SPECIES STATUS ASSESSMENT FOR THE SANTA ANA SPECKLED DACE

(*Rhinichthys gabrielino*)

Photo Credit: USFWS

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In particular we thank: Jennifer Pareti and Michael Sturkie from the California Department of Fish and Wildlife (CDFW) and Kerwin Russell of Riverside-Corona Resource Conservation District. We would also like to thank Robert Fisher of U.S. Geological Survey (USGS), Peter Moyle (UC Davis), and Camm Swift (Natural History Museum of Los Angeles County). We appreciate these efforts and look forward to continued collaboration as we refine methodologies to learn more about the species and implement actions that support Santa Ana speckled dace conservation.

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EXECUTIVE SUMMARY

We, the U.S. Fish and Wildlife Service (Service), were petitioned to list the Santa Ana speckled dace (SASD) (*Rhinichthys gabrielin*) as either endangered or threatened with designated critical habitat in 2020 (CBD 2020, entire), under the Endangered Species Act of 1973 (Act), as amended (16 U.S.C. 1531 *et seq*.). In 2021 we completed a 90-day finding where we found that the petition presented substantial scientific or commercial information indicating the petitioned action may be warranted (Service 2021, entire). SASD is restricted to 17 occurrences within four river systems in southern California.

SASD was historically found throughout river systems at the bases of the San Gabriel, San Bernardino, and San Jacinto Mountain ranges in Los Angeles, San Bernardino and Riverside Counties, California. The northern extent of this species' range was likely the northern San Gabriel Mountains in Los Angeles County and the southernmost extent south of Hemet in Riverside County. The majority of currently occupied habitat is on Federal lands and the species occurs in four small populations distributed across four isolated river systems. These four populations are composed of 17 extant occurrences found in a highly fragmented environment in the isolated remnants of the headwaters that resulted from historical habitat loss and habitat degradation.

In this SSA Report, we evaluated threats impacting SASD and their habitat. This included habitat loss (development, agricultural activities), habitat degradation (roadways, reactional activities, mining activities, and hydrological modifications and diversions), habitat fragmentation, increased fire frequency and intensity, climate change effects, nonnative species (invasive aquatic species predation and competition) and small population effects.

Species needs, current conditions, and future conditions were determined for SASD and are summarized in Table E-1 as they relate to resiliency, redundancy, and representation. The main needs for population resiliency focus on having adequate amounts of high-quality habitat that are connected to other occupied occurrences. For representation, the species needs to maintain robust population sizes distributed across the fours river systems to capture the breadth of its remaining evolutionary lineages and ecological niches. Maintaining occupancy in these systems is also important for redundancy for the species to withstand catastrophic events.

Currently, SASD populations are relatively small and isolated. In the near term, if current trends continue, the threats that limit habitat availability (especially drought and increased water temperatures) may result in further habitat losses. Abundance of SASD has been reported as stable in these systems, though at relatively low numbers. This makes each of the systems vulnerable to environmental stochasticity. SASD occur in four analysis units across three mountain ranges that span three counties in southern California. The San Gabriel River analysis unit is currently the most resilient, with portions of connected habitat and the most available water left in the area. The Santa Ana River analysis unit has the most occupied river miles, although many occurrences are smaller and less connected than San Gabriel River analysis unit, making this unit more variable in its resiliency. Both the Los Angeles River and San Jacinto River units are small, with two and one extant occurrences and low resiliency. Relative to the historical distribution, SASD has likely lost much of its adaptive capacity. Loss of the lower extent of its range limits its ability to respond to large disturbances and influences its ability to adapt to changing environmental conditions. The 17 occurrences distributed across four river systems provide some redundancy against large catastrophic events.

Future scenarios for SASD populations point to a continuation of conditions that will further degrade the viability of the species (Figure E-1). Under a lower emissions climate change scenario (Scenario 1, RCP 4.5) only one of three analytical units will be likely to persist at moderate levels through stochastic environmental and demographic disturbances through late century. Reduced resiliency rangewide will contribute to ongoing reductions in adaptive capacity and keep populations at high risk of extirpation from catastrophic events due to very limited capacity to respond and recover from high consequence events, such as fire, drought, and high flow events. Under a higher emissions climate change scenario (Scenario 2, RCP 8.5), two analytical units are projected to be extirpated by late century, with two units remaining in low condition. Losses of redundancy and representation due to extirpation of two analytical units will dramatically reduce overall species viability. Overall, future species resiliency is projected to be low, representation will remain limited, and limited redundancy will keep the species at high risk from catastrophic events. Thus, SASD will have significantly reduced capacity to sustain populations in the wild in the future, reducing viability and elevating extinction risk.

Table E-1. Summary Resiliency Table for Current and Future Conditions

Analysis Unit	**Current**	**Future Scenario 1 Mid Century**	**Future Scenario 1 Late Century**	**Future Scenario 2 Mid Century**	**Future Scenario 2 Late Century**
Los Angeles River	Low	Low	Low	Low	Extirpated
San Gabriel River	Moderate	Low/Moderate	Low	Low	Low
Santa Anta River	Low/Moderate	Moderate	Moderate	Low	Low
San Jacinto River	Low	Low	Low	Low	Extirpated

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LIST OF ACRONYMS USED

Ac = Acres
ACOE = Army Corps of Engineers
Act = Endangered Species Act
°C = Degrees Celsius
CDFW = California Department of Fish and Wildlife
CEQA = California Environmental Quality Act
CESA = California Endangered Species Act
CWA = Clean Water Act
°F = Degrees Fahrenheit
GCM = Generalized Circulation Model
GHG = greenhouse gas
GIS = Geographic Information System
Ha = hectare
INRMP = Integrated Natural Resource Management Plan
IPCC = Intergovernmental Panel on Climate Change
NCCP = Natural Community Conservation Planning
NEPA = National Environmental Policy Act
NFMA = National Forest Management Act
RCRCD = Riverside-Corona Resource Conservation District
RPC = Representative Concentration Pathway
SAS = Santa Ana sucker
SASD = Santa Ana speckled dace
Service = U.S. Fish and Wildlife Service
SSA = Species Status Assessment
SRMA = Southwest Resource Management Association
USDA = U.S. Department of Agriculture
USFS = U.S. Forest Service
USGS = U.S. Geological Survey
USFWS = U.S. Fish and Wildlife Service

CHAPTER 1. INTRODUCTION

1.1 PURPOSE OF SSA

The SSA Report for Santa Ana speckled dace (SASD) is intended to provide the biological information for determining whether this species meets the definition of either a threatened or an endangered species and if so, provide the biological and ecological information to inform any critical habitat designation. An SSA Report is, in essence, a summary of the available information about a species and, simultaneously, a biological risk assessment to aid decision makers who must use the best available scientific information to make policy-guided decisions. The SSA Report provides decision makers with a scientifically rigorous characterization of the species' biological and conservation status, focusing on the likelihood of whether the species will sustain populations within its ecological settings while also explicitly acknowledging uncertainties in that characterization. The SSA process and this SSA Report do not represent a decision by the U.S. Fish and Wildlife Service (Service) whether or not to list the species under the Act. Instead, a SSA Report provides a review of the best available scientific information for comparison to policy standards to guide decisions under the Act.

1.2 SPECIES OVERVIEW

The taxonomy of the petitioned entity has recently been revised by Moyle et al. (2023, entire), who identify it as a distinct species. This study provides a taxonomic treatment of the speckled dace species complex in California and designates SASD as a new species (*Rhinichthys gabrielino*). Several factors were used in this taxonomic determination, including genetic, morphometric, and meristic characteristics (Moyle et al. 2023, p. 515). The speckled dace complex is a wide-ranging group of species of small freshwater fish that occur in multiple, often separate and hydrologically disconnected watersheds across western North America. The petitioned species occurs in the watersheds of the Los Angeles, San Gabriel, Santa Ana, and San Jacinto Rivers. These watersheds are physically separated and not hydrologically connected with watersheds where other populations of speckled dace occur.

1.3 PREVIOUS FEDERAL ACTIONS

On May 11, 2020, we received a petition from the Center for Biological Diversity requesting that SASD be listed as a threatened or endangered species and critical habitat be designated for this species under the Act. The petition clearly identified itself as such and included the requisite identification information for the petitioner, required at 50 CFR 424.14(c). In 2021 we completed a 90-day finding where we found that the petition presented substantial scientific or commercial information indicating the petitioned action may be warranted (Service 2021, entire).

1.4 STATE LISTING STATUS

SASD are not listed under the California Endangered Species Act (CESA) but have the status of "critical concern" (Moyle 2015, p. 1).

CHAPTER 2. METHODOLOGY AND DATA SOURCE

This document draws scientific information from resources such as peer-reviewed literature, reports submitted to the Service and other public agencies, occurrence information in Geographic Information Systems (GIS) databases, and expert experience and observations. It is preceded by, and draws upon, analyses presented in the 90-day finding (Service 2021, entire). Finally, we coordinated with our Federal, State, Tribal, and local partners, including researchers and experts involved in field investigations. We consider the information we obtained to be the most current scientific conservation status information available for SASD. In the future, should additional information become available, and the need arise, we will revise this document to reflect the most current scientific and conservation status information available.

2.1 SSA FRAMEWORK

The Service uses the SSA analytical framework (Figure 2-1); (Service 2016, entire) designed to assess a species' current biological condition and its projected capability of persisting into the future ((Service 2021, entire). Building on the best of our current analytical processes and the latest scientific information in conservation biology, this framework integrates analyses that are common to all functions under the Act, eliminates duplicative and costly processes, and allows the Service to strategically focus on our core mission of preventing extinction and achieving recovery. The document is temporally structured, generally walking the reader through what is known from past data, how data inform current species' status, and what potential changes to this status may occur in the future based on data and models. The future condition analysis includes a range of the potential conditions that the species or its habitat may face and discusses a range of plausible future scenarios if those conditions come to fruition. The range of plausible future scenarios include consideration of the threats most likely to impact the species in the future, at the individual, population, or rangewide scales in the future.

For this assessment, we define species viability as the ability of the species to sustain populations in the natural ecosystem over time. There is increasing uncertainty as persistence is modeled into the future; therefore, we will use timeframes for future model forecasts that are available for threats identified in this assessment and will project species viability at mid-century (2030-2059) and late-century (2070-2099). We developed our future condition evaluation based on these threats, while acknowledging there is uncertainty on how these threats may change singly and cumulatively, and their effect on the species.

Using the SSA framework (Figure 2-1), we consider what the species needs to maintain viability by characterizing the status of the species in terms of resiliency, redundancy, and representation (Shaffer and Stein 2000, pp. 301–302; Wolf et al. 2015, entire). In general, these three concepts (or analogous ones) apply at the population and species levels and are explained that way below for simplicity and clarity as we introduce them.

Resiliency is the ability of a species to withstand stochastic events and normal year-to-year variations in both environmental conditions (i.e., temperature; rainfall), periodic disturbances within the normal range of variation (such a drought, wildfires, or floods) and demographic stochasticity (i.e., mortality, fecundity; (Redford et al. 2011, p. 41)). Determined by the size and growth rate of the species population(s), resiliency can be evaluated to gauge the ability of a species to withstand the natural range of favorable and unfavorable conditions.

In many instances, however, data are insufficient or completely lacking regarding a population's size and growth rate. In the absence of such data, it can be reasonable to examine other characteristics that may serve as surrogate indicators of general population health and subsequently, resiliency. Essentially, an assessment of the availability of a species' identified needs (e.g., suitable habitat, resources) may allow us to make assumptions about the potential resiliency of any given population. However, unless there is a documented positive correlation between species needs availability and a population's known demographic condition, the uncertainty regarding such assumptions must be made clear.

Redundancy is the ability of a species to withstand catastrophic events that would result in the loss of a substantial component of the species' total overall population. Such a loss could be of one or more populations of a species which is comprised of multiple populations or the catastrophic loss of a substantial number of individuals from a species with only a single population. However, redundancy is not simply a measure of the total number of individuals or populations of a species, but instead must also be evaluated in the context of an assessment of reasonably plausible catastrophic events. For example, a species with numerous small populations does not necessarily translate to a greater ability to withstand catastrophic events if those populations are very close together, and the only reasonably plausible potential catastrophe is one that would affect them all equally. Conversely, a species with only one population, but one which is very large and widely distributed, could have a high ability to withstand a catastrophic event that would only affect a small percentage of the total overall population. Therefore, our characterization of a species' redundancy takes into consideration both an assessment of the size and distribution of its population(s), and an evaluation of the kinds and likelihood of reasonably plausible catastrophic events to which the species could be exposed.

Representation is the ability of a species to withstand and adapt to long-term changes in environmental conditions (i.e., significant changes outside the range of normal year-to-year variations). The measure of a species' representation may be determined by the breadth of genetic and phenotypic diversity within and among populations, however, in the absence of information on a species' genetic and phenotypic diversity, we may also evaluate a species' known environmental diversity (i.e., the diversity of environmental conditions over which it is known to occur) as an alternative measure of its ability to withstand and adapt to long-term changes.

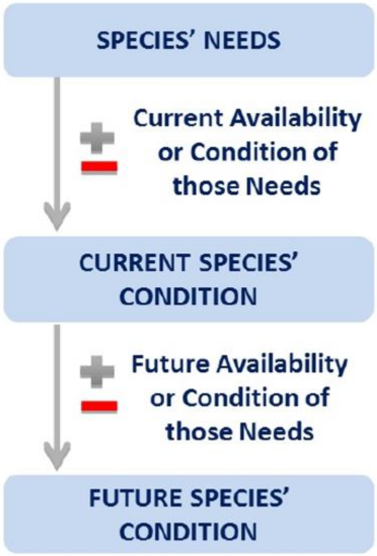


Figure 2-1. The step-wise process for assessing a species' status, as envisioned by the Services' SSA Framework (Service 2016b, p. 6).

Using the SSA framework, we consider what the species needs to maintain viability by characterizing the status of SASD in terms of its resiliency, redundancy, and representation. The species' biology, ecology, and habitat requirements are described in Chapter 3; the current distribution and abundance are described in Chapter 4, and the species' needs are described in Chapter 5. In Chapter 6, we discuss the factors influencing viability. Chapter 7 includes an assessment of Current Conditions based on the needs outlined in Chapters 3 and 4. Lastly, in Chapter 8 we forecast plausible future scenarios for SASD based on the species' biology and current and future threats. As a matter of practicality, the full range of potential future scenarios and the range of potential future conditions for each potential scenario are too large to analyze and describe them individually. Therefore, the chosen scenarios do not include all possible futures, but rather include specific plausible scenarios that represent examples from the continuous spectrum of possible futures.

In summary, the SSA is a scientific review of the best information available, including scientific literature and discussions with experts, related to the biology and conservation status of SASD.

2.2 SPECIES NEEDS

The SSA Report includes a compilation of the best available biological information on SASD including their ecological needs based on how environmental factors are understood to act on SASD and their habitat.

- Habitat Needs: These resource needs are those life history characteristics that influence the successful completion of each life stage.

- Demographic Needs: These components of SASD’s life history profile describe the resources, circumstances, and demographics that most influence **resiliency** of the populations.
- Species Needs: This is an exploration of what influences **redundancy** and **representation** for SASD. This requires an examination of SASD’s evolutionary history and historical distribution to understand how SASD functions across its range.

2.3 CURRENT CONDITION

The SSA Report describes the current known condition of SASD’s habitat and demographics. We considered the distribution, abundance, and factors currently influencing the viability of SASD. We identified known historical and current distribution and examined factors that negatively and positively influence SASD. Scale, intensity, and duration of threats were considered for their impacts on the populations and habitat across its range.

The current condition analyses are described across four populations in which the species is found. We gathered information from researchers and stakeholders to describe current conditions. Current conditions evaluated the status of SASD from approximately 2010 through 2023 depending on the available information. Additional detail on the current condition analysis methodology is presented in Chapter 5.

2.4 FUTURE CONDITION

In the future conditions section of the SSA Report, we evaluate how the threats identified are likely to affect SASD’s needs into the future and forecast SASD’s response to a range of plausible future scenarios of environmental conditions and conservation efforts. This involves an analysis and description of a range of plausible future environmental conditions and the projected consequences on the species’ ability to sustain populations in the wild over time, based on resiliency, redundancy, and representation. For this evaluation, the future extends only as far as we can reasonably project the future threats and SASD’s responses to those threats; in addition, the uncertainty increases the further into the future we look. To establish a reasonable timeframe, we consider the life-history characteristics, threat-projection timeframes, and environmental variability. Given SASD’s short generation time and the importance of the likely effects of climate change, we assess the potential response of SASD under two future scenarios that illustrate a plausible range of environmental and conservation conditions through the end of the century.

CHAPTER 3. SPECIES BACKGROUND AND ECOLOGY

3.1 PHYSICAL DESCRIPTION

The speckled dace is a small freshwater fish with an average size of 8-11cm (Moyle et al. 2015, p. 1). This small-scaled fish has a small downfacing mouth and a pointed snout with a small barbel on each end of the maxilla. A small patch of skin connects the snout to the upper lip. Adults usually have 8 rays in their dorsal fin which originates behind the beginning of the pelvic fins, whereas the anal fin has 6-8 rays. Distinctive dark spots on the sides and upper parts of the body as well as dark lateral band running to the snout usually occur once the fish becomes larger than 3 cm. The body is an olive to darkish yellow, with the stomach area paler in color. During the breeding season, both males and females have orange or red tipped fins, with males also have red snouts and lips.

3.2 GENETICS

The Southern California population is genetically distinguishable from other speckled dace populations from throughout the speckled dace's overall range as noted by (2004, entire) Pfrender (2004, entire), Nerkowski (2015, entire), Smith *et al.* (2017, entire), (VanMeter 2017, entire), Greaver (2019, entire), and Su et al. (2022, entire). Available information suggests that the observed genetic differences are substantial enough that the Southern California speckled dace population should be taxonomically recognized at the species rank (VanMeter 2017, p. 72; Greaver 2019, p. 58; Moyle et al. 2023, p. 509-517), although Moyle (2002, p. 162) had previously suggested that recognition at the taxonomic rank of subspecies may have been appropriate. Smith and Dowling (2008, entire) states that dace in the Los Angeles basin (Santa Ana and San Gabriel rivers) have been isolated long enough to form unique morphological differences. Furthermore, the isolated dace in the Los Angeles basin appear to have undergone rapid molecular evolution based on the long phylogenetic branch lengths found in the population.

Results from analyses of microsatellite DNA (Nerkowski 2015, entire), mitochondrial DNA (VanMeter 2017, entire), and nuclear sequence DNA (Greaver, entire) consistently showed (although with some minor variation in the details among the studies) that the speckled dace in Southern California are genetically distinguishable from other geographically proximal populations of speckled dace. More recently, Su et al. (2022, entire) used hundreds of thousands of nuclear single nucleotide polymorphisms (SNPs) to reveal clear genetic differentiation of SASD populations from all other speckled dace lineages, indicating that these populations represent a distinct lineage that has evolved for long periods without gene flow with other populations. Finally, Moyle et al. (2023, entire) have recently provided a taxonomic treatment of the speckled dace species complex in California, designating the SASD as a new species (*Rhinichthys gabrielino*).

3.3 AGE, GROWTH, AND POPULATION STRUCTURE

Speckled dace lifespan is coarsely correlated with maximum size, with dace under 80 mm fork length (FL) (the typical size of SASD) living for roughly three years. Dace in the upper reaches of the San Gabriel River drainage commonly reach over 110 mm standard length (SL); in other locations dace this large can live up to six years (Moyle et al. 2015, p. 3). Dace grow to 20-30mm SL by the end of their first summer, and grow each subsequent year by an average of 10-15 mm SL. Typically females grow faster than males. Under stressful environmental conditions, limited food, or high population densities, growth rates can decrease.

3.4 REPRODUCTION

Dace reach sexual maturity by the end of the second summer; based on size and location, females generate between 190-800 eggs (Moyle et al. 2015, p. 3). Because of their small size, SASD are assumed to produce eggs on the lower end of this range. High flow events and/or rising water temperatures are normally correlated with dace spawning, making March-May the presumed spawning period for SASD. Moyle (2015, p. 3) describes SASD observed spawning at Bear Creek in May, 2010. Several males tried to spawn with several females between 14:00-15:00 hours with water temperatures recorded at 18°C. In lakes, the primary areas for spawning are in shallow gravel areas or upstream on the edges of riffles of inlet streams. Before a female lays her eggs, groups of males will clear the gravel surface of any algae or detritus and surround the female when she enters the newly cleared area. Males release sperm on newly deposited eggs that the female placed under rocks or near the gravel bottom. Gravel is an ideal substrate for females to lay their eggs because the eggs adhere to the gravel as they settle. After fertilization, eggs hatch in 6 days when temperatures are between 18-19°C, after which larvae remain in the gravel for another 7-8 days. In streams, fry move to warm shallow water (commonly in channels) that contain rocks and emergent vegetation.

3.5 HABITAT

Moyle (2002, p. 2) states that based on the relative streamlined body (for speckled dace), SASD are adapted for living in moving water. SASD live in the cool headwaters of perennial streams and rivers in the mountains north and east of Los Angeles. These perennial streams are formed by cool spring water creating summer temperatures that typically stay below 20°C (Moyle et al. 2015, p. 3). The literature describes a wide variety of habitat occupied by the dace, including shallow riffles with overhanging vegetation on the banks and gravel and cobble substrate (Moyle et al. 2015, p. 3). In the San Gabriel drainage, O'Brien et al. (2011, p. 152) observed dace in a variety of habitat including riffles, runs, and pools. Feeney and Swift (2008, p. 72) found dace preferred habitat as slow moving pools in low-gradient streams (0.5-2.5% slope) with substrates varying from sand to boulder. The paper also described observing dace in fast moving water along stream banks, which also supports the idea that SASD inhabit a variety of habitat types within a stream. One noted habitat type that is avoided, except during the breeding season, are large shoals (Moyle et al. 2015, p. 2). It is important to note that Santa Ana sucker and SASD are commonly observed inhabiting the same stretches of water and are both described as preferring riffle habitat (CDFW 2020, p. 10).

3.6 FOOD, WATER, NUTRIENTS

Speckled dace's subterminal mouth and tooth structure make it ideal for consumption of small aquatic invertebrates (hydropsychid caddisflies, baetid mayflies, and chironomid and simuliid midges) most common in riffles that generally make up the bulk of their diet and is supplemented by filamentous algae (Moyle et al. 2015, p. 2). Dace have been documented foraging on the East Fork of the San Gabriel River by picking through cobble in the riffle and pool tail-out areas. Speckled dace prey opportunistically, which varies their diet of invertebrates depending on available food sources that may change during the seasons. Food preferences can be influenced by the existence of other fish species with similar habitat needs, notably arroyo chub or Santa Ana sucker. Dace can be active both in the day and at night, with water temperatures influencing their level of activity. Dace are active year-round when stream temperatures stay above 4°C, which is typical of the waters SASD inhabit. Members of the speckled dace complex in other regions can tolerate water temperatures as high as 26-28°C (Moyle et al. 2015, p. 3).

3.7 DISPERSAL AND MIGRATION

Given connected waterways and lack of barriers, SASD can disperse and migrate throughout miles of suitable habitat in streams and rivers. During heavy flows during floods, dace can be dispersed downstream of barriers, but these barriers (including dams) prevent upstream migration after these events. Moyle et al. (2015, p. 6) states that reintroduced dace have been documented migrating 3.2 river miles downstream. Please note SASD has been collected in the lower Santa Ana River after heavy winter storm events sweep them downstream including in February 2011 when found immediately upstream of the Rialto Channel, 14 miles downstream of the closest known occurrence in the Santa Ana River AU. These fish are extirpated once waters recede and warm up to lethal levels. During low flows, stream drying eliminates significant portions of suitable habitat, making dispersal and migration impossible.

CHAPTER 4. ABUNDANCE AND DISTRIBUTION

4.1 HISTORICAL AND CURRENT ABUNDANCE AND DISTRIBUTION

Streams in the upland areas of the Santa Ana, San Gabriel, San Jacinto, and Los Angeles river systems interconnected by low-elevation floodplains made up the historical range of SASD (Moyle et al. 2015, p. 4; Moyle et al. 2023, pp. 516–517) (Figure 4-1). Historically, these basins were connected during flood events, allowing for movement of dace among basins (Moyle et al. 2023, p. 511). Many areas where dace were historically found are now extirpated, including middle portions of the Santa Ana River, Strawberry Creek (Santa Ana River), Mill Creek (Santa Ana River), and most of the Los Angeles River and San Jacinto River basins. While the cooler waters found in the headwater streams of these basins remain suitable for SASD, the lower reaches of these streams are now too warm and urbanized to sustain the dace or allow for movement among basins. Estimates of historical range loss are as high as 75% (Moyle et al. 2023, p. 517). The historical range shown in Figure 4-1 was developed by combining UC Davis's historical range shapefiles with documented historical SASD records from Swift et al. (1993, p. 118). These historical records were buffered out to include HUC 12 watersheds that connected to the upper watersheds in the UC Davis data. Note this historical range is a conservative estimate as it only accounts for historical records presented in reviewed literature.

Currently SASD is found in the headwaters of San Jacinto, Santa Ana, San Gabriel, and Los Angeles rivers (Figure 4-2). Compared to the historical distribution, the remaining dace populations are relatively small and isolated (Figure 4-1). Below is a complete breakdown of known dace populations.

