Central Valley Landscape Conservation Project

Climate Change Vulnerability Assessment (January 2017 version)

San Joaquin Desert

Vulnerability Assessment Summary

Overall Vulnerability Score and Components:

Vulnerability Component	Score
Sensitivity	High
Exposure	Moderate-high
Adaptive Capacity	Low-moderate
Vulnerability	**Moderate-high**

Overall vulnerability of the San Joaquin Desert was scored as moderate-high. The score is the result of high sensitivity, moderate-high future exposure, and moderate adaptive capacity scores.

Key climate factors for San Joaquin Desert habitats include precipitation amount and timing, soil moisture, drought, and air temperature. These factors influence desert plant phenology, growth, and recruitment, and also influence wildlife habitat quality by altering invasive plant cover.

Key disturbance mechanisms for San Joaquin Desert habitats include wildfire and grazing. Desert habitats are not very resilient to fire, which leads to shrub mortality and can perpetuate exotic species establishment and invasion; grazing may help mitigate invasive species impacts, but can also negatively affect native vegetation depending on browse season.

Key non-climate factors for San Joaquin Desert habitats include urban/suburban development, agricultural and rangeland practices, land use change, invasive and problematic species, and roads, highways, and trails. Urban, agricultural, and industrial development, land use change, and transportation corridors destroy and fragment San Joaquin Desert habitat, while exotic species outcompete native vegetation, perpetuate shifting wildfire regimes, and degrade wildlife habitat quality by altering vegetation cover and structure.

Due to extensive habitat loss to human development, San Joaquin Desert habitats have a very patchy distribution in the Central Valley, which makes extant populations of endemic species vulnerable to extirpation and which may impede wildlife dispersal in response to climate change. Persistent seed banks make some desert species resilient to changing conditions, but in general, desert habitats are vulnerable to and slow to recover from disturbance, although annual components of this system may be slightly more resilient. San Joaquin Desert habitats support high biodiversity and endemism.

Management potential for San Joaquin Desert habitats was scored as moderate, and includes regulatory support from the Endangered Species Act, retiring and restoring poor agricultural land to increase desert habitat continuity, and partnering with landowners to protect desert refugia on private land.

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Introduction

Description of Priority Natural Resource

The San Joaquin Desert occurs in the southern and western portions of the San Joaquin Valley, as well as on the Carrizo Plain and Cuyama Valley. It is characterized by a spring herbaceous layer (mainly exotic) and distributed saltbush shrubs, and features many endemic species (Germano et al. 2011).

As part of the Central Valley Landscape Conservation Project, workshop participants identified the San Joaquin Desert as a Priority Natural Resource for the Central Valley Landscape Conservation Project in a process that involved two steps: 1) gathering information about the habitat's management importance as indicated by its priority in existing conservation plans and lists, and 2) a workshop with stakeholders to identify the final list of Priority Natural Resources, which includes habitats, species groups, and species.

The rationale for choosing the San Joaquin Desert as a Priority Natural Resource included the following: the habitat has high management importance, and because of its importance to the San Joaquin and Tulare Basins for supporting high biodiversity and endemism. Please see Appendix A: "Priority Natural Resource Selection Methodology" for more information.

Vulnerability Assessment Methodology

During a two-day workshop in October of 2015, 30 experts representing 16 Central Valley resource management organizations assessed the vulnerability of priority natural resources to changes in climate and non-climate factors, and identified the likely resulting pressures, stresses, and benefits (see Appendix B: "Glossary" for terms used in this report). The expert opinions provided by these participants are referenced throughout this document with an endnote indicating its source[1]. To the extent possible, scientific literature was sought out to support expert opinion garnered at the workshop. Literature searches were conducted for factors and resulting pressures that were rated as high or moderate-high, and all pressures, stresses, and benefits identified in the workshop are included in this report. For more information about the vulnerability assessment methodology, please see Appendix C: "Vulnerability Assessment Methods and Application." Projections of climate and non-climate change for the region were researched and are summarized in Appendix D: "Overview of Projected Future Changes in the California Central Valley".

