Central Valley Landscape Conservation Project

Climate Change Vulnerability Assessment (January 2017 version)

Large Wide-ranging Mammals

Vulnerability Assessment Summary

Overall Vulnerability Score and Components:

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

Overall vulnerability of the large wide-ranging mammals species group was scored as low-moderate. The score is the result of moderate sensitivity, low-moderate future exposure, and moderate adaptive capacity scores.

No climate factors were identified as having more than a low-moderate impact on large wide-ranging mammals. In general, shifts in temperature, water availability, and forage availability will affect the distribution, reproduction, and behavior of this species group, and climate impacts may be exacerbated by habitat fragmentation in the study region.

Key non-climate factors for large wide-ranging mammals include agricultural and rangeland practices, urban/suburban development, land use change, and roads, highways, and trails. These factors contribute to direct mortality (e.g., through vehicular strikes) and destroy, fragment, and degrade habitat availability and quality, affecting large mammal recruitment, diversity, abundance, and dispersal opportunities.

Key disturbance mechanisms for large wide-ranging mammals include wildfire, disease, flooding and grazing. Wildfire can temporarily reduce habitat quality, disease exposure may increase as a result of habitat fragmentation, and grazing may increase competition with native ungulates or impact dispersal because of the presence of fencing and other infrastructure. Large wide-ranging mammals exhibit a moderate degree of specialization; most species are habitat and forage/prey generalists, but they do rely on fairly large intact habitat areas.

Large wide-ranging mammal populations in the Central Valley are generally degraded and isolated, and habitat fragmentation limits dispersal of these highly mobile species. Agriculture, urban development, roads, energy development and mining, dams, levees, and water diversions, land use change, poaching, and lack of undeveloped riparian corridors act as

landscape barriers, affecting large wide-ranging mammal dispersal and gene flow by fragmenting habitat.

This species group exhibits moderate intraspecific species diversity; most species exhibit some form of behavioral diversity in response to altered habitat conditions, but genetic diversity varies widely amongst species. Large wide-ranging mammals are not resistant to or able to recover from the impacts of habitat fragmentation and other human activities, which reduces their natural resilience to climate and disturbance regimes.

Management potential for this species group was scored as moderate-high, and is focused on maintaining landscape and habitat connectivity (e.g., protecting riparian areas, managing altered landscapes for ecological permeability and function) and mitigating negative interactions between carnivores and human property and safety. Assisted migration is a tool currently being used to maintain some of these species following habitat fragmentation, and may become increasingly important in the face of climate change.

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Introduction

Description of Priority Natural Resource

Large wide-ranging mammals are defined as animals that are dependent on habitat connectivity at a landscape scale, and habitat includes but is not restricted to riparian areas[1].

Species included under the vulnerability assessment of large wide-ranging mammals are tule elk (*Cervus canadensis nannodes*), mule deer (*Odocoileus hemionus*), pronghorn (*Antilocarpa americana*), bobcat (*Lynx rufus*), mountain lion (*Puma concolor*), and gray fox (*Urocyon cinereoargenteus*).

As part of the Central Valley Landscape Conservation Project, workshop participants identified the large wide-ranging mammals species group as a Priority Natural Resource for the Central Valley Landscape Conservation Project in a process that involved two steps: 1) gathering information about the species group'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 large wide-ranging mammals species group as a Priority Natural Resource included the following: the species group has high management importance, the species group's conservation needs are not entirely represented within a single priority habitat, and because they depend on habitat connectivity and so are an indicator for that aspect of landscape ecosystem function, and existing fragmented habitat make them particularly vulnerable to climate change. Please see Appendix A: "Priority Natural Resource Selection Methodology" for more information.

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	Low-moderate	Low-moderate
Altered stream flow	Low-moderate	Low-moderate
Extreme events: drought	Low-moderate	Low-moderate
Extreme events: more heat waves	-	Low-moderate
Extreme events: storms	Low-moderate	-
Increased flooding	-	Low-moderate
Increased wildfire	-	Low-moderate
Precipitation (amount)	Low-moderate	Low-moderate
Precipitation (timing)	Low-moderate	Low-moderate
Snowpack amount	Low-moderate	Low-moderate
Soil moisture	Low-moderate	-
Timing of snowmelt/runoff	Low-moderate	Low-moderate
Water temperature	Low-moderate	Low-moderate
Overall Scores	**Low-moderate**	**Low-moderate**

Large wide-ranging herbivores, including pronghorn, elk, and mule deer, are likely somewhat sensitive to changes in forage and water availability as a result of climate change. For example, drought, reduced precipitation, and lower soil moisture can decrease upland productivity, which reduces available forage (Gogan & Barrett 1987; Bright & Hervert 2005; Pierce et al. 2012). Forage reductions may be exacerbated in areas where ungulate populations are in competition with other native and domestic browsers, and impacts may be particularly acute for ungulate populations whose movements are restricted by land use conversion (Gogan & Barrett 1987). Drought, reduced snowpack, and shifts in precipitation can also affect available surface water (Watt 2015), which many large wide-ranging mammals depend on for survival (Zeiner et al. 1990). Shifts in resource availability as a result of climate change may increase starvation-related mortality, depress ungulate reproduction (Gogan & Barrett 1987; Pierce et al. 2012; Watt 2015), or alter predation exposure by forcing animals to forage in areas with low cover or few escape opportunities (Bright & Hervert 2005).

Large wide-ranging carnivores are likely sensitive to climate-driven shifts in their prey base, which can affect survival, reproduction, distribution, and behavior (Tewes & Hornocker 2007; Pierce et al. 2012). Carnivore distribution may also be limited by declines in water availability; for example, grey fox dens are typically found near available surface water (Zeiner et al. 1990).