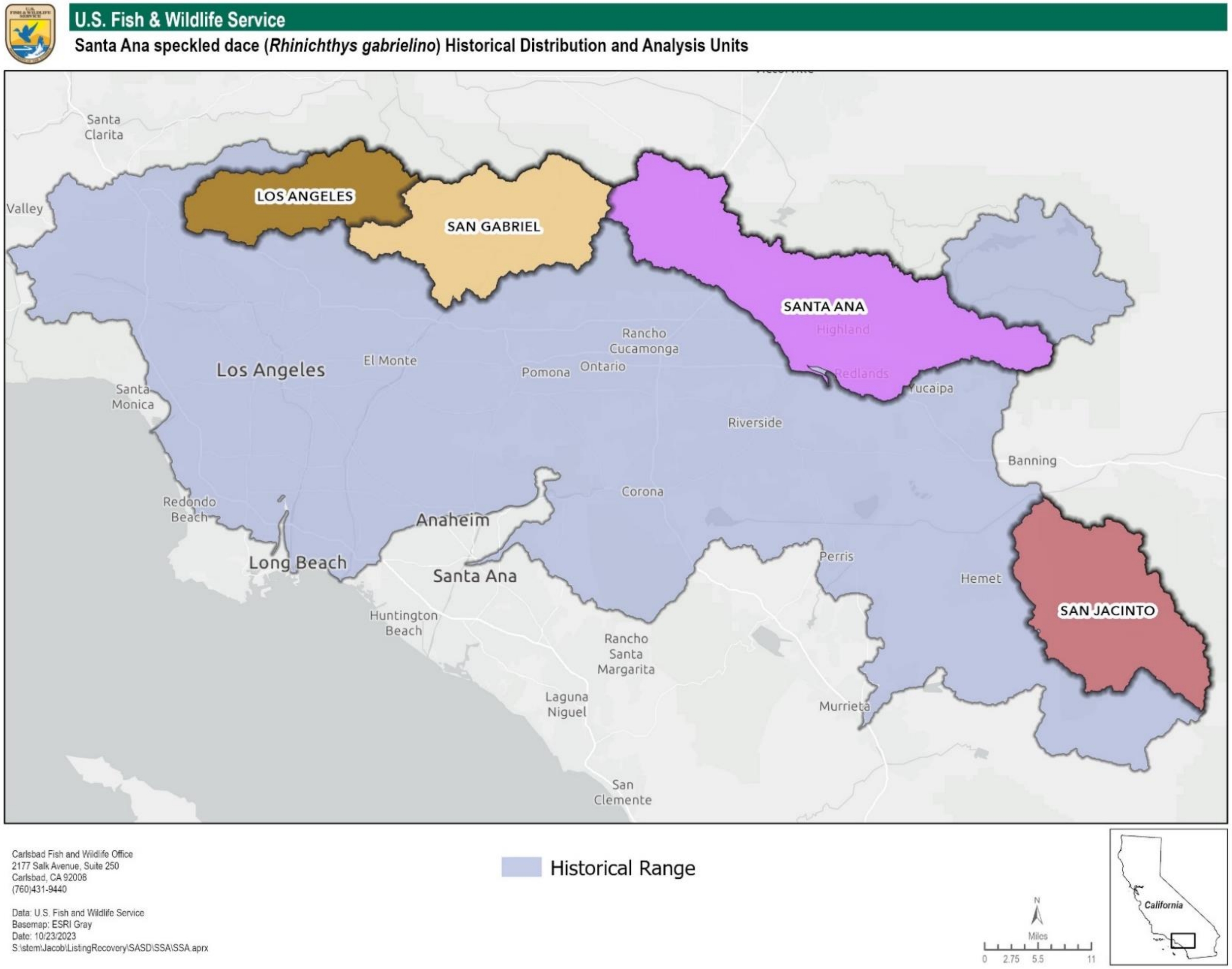
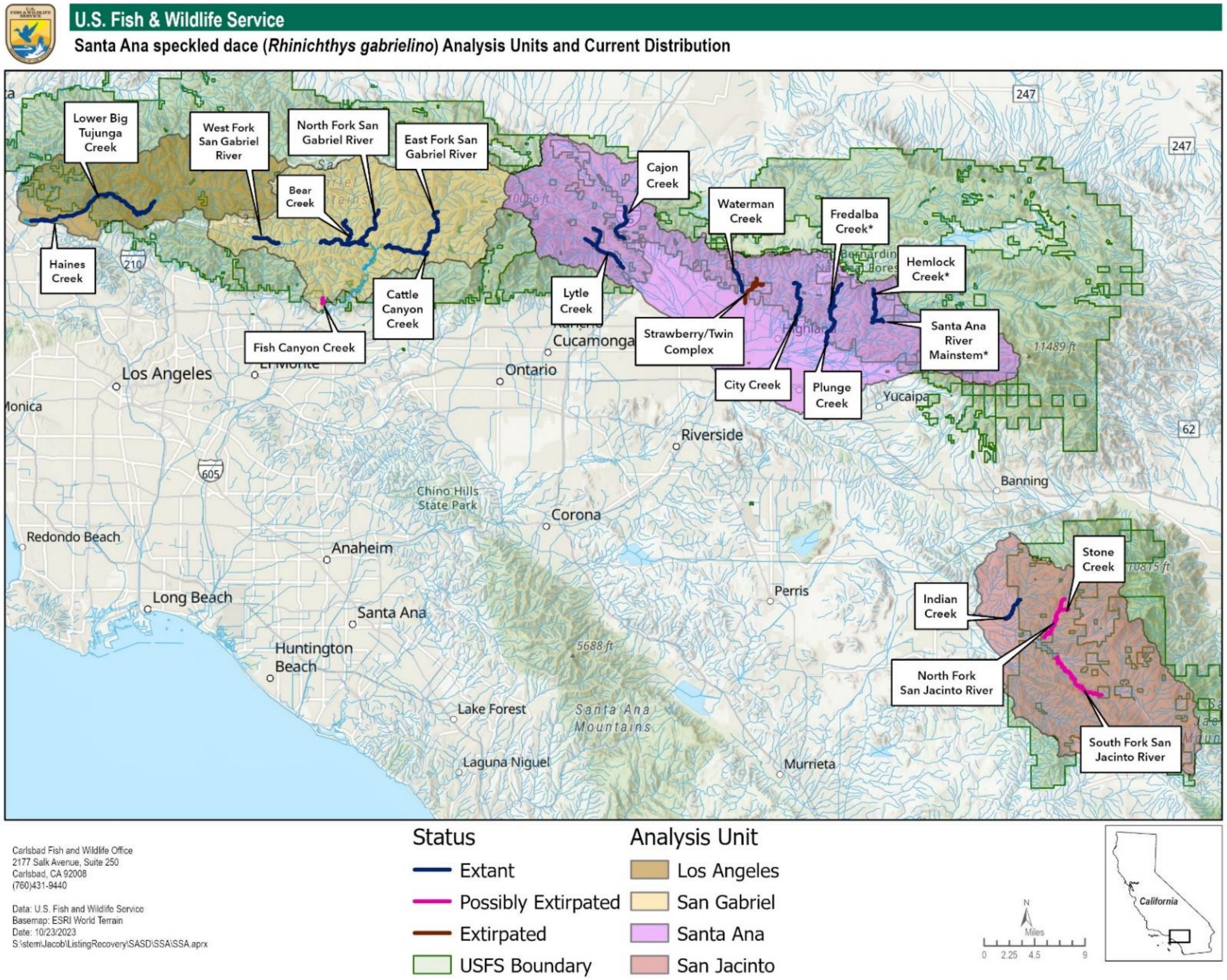


Figure 4-1. Santa Ana speckled dace historical distribution (blue) and currently extant Analysis Units: Los Angeles, San Gabriel, Santa Ana, and San Jacinto.



Carlsbad Fish and Wildlife Office
2177 Salk Avenue, Suite 250
Carlsbad, CA 92008
(760)431-9440

Data: U.S. Fish and Wildlife Service
Basemap: ESRI World Terrain
Date: 10/23/2023
S:\stem\Jacob\ListingRecovery\SASD\SSA\SSA.aprx

* Reintroduced

Figure 4-2. Current Rangewide Distribution of Santa Ana Speckled Dace.

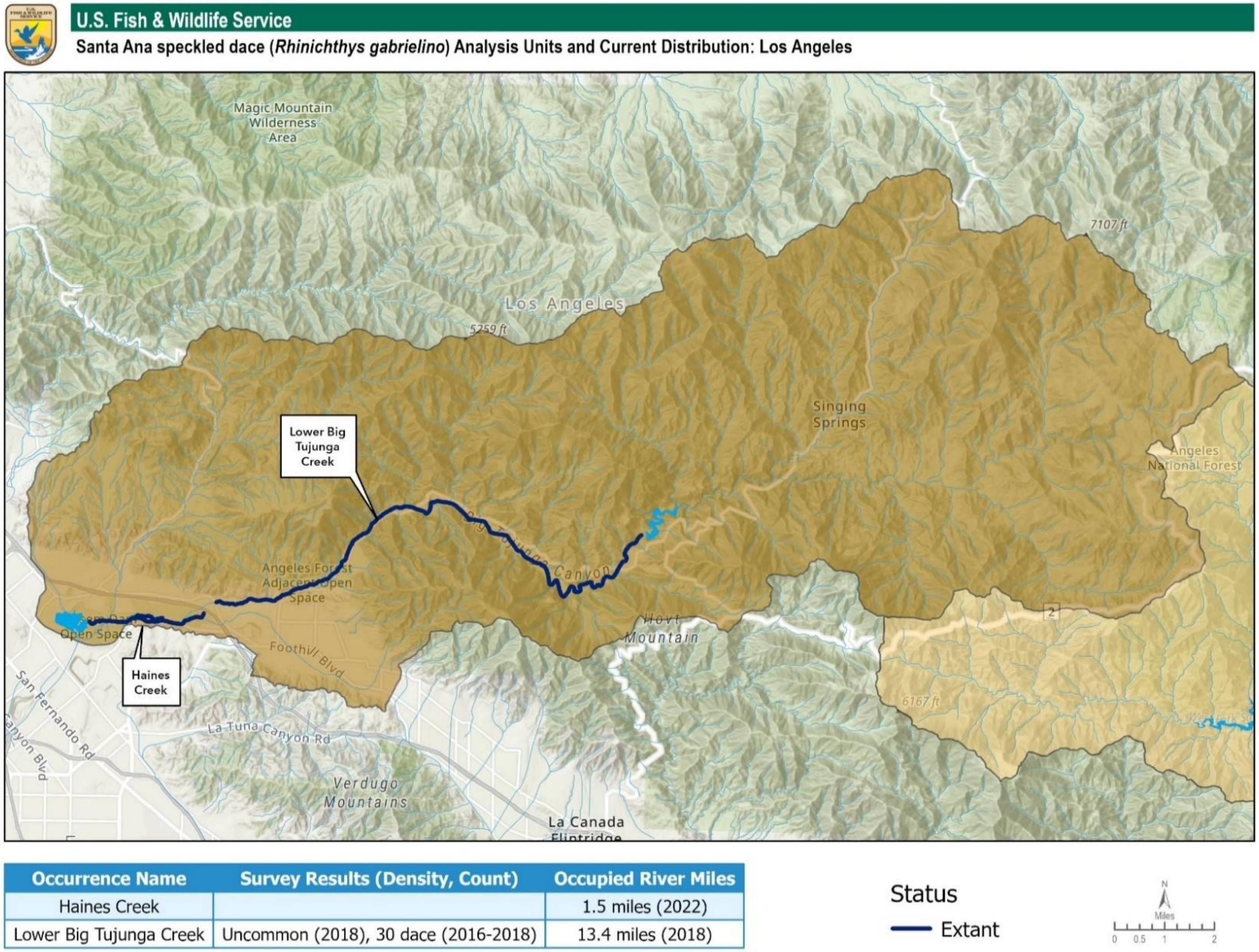
4.2 LOS ANGELES RIVER SYSTEM

Lower Big Tujunga Creek

Lower Big Tujunga Creek is a tributary to the Los Angeles River (Figure 4-3). Currently SASD are only known to occupy the creek below the Big Tujunga Dam. SASD were once thought to be extirpated from the area due to the introduction of red shiner (*Cyprinella lutrensis*) and low flows from drought. In 2009, the Station Fire burned through the area, but subsequent surveys found dace rebounded in the years following the fire (Psomas 2019, p. 58). Surveys from 2009-2018 indicate an increase after the 2009 Station Fire, topping out at 3,215 captured dace with a sharp decrease starting in 2013 (146 captured dace) and leveling off to just under 30 captured dace yearly from 2016-2018, the last years sampled. Predatory invasive species including largemouth bass (*Micropterus salmoides*), bullhead (*Ameiurus natalis* and *A. nebulosus)*, and red swamp crayfish (*Procambarus clarkia)* have been found and are most likely decreasing dace abundance in the creek (USGS 2022b, p. 21). This creek is consistently found to be occupied, but with low numbers.

Haines Creek

Haines Creek is a small creek (roughly 1.5 miles of occupied habitat) that connects with Big Tujunga Creek below Interstate 210, just upstream of Hansen Dam (Figure 4-3). Because of prior restoration efforts including removal of nonnative species, certain sections of the creek are now high quality habitat. SASD are consistently found in the creek, but in low numbers (Expert Working Group 2023, p. 9). When surveying part of Haines Creek (1 kilometer (km)) and the lower portion of Big Tujunga Creek (roughly 1.5-2.5 km below Interstate 210) in 2021, USGS found a total of 35 adult dace (USGS 2022b, p. 29). This is consistent with low numbers being observed in both creeks.



Occurrence Name	Survey Results (Density, Count)	Occupied River Miles
Haines Creek		1.5 miles (2022)
Lower Big Tujunga Creek	Uncommon (2018), 30 dace (2016-2018)	13.4 miles (2018)

Figure 4-3. Current Dace Distribution in Los Angeles River Analysis Unit.

4.3 SAN GABRIEL RIVER SYSTEM

Fish Canyon Creek

Fish Canyon creek is a tributary to the San Gabriel River that is genetically isolated below Morris dam and holds a small population of SASD (Figure 4-4). Rock quarry operations have degraded dace habitat although more recent operations have focused on restoring the streambed to improve dace habitat. CDFW concluded that the dace inhabit roughly 0.8 km section of the stream with Angeles National Forest after conducting surveys in 2006 and 2008 (Moyle et al. 2015, p. 5). The last documented dace observations were in 2016 by CDFW, although subsequent repeated surveys have not found fish following the 2016 Fish Fire Complex Fire (Pareti 2023, entire). No recent surveys by CDFW have occurred and this tributary is considered possibly extirpated.

West Fork San Gabriel River

The three forks of the upper San Gabriel River are the best remaining SASD habitat across the current range (Moyle et al. 2015, p. 5). Extensive surveys of the upper San Gabriel River by O’Brien et al. (2011, p. 159) from 2007 through 2008 found a correlation in distribution between dace and Santa Ana sucker, finding dace at every observed sucker location surveyed. The report also noted that both dace and sucker were observed in all habitat types of the upper San Gabriel River, not just in riffles and other habitat with current.

While the North and East Forks of the river are not influenced by dams, the lower portion of the West Fork is downstream of Cogswell Reservoir which is managed for flood control. This makes the dace vulnerable to high water and sediment releases from the dam, which has occurred in 1981 and 1991, burying the habitat under sediment until flushed out by rainfall and water released from the dam in 1988 (Moyle et al. 2015, p. 5). In 2005, dace were abundant above Cogswell Reservoir. In 2006, surveys on the West Fork found dace in one of three locations, while in 1993 electrofishing survey results found 29 dace in 68 meters of stream. O’Brien et al. 2011 (p. 159) state that prior studies from the 1980’s, 90’s, and 2003-2004 found fish abundance on the West Fork fluctuates wildly year to year with no apparent trend. In a comprehensive survey of the West Fork, O’Brien et al. (2011, p. 154) found dace inhabited 14 km of the 25 km that were surveyed, making the West Fork the second most widely distributed area surveyed, in the upper San Gabriel River with the lowest gradient (1%).

North Fork San Gabriel River

In contrast, the North Fork was found to have the highest SASD density in the same comprehensive survey of the Upper San Gabriel River carried out in 2007 and 2008 (O’Brien et al. 2011, p. 154). The fish were found in 4.5 km of the 7.5 km area surveyed, the shortest and steepest (5% gradient) of the three forks. Unlike the West Fork, there is no dam impacting the flow in the North Fork, although the river becomes too steep for dace to disperse further upstream (Expert Working Group 2023, p. 20). The San Gabriel Reservoir is being drained, creating new miles of river in the upper forks that were formally flooded. Fish, including dace are being captured from this area and translocated further upstream in the North Fork, augmenting this occurrence (Expert Working Group 2023, p. 20). Snorkeling surveys by CDFW consistently find dace in the tens (Expert Working Group 2023, p. 20), suggesting a consistently low number of dace in the river.

East Fork San Gabriel River

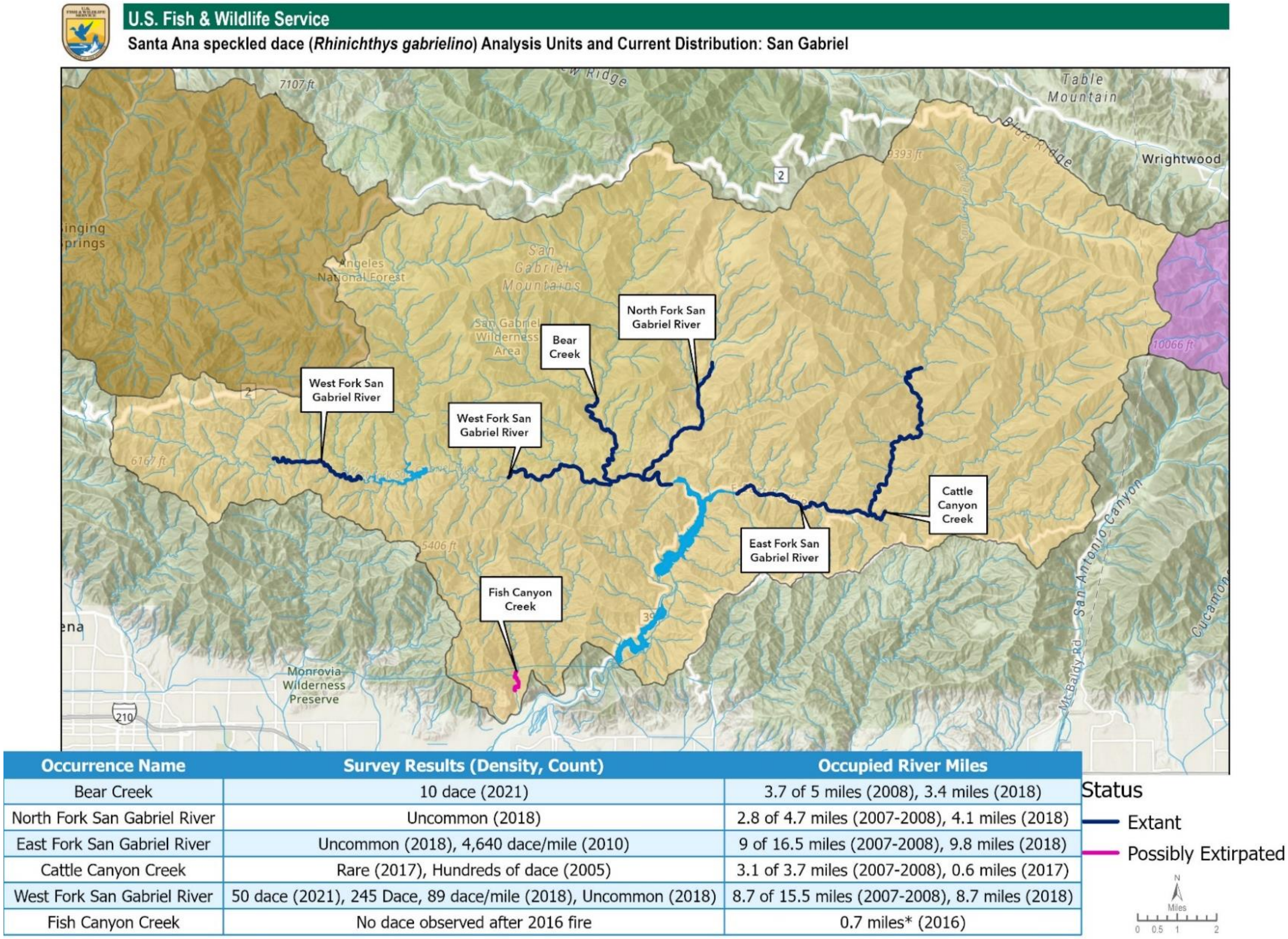
The East Fork the largest distribution in the O'Brien et al. (2011, p. 154) survey, with SASD distributed in 14.5 km of the 26.5 km surveyed. The East Fork has a 2% gradient, making it the 2nd steepest of the three forks. Between 1997-2010, CDFW has completed multiple-pass electrofishing surveys in the middle section of the East Fork (Heaton Flat and Shoemaker Canyon) to determine the average estimated dace density (fish/mile) (Weaver and Mehalick p. 15). The report summarized the estimated dace density in 1997 as 2,143 fish/mile, 4,113 fish/mile in 2000, and 4,640 fish/mile in 2010. Like the North Fork, the East Fork also does not have a dam influencing flows although it has heavy impacts from human alteration including recreational mining as well as recreational dams (Expert Working Group 2023, p. 22). An incidental observation was collected in 2014 noted a dead SASD immediately downstream of heavy recreational mining that was recontouring the stream.

Bear Creek

Bear Creek is a third order tributary to the West Fork of the San Gabriel River, with a 2% gradient (O'Brien et al. 2011, p. 154). SASD were observed in the creek by CDFW in 2022 from the confluence of the West Fork of the San Gabriel River upstream to the West Fork of Bear Creek confluence (Figure 4-4). CDFW has not conducted recent surveys past this point, with the West Fork Bear Creek appearing to be suitable for dace (Expert Working Group 2023, p. 17). Surveys in 2007 and 2008 found abundant numbers of dace in the lower 6 km of the 8 km surveyed including several gravid females in May (O'Brien et al. 2011, pp. 153–154).

Cattle Canyon Creek

A third order tributary of East Fork of the San Gabriel River, with a 4% gradient, Cattle Canyon Creek has been repeatedly documented as having SASD present. CDFW last surveyed the creek in 2022, where dace were present from the confluence of the San Gabriel River upstream 0.61 miles (Figure 4-4). Surveys above this location have not been recently completed by CDFW (Pareti 2022, entire). O'Brien et al. (2011, p. 154) found dace in 5 km of the 6 km of surveyed water. Abbas (pers comm. 2008, as cited by Moyle 2015, p. 5), states surveys in 2005 documented hundreds of dace. Recreational mining in the area may be negatively influencing dace habitat (Moyle et al. 2015, p. 8).



Occurrence Name	Survey Results (Density, Count)	Occupied River Miles
Bear Creek	10 dace (2021)	3.7 of 5 miles (2008), 3.4 miles (2018)
North Fork San Gabriel River	Uncommon (2018)	2.8 of 4.7 miles (2007-2008), 4.1 miles (2018)
East Fork San Gabriel River	Uncommon (2018), 4,640 dace/mile (2010)	9 of 16.5 miles (2007-2008), 9.8 miles (2018)
Cattle Canyon Creek	Rare (2017), Hundreds of dace (2005)	3.1 of 3.7 miles (2007-2008), 0.6 miles (2017)
West Fork San Gabriel River	50 dace (2021), 245 Dace, 89 dace/mile (2018), Uncommon (2018)	8.7 of 15.5 miles (2007-2008), 8.7 miles (2018)
Fish Canyon Creek	No dace observed after 2016 fire	0.7 miles* (2016)

Figure 4-4. Current Dace Distribution in San Gabriel River Analysis Unit.

4.4 SANTA ANA RIVER SYSTEM

Lytle Creek

CDFW visually confirmed the presence of SASD in Lytle Creek during the summer of 2021, just below the upper Edison facility (Figure 4-5). The creek runs along Lytle Creek Road where water still flows during the summer. Visual surveys were conducted in the summer of 2019 by Southwest Resource Management Association (SRMA) which found consistent flows and a robust population (SRMA 2021, p. 2). According to Abbas (pers comm. 2008, as cited in Moyle 2015, p. 5), a 1.4 mile stretch of the mainstem of Lytle Creek between Miller's Narrows downstream to Turk Point is the dace stronghold for the entire watershed, as this is the only area where they consistently persist. Since at least 2009, the U.S. Forest Service (USFS) has monitored this reach, and regardless of floods, drought, or stable conditions, dace have always been present. Periods of low flows from drought are correlated with decreased population densities while stable water flows have created quick increases in population density (Abbas pers comm. 2008, as cited in Moyle 2015, pp. 5–6). "Long Bridge" is a known barrier during low water years, preventing SASD from moving upstream to year-round surface water. Fish mortality has been observed just below "Long Bridge" in late spring/early summer. This stretch of Lytle Creek is negatively impacted by heavy equipment used to protect infrastructure, including roads, utilities, and private access routes. Heavy recreation is also thought to negatively impact SASD.

In 2005 roughly 1,000 SASD were introduced on the North Fork of Lytle Creek from the lower mainstem. Abbas (pers comm. 2008, as cited in Moyle 2015, p. 6), considers the mainstem upstream of Turk Point as occupied due to dace captures above Miller's Narrows. These fish are assumed to have migrated 3.2 river miles downstream from their reintroduction site on the North Fork. Similarly, when there are sustained flows below Turk Point, Abbas (pers comm. 2008, as cited in Moyle et al. 2015, p. 6) concludes that this downstream reach of the mainstem is occupied based on observations of dace in the year-round flows of 2005 and 2006. In those years, dace (including juveniles) were found 1.8 river miles downstream of Turk Point inside Fontana Union Water Company infrastructure.

Cajon Creek

Cajon Creek runs alongside a transportation corridor which includes Interstate 15 and a railroad. Moyle (2015, p. 6) states that SASD appear to be abundant in this drainage, a tributary to Lytle Creek, with highest densities upstream and downstream of Interstate 15. CDFW completed visual surveys in 2021 near Cajon Blvd, noting dace were considered common throughout the area surveyed (Sturkie 2022, entire). Southwest Resource Management Association (SRMA) also noted consistent flows and a robust population in Cajon Creek (SRMA 2021, p. 2). USGS classified the entire 250-meter survey area as a high abundance of dace, with 25 observed (USGS 2022a, p. 3). High levels of human activity including encampments and debris were also noted. Surveys in 2005 also documented dace (Abbas pers. comm. 2008, as cited by Moyle et al. 2015, p. 6). The creek is threatened by both recent fires as well as toxic spills. In the past USFS, CDFW, and BNSF Railroad have moved dace from Lytle Creek to tributaries in an attempt to mitigate impacts from spills originating from the railway or highway (Moyle 2015, p. 7).

City Creek

City Creek is a south flowing tributary of the Santa Ana River, originating in the San Bernardino Mountains. In 2019, SRMA surveyed both the West Fork and mainstem of City Creek and found robust SASD populations in variable flow (SRMA 2021, p. 2). USGS surveyed a portion of the creek in November 2020 where 26 dace were observed followed by an estimate of 4,100 dace in August 2021 (USGS 2022a, p. 6). Prior surveys described in Moyle et al. 2015 (p. 7) describe no dace being found in 2005-2007 surveys, with a small population being found on the West Fork in 2008 and 2009.

Plunge Creek

Plunge Creek is a south flowing tributary of the Santa Ana River, originating in the San Bernardino Mountains, east of City Creek. In 2019, SRMA observed a robust SASD population with a variable flow (SRMA 2021, p. 2). Twenty-five dace were captured by USGS in November 2020 (USGS 2022a, p. 6). In 2004 dace were collected and held to protect the fish from potential flooding and were returned after the threat had passed (Moyle et al. 2015, p. 7). Dace were also observed in 2001 (9 individuals) and 2005.

Waterman Creek

Waterman Creek is a small creek starting in the San Bernardino Mountains located west of City Creek. Forty captive SASD that originated from Lytle Creek were translocated in August 2017 to augment the population (Riverside-Corona Resource Conservation District (RCRCD) (2018, p. 4). In 2021, CDFW and SRMA surveyed the wetted portion of the creek above private property (SRMA 2021, p. 2). Three dace were caught near the private property fence line. Future surveys downstream where the creek intermittently dries out will be conducted to better gauge the overall creek population and to move fish upstream to more reliable conditions.

