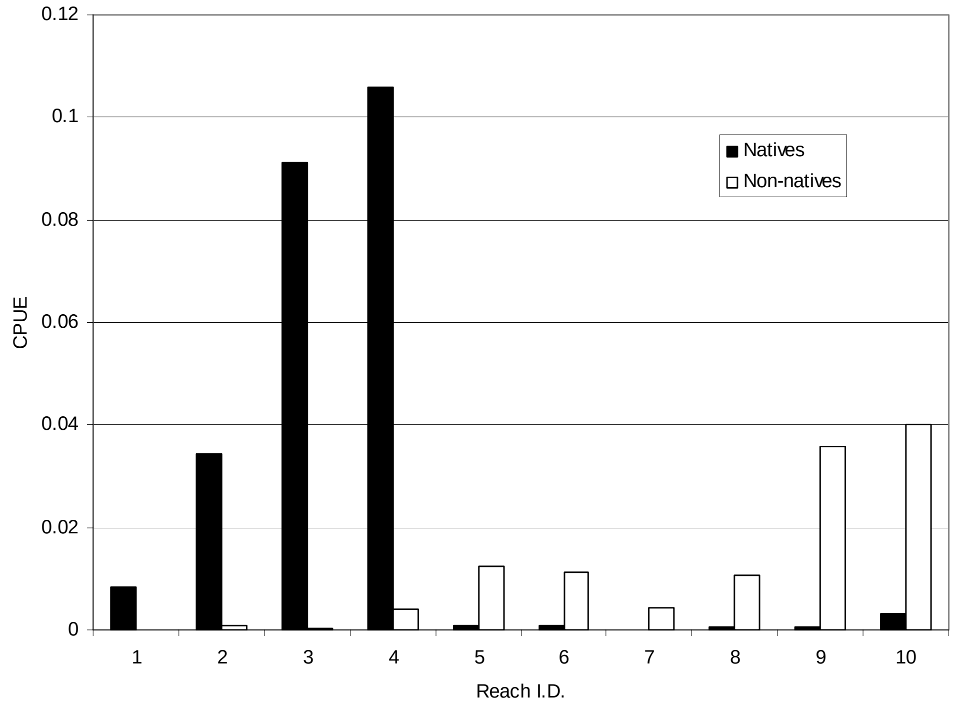


FIGURE 20. Catch per unit effort (CPUE) of native and non-native fish during biological sampling on the lower San Joaquin River, 2003-2005.

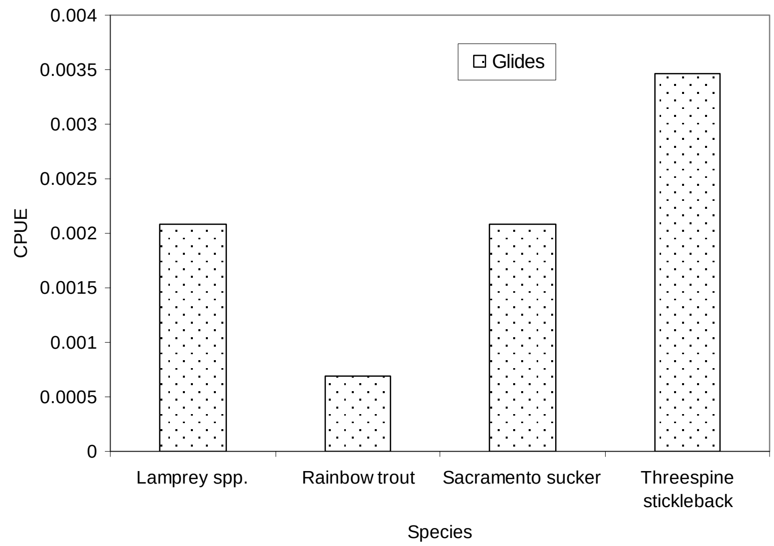


FIGURE 21. Fish species captured in Reach 1 of the lower San Joaquin River, 2003-2005.

