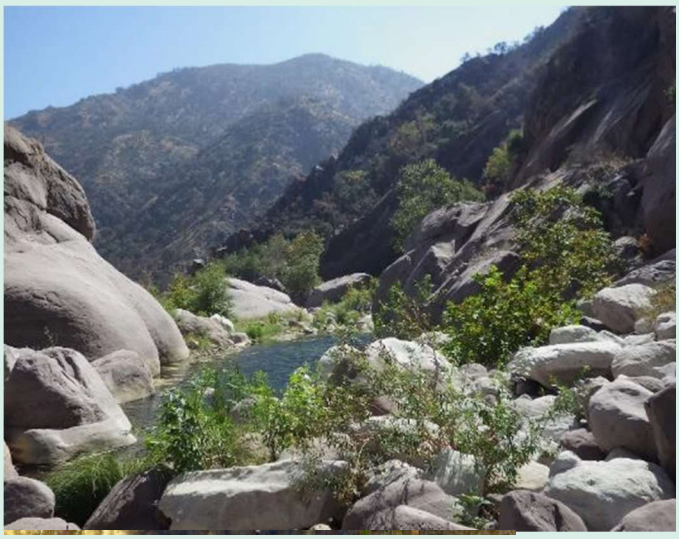
TECHNICAL MEMORANDUM ◦ AUGUST 2019

Aquatic Species Assessment for the Sespe Creek Watershed



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Cover photos: High gradient section of Sespe Creek in Reach 2 (upper left), bull frog (upper right), nonnative juvenile bullhead catfish (bottom left) and Sespe Creek in Reach 5 (bottom right).

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1 EXECUTIVE SUMMARY

Humans have served as accidental and deliberate dispersers of invasive species since antiquity; however, since around 1500 the worldwide spread of non-native species increased rapidly with expanding transport and global commerce (e.g., marine ballast water, recreational fishing, game hunting, pet trade). The impacts of aquatic invasive species include the alteration of ecosystem structure and function through 1) competition, 2) predation, 3) changes to food webs, 4) disease transmission, 5) habitat changes (e.g., ecosystem engineering), 6) hydrologic shifts, and 7) changes in nutrient concentration and composition and water quality.

Sespe Creek has gone through dramatic shifts in species composition through the introduction of both inadvertent and intentional invasive species introductions in recent years, with commonplace sightings of American bullfrog, red swamp crayfish, green sunfish, bluegill, and bullhead catfish. It also offers the greatest potential for immediate steelhead recovery in the Santa Clara River watershed. However, historic and on-going stocking of non-native fish species in the Rose Valley Lakes has led to a chronic source population of aquatic invasive species (AIS) with potential for strong impacts to native aquatic species in the watershed. AIS present in Sespe Creek prey on and compete with native fish, reptiles and amphibians. The impact of AIS is identified as a "Very High Threat" to steelhead in the Southern California Steelhead Recovery Plan (2012).

The goal of this study was to evaluate the current composition and distribution of AIS and their co-occurrence with native aquatic species. Additionally, we looked at habitat conditions and aquatic species distributions compared to burn areas to assess the impacts from recent wildfires (2002 through 2017) on the Sespe Creek watershed. Results from this study will be used to inform future AIS management actions in the Sespe Creek watershed.

To assess current composition and distribution of fish, stream surveys were conducted throughout the mainstem of Sespe Creek and several tributaries. Snorkel surveys were conducted to document observations of aquatic species and habitat characteristics for each habitat unit sampled. AIS (e.g., green sunfish and bullhead catfish) were observed in high abundances throughout most of Sespe Creek downstream of the confluence with Howard Creek where the Rose Valley Lakes eventually convey. Steelhead abundance was highest in locations lacking AIS, and young-of-the-year steelhead (fish < 100 mm) were observed almost exclusively in tributaries where AIS were absent. No AIS were observed upstream of Rose Valley Lakes, consistent with the hypothesis that the lakes are the primary source of AIS in the watershed.

The primary impact of fires in the Sespe Creek watershed appears to be increased sediment delivered to the stream channel while locations within burn areas appeared to have intact, healthy riparian habitat where water was found. Fine sediment was abundant in most locations throughout Sespe Creek typically in the form of sand deposits along the edges of pool habitat and in some locations moderate infilling of pools. Since fine sediment is so widespread throughout the watershed, it is difficult to attribute overall sediment loads to any single fire event. In addition to wildfires, drought may play a large role in aquatic species distribution and abundance. This survey occurred during the end of a six-year drought in the Sespe Creek watershed which likely influenced fish distributions and abundance during this effort.

Based on the results of this study the following recommendations are made for managing AIS in the Sespe Creek watershed and are listed in order of importance:

1. Address source populations of AIS in Rose Valley Lakes by altering the habitat in Rose Valley Lakes so it no longer supports AIS.
2. AIS suppression efforts should be conducted in locations where both AIS abundance is high and where there is suitable habitat for steelhead and other native biota.
3. Focused AIS suppression efforts should be conducted where habitat conditions are favorable to AIS, and reproduction of AIS appears to be occurring.

2 INTRODUCTION

The Los Padres National Forest is home to several native fish species, including the endangered Southern California steelhead (anadromous *Oncorhynchus mykiss*) (Kelley 2004). Sespe Creek (a tributary to the Santa Clara River), flows through the Los Padres National Forest (LPNF), sustains the highest relative abundance of wild *O. mykiss* of all Santa Clara's tributaries, contains 198 km of habitat historically accessible to anadromous steelhead, lacks mainstem migration barriers, and thus, offers the greatest potential for immediate steelhead recovery in the watershed (Stoecker and Kelley 2005). However, historic and on-going stocking of non-native fish species has led to a seemingly widespread population of aquatic invasive species (AIS). Native fish in Sespe Creek are increasing impacted by AIS. The threat of invasive species has prompted the U.S. Department of the Interior to publish an interdepartmental report, Safeguarding America's Lands and Waters from Invasive Species: A National Framework for Early Detection and Rapid Response (USDI, 2016). It states that invasive species pose one of the greatest ecological threats to America's lands and waters. The Southern California Steelhead Recovery plan also lists non-native species as a "Very High Threat" to steelhead in Sespe Creek (NMFS 2012). AIS in Sespe Creek are also direct threats to other native fish, reptiles and amphibians, including partially armored three-spine stickleback (*Gasterosteus aculeatus microcephalus*), federally endangered arroyo toad (*Anaxyrus californicus)* (Sweet 1991 and 1992, USFWS 2014) and federally threatened California red-legged frog (*Rana draytonii*) (USFWS 2002). Other native fish species that may occur in the watershed include Pacific lamprey *(Entosphenus tridentata*) (Reid 2015, Reid and Goodman 2016, Swift and Howard 2009), most recently observed in the Santa Clara River in 2017 (M. Booth, pers. comm. 2017, as cited in NOAA 2019). Other native reptiles and amphibians occuring in the watershed include two-striped garter snake (*Thamnophis elegans hammondii*), western toad (*Bufo boreas halophilus*), canyon treefrog (*Hyla arenicolor),* Pacific treefrog (*Hyla regilla*), and western pond turtle (*Clemmys marmorata pallida*). Historically, foothill yellow-legged frog (*Rana Boylii*) (Hayes et al 2016) inhabited the Sespe Creek watershed but no observations have been reported since 1970 (S. Sweet, pers.comm. 2019, as cited in NOAA 2019). For additional information on native aquatic species in the Sespe Creek watershed please see the following references: Moore 1980, Moyle 2002, Sanders 1950, Swift et al 1993, and USFS 1997.

AIS present in Sespe Creek include bullhead catfish (*Ameiurus* spp.), green sunfish (*Lepomis cyanellus*), and American bullfrog (*Rana catesbeianus*) (Stoecker and Kelley 2005, Reid 2015) all of which are known to prey on and/or compete with native biota including *O. mykiss*. Other nonnative fish species that occur in the Sepse Creek watershed include arroyo chub (*Gila orcuttii*), Santa Ana sucker (*Catostomus santannae*), and Owens sucker (*Catostomus fumeiventris*). Although arroyo chub and Santa Ana sucker have been introduced to Sespe Creek, they are discussed separately from AIS since they are endemic and sympatric with Southern California steelhead in many locations throughout their range and are non-piscivorous. The Owens sucker does not have a sympatric relationship with steelhead; however, this species is non-piscivorous and may hybridize with Santa Ana sucker, and is therefore, discussed separately from AIS.

The most common AIS in the Sespe Creek watershed include bullhead catfish, green sunfish, and American bullfrog all of which are not native to California waters. These species can tolerate a high range of habitat conditions but are typically found in warmer water. Bullhead catfish can survive water temperatures up to 35°C while green sunfish can tolerate temperatures up to 38°C,

and both species can survive in locations with low dissolved oxygen levels (<1 mg/L). Optimal growth seems to occur with water temperatures ranging from 20°C–30°C for bullhead catfish and 26°C–30°C for green sunfish. Bullhead catfish are highly social and opportunistic predators, typically feed at night in large groups on anything from small crustaceans to small fish. Adult green sunfish are highly aggressive and voracious predators that feed primarily on invertebrates and small fish. American bullfrog feed on all life stages of arroyo toads (Sweet 1992, Ramirez 2007, Brehme et al. 2011) while green sunfish and bullhead catfish have been found to feed on arroyo toad larvae (Sweet 1991). These AIS also prey on California red-legged frogs (USFWS 2002). Both bullhead catfish and green sunfish typically reach sexual maturity in their third year and spawn when water temperatures reach 19°C (green sunfish) or 20°C (bullhead catfish) typically from May to July. Bullhead catfish spawn in small, natural depressions in sand or mud substrate near submerged structure such as logs or aquatic vegetation where water velocities are low. Female fecundity ranges from 2,000-14,000 eggs. Green sunfish spawn in shallow water (40–50 cm deep) with fine gravel substrate, low water velocities, and overhanging vegetation. Female green sunfish lay 2,000–10,000 eggs, depending on her size, and may mate with multiple males (Moyle 2002).

Within the Sespe Creek watershed, Rose Valley Lakes has been identified as the likely source of AIS into Sespe Creek (Stoecker and Kelley 2005). It is speculated that during large flow events, nonnative fish and amphibians from Rose Valley Lakes wash over the dam and into Rose Valley Creek which connects to Howard Creek before joining Sespe Creek. Downstream dispersal of nonnative species from Rose Valley Lakes can spread rapidly. For example, field researchers report that American bullfrogs appeared in the upper Rose Valley lake in the summer of 1980 and were breeding downstream of Lion Canyon as early as 1981 (S. Sweet, pers. comm. 2019, as cited in NOAA 2019).

The Rose Valley Lakes were constructed between the 1950's and 1970's by the US Navy for construction personnel (Seabees) and are now located on US Forest Service land within the Los Padres National Forest. The lakes are a popular destination point, and in the past have supported a seasonal fishery for a variety of sport fish species through periodic stocking by the California Department of Fish and Wildlife (CDFW). The last stocking effort by CDFW occurred in May 2009 (M. Larson pers. comm. 2019); however, there has been unauthorized stocking by private individuals with a variety of non-native fishes and amphibians (NOAA 2019). Aquatic species in the Rose Valley Lakes are periodically extirpated when the lakes temporarily dry up in the summer during low rainfall years or during periods of extended droughts (as they did during the most recent drought). The lack of regular on-site management of the lakes results in the periodic unauthorized re-stocking of the lakes, including with AIS.

The overall impact of AIS on native aquatic species may be further compounded by limiting the ability of native species to persist through disturbance events (such as drought or fire). This study was conducted in 2018, following a recent six-year drought that was classified as "abnormally dry" in 2012, "severe drought" in 2013, "extreme drought" in 2014, and increased to "exceptional drought" for all of 2015–2016, before decreasing back down to "severe drought" during 2017 and 2018 (US Drought Monitor 2019).

Dunham et al. (2003) states that "how fire might influence the interaction between native and non-native fish species is unknown but is of substantial concern." Since the Dunham et al. study was completed, there have been some investigations that examined the response of native and non-native salmonid species to fire and have found native species to be quite resilient to fire effects (e.g., Rieman et al. 2012) in the absence of other disturbance such as drought. However,

the interactions of native salmonids and non-native warm-water competitors following fire has not been thoroughly investigated. Habitat conditions during drought may favor warm-water AIS over native salmonids since lower stream flows can lead to warmer water temperatures and decreased dissolved oxygen levels.

The Sespe Creek watershed is highly prone to wildfire. Since the early 2000's several largescale wildfires have burned throughout watershed (Table 1 and Figure 1). Wildfires can result in dramatic episodic increases in ash and fine sediment deposition to the channel (Swanson 1981, Lanier 2011, Warrick et al. 2012). In the long-term, natural wildfires in forested watersheds can contribute to the formation of complex and suitable steelhead habitat (Rieman and Clayton 1997, Gresswell 1999) but in the short-term, elevated fine sediment from and after wildfire is a threat to suitable rearing habitat, as it can embed spawning substrates and smother incubating eggs, and temporarily fill pools and interstitial spaces used for summer and winter rearing (Barro et al. 1991, Rieman and Clayton 1997, Gresswell 1999). Wildfires can also increase the magnitude of high flow events, reduce the future recruitment of large woody debris, decrease stream complexity (through removal of large wood and filling of pools with fine sediment) and decrease stream shade, which increases stream temperature (Rieman et al. 2012).