Fredalba Creek

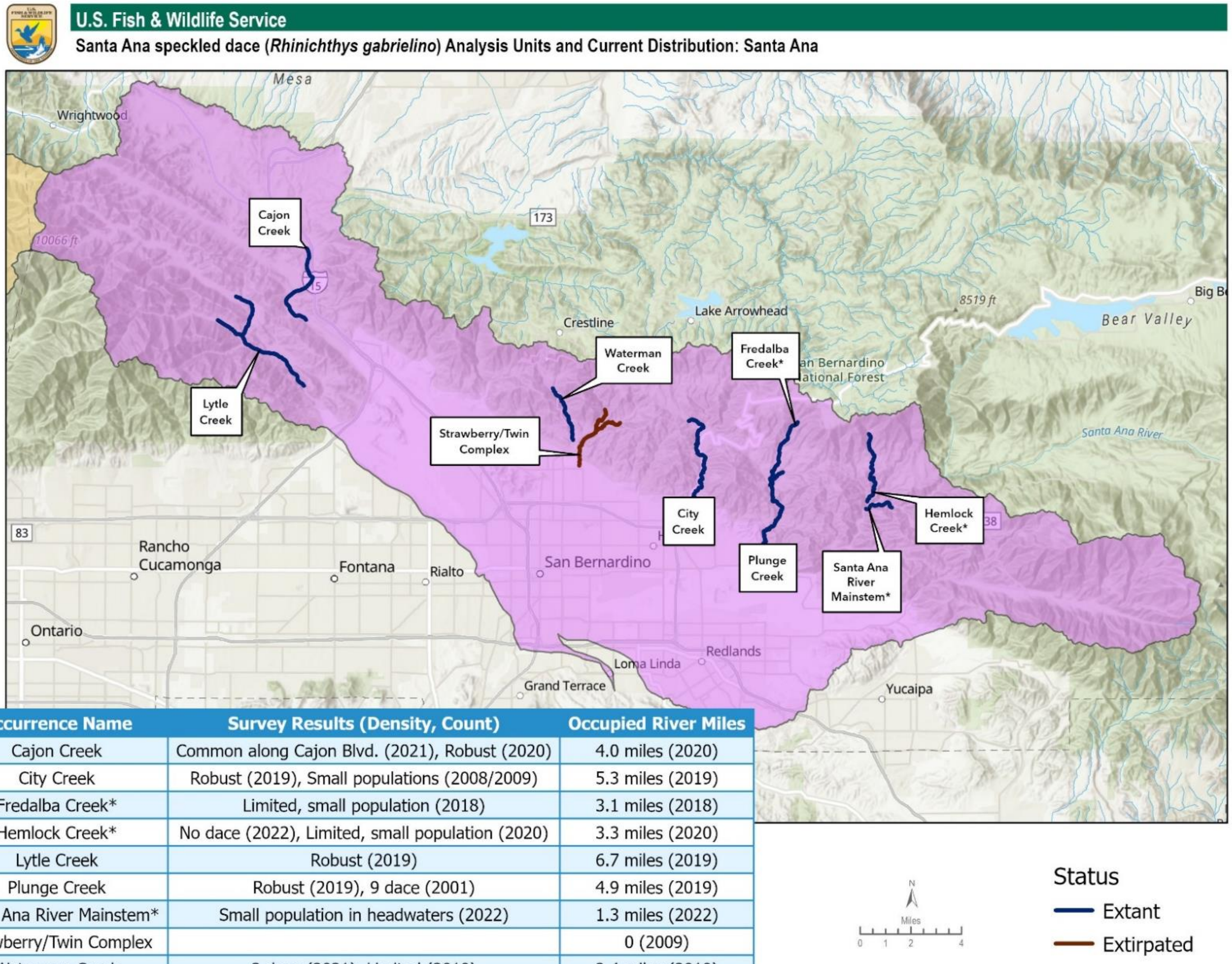
Fredalba Creek is a small tributary to Plunge Creek with a consistent flow, located to the west of Plunge Creek. Over 100 SASD with lineage originating from Plunge Creek were reintroduced in September 2017 to the upper portions of the creek (RCRCD 2018, p. 2). In 2018, a small population was observed by SRMA during surveys (SRMA 2021, p. 2). Surveys by CDFW are planned in the near future to relocate this dace population.

Hemlock Creek

Hemlock Creek is a tributary to the headwaters of the Santa Ana River above Seven Oaks Dam. In August of 2017, 40 SASD were reintroduced into the upper reaches of this creek and have since been noted as having successful reproduction (RCRCD 2018, p. 4). In 2020 surveys, RCRCD noted the creek had a consistent flow and observed a small dace population (Surkie 2022, entire). 2022 surveys by CDFW did not locate dace in previously occupied area downstream of the creek's fork but believe recent rain events may have washed the population downstream. Future surveys by CDFW are planned to confirm if this is true.

Santa Ana River Mainstem

Dace are believed to be extirpated from most of the river, with only a few specimens documented in 2000 and 2005 in the lower reaches (Moyle 2015, p. 5). Two dace were documented in 2011 immediately upstream of Interstate 10, just below a drop structure (Russell 2023, entire). In 2022, CDFW conducted a visual survey and found a small population of dace around Edison Generating Powerhouse 1 in the headwaters of the river above Seven Oaks Dam (Figure 4-5) (Sturkie 2022, entire).



Occurrence Name	Survey Results (Density, Count)	Occupied River Miles
Cajon Creek	Common along Cajon Blvd. (2021), Robust (2020)	4.0 miles (2020)
City Creek	Robust (2019), Small populations (2008/2009)	5.3 miles (2019)
Fredalba Creek*	Limited, small population (2018)	3.1 miles (2018)
Hemlock Creek*	No dace (2022), Limited, small population (2020)	3.3 miles (2020)
Lytle Creek	Robust (2019)	6.7 miles (2019)
Plunge Creek	Robust (2019), 9 dace (2001)	4.9 miles (2019)
Santa Ana River Mainstem*	Small population in headwaters (2022)	1.3 miles (2022)
Strawberry/Twin Complex		0 (2009)
Waterman Creek	3 dace (2021), Limited (2019)	2.4 miles (2019)

Figure 4-5. Current Dace Distribution of Santa Ana River Analysis Unit.

4.5 SAN JACINTO RIVER SYSTEM

North Fork and South Fork San Jacinto River

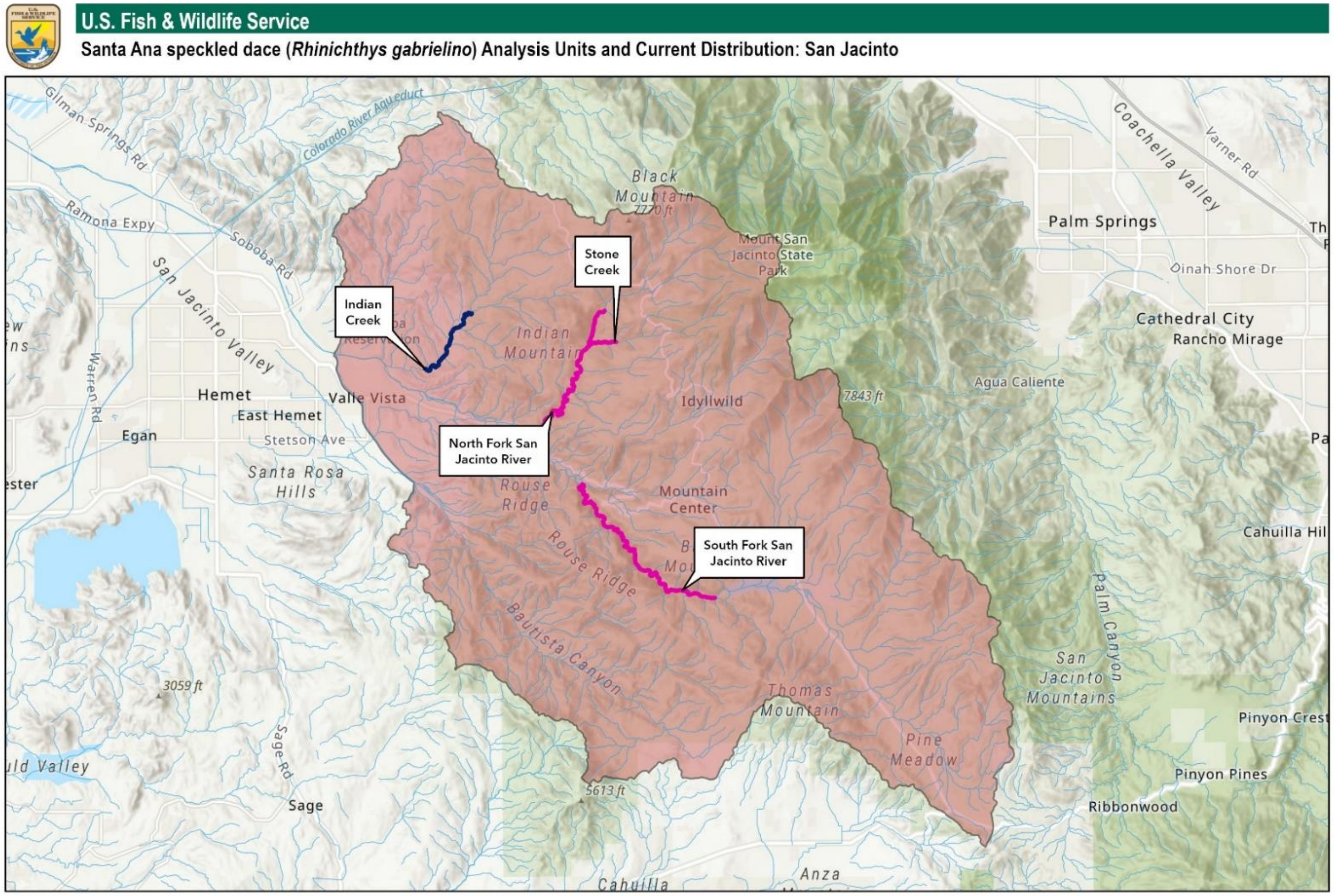
Prior to the mid 1980s, 15-30km of the mainstem of the river were recorded as having SASD, although now large portions of the river dry up during the summer months (Moyle 2015, p. 7). Surveys in 2005 did not find any dace in either the mainstem or either the North or South Forks. Brown trout are known to occur in both forks, which may be predating on the SASD. SASD that originated from Indian Creek were reintroduced to the North Fork, although Kerwin Russell (RCRCD) hasn't found any in the subsequent years, and is not confident they are extant (Expert Working Group 2023, p. 29). SASD are presumed extirpated from both the North and South Fork of the San Jacinto River (Expert Working Group 2023, p. 29).

Stone Creek

Stone Creek is a tributary to the North Fork of the San Jacinto River in the headwaters region of the San Jacinto Mountains. Surveys conducted of the lower reach in 2020 by SRMA found low flows and a small population of SASD (SRMA 2021, p. 2). Because of low water and few surveys, the status of the occurrence was categorized as possibly extirpated by the working group (Expert Working Group 2023, p. 29). It was noted that there is limited water in the creek during drought conditions, making occupancy unlikely.

Indian Creek

Indian Creek is a tributary to the mainstem of the San Jacinto River, flowing through the Soboba Reservation, west of the other tributaries listed above (Figure 4-6). This is widely believed to be the only occupied occurrence in the entire analysis unit, although access to this creek is difficult to obtain (Expert Working Group 2023, p. 29). Flows are intermittent and variable throughout the year, and it is thought that SASD survive in pools when the flows are reduced during the dry summer months. Moyle et al. 2015 (p. 7) discusses how dace from the creek were relocated in 2006 for captive breeding after the Esperanza Fire (Abbas pers. comm. 2008, as cited by Moyle et al. 2015, p. 7). Moyle notes the fish survived the fire and the population is recovering and self-sustaining due to the lack of significant flooding. The last survey occurred in 2018, as stream access is limited. Results from the SRMA survey found variable flows with the main population located on the Soboba tribal land (SRMA 2021, p. 2). CDFW hopes to gain access from the tribe to conduct future surveys to get an update on status of dace in the creek.



Occurrence Name	Survey Results (Density, Count)	Occupied River Miles
Stone Creek	Sparse, small population (2020)	0.9 miles (2020)
Indian Creek	Several dozen dace observed just below the beginning of the wetted reach (2018)	2.8 miles (2018)
North Fork San Jacinto River	Limited to sparse; small population in headwaters (2020)	5.5 miles (2020)
South Fork San Jacinto River	Sparse population (2020)	7.5 miles (2020)

Figure 4-6. Current Dace Distribution of San Jacinto River Analysis Unit.

CHAPTER 5. RESOURCE NEEDS

5.1 INDIVIDUAL-LEVEL RESOURCE NEEDS

Individual needs for speckled dace revolve around having consistent clean cool water (temperatures that stay below 28℃ in the summer months) with access to aquatic invertebrates as a food source. Fertilized eggs and larvae utilize gravel bottom during development and later larvae use rocks and emergent vegetation for cover. Adult SASD inhabit a variety of stream habitat, commonly inhabiting the same stretches of water as Santa Ana sucker, with a preference for moving water. Although dace have been found in streams with a gradient as high as 10%, gradients above 5% seem to limit their movement due to cascading water from the steep terrain (O’Brien et al. 2011, pp. 156, 158).

5.2 POPULATION-LEVEL NEEDS

Populations need abundant individuals within habitat patches of adequate area and quality to maintain survival and reproduction in spite of disturbance. For dace this revolves around having adequate flows of cold water that connect the populations within each watershed. Having enough water in ephemeral creeks and limiting fish barriers is important to allow dace within the population to disperse throughout connected habitat and not become isolated. Having multiple connected occurrences in the watershed is important to mitigate impacts from localized threats, such as high flow events and fire. Dace population size varies greatly based on the annual conditions of the habitat and populations will rebound when conditions are conducive. The amount of water is strongly correlated with the annual fluctuation in habitat conditions, with droughts correlated to lower dace numbers. Without enough cold water throughout the year, populations will become isolated and will not be resilient, especially in the presence of additional threats.

We evaluated population resiliency using both habitat and demographic needs as described below. The specific habitat needs were the amount of habitat and quality of habitat, while the demographic needs included connectivity and population size.

5.2.1 Habitat Needs

Amount of Habitat

The amount of habitat is mainly driven by cold flowing water in the streams throughout the watersheds that the SASD occupy. Having reaches of flowing water (as opposed to dry creek beds) that dace can occupy and use to disperse to new areas in the watershed is important for population resiliency. The species inhabits a relatively small area, making adequate amounts of suitable habitat important for the resiliency of the species.

Quality of Habitat

Quality of habitat revolves around water quality. This includes maintaining water temperatures below 28°C and limiting pollution and sedimentation/debris inputs. Invasive species can also negatively impact habitat quality directly by changing dissolved oxygen and pH levels of the water or by increasing predation and competition.

5.2.2 Demographic Needs

Connectivity

Connectivity allows individuals to move among reaches in a watershed, for example, upstream and downstream without barriers impeding movement. Connectivity allows for movement of individuals in response to stressors such as high flow events or fire, as well as dispersal and gene flow among SASD occurrences, which maintains genetic diversity and increases population resiliency. Connectivity within a watershed becomes increasingly important as localized threats increase, forcing dace to find more suitable habitat to survive.

Size of Population

Having populations large enough to be self-sustaining and repopulate extirpated habitats in a highly variable and unpredictable environment is important for SASD resiliency. Due to the low annual rainfall and high risk of wildfire in occupied habitat, SASD populations must be resilient enough to repopulate habitat as these adverse conditions ebb and flow. Drought and high fire conditions are only exacerbated by climate change, making large resilient populations even more important.

5.3 SPECIES-LEVEL NEEDS

In order for SASD to have high viability the species needs to maintain its representation (adaptive capacity) by having multiple resilient populations (redundancy) in different watersheds. Having multiple resilient populations throughout its historical distribution will ensure it has high levels of redundancy and representation, helping to mitigate impacts from threats and stochastic events such as fire and flooding. Having multiple populations helps maintain genetic diversity and adaptive capacity, which are increasingly important due to the predicted impacts of climate change.

5.4 SUMMARY OF SPECIES NEEDS

SASD is a hardy fish where populations can naturally fluctuate through boom-and-bust cycles. To determine the current species needs, it is important to put the current distribution in the context of its historical distribution. Currently the species inhabits only small remnants of its historical range (making up four analysis units), due to habitat loss and habitat degradation. The species now exclusively occupies headwaters in relatively steep mountainous regions that are susceptible to drought, fire, and debris flows during high water years. The species needs adequate flows of low gradient (5% or less) cold, clear water with gravel or cobble substrate for reproduction. The dace also needs adequate numbers of aquatic invertebrates for food and limited or no invasive predators for higher abundances. Dace also require connectivity among remaining occurrences to maintain genetic diversity and allow for recolonization of extirpated occurrences in response to stochastic events like drought, fire, and debris flows. Having resilient populations in the remaining four analysis units across three mountain ranges will help retain species redundancy and maintain representation via genetic diversity and spatial heterogeneity.

5.5 UNCERTAINTIES

Although surveys have been completed in many known occupied areas in the past few years, there are many tributaries and other waterways that may currently support SASD that have not been surveyed. A comprehensive habitat suitability model has not been created, which would assist in finding potential reintroduction sites or currently extant populations. An overall population estimate and subsequent trends are unknown for the species. Robust monitoring would be needed to estimate long-term trends as the population fluctuates year to year based on habitat conditions. Better understanding critical thresholds for dace including stream temperature, stream flow, steepness (gradient level that becomes a barrier), impacts of rainbow trout and invasive species, and recreational mining would improve survey and recovery efforts.

CHAPTER 6. FACTORS INFLUENCING VIABILITY

In this section, we describe the current conditions and current factors influencing SASD. We provide a summary of potential threats affecting the species using the same habitat and demographic factors identified in **Chapter 3.0 Species Background and Ecology**. We consider the potential contributions of these threats and how these threats are negatively impacting the species' habitat and demography. We evaluate these threats in the context of (1) any existing regulatory mechanisms (Appendix C) that may reduce impacts to the species or its habitat, and (2) other existing efforts to protect or conserve the species. In this section, we identify current threats affecting SASD, summarized in **Table 6-1**. We use the term threat to refer to actions or conditions that may be or are reasonably likely to negatively affect individuals of the species directly or impact aspects of their ecology. Threats include actions or conditions that have a direct impact on individuals, as well as those affecting individuals through alteration of their habitat or required resources. A threat's significance or magnitude depends upon a population-level assessment of the scope, intensity, likelihood, and immediacy of the threat as well as potential direct or indirect impacts it may have on SASD or its habitat across all life history stages. Scope is defined as the spatial extent of a threat within the context of the species' range (localized, moderate, high, or pervasive). Intensity indicates the magnitude of the impact on SASD individuals (e.g., lethal or sublethal effects that may be negligible, low, moderate, strong, or severe). Likelihood describes the probability that the threat will impact SASD in the future. Immediacy refers to the time frame of the threat (ongoing, past, imminent, future). Threats may be reduced through existing conservation mechanisms or management activities and those mitigating measures are described below where appropriate. Below we outline the main threats currently affecting SASD as informed by the recent past. These influences may impact individual, population, and species needs, and ultimately the viability of SASD. The relationships between threats, sources, species' ecology, and demographic parameters are illustrated in the effects pathway (

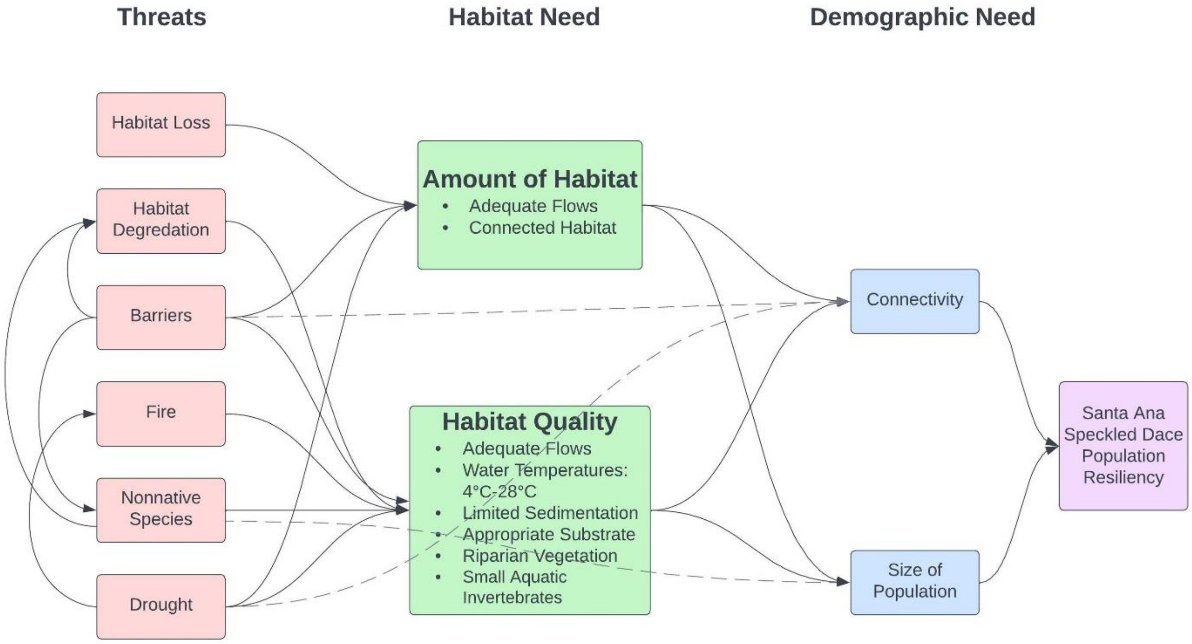


Figure 6-1).

We evaluated impacts from the following primary threats on SASD: (1) habitat loss (urban development and agricultural activities); (2) habitat degradation (recreational activities, mining, roadways, hydrological activities and diversions); (3) habitat fragmentation; (4) increased risk of wildfire; (5) changing climate trends (e.g., increased temperatures and longer, more frequent drought periods); (6) nonnative species (increased competition and predation); and (7) small population effects (

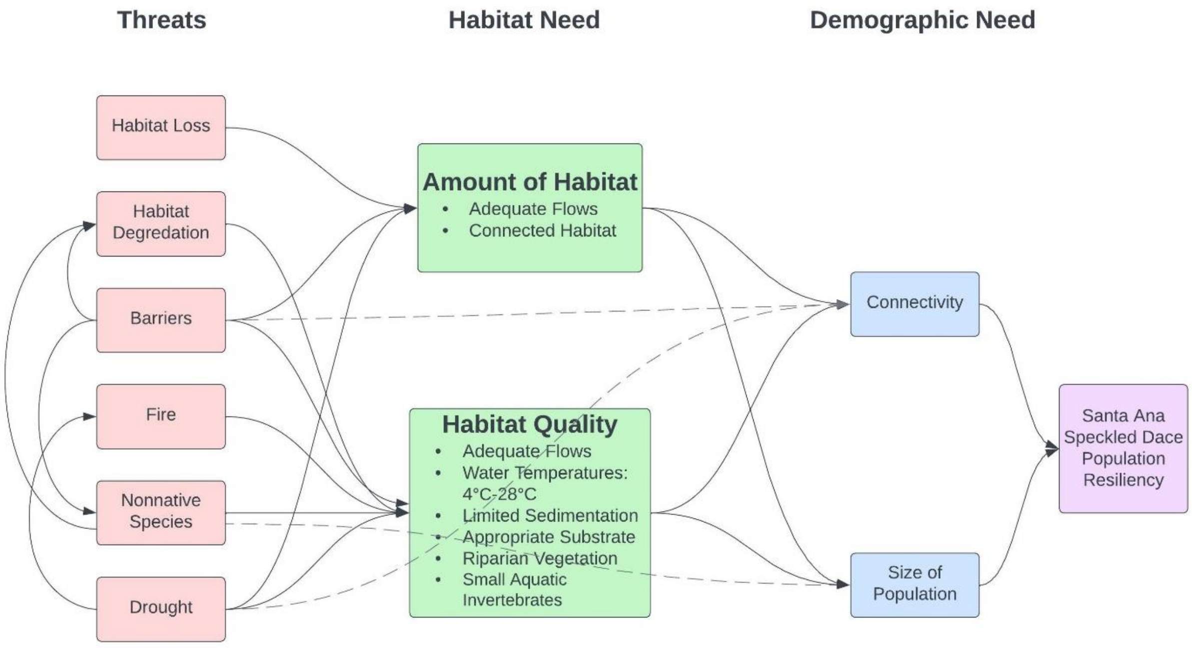


Figure 6-1, **Table 6-1**).

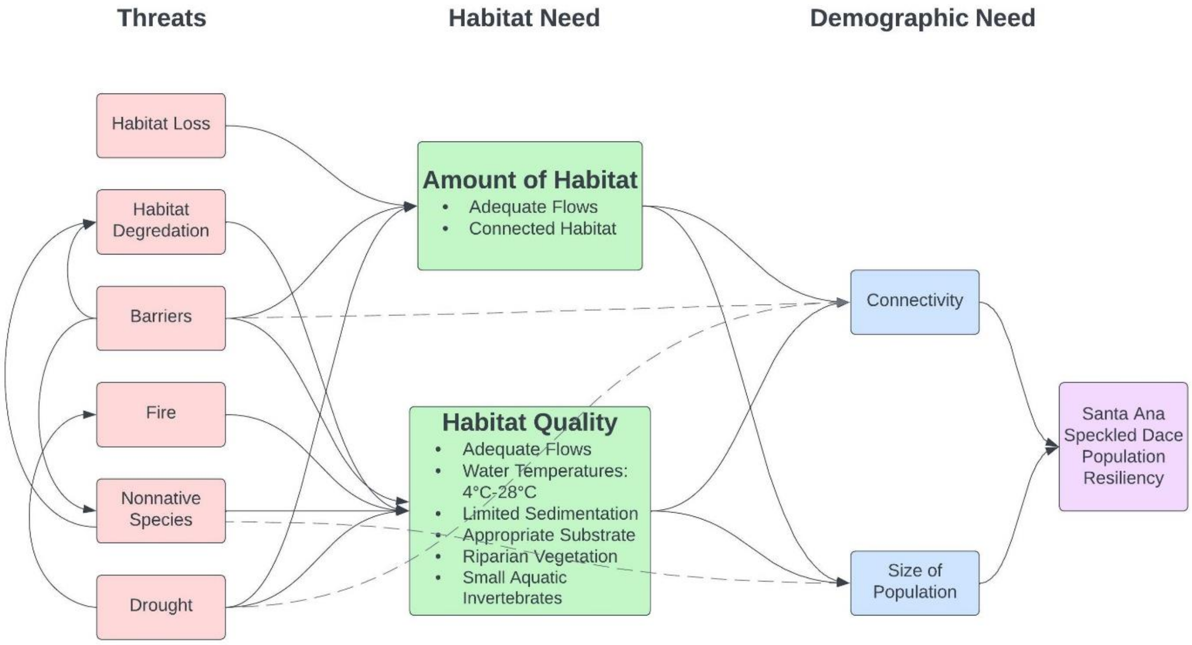


Figure 6-1 is a conceptual model showing the relationships of the identified threats impacting the species' habitat and life history needs directly or indirectly at the population level. While we generally discuss these threats individually, threats can also occur simultaneously and interact

synergistically, thus additively affecting the resiliency of SASD. Where different individual threats occur at the same time and place, we will describe how they may interact. Threats may be reduced through the implementation of existing regulatory mechanisms or other conservation efforts that benefit SASD and its habitat. Regulatory mechanisms are summarized in Appendix C and are also discussed below throughout the text. SASD's habitat needs (e.g., water quality, cool water temperatures, low sedimentation, appropriate substrate, adequate flows, native riparian vegetation, small aquatic invertebrates, connected habitat) will be discussed under **Chapter 7.0 Current Conditions** and evaluated with respect to habitat quantity (quantity of occupied habitat) and habitat quality (invasive grass cover and ecological variability). The demographic need for dispersal will be evaluated by identifying barriers and streams with adequate flows, while population size will be estimated by recent (2013-2023) survey reports of SASD. Threats are broken down by occurrence in each watershed (**Table 6-2**).