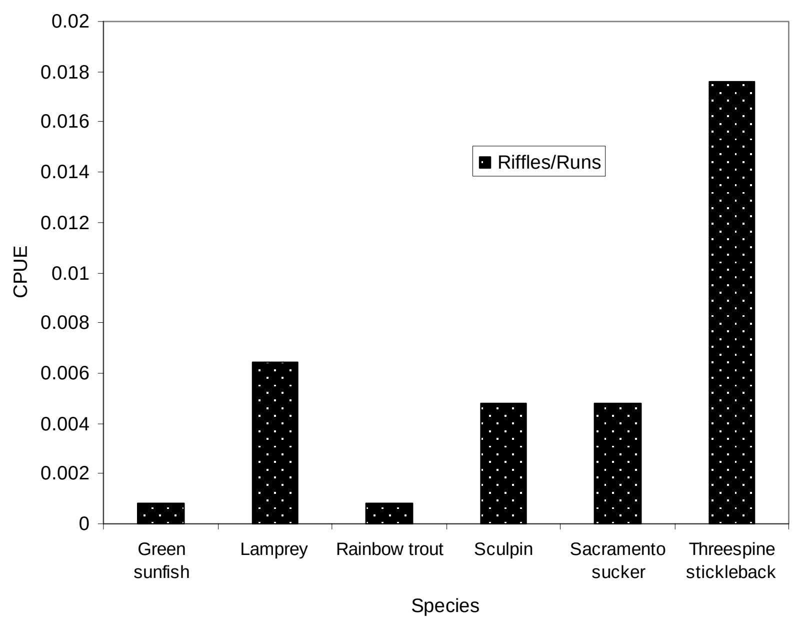


FIGURE 22. Fish species captured in Reach 2 of the lower San Joaquin River, 2003-2005.

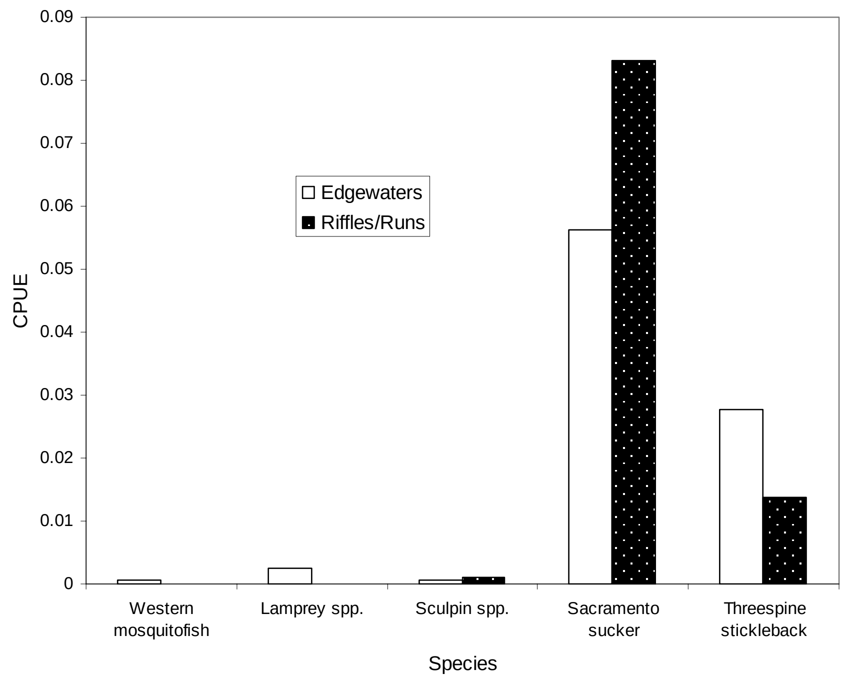


FIGURE 23. Fish species captured in Reach 3 of the lower San Joaquin River, 2003-2005.

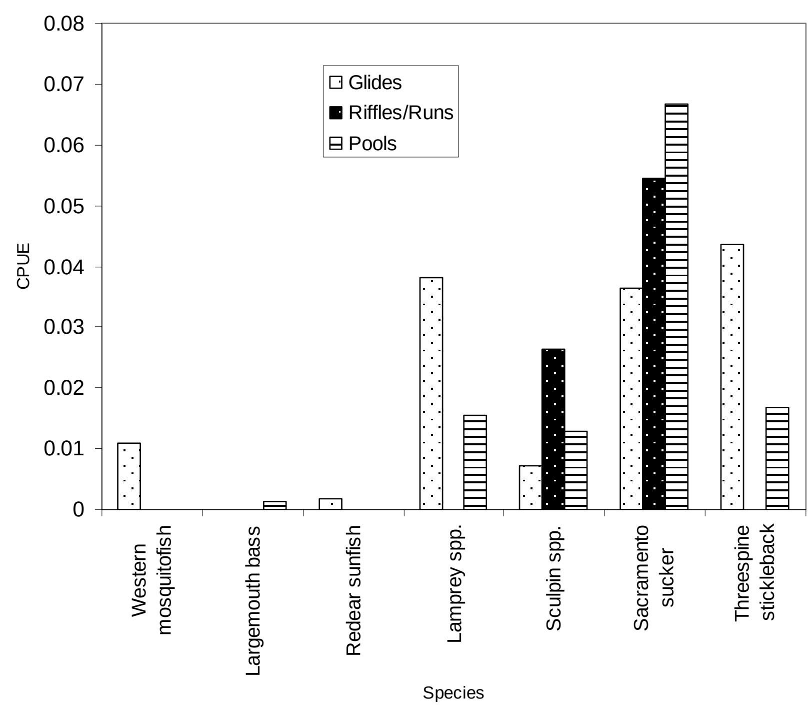


FIGURE 24. Fish species captured in Reach 4 of the lower San Joaquin River, 2003-2005.