Vulnerability Assessment Details

Climate Factors

Workshop participants scored the resource's sensitivity to climate factors and this score was used to calculate overall sensitivity. Future exposure to climate factors was scored and the overall exposure score used to calculate climate change vulnerability.

Climate Factor	Sensitivity	Future Exposure
Air temperature	Moderate-high	Moderate
Extreme events: drought	High	High
Increased wildfire	-	Moderate
Precipitation (amount)	High	High
Precipitation (timing)	High	High
Soil moisture	High	-
Overall Scores	**High**	**Moderate-high**

Habitat modeling by Thorne et al. (2016) indicates that saltbush shrub distributions in the Central Valley may become climatically stressed and no longer climatically suitable by the end of the century, particularly if warmer and wetter conditions prevail. Comparatively, projections indicate that under hotter and drier conditions, some current saltbush habitat may remain climatically suitable, although habitat losses will still occur (Thorne et al. 2016).

Precipitation (amount)

Sensitivity: *High (high confidence)*
Future exposure: *High (high confidence)*

The San Joaquin Desert has two precipitation gradients running from west to east and south to north; the southern and western portions of the habitat area receive the lowest rainfall. These precipitation gradients influence plant and animal distributions, with the most arid-adapted species being restricted to the southern and western areas of the San Joaquin Valley (Germano et al. 2011).

High inter-annual precipitation variability alters native desert vegetation growth, flowering, recruitment, and abundance (U.S. Fish and Wildlife Service 1998; Cypher 2005). Higher precipitation increases plant growth and cover, and may favor invasive grass expansion at the expense of native annuals (e.g., Kern mallow; *Eremalche kernensis*) (Germano et al. 2001). Increased precipitation can also impact wildlife through altering habitat structure and composition. Small desert vertebrate populations in the San Joaquin Valley have been shown to decline after multiple years of average- to above-average precipitation (Germano et al. 2001, 2012).

Precipitation (timing)

Sensitivity: *High (high confidence)*
Future exposure: *High (high confidence)*

Precipitation timing, including fall/winter germinating rains and spring rains, influences native plant germination, growth, recruitment, and senescence timing by affecting available soil moisture (U.S. Fish and Wildlife Service 1998).

Drought

Sensitivity: *High (high confidence)*
Future exposure: *High (high confidence)*

Compared to the preceding century (1896-1994), drought years in California have occurred twice as often in the last 20 years (1995-2014; Diffenbaugh et al. 2015). Additionally, the recent drought (2012-2014) has been the most severe drought on record in the Central Valley (Williams et al. 2015), with record accumulated moisture deficits driven by high temperatures and reduced, but not unprecedented, precipitation (Griffin & Anchukaitis 2014; Williams et al. 2015). Recent studies have found that anthropogenic warming has substantially increased the overall likelihood of extreme California droughts, including decadal and multi-decadal events (Cook et al. 2015; Diffenbaugh et al. 2015; Williams et al. 2015). The frequency and severity of drought is expected to increase over the next century due to climate change (Hayhoe et al. 2004; Cook et al. 2015; Diffenbaugh et al. 2015; Williams et al. 2015), as warming temperatures exacerbate dry conditions in years with low precipitation, causing more severe droughts than have previously been observed (Cook et al. 2015; Diffenbaugh et al. 2015). The San Joaquin Valley is projected to experience slightly drier conditions by the end of the century (Snyder & Sloan 2005).

Desert vegetation and wildlife species are fairly drought-adapted (U.S. Fish and Wildlife Service 1998; USDA Natural Resource Conservation Service 2016). However, severe or prolonged droughts may reduce native desert plant productivity, germination, and recruitment (U.S. Fish and Wildlife Service 1998; Garcia and Associates 2006; Koopman et al. 2010), indirectly impacting wildlife recruitment and causing population declines (U.S. Fish and Wildlife Service 1998). Drought periods may also reduce invasive plant pressure (Germano et al. 2012).

Soil moisture

Sensitivity: *High (high confidence)*

Between 1951-1980, climatic water deficit increased by 2 mm in the Central Valley, compared to an average of 17 mm statewide (Thorne et al. 2015). Regardless of changes in precipitation, warmer temperatures are expected to increase evapotranspiration and cause drier conditions (Cook et al. 2015). For example, Thorne et al. (2015) project that climatic water deficit is expected to increase by 131 mm in the Central Valley (compared to 140 mm statewide) by 2070-2099 under a drier scenario and 44 mm (compared to 61 mm statewide) under a wetter scenario.