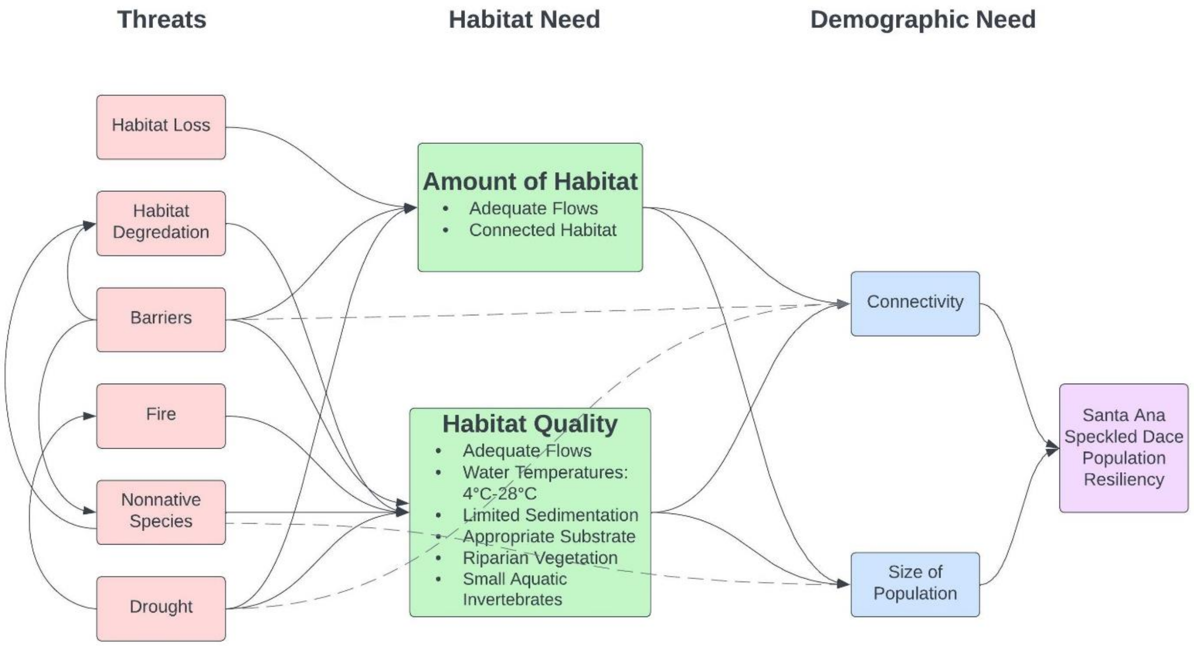


Figure 6-1. Santa Ana Speckled Dace Effects Pathway.
Threats are highlighted in red, habitat needs in green, demographic needs are in blue which all contribute to dace resiliency. Dashed lines indicate threats that impact demographic needs directly.

6.1 HABITAT LOSS

6.1.1 Urban Development

The lower portions of the San Gabriel, Santa Ana, and Los Angeles rivers that were part of SASD's historical range are now extirpated because of habitat loss from extensive urbanization. The middle and lower reaches of these rivers have been channelized and impounded for flood control, and riparian corridors have been replaced with concrete lined canals. Water quality has also been degraded and become unsuitable for dace due to urbanization. For example, the lower reaches of the San Gabriel, Santa Ana, and Los Angeles rivers have highly unsuitable levels of pH, ammonia, lead, coliform, trash, scum algae, total dissolved solids, heavy metals, pathogens, bacteria, and nutrients (Moyle et al. 2015, p. 8). Currently suitable dace habitat is restricted to headwater habitats that are not threated by urbanization.

6.1.2 Agricultural Activities

Although most agriculture lands have been developed, runoff from remaining dairy farms and citrus orchards are a source of pollution, degrading water quality for some streams. Grazing was listed as a low threat by Moyle et al. 2015 (p. 10) due to low intensity grazing in localized areas. Impacts from grazing can be minimized through established monitoring and management practices. Because the threat from agriculture is mild and localized, it is considered a negligible threat currently and in the future, and will not be considered further in this analysis.

6.2 HABITAT DEGRADATION

6.2.1 Roadways

Roadways that run along or cross occupied SASD habitat create a variety of impacts that degrade habitat and impact water quality. Roads are sources of nonpoint pollution (chemical and trash) and sediment inputs and can also constrict the natural morphology of the waterway (straighten out a naturally braided stream), restricting dispersal capacity for dace. Roads can also negatively impact or eliminate vegetation near riverbanks, degrading water quality and overall habitat quality. Nonpaved roads increase the potential for erosion and sediment inputs, especially in mountainous terrain, where most of the remaining dace habitat is found. Where roads facilitate recreational access and activities and increase associated negative effects impacts are moderately impacting SASD (see below).

6.2.2 Recreational Activities

Much of the remaining occupied SASD habitat is located in the Angeles and San Bernardino National Forests, which are some of the most heavily visited National Forests in the country. Impacts from recreation is an increasing threat for dace, particularly in the small waterways they inhabit. Recreational activities that directly impact dace and its habitat include swimming, OHV use, dam building, littering, camping, and recreational mining. These activities stress and displace fish in previously high quality habitat. The artificial impoundments erected to create swimming and bathing areas impact water quality (including temperature and sedimentation) and fragment the habitat by limiting dispersal. OHV use directly disturbs waterways and nearby vegetation and soils, as well as increases nonpoint sources of pollution (including trash) and sedimentation. The main OHV use occurs at the 160-acre (65-hectare) San Gabriel Canyon OHV area, which is managed by the USFS to reduce impacts to the Santa Ana sucker and its habitat (i.e., OHV drivers are authorized to cross the river at certain locations and the site is monitored for compliance) (USFS 2012, entire). The USFS also monitors the effectiveness of management actions. These OHV management actions and enforcement will also help protect SASD. Based on current levels, recreational activities are a moderate and rangewide threat to the dace.

6.2.3 Mining Activities

Suction dredging is currently banned in California, although it was used in the past in the San Gabriel River and in the Cajon Wash and Lytle Creek. Recreational mining for gold has increased in these same areas in recent years with the increase in gold prices. This activity lowers water quality, destroys sensitive habitat, and disturbs SASD in the surrounding areas. In the San Gabriel River watershed, mining operations are impacting dace in the East Fork of the San Gabriel River and Cattle Creek. For example, 6-foot holes and subsequent substrate piles have been observed from recreational mining in portions of East Fork that have negatively changed the morphology of the river. Habitat in Fish Canyon has also been impacted by a rock quarry although Moyle et al. 2015 (p. 8) states that the mining company is in the process of restoring dace habitat. Any mining activities that affect the water channel can also directly kill or injure individual SASD. Overall, mining activities occur in a few areas and appear to be less extensive than other recreational activities. While mining is not currently considered a substantial threat, recreational mining is currently degrading habitat quality and changes in restrictions that increase the rangewide extent of mining activities could have a substantial increase in impact on dace in the future.

6.2.4 Hydrological Modifications and Diversions

Water flow in Big Tujunga Creek and in the West Fork of the San Gabriel River is regulated by large permanent dams that impact habitat quality, stream flow, water temperature, sediment transport, stream morphology, and dispersal. Unregulated flows are available to maintain habitat for SASD in the East and North Forks of the San Gabriel River and their associated tributaries. Several unregulated tributaries also flow into Big Tujunga Creek.

Dams and regulated flows reduce the delivery of coarse substrates (for example, cobble and gravel) to occupied downstream reaches, reducing breeding and forage habitat. Above dams, the accumulation of sediments converts actively flowing stream channels to still-water marshes. Marsh habitat favors nonnative species, such as largemouth bass (*Micropterus salmoides*) and other centrarchids that are predators on SASD (USACE 2001, p. 4-28). Slow or standing water also allows fine materials to settle out resulting in a substrate that does not support breeding and foraging habitat for SASD. In periods of extreme drought, releases from dams have helped provide needed flows for SASD downstream.

Levees and other methods of channelizing streams limit and often prevent the natural meandering process of rivers, limiting them to more linear paths. As such, levees confine available habitats to a narrower geographical area and, under most conditions, a shorter linear length. Additionally, during flood events, water confined within levees flows faster and areas that serve as refugia/sheltering habitat become scarce. In summary, hydrological modifications—dams and stream channelization activities—have significantly altered and degraded SASD habitat throughout the dace’s historical range, reducing its current habitat conditions compared to its historical condition and represents a moderate/high level threat.

6.3 HABITAT FRAGMENTATION

6.3.1 Barriers

Hydrological modification also limit or sever habitat connectivity, which affects the dispersal of SASD. Such modifications include flood control dams, drop structures, recreational dams, road crossings (for example, culverts) and levees. Large dams, such as Cogswell Dam, severely limit connectivity between SASD, only allowing limited, unidirectional migration downstream. These and other barriers reduce fish passage, in turn reducing gene flow and limiting or preventing population replenishment. Drop structures also impede or prevent upstream movement. Recreational dams, constructed out of rocks, vegetation, or other debris to create pools for recreational waterplay, create barriers during low-flow conditions but may be passable during higher flow conditions. Though recreational dams are typically destroyed by high winter flows, recreationalists subsequently rebuild new dams. Trash and debris can also build up during high flows and create barriers. Culverts and other road crossings may prevent access into tributaries or limit connectivity within the main river channel. Additionally, prolonged periods of low flows as a result of reduced water input (such as through flood control measures, storage, or diversion, or through drought conditions) can allow native and nonnative vegetation to accumulate, which can sometimes serve as barriers to fish passage (for example, (OCWD 2012, entire). Barriers are currently present rangewide, causing a moderately high impact on the dace.

6.4 DEBRIS FLOWS AND INCREASED FIRE FREQUENCY AND INTENSITY

Heavy precipitation in steep areas can cause debris flows, which negatively impact SASD occupancy and can extirpate small, isolated occurrences. Currently, debris flows are a disproportionate threat because all remaining dace habitat now occurs in these small, steep waterways due to the loss of less steep downstream habitat to development and human activities. Debris flows can result from an excess overland flow from intense precipitation in steep mountain catchments with available sediment. In southern California mountains, debris flows are driven by precipitation and occur in both burned and unburned terrain (Wohlgemuth 2022, entire). However, wildfires greatly increase the likelihood of debris flows within the burned area by removing vegetation and temporarily elevating soil hydrophobicity (Staley et al. 2017, entire), where hydrophobic layers are created in the soil profile from the heat. When debris flows occur, they can cause significant erosion to hillslopes and channels, resulting in large amounts of sediment being carried downstream (Wohlgemuth 2022, entire). This excessive sediment can fill in pools, causing profound negative impacts on local wildlife, including fish such as the SASD.

Wildfire has impacted all SASD occupied habitat in the 4 AUs over the prior 30 years (Figure 6-2) and continues to have the potential to impact SASD habitat throughout the entire occupied and unoccupied reaches of all watersheds in the future. Most of the current occupied habitat has burned at least one time during the prior 30 years. Wildfire also eliminates vegetation that shades the water and moderates water temperature and may further impact water transport, sediment transport, water quality, and flow regime. Fires followed by debris flows have the potential to extirpate occurrences (especially small, isolated occurrences), especially when fire frequency increases. Burned uplands in the watersheds affects SASD habitat by producing silt-and-ash-laden runoff that can fill in pools and significantly increase turbidity of rivers. Large wildfires have caused local extirpations in isolated dace occurrences (Expert Working Group 2023, p. 23). Wildfire will impact SASD throughout its remaining range, although the location, frequency, and size of these events cannot be precisely predicted. Wildfire is currently a substantial threat to SASD habitat that is projected to increase in the future due to a changing climate.

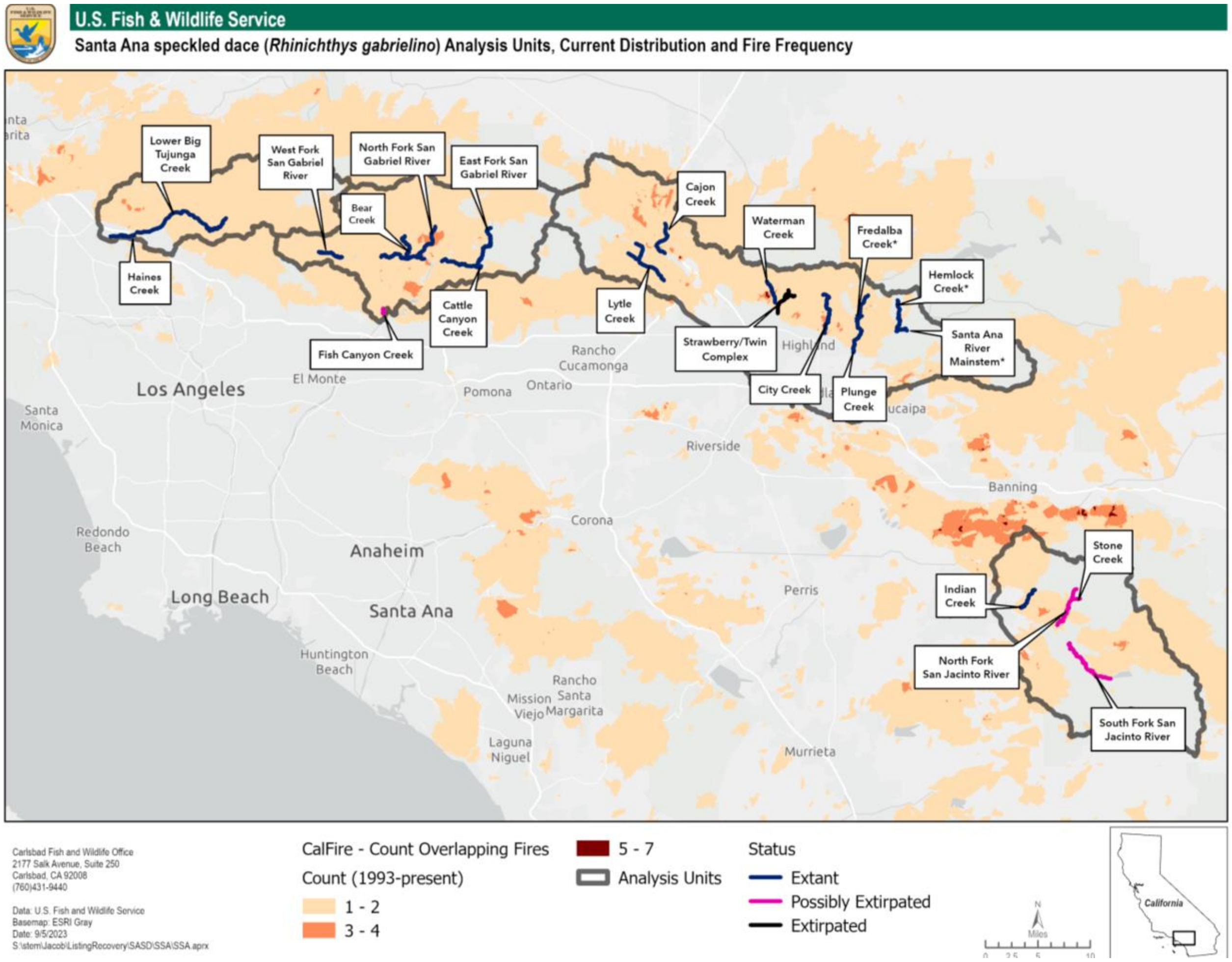


Figure 6-2. 30-year fire frequency footprint.
Fire footprints of fires that occurred from 1993-2023 overlapped with SASD occurrences and analysis unit boundaries.

6.5 NONNATIVE SPECIES

6.5.1 Invasive Aquatic Vegetation

Aquatic habitat may be modified by the presence of nonnative vegetation in a variety of ways. For SASD, the giant reed (*Arundo donax*), an invasive, bamboo-like, perennial grass (*Poaceae*), poses a host of problems that degrade remaining habitats. Giant reed is commonly found growing along lakes, streams, and other wetted areas, and once established it can survive long periods of drought. Where dominant, giant reed is correlated with increased levels of pH and ammonia and decreases in dissolved oxygen (Moyle et al. 2015, p. 9). Compared to other riparian vegetation, it uses large amounts of water to support exceptionally high growth rates (Bell 1997, p. 104). This species is considered a primary threat to riparian corridors, and thus SASD habitat, because of its ease of establishment and spread and its ability to alter the hydrology of riparian systems (CDFW 2015, p. F-11). While the presence of *Arundo donax* can allow hydrologic processes that create small pools that serve as habitat for Santa Ana suckers (Swift 2015, entire), *Arundo donax* also tends to form large, continuous masses through colonial (rhizomatous) growth. These dense masses can stabilize stream banks, alter flow regimes, and prevent or alter natural dynamic processes such as stream meandering and sediment deposition and scouring (Bell 1997, p. 106). As a result of altered flow regimes, giant reed reduces habitat quality for SASD and improves habitat quality for nonnative aquatic predators. Invasive aquatic vegetation such as giant reed is impacting populations scattered throughout the range, causing a moderate impact on the dace.

6.5.2 Predation and Competition from Invasive Species

There are numerous nonnative fish species that are common in all four of the river systems SASD are found in. These species are concentrated in the reservoirs and degraded streams within these watersheds. Brown trout (*Salmo trutta*), hatchery-stocked rainbow trout (*Oncorhynchus mykiss)* and red shiners (*Cyprinella lutrensis*) can either directly compete with or predate on dace (Moyle et al. 2015, p. 9). The American bullfrog (*Lithobates catesbeiana*), another potential predator, has also been observed in Big Tujunga Creek, and may predate on varying life stages of the dace (Haines Creek) (ECORP Consulting Inc. 2013, pp. 29–31). Additionally, the red swamp crayfish (*Procambarus clarkii*) is known from Big Tujunga Creek (O’Brien 2015, entire) and may also be more widespread. Dams and impoundments (such as engineered flood control dams, recreational dams, drop structures, and groundwater recharge basins) and pools created as the result of changes in hydrology from *Arundo donax* can improve habitat for nonnative predators, allowing their populations to increase. These areas can serve as source populations, from which predators can disperse, as has been suggested for Hansen Dam reservoir on Big Tujunga Creek, San Gabriel Dam reservoir on the San Gabriel River (Service 2017, p. I–21).

Impacts from nonnative predators are rangewide and can be severe at the population scale. However, the conditions that promote exposure to predation are highly variable across locations and over time. Therefore, the threat of nonnatives on the SASD is considered a low to moderate threat. Further study is needed to determine the quantity of SASD habitats accessible to and occupied by nonnative predators in order to better describe the magnitude of this threat. Despite these uncertainties, predation of dace by nonnative aquatic species will further exacerbate the threats posed by changes in hydrology due to human disturbance and invasive vegetation.

6.6 CLIMATE CHANGE

Climate change forecasts for the Northern Hemisphere predict warmer air temperatures, more intense precipitation events (both drought and flooding), and increased summer continental drying by the year 2100 (Cayan et al. 2005, p. 6). SASD require cooler water, with temperatures that stay below 28℃. They are capable of withstanding elevated water temperatures (Moyle et al. 2015, p.11), but their lethal upper temperature limit is unknown. Fish are generally more stressed at the upper extremes of their temperature range and though they may be able to survive, elevated temperature is an example of a stressor that may affect them through reduced disease resistance (Moyle 2015, p.11). Currently, impacts from climate change are considered moderate, but are projected to increase in the future. Predicted decreases in summer and fall flows will reduce connectivity within currently occupied watersheds, further isolating dace, limiting available habitat, and degrading remaining habitat. Additionally, increasing summer air temperatures and stable precipitation will likely impact the availability of suitable cooler-water habitat during the summer and fall months, when dace are already most vulnerable to low flows and high water temperatures. Increases in precipitation from wintertime storms could have both beneficial impacts to the streams (mitigating impacts from drought including flushing systems, reconnecting isolated reaches). However, increases in wintertime precipitation in southern California due to climate change would most likely lead to more frequent intense storms that can initiate debris flows, both in burned and unburned settings. Climate change is also predicted to increase fire probability (Section 6.4). The combination of elevated water temperatures with stable risk from drought (in summer), increased risk from rainfall (in winter) and fire throughout the remaining range of dace suggest a higher threat from climate change in the future. Appendix D has several tables and figures depicting the predicted changes in parameters centered around fire, stream flow, flooding events, precipitation, and stream temperature.

6.7 SMALL POPULATION EFFECTS

SASD mostly occur in small, isolated populations throughout their range. These small, isolated populations are vulnerable to a number of deleterious effects including: “(1) demographic fluctuation due to random variation in birth and death rates and sex ratio, (2) environmental fluctuation in resource or habitat availability, predation, competitive interactions and catastrophes, (3) reduction in co-operative interactions and subsequent decline in fertility and survival (i.e., Allee effects), (4) inbreeding depression reducing reproductive fitness, and (5) loss of genetic diversity reducing the ability to evolve and cope with environmental change” (Traill et al. 2010, p. 29). In particular, small populations of SASD are more vulnerable to extirpation during catastrophic or stochastic events, such as flood events (that can physically wash dace away), debris flows (which are much more likely after fire and reduce habitat quality and population size), or sustained drought (that can result in the loss or reduction of surface flows and concomitant increases in water temperature). Isolation means that any remnant populations following these events are unlikely to benefit from demographic or genetic rescue, further elevating risks of inbreeding depression, loss of genetic diversity, and reductions in evolutionary potential that can contribute to population extirpation. These small population effects interact with other factors to pose a low/moderate threat across the species' current range.

Table 6-1. Summary of current threats to the Santa Ana speckled dace and its habitat

Threat	Scope	Intensity	Likelihood	Immediacy	Magnitude
Habitat Loss	Localized	Individuals	High	Current	Low
Habitat Degradation	Rangewide	Population	High	Current	Moderate
Habitat Fragmentation	Rangewide	Population	High	Current	Moderate
Fire	Rangewide	Population	High	Current	High
Nonnative Species	Rangewide	Population	High	Current	Low/Moderate
Climate Change	Rangewide	Population	High	Current	Moderate
Small Population	Population and Rangewide	Population	Moderate	Future	Low/Moderate

Table 6-2. Santa Ana speckled dace Occurrence and Threats Table.
Data from reports cited in text. Hypothesized occupancy status is based on the most recently available information; orange font indicates possible extirpations and red font indicates known extirpations. Majority landowner listed first. Current status with an asterisk (*) indicates a reintroduced occurrence.

Analysis Unit	Occurrences	Current Status	Estimated Abundance	Occupied Length (Stream Miles)	Last Year Observed	Ownership	Analysis Unit Threats
Los Angeles River	Haines Creek	Extant	Low	1.52	2022	ACOE Local	• Invasive Species • Habitat Degradation ○ Garbage Dumping ○ Low Flows • Fire • Climate Change ○ Heavy downpours ○ Drought
Los Angeles River	Lower Big Tujunga Creek	Extant	Low	13.47	2022	USFS Local Private ACOE	
San Gabriel River	Fish Canyon Creek	Possibly Extirpated	Low	0.71	2016	Private	• Habitat Degradation ○ Recreational Dams ○ Recreational Mining ○ Human Activities ○ Dam Management • Habitat Fragmentation • Fire • Climate Change ○ Heavy downpours ○ Drought
San Gabriel River	West Fork San Gabriel River	Extant	High	8.69	2022	USFS	
San Gabriel River	North Fork San Gabriel River	Extant	Moderate	4.14	2022	USFS	
San Gabriel River	East Fork San Gabriel River	Extant	Moderate	9.79	2022	USFS	
San Gabriel River	Bear Creek	Extant	Moderate	3.37	2022	USFS	
San Gabriel River	Cattle Canyon Creek	Extant	Low	0.61	2022	USFS	

Analysis Unit	Occurrences	Current Status	Estimated Abundance	Occupied Length (Stream Miles)	Last Year Observed	Ownership	Analysis Unit Threats
Santa Ana River	Lytle Creek	Extant	High	6.73	2021	USFS Private	• Fire • Climate Change ○ Heavy Downpours ○ Drought • Habitat Degradation ○ Garbage Dumping ○ Low Flows • Habitat Fragmentation
Santa Ana River	Cajon Creek	Extant	High	3.97	2021	USFS Private	
Santa Ana River	City Creek	Extant	High	5.34	2022	USFS Private	
Santa Ana River	Strawberry/ East Twin Creek	Extirpated	Extirpated	-		USFS	
Santa Ana River	Plunge Creek	Extant	High	4.89	2023	USFS Private	
Santa Ana River	Waterman Creek	Extant	Moderate	2.38	2021	Private	
Santa Ana River	Fredalba Creek	Extant*	Moderate	3.13	2021	USFS	
Santa Ana River	Hemlock Creek	Extant*	Moderate	3.30	2022	USFS	
Santa Ana River	Santa Ana River Mainstem	Extant*	Low	1.31	2022	USFS Private	
Santa Ana River	Silverado Canyon	Extirpated	Extirpated	-	1987	USFS	
Santa Ana River	Santiago Creek	Extirpated	Extirpated	-		USFS	

Analysis Unit	Occurrences	Current Status	Estimated Abundance	Occupied Length (Stream Miles)	Last Year Observed	Ownership	Analysis Unit Threats
San Jacinto River	San Jacinto River- North Fork	Possibly Extirpated*	-	5.50	2020	USFS	• Small Population • Fire • Climate Change ○ Heavy Downpours ○ Drought • Habitat Degradation ○ Low Flows
San Jacinto River	San Jacinto River- South Fork	Possibly Extirpated	-	7.52	2020	USFS Private	
San Jacinto River	Stone Creek	Possibly Extirpated*	-	0.88	2020	USFS	
San Jacinto River	Indian Creek	Extant	Moderate	2.80	2018	Tribal USFS	

CHAPTER 7. CURRENT CONDITIONS

7.1 SUMMARY OF METHODS

When determining population resiliency for SASD, we examined the four currently occupied river systems as separate populations or analytical units. We used four metrics representing habitat and demographic needs to evaluate population resiliency: amount of habitat, quality of habitat, connectivity, and population size (**Table 7-1**). Conditions for low, moderate, and high categories are defined in **Table 7-1**. We determined the overall resiliency condition for each unit by narratively integrating two habitat needs (habitat quality, amount of habitat) and two demographic needs (size of population, connectivity), with the size of population dictating the overall resiliency condition. We evaluated representation by examining available data on the breadth of genetic, phenotypic, and ecological diversity across the dace's range from historical to current conditions, as well as its ability to disperse and colonize new areas. We evaluated redundancy by analyzing the number and distribution of populations from historical to current conditions relative to the magnitude of anticipated catastrophic events, such as floods and wildfires. Land ownership of currently occupied river miles is available in Appendix A.