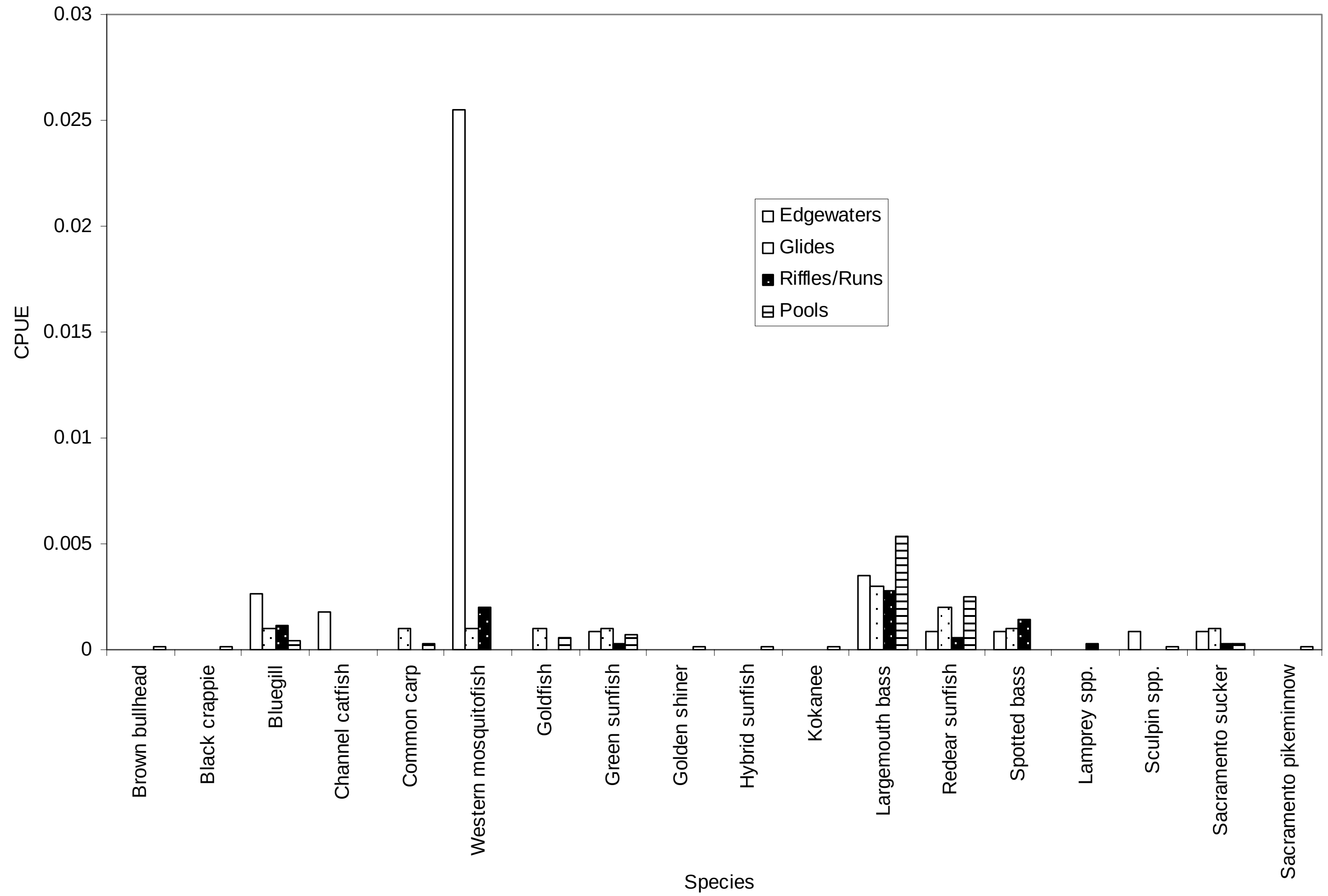


FIGURE 25. Fish species captured in Reach 5 of the lower San Joaquin River, 2003-2005.