Available soil moisture can prolong the spring flowering period of rare native desert annuals, including the Kern mallow (Cypher 2005) and California jewelflower (*Caulanthus californicus*) (U.S. Fish and Wildlife Service 1998). Extended periods of high soil moisture can spoil desert rodent seed caches (Germano et al. 2001), although soil moisture deficits are characteristic of this habitat for 4-8 months per year (Garcia and Associates 2006).

Air temperature

Sensitivity: *Moderate-high (high confidence)*
Future exposure: *Moderate (moderate confidence)*

Higher temperatures have contributed to regional drought conditions and increased climatic water deficit by enhancing evaporation (Griffin & Anchukaitis 2014; Williams et al. 2015). Air temperature in the San Joaquin Valley increased roughly 3°C from 1910-2003, with largest increases in fall and summer (Christy et al. 2006). The San Joaquin Valley is projected to experience increased temperatures (+2.5°C) by the end of the century (Snyder & Sloan 2005).

Increased air temperatures can reduce desert annual plant recruitment by causing early mortality prior to seed-set, particularly when combined with low annual rainfall (U.S. Fish and Wildlife Service 1998).

Non-Climate Factors

Workshop participants scored the resource's sensitivity and current exposure to non-climate factors, and these scores were then used to assess their impact on climate change sensitivity.

Non-Climate Factor	Sensitivity	Current Exposure
Agriculture & rangeland practices	Moderate-high	Moderate-high
Invasive & other problematic species	High	High
Land use change	High	High
Nutrient loading	Moderate	Moderate-high
Roads, highways, & trails	Moderate-high	Moderate-high
Urban/suburban development	High	-

Overall Scores	Moderate-high	High

Invasive & other problematic species

Sensitivity: *High (high confidence)*
Current exposure: *High (high confidence)*
Pattern of exposure: *Consistent across the landscape.*

Numerous exotic plant species have invaded the San Joaquin Valley and displaced native vegetation (U.S. Fish and Wildlife Service 1998). Common invaders include red brome (*Bromus rubens madritensis*), mouse-tail fescue (*Vulpia myuros*), Arabian grass (*Schismus arabicus*), foxtail (*Hordium murinum glaucum*), ripgut brome (*Bromus diandrus*), and soft chess (*Bromus hordeacus*) (Germano et al. 2001). Invasive non-native plants alter desert plant community composition and structure by outcompeting native vegetation, particularly native annuals (U.S. Fish and Wildlife Service 1998). Exotic grass invasion degrades wildlife habitat quality by increasing vegetation density and height (Germano et al. 2001, 2011). Invasive non-native grasses also perpetuate more frequent and larger fires (Germano et al. 2012) by increasing fine fuel availability and continuity, which is typically low in unaltered desert habitats (USDA Natural Resource Conservation Service 2016).

Land use change

Sensitivity: *High (high confidence)*
Current exposure: *High (moderate confidence)*
Pattern of exposure: *Consistent across the landscape.*

Continued land use changes may destroy and further fragment remnant desert habitat in the Central Valley (U.S. Fish and Wildlife Service 1998). Land use changes will also likely interact with climate change to alter rates of temperature increase in the San Joaquin Valley (Gardali et al. 2012).

Urban/suburban development

Sensitivity: *High (high confidence)*
Current exposure: *Moderate-high (high confidence)*
Pattern of exposure: *Localized.*

Urban/suburban development has greatly reduced and fragmented San Joaquin Desert habitat (Germano et al. 2011). In combination with agricultural and industrial development, urban development has also contributed to many endangered and threatened species listings of desert and other San Joaquin Valley wildlife (U.S. Fish and Wildlife Service 1998).