7.2 CURRENT POPULATION RESILIENCY

Current population resiliency is evaluated for each of the four extant analysis units (AUs) below. It is important to note that some of the historical viability afforded to the SASD has been permanently lost to development and other human impacts, particularly in the lower reaches of these watersheds. Historically, dace occupied the lower gradient reaches of these river systems that provided both additional suitable habitat and connectivity among watersheds (Figure 4-2). These lower reaches played an important role as refuge habitat during stochastic and catastrophic events including fire, drought, and debris flows by allowing the fish to recolonize the upper, steeper portions of the headwaters once conditions improved. The steeper portions in the headwaters, where dace are now restricted, are the remnants of the historical range that are still considered suitable and occupied. Below we evaluate the habitat and demographic condition of each of these portions to analyze population resiliency in each of the AUs.

7.2.1 Los Angeles River Analysis Unit

The Los Angeles River AU is a smaller unit that has two occupied occurrences. The largest occurrence is bounded by dams on both ends (Big Tujunga Creek), with stretches that are heavily impacted by human impacts and invasive predators. Though water flow is regulated by the dam, some lower sections of this reach are reported to dry out regularly during the summer. An occupied tributary to Big Tujunga Creek is Haines Creek. This creek is less impacted by invasive species relative to Big Tujunga, making for better habitat quality. The unit is near urban development with easy access by the public, making it highly susceptible to human impacts, most notably garbage dumping (including construction debris and other toxic materials) and recreation. Recreational dams have been observed on both creeks, although recent efforts have removed several dams on an occupied portion of Haines Creek. Due to recent drought years around the 2009 Station fire, there are less consistent flows/decreased velocity from water released from the upper dam. There are also fewer flushing events, which has degraded habitat quality with changes in vegetation (cattail invasion) and substrate (from gravel/cobble to silt). Adaptive management strategies are being formed based on the results of a study looking to improve Santa Ana sucker habitat, a sympatric species. SASD survey numbers (Psomas 2019, p. 58) in Big Tujunga Creek correlate with water quality measures including average benthic index of biotic integrity, habitat suitability, annual rainfall, and median dissolved oxygen (Psomas 2019, p. 87), indicating water quality is tied to SASD abundance.

We estimate a total of 15 river miles of occupied habitat, with 7.9 miles falling either on Forest Service (5.9 miles) or Army Corps of Engineers (2.0 miles) land (Appendix A). Survey results after 2012 indicate consistent occupancy in low but stable numbers coinciding with low water during drought years. The two occupied occurrences are connected, although low flows and dams limit connectivity upstream on Big Tujunga Creek. Based on the limited habitat, degraded habitat quality, and consistently low abundance estimates, the Los Angeles River AU has a low resiliency, meaning it may be less able to withstand stochastic events and contribute to species viability.

Habitat amount in this AU was scored as low because there was less than 20 miles of occupied habitat that does not need management. Habitat quality was rated as low/moderate because some of the essential features, including habitat free of nonnative species, adequate flows, appropriate water quality, and proper substrate, are degraded. Connectivity is considered low/moderate even though there are less than four occurrences in the AU because the two extant occurrences are connected, making dispersal possible. Size of population rated as low due to consistently few fish observed during sampling, which is most likely linked to the presence of nonnative predators. Resiliency condition is tied to the size of the population score; specifically, the resiliency score could not be higher than the population size score.

7.2.2 San Gabriel River Analysis Unit

The San Gabriel River AU is the most intact unit with the most high-quality habitat remaining in southern California. There are five occupied occurrences in this unit that are well connected. However, the San Gabriel River also has multiple large-scale dams that limit dispersal and connectivity, while also affecting habitat suitability (restricting sediment input). Smaller recreational dams also occur throughout many of the more accessible areas (near roads) of occupied habitat and degrade habitat quality and connectivity. Additional impacts to water quality and habitat from recreation include recreational mining, trash, and human contamination from people living and cooking on site. Impacts to water quality have been documented extensively by USGS on the East Fork. The two biggest threats, fire and drought, contribute to habitat degradation and loss, and both are difficult to predict and manage for. Fish salvage operations have occurred in recent years to limit the impacts of debris flows after fires, including the 2020 Bobcat Fire which affected the West Fork and Bear Creek. However, increasing abundance of SASD dace in these occurrences has since been documented, illustrating some level of resiliency to these large events.

In the San Gabriel River AU, we estimate a total of 27 river miles of occupied habitat, with 24.8 miles falling on Forest Service land. Except for Fish Canyon Creek to the south (which is considered possibly extirpated), occupancy in the remaining areas has been consistently low. Snorkel surveys through pools are consistently documenting tens of dace in North Fork, although recent fish relocation efforts from the upper portions of the San Gabriel Reservoir are augmenting this occurrence. Despite impacts from dams, this unit has consistent year-round flows, allowing for portions to maintain a degree of connectivity with limited impacts from invasive species found in the lower portions. With the best and most consistent dace habitat left, along with stable but relatively low abundances, resiliency in the San Gabriel River AU is moderate. Though occupancy may be lost in some areas the unit is likely to contribute to species viability despite stochastic events.

Habitat amount in this AU was scored as moderate because there was 21-40 miles of occupied habitat, with an unknown but substantial amount of suitable habitat. Habitat quality was rated as moderate because some of the essential features, including adequate flows, appropriate water quality, and proper substrate, are degraded. Connectivity is considered moderate because there are between 4-10 occurrences in the AU, with several connected with no impact from barriers. Size of population rated as moderate due to surveys consistently finding fish in moderate numbers. Resiliency condition is tied to the size of the population score; specifically, the resiliency score could not be higher than the population size score.

7.2.3 Santa Ana River Analysis Unit

The Santa Ana River AU is the largest unit with eight occupied occurrences, although much of the habitat is disconnected with low flows. The AU is impacted by similar human activities as the Los Angeles Unit, including garbage dumping, recreational dams, homeless encampments, and miscellaneous recreational activities. Impacts from fire, drought, barriers, and debris flows from heavy rainfall are the predominant threats currently degrading SASD habitat. Some occurrences are more isolated with degraded habitat due to lack of flow, although a few occurrences including Hemlock Creek and City Creek have consistent flows year-round.

Three of the currently extant occurrences were recently reintroduced by RCRCD after being extirpated, illustrating the volatility of smaller reaches and the recovery potential of the fish. Most occurrences are documented as small populations, where few dace are observed. A few occurrences, including City Creek, have been documented having boom and bust cycles (USGS 2022a, p. 6). Higher abundance has also been reported at Lytle, Cajon, and Plunge Creeks and these occurrences have recently been described as robust.

Overall, there are 31 river miles of occupied habitat. Connectivity is limited throughout the range due to low flows and barriers from human activities in the lower reaches. Increased drought continues to exacerbate the lack of connectivity between occurrences. Resiliency in this AU is low to moderate because of the disconnected occurrences, low population numbers, and low flows. This unit is impacted by the same predominant threats of fire, drought, and debris flows during downpours. Successful reintroduction to multiple formerly extirpated sites has helped to increase this AU’s resiliency and demonstrates their resiliency to bounce back from low numbers.

Habitat amount in this AU was scored as moderate because there are 21-40 miles of occupied habitat. Habitat quality was rated as moderate because some of the essential features, including adequate flows and appropriate water quality, are degraded. Connectivity is considered low because many of the occurrences in the AU are disconnected, making dispersal impossible under normal conditions. Size of population was rated as low/moderate due to the highest number of extant occurrences with variable densities throughout the AU. Resiliency condition is tied to the size of the population score; specifically, the resiliency score could not be higher than the population size score.

7.2.4 San Jacinto River Analysis Unit

The San Jacinto River is the smallest and least surveyed of the AUs. There is one known occupied occurrence, Indian Creek, that occurs mainly on tribal lands. Indian Creek is consistently occupied although it has intermittent and varied flows, especially during dry periods where water flow is heavily reduced. Compared to other AUs, occurrences in this unit are not influenced by high levels of human impact. Instead, impacts from drought, fire, and debris flows are the main threats affecting resiliency. When flows are adequate, connectivity between occurrences is possible as there are no permanent barriers to block dispersal.

We estimate a total of 2.8 river miles of occupied habitat, with 0.3 miles falling on Forest Service land and 2.5 miles on tribal lands. There is the threat of novel invasive species in Indian Creek from an upstream lake. Other occurrences were reported as extant in the recent past but are now possibly extirpated even though these areas are still considered suitable. Brown trout are present in the North and South Forks of the San Jacinto River, which may have contributed to the possible extirpation of SASD from these sites. With only one small extant occurrence remaining and a limited amount of potential habitat available, the San Jacinto River AU has a low resiliency suggesting it is less likely to be able to persist from stochastic events.

Habitat amount in this AU was scored as low because there are less than 20 miles of occupied habitat that does not need management. Habitat quality was rated as low/moderate because some of the essential features, including habitat free of nonnative species and adequate flows, are degraded. Connectivity is considered low/moderate even though there are less than four occurrences in the AU because the one extant occurrence is connected to historically occupied habitat that could become occupied again in the future, making dispersal possible between these areas. Size of population rated as low due to only one known extant occurrence with flows becoming very small during dry conditions, limiting dace abundance. Resiliency condition is tied to the size of the population score; specifically, the resiliency score could not be higher than the population size score.

7.3 CURRENT SPECIES REPRESENTATION

Representation, or adaptive capacity, is maximized in a species with healthy populations distributed across the breadth of its evolutionary lineages and ecological niches that is capable of moving to new, suitable environments or capable of altering their physical or behavioral traits (phenotypes) to match changing environmental conditions through either plasticity or genetic change (Nicotra et al. 2015, p. 1270; Beever et al. 2016, p. 132). By this definition, the adaptive capacity of SASD from historical to current conditions has dramatically decreased due to the permanent loss of historically occupied habitats across the range and isolation of small remnant populations in headwater habitats. This has reduced representation of evolutionary lineages in each watershed and the diversity of occupied ecological niches (i.e., due to population extirpations and complete loss of lower watershed habitats). Remnant populations are relatively small and isolated, both within and across the four remaining analytical units. Disrupted connectivity and restriction to headwaters means that dace populations have extremely limited capacity to colonize new habitats or shift their distribution to avoid/mitigate threats. Disrupted connectivity also reduces or eliminates gene flow, increasing the impacts of genetic drift and inbreeding, and reducing evolutionary potential that could allow populations to adapt to changing environmental conditions, such as warming stream temperatures. While other populations of speckled dace have shown plasticity in feeding behavior that facilitates responses to fluctuating resource availability, feeding plasticity is reduced in anthropogenically impacted populations (Behn and Baxter 2019, pp. 17–19) such as SASD. Additionally, relative to other native fish, other species in the speckled dace complex have limited plasticity (i.e., acclimation capacity) in their upper thermal tolerance, reducing tolerance for increasing temperatures (tolerance levels were above current temperature range of occupied habitat) (Carveth et al. 2006, pp. 1436–1438). Overall, these constraints on dispersal capacity, evolutionary potential, and plasticity, in combination with low to moderate resiliency of SASD populations, point to currently limited adaptive capacity within populations and across the species' range.

7.4 CURRENT SPECIES REDUNDANCY

As with representation, redundancy from historical to current conditions for SASD has been reduced due to permanent loss of historically occupied habitats. In particular, loss of the lower reaches of the currently occupied watersheds has eliminated access to refugial habitats that historically protected fish from extirpation during stochastic and catastrophic events including fire, drought, and debris flows. These habitats also allowed for recolonization of upper headwaters once conditions improved. These habitat losses have placed all remaining remnant populations at much higher risk of extirpation due to catastrophic and even less severe stochastic events. This is illustrated by fish salvage efforts (e.g., in the San Gabriel River unit) that were needed after the 2020 Bobcat Fire to protect populations from debris flows; historical access to lower elevation habitats would likely have allowed populations to persist and recolonize naturally (i.e., without human intervention) in response to fire and debris flow events. Currently, SASD occupy 17 occurrences across four river systems. This relatively broad distribution provides some level of redundancy and helps ensure that multiple populations contribute to species viability since all occurrences are unlikely to be impacted simultaneously by any single catastrophic event. Two of the AUs with lower resiliency are more at risk of stochastic and catastrophic events and the loss of either of these would significantly reduce redundancy. The remaining two AUs are significantly larger and less likely to become extirpated from stochastic or catastrophic events. Overall, redundancy has been severely reduced compared to historical conditions. The fact that dace have been able to recolonize areas shortly after a catastrophic event suggests that there is recovery potential where risks can be mitigated via human interventions, which could help to maintain some level of redundancy in the future.

7.5 SUMMARY OF CURRENT CONDITIONS

Currently, SASD occur in four analysis units across three mountain ranges that span three counties in southern California. The San Gabriel River AU is currently the most resilient AU, with portions of connected habitat and the most available water left in the area, with overall moderate resiliency. The Santa Ana River AU has the most occupied river miles, although many occurrences are smaller and less connected than the San Gabriel River AU, making this unit more variable in its resiliency, with overall low/moderate resiliency. Both the Los Angeles River and San Jacinto River AUs are small, with two and one extant occurrences, respectively, with overall low resiliency.

Table 7-2 summarizes the current conditions for each resiliency category in each population. Relative to the historical distribution, the SASD has likely lost much of its adaptive capacity. Loss of the lower extent of its range limits its ability to respond to large disturbances and influences its ability to adapt to changing environmental conditions. The species is currently limited to 17 occurrences across four river systems, which provides some level of redundancy against large catastrophic events. Low to moderate resiliency combined with limited representation and reduced redundancy indicate that SASD have reduced species viability relative to historical conditions. These are the baselines used when projecting future conditions.

Table 7-1. Condition of Category Table.

Condition	Amount of Habitat	Quality of Habitat	Connectivity	Size of Population
Low	Not enough habitat to support the long-term survival absent habitat management. Less than 20 river miles of occupied habitat.	Most or all of the essential features are degraded or absent including: cold clean water (4-28℃), adequate flows, no/low sedimentation, cobble substrate, no/limited invasive species, aquatic/riparian vegetation, and aquatic invertebrates present.	None, or very little successful dispersal is likely; known barriers with dace streams commonly drying up. Occupy 1-3 isolated reaches in river system.	SASD detected less frequently over time or in very few numbers.
Moderate	Enough habitat to support the long-term survival with some habitat management. Between 21 and 40 river miles of occupied habitat.	Some or most of the essential features of the habitat listed below are degraded but not eliminated including: cold clean water (4-28℃), adequate flows, no/low sedimentation, cobble substrate, no/limited invasive species, aquatic/riparian vegetation, and aquatic invertebrates present.	Limited dispersal is likely; reduced connectivity between occupied creeks from barriers and intermittent flowing creeks. Occur in large portions of river system. Occupy 4-10 reaches in river system.	SASD consistently detected over time and in moderate numbers.
High	Enough habitat to support a self-sustaining population absent habitat management. At least 41 river miles of occupied habitat.	Quality habitat containing the appropriate essential features including: cold clean water (4-28℃), adequate flows, no/low sedimentation, cobble substrate, no/limited invasive species, aquatic/riparian vegetation, and aquatic invertebrates present to support SASD.	Sufficient stream flows to consistently facilitate dispersal; limited barriers within a population. Occur throughout river system. Occupy more than 10 reaches in river system.	Occurrences of SASD detected more broadly and frequently over time.

Table 7-2. Current Condition Table for Population Resiliency.
Overall resiliency conditions for each AU reflect the size of population score as this parameter is the most important in determining resiliency. Specifically, the resiliency score could not be higher than the size of population score.

Population	Amount of Habitat	Quality of Habitat	Dispersal	Size of Population	Resiliency
Los Angeles River	Low	Low/Moderate	Low/Moderate	Low	**Low**
San Gabriel River	Moderate	Moderate	Moderate	Moderate	**Moderate**
Santa Ana River	Moderate	Moderate	Low	Low/Moderate	**Low/Moderate**
San Jacinto River	Low	Low/Moderate	Low/Moderate	Low	**Low**

CHAPTER 8. FUTURE CONDITIONS

Scenario planning is a comprehensive exercise that involves the development of scenarios that capture a range of plausible future conditions, which is then followed by an assessment of the potential effects of those scenarios on a given species. Scenarios are not projections or forecasts of what will happen in the future for a species but are projections or explorations into the range of conditions that may exist based on current information (**Figure 8-1**). The scenarios are intended to provide the "upper" and "lower" bounds of plausible conditions (**Figure 8-2**), outline uncertainties, and provide decision makers with a means for managing risk and maintaining flexibility in current and future decisions.

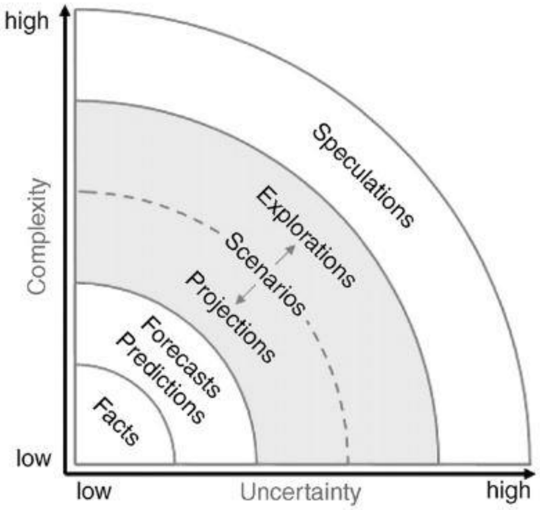


Figure 8-1. Levels of uncertainty and complexity diagram.
The levels of uncertainty and complexity in situations for which scenarios can be useful in considering future possibilities (adapted from Roland et al. 2014).

A range of time frames with a multitude of possible scenarios allows us to create a "risk profile" for SASD and its viability into the future. While we do not expect every condition for each scenario to be fully realized, we are using these scenarios as examples for the range of possibilities. For each scenario, we describe the threats that would occur in each population and how they may change in the future. We used the best available science to project trends in future threats facing SASD. Data availability varies across the range of the species and individual populations. Where data on future threats or trends are not available, we look to past threats and their trends. We evaluate if it is reasonable to assume these trends will continue into future and to what degree.

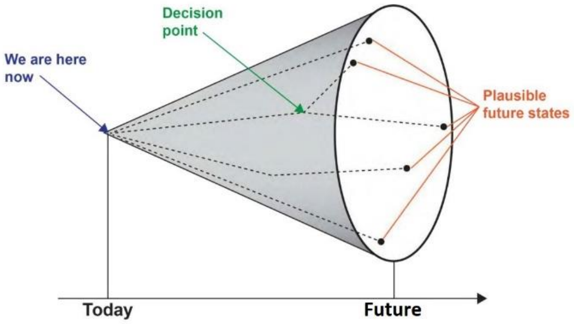


Figure 8-2. Conceptual diagram of plausible alternative futures.
Conceptual diagram of the broadening range of plausible alternative futures as one moves farther away from the present and different events and decision points shift trajectories. (Roland et al. 2012, adapted from Reclamation 2012).

To analyze future conditions, we developed two plausible scenarios to assess how the species needs, threats, and habitat conditions may change at both mid-century and late-century. We considered what SASD needs for species viability, and we evaluated the past, current, and future influences that are affecting habitat and demographic needs. Habitat loss, habitat degradation, habitat fragmentation, increased fire risk, nonnative species, climate change, and small population sizes are the threats evaluated in the future scenarios section as they are projected to influence SASD viability. None of the threats we identified were insignificant enough to exclude in our future condition evaluation. We apply our future forecasts to the concepts of resiliency, representation, and redundancy to describe the future viability of SASD.

8.1 SUMMARY OF METHODS

Climate change projections were used to evaluate changes in fire, stream flow, stream temperature, and extreme precipitation metrics (10-year flood events) over time (mid and late century). Fire data (area burned and decadal wildfire probability) were taken from the Cal-Adapt website (cal-adapt.org/tools/wildfire), derived from Westerling (2018, entire) and Thomas et al. (2018, entire). Cal-Adapt wildfire projections are based on a spatially-explicit simulation model that evaluates historical climate, vegetation, population density, and fire history in combination with regionally downscaled climate projections and projections of population and vegetation dynamics (Thomas et al. 2018, p. 11). For fire metric projections, we selected the CanESM2 generalized circulation model (GCM), which is considered an average model of climate change projections in California.

For fire probability, we downloaded raster data for decadal fire probabilities for RCP 4.5 and RCP 8.5. Within each AU, we calculated a weighted average of fire probability for each cell based on the area falling within the AU to estimate a decadal fire probability for each AU. Decadal probabilities were aggregated to 30-year probabilities using the following equation:

$$p_{one\ or\ more\ fires\ in\ an\ AU\ over\ 30\ years} = 1 - (1 - p_{decade\ 1}) * (1 - p_{decade\ 2}) * (1 - p_{decade\ 3})$$

Where:

- $p_{one\ or\ more\ fires\ in\ an\ AU\ over\ 30\ years}$ is the probability of occurrence of one or more fires in an AU over 30 years
- $p_{decade\ \#}$ is the probability of occurrence of one or more fires in an AU during each relevant decade

For area burned, we used the Cal-Adapt boundary selection tool to upload AU shapefiles to aggregate annual hectares burned in each AU (where data were available) for each RCP. We calculated the 30-year average of annual area at risk of burning in an AU (in hectares) by averaging burn areas across each relevant 30-year period. For both fire probabilities and area burned, we used the following 30-year periods: 1990-2019 (baseline), 2030-2059 (mid-century), and 2070-2099 (late-century).

Stream flow data were derived from the U.S. Stream Flow Metric Dataset: Modeled Flow Metrics for Stream Segments in the United States Under Historical Conditions and Projected Climate Change Scenarios (USDA Forest Service Office of Sustainability and Climate 2022, entire). Stream temperature data were derived from the NorWeST summer stream temperature model (Isaak et al. 2017, entire). For both flow and temperature data, stream segments were selected that overlapped with occupied stream reaches for SASD. For each occurrence, we took the weighted average of the available flow or temperature metrics based on contributions of each stream segment to the total occurrence.

Flow data were available at three-time steps: 1977-2006 (baseline), 2030-2059 (mid-century), and 2070-2099 (late-century) for RCP 8.5. To estimate flow for RCP 4.5, we followed guidance in the Flow Metrics Data Guide indicating that changes in flows "…would scale roughly with the amount of added greenhouse gas forcing as compared to RCP 8.5" (USDA Forest Service Office of Sustainability and Climate 2022, p. 4). To evaluate relative greenhouse gas forcings between RCP 4.5 and RCP 8.5, we used the RCP Database v. 2.0.5 (available at: https://tntcat.iiasa.ac.at/RcpDb) referenced in the IPCC AR5 publication by Clarke et al. (2014, p. 431). Using total CO_2 emissions as a reference, we calculated the average differences in CO_2 emissions between RCP 4.5 and RCP 8.5 for 2030-2060 and 2070-2100 to estimate a percentage difference in emissions between RCPs. The average percentage of RCP 8.5 emissions for the RCP 4.5 corrections were 60% of RCP 8.5 emissions for 2030-2060 and 18% of RCP 8.5 emissions for 2070-2100. These corrections were applied to increase mean summer (June-July-August) flows under RCP 4.5 relative to RCP 8.5 and to decrease mean winter (December-January-February) and 10-year flood flows under RCP 4.5 relative to RCP 8.5.

Modeled mean August stream temperature data were available for only the baseline time step (1993-2011) in the southern California region. To estimate projected stream temperatures, we extracted average maximum air temperatures for 1993-2011 (baseline), 2030-2059 (mid-century), and 2070-2099 (late-century) for each AU under both RCP 4.5 and RCP 8.5 under the CanESM2 GCM using the Cal-Adapt boundary selection tool. We then calculated the average change from the baseline temperature for mid and late century under each RCP. Because stream temperatures will generally be buffered from maximum air temperatures, we subtracted one degree Celsius from these average changes and applied the estimated temperature correction to each stream segment. For RCP 4.5 the corrections were 1.0 °C for 2030-2059 and 1.5 °C for 2070-2099. For RCP 8.5 the corrections were 1.4 °C for 2030-2059 and 3.4 °C for 2070-2099.

Finally, our analysis relies on changes in 10-year flood events and average annual precipitation as a correlate for extreme precipitation events that could initiate debris flows, either with or without the aggravating factor of wildfire burn scars. We evaluated the frequency and intensity of extreme precipitation events across HUC 10 watersheds in our analysis units in order to assess the assumption that intense rainfall and flood events are correlated. Extreme precipitation data were taken from the Cal-Adapt website (cal-adapt.org/tools/extreme-precipitation) for six HUC 10 watersheds that corresponded with our analysis units. We used default Cal-Adapt settings for extreme event return period (20 years), event duration (2 days), spatial aggregation (mean), and event definition (lowest value from annual maximum values in the historical period 1960-1990). We used the following 30-year periods: 1960-1990 (baseline), 2034-2064 (mid-century), and 2069-2099 (late-century) based on available statistics for extreme event intensity. We evaluated both intensity (the estimated intensity (return level) of extreme precipitation events) and frequency (the number of extreme precipitation events per water year) of extreme precipitation events. For annual precipitation data, we used the Cal-Adapt boundary selection tool to upload AU shapefiles to aggregate average annual precipitation (mean and range in inches) in each AU and each RCP for the following 30-year periods: 1990-2019, 2030-2059, and 2070-2099.

8.2 FUTURE SCENARIO CONSIDERATIONS

8.2.1 Evaluated Threats

After evaluating current threats described above, we determined that SASD will likely continue to be impacted by all current identified threats. Because future changes in the global climate have the potential to affect a number of current threats, we developed two plausible future scenarios based on the recommended lower and upper bounds for climate change emissions scenarios, Representative Concentration Pathway (RCP) 4.5 and RCP 8.5 at mid-century (2030-2059) and late-century (2070-2099) timepoints (Service 2023, p. 10). These future scenarios examine the same threats as identified in the Current Conditions section including habitat loss, habitat degradation, habitat fragmentation, nonnative species, small population effects, and climate change (specifically changes in fire, stream flows, and stream temperatures). Current threats are predicted to be ongoing based on analysis including climate change models, discussions with species experts and land managers, and review of reports and other literature. Impacts from recreation and other human related impacts (including maintaining current dams that fragment the habitat) are expected to continue in the future, while all climate models predict the main impacts of climate change will continue through the century. Since invasive species are hard to eradicate, we confidently predict impacts from these species will continue in the future, although management decisions will influence the level of impact.