The goal of this study was to evaluate the current composition and distribution of AIS and their co-occurrence with native aquatic species. Additionally, we looked at habitat conditions and aquatic species distribution compared to burn areas to assess the impacts from recent wildfires (2002 through 2017) on the Sespe Creek watershed. Results from this study will be used to inform future AIS management actions in the Sespe Creek watershed.

Table 1. Summary of recent (since 2000) wildfires and areas burned within the Sespe Creek watershed.

Fire Name (Year)	Acres of Watershed Burned	Percent of Watershed Burned
Wolf (2002)	21,107	12%
Piru (2003)	22,916	14%
Day (2006)	55,257	33%
Thomas (2017)	32,840	19%
Unburned Area (2002-2017)	41,120	24%
Total Sespe Creek Watershed Acreage	*169,571*	*100%*

3 METHODS

3.1 Reach Selection

Eight study reaches were selected throughout the Sespe Creek watershed covering lower Sespe Creek near the town of Fillmore and extending upstream of Rose Valley Lakes to the confluence of Tule Creek (Figure 1). Reaches were selected to assess species distribution throughout the watershed and to assess conditions upstream, downstream and within recent fire burn areas in the watershed (Table 2).

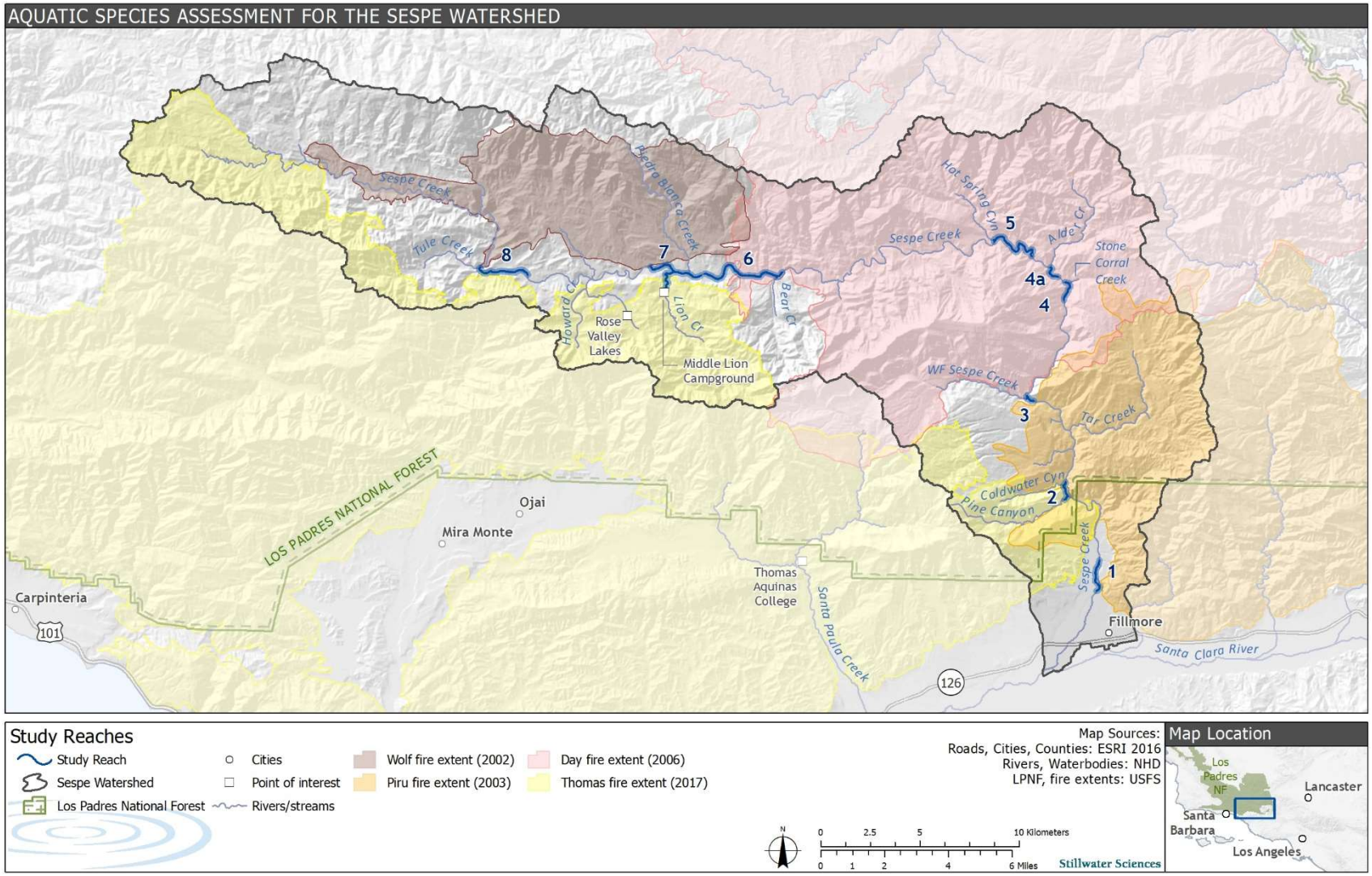


Figure 1. Sespe Creek watershed with locations of recent wildfires.

Table 2. Aquatic species assessment survey reach locations and rationale.

Target reach #	Location	Downstream Latitude/ longitude	Upstream Latitude/ longitude	Reason for inclusion
1	Lower Sespe Creek	34.418161/ -118.925557	34.432413/ -118.924124	Determine the downstream distribution of AIS in Sespe Creek and assess habitat conditions downstream of recent fires.
2	Lower Sespe Creek, within high gradient canyon section	34.461188/ -118.942150	34.467517/ -118.943680	Determine the downstream distribution of AIS in Sespe Creek and assess habitat conditions within burn areas of the Piru and Thomas fires.
3	Middle Sespe Creek at confluence with West Fork Sespe Creek	34.504088/ -118.962119	34.506367/ -118.965859	Location of highly suitable steelhead habitat, and within burn areas of the Piru and Day fires.
4	Middle Sespe Creek, near Alder Creek	34.550254/ -118.946358	34.564663/ -118.954326	Determine downstream distribution of AIS in Sespe Creek and assess habitat conditions, fish species composition, and species abundance within the burn area of the Day Fire.
5	Middle Sespe Creek, downstream of Hot Springs Canyon	34.569834/ -118.964755	34.576066/ -118.985355	Within the burn area of the Day Fire. Warm water temperatures suitable for AIS enter Sespe Creek from Hot Springs Canyon. and perennial flows emerge in this reach and continue downstream.
6	Middle Sespe Creek, between Trout Creek and Bear Creek	34.560196/ -119.101682	34.558863/ -119.144214	Determine downstream influence of source AIS population in Rose Valley Lakes. Assess channel conditions, species composition, and species abundance within the burn area of the Day Fire.
7	Sespe Creek near Lion Creek	34.558207/ -119.145892	34.561318/ -119.173988	Near source AIS population in Rose Valley Lakes. Assess channel conditions, species composition, and species abundance within the burn area of the Wolf and Thomas fires.
8	Upper Sespe Creek, upstream of Howard Creek to Tule Creek	34.556562/ -119.241449	34.559342/ -119.267509	Isolate the effect of Rose Valley Lakes by assessing species composition and abundance upstream of the influence of the source population in Rose Valley Lakes, within the burn areas of the Wolf and Thomas fires.

3.2 Surveys

3.2.1 Snorkel surveys

Snorkel surveys were conducted during September 2018 to coincide with low flows. Surveys were primarily conducted in locations deep enough to snorkel (> 0.3 m), typically pools, runs, or glide habitats. AIS relative abundance was estimated for each habitat unit sampled within the eight targeted reaches. Direct observation, using standard daytime snorkel protocol counts were conducted at the habitat unit scale. Habitat units were sampled from downstream to upstream by one or two adjacent divers in assigned dive lanes, counting fish as they escaped downstream of each diver using well-established methods (Thurow 1994). If fish were observed to escape upstream, divers took care to avoid counting these fish twice. Counts focused on AIS, but observations of other aquatic species (e.g., steelhead and Arroyo chub) were also recorded. Fish size was estimated and recorded for all observations.

3.2.2 Habitat characteristics

Habitat characteristics were recorded for each habitat unit sampled. These characteristics included water temperature, substrate composition, fish cover type and percent, and maximum pool depth. To assess fish distribution in relationship to general water temperatures patterns, locations were identified as "Cold" when water temperatures were 20°C or less, and "Hot" when water temperature were greater than 20°C. Although southern California steelhead can survive in water temperatures well over 20°C (Sloat and Osterback 2012), steelhead have been reported to have reduced growth at temperatures of 20°C and higher when warm-water species are present (Reese and Harvey 2002). Locations in the Sespe Creek watershed with temperatures that remain below 20°C are not likely to support spawning for green sunfish and bullhead catfish which spawn when water temperatures are 19°C or above (Moyle 2002). Furthermore, previous studies in the Sespe Creek Watershed reported the average temperature for reaches with AIS was 19.5ºC versus 13.5ºC for reaches that did not have AIS (Stoecker and Kelley 2005). While 20°C is not expected to limit native aquatic species distribution, it is considered informative to assess distribution patterns.

4 RESULTS

4.1 Species Composition and Distribution

Six fish species were observed in the Sespe Creek watershed during this study; two native fish species (steelhead and three-spine stickleback) and four non-native fish species (Arroyo chub, bullhead catfish, green sunfish, and sucker). Other aquatic species observed included non-native American bullfrog (*Rana catesbeiana)* and native Western pond turtle (*Actinemys marmorata*). Aquatic species observations are summarized by reach in Section 3.3 and location specific observations are provided in Appendix A (Table A-1).

AIS were observed in high abundance throughout most of Sespe Creek, with the exception of Sespe Creek upstream of Rose Valley Lakes (Reach 8), and in lower Sespe Creek downstream of the highly confined canyon section (Reach 1) (Figure 1 and Table 3) where no AIS were observed. In addition, no AIS were observed in any of the four tributaries surveyed (including Lion, Bear, West Fork Sespe, and Pine creeks [Figure 1]). Although Howard Creek was not surveyed during this study, native steelhead were the only fish species observed in Howard Creek

during a 2019 reconnaissance effort (NOAA 2019). Bullhead catfish were the most abundant AIS observed during this survey and were often found in large schools (>50 fish) containing young-of-the-year fish (<100 mm long) (Figure 2). Large schools of age-1+ juvenile bullhead catfish (100–150 mm long) were also common, while only a few bullhead catfish observed exceeded 150 mm in length with the largest bullhead catfish observed estimated to be in 250–300 mm size range. Green sunfish were slightly less abundant than bullhead catfish but were still observed in large numbers, primarily due to high abundance of juvenile fish (<100 mm) while fish over 150 mm were uncommon. The largest green sunfish were estimated to be in the 200–250 mm size range (Table A-2). In total, only 12 bullhead catfish over 200 mm were observed; however, bullhead catfish over 200 mm were often observed in deep cover and deep pools with low visibility, so this number may not be representative of the actual abundance of larger fish. Only five green sunfish over 200 mm were observed and appeared easy to detect while snorkeling, since green sunfish over 200 mm would typically swim very close to snorkelers in what was interpreted to be an aggressive behavior.

Table 3. Fish species abundance by reach.

Reach	Native fish species		Non-native fish species				American bullfrog	Western pond turtle	Total
	Steelhead	Three-spine stickleback	Bullhead catfish	Green sunfish	Arroyo chub	Sucker species			
Reach 1	0	0	0	0	102	0	0	0	**102**
Reach 2	0	0	25	2	506	30	0	1	**563**
Pine Creek (Reach 2)	0	0	0	0	0	0	0	0	**0**
Reach 3	11	0	55	263	254	0	0	1	**583**
West Fork Sespe Creek (Reach 3)	8	0	0	0	0	0	0	0	**8**
Reach 4	1	0	914	49	971	0	5	2	**1,935**
Reach 5	0	0	522	129	1599	0	1	1	**2,250**
Reach 6	28	51	164	663	207	0	102	0	**1,164**
Bear Creek (Reach 6)	5	0	0	0	0	0	0	0	**5**
Reach 7	6	0	255	358	61	0	408	1	**680**
Lion Creek (Reach 7)	8	51	0	0	0	0	0	0	**59**
Reach 8	45	579	0	0	768	0	0	1	**1,392**
Total observations	**112**	**681**	**1,935**	**1,477**	**4,468**	**30**	**516**	**7**	**8,754**

Figure 2. School of juvenile bullhead catfish observed in Reach 7.

AIS were observed in locations with temperatures ranging from 14°C to 24°C and were observed in high abundance in low-gradient reaches with deep pool habitat (>1 m) (reaches 4–7). AIS were observed in relatively low abundance within Reach 2 and Reach 3 both of which are characterized by deep pool habitat and high channel gradient (>2%) and are within the burn areas of the Piru and Day fires (Reach 3) or the Piru and Thomas fires (Reach 2).

Arroyo chub was the most abundant and widespread species and was observed in all reaches of Sespe Creek. However, no Arroyo chub were observed in any of the tributaries surveyed. Three-spine stickleback were observed in high abundance in middle and upper Sespe Creek (downstream of the confluence with Bear Creek, Reach 6, and throughout Reach 8), and in Lion Creek. Steelhead were observed in low abundance in upper Sespe Creek (upstream of the confluence with Howard Creek; Reach 8), as well as within three of the four tributaries surveyed (Table 3). Steelhead were also observed in Howard Creek during a 2019 reconnaissance effort (NOAA 2019). Steelhead were also observed in the mainstem directly downstream of the confluence with tributaries within reaches 3, 6, and 7, and were only found in locations with low water temperatures less than 21ºC. Steelhead and Arroyo chub were observed in the vicinity of AIS, whereas three-spine stickleback were almost entirely absent from reaches where AIS were observed.