Agricultural & rangeland practices

Sensitivity: *High (high confidence)*
Current exposure: *Moderate-high (high confidence)*
Pattern of exposure: *Consistent across the landscape.*

Irrigated agriculture has replaced and fragmented large portions of San Joaquin Desert habitat (U.S. Fish and Wildlife Service 1998; Germano et al. 2011). Expansion of irrigated agriculture may contribute to high rates of temperature increase in the San Joaquin Valley by reducing albedo (Christy et al. 2006), although irrigation can also mediate daytime temperatures (Gardali et al. 2012). Pesticide application in agricultural areas may impact native pollinators, with detrimental impacts to native annual desert species (U.S. Fish and Wildlife Service 1998).

Roads, highways, & trails

> ***Sensitivity:*** *Moderate-high (high confidence)*
> ***Current exposure:*** *Moderate-high (moderate confidence)*
> ***Pattern of exposure:*** *Localized.*

Roads and transportation corridors fragment and destroy desert habitat (U.S. Fish and Wildlife Service 1998) and contribute to lower survival of desert vegetation, including rare species such as the Kern Mallow (Cypher 2005). Specific impacts include soil disturbance and nitrogen deposition from exhaust (Cypher 2005).

Nutrient loading

> ***Sensitivity:*** *Moderate (low confidence)*
> ***Current exposure:*** *Moderate-high (moderate confidence)*
> ***Pattern of exposure:*** *Consistent across the landscape.*

Disturbance Regimes

> ***Overall sensitivity to disturbance regimes:*** *High (high confidence)*

Wildfire

> ***Future exposure:*** *Moderate (moderate confidence)*

In general, desert ecosystems are not fire-adapted. Fires in San Joaquin Desert habitat can perpetuate invasive plant dominance and cause mortality of native saltbush species (*Atriplex* spp.) (Germano et al. 2001, 2012). Repeated fires can facilitate conversion to non-native annual grassland (Cypher 2005) because native desert plant species are slow to recover from fire (e.g., see USDA Natural Resource Conservation Service 2016). Wildfire may temporarily stimulate native vertebrate populations by reducing thatch associated with invasive annual grasses (Germano et al. 2001), but desert vertebrates (e.g., burrowing rodents) suffer if more frequent fires and/or high levels of precipitation following burns promote high cover of exotic herbaceous vegetation (Germano et al. 2012), which reduces animal mobility and foraging opportunities (U.S. Fish and Wildlife Service 1998).

Grazing

Targeted grazing may help control invasive plants in San Joaquin Desert habitats, particularly during average or above-average rainfall years (Germano et al. 2001, 2012). Through controlling invasive grasses, grazing experiments in the San Joaquin Valley have been shown to improve abundance of small desert vertebrates while having no negative impact on native perennial saltbush species (Germano et al. 2012). However, grazing may have negative impacts on native desert vegetation if plants are grazed during key reproductive periods (U.S. Fish and Wildlife Service 1998) or during the summer (USDA Natural Resource Conservation Service 2016).

Adaptive Capacity

Workshop participants scored the resource's adaptive capacity and the overall score was used to calculate climate change vulnerability.

Adaptive Capacity Component	Score
Extent, Integrity, & Continuity	Low
Landscape Permeability	Low-moderate
Resistance & Recovery	Low-moderate
Habitat Diversity	Moderate
Overall Score	**Low-moderate**

Extent, integrity, and continuity

Overall degree of habitat extent, integrity, and continuity: *Low (high confidence)*
Geographic extent of habitat: *Endemic to a particular area (moderate confidence)*
Structural and functional integrity of habitat: *Fairly degraded (moderate confidence)*
Continuity of habitat: *Patches, some patches are connected (high confidence)*

The San Joaquin Desert historically covered 28,493 square kilometers in the Carrizo Plain, Cuyama Valley, and western and southern majority of the San Joaquin Valley. However, agricultural, industrial, and urban land use activities have caused significant losses and fragmentation of this habitat (U.S. Fish and Wildlife Service 1998), and only 41% of the habitat remains (Germano et al. 2011). The largest blocks of undisturbed habitat occur in the more arid western part of the San Joaquin Valley (Germano et al. 2012). Habitat fragmentation and degradation increase the vulnerability of San Joaquin Desert species to extirpation from extreme events, such as drought (U.S. Fish and Wildlife Service 1998). There have been some land protection efforts for desert habitat in the study region, such as the establishment of the 100,000 hectare Carizzo Plain National Monument (Germano et al. 2011).