Modeled climate change-related parameters include fire (probability and area at risk of burning), stream flow, and stream temperature. The largest change in these parameters was an increase in the probability of fires in both scenarios (Table D-1) as well as increases in average wintertime flows (Table D-4), 10-year flood magnitude (Table D-5; all summarized in Table 8-1), and average annual precipitation (Table D; all summarized in Table 8-1). The probability of occurrence of one or more fires in an AU over 30 years increased most over baseline conditions in the San Gabriel AU across both scenarios (9% increase by late century for RCP 4.5 and 22% increase by late century for RCP 8.5, Table D-1) and increased least in the Santa Ana AU under RCP 4.5 (2% increase by late century) and San Jacinto AU under RCP 8.5 (12% increase by late century, Table D-1). Mean winter (December, January, February) stream flows increased similarly across AUs for RCP 4.5, with an average increase of 1.4-1.5 times baseline flows at mid-century, and 1.2 times baseline flows at late-century (Table D-4). Average winter flows were higher under RCP 8.5, increasing on average 1.7-1.8 times baseline flows at mid-century, and 1.9-2.3 times baseline flows by late-century (Table D-4). In all cases, the Santa Ana River Mainstem (in the Santa Ana AU) showed the largest increases in winter flows. We see similar trends in the magnitude of 10-year flood events, where a 10-year flood is a flood magnitude that typically occurs only once every 10 years, on average, representing the upper 90th quantile of the maximum annual flood amount. The magnitude of 10-year flood events increased similarly across AUs for RCP 4.5, with an average increase of 1.2-1.4 times baseline events at mid-century, and 1.1-1.2 times baseline events at late century (Table D-5). Flood events were particularly elevated at mid-century for Cajon Creek (1.5x baseline) and Santa Ana River Mainstem (1.9x baseline) in the Santa Ana AU. The magnitude of 10-year flood events was higher under RCP 8.5, increasing on average 1.4-1.7 times baseline events at mid-century, and 1.5-2.1 times baseline events by late-century (Table D-5). The increase in the magnitude of flood events was particularly high across the Santa Ana AU at both mid and late-century (Table D-5), putting SASD occurrences in this unit at elevated risk from high flow events either alone or in combination with fire.

Average annual precipitation was also evaluated for both scenarios (Table 8-1). Both scenarios at both timepoints show increases in precipitation, with precipitation further increasing from mid-century to late-century. Under Scenario 1, average annual precipitation increases range from 6-11% by mid-century and by 21-34% by late-century. Scenario 2 increases are more pronounced, with increases ranging from 13-15% by mid-century and 39-44% by late-century. The increase in winter base flows, stable summer base flows, and more intense 10-year flood events indicate that the increase in precipitation will occur during the winter months, raising the likelihood of debris flows. We evaluated the frequency and intensity of extreme precipitation events across HUC 10 watersheds in our analysis units in order to assess the assumption that intense rainfall and flood events are correlated. Because these data differ across both timesteps (i.e., 30-year periods) and spatial scale (i.e., reach scale for flood events and HUC 10 watersheds for precipitation) we use a qualitative approach for this assessment. As discussed above, the magnitude of 10-year flood events generally increases across AUs in both RCP 4.5 and RCP 8.5. Similarly, the mean number of extreme precipitation events per water year is also projected to increase across watersheds in nearly all cases (Figure D-1). The mean estimated intensity of extreme precipitation events is also generally projected to increase across watersheds under RCP 8.5, with more variable responses under RCP 4.5 (Figure D-2). These trends support a correlation between increasing frequency and intensity of extreme precipitation events in the SASD study area and increasing magnitudes of 10-year flood events, providing support for our use of 10-year flood events in our future scenarios as a proxy for changes in extreme precipitation events that could lead to debris flows. Other modeled climate change-related parameters changed slightly less from their baselines. The 30-year average annual area at risk of burning in each AU was relatively consistent across AUs (i.e., most values are within +/- 100 hectares from baseline), though the San Gabriel AU shows elevated increases in area at risk of burning relative to other AUs in both scenarios, especially by late-century in RCP 8.5 (Table D-2). Mean summer (June, July, August) flows are also relatively stable over time, with small changes under RCP 4.5 and small declines under RCP 8.5 (Table D-3), likely due to stability in base flows as a result of groundwater inputs in these watersheds. Mean annual precipitation increases across all AUs under both scenarios at both time points (Table D-6). Finally, August stream temperatures increased over time over baseline conditions, averaging +1.0°C at mid-century for RCP 4.5 and +1.5°C at late-century; with larger increases for RCP 8.5: +1.4°C at mid-century and +3.4°C at late century (Table D-7).

Table 8-1 summarizes changes to the modeled parameters from the modeled baselines. Data for the seven climate change parameters are provided in Appendix D. Table 8-2 summarizes how changes to the modeled parameters outlined in Table 8-1 are expected to impact threats in both scenarios at both timepoints. Most of the analyzed threats are expected to increase in severity or remain at the current rate of impact (Table 8-2).

Table 8-1. Future Scenario Comparison Table: Change in Parameters from Modeled Baseline.

	Scenario 1: RCP 4.5		**Scenario 2: RCP 8.5**	
Parameter	**Mid century**	**Late century**	**Mid century**	**Late century**
Fire Probability	Slight increase 1-6% increase	Slight increase 2-9% increase	Increase 8-13% increase	Significant increase 12-22% increase
Fire: Area Burned	Stable	Stable	Slight increase	Slight increase
Mean Summer Stream Flows	Stable to Slight decline	Stable to Slight decline	Stable to Slight decline	Stable to Slight decline
Mean Winter Stream Flows	Increase 1.4-1.7 times higher	Increase 1.1-1.4 times higher	Significant increase 1.6-2.2 times higher	Significant increase 1.8-3.2 times higher
10-year Flood Events	Increase 1.1-1.9 times higher	Slight increase 1.0-1.5 times higher	Increase 1.1-2.5 times higher	Significant increase 1.2-3.6 times higher
Aug. Stream Temperatures	1℃ increase Highest temp 24℃	1.5℃ increase Highest temp 24.5℃	1.4℃ increase Highest temp 24.4℃	3.4℃ increase Highest temp 26.4℃
Average Annual Precipitation	Slight increase 6-11% increase	Significant increase 21-34% increase	Increase 13-15% increase	Significant increase 39-44% increase

8.2.2 Scenarios

We forecasted the viability of SASD in terms of resiliency, representation, and redundancy under two plausible future scenarios, a low to moderate greenhouse gas emissions scenario (RCP 4.5) and a high greenhouse gas emissions scenario (RCP 8.5). We forecast the future scenarios at two timepoints (mid-century, 2030-2059, and late-century, 2070-2099) because these time periods are within the range of the available climate change model projections that we used to project changes in stream temperature, stream flow, and fire, and are considered the best available science (Service 2023, pp. 15–16) (Table 8-1). The impacts of projected parameter changes are summarized in Table 8-2. Quantitative changes from the baseline within each AU and/or occurrence are provided for individual parameters in Appendix D.

For each scenario we describe the threats that would occur in each AU. We examine resiliency, representation, and redundancy under each of these two plausible scenarios. In this analysis, population resiliency depends on demographic conditions (including distribution size, population size and connectivity) and the overall amount and quality of habitat that is available. Debris flows caused by heavy precipitation events (primarily wintertime storms that result in flood events) with or without the aggravating impact of wildfire burn scars are a primary threat that influences resiliency for each AU.

We expect each AU to experience changes to the condition of habitat and demographic needs in different ways under the different scenarios. We projected the expected future resiliency of each AU based on the events that may occur under each scenario and then projected an overall condition for each AU. For these projections, AUs in **high condition** are expected to have high resiliency at that time period; i.e., large amount of occupied river miles, high quality habitat, connected occurrences, large abundant populations that can survive adverse conditions. An overall high condition is an indicator of high probability that the population will contribute to species viability. Analysis units in high condition are expected to persist into the future, beyond the end of the century, and have the ability to withstand stochastic events that may occur. Analysis units in **moderate condition** are less resilient, but the majority (approximately 50 to 90 percent) of these individuals are expected to persist beyond late century and the unit is likely to contribute to species viability. A moderate condition is an indicator that the probability of persistence may be compromised by the lack of one or more needs but the unit will still be occupied. Analysis units in moderate condition are smaller and less dense than those in high condition and may have less occupied river miles within their respective unit. Analysis units in **low/moderate condition** have a resiliency in between low and moderate condition. A low/moderate condition is an indicator that the probability of persistence is compromised by the lack of multiple needs but the unit will still be occupied, although persistence is not definite. Finally, those AUs in **low condition** have low resiliency, indicating they have a lower probability of persistence in the region. The unit may not be able to withstand environmental stochasticity, depending on the amount of occupied river miles and the number of extant occurrences. As a result, AUs in low condition are less likely to remain viable until late century and are at higher risk of extirpation.

Table 8-2. Future Scenario Comparison Table: Change in Impact from Current Condition.

	Baseline	**Scenario 1: RCP 4.5**		**Scenario 2: RCP 8.5**	
Parameter	**Current period**	**Mid century**	**Late century**	**Mid century**	**Late century**
Fire Probability	High	Slight Increase	Slight Increase	Increase	Significant Increase
Fire: Area Burned	High	Current Rate	Current Rate	Current Rate	Current Rate
Mean Summer Stream Flows	Low	Current Rate or Slight Decrease	Current Rate or Slight Decrease	Current Rate or Slight Decrease	Current Rate or Slight Decrease
Mean Annual Precipitation	Moderate	Increase	Significant Increase	Increase	Significant Increase
Mean Winter Stream Flows	Moderate	Significant Increase	Increase	Significant Increase	Significant Increase
10-year Flood Events	Moderate	Increase	Slight Increase	Increase	Significant Increase
Summer Stream Temperatures	Moderate	Slight Increase	Slight Increase	Slight Increase	Slight Increase
Habitat Fragmentation	Moderate	Slight Increase	Slight Increase	Slight Increase	Slight Increase
Habitat Loss	Moderate	Current Rate	Current Rate	Current Rate	Current Rate
Habitat Degradation	Moderate	Slight Increase	Slight Increase	Increase	Significant Increase
Nonnative species	Low	Current Rate	Current Rate	Current Rate	Current Rate
Small Population Effects	Moderate	Slight Increase	Increase	Increase	Increase

8.3 SCENARIO 1

Under Scenario 1, a low-moderate emission scenario (RCP 4.5) was used to predict impacts from threats related to climate change at mid and late century (including fire, stream flows, and stream temperatures, see Section 8.1 for more detail). In this scenario, habitat loss, habitat degradation (human recreation activities, mining, roadways, hydrological modifications, and diversions), habitat fragmentation, nonnative species and small population effects continue at the same rate. Impacts from a changing climate are already influencing SASD habitat at all AUs, and are projected to increase in the future under RCP 4.5, albeit less than under RCP 8.5. Based on the climate change projections, impacts from fire (area burned and fire frequency) and stream flow (primarily heavy winter flows and 10-year flood events) are predicted to vary based on the AU, but in general the probability of fire and the magnitude of 10-year flood events will increase. As described above, modeled changes in wintertime base flows and the magnitude of 10-year flood events are proxies for changes in extreme precipitation/wintertime storms. Heavy precipitation events, with or without the aggravating impact of wildfire burn scars, have an outsized influence over future debris flows, which are widely acknowledged to lower resiliency of dace by reducing population size and degrading habitat. The future condition for the four AUs under Scenario 1 is shown in Table 8-3 and 8-4 for mid-century and late-century projections, respectively.

Table 8-3. Future Scenario 1 (RCP 4.5) Mid Century Condition Table.

Analysis Unit	**Amount of Habitat**	**Quality of Habitat**	**Dispersal**	**Size of Population**	**Resiliency**
Los Angeles River	Low	Low/Moderate	Low/Moderate	Low	**Low**
San Gabriel River	Moderate	Low/Moderate	Moderate	Low/Moderate	**Low/Moderate**
Santa Anta River	Moderate	Moderate	Low/Moderate	Moderate	**Moderate**
San Jacinto River	Low	Low/Moderate	Low/Moderate	Low	**Low**

Table 8-4. Future Scenario 1 (RCP 4.5) Late Century Condition Table.

Analysis Unit	**Amount of Habitat**	**Quality of Habitat**	**Dispersal**	**Size of Population**	**Resiliency**
Los Angeles River	Low	Low	Low/Moderate	Low	**Low**
San Gabriel River	Moderate	Low	Moderate	Low	**Low**
Santa Anta River	Moderate	Moderate	Low/Moderate	Moderate	**Moderate**
San Jacinto River	Low	Low/Moderate	Low/Moderate	Low	**Low**

8.3.1 Resiliency

Los Angeles River Analysis Unit

In Scenario 1 at mid-century, the Los Angeles River AU analysis unit continues to be one of the smallest Aus. Though it has only two extant occurrences there are 15 occupied river miles. Invasive species are an ongoing threat that can reduce resiliency, although some efforts have been implemented to reduce this impact. Due to the easy accessibility and proximity to urban areas, human impacts from recreation, dam operations, and garbage dumping outlined above will continue to degrade habitat and reduce connectivity at the current rates. Ongoing efforts are implemented to remove recreational dams and reduce impacts to SASD in this system. However, it is difficult to manage some of these impacts due to proximity to urbanized areas. Based on modeling, mid-century summer flows will decrease slightly while summer water temperatures increase by 1℃, which will slightly lower quality of habitat and amount of habitat (as portions of stream will dry up during summer months and the remaining flow will be warmer). Modeling predicts that the magnitude of 10-year flood events will increase roughly 1.2 times higher than baseline conditions, and winter flows will increase, roughly 1.4 times more than modeled baseline flows. These increased winter flows will help improve habitat conditions, most notably sediment deposits, leading to higher reproductive rates. While increase winter flows can help flush the systems, heavy rainfall events (which can increase winter flows and the magnitude of 10-year flood events) can have devastating impacts on dace and their habitat if they are preceded by fire during the dry months. The model predicts a slight increase in fire probability, with a 3% increase projected above baseline conditions for mid-century. The combination of fire during the dry summer/autumn followed by heavy rainfall could lead to large debris flows that are known to reduce population numbers and habitat quality to the point of localized extirpations within a watershed. While increased threats are projected to reduce resiliency by mid century, compared to current condition, overall resiliency for this AU is maintained as low suggesting that occupancy is maintained but there is still a lower probability of persistence in this unit.

By late century, the changes to threats in Scenario 1 consist of increased fire probability (6% increase above baseline conditions), increased wintertime flows (1.2 times higher), and increases in summer water temperatures of 1.5℃. Fire probability and heavy precipitation (modeled via the magnitude of 10-year floods and wintertime flows) continue to be the two biggest factors influencing dace resiliency in the AU. Compared to mid-century, increases to fire risk and debris flow risk reduce habitat quality and result in slightly lower resiliency. However, resiliency is still considered low by the late century. Therefore, the Los Angeles River AU is projected to have low resiliency at both mid and late century, which means the AU continues to be at risk of extirpation in the future.

Table 8-5. Summary of Los Angeles River AU- Current and Future Scenario 1 (RCP 4.5) Condition Table.

Time Frame	Amount of Habitat	Quality of Habitat	Dispersal	Size of Population	Resiliency
Current	Low	Low/Moderate	Low/Moderate	Low	**Low**
Mid Century	Low	Low/Moderate	Low/Moderate	Low	**Low**
Late Century	Low	Low	Low/Moderate	Low	**Low**

San Gabriel River Analysis Unit

In Scenario 1, at mid-century, the San Gabriel River AU is projected to be impacted by increased probability of fire and elevated precipitation as projected through the magnitude of 10-year flood events, which means an increased risk of debris flows. Fire probability for mid-century increases by 7% over the baseline (the highest increase of any of the four AUs), while the magnitude of 10-year flood events increased by 1.2 times more than the modeled baseline. The impacts from debris flows are well documented in drastically reducing population size or causing local extirpations, especially when occupied areas are small and isolated or there are more frequent fires (shorter fire interval). As described above, without prior impacts from fire, higher winter flows can help flush systems, helping to reset sediment and is generally beneficial to fish abundance. Human impacts from recreation and dam operations will continue to degrade habitat quality and dace connectivity, impacting resiliency. As with Los Angeles River AU, increased water temperatures of 1℃ and slightly lower summertime flows may further degrade habitat quality, although these changes are not considered a major influencer of resiliency. Because of the higher threat of fire and subsequent debris flows after large rainfall events, resiliency is projected to decrease from moderate to low/moderate by mid-century, suggesting that some occupied areas could be lost but that most of the unit is likely to remain occupied.

By late century, the changes to threats in Scenario 1 consist of increase in fire probability (9% increase above baseline conditions), a smaller increase in the magnitude of 10-year flood events, compared to mid-century (1.1 times higher), and an increase in summer water temperatures (1.5℃). Fire probability and increased precipitation events continue to be the two biggest factors influencing SASD resiliency. The resulting debris flow can reduce population size and habitat quality. Compared to mid-century, resiliency will continue to decrease from the increased fire risk and increased magnitude of 10-year flood events from the modeled baseline. Resiliency is projected to decrease from low/moderate at mid-century to low by late-century, such that the AU is at risk of extirpation in the future.

Table 8-6. Summary of San Gabriel River AU- Current and Future Scenario 1 (RCP 4.5) Condition Table.

Time Frame	Amount of Habitat	Quality of Habitat	Dispersal	Size of Population	Resiliency
Current	Moderate	Moderate	Moderate	Moderate	**Moderate**
Mid Century	Moderate	Low/Moderate	Moderate	Low/Moderate	**Low/Moderate**
Late Century	Moderate	Low	Moderate	Low	**Low**

Santa Ana River Analysis Unit

Under Scenario 1, at mid-century, the Santa Ana River AU has the lowest projected increase in fire frequency of all four AUs. Because fire frequency is projected to increase by 1% by mid-century, the positive effects of higher winter flows (on average 1.5 times higher than baseline flows) without fire as described above will help increase the resiliency of the AU by increasing habitat quality, connectivity, and population size of SASD. While the probability of fire risk is mostly unchanged from the modeled baseline (56%), the model still predicts a 57% probability of occurrences of one or more fires in the AU over 30 years. This means the AU resiliency continues to be negatively impacted by the risk of fire, although the risk is only slightly increased from current conditions to mid-century. Impacts from recreation, dam operation, slight decreases in summer flows, and higher August stream temperatures of 1℃ will continue to have similar negative impacts on habitat quality and connectivity. It should be noted that the magnitude of 10-year flood events increase in size by roughly 1.4 times the modeled baseline, indicating extreme precipitation events could still cause debris flows even without prior impacts from a fire. Because of the relatively stable level of fire risk and the potentially beneficial impacts of higher flows in the absence of fire, resiliency is projected to slightly increase to moderate by mid-century.

By late century, the changes to threats in Scenario 1 consist of increases in mean wintertime flows and the magnitude of 10-year flood events (1.2 times higher on average for both) and increases in August stream temperatures by 1.5℃. The most notable exception to changes between the time points is no change in fire probability. This is one of the most important parameters impacting resiliency and there was no projected change. Therefore by late century resiliency is projected to remain at a moderate condition as many of the threats impacting the dace will remain similar or unchanged.

Table 8-7. Summary of Santa Ana AU- Current and Future Scenario 1 (RCP 4.5) Condition Table.

Time Frame	Amount of Habitat	Quality of Habitat	Dispersal	Size of Population	Resiliency
Current	Moderate	Moderate	Low	Low/Moderate	**Low/Moderate**
Mid Century	Moderate	Moderate	Low/Moderate	Moderate	**Moderate**
Late Century	Moderate	Moderate	Low/Moderate	Moderate	**Moderate**

San Jacinto River Analysis Unit

Under Scenario 1, at mid-century, the San Jacinto River AU continues having similar levels of impacts from threats with fire increasing by 3% from modeled baseline, while winter flows and the magnitude of 10-year flood events increased similar to other AUs (1.5 and 1.2 times higher than the baseline on average). Summer temperatures are projected to increase by 1℃ and summer flows are slightly decreased, both of which are not projected to have a major negative impact on resiliency. As noted above, with the absence of fire, higher winter flows are known to have generally beneficial effects on SASD, including higher population numbers, connectivity, amount and quality of habitat. The fire probability for San Jacinto is second lowest of the AUs at mid-century (63%), with Santa Ana AU having the lowest fire risk (57%). The combination of fire during the dry summer/autumn followed by heavy wintertime precipitation could lead to large debris flows that are known to reduce population numbers and habitat quality and cause localized extirpations within a watershed. Small isolated populations would also increase risks of small population effects. While resiliency for the AU is maintained as low, the slight increase in threats lowers the predicted resiliency compared to current condition.

At the late-century timepoint, fire probability decreases by 1%, making it 2% higher than the original modeled baseline of 60%. Winter stream flows and 10-year flood events (1.2 and 1.1 times higher than baseline on average) and summer stream temperatures continue to increase (by 1.5℃) similar to other AUs. Compared to mid-century, a slight decrease to fire risk and an increase in winter flows slightly raises resiliency, although resiliency is still considered low by late century. It should be noted that the magnitude of 10-year flood events increase in size by roughly 1.4 times the modeled baseline, indicating extreme precipitation events could still cause debris flows even without prior impacts from a fire. Other threats described above in the threats section (Chapter 6) are expected to continue at the current rate, limiting the resiliency of the AU. This AU, at both a mid and late century, is projected to have low resiliency, which means the AU continues to be at risk of extirpation in the future.

Table 8-8. Summary of San Jacinto River AU- Current and Future Scenario 1 (RCP 4.5) Condition Table.

Time Frame	Amount of Habitat	Quality of Habitat	Dispersal	Size of Population	Resiliency
Current	Low	Low/Moderate	Low/Moderate	Low	**Low**
Mid Century	Low	Low/Moderate	Low/Moderate	Low	**Low**
Late Century	Low	Low/Moderate	Low/Moderate	Low	**Low**

8.3.2 Representation

In this scenario, adaptive capacity is further reduced from historical levels with impacts to the four AUs that represent the last remnants of the species' historical range (the headwaters of four river systems). The San Gabriel River AU is projected to become more degraded by the increased risk of fire and high rainfall events, reducing dispersal capacity and evolutionary potential within the current stronghold AU. The Santa Ana River AU has the best chance of maintaining current habitat and population sizes as the increase in fire risk is minimal, though not zero. The least resilient AUs, the San Jacinto River and Los Angeles River, are likely to remain small due to increased fire risk. In summary, ongoing reductions in habitat quantity, habitat quality, connectivity, and population sizes will continue degrading representation rangewide, contributing to reduced ability to adapt to changing conditions in the future under this scenario.

8.3.3 Redundancy

In this scenario, all four AUs are projected to remain extant, though reduced resiliency and representation keep dace populations at high risk of extirpation from catastrophic events. Though the distribution remains spread over four river systems, dace generally occur in the upper tributaries where there is a limited capacity to recover from high consequence events, such as fires, droughts, and debris flows. Two of the AUs with lower resiliency are more at risk of stochastic and catastrophic events and the loss of either of these would significantly reduce redundancy. The remaining two AUs are significantly larger and less likely to become extirpated from stochastic or catastrophic events. The magnitude (i.e., flow levels) of 10-year flood events, representing potentially catastrophic events that could extirpate dace occurrences, are 1.1 to 1.9 times higher than baseline 10-year flood events by mid-century (Appendix D, Table D-5). In particular, Cajon Creek and the Santa Ana River Mainstem in the Santa Ana AU are projected to see flooding at 1.5 and 1.9 times baseline flood levels, respectively, placing these occurrences at higher risk of extirpation. By late century, reduced emissions under RCP 4.5 lower the magnitude of 10-year flood events to 1.0-1.5 times baseline flood levels, slightly reducing the risk of extirpation due to debris flows caused by storms. Overall, it is unlikely that catastrophic events such as floods and subsequent debris flows would impact all AUs, though some are at higher risk than others.

8.4 SCENARIO 2

Under Scenario 2, a high emission scenario (RCP 8.5) was used to evaluate impacts from threats related to climate change at mid and late century (including fire, stream flows, and stream temperatures, see Section 8.1 for more detail). In this scenario, habitat loss, habitat degradation (human recreation activities, mining, roadways, hydrological modifications and diversions), habitat fragmentation, nonnative species and small population effects continue at the same rate. Impacts from a changing climate are already influencing SASD at all AUs, and the future impacts under RCP 8.5 will continue to increase. Based on the climate change projections, impacts from fire and flows are predicted to increase the probability of fire and increase the magnitude of 10-year flood events. As described above, modeled changes in wintertime base flows and the magnitude of 10-year flood events are proxies for changes in extreme precipitation/wintertime storms. Heavy precipitation events, with or without the aggravating impact of wildfire burn scars, have an outsized influence over future debris flows, which are widely acknowledged to lower resiliency of dace by reducing population size and degrading habitat. The future condition for the four AUs under Scenario 2 is shown in Table 8-9 and Table 8-10.

Table 8-9. Future Scenario 2 (RCP 8.5) Mid Century Condition Table.

Analysis Unit	Amount of Habitat	Quality of Habitat	Dispersal	Size of Population	Resiliency
Los Angeles River	Low	Low	Low/Moderate	Low	**Low**
San Gabriel River	Moderate	Low	Low/Moderate	Low	**Low**
Santa Anta River	Moderate	Low/Moderate	Low/Moderate	Low	**Low**
San Jacinto River	Low	Low	Low/Moderate	Low	**Low**

Table 8-10. Future Scenario 2 (RCP 8.5) Late Century Condition Table.

Analysis Unit	Amount of Habitat	Quality of Habitat	Dispersal	Size of Population	Resiliency
Los Angeles River	Low	Low	Low/Moderate	Extirpated	**Extirpated**
San Gabriel River	Low/Moderate	Low	Low	Low	**Low**
Santa Anta River	Low/Moderate	Low	Low	Low	**Low**
San Jacinto River	Low	Low	Low/Moderate	Extirpated	**Extirpated**

8.4.1 Resiliency

Los Angeles River Analysis Unit

In Scenario 2, at mid-century, modeling predicts the Los Angeles River AU will be negatively impacted by increased fire probability, which increases by 11%, almost 4 times higher than Scenario 1 (3% increase). The increase in fire probability coupled with the higher magnitude of 10-year flood events (1.4 times higher than baseline) increases the possibility of debris flows, including multiple debris flows occurring over a short interval of a few years. These debris flows significantly reduce the resiliency of this AU by lowering habitat quality and population numbers, especially since there are currently only two occurrences, both of which have low abundance. Modeling also predicts the average summer temperatures increase by 1.4℃ and summer flows will also slightly decrease, both of which further lower resiliency. Due to the easy accessibility and proximity to urban areas, human impacts from recreation, dam operations, and garbage dumping outlined above will continue to degrade habitat and reduce connectivity at the current rates. Management actions have been successful to limit impacts in localized areas, but impacts will be hard to control due to proximity to urbanized areas. Threats for this AU are worse under Scenario 2 than compared to Scenario 1. While resiliency for the AU is maintained as low, the increase in threats lowers the predicted resiliency compared to current condition.