No clear pattern was observed for fish species distribution in relation to fire burn areas. Steelhead were observed within areas burned in the most recent fire (Reach 7 and Reach 8) by the Piru and Day fires (Reach 3), the Thomas and Wolf fires (Reach 7 and Reach 8) and the Day Fire in Reach 6. Fish species distribution and abundance is discussed by reach in Section 4.3.

For AIS, smaller fish were the most abundant with most non-natives estimated to be less than 100 mm. However, no AIS less than 100 mm were observed in Reach 2 and AIS less than 100 mm were in lower abundance in Reach 3 compared to other locations where AIS were observed. Arroyo chub and three-spine stickleback do not grow very long, and these fish were also most

abundant in sizes less than 100 mm. Steelhead, however, were most abundant at lengths ranging from 100 to 150 mm and steelhead less than 100 mm were rare in locations where AIS were observed. Steelhead less than 100 mm were fairly common in locations where AIS were not observed, such as in tributaries or in Sespe Creek upstream of Rose Valley Lakes. Fish size ranges by are summarized by reach in Appendix A (Table A-2).

4.2 Habitat Data

Habitat conditions in Sespe Creek during the survey were characterized by intermittent pools separated by long dry low-gradient riffles in the upper reaches (reaches 6–8). Downstream of Hot Spring Canyon (Reach 5) Sespe Creek begins to have perennial flow. Reach 4 is located in the upstream end of the confined canyon section and is relatively low gradient. Downstream of Reach 4 the channel steepens and the gradient increases to over 2% as Sespe Creek enters a highly confined canyon where stream habitat is generally comprised of large boulder pools separated by high gradient riffles (reaches 2 and 3). Downstream of the canyon (Reach 1), Sespe Creek becomes a low-gradient stream with long shallow pools separated by long low-gradient riffles. During the survey Sespe Creek was dry in the lower section of Reach 1 and remained dry downstream to the confluence with the Santa Clara River.

Sand was the dominant substrate observed throughout most of Sespe Creek with seven out of the eight study reaches having sand as the dominant substrate. Only Reach 2 (high gradient) had boulder as the dominant substrate type. Tributaries contained coarser substrate with either boulder or gravel being dominant, while subdominant substrate in tributaries was primarily cobble, with the exception of West Fork Sespe Creek which had gravel as the subdominant substrate (Table 4). Suitable spawning gravel for steelhead was observed in reaches 4–8 and in Bear Creek.

Water temperatures during the survey ranged from 13°C to 26°C. Overall, water temperatures were generally 21°C or less in Sespe Creek except in locations with isolated pools where temperatures often reached 24°C. The warmest water temperatures observed (26°C) in Sespe Creek were downstream of Hot Springs Canyon, as a result of the influence of hot springs located in Hot Springs Canyon. The warmest water temperatures observed in tributaries was in Hot Springs Canyon (26°C) while other tributaries had water temperatures that ranged from 14°C to 23°C. Colder temperatures in Sespe Creek were often found in, and in the vicinity of cold-water tributaries. There were also locations in upper Sespe Creek (Reach 8) where it appeared that cold water (13°C–14°C) was upwelling from groundwater. Overall, the coldest temperatures (13°C) were observed in upper Sespe Creek (Reach 8). Water temperatures are discussed by reach in Section 4.3.

Table 4. Habitat characteristics in study reaches of the Sespe Creek watershed.

Reach	Gradient	Water temp (°C)		Average max pool depth (m)	Substrate		Steelhead Spawning Gravel	Dominant fish cover type	Sub-dominant fish cover type
		Min	Max		Dominant	Sub-dominant			
1	0.8%	20	20	0.5	Sand	Cobble	No	Aquatic Veg	Aquatic Veg
2	3.3%	21	22	1.4	Boulder	Sand	No	Boulder	Aquatic Veg
Pine Creek (Reach 2)	8.7%	23	23	0.5[a]	Gravel	Cobble	No	Boulder	Bubble Curtain
3	2.2%	19	21	1.5	Sand	Boulder	No	Aquatic Veg	Boulder
West Fork Sespe Creek (Reach 3)	9.5%	16	16	1.4	Boulder	Gravel	No	Boulder	Aquatic Veg
4	1.6%	17	21	1.2	Sand	Boulder	Yes	Boulder	Aquatic Veg
5	1.3%	15	26	1.5	Sand	Gravel	Yes	Boulder	Aquatic Veg
6	0.8%	14	21	1.7	Sand	Boulder	Yes	Boulder	Aquatic Veg
Bear Creek (Reach 6)	2.8%	14	14	0.2[b]	Gravel	Cobble	Yes	Boulder	Bubble Curtain
7	0.7%	14	24	1.4	Sand	Boulder	Yes	Aquatic Veg	Boulder
Middle Lion Creek (Reach 7)	2.9%	20	20	0.9	Boulder	Cobble	No	Boulder	Boulder
8	1.1%	13	25	0.6	Sand	Gravel	Yes	Aquatic Veg	Boulder

[a] No pools observed, maximum depth value is from pocket water.
[b] No pools observed, maximum depth value is from a low-gradient riffle.

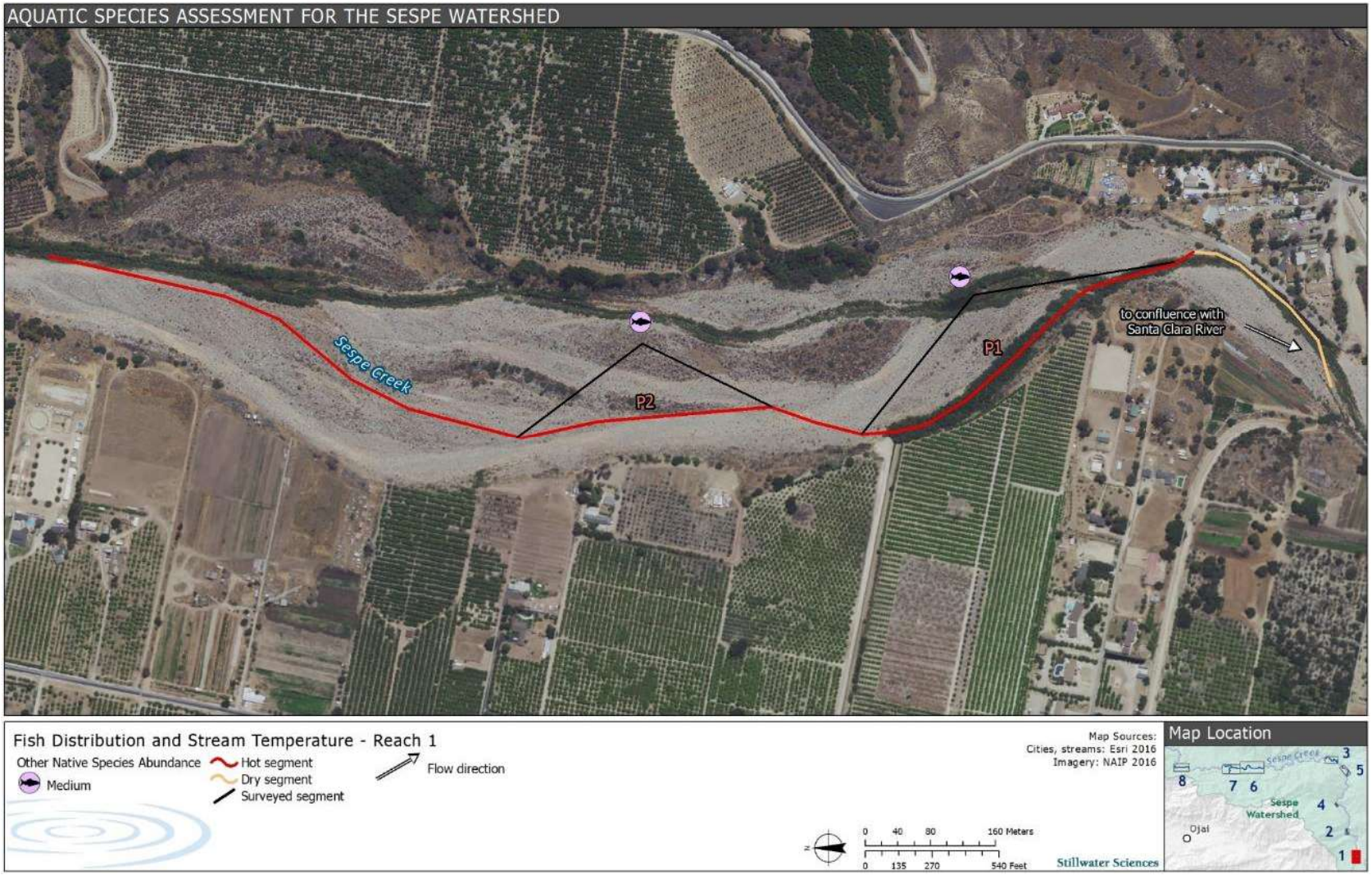
4.3 Study Reaches

4.3.1 Reach 1

Reach 1 is located in lower Sespe Creek downstream of recent wildfire burn areas. Sespe Creek within this reach has a low-gradient channel, a wide floodplain, long low-gradient riffles, and long shallow pools (Figure 3). Substrate in Reach 1 is primarily comprised of sand with lesser amounts of cobble substrate particularly along the edges of the channel and within low-gradient riffles between pools. The large volume of sand observed, and shallow pools are likely a result of recent wildfire activity upstream resulting in increased sediment input. During the survey significant flow was observed entering Reach 1 (approximately mid-reach) from a large cement canal that appeared to convey agricultural runoff. Water temperatures in Reach 1 were around 20°C during the survey. General habitat conditions in Reach 1 are shown in Figure 3. Sespe Creek had flowing water throughout most of Reach 1 but was dry at the downstream end.

Arroyo chub were observed throughout Reach 1 and were the only fish observed there (Table 3 and Figure 4).

Figure 3. Reach 1 representative pool habitat (left) and riffle habitat (right).



* Species abundance: Low <50 fish, Medium = 50–100 fish, and High >100 fish. Hot segment >20 °C and Cold segment ≤20 °C

Figure 4. Fish distribution and water temperatures in Reach 1.

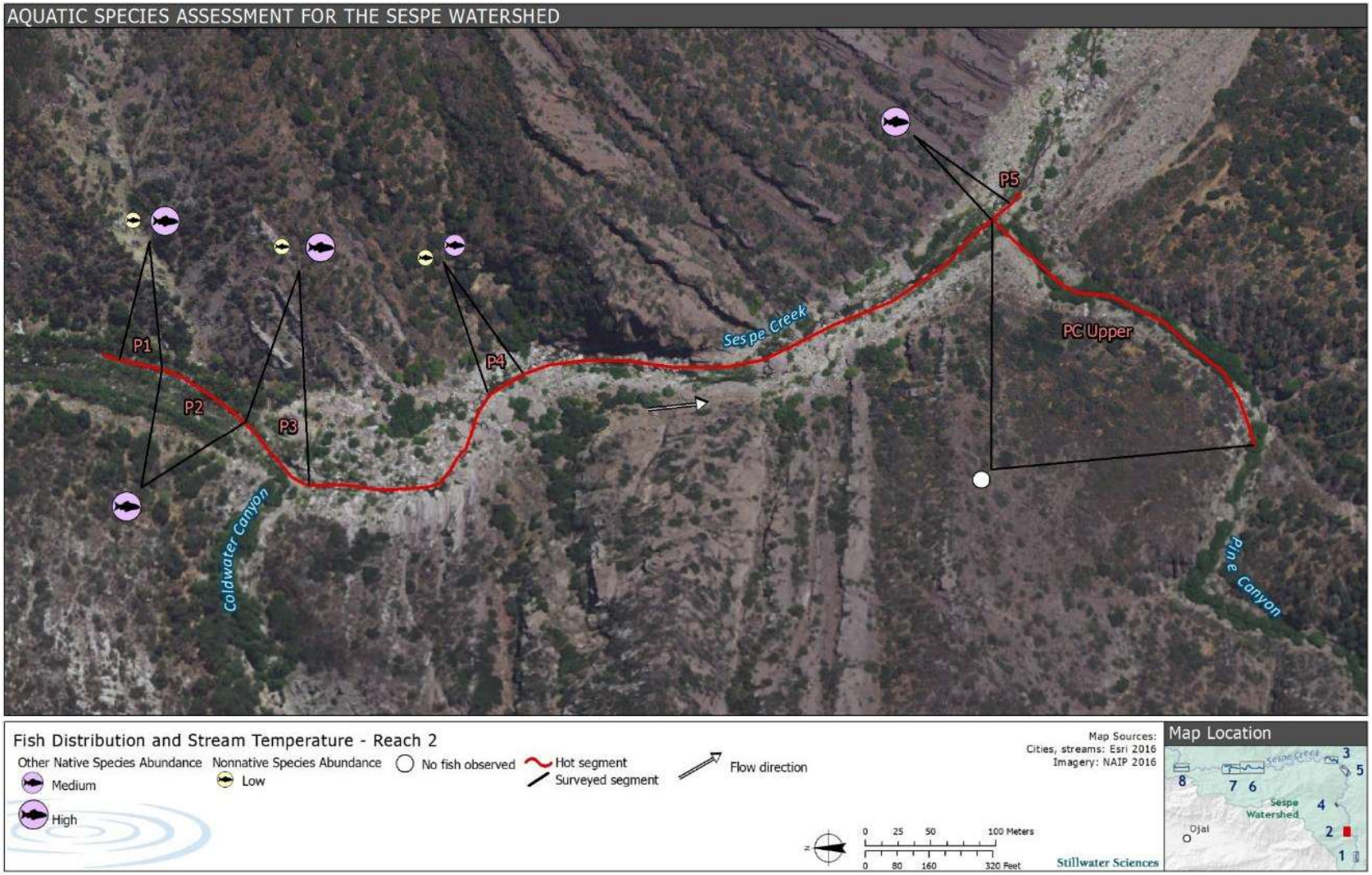
4.3.2 Reach 2

Reach 2 is located within a highly confined canyon and is characterized by having a high gradient channel with deep pool habitat formed around large boulders (Figure 5) which are separated by high gradient riffles. This section of the watershed was burned during the Piru Fire in 2003 and by the Thomas Fire in 2017. The substrate in Reach 2 is primarily comprised of boulders with small patches of sand. Although the recent wildfires likely increased sediment input, the high transport capacity of the channel in Reach 2 appears to mobilize excess sediment downstream and pool filling is not apparent. Fish cover is abundant throughout the reach in the form of large boulders. Water temperatures in Reach 2 were fairly consistent and ranged from 21°C to 22°C during the survey. Sespe Creek had flowing water throughout the reach during the survey. Pine Creek enters Sespe Creek at the downstream end of Reach 2. Perennial flows were observed in Pine Creek during the survey (Figure 6), and water temperatures were 23°C. Substrate in Pine Creek was predominantly gravel with lesser amounts of cobble.