Mammals in the western U.S. are projected to experience slower climate velocities (rate of climate change) relative to other mammals throughout the world (Schloss et al. 2012). However, rates of change in the western U.S. (1 km/yr) are still projected to exceed the dispersal velocity of mammals in the region (0.1-0.5 km/year), indicating that these mammals will still be exposed to climate impacts and may be unable to track climate shifts as they occur (Schloss et al. 2012). Please note that Schloss et al. (2012) was a global study of mammal dispersal capacity and exposure to climate change; local and regional factors could significantly alter climate and dispersal velocities of this species group. However, carnivores and even-toed ungulates may have higher dispersal capacity than other mammalian groups due to high mobility and generally shorter required dispersal distances (Schloss et al. 2012). Large wide-ranging mammals are highly mobile and can seek cover in cooler, wetter places. Riparian areas will be more resilient, and hopefully will act as a refuge for this species group[1].

Air temperature

Sensitivity: *Low-moderate (high confidence)*
Future exposure: *Low-moderate (moderate confidence)*
Potential refugia: *Riparian areas.*

Large wide-ranging herbivores are sensitive to air temperatures and frequently seek out thermal refugia during warm and cold periods (Zeiner et al. 1990). Carnivores may be sensitive to increased air temperatures, as some species (e.g., mountains lions) utilize thermal refugia for denning and rearing (Bleich et al. 1996). Maintaining and protecting areas with topographical diversity is likely to provide increased areas of thermal refugia for this species group (Zeiner et al. 1990).

Workshop participants did not further discuss the following factors beyond assigning scores.

Precipitation (amount)

Sensitivity: *Low-moderate (high confidence)*
Future exposure: *Low-moderate (moderate confidence)*
Potential refugia: *Riparian areas.*

Precipitation (timing)

Sensitivity: *Low-moderate (high confidence)*
Future exposure: *Low-moderate (moderate confidence)*
Potential refugia: *Riparian areas.*

Snowpack amount

Sensitivity: *Low-moderate (high confidence)*
Future exposure *Low-moderate (moderate confidence)*
Potential refugia: *Riparian areas.*

Timing of snowmelt & runoff

Sensitivity: *Low-moderate (high confidence)*
Future exposure: *Low-moderate (moderate confidence)*
Potential refugia: *Riparian areas.*

Streamflow

Sensitivity: *Low-moderate (high confidence)*
Future exposure: *Low-moderate (moderate confidence)*
Potential refugia: *Riparian areas.*

Riparian areas are buffered from climate change, but variable stream flows may affect important riparian refugia[1].

Workshop participants did not further discuss the following climate factors beyond assigning scores.

Water temperature

Sensitivity: *Low-moderate (high confidence)*
Future exposure: *Low-moderate (moderate confidence)*
Potential refugia: *Riparian areas.*

Drought

Sensitivity: *Low-moderate (high confidence)*
Future exposure: *Low-moderate (moderate confidence)*
Potential refugia: *Riparian areas.*

Soil moisture

Sensitivity: *Low-moderate (high confidence)*

Storms

Sensitivity: *Low-moderate (high confidence)*

Heat waves

Future exposure: *Low-moderate (moderate confidence)*
Potential refugia: *Riparian areas.*

Climatic changes that may benefit the species group:

- May benefit indirectly through habitat change.

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	High	High
Invasive & other problematic species	Low-moderate	Low-moderate
Land use change	High	High
Other factors	Moderate	Moderate-high
Pollution & poisons	Moderate	High
Roads, highways, & trails	High	High
Urban/suburban development	High	Moderate
Overall Scores	**Moderate-high**	**Moderate-high**

Non-climate factors constitute the most important impacts to large wide-ranging mammals[1]. The growing human population will likely result in increased development and habitat fragmentation, which will make it harder for these species to be resilient, so sensitivity to climate changes will increase with increased human pressure (Huber et al. 2012, 2014).

Agricultural & rangeland practices

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

Along with urban development, agricultural and rangeland development have destroyed, altered, and fragmented natural landscapes in the Central Valley, impacting habitat availability and connectivity for large wide-ranging mammals (Huenneke 1989). Fencing used to protect agricultural crops and/or influence stock movement can affect large wide-ranging mammal dispersal, health, survival, and access to refugia and other resources (Gates et al. 2012). However, agricultural landscapes – particularly rangelands – do provide more dispersal opportunities for large wide-ranging mammals than urban/suburban areas (Huber et al. 2012).

Roads, highways, & trails

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

Roads, highways, and trails fragment large wide-ranging mammal habitat and can cause reductions or shifts in home range. Many of these mammal species actively avoid road areas,

which influences broader movements across the landscape. Roads, highways, and trails can serve as major sources of large mammal mortality in some areas via vehicle strikes, and also increase exposure to poaching (Trombulak & Frissell 2000).

Land use change

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

Similar to other fragmented landscapes across the world, continued land use change (e.g., conversion to vineyards) in the Central Valley may continue to isolate remaining large mammal refugia and limit dispersal corridors, migration opportunities, and habitat suitability for these wide-ranging species (DeFries et al. 2007; Huber et al. 2012, 2014). Modeling efforts have demonstrated how extensive human land use undermines mammalian dispersal capacity (Huber et al. 2012). By causing circuitous migration pathways, human land use forces mammals to move 0.8 km/year faster, on average, to adequately track climate-driven shifts in habitat availability, which increases their exposure to climate impacts (Schloss et al. 2012).

Urban/suburban development

Sensitivity: *High (high confidence)*
Current exposure: *Moderate (high confidence)*
Pattern of exposure: *Highly localized.*