Landscape permeability

Overall landscape permeability: *Moderate-high (high confidence)*
Impact of various factors on landscape permeability:
- ***Agricultural practices:*** *High (high confidence)*
- ***Urban/suburban development:*** *High (high confidence)*

Roads, highways, & trails: *Moderate-high (high confidence)*
Energy production & mining: *Moderate (low confidence)*
Geologic features: *Low-moderate (moderate confidence)*
Rangeland practices: *Low (high confidence)*

Agricultural, industrial, and urban development are the primary drivers of habitat fragmentation in the San Joaquin Desert, and there is little habitat continuity on the valley floor (U.S. Fish and Wildlife Service 1998). Habitat fragmentation prevents species migration in the face of climate change and other disturbances (U.S. Fish and Wildlife Service 1998).

Resistance and recovery

Overall ability to resist and recover from stresses: *Low-moderate (moderate confidence)*
Resistance to stresses/maladaptive human responses: *Low-moderate (moderate confidence)*
Ability to recover from stresses/maladaptive human response impacts: *Moderate (moderate confidence)*

Some desert species (e.g., California jewelflower) appear to have persistent seed banks, which may help them weather unfavorable climatic periods (U.S. Fish and Wildlife Service 1998; USDA Natural Resource Conservation Service 2016). Additionally, some desert annuals (e.g., Kern mallow) have been documented to reinvade disturbed sites adjacent to persisting populations (U.S. Fish and Wildlife Service 1998). Comparatively, some desert scrubs are slow to recover from disturbances (USDA Natural Resource Conservation Service 2016), which reduces resilience to climate- and human-driven landscape changes.

Habitat diversity

Overall habitat diversity: *Moderate (high confidence)*
Physical and topographical diversity of the habitat: *Moderate (high confidence)*
Diversity of component species within the habitat: *Moderate (high confidence)*
Diversity of functional groups within the habitat: *Moderate-high (high confidence)*

Component species or functional groups particularly sensitive to climate change:

- All

Keystone or foundational species within the habitat:

- Giant kangaroo rat (and other rats)

San Joaquin Desert habitats harbor many rare and endemic species (Germano et al. 2011), including five endangered plants, one threatened plant, five endangered animals, and many more candidate species for federal listing (U.S. Fish and Wildlife Service 1998). Kangaroo rats, particularly the Giant kangaroo rat (*Dipodomys ingens*), are considered keystone species because their burrowing activity creates topographical diversity, alters soil mineral composition, and provides shelter and growing space for other endangered species (U.S. Fish and Wildlife Service 1998). Saltbush species are also important components of this system, providing favorable microsites for establishment other species (U.S. Fish and Wildlife Service 1998; USDA Natural Resource Conservation Service 2016).

Management potential

Workshop participants scored the resource's management potential.

Management Potential Component	Score
Habitat value	Low-moderate
Societal support	Moderate-high
Agriculture & rangeland practices	High
Extreme events	Low-moderate
Converting retired land	Moderate
Managing climate change impacts	Moderate-high
Overall Score	**Moderate**

Value to people

Value of habitat to people: *Low-moderate (high confidence)*

Support for conservation

Degree of societal support for managing and conserving habitat: *Moderate-high (moderate confidence)*

Degree to which agriculture and/or rangelands can benefit/support/increase the resilience of this habitat: *High for rangelands only (high confidence)*

Degree to which extreme events (e.g., flooding, drought) influence societal support for taking action: *Low-moderate (high confidence)*

Likelihood of converting land to habitat

Likelihood of (or support for) converting retired agriculture land to habitat: *Moderate (moderate confidence)*

Likelihood of managing or alleviating climate change impacts on habitat: *Moderate-high (moderate confidence)*

There is some regulatory support for maintaining and protecting San Joaquin Desert habitats through the Endangered Species Act. Agricultural land, particularly areas with drainage problems or that lack irrigation water, may be retired and restored to enhance habitat connectivity. In addition, there is some opportunity for partnering with private landowners to protect desert habitat refugia on private land (U.S. Fish and Wildlife Service 1998).

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