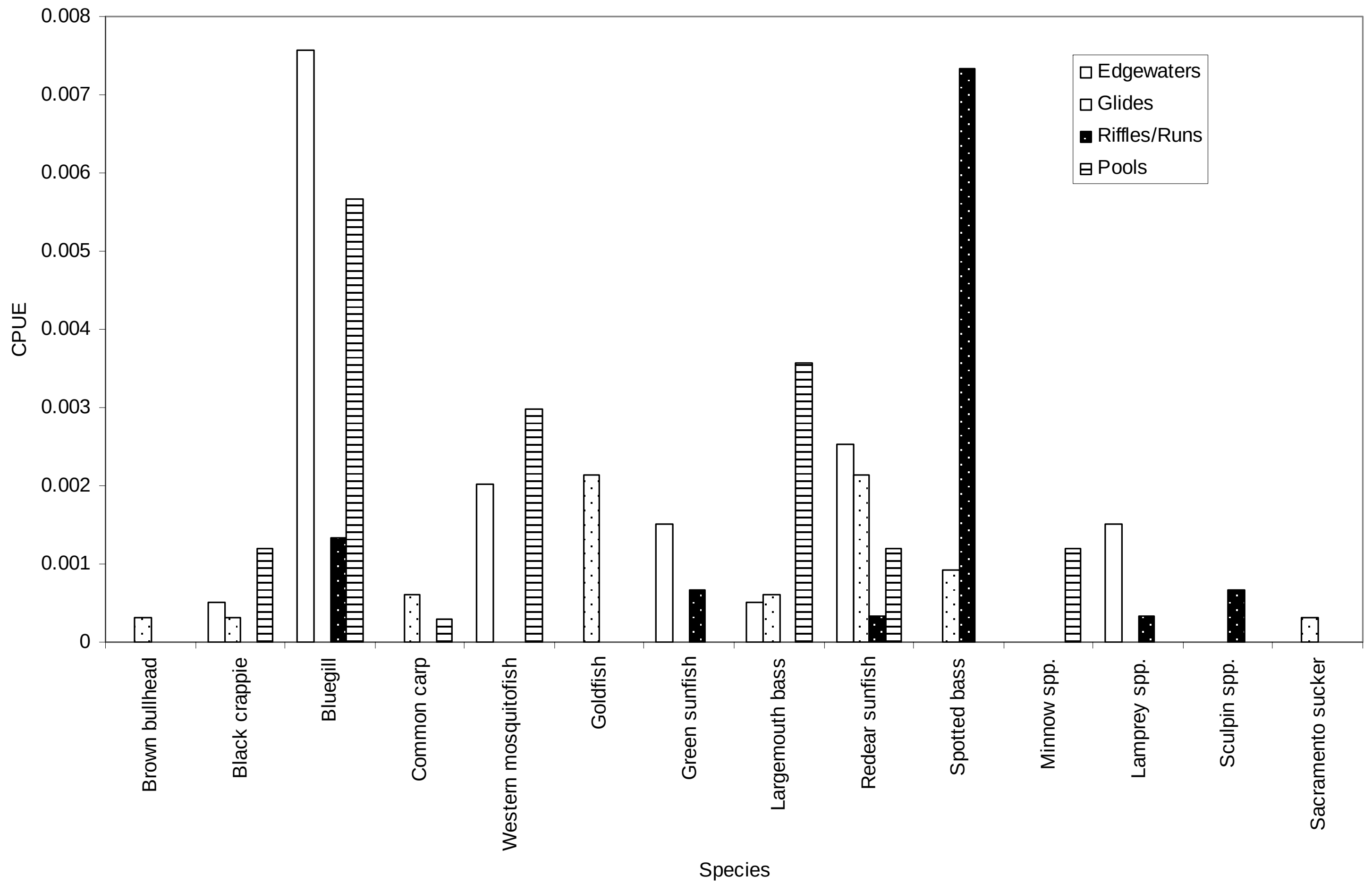


FIGURE 26. Fish species captured in Reach 6 of the lower San Joaquin River, 2003-2005.