By late century, the changes to threats in Scenario 2 consist of a significant increase in the probability of fire (19% increase) as well as a higher magnitude of 10-year flood events (1.5 times higher than baseline) compared to mid-century. Summer temperatures increase by 3.4℃, the highest increase of any analyzed scenario timepoint, but water temperatures stay below the estimated conservative threshold of 26-28℃, when SASD are thought to become stressed. Resiliency is projected to be low in the AU by mid century and the AU is projected to become extirpated by late century.

Table 8-11. Summary of Los Angeles River AU- Current and Future Scenario 2 (RCP 8.5) Condition Table.

Time Frame	Amount of Habitat	Quality of Habitat	Dispersal	Size of Population	Resiliency
Current	Low	Low/Moderate	Low/Moderate	Low	**Low**
Mid Century	Low	Low	Low/Moderate	Low	**Low**
Late Century	Low	Low	Low/Moderate	Extirpated	**Extirpated**

San Gabriel River Analysis Unit

In Scenario 2 at mid-century, the San Gabriel River AU has low resiliency as a direct result of increased fire probability and higher magnitude 10-year flood events increasing the risk and severity of debris flows. Fire probability for mid-century increases by 14% over the baseline (the highest increase of any of the four AUs), while 10-year flood events increase 1.4 times over the baseline. The impacts from debris flows after heavy rainfall are well documented in drastically reducing population size if not extirpating impacted occurrences, especially when small and isolated or the fire interval is short. Human impacts from recreation and dam operations are hard to prevent and will continue to degrade habitat quality and dace connectivity, impacting resiliency. As with the other AUs, increased water temperatures of 1.4℃ and slightly lower summertime flows will further degrade habitat quality, although these changes are not considered a major influencer of resiliency. Because of the higher threat of fire and subsequent debris flows, resiliency drops to low by mid-century.

By late century, the changes to threats in Scenario 2 consist of increased fire probability (9% increase above baseline conditions), further increased magnitude of 10-year flood events (1.7 times higher than baseline), and the highest increases in August water temperatures of 3.4℃ (highest temperature is projected at 22.9℃, below the estimated threshold of 26-28℃). Fire probability and debris flows continue to be the two biggest factors influencing SASD resiliency in the AU by reducing population size and habitat quality. Compared to mid-century, increases to both fire risk and the higher magnitude of 10-year flood events lowers resiliency further, with resiliency maintaining at low condition by the late century. This AU, at both mid and late century, is projected to have low resiliency, which means the AU is at risk of extirpation in the future.

Table 8-12. Summary of San Gabriel River AU- Current and Future Scenario 2 (RCP 8.5) Condition Table.

Time Frame	Amount of Habitat	Quality of Habitat	Dispersal	Size of Population	Resiliency
Current	Moderate	Moderate	Moderate	Moderate	**Moderate**
Mid Century	Moderate	Low	Low/Moderate	Low	**Low**
Late Century	Low/Moderate	Low	Low	Low	**Low**

Santa Ana River Analysis Unit

Under Scenario 2 at mid-century, the Santa Ana River AU has significantly higher increase in fire probability compared to Scenario 1 (9% vs 1% increase). As described before, the increase in fire probability and the magnitude of 10-year flood events (1.7 times higher than baseline) increases the likelihood of debris flows which have significant deleterious effects on resiliency by lowering habitat quality and population sizes. Impacts from recreation, dam operation, slight decreases in summer flows, and higher August stream temperatures of 1.4℃ will continue to have similar negative impacts on habitat quality and connectivity. Because of the elevated risk of fire and debris flows, resiliency slightly decreases to low by mid-century.

By late century, the changes to threats in Scenario 2 consist of increases in mean wintertime flows and increases in August stream temperatures by 3.4℃, with three streams crossing the 26-28℃ threshold (with the highest being 26.4℃). Fire probability increases by 15% over modeled baseline conditions and the magnitude of 10-year flood events increases 2.1 times higher than baseline making the threat of debris flows higher. Resiliency maintains a low condition although impacts from threats become more acute. This AU, at both mid and late century, is projected to have low resiliency, which means the AU is at risk of extirpation in the future.

Table 8-13. Summary of Santa Ana AU- Current and Future Scenario 2 (RCP 8.5) Condition Table.

Time Frame	Amount of Habitat	Quality of Habitat	Dispersal	Size of Population	Resiliency
Current	Moderate	Moderate	Low	Low/Moderate	**Low/Moderate**
Mid Century	Moderate	Low/Moderate	Low/Moderate	Low	**Low**
Late Century	Low/Moderate	Low	Low	Low	**Low**

San Jacinto Analysis Unit

Under Scenario 2 mid-century, the San Jacinto River AU has elevated fire probability increasing by 8% from modeled baseline, while the magnitude of 10-year flood events was 1.4 times higher than baseline (Table D-5). August temperatures rise by 1.4℃ and summer flows slightly decrease, both of which are not projected to have a major negative impact on resiliency. The combination of fire during the dry summer/autumn followed by heavy wintertime precipitation events and 10-year flood events would lead to large debris flows that are known to reduce population numbers and habitat quality to the point of localized extirpations within a watershed. Small, isolated populations (like those in this AU) may suffer from inbreeding effects associated with small populations. While resiliency for the AU is maintained as low, the increase in threats lowers the predicted resiliency compared to the current condition.

At the late century timepoint, fire probability is 12% higher than the original modeled baseline. The magnitude of 10-year flood events (1.7 times higher than baseline) and August stream temperatures continue to increase (by 3.4℃) similar to other AUs. Compared to mid-century, an increase to fire risk and an increase in the magnitude of 10-year flood events decreases resiliency, with extirpation considered likely by late century. Other threats described above in the threats section (Section 6) are expected to continue at the current rate, limiting the resiliency of the AU.

Table 8-14. Summary of San Jacinto River AU- Current and Future Scenario 2 (RCP 8.5) Condition Table.

Time Frame	Amount of Habitat	Quality of Habitat	Dispersal	Size of Population	Resiliency
Current	Low	Low/Moderate	Low/Moderate	Low	**Low**
Mid Century	Low	Low	Low/Moderate	Low	**Low**
Late Century	Low	Low	Low/Moderate	Extirpated	**Extirpated**

8.4.2 Representation

Due to the heightened threats described in Scenario 2, the trajectory for projected loss of representation relative to historical and current conditions is more severe when compared to Scenario 1. This is driven by the potential extirpation of two of the four AUs, which represent the most southern and most western populations. These extirpations would represent complete loss of evolutionary lineages and occupancy of potentially unique habitats across the species' range. These decreases in the species' range would limit recovery potential as genetic and phenotypic diversity and the corresponding adaptive capacity in these AUs would be permanently lost.

8.4.3 Redundancy

As with adaptive capacity, the extirpation of two AUs by late century and low condition for all AUs at mid-century points to a sharp drop in redundancy across the species' range. In addition to reductions in resiliency, all AUs face elevated risks from high magnitude 10-year flood events at both mid and late-century, which correlates to higher risk of debris flows. In particular, all eight current occurrences within the Santa Ana AU will see 10-year flood events that are 1.4-2.5 times baseline flood levels at mid-century, placing the entire AU at risk from catastrophic debris flow events from extreme precipitation events. By late century, the magnitude of 10-year flood events is 1.2-3.6 times baseline flood flows rangewide, with almost all occurrences facing significantly higher 10-year flood levels, elevating AU-wide extirpation risks. Combined with reduced resiliency, these increases in potentially catastrophic flood events (and resulting debris flows from storms) indicate that at least two AUs are likely to be extirpated under Scenario 2 by late-century.

8.5 SUMMARY OF FUTURE CONDITIONS

We used the best available information to evaluate the future conditions of SASD. Our results describe the upper and lower plausible bounds of future viability for the dace in terms of resiliency, representation, and redundancy (Table 8-15). Species viability is also broken down in Table 8-16 and Table 8-17, showing species needs and current and future conditions.

The SASD faces a variety of risks from future habitat loss and degradation, habitat fragmentation, predation, small population effects, and continued impacts from climate change (flooding, drought). These risks, and the level at which they act upon the various populations, play a large role in the future viability of the species. Under the lower emissions climate change scenario (Scenario 1, RCP 4.5) only one of three analytical units will be likely to persist at moderate levels through stochastic environmental and demographic disturbances through late century. Note, San Gabriel River AU is projected to be the most susceptible to fire, which is likely caused by the AU being heavily forested. In contrast, the threat of fire is not projected to be as severe in the Santa Ana AU, because of increased development and reduced fuel loads in the AU. Reduced resiliency rangewide will contribute to ongoing reductions in adaptive capacity and keep populations at high risk of extirpation from catastrophic events due to very limited capacity to respond and recover from high consequence events, such as fire, drought, and debris flows caused by heavy precipitation events. Under the higher emissions climate change scenario (Scenario 2, RCP 8.5), two analytical units are projected to be extirpated by late century, with two units remaining in low condition. Losses of redundancy and representation due to extirpation of two analytical units will dramatically reduce overall species viability. Overall, future species resiliency is projected to be low, representation will remain limited, and limited redundancy will keep the species at high risk from catastrophic events.

Table 8-15. Current and Future Condition Category Comparison Table

Analysis Unit	Current	Future Scenario 1 Mid Century	Future Scenario 1 Late Century	Future Scenario 2 Mid Century	Future Scenario 2 Late Century
Los Angeles River	Low	Low	Low	Low	Extirpated
San Gabriel River	Moderate	Low/Moderate	Low	Low	Low
Santa Anta River	Low/Moderate	Moderate	Moderate	Low	Low
San Jacinto River	Low	Low	Low	Low	Extirpated

Table 8-16. Summary of Species Viability broken down by Species Needs and Current and Future Conditions.

Species Viability	Needs	Current Condition	Future Scenario 1	Future Scenario 2
Resiliency	Maintain adequate flows of cool, clear water. Able to disperse as well as withstand stochastic events including fire, flooding, and drought.	High water quality is seasonally available, with flows decreasing throughout the summer, making dispersal hard or impossible. Populations survive in remaining pools during drought conditions.	Threats related to human activities persist, lowering resiliency. Risk of debris flows is increased by the combination of increased fire probability and high winter flows. Debris flows greatly reduce resiliency.	Resiliency further reduced by higher risks of debris flows caused by the combination of increased fire probability and high winter flows. Threats related to human activities persist, lowering resiliency.
Redundancy	Occupy resilient AUs in different river systems throughout range.	Four AUs in different river systems throughout it's known range. Large reductions relative to historical redundancy. Not all populations are resilient, including San Jacinto.	Four AUs in different water sheds throughout it's known range. Overall reduced resiliency including low condition AUs, San Jacinto River and Los Angeles River.	Half of extant AUs are lost, including the most spatially distinct AU. Remaining two AUs have low resiliency.
Representation	Maintain remaining adaptive capacity by conserving all four remaining AUs; improve connectivity to reduce isolation effects.	Four AUs in the headwaters of 3 mountain ranges. Large reductions relative to historical representation; constraints on dispersal capacity, evolutionary potential and plasticity combined with low to moderate resiliency.	Four populations in the headwaters of 3 mountain ranges. Populations have reduced resiliency ranging from low to moderate. Southernmost and westernmost AUs have lowest resiliency.	Representation is lower than in Scenario 1 or current condition. The most spatially distinct AU and presumably most genetically diverse AU is lost (San Jacinto River).

Table 8-17. Summary of Species Viability broken down by the 3 R's for Current and Future Conditions.

3 R's	**Current Condition**	**Mid-Century (2030-2059)**		**Late Century (2070-2099)**	
-		**Scenario 1**	**Scenario 2**	**Scenario 1**	**Scenario 2**
Resiliency	Low/Moderate	No change	Decrease among all AUs	Slight reduction	Substantial reduction (Reduced to 2 AUs)
Redundancy	Substantial reduction from historical (4 AUs)	No change	Reduced	No change	Substantial reduction (Reduced to 2 AUs)
Representation	Substantial reduction from historical (3 mountain ranges)	No change	Reduced	Slight reduction	Substantial reduction
Viability	**LOW TO MODERATE**	**LOW TO MODERATE**	**LOW**	**LOW**	**LOW TO EXTINCTION**

CHAPTER 9. OVERALL SYNTHESIS AND SUMMARY

The historical distribution of SASD once extended across the upland and middle reaches of the Los Angeles, San Gabriel, Santa Ana, and San Jacinto rivers (Figure 4-2). These systems were historically connected in the alluvial plain during flood events, allowing for connectivity among watersheds. Additionally, these areas provided suitable habitat as well as refuge for populations during stochastic and catastrophic events such as fire, drought, and debris flows. The historical viability afforded to dace by this diversity and extent of available habitats has been permanently lost to development and other human impacts in the lower reaches of these watersheds. Impacts of these changes from historical to current conditions on SASD include substantial reductions in currently available habitat, reduced quality of remaining available habitat, minimal to no connectivity among occupied river occurrences within and among watersheds and presumed small population sizes based on declining detections over time and/or small numbers of observed fish. This historical context for the current status of SASD sets the stage for its overall reduced capacity to withstand environmental and demographic stochasticity and disturbances (resiliency), catastrophic events (redundancy), and novel changes in its biological and physical environment (representation).

The current condition of SASD populations varies among the four AUs, with the San Gabriel AU retaining the most high-quality and intact habitat across the range, and moderate resiliency. Relative to other AUs, this unit is more connected, though dispersal is limited among some occurrences due to development. Despite the availability of higher quality habitat, dace populations are at low abundance in this AU but appear to be relatively stable. By contrast, the Los Angeles AU has limited habitat availability with degraded habitat quality and limited connectivity, and low resiliency. Dace populations appear to be consistent at low but stable numbers. The Santa Ana AU has the most known occurrences and most occupied river miles, and low/moderate resiliency. However, these populations are isolated by overall low flows and populations are small with few observed records. Finally, the San Jacinto AU is less impacted by human disturbance relative to the other units, but available habitat is limited and only one small population is thought to remain extant, resulting in low resiliency. Rangewide, this overall low habitat availability combined with low quality in many units, limited connectivity, and small population sizes reduce the ability of populations to withstand environmental and demographic stochasticity. This low to moderate resiliency across the four extant units in addition to significant losses across the historical range contributes to reduced adaptive capacity for dace populations, limiting their ability to respond to novel changes in the environment. Small population sizes not only increase risks from demographic and environmental stochasticity but also reduce the genetic and trait diversity that supports evolutionarily adaptive and plastic responses to change. Lack of connectivity and limited habitat availability also reduce the ability of populations to shift in space in response to change. The species is currently limited to 17 occurrences across four river systems, which provides some level of redundancy against large catastrophic events. Low to moderate resiliency combined with limited representation and reduced redundancy indicate that SASD has reduced species viability relative to historical conditions and an overall low to moderate ability to sustain populations in the wild over time (i.e., viability) under current conditions. These are the baselines used when projecting future conditions.

Future scenarios for SASD populations point to a continuation of conditions that will further degrade the viability of the species. Under a low to moderate emissions climate change scenario (Scenario 1, RCP 4.5) only one of three analytical units will be likely to persist at moderate levels through stochastic environmental and demographic disturbances through late century. Reduced resiliency rangewide will contribute to ongoing reductions in adaptive capacity and keep populations at high risk of extirpation from catastrophic events due to limited capacity to respond and recover from high consequence events, including increased fire and debris flows. Under a higher emissions climate change scenario (Scenario 2, RCP 8.5), two analytical units are projected to be extirpated by late century, with two units remaining in low condition. All units will face elevated risks of extirpation from high-magnitude flood events and continued impacts from threats described in Chapter 6. Current threats will continue to degrade and limit habitat, decrease dace abundance, and limit connectivity. Losses of redundancy and representation due to extirpation of two analytical units will dramatically reduce overall species viability. Overall, future species resiliency is projected to be low, representation will remain very limited, and limited redundancy keeps the species at high risk from catastrophic events. Thus, SASD will have very low capacity to sustain populations in the wild in the future, reducing viability and elevating extinction risk.

9.1 ASSUMPTIONS

Because we lack demographic data and systematic abundance surveys for SASD populations, we used four metrics representing habitat and demographic needs as proxies for population resiliency: amount of habitat, quality of habitat, connectivity, and population size. We assume that these metrics correspond to species viability such that higher amounts and quality of habitat, improved connectivity, and larger population sizes will lead to higher levels of fecundity, juvenile survival, and population abundance (influencing resiliency and representation), greater connectivity among populations (influencing resiliency, representation, and redundancy), and more widely distributed populations (influencing resiliency, representation, and redundancy). Similarly, if the amount and quality of habitat decline, connectivity is reduced, and population sizes decline, we would expect reduced fecundity, survival, and population abundance, reduced connectivity among populations (reducing gene flow and potential demographic rescue), and constrained or retracting population distributions. Finally, we evaluated the frequency and intensity of projected extreme precipitation events to assess the assumption that intense rainfall and flood events are correlated. Trends among these data sets support a correlation between increasing frequency and intensity of extreme precipitation events in the SASD study area and increasing magnitudes of 10-year flood events, providing support for our use of 10-year flood events in our future scenarios as a proxy for changes in extreme precipitation events that could lead to debris flows.

9.2 UNCERTAINTIES

The primary uncertainties in our analysis of SASD viability relate to data deficiencies. For example, sampling has not been exhaustive across potential dace habitat, so it is possible that additional extant populations persist across the range. These unknown populations could contribute to species viability within and across AUs. However, due to the number and geographic distribution of surveys to date, it is unlikely that a large number of unknown robust populations exist such that species-level viability would be significantly changed from the current assessment.

Finally, though we have estimated and qualitative assessments of threat impacts on dace populations, we often lack specific quantitative information on critical thresholds. Quantitative data could allow for more precise estimates of current and future impacts, as well as potential synergistic interactions among threats. However, it is unlikely that these more precise estimates would change the directionality or significantly alter the magnitude of estimated impacts on dace viability.

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APPENDICES

APPENDIX A: LAND OWNERSHIP OF OCCUPIED RIVER MILES

Analysis Unit	Grand Total	Percent	Federal	Tribal	Local Government	Private	Unknown
Los Angeles River		**19.6%**					
Within USFS boundary, NON-FS	3.63	24%			0.49	2.77	0.38
Within USFS boundary, USFS	5.91	39%	5.91				
Outside USFS boundary	5.44	36%	1.95		3.28	0.21	
Los Angeles Total	**14.98**		**7.86**	**-**	**3.76**	**2.98**	**0.38**
San Gabriel River		**35.8%**					
Within USFS boundary, NON-FS	2.23	8%				1.79	0.44
Within USFS boundary, USFS	24.82	91%	24.82				
Outside USFS boundary	0.26	1%				0.26	
San Gabriel Total	**27.31**		**24.82**	**-**	**-**	**2.05**	**0.44**
San Jacinto River		**3.7%**					
Within USFS boundary, NON-FS	0						
Within USFS boundary, USFS	0.30	11%	0.30				
Outside USFS boundary	2.51	89%		2.51			
San Jacinto Total	**2.81**		**0.30**	**2.51**	**-**	**-**	**-**
Santa Ana River		**40.9%**					
Within USFS boundary, NON-FS	7.49	24%				6.94	0.55
Within USFS boundary, USFS	21.50	69%	21.50				
Outside USFS boundary	2.20	7%			0.24	1.95	0.01
Santa Ana Total	**31.20**		**21.50**	**-**	**0.24**	**8.90**	**0.57**
Grand Total	**76.29**	**100%**	**54.47**	**2.51**	**4.00**	**13.92**	**1.39**

APPENDIX B – SANTA ANA SPECKLED DACE OCCURRENCE INFORMATION

Data from reports cited in text. Hypothesized occupancy status is based on the most recently available information; orange font indicates possible extirpations and red font indicates known extirpations. Majority landowner listed first.

Analysis Unit	Occurrences	Current Status	Occupied Length (Stream Miles)	Estimated Abundance	Last Year Observed	Ownership
Los Angeles River	Haines Creek	Extant	1.52	Low	2022	ACOE Local
Los Angeles River	Lower Big Tujunga Creek	Extant	13.47	Low	2022	USFS Local Private ACOE
San Gabriel River	Fish Canyon Creek	Possibly Extirpated	0.71	Low	2016	Private
San Gabriel River	West Fork San Gabriel River	Extant	8.69	High	2022	USFS
San Gabriel River	North Fork San Gabriel River	Extant	4.14	Moderate	2022	USFS
San Gabriel River	East Fork San Gabriel River	Extant	9.79	Moderate	2022	USFS Private
San Gabriel River	Bear Creek	Extant	3.37	Moderate	2022	USFS
San Gabriel River	Cattle Canyon Creek	Extant	0.61	Low	2022	USFS
Santa Ana River	Lytle Creek	Extant	6.73	High	2021	USFS Private
Santa Ana River	Cajon Creek	Extant	3.97	High	2021	USFS Private
Santa Ana River	City Creek	Extant	5.34	High	2022	USFS Private

Santa Ana River	Strawberry/ East Twin Creek	Extirpated	-	Extirpated		USFS
Santa Ana River	Plunge Creek	Extant	4.89	High	2023	USFS Private
Santa Ana River	Waterman Creek	Extant	2.38	Moderate	2021	Private
Santa Ana River	Fredalba Creek	Extant*	3.13	Moderate	2021	USFS
Santa Ana River	Hemlock Creek	Extant*	3.30	Moderate	2022	USFS
Santa Ana River	Santa Ana River Mainstem	Extant*	1.31	Low	2022	USFS Private
Santa Ana River	Silverado Canyon	Extirpated	-	Extirpated	1987	USFS
Santa Ana River	Santiago Creek	Extirpated	-	Extirpated	2000	USFS
San Jacinto River	San Jacinto River-North Fork	Possibly Extirpated*	5.50	-	2020	USFS
San Jacinto River	San Jacinto River-South Fork	Possibly Extirpated	7.52	-	2020	USFS Private
San Jacinto River	Stone Creek	Possibly Extirpated*	0.88	-	2020	USFS
San Jacinto River	Indian Creek	Extant	2.80	Moderate	2018	Tribal USFS

* Reintroduced

APPENDIX C: REGULATORY MECHANISMS

Regulatory mechanisms thought to have some potential to protect SASD include: (1) California Endangered Species Act (CESA) (where the dace occurs with State-listed species), (2) California Environmental Quality Act (CEQA), (3) National Environmental Policy Act (NEPA), (4) CWA, (5) the Act (where SASD co-occurs with other federally-listed species), and (6) land management or conservation measures by Federal, State, or local agencies or by private groups and organizations. Each of these regulatory mechanisms provide some level of support to help protect SASD throughout its range. Several State and Federal mechanisms provide a conservation benefit to the Santa Ana sucker, as described in the following paragraphs, which also provide a benefit to SASD where the species co-occur.

State Protections in California

The State's authority to conserve rare fish and wildlife is contained within three major statutes: CESA, CEQA, and the Natural Community Conservation Planning (NCCP) Act. The primary law in California for regulating water quality is the California Porter-Cologne Act of 1969. Another relevant program, the California Lake and Streambed Alteration Program, which is overseen by the CDFG concerns aquatic habitat conservation.

California Endangered Species Act (CESA)

The State of California considers SASD a "species of special concern." The SASD is not listed as endangered or threatened by the State, and "species of special concern" are afforded no protection under CESA (CDFG Code, section 2080 *et seq*.). When a project has no Federal nexus, SASD may potentially receive some indirect protection under CESA when occurring in close proximity to other species that are listed under CESA. These protections are similar to protection afforded by the Act and may include consultation and project planning to avoid potential impacts. State-listed species known to occur within or near stream/river reaches occupied by populations of SASD include Santa Ana sucker (*Catostomus santaanae*), southwestern willow flycatcher (*Empidonax traillii extimus*), least Bell's vireo (*Vireo bellii pusillus*), and yellow billed cuckoo (*Coccyzus americanus*).

California Environmental Quality Act (CEQA)

CEQA (California Public Resources Code 21000–21177) is the principal statute mandating environmental assessment of projects in California. The purpose of CEQA is to evaluate whether a proposed project may have an adverse effect on the environment and, if so, to determine whether that effect can be reduced or eliminated by pursuing an alternative course of action or through mitigation. CEQA applies to projects proposed to be undertaken or requiring approval by State and local public agencies and requires disclosure of potential environmental impacts and a determination of "significant" if a project has the potential to reduce the number or restrict the range of a rare or endangered species. However, projects may move forward if there is a statement of overriding consideration. If significant effects are identified, the lead agency has the option of requiring mitigation through changes in the project or to decide that overriding considerations make mitigation infeasible (Public Resources Code 21000; CEQA Guidelines at California Code of Regulations, Title 14, Division 6, Chapter 3, Sections 15000–15387).

Natural Community Conservation Planning (NCCP) Act

In 1991, the State of California passed the NCCP Act to address the conservation needs of natural ecosystems throughout the State (CFG 28002835). The NCCP program is a cooperative effort involving the State of California and numerous private and public partners to protect regional habitats and species. The primary objective of NCCPs is to conserve natural communities at the ecosystem scale while accommodating compatible land uses. NCCPs help identify, and provide for, the regional- or area-wide protection of plants, animals, and their habitats while allowing compatible and appropriate economic activity. Many NCCPs are developed in conjunction with Habitat Conservation Plans (HCPs) prepared pursuant to the Act. Regional NCCPs may provide protection to federally-listed species by conserving native habitats upon which the species depend. The plans that currently provide the most significant protection to SASD are the Upper Santa Ana River Wash HCP and the Western Riverside County Multiple Species HCP.

The California Porter-Cologne Act of 1969

The primary law regulating water quality in California is the California Porter-Cologne Act of 1969 (Section 13000 *et seq.*, California Water Code). This Act designates authority over surface water and groundwater quality to the State Water Resources Control Board and the nine Regional Water Quality Control Boards and applies to surface waters, wetlands, and groundwater and to both point and nonpoint sources of pollution. Under the Porter-Cologne Water Quality Control Act (California Water Code, Division 7, Chapter 2 §13050), 23 beneficial uses and water quality objectives are established for all waters of the State, both surface and subsurface (groundwater). Of these 23 beneficial uses, several definitions may be relevant to indirectly benefit SASD through Santa Ana sucker conservation, including (but not limited to): warm freshwater habitat; cold freshwater habitat; rare, threatened, and endangered species waters; and spawning, reproduction, and development waters (CRWQCB 2008, pp. 3-3–3-4). Three of the four definitions exist within occupied reaches of the Santa Ana River (warm freshwater habitat; rare, threatened, and endangered species waters; and spawning, reproduction, and development waters) (CRWQCB 2008, p. 3-25). The regulations allow more than one beneficial use to be identified for a given water body, although the most sensitive use must be protected. The Regional Board, however, has the final say in resolving conflicts among beneficial uses based on the facts in a given case (CRWQCB 2008, p. 3-4).

California Lake and Streambed Alteration Program

The Lake and Streambed Alteration Program (CDFG Code sections 1600-1616) may promote the recovery of listed species in some cases. This program provides a permitting process to reduce impacts to fish and wildlife from projects affecting important water resources of the State, including lakes, streams, and rivers. This program also recognizes the importance of riparian habitats to sustaining California’s fish and wildlife resources, including listed species, and helps prevent the loss and degradation of riparian habitats. Therefore, potential projects that may substantially modify a river, stream, or lake would be evaluated and must comply with CEQA.