Figure 5. Reach 2 representative pool habitat.

Figure 6. Pine Creek.

Arroyo chub were abundant in Reach 2, with relatively few suckers and AIS (bullhead catfish and green sunfish) observations in Reach 2 (Table 3 and Figure 7). Arroyo chub were observed throughout the reach while suckers were only observed in one pool (Pool 4) near the middle of Reach 2. Suckers were not observed in any other locations during this study. Reach 2 had the lowest abundance of AIS in comparison with the reaches where AIS were observed. Although no AIS smaller than 100 mm were observed in Reach 2, bullhead catfish up to 250 mm were observed. No fish were observed in Pine Creek.



* Species abundance: Low <50 fish, Medium = 50–100 fish, and High >100 fish. Hot segment >20 °C and Cold segment ≤20 °C

Figure 7. Fish distribution and water temperatures in Reach 2.

4.3.3 Reach 3

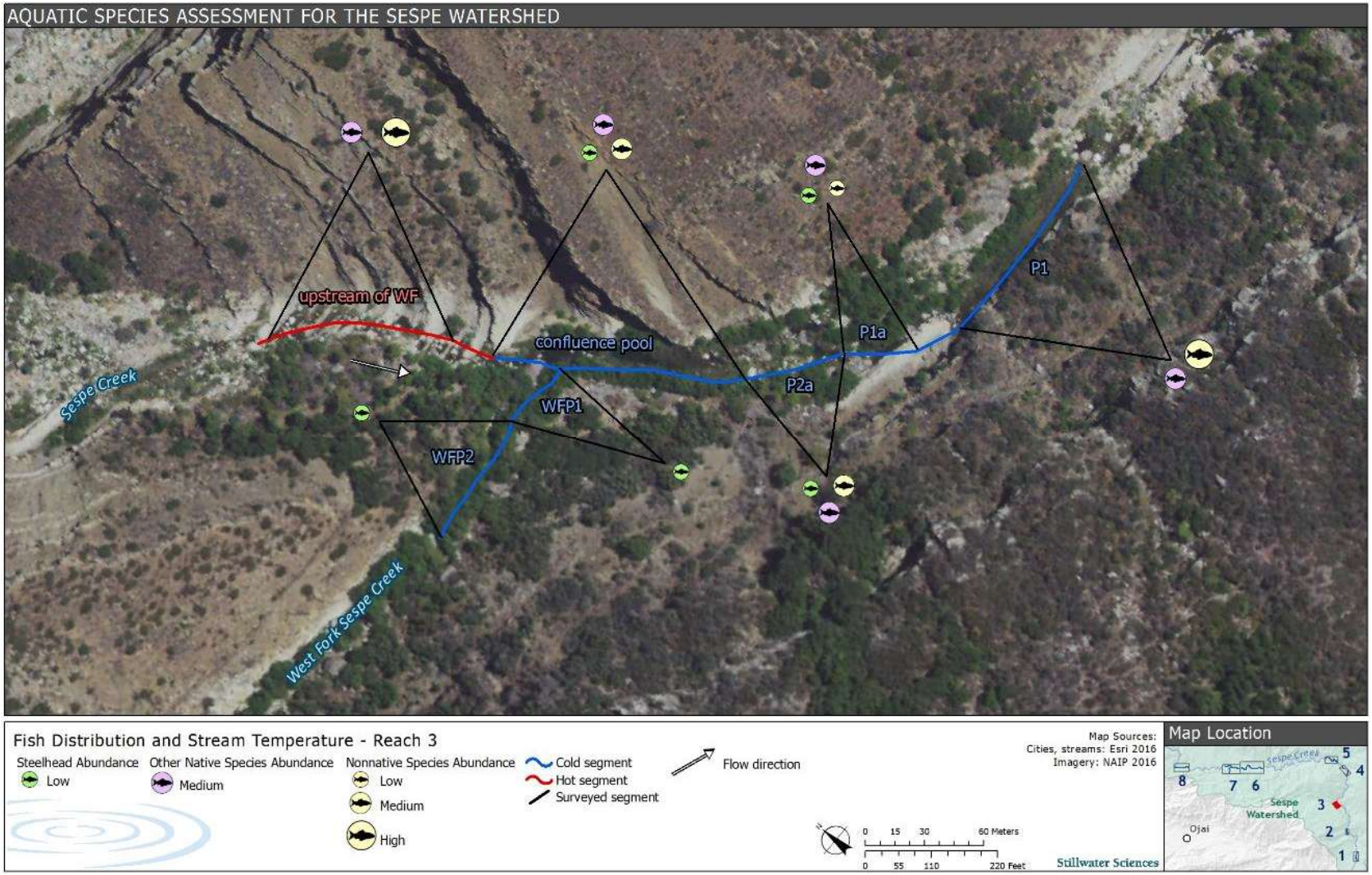
Reach 3 is located near the middle of the Sespe Creek watershed and includes the confluence with West Fork Sespe Creek near the upstream end of the reach. This section of the watershed was burned by the Piru Fire in 2003 and the Day Fire in 2006. Likely owing to sediment input from the recent fires, sand is the dominant substrate in Reach 3 and boulders are the subdominant substrate (although bedrock formed pools were also common). Habitat in Reach 3 is characterized by bedrock and boulder pools separated by high gradient riffles. Apparent infilling of pool habitat with fine sediment was variable in Reach 3 with some locations showing not apparent infilling and others with large deposits of fine sediment (Figure 8). Fish cover in the form of large boulders is abundant throughout the reach. Sespe Creek during the survey had flowing water throughout the reach, and water temperatures ranged from 19°C downstream of West Fork Sespe Creek to 21°C upstream of West Fork Sespe Creek. The water temperature in West Fork Sespe Creek was 16°C during the survey. Deep boulder pools were common in West Fork Sespe Creek (Figure 9) where boulders are the dominant substrate and gravel is the subdominant substrate.

Figure 8. Reach 3 representative pool habitat with no fine sediment infilling (left) and pool with fine sediment around boulders (right).

Figure 9. Pool habitat in West Fork Sespe Creek.

In Reach 3 AIS were observed in greater abundance than native fish. Green sunfish were the most abundant fish species observed (Table 3) and were found in nearly every mainstem habitat unit snorkeled with fish up to 250 mm observed in Reach 3. Arroyo chub were the next most common fish species observed and were found in all mainstem habitat units snorkeled. Other species

observed included, bullhead catfish, and steelhead. Steelhead were observed downstream of, and within, West Fork Sespe Creek, but they were not observed upstream of West Fork Sespe Creek (Figure 10). Reach 3 was the downstream most reach where steelhead were observed during this survey.



* Species abundance: Low <50 fish, Medium = 50–100 fish, and High >100 fish. Hot segment >20 °C and Cold segment ≤20 °C

Figure 10. Fish distribution and water temperatures in Reach 3.

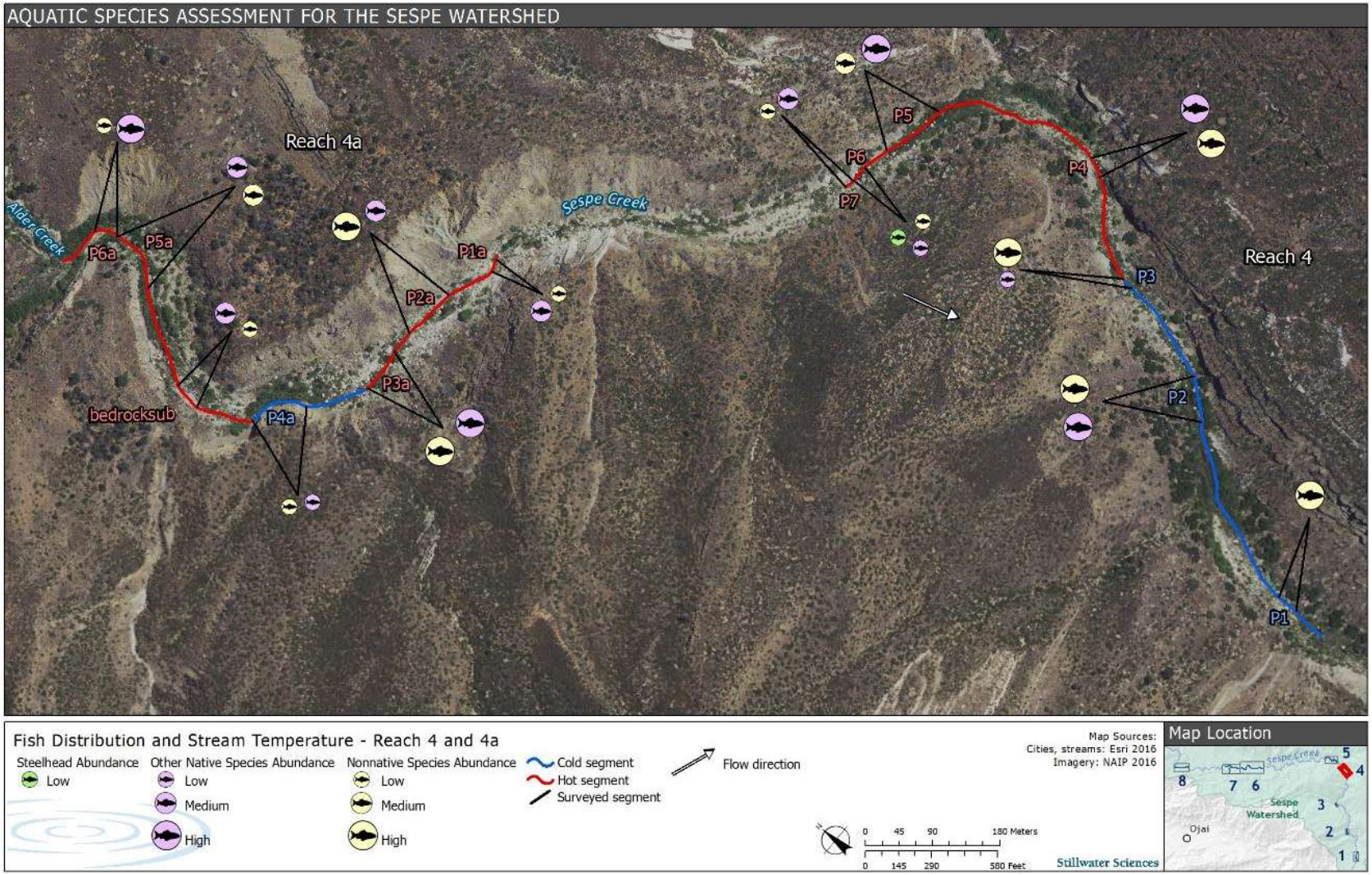
4.3.4 Reach 4

Reach 4 is located near the Middle of the Sespe Creek watershed downstream of Alder Creek. This section of the watershed was burned during the Day Fire in 2006. Within Reach 4, Sespe Creek begins to narrow as it flows into a highly confined canyon section that extends downstream of Reach 2. Sand is the dominant substrate in Reach 4 and boulders are the subdominant substrate but gravel suitable for steelhead spawning was also abundant. Habitat in Reach 4 is characterized by deep boulder formed pools separated by low-gradient riffles. Sand deposits were common along pool margins and between boulder substrate with moderate levels of infilling observed in pools (Figure 11). Fish cover in the form of large boulders is abundant throughout the reach. During the survey Sespe Creek had flowing water throughout the reach, and water temperatures ranged from 17°C to 21°C. No surface flows were observed in Alder Creek during the survey.

Figure 11. Reach 4 representative pool habitat.