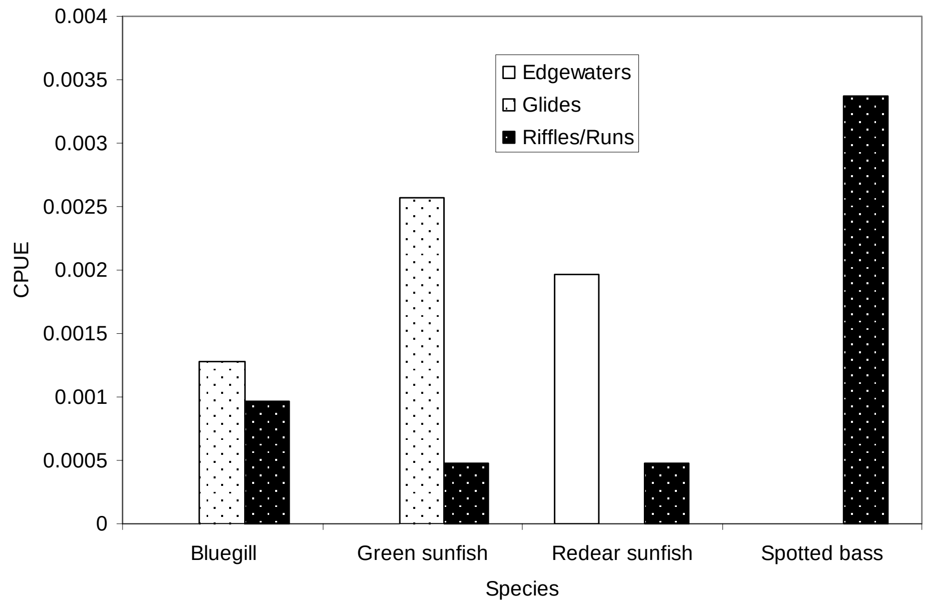


FIGURE 27. Fish species captured in Reach 7 of the lower San Joaquin River, 2003-2005.

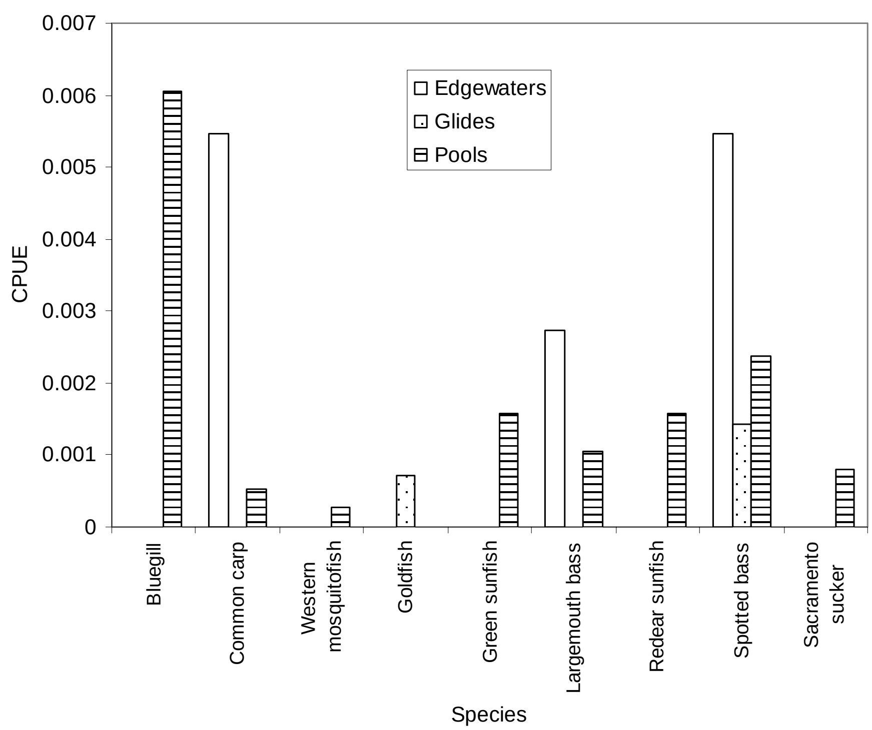


FIGURE 28. Fish species captured in Reach 8 of the lower San Joaquin River, 2003-2005.