Federal Protections

Rivers and Harbors Act

The Rivers and Harbors Act of 1899 is the oldest environmental law in the United States. Section 9 regulates the construction of bridge, dam, dike, or causeway over or in navigable waterways of the United States without Congressional approval. Section 10 regulates the obstruction or alteration of any navigable water of the United States, such as building of any wharf, pier, jetty, or other structure without Congressional approval. The U.S. Coast Guard and Army Corps of Engineers (ACOE) authorize such actions, respectively. This Federal regulation prohibits the use of Federal funds for activities, which may have an adverse effect on those characters which cause a river to be classified as wild, scenic, or recreational. SASD may benefit indirectly from this regulation because portions of its occupied range (within the San Gabriel River watershed) are considered wild and scenic.

National Environmental Policy Act (NEPA)

All Federal agencies are required to adhere to the NEPA of 1970 (42 U.S.C. 4321 *et seq.*) for projects they fund, authorize, or carry out. Prior to implementation of such projects with a Federal nexus, NEPA requires the agency to analyze the project for potential impacts to the human environment, including natural resources. The Council on Environmental Quality's regulations for implementing NEPA state that agencies shall include a discussion on the environmental impacts of the various project alternatives (including the proposed action), any adverse environmental effects that cannot be avoided, and any irreversible or irretrievable commitments of resources involved (40 CFR part 1502.16). Its public notice provisions provide an opportunity for the Service and others to review proposed actions and provide recommendations to the implementing agency. NEPA does not impose substantive environmental obligations on Federal agencies—it merely prohibits an uninformed agency action. However, if an Environmental Impact Statement is prepared for an agency action, the agency must take a "hard look" at the consequences of this action and must consider all potentially significant environmental impacts. Effects on threatened and endangered species is an important element for determining the significance of an impact of an agency action (40 CFR § 1501.3(b)(1)). Thus, although NEPA does not itself regulate activities that might affect SASD, it does require full evaluation and disclosure of information regarding the effects of contemplated Federal actions on sensitive species and their habitats such as the co-ocurring Santa Ana sucker. Federal agencies may also include mitigation measures in the final Environmental Impact Statement as a result of the NEPA process that help to conserve habitat that may benefit SASD and these may include measures that are different than those required through the section 7 consultation process.

Clean Water Act

The Clean Water Act (CWA) is the primary mechanism in the United States for surface water quality protection. It establishes the basic structure for regulating discharges of pollutants into waters of the United States. It employs a variety of regulatory and non-regulatory tools to reduce direct water quality impacts, finance water treatment facilities, and manage polluted run-off. The CWA made it unlawful to discharge any pollutant from a point source into navigable water unless a permit was obtained. The EPA's National Pollutant Discharges Eliminations System permit program controls discharges. The EPA determines water quality standards for each state and the CWA requires states to either adopt this level or determine another with documentation (EPA 2000, p. 31682). In California, the State Water Resources Control Boards regulate and enforce surface water quality standards (see discussion above on **The California Porter-Cologne Act of 1969**). The chemicals or pollutants included on the State Water Resources Control Board’s list are considered regulated pollutants. Any chemicals not on this list of regulated pollutants are therefore unregulated, and no standards or limits apply.

Section 303 of the CWA defines water quality standards consisting of both the uses of the surface (or navigable) waters involved and the water quality criteria which are applied to those uses. Therefore, the State Water Resources Control Board is required to determine what beneficial uses and water quality objectives are to be established for surface water bodies. They must define beneficial uses and determine which water bodies may be impaired (and place them on the 303d list) and create a plan to remove this water body from the impaired list (303d). No occupied areas in the San Gabriel River or Big Tujunga Creek are included in the list of impaired waters. In the occupied range of Santa Ana sucker, one reach of the Santa Ana River is considered impaired due to pathogens (Reach 4 – from Mission Boulevard in Riverside to San Jacinto Fault in San Bernardino). In the Santa Ana River, all but one of the occupied areas by the Santa Ana sucker have been identified as supporting habitat necessary for rare, threatened, or endangered species (RARE designation (CRWQCB 2008, p. 3-25)). The area not included is also Reach 4. This area does contain Santa Ana suckers and recent surveys indicate that this area, which includes the Riverside Narrows, is a very important location for the species persistence (SMEA 2009, pp. 1–4). The reaches upstream, including upstream to Seven Oaks Dam was historically occupied and is very important to maintaining the processes necessary for suitable habitat conditions within the currently occupied range; however, these reaches are not currently designated as RARE (CRWQCB 2008, p. 3-25). Designation by CRWQCB of these areas as RARE would ensure that water quality at these areas is of sufficient quality to support Santa Ana suckers.

Under section 404, the ACOE regulates the discharge of fill material into waters of the United States, which include navigable and isolated waters, headwaters, and adjacent wetlands (33 U.S.C. 1344). Any action with the potential to impact waters of the United States must be reviewed under provisions of the CWA, NEPA, and the Act. These reviews require consideration of impacts to listed species and their habitats, and recommendations for mitigation of significant impacts.

Organic Administration Act of 1897 and the Multiple-Use, Sustained-Yield Act of 1960

The USFS Organic Act of 1897 (16 U.S.C. § 475–482) established general guidelines for administration of timber on USFS lands, which was followed by the Multiple-Use, Sustained-Yield Act (MUSY) of 1960 (16 U.S.C. § 528–531), which broadened the management of USFS lands to include outdoor recreation, range, watershed, and wildlife and fish purposes. Under general provisions of the USFS Organic Act (16 U.S.C. § 472) and MUSY (16 U.S.C. § 551), the USFS can also designate Special Areas for protection based on their unique or outstanding physical features, environmental values, or social significance (USFS 2005e, Volume 1, p. 13). Special Areas also include administrative designations, such as Research Natural Areas (RNAs) and Special Interest Areas (USFS 2005e, Volume 1, p. 13).

Designated RNAs are permanently protected and maintained in natural conditions, for the purposes of conserving biological diversity, conducting non-manipulative research and monitoring, and fostering education (*http://www.fs.fed.us/rmrs/research-natural-areas/*). These areas fall under Forest Service Manual Directive 4063, Research Natural Areas, and these areas are subject to use only for research and development, study, observation, monitoring, and educational activities that maintain unmodified conditions. In addition, Directive 4063.3 provides direction regarding protection and management standards for RNAs that covers a broad range of activities including the following: No roads, trails, fences, or signs are permitted on an established RNA unless they contribute to the objectives or to the protection of the area (USFS 2005d, Appendix A, p. 19).

National Forest Management Act (NFMA)

The NFMA (16 U.S.C. § 1600 *et seq*.) requires the USFS to develop a planning rule under the principles of the Multiple-Use Sustained-Yield Act of 1960 (16 U.S.C. § 528–531). The NFMA outlines the process for the development and revision of the land management plans and their guidelines and standards (16 U.S.C. § 1604(g)).

A National Forest System (NFS) land management planning rule (planning rule) was adopted by USFS, effective May 9, 2012 (USFS 2012a). The new planning rule guides the development, amendment, and revision of land management plans for all units of the NFS to maintain and restore NFS land and water ecosystems while providing for ecosystem services and multiple uses (USFS 2012a, p. 21162). Land management plans (also called Forest Plans) are to be designed to: (1) provide for the sustainability of ecosystems and resources; (2) meet the need for forest restoration and conservation, watershed protection, and species diversity and conservation; and (3) assist the USFS in providing a sustainable flow of benefits, services, and uses of NFS lands that provide jobs and contribute to the economic and social sustainability of communities (USFS 2012a, p. 21162). A land management plan does not authorize projects or activities, but projects and activities must be consistent with the plan (USFS 2012a, p. 21261). The plan must provide for the diversity of plant and animal communities including species-specific plan components in which a determination is made as to whether the plan provides the ecological conditions necessary to contribute to the recovery of federally listed species (USFS 2012a, p. 21265). The decision of record for the final planning rule was prepared in accordance with the requirements of NEPA. In addition, the NFMA requires specific land management plans to be developed in accordance with the procedural requirements of NEPA, with a similar effect as zoning requirements or regulations as these plans control activities on the national forests and are judicially enforceable until properly revised (Coggins *et al*. 2001, p. 720).

Since listing of Santa Ana sucker, a co-occurring species with SASD, USFS has adopted additional guidance and proposals to protect this species. The revised Land Management Plans for the four southern California National Forests (USFWS 2005c) included strategic direction in the form of land use zoning and standards. The land use zoning and standards indicated that for projects on USFS lands under the Land Management Plans, potential impacts should be minimized due to dispersed recreation activities, and expansion of existing facilities or new facilities will focus recreational use away from Santa Ana suckers. Future projects will be implemented to promote the recovery of Santa Ana sucker with the potential exception of fire abatement activities (fuel treatments) in wildland-urban interface areas (USFWS 2005c, p. 45). USFS standards indicate that the operation of dams and water extraction operations occur, such that habitat conditions are maintained and enhanced for Santa Ana sucker, as determined by site-specific section 7 consultations and analysis (USFWS 2005c, p. 45). Although actions could still occur outside the parameters of the revised Land Management Plans, we anticipate implementation of the management outlined in these documents will reduce threats to the Santa Ana sucker, which provides a layer of protection to SASDs in co-occurring systems.

Endangered Species Act of 1973, as amended (Act)

The Act is the primary Federal law providing protection for Santa Ana sucker and where SASD cooccurs in the Los Angeles River, San Gabriel River, and Santa Ana River systems they are also benefitting from some of these protections. Under the Act, the Service analyzes the potential effects of Federal projects under section 7(a)(2) of the Act, which requires Federal agencies to consult with the Service prior to authorizing, funding, or carrying out activities that may affect listed species. A jeopardy determination is made for a project that is reasonably expected, either directly or indirectly, to appreciably reduce the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution (50 CFR 402.02). A non-jeopardy determination generally requires inclusion of reasonable and prudent measures in an incidental take statement that the Service believes are necessary or appropriate to minimize the amount or extent of incidental take of listed species associated with a project. Critical habitat was also designated for Santa Ana sucker and overlaps with the distribution of SASD in the Los Angeles and San Gabriel River systems. The Service has analyzed the potential effects of Federal actions under section 7(a)(2) of the Act, which requires Federal agencies to consult with the Service prior to authorizing, funding, or carrying out activities that may affect the species or may destroy or adversely modify areas designated as critical habitat.

Section 9 of the Act prohibits the taking of any federally-listed endangered or threatened species. Section 3(18) defines “take” to mean “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.” Service regulations (50 CFR 17.3) define “harm” to include significant habitat modification or degradation which actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harassment is defined by the Service as an intentional or negligent action that creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. The Act provides for civil and criminal penalties for the unlawful taking of listed species. Incidental take refers to taking of listed species that result from, but is not the purpose of, carrying out an otherwise lawful activity by a Federal agency or applicant (50 CFR 402.02). For projects without a Federal nexus that would likely result in incidental take of listed species, the Service may issue incidental take permits to non-Federal applicants pursuant to section 10(a)(1)(B) of the Act. To qualify for an incidental take permit, applicants must develop, fund, and implement a Service-approved HCP that details measures to minimize and mitigate the project's adverse impacts to listed species. Regional HCPs in some areas now provide an additional layer of regulatory protection for covered species, and many of these HCPs are coordinated with California's related NCCP program. The draft Upper Santa Ana River HCP has a conservation strategy with objectives and actions that help benefit SASD in the Santa Ana River AU including long term monitoring, threats analysis, removing barriers and installing fishway passages to increase connectivity, nonnative species control, and salvage operations to relocate individuals after floods. The SASD is also a covered species under the Big Tujunga Dam Low-Effect HCP where SASD in the LA River AU benefit from multiple conservation measures. Avoidance and minimization measures are implemented to limit impacts on SASD and Santa Ana sucker, including the timing of dam releases, storing and releasing supplemental water during the dry season to improve habitat quality, habitat monitoring, dace monitoring, and potential habitat enhancement measures.

Federal projects (evaluated under section 7 of the Act), other projects (evaluated under section 10(a)(1)(B) of the Act), or recovery actions (evaluated under section 10(a)(1)(A) of the Act) may result in incidental take of the Santa Ana sucker. Since listing, we conducted numerous informal consultations under section 7 of the Act that resulted in incidental take of the Santa Ana suckers and impacts to habitat or the riparian area that is currently designated as critical habitat for the Santa Ana sucker. These formal and informal consultations addressed project impacts to Santa Ana sucker or designated critical habitat as a result of: dam operations or construction; flood control activities such as levee installation or repair, bridge repair, replacement or modification, sediment removal, and bank stabilization; wastewater treatment releases; and nonnative vegetation removals. None of the biological opinions that were issued as a result of the above consultations determined an adverse modification of critical habitat. Santa Ana sucker critical habitat that occurs in the San Gabriel Mountains indirectly provides protection for the SASD in the San Gabriel River and LA River AUs, as they both occupy areas within the Critical Habitat boundaries.

Summary of Factor D

In summary, there are a number of Federal and State regulatory mechanisms that provide discretionary protections for SASD based on current management direction. The dace is also provided indirect protections to habitat where its distribution aligns with the Santa Ana sucker. Inadequacies in provisions or implementation of regulatory mechanisms are not considered a threat to the species, although inadequacies may permit or precipitate actual threats that are attributable to and described under Factors A, C, and E.

APPENDIX D: PARAMETER DATA

Table D-1. 30-year fire probability in each analytical unit for RCP 4.5 and RCP 8.5. These data represent the probability of occurrence of one or more fires in an analytical unit over 30 years. Note that probabilities during the baseline timestep (1990-2019) vary across RCP scenarios because these probabilities are based on modeled data.

Scenario	Time Period	Los Angeles	San Gabriel	Santa Ana	San Jacinto
RCP 4.5	1990-2019	0.62	0.66	0.56	0.60
	2030-2059	0.65	0.73	0.57	0.63
	2070-2099	0.68	0.75	0.57	0.62
RCP 8.5	1990-2019	0.56	0.59	0.49	0.58
	2030-2059	0.67	0.73	0.58	0.66
	2070-2099	0.75	0.81	0.64	0.70

Table D-2. 30-year average annual area (in hectares) at risk of burning in each analytical unit for RCP 4.5 and RCP 8.5. Note that data during the baseline timestep (1990-2019) varies across RCP scenarios because these values are based on modeled data.

Scenario	Time Period	Los Angeles	San Gabriel	Santa Ana	San Jacinto
RCP 4.5	1990-2019	750	1245	1583	1008
	2030-2059	781	1320	1483	992
	2070-2099	812	1402	1488	971
RCP 8.5	1990-2019	666	1174	1452	900
	2030-2059	713	1281	1477	971
	2070-2099	774	1432	1446	832

Table D-3. Mean summer (June, July, August) stream flows (cubic feet per second) in each occurrence for the baseline time period (1977-2006) and mid (2030-2059) and late (2070-2099) century time periods for RCP 4.5 and RCP 8.5.

Analytical Unit	**Occurrence**		**RCP 4.5**		**RCP 8.5**	
		1977-2006	**2030-2059**	**2070-2099**	**2030-2059**	**2070-2099**
Los Angeles	Lower Big Tujunga Creek	6.8	6.7	6.7	6.6	6.2
San Gabriel	Fish Canyon Creek	0.5	0.5	0.5	0.5	0.4
	North Fork San Gabriel River	0.7	0.7	0.7	0.7	0.6
	Bear Creek	1.4	1.3	1.3	1.3	1.2
	Cattle Canyon Creek	1.4	1.3	1.3	1.3	1.1
	West Fork San Gabriel River	2.8	2.7	2.8	2.7	2.5
	East Fork San Gabriel River	4.4	4.1	4.2	3.9	3.3
Santa Ana	Hemlock Creek	0.1	0.1	0.1	0.1	0.1
	Fredalba Creek	0.2	0.2	0.2	0.2	0.2
	Waterman Creek	0.4	0.4	0.4	0.4	0.4
	Plunge Creek	0.7	0.7	0.7	0.7	0.7
	City Creek	1.0	1.0	1.0	1.0	0.9
	Lytle Creek	1.4	1.4	1.4	1.4	1.3
	Cajon Creek	2.4	2.4	2.4	2.4	2.4
	Santa Ana River Mainstem	16.5	15.4	15.8	14.6	12.5
San Jacinto	Stone Creek	0.6	0.6	0.6	0.5	0.5
	Indian Creek	1.4	1.3	1.4	1.3	1.6
	North Fork San Jacinto River	2.5	2.2	2.4	2.1	2.1
	South Fork San Jacinto River	4.2	4.2	4.3	4.2	4.7

Table D-4. Mean winter (December, January, February) stream flows (cubic feet per second) in each occurrence for the baseline time period (1997-2006) and mid (2030-2059) and late (2070-2099) century time periods for RCP 4.5 and RCP 8.5.

Analytical Unit	Occurrence		RCP 4.5		RCP 8.5	
		1977-2006	2030-2059	2070-2099	2030-2059	2070-2099
Los Angeles	Lower Big Tujunga Creek	193.9	271.5	223.9	324.8	360.6
San Gabriel	Bear Creek	53.0	74.4	61.5	89.2	100.0
	Cattle Canyon Creek	31.5	46.4	37.8	56.6	66.4
	East Fork San Gabriel River	106.6	159.0	129.1	195.0	231.7
	Fish Canyon Creek	9.9	13.5	11.4	16.1	18.0
	North Fork San Gabriel River	22.4	32.6	26.5	39.6	45.5
	West Fork San Gabriel River	80.6	111.6	92.8	132.9	148.4
Santa Ana	Cajon Creek	28.2	44.2	34.7	55.2	64.1
	City Creek	15.8	21.8	18.3	26.0	29.9
	Fredalba Creek	4.7	6.7	5.5	8.2	9.5
	Hemlock Creek	3.4	5.0	4.1	6.1	7.0
	Lytle Creek	27.2	41.2	32.8	50.8	58.3
	Plunge Creek	14.5	20.7	17.1	25.0	28.8
	Santa Ana River Mainstem	136.9	232.8	192.3	298.7	444.7
	Waterman Creek	4.7	6.5	5.5	7.8	9.2
San Jacinto	Indian Creek	16.2	23.0	19.3	27.7	33.1
	North Fork San Jacinto River	16.8	25.6	21.3	31.6	41.9
	South Fork San Jacinto River	32.8	46.8	39.9	56.4	72.1
	Stone Creek	4.0	6.2	5.1	7.7	10.2

Table D-5. Magnitude of 10-year flood events (cubic feet per second) in each occurrence for the baseline time period (1997-2006) and mid (2030-2059) and late (2070-2099) century time periods for RCP 4.5 and RCP 8.5.

Analytical Unit	**Occurrence**		**RCP 4.5**		**RCP 8.5**	
		1977-2006	**2030-2059**	**2070-2099**	**2030-2059**	**2070-2099**
Los Angeles	Lower Big Tujunga Creek	15610	19028	16952	21379	23060
San Gabriel	Bear Creek	3601	4335	4059	4840	6142
	Cattle Canyon Creek	1681	2225	1951	2599	3181
	East Fork San Gabriel River	6155	7818	7223	8963	12085
	Fish Canyon Creek	758	802	811	832	1056
	North Fork San Gabriel River	1515	1926	1776	2209	2961
	West Fork San Gabriel River	5564	6618	6125	7342	8680
Santa Ana	Cajon Creek	1885	2848	2202	3510	3647
	City Creek	1033	1282	1162	1453	1746
	Fredalba Creek	273	375	325	445	564
	Hemlock Creek	205	282	245	336	429
	Lytle Creek	1584	2216	1830	2652	2952
	Plunge Creek	883	1156	1031	1343	1705
	Santa Ana River Mainstem	7172	13426	10564	17728	26009
	Waterman Creek	308	376	346	424	521
San Jacinto	Indian Creek	1503	1631	1570	1718	1872
	North Fork San Jacinto River	1169	1429	1359	1607	2223
	South Fork San Jacinto River	2666	3434	2930	3962	4129
	Stone Creek	272	336	322	380	548

Table D-6. Mean Annual Precipitation (inches of precipitation) in each occurrence for the baseline time period (1990-2019) and mid (2030-2059) and late (2070-2099) century time periods for RCP 4.5 and RCP 8.5.

Scenario	Time Period	Los Angeles	San Gabriel	Santa Ana	San Jacinto
RCP 4.5	1990-2019	24.5	28.6	24.0	17.1
	2030-2059	26.2	30.4	25.4	19.0
	2070-2099	29.6	35.3	30.5	23.0
RCP 8.5	1990-2019	27.1	31.7	26.3	19.3
	2030-2059	30.6	35.9	30.1	21.8
	2070-2099	37.8	44.1	36.9	27.8

Table D-7. Mean August stream temperature (° C) in each occurrence for the baseline time period (1993-2011) and mid (2030-2059) and late (2070-2099) century time periods for RCP 4.5 and RCP 8.5.

Analytical Unit	**Occurrence**		**RCP 4.5**		**RCP 8.5**	
		1993-2011	**2030-2059**	**2070-2099**	**2030-2059**	**2070-2099**
Los Angeles	Lower Big Tujunga Creek	20.5	21.5	22.0	21.9	23.9
San Gabriel	Bear Creek	19.4	20.4	20.9	20.8	22.8
	Cattle Canyon Creek	19.2	20.2	20.7	20.6	22.6
	East Fork San Gabriel River	19.3	20.3	20.8	20.7	22.7
	Fish Canyon Creek	19.3	20.3	20.8	20.7	22.7
	North Fork San Gabriel River	18.6	19.6	20.1	20.0	22.0
	West Fork San Gabriel River	19.5	20.5	21.0	20.9	22.9
Santa Ana	Cajon Creek	22.1	23.1	23.6	23.5	25.5
	City Creek	23.0	24.0	24.5	24.4	26.4
	Fredalba Creek	21.7	22.7	23.2	23.1	25.1
	Hemlock Creek	20.6	21.6	22.1	22.0	24.0
	Lytle Creek	21.1	22.1	22.6	22.5	24.5
	Plunge Creek	23.0	24.0	24.5	24.4	26.4
	Santa Ana River Mainstem	22.8	23.8	24.3	24.2	26.2
	Waterman Creek	22.1	23.1	23.6	23.5	25.5
San Jacinto	Indian Creek	21.4	22.4	22.9	22.8	24.8
	North Fork San Jacinto River	20.9	21.9	22.4	22.3	24.3
	South Fork San Jacinto River	21.3	22.3	22.8	22.7	24.7
	Stone Creek	19.2	20.2	20.7	20.6	22.6

Figure D-1. Number of extreme precipitation events per water year (in days) across HUC 10 watersheds within analysis units. Time periods are: baseline (1960-1990, observed data), mid-century (2030-2064, modeled data), and late-century (2069-2099, modeled data). Points represent the mean value, whiskers represent the minimum and maximum values.

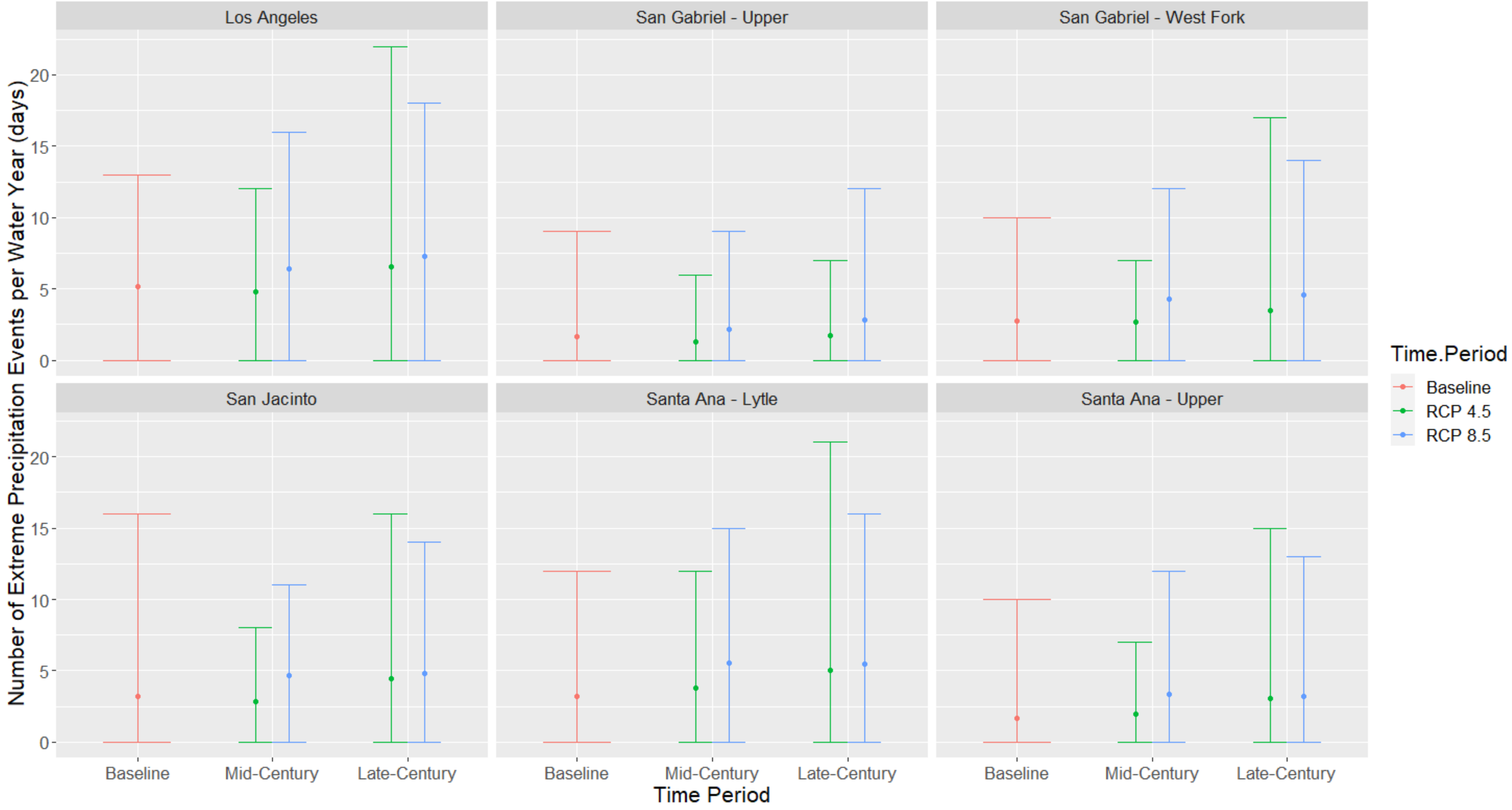

Figure D-2. Estimated intensity of extreme precipitation events (in inches) across HUC 10 watersheds within analysis units. Time periods are: baseline (1960-1990, observed data), mid-century (2030-2064, modeled data), and late-century (2069-2099, modeled data). Points represent the mean value, whiskers represent the lower and upper 95% confidence intervals.