Arroyo chub were the most abundant fish species observed in Reach 4 and were found throughout the reach. The only native fish species observed in Reach 4 was a single dead steelhead. Based on fish color and markings, it appeared that the steelhead died within a day or two prior to the survey (Figure 11). AIS observed in Reach 4 included bullhead catfish and green sunfish. Large bullhead catfish up to 300 mm were observed in Reach 4. Fish abundance in Reach 4 was similar for native and AIS (Table 3 and Figure 13).

Figure 12. Dead steelhead observed in Reach 4.



* Species abundance: Low <50 fish, Medium = 50–100 fish, and High >100 fish. Hot segment >20 °C and Cold segment ≤20 °C

Figure 13. Fish distribution and water temperatures in Reach 4.

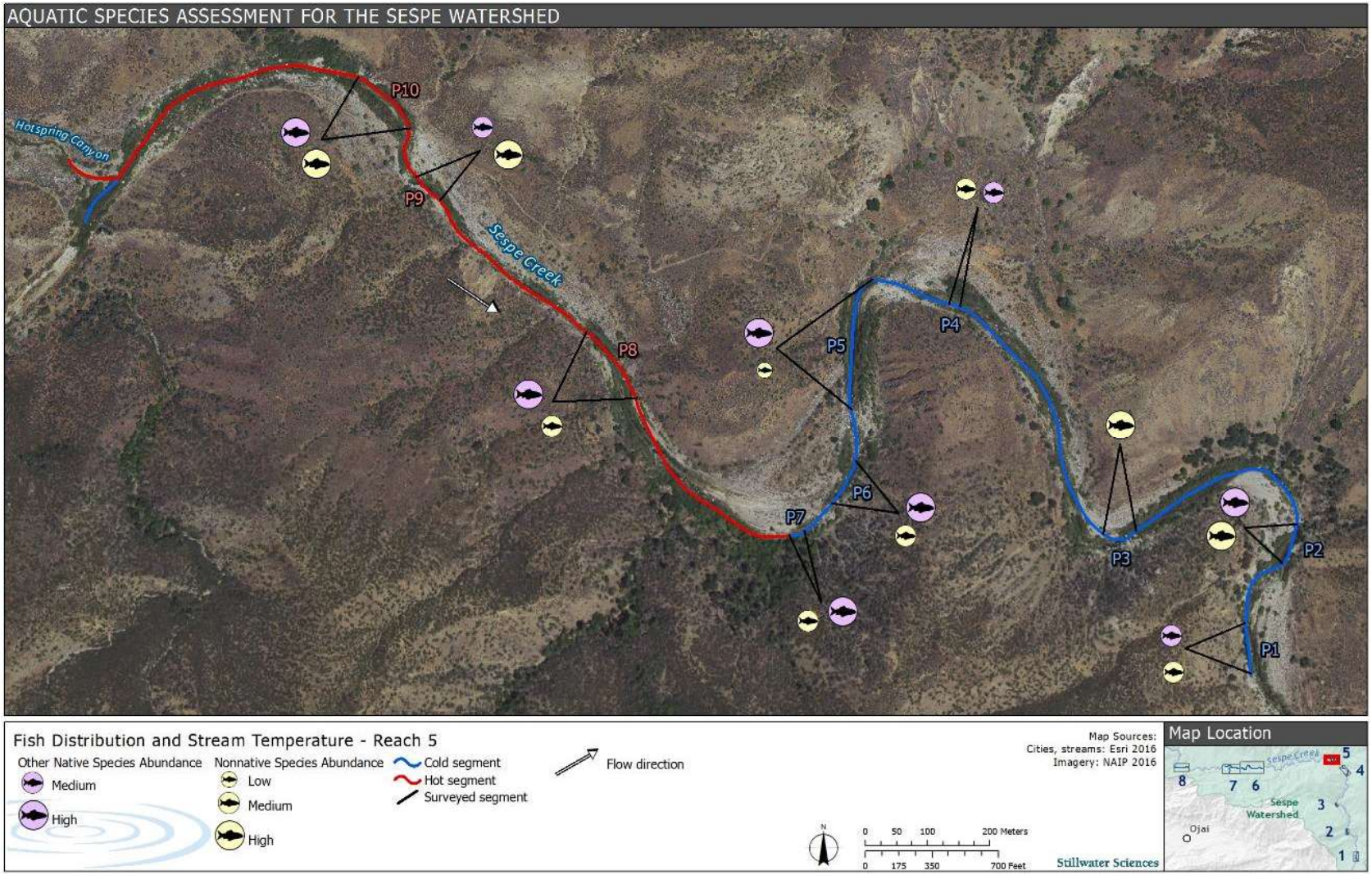
4.3.5 Reach 5

Reach 5 is located near the Middle of the Sespe Creek watershed downstream of Hot Springs Canyon. This section of the watershed was burned during the Day Fire in 2005. Reach 5 is located upstream of the confined canyon section of Sespe Creek and has a low-gradient channel. The dominant substrate in Reach 5 is composed of sand with intermittent large boulders and small patches of gravel suitable for steelhead spawning were also present along the channel margins. Habitat in Reach 5 is characterized by deep boulder formed pools separated by low-gradient riffles. Sand and gravel deposits were found along channel margins throughout Reach 5 with moderate levels of apparent sand infilling of pool habitat (Figure 14). Fine sediment mixed with gravel was also observed within Hot Spring Canyon (Figure 15). Fish cover is abundant throughout the reach in the form of large boulders. Sespe Creek had flowing water throughout the reach during the survey with temperatures ranging from 15°C to 19°C in the lower half of Reach 5 while water temperatures in the upper half ranged from 19°C to 26°C with temperatures increasing in proximity to the confluence with Hot Springs Canyon. Upstream of Hot Springs Canyon, water temperatures dropped back to 19°C. Hot Springs Canyon delivers significant flow into Sespe Creek at the upstream end of Reach 5 (Figure 15) and water temperatures within Hot Spring Canyon were 26°C during the survey.

Figure 14. Reach 5 representative pool habitat.

Figure 15. Hot Springs Canyon Creek.

No native fish species were observed in Reach 5. Arroyo chub were the most abundant species observed followed by bullhead catfish and green sunfish (Table 3 and Figure 16). One bullhead catfish estimated to be between 250–300 mm was observed in Reach 5.



* Species abundance: Low <50 fish, Medium = 50–100 fish, and High >100 fish. Hot segment >20 °C and Cold segment ≤20 °C

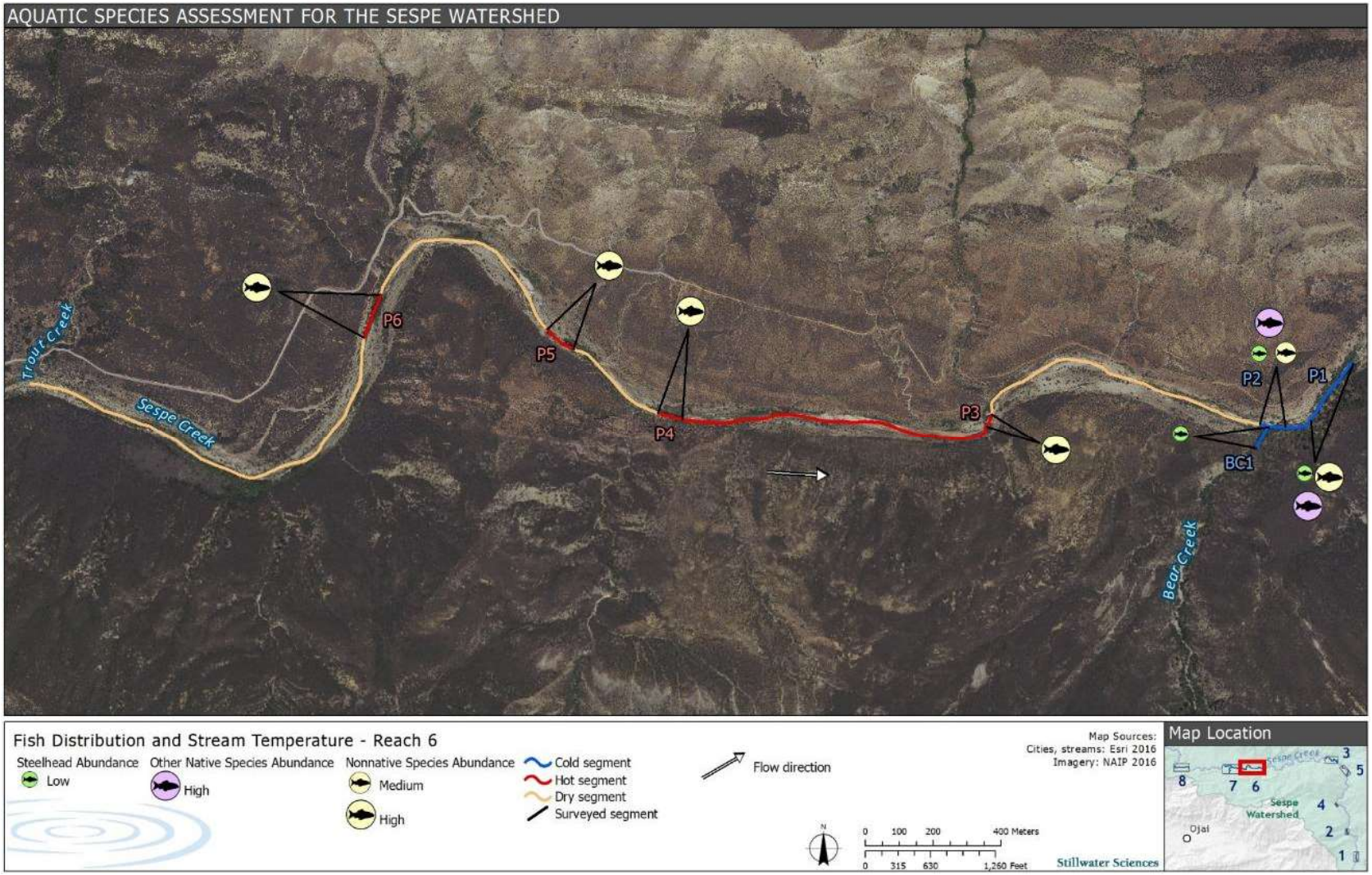
Figure 16. Fish distribution and water temperatures in Reach 5.

4.3.6 Reach 6

Reach 6 is located between Trout Creek and Bear Creek. This section of the watershed was burned during the Day Fire in 2006. Within Reach 6 Sespe Creek flows through a relatively wide floodplain. Flows were intermittent in Reach 6 during the survey and fish habitat was generally found in isolated pools (Figure 17) separated by long dry sections of stream channel. The dominant substrate in Reach 6 is composed of sand with boulder substrate being subdominant but gravel suitable for steelhead spawning was also abundant within the active channel. Pool habitat in Reach 6 appeared to have extensive infilling of fine sediment and many pools were observed to to have scouring of sand substrate associated with a few large boulders (Figure 17). Fish cover is limited within pools and is primarily available in the form of boulders and to a lesser extent aquatic vegetation. Water temperatures during the survey ranged from 14°C to 17°C at the downstream end of the reach where Bear Creek enters Sespe Creek and ranged from 20°C to 21°C upstream of Bear Creek. Trout Creek did not have surface flow during the survey, but Bear Creek was flowing, with water temperature measured at 14°C. Within Bear Creek stream habitat was primarily pocket water and riffles. Gravel was the dominant substrate in Bear Creek and was suitable for steelhead spawning while cobble was the subdominant substrate.

Figure 17. Reach 6, isolated boulder scour pool (left) and pool downstream of Bear Creek where steelhead were observed (right).

Green sunfish were the most abundant fish species observed in Reach 6, followed by bullhead catfish and Arroyo chub, other non-native species observed in high abundance were bull frog tadpoles (Table 3 and Figure 18). Steelhead and three-spine stickleback were observed in low abundance and were only observed at or downstream of the confluence of Bear Creek. Steelhead young-of-the-year fish (<100 mm long) were the only fish observed in Bear Creek.



* Species abundance: Low <50 fish, Medium = 50–100 fish, and High >100 fish. Hot segment >20 °C and Cold segment ≤20 °C

Figure 18. Fish distribution and water temperatures in Reach 6.

4.3.7 Reach 7

Reach 7 is downstream of the confluence with Howard Creek (includes Rose Valley Lakes) and extends from just downstream of Lion Creek to just upstream of Trout Creek. This section of the watershed was burned during the Wolf Fire in 2002 and the Thomas Fire in 2017. Within Reach 7, Sespe Creek flows through a relatively wide low-gradient floodplain. Reach 7 had intermittent flows during the survey with the middle of the reach containing two small isolated pools and the upper and lower sections of the reach containing long wet sections that were adjoined by dry channel on both the upstream and downstream ends. Aquatic vegetation is abundant where water occurs, and dense riparian habitat occurs in the longer wetted sections at the upper and lower ends of the reach (Figure 19). Sand is the dominant substrate and boulders are the subdominant substrate but gravel suitable for steelhead spawning was also abundant within the active channel. Pool habitat in Reach 7 appeared to have extensive infilling of fine sediment and many pools were observed to have scouring of sand substrate associated with a few large boulders (Figure 19). Fish cover is abundant within pools and is primarily available in the form of aquatic vegetation. Water temperatures in Reach 7 ranged from 14°C to 24°C during the survey with the warmer temperatures found within small (<30 m long) isolated pools. Although Lion Creek was only a trickle where it enters Sespe Creek, further upstream there was flowing water. The water temperature in Lion Creek was 20°C during the survey. Habitat in Lion Creek was primarily step-pools separated by low-gradient riffles (Figure 20). Substrate in Lion Creek was primarily boulders with large amounts of cobble.