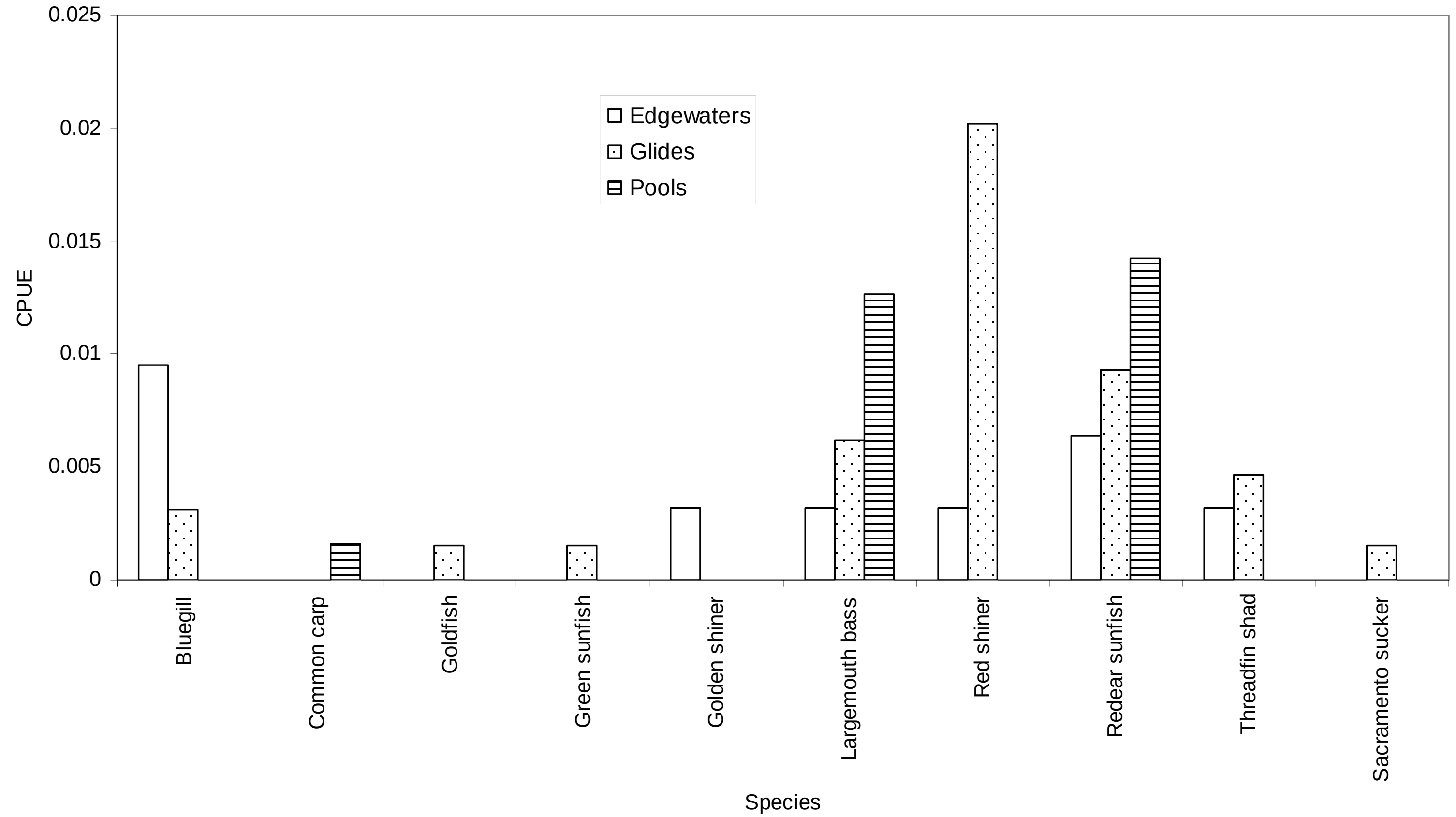


FIGURE 29. Fish species captured in Reach 9 of the lower San Joaquin River, 2003-2005.

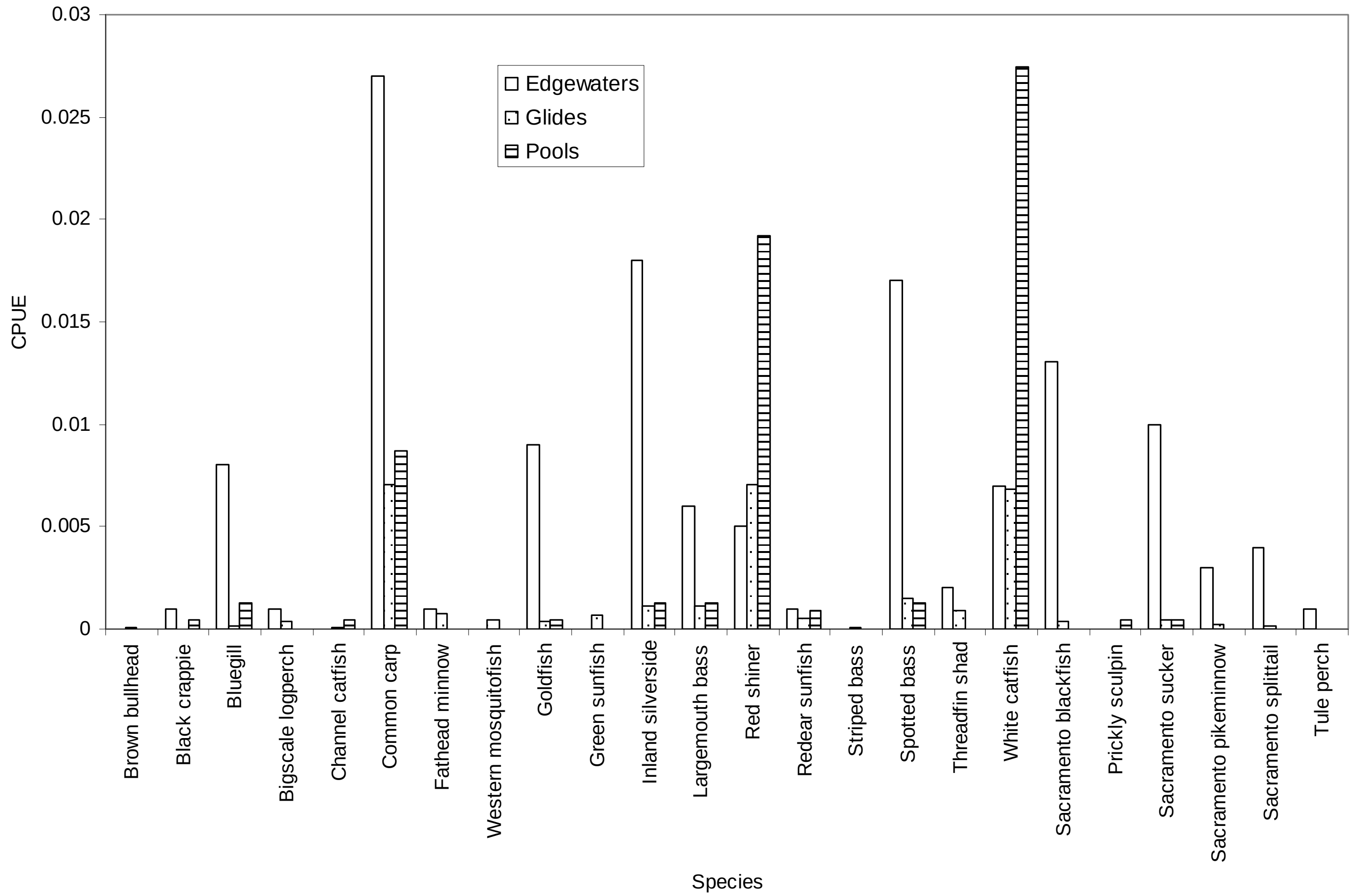


FIGURE 30. Fish species captured in Reach 10 of the lower San Joaquin River, 2003-2005.

identified to species, although collections were made and identification confirmed (P.B. Moyle, personal communication) of both Pacific lamprey (*Lampetra tridentata*) and Kern brook lamprey (*L. hubbsi*) from riffles near Friant, in Reach 2. Likewise, sculpins (*Cottus spp.*) were not identified to species on all occasions, although during one targeted sampling effort at various locations for riffle sculpins (*Cottus gulosus*), only Central Valley prickly sculpins (*C. asper ssp.*) were found; thus riffle sculpins were not confirmed during this study. One juvenile kokanee (*Oncorhynchus nerka*) was detected in Reach 5, presumably escaped from the Friant Fish Hatchery during the high flows of June 2005.

Macroinvertebrate Sampling. Groups of animals were generally not identified past the taxonomic level of Order, although some insect families, one amphipoda species, and one cnidarian species were identified (Table 6). Riffles and run were the most common habitat type sampled (Table 6). The freshwater jellyfish (*Craspedacusta sowberii*) was detected during habitat sampling of Reach 7.

Discussion

<u>Water Conditions and Habitat Characterization and Mapping</u>

Stream discharge was relatively stable and constant for the duration of the study, except for the first 6 months in 2005 (Figure 5). Most habitat sampling was conducted in 2004, but several fish sampling surveys were conducted in 2005 when flows were substantially different when compared to surveys conducted in 2004 (Table 4).

Table 6. Invertebrate groups found during sampling on the lower San Joaquin River, 2003-2005.