Figure 19. Reach 7 isolated boulder scour pool (left) and dense riparian habitat in the upper reach (right).

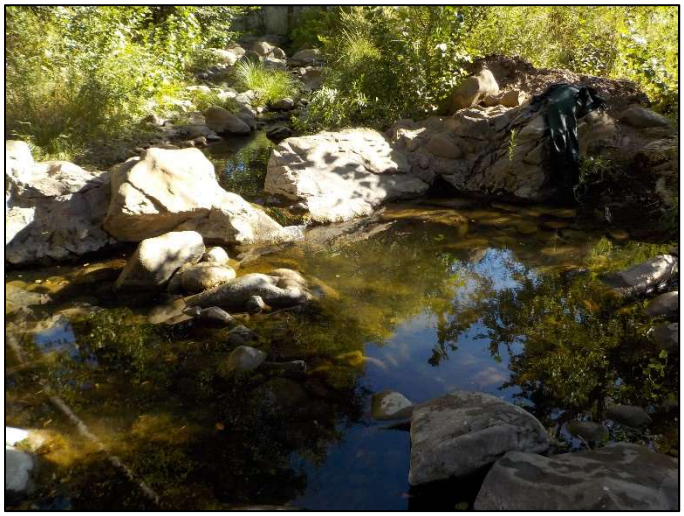


Figure 20. Lion Creek, step-pool habitat.

Green sunfish and bullhead catfish were abundant in Reach 7 with relatively few observations of Arroyo chub and steelhead. While green sunfish and bullhead catfish were observed throughout Reach 7, Arroyo chub and steelhead were only observed in one segment located downstream of the confluence with Lion Creek (Table 3 and Figure 21). American bullfrog tadpoles were also abundant throughout Reach 7. Within Lion Creek, steelhead and three-spine stickleback were the only fish species observed.

* Species abundance: Low <50 fish, Medium = 50–100 fish, and High >100 fish. Hot segment >20 °C and Cold segment ≤20 °C

Figure 21. Fish distribution and water temperatures in Reach 7.

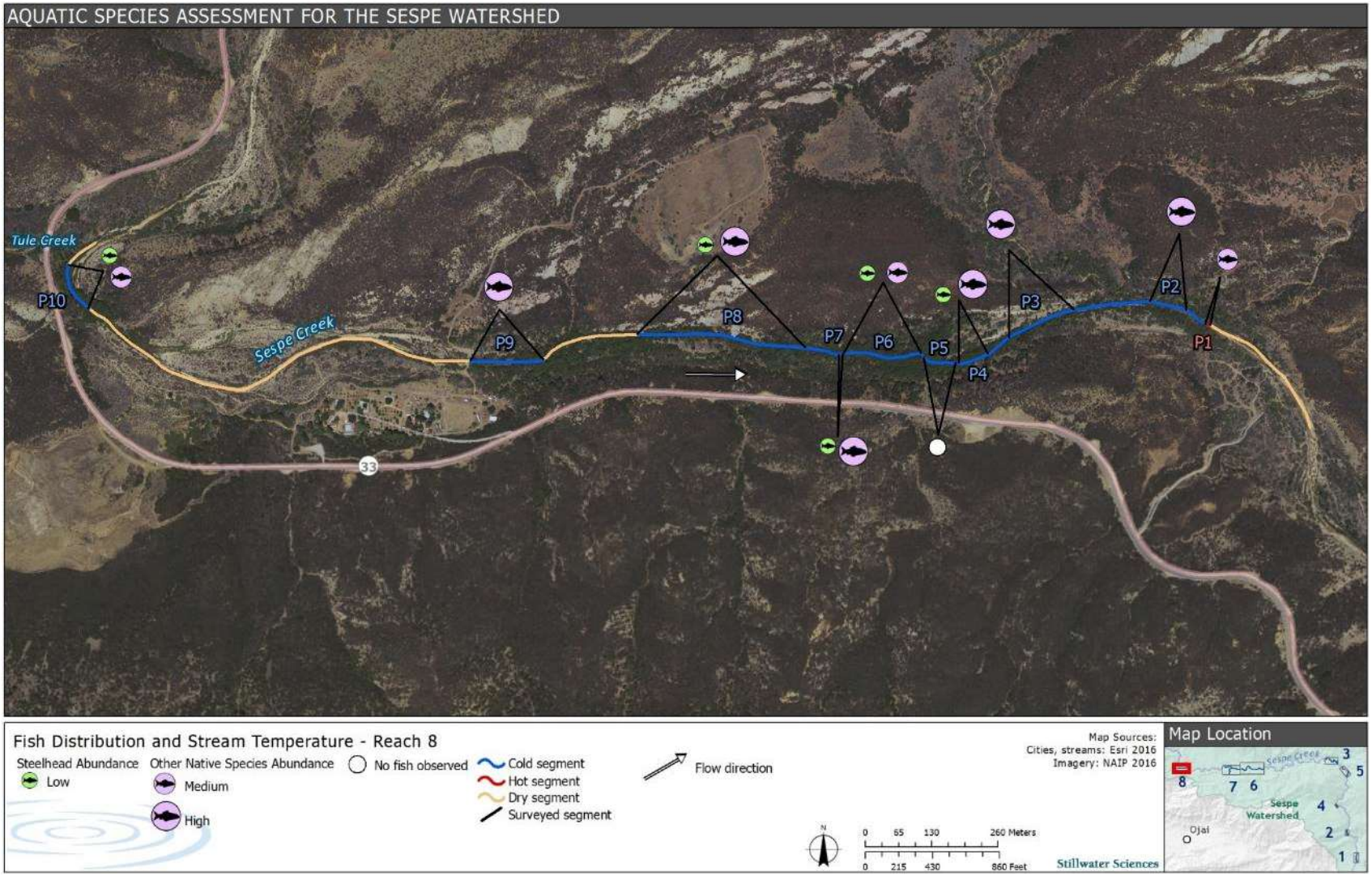
4.3.8 Reach 8

Reach 8 was the upstream most reach surveyed and is upstream of the Howard Creek confluence. This section of the watershed was burned during the Wolf Fire in 2002 and the Thomas Fire in 2017. Within Reach 8 the channel has intermittent flows and the channel is characterized primarily by pool habitat separated by low-gradient riffles and long segments of channel that were dry during the survey (Figure 22 and Figure 23). Sand is the dominant substrate and primarily found within pool habitat while gravel is subdominant and was observed in higher abundance along with cobble in low gradient riffle sections of Reach 8. Suitable spawning gravel for steelhead is abundant in Reach 8. Aquatic vegetation was abundant in locations were water was found, and locations with water were found within dense riparian habitat. Water temperatures in Reach 8 ranged from 13°C to 17°C except for one small section at the downstream end of the reach that included a few small isolated pools where the water temperature was 25°C during the survey.

Native fish species were abundant in Reach 8 with steelhead and three-spine stickleback observed throughout the reach (Table 3 and Figure 24). Arroyo chub were the most abundant fish species observed and were the only non-native fish observed in Reach 8.

Figure 22. Reach 8 representative pool habitat and dense riparian vegetation.

Figure 23. Dry segment within Reach 8.



* Species abundance: Low <50 fish, Medium = 50–100 fish, and High >100 fish. Hot segment >20 °C and Cold segment ≤20 °C

Figure 24. Fish distribution and water temperatures in Reach 8.

5 DISCUSSION

Overall, AIS appear to be distributing to downstream locations from upstream source populations. No AIS were observed on Sespe Creek upstream of Howard Creek confluence (i.e., confluence with lower Rose Valley Lake) even though suitable habitat was present (e.g. large pools with warm water) within Reach 8, and no AIS were observed in any tributaries. AIS were prevalent throughout most of the mainstem Sespe Creek downstream of Howard Creek from Reach 7 through Reach 4 (near Alder Creek). Downstream of Reach 4 AIS were observed in lower abundance (reaches 2 and 3) and no AIS were observed in Reach 1. This pattern of abundance is similar to what is observed in 2004 (Stoecker and Kelley 2005); however, in 2004, the highest numbers of AIS were observed further downstream (near the upstream end of Reach 2) to the downstream end of Reach 6 (at the confluence with Bear Creek). Both studies observed high densities of AIS within reaches 4–6 with few to no observations of AIS in reaches 1, 2, and 8, and neither study observed AIS in any of the tributaries sampled. Observations by Stoecker and Kelley (2005) occurred during an "abnormally dry" year, whereas this study occurred during a "severe drought" (US Drought Monitor 2019) ; which may influence the apparent differences in distributions observed. The low abundance of AIS observed in Reach 7 during 2004 may have been a result of poor habitat conditions following the Wolf Fire (2003) which burned along Sespe Creek at Reach 7. However, the Thomas Fire burned also burned along Sespe Creek at Reach 7 a year before this study was conducted in 2018.

It is not known if the distribution of AIS in the Sespe Creek watershed is limited by cooler water temperatures, high gradient sections, shallow water depths, or a combination of these factors. For example, no AIS were observed in Reach 1 which had warm water and is low-gradient but lacks deep pool habitat. High gradient may be attributed to the low abundance of AIS observed in Reach 2 where warm water and deep pool habitat is common, but the channel gradient is over two-percent. The reaches where AIS abundance was highest (reaches 4–7) had low-gradient channels (<2%), with deep pools, and warm water. These areas also had a high abundance of juvenile AIS (<100 mm) while smaller AIS (<100 mm) were not observed in Reach 2 and were less common in Reach 3 compared to other reaches where AIS were observed. The lack of smaller fish may indicate that conditions in these reaches limit AIS reproduction. While the absence of AIS upstream of the confluence with Howard Creek (and the influence of Rose Valley Lake) (Reach 8) appears to be related to the lack of deep pool habitat and water temperatures that typically fell within the lower range of where AIS were observed during this survey.

Native fish species, and steelhead in particular, appeared in highest abundance in areas with cool water, deep pools, and higher gradient (higher gradient was associated with cooler water). Channel locations with higher gradient have higher sediment transport capacity, and thus higher natural resiliency to sediment deposition related to wildfires. The widespread distribution and high abundance of AIS in the Sespe Creek watershed are likely impacting native steelhead and three-spine stickleback. There were several portions of the study area that had cool water with deep pools (apparently suitable for steelhead) where no steelhead were observed, but AIS were observed in high abundance, most notably in reaches 4, 5, and 7. In these locations, steelhead distribution may be limited by competition with juvenile AIS which were common in these locations. Additionally, the larger green sunfish (up to 250 mm) observed in Reach 4 and the larger bullhead catfish (up to 300 mm) observed in Reach 5 may be reducing steelhead abundance in these locations through direct predation. Steelhead abundance is highest in locations that lack AIS, and young-of-the-year steelhead (fish < 100 mm), which may be particularly vulnerable to

predation by AIS were observed almost exclusively in locations where AIS were absent. The one exception was Reach 3, where three young-of-the-year steelhead were observed in Sespe Creek downstream of West Fork Sespe Creek where bullhead catfish were also observed. Larger steelhead (>100 mm) were found in low abundance in locations where AIS occur, but their distribution seems to be limited to locations with access to potential refuge from AIS (e.g., cold-water tributaries) such as in Reach 6 near Bear Creek and in Reach 7 near Lion Creek. High gradient and cold-water tributaries appear to provide important refuge habitat for steelhead. In reaches 4, 5, and part of 6 steelhead were not observed in locations that had AIS but were otherwise suitable (e.g., deep pool habitat with cold water). Three-spine stickleback were generally only observed in locations where AIS were absent, with the exception of Reach 6, where three-spine stickleback were observed just downstream of Bear Creek. The restricted distribution of three-spine stickleback suggests they may be vulnerable to the presence of AIS either from competition for resources, predation, or both.

The primary impact of fires in the Sespe Creek watershed appears to be increased sediment delivered to the stream channel. Research has shown that the impacts of wildfire on sediment delivery into a watershed can last up to ten years after a burn (LACFCD 1959, USFS 1997); however, the 5 years following a fire has been suggested to be the most critical for fire-induced sediment production (Lave and Burbank). The effects of the 2006 Day Fire, in addition to several other recent wildfires, resulted in a short-term (5 – 10 years) increase in fine sediment-production from burned hillslopes and subsequent delivery to the mainstem channel (Stillwater 2010). For example, shortly after the 2006 Day Fire, field observations in 2008 observed accumulations of poorly-sorted sediment were common in the mid-watershed which was within the area burned by the Day Fire (Figure 1) while further downstream where reaches 2 and 3 of this study were located, evidence of infilling of pools by sandy sediments was observed (Stillwater 2010). The high frequency of fires in the Sespe Creek watershed and the increases in sediment that can occur within ten years following a fire make it difficult to identify trends in fish distribution resulting from recent fires. Nonetheless, the high frequency of fire makes the Sespe Creek watershed a highly dynamic system which is expected to result in shifting habitat suitable for AIS and native aquatic species.

In addition to wildfires, drought may play a large role in aquatic species distribution and abundance. This survey occurred during the end of a six-year drought (2012–2018) in the Sespe Creek watershed which likely influenced fish distribution and abundance during this effort. Drought can lead to fragmented stream habitat (limiting fish migration), while low stream flows during periods of drought can lead to warmer water temperatures (favoring warm-water AIS). Drought can also decrease sediment transport capacity, increasing the duration of influence of wildfires. For example, no large stream flows had occurred between the time of this survey and the recent Thomas Fire (Figure 25).