Taxonomic Group	Reach Number and Habitat Type*																	
	1			2		3		4		5		6		7		8		10
	R	E	G	R	R	R	R	P	R	R	R	E	R	P	R	R	G	P
Craspedacusta sowberii														•				
Class Turbellaria				•	•	•			•	•		•	•	•	•	•		
Phylum Nematomorpha															•			
Class Gastropoda	•			•				•	•	•		•	•		•	•		
Class Bivalvia								•		•			•	•	•	•	•	
Class Oligochaeta	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Class Hirudinea		•	•	•	•			•			•			•				
Order Acariformes			•	•	•	•	•	•	•	•	•		•	•	•	•		
Class Branchiopoda			•	•	•				•	•		•	•	•			•	•
Order Spinicaudata				•								•		•				•
Class Maxillopoda	•		•				•		•	•		•	•	•		•	•	•
Order Amphipoda				•	•	•		•	•		•	•						•
Corophium sp.																		•
Order Ephemeroptera	•			•	•	•	•	•	•	•			•	•	•			
Order Lepidoptera						•				•					•	•		
Order Trichoptera				•		•	•	•	•	•	•	•	•	•	•	•		•
Order Hemiptera			•			•		•							•			•
Order Diptera																		
Family Simulidae	•			•	•	•			•	•			•	•	•		•	
Family Chironomidae	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•
Family Tipulidae				•														
Unknown Diptera	•										•	•	•	•	•	•	•	
Order Collembola															•			

* Habitat type codes: R=riffle/run, E=edgewater, G=glide, P=pool

Biological Sampling

Fish Sampling.

It is worth investigating further the apparent shift in species composition from native to non-native fish assemblages with increasing distance downstream from Friant Dam (Figure 20). While our data appear to indicate this pattern, it should be noted that these findings are based on a relatively small number of electrofishing surveys that were conducted under various flow conditions and in different seasons. Furthermore, the variation in CPUE displayed at each of the reaches (Figures 21-30) indicates that the species detected could be due to chance and larger sample sizes are necessary for more solid conclusions. Also, there was considerable variation in the amount of effort expended during electrofishing surveys (Figure 18). Certain species move to shallower waters in different seasons and thus may become more detectable in those seasons, while other species may remain in shallow water in all seasons. Due to small sample sizes, we chose to analyze the fish data as a function of CPUE, and did not take into account relative sizes or biomass of the various species. It should be noted that fish populations in stream environments show significant variation in numbers and biomass from year to year (Moyle and Baltz 1985). There was also a corresponding downstream shift in habitat type dominance by area, from glides to pools (Figure 5). This shift could mean that non-native species are favored in the pools, or that the species that were detected by electrofishing in pools are over-represented due to differences in behavior. In California streams, some species, such as many of the introduced centrarchids, tend to increase their populations with increased human disturbance of habitats, such as lowered stream flows, increased number of pools, and increased turbidity (Moyle and Nichols 1973). Additional studies are necessary that include a more intensive fish sampling effort across seasons and flow conditions to either support or not support our conclusion of shifting patterns of fish assemblages. We do, however, believe that the downstream shift in fish assemblages is real and a result of habitat alterations relative to historic conditions, including reduced stream flow and temperature, and increased habitat (such as pools with silt bottoms and submerged vegetation) for non-native species. The dominant non-native species encountered are considered warm-water fishes (Moyle 2002) and are known to outcompete the native species we encountered when habitats have been altered from historic conditions (Baltz and Moyle 1993, Moyle and Nichols 1973, Moyle and Williams 1990). The first four reaches, where the native species were more prevalent, had cooler temperatures and fewer pools than those reaches further downstream (Figure 5). While the non-native fishes are able to live in such environments, it is possible that they do not have a significant competitive advantage over the native species encountered until temperatures are within their optima for longer periods of time. Also, the downstream shift from glides to pools was primarily a result of changes to the river due to historical instream gravel mining operations. Thus, the pools encountered were relatively large in volume and often contain submerged vegetation, conditions favorable for many warm-water species (Moyle 2002). It should be noted that the more downstream reaches were completely dominated by non-native species in all habitat types. It is possible that cooler temperatures allow for more distinct habitat partitioning, but as temperatures increased, non-native species dominated in all habitats. The highly reduced flows on the river, compared to historic conditions, undoubtedly contribute to the increasing temperatures and the stable, low flows in pools, both of which provide excellent habitat for non-native fishes, particularly centrarchids.

Of particular concern is the absence of certain native species altogether from our surveys. Jones and Stokes (1987) found Sacramento hitch and San Joaquin roach in Reach 10 of our study area. Although Reach 10 is where we expended the most amount of effort electrofishing (Figure 18), we did not detect these species. Hardhead (*Mylopharodon conocephalus*), a California Species of Special Concern (Moyle et al. 1995) are believed to have once occurred in the study area. While in recent years they have been observed in the lower Kings River on the Valley floor and in the San Joaquin River above Millerton Lake (R.M. Tibstra, personal observation), they were not detected during this study.

It is important to note that for each of the investigations reported, sample sizes were small and represent a limited view of the river's aquatic fauna at one point in time. There is considerable variation in fish, macroinvertebrate, and habitat among seasons, years, and flow conditions. The results should be interpreted with this in mind. This work does provide, however, valid observations to lead to testable hypotheses in the future.

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