Fine sediment was abundant in most locations throughout Sespe Creek. Large sand deposits were commonly observed along the edges of pool habitat and in some locations infilling of pools was observed to be moderate (reaches 3-5) to extensive (reaches 6-7). Since fine sediment was so widespread in the watershed, it was difficult to attribute it to any single fire. However, there were no obvious effects of the wildfires on fish distribution. Native fish species were observed in similar abundance upstream, within, and downstream of recent burn areas.

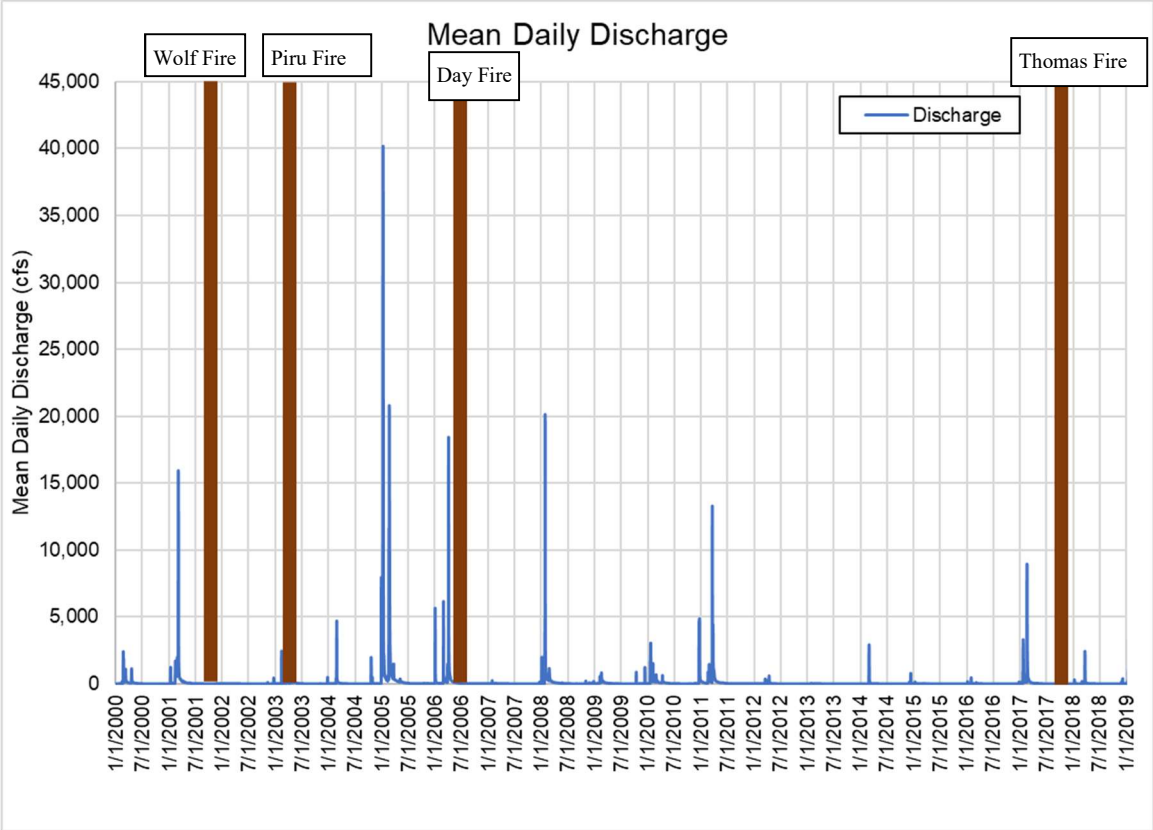


Figure 25. Mean daily discharge in Sespe Creek near Fillmore (USGS Gage 11113000) shown with recent wildfires.

Based on the results of this study the following recommendations are made for managing AIS in the Sespe Creek watershed and are listed in order of importance:

1. Address the source population of AIS by altering the habitat in the Rose Valley Lakes so it no longer supports AIS.
2. AIS suppression efforts should be conducted in Reach 6 and Reach 7 where AIS abundance is high, reproduction of AIS appears to be occurring, and suitable habitat occurs for steelhead and other native biota.
3. Focused AIS suppression efforts should be conducted in Reach 4 and Reach 5 where habitat conditions are favorable to AIS, and reproduction of AIS appears to be occurring. The lack of native species in these reaches would allow more intensive suppression techniques.

Because the field investigation for this assessment was conducted following a 6-year drought, the results of the current investigation does represent the full variability in the distribution and composition of both native aquatic species and AIS. Management for the suppression of AIS within Sespe Creek should include an adaptive management component to maximize the effectiveness of the aquatic invasive species suppression efforts.

6 REFERENCES

Barro, S. C., and S. G. Conrad. 1991. Fire effects on California chaparral systems: an overview. Environmental International 17: 135–149.

Brehme, C. S., T. A. Matsuda, G. M. VanScoy, and R. N. Fisher. 2011. MCBCP Arroyo Toad Monitoring Results for 2010 with Multi-Year Trend Analysis. U.S. Geological Survey Data Summary prepared for Marine Corps Base Camp Pendleton. 48 pp.

Capelli, M. H. 2018. *O. mykiss* Observations, Howard Creek (tributary to Rose Valley Creek and Middle Reaches of Sespe Creek), June 10, 2018. Memo to File. National Marine Fisheries Service. California Coast Branch.

Coggins Jr., G. Lewis, M. D. Yard, and W. E. Pine III. 2011. Non-native fish control in the Colorado River in Grand Canyon, Arizona: an effective program or serendipitous timing? Transactions of the American Fisheries Society 140: 456–470.

Dunham, J.B., M.K. Young, R.E. Gresswell, and B.E. Rieman. 2003. Effects of fire on fish populations: landscape perspectives on persistence of native fishes and non-native fish invasions. Forest Ecology and Management 178:183-196.

Gresswell, R. E. 1999. Fire and aquatic ecosystems in forested biomes of North America. Transactions of the American Fisheries Society 128: 193–221.

Hayes, Marc P., C. A. Wheeler, A. J. Lind, G. A. Green, and D. C. McFarlane. 2016. Foothill Yellow-legged Frog Conservation in California. U.S. Forest Service. Pacific Southwest Research Station. General Technical Report PSW-GTR-248.

Kelley, Elise. 2004. Information Synthesis and Priorities Regarding Steelhead trout (*Oncorhynchus mykiss)* on the Santa Clara River. Prepared for The Nature Conservancy.

Klose, K. 2007. Complex effects of an invasive consumer (*Procambarus clarkii*) on stream communities in southern California and Hawaii. PhD dissertation. University of California, Santa Barbara.

Lanier, C. 2011. Potential impacts of groundwater withdrawal and wildfires along the Big Sur River: an assessment of *Oncorhynchus mykiss* habitat. Master's thesis. California State University, Monterey Bay.

LACFCD (Los Angeles County Flood Control District). 1959. Report on debris reduction studies for mountain watersheds of Los Angeles County. Los Angeles, California.

Lavé, J., and D. Burbank. 2004. Denudation processes and rates in the Transverse Ranges, southern California: erosional response of a transitional landscape to external and anthropogenic forcing. Journal of Geophysical Research 109: F01006, doi:10.1029/2003JF000023.

Lepak, J. M., C. E. Kraft, and B. C. Weidel. 2006. Rapid food web recovery in response to removal of an introduced apex predator. Canadian Journal of Fisheries and Aquatic Science 63: 569–575.

Marchetti, M. P., P. B. Moyle, and R. Levine. 2004. Alien fishes in California watersheds: characteristics of successful and failed invaders. Ecological Applications 14: 587–596.

Moore, Mark R. 1980. Stream Survey: Ojai Ranger District, Los Padres National Forest.

Moyle, Peter B. 2002. Inland Fishes of California. Revised and Expanded. University of California Press.

NMFS (National Marine Fisheries Service). 2012. Southern California Steelhead Recovery Plan. Prepared by NMFS, Southwest Region, Protected Resources Division, Long Beach, California.

NOAA (National Oceanic and Atmospheric Administration). 2019. Comments on the draft aquatic species assessment for the Sespe Creek Watershed (January 2019).

Ramirez, R.S., Jr. 2007. Arroyo toad (*Bufo californicus*) hydrogeomorphic habitat baseline analysis/radio telemetry study - Rancho Las Flores – West Fork Mojave River & Grass Valley Creek – San Bernardino County, California. Prepared for Rancho Las Flores Limited Partnership by Cadre Environmental, Carlsbad, California. vi + 116 pp.

Reid, S.B. 2015 Assessment of occupancy and potential habitat for Pacific Lamprey in the Santa Clara River drainage. Report to United Water Conservation District, Santa Paula CA.

Reid, Stewart B. and Damon H. Goodman. 2016. Pacific Lamprey in Coastal Drainages of California: Occupancy Patterns and Contraction of the Southern Range. *Transactions of the American Fisheries Society*.

Rieman, B., and J. Clayton. 1997. Wildfire and native fish: issues of forest health and conservation of sensitive species. Fisheries 22: 6–15.

Rieman, B., R. Gresswell, and J. Rinne. 2012. Fire and fish: A synthesis of observation and experience. Pages 159-175 *in* C. Luce, P. Morgan, K. Dwire, D. Isaak, Z. Holden, and B. Rieman, editors. Climate change, forests, fire, water, and fish: Building resilient landscapes, streams, and managers. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado.

Sanders, Robert B. 1950. A Herpetological Survey of Ventura County California. M.S. Thesis. Stanford University.

Sloat, M.R. and A. Osterback. 2012. Maximum stream temperatures and the occurrence, abundance, and behavior of steelhead trout (*Oncorhynchus mykiss*) in a southern California stream. Canadian Journal of Fisheries Aquatic Sciences. 70:64-73.

Stillwater Sciences. 2010. Sespe Creek hydrology, hydraulics, and sedimentation analysis: watershed assessment of hillslope and river geomorphic processes – final draft. Prepared by Stillwater Sciences, Berkeley, California for Ventura County Watershed Protection District, Ventura, California. April.

Stoecker, M., and E. Kelley. 2005. Santa Clara River steelhead trout: assessment and recovery opportunities. Prepared for The Nature Conservancy and The Santa Clara River Trustee Council, Santa Barbara, California.

Swanson, F. J. 1981. Fire and geomorphic processes. In: Mooney, H.; Bonnicksen, T. M.; Christensen, N. L.; Lotan, J. E.; Reiners, W. A., tech. coords. Proceedings of the conference; Fire regimes and ecosystem properties, December 11-15, 1979, Honolulu, HI. Gen. Tech. Rep. WO-26. Washington, DC: U.S. Department of Agriculture, Forest Service: 410-420.

Sweet, Samuel S. 1991. Ecology and Status of the Arroyo Toad (*Bufo micorscaphus californicus*) on the Los Padres National Forest of Southern California, with Management Recommendations. Department of Biological Sciences, University of California, Santa Barbara.

Sweet, Samuel S. 1992. Initial Report on the Ecology and Status of the Arroyo Toad (*Bufo micorscaphus californicus*) on the Los Padres National Forest of Southern California, with

Management Recommendations. Revised March 15, 1992. Contract Report, U.S. Forest Service, Los Padres National Forest, Goleta, California.

Swift, Camm C. and Steve R. Howard. 2009. Current Status and Distribution of the Pacific Lamprey South of Point Conception, Coastal Southern California. *American Fisheries Society Symposium.* 72:269-278.

Swift, Camm C., Thomas R. Hagland, Mario Ruiz, and Robert N. Fisher. 1993. The Status and Distribution of Freshwater Fishes of Southern California. Bulletin of the Southern California Academy of Sciences. 92(3).

Thurow, R.F. 1994. Underwater methods for study of salmonids in the intermountain west. United States Department of Agriculture, Forest Service. General Technical Report INT-GTR-307.

USDI (U.S. Department of the Interior). 2016. Safeguarding America's lands and waters from invasive species: A national framework for early detection and rapid response, Washington D.C., 55p.

US Drought Monitor. 2019. National Drought Mitigation Center (NDMC), the U.S. Department of Agriculture (USDA) and the National Oceanic and Atmospheric Administration (NOAA). Available at droughtmonitor.unl.edu.

USFWS (United States Fish and Wildlife Service). 2002. Recovery Plan for the California Red-legged Frog (*Rana aurora draytonii*). Region 1. U.S. Fish and Wildlife Service.

USFWS. 2014. Arroyo toad (*Anaxyrus californicu*s) Species Report. Ventura Fish and Wildlife Office, Ventura, California.

USFS (United States Forest Service). 1997. Sespe Watershed Analysis: Ojai Ranger District, Los Padres National Forest.

Warrick, J. A., J. A. Hatten, G. B. Pasternack, A. B. Gray, M. A. Goni, and R. A. Wheatcroft. 2012. The effects of wildfire on the sediment yield of a coastal California watershed. Geological Society of America Bulletin 124: 1,130-1,146.

APPENDIX A

Aquatic Species Distribution and Abundance Data

Table A-1. Temperature, aquatic species distribution, and species abundance by location in the Sespe Creek watershed.

Study reach	Segment	Time of survey	Habitat Type	Segment Length (m)	Water temp. (°C)	Hot/ Cold	Species abundance							Total fish
							Native species		Non-native species					
							Steelhead	Three-spine stickleback	Bullhead catfish	Green sunfish	American bullfrog	Arroyo chub	Sucker	
Reach 1	P1	9:00	Pool	30	20	Hot	0	0	0	0	0	51	0	51
	P2	10:00	Pool	90	20	Hot	0	0	0	0	0	51	0	51
Reach 2	P1	12:48	Pool	30	22	Hot	0	0	0	2	0	101	0	103
	P2	12:40	Run	60	22	Hot	0	0	0	0	0	102	0	102
	P3	13:00	Pool	30	21	Hot	0	0	10	0	0	150	0	160
	P4	13:45	Pool	30	21	Hot	0	0	15	0	0	51	30	96
	P5	14:55	Pool	15	22	Hot	0	0	0	0	0	102	0	102
Pine Creek (Reach 2)	PC Upper	14:31	Low gradient riffle	30	23	Hot	0	0	0	0	0	0	0	0
Reach 3	Confluence Pool	13:30	Pool	120	19	Cold	4	0	51	0	0	51	0	76
	P1	11:35	Pool	90	19	Cold	0	0	0	107	0	51	0	211
	P1a	17:01	Pool	12	19	Cold	4	0	0	3	0	50	0	235
	P2a	17:20	Pool	10	19	Cold	3	0	0	51	0	51	0	82
	U/S of WF	13:45	Pool series	150	21	Hot	0	0	55	51	0	51	0	207
West Fork Sespe (Reach 3)	WFP1	12:30	Step-pool	30	16	Cold	1	0	0	0	0	0	0	173
	WFP2	12:47	Step-pool	45	16	Cold	7	0	0	0	0	0	0	127

Study reach	Segment	Time of survey	Habitat Type	Segment Length (m)	Water temp. (°C)	Hot/ Cold	Species abundance							Total fish
							Native species		Non-native species					
							Steelhead	Three-spine stickleback	Bullhead catfish	Green sunfish	American bullfrog	Arroyo chub	Sucker	
Reach 4	Bedrock Sub	18:00	Pool	15	20	Hot	0	0	2	0	0	50	0	52
	P1a	17:01	Pool	15	20	Hot	0	0	11	0	0	30	0	41
	P2a	17:20	Step-pool	30	20	Hot	0	0	126	0	0	60	0	186
	P3a	17:30	Pool series	25	20	Hot	0	0	223	0	0	201	0	424
	P4a	17:48	Pool	25	19	Cold	0	0	10	11	5	15	0	36
	P5a	18:15	Pool	30	21	Hot	0	0	35	10	0	30	0	75
	P6a	18:21	Pool	45	20	Hot	0	0	2	20	0	101	0	123
	P1	11:35	Step-pool	30	18	Cold	0	0	103	3	0	101	0	207
	P2	11:50	Pool series	60	17	Cold	0	0	111	0	0	101	0	212
	P3	12:02	Pool	12	19	Cold	0	0	101	0	0	10	0	111
	P4	12:11	Pool	30	21	Hot	0	0	125	0	0	101	0	226
	P5	12:40	Pool series	60	21	Hot	0	0	1	0	0	10	0	11
	P6	12:50	Pool	25	21	Hot	0	0	1	0	0	10	0	11
	P7	13:00	Pocket water	10	21	Hot	0	0	10	0	0	60	0	70

Study reach	Segment	Time of survey	Habitat Type	Segment Length (m)	Water temp. (°C)	Hot/ Cold	Species abundance							Total fish
							Native species		Non-native species					
							Steelhead	Three-spine stickleback	Bullhead catfish	Green sunfish	American bullfrog	Arroyo chub	Sucker	
Reach 5	P1	9:38	Pool	90	15	Cold	0	0	18	7	1	51	0	76
	P2	10:20	Pool	60	18	Cold	0	0	108	2	0	101	0	211
	P3	10:45	Pool	60	16	Cold	0	0	34	0	0	201	0	235
	P4	11:10	Pool	4	19	Cold	0	0	5	26	0	51	0	82
	P5	11:32	Low Gradient Riffle	245	18	Cold	0	0	6	0	0	201	0	207
	P6	11:50	Pool	150	18	Cold	0	0	22	30	0	121	0	173
	P7	12:30	Pool	45	19	Cold	0	0	21	5	0	101	0	127
	P8	12:56	Pool series	90	21	Hot	0	0	8	35	0	501	0	544
	P9	13:24	Pool	30	21	Hot	0	0	100	20	0	70	0	190
	P10	13:37	Pool	90	24	Hot	0	0	200	4	0	100	0	304
	D/S of Hot Spring Canyon	14:40	Low Gradient Riffle	100	26	Hot	NA[1]	NA[1]	NA[1]	NA[1]	0	NA[1]	NA[1]	0
	Hot Spring Canyon	14:45	Low Gradient Riffle	30	26	Hot	NA[1]	NA[1]	NA[1]	NA[1]	0	NA[1]	NA[1]	0
	U/S of Hot Spring Canyon	1450	Low Gradient Riffle	30	19	Cold	NA[1]	NA[1]	NA[1]	NA[1]	0	NA[1]	NA[1]	0
Reach 6	P1	9:50	Pool series	215	17	Cold	9	51	62	153	0	105	0	380
	P2	10:44	Pool	90	14	Cold	19	0	0	51	0	102	0	172
	P3	11:30	Pool series	30	20	Hot	0	0	51	51	51	0	0	102
	P4	11:40	2 Isolated pools	80	20	Hot	0	0	51	51	51	0	0	102
	P5	12:35	2 Isolated pools	30	21	Hot	0	0	0	153	0	0	0	153
	P6	13:05	2 Isolated pools	60	21	Hot	0	0	0	204	0	0	0	204

Study reach	Segment	Time of survey	Habitat Type	Segment Length (m)	Water temp. (°C)	Hot/ Cold	Species abundance							Total fish
							Native species		Non-native species					
							Steelhead	Three-spine stickleback	Bullhead catfish	Green sunfish	American bullfrog	Arroyo chub	Sucker	
Bear Creek (Reach 6)	BC1	11:00	Low gradient riffle	30	14	Cold	5	0	0	0	0	0	0	5
Reach 7	P1a	14:30	Isolated pool	12	24	Hot	0	0	0	0	51	0	0	0
	P2a	14:50	Pool	60	19	Cold	0	0	0	1	51	0	0	1
	P3a	15:00	Pool	60	17	Cold	0	0	0	51	51	0	0	51
	P4a	15:30	Pool series	180	19	Cold	6	0	51	51	51	61	0	169
	P1	15:45	Isolated pool	15	24	Hot	0	0	51	51	0	0	0	102
	P2	16:00	Pool	10	24	Hot	0	0	51	51	51	0	0	102
	P3	16:16	Pool	90	23	Hot	0	0	51	51	0	0	0	102
	P4	16:20	Isolated pool	15	14	Cold	0	0	0	51	51	0	0	51
	P5	16:30	Pool	150	18	Cold	0	0	51	0	51	0	0	51
	P6	16:45	Off channel Pool	15	18	Cold	0	0	0	0	51	0	0	0
	P7	17:00	Pool	30	18	Cold	0	0	0	51	0	0	0	51
Lion Creek (Reach 7)	Campground	17:00	Plunge pool	5	20	Hot	8	51	0	0	0	0	0	59

Study reach	Segment	Time of survey	Habitat Type	Segment Length (m)	Water temp. (°C)	Hot/ Cold	Species abundance							Total fish
							Native species		Non-native species					
							Steelhead	Three-spine stickleback	Bullhead catfish	Green sunfish	American bullfrog	Arroyo chub	Sucker	
Reach 8	P1	11:00	Isolated pool	1	25	Hot	0	20	0	0	0	20	0	40
	P2	11:15	Pool series	25	14	Cold	0	95	0	0	0	85	0	180
	P3	11:40	Pool series	15	14	Cold	0	150	0	0	0	130	0	280
	P4	12:15	Pool	15	13	Cold	3	60	0	0	0	58	0	121
	P5	12:20	Pool	70	14	Cold	0	0	0	0	0	0	0	0
	P6	12:30	Pool	18	14	Cold	8	30	0	0	0	30	0	68
	P7	12:50	Pool	15	15	Cold	8	51	0	0	0	51	0	110
	P8	13:15	Pool	60	16	Cold	23	71	0	0	0	241	0	335
	P9	13:37	Pool series	45	17	Cold	0	102	0	0	0	102	0	204
	P10	14:00	Pool	90	16	Cold	3	0	0	0	0	51	0	54

[1] Temperature data was collected but location was not snorkeled.

Table A-2. Number of fish observed by species and size range.

Reach	Species	Size range							Total
		0–50	**50–100**	**100–150**	**150–200**	**200–250**	**250–300**	**300–350**	
1	Steelhead	0	0	0	0	0	0	0	**0**
	Three-spine stickleback	0	0	0	0	0	0	0	**0**
	Arroyo chub	0	102	0	0	0	0	0	**102**
	Bullhead catfish	0	0	0	0	0	0	0	**0**
	Green sunfish	0	0	0	0	0	0	0	**0**
	Sucker	0	0	0	0	0	0	0	**0**
	Total	**0**	**102**	**0**	**0**	**0**	**0**	**0**	**102**
2	Steelhead	0	0	0	0	0	0	0	**0**
	Three-spine stickleback	0	0	0	0	0	0	0	**0**
	Arroyo chub	152	354	0	0	0	0	0	**506**
	Bullhead catfish	0	0	5	15	5	0	0	**25**
	Green sunfish	0	0	2	0	0	0	0	**2**
	Sucker	0	0	0	20	10	0	0	**30**
	Total	**152**	**354**	**7**	**35**	**15**	**0**	**0**	**563**
3	Steelhead	0	3	1	6	1	0	1	**12**
	Three-spine stickleback	0	0	0	0	0	0	0	**0**
	Arroyo chub	0	254	0	0	0	0	0	**254**
	Bullhead catfish	0	5	50	0	0	0	0	**55**
	Green sunfish	0	204	54	0	5	0	0	**263**
	Sucker	0	0	0	0	0	0	0	**0**
	Total	**0**	**466**	**105**	**6**	**6**	**0**	**1**	**584**

Reach	Species	Size range							Total
		0–50	50–100	100–150	150–200	200–250	250–300	300–350	
West Fork Sespe Creek	Steelhead	5	1	0	0	0	0	0	**6**
	Total	**5**	**1**	**0**	**0**	**0**	**0**	**0**	**6**
4	Steelhead	0	0	0	0	1	0	0	**1**
	Three-spine stickleback	0	0	0	0	0	0	0	**0**
	Arroyo chub	115	856	0	0	0	0	0	**971**
	Bullhead catfish	60	679	163	6	3	3	0	**914**
	Green sunfish	40	0	9	0	0	0	0	**49**
	Sucker	0	0	0	0	0	0	0	**0**
	Total	**215**	**1535**	**172**	**6**	**4**	**3**	**0**	**1,935**
5	Steelhead	0	0	0	0	0	0	0	**0**
	Three-spine stickleback	0	0	0	0	0	0	0	**0**
	Arroyo chub	101	1498	0	0	0	0	0	**1,599**
	Bullhead catfish	101	277	135	8	0	1	0	**522**
	Green sunfish	0	50	71	8	0	0	0	**129**
	Sucker	0	0	0	0	0	0	0	**0**
	Total	**202**	**1825**	**206**	**16**	**0**	**1**	**0**	**2,250**
6	Steelhead	0	0	0	24	4	0	0	**28**
	Three-spine stickleback	51	0	0	0	0	0	0	**51**
	Arroyo chub	0	153	54	0	0	0	0	**207**
	Bullhead catfish	0	158	6	0	0	0	0	**164**
	Green sunfish	51	357	255	0	0	0	0	**663**
	Sucker	0	0	0	0	0	0	0	**0**
	Total	**102**	**668**	**315**	**24**	**4**	**0**	**0**	**1,113**

Reach	Species	Size range							Total
		0–50	50–100	100–150	150–200	200–250	250–300	300–350	
Bear Creek	Steelhead	5	0	0	0	0	0	0	**5**
	Total	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**5**
7	Steelhead	0	0	0	0	6	0	0	**6**
	Three-spine stickleback	0	0	0	0	0	0	0	**0**
	Arroyo chub	0	51	10	0	0	0	0	**61**
	Bullhead catfish	51	204	0	0	0	0	0	**255**
	Green sunfish	51	307	0	0	0	0	0	**358**
	Sucker	0	0	0	0	0	0	0	**0**
	Total	**102**	**562**	**10**	**0**	**6**	**0**	**0**	**680**
Lion Creek	Steelhead	0	5	3	0	0	0	0	**8**
	Three-spine stickleback	51	0	0	0	0	0	0	**51**
	Total	**51**	**5**	**3**	**0**	**0**	**0**	**0**	**59**
8	Steelhead	18	4	8	5	7	3	0	**45**
	Three-spine stickleback	260	319	0	0	0	0	0	**579**
	Arroyo chub	260	498	10	0	0	0	0	**768**
	Bullhead catfish	0	0	0	0	0	0	0	**0**
	Green sunfish	0	0	0	0	0	0	0	**0**
	Sucker	0	0	0	0	0	0	0	**0**
	Total	**538**	**821**	**18**	**5**	**7**	**3**	**0**	**1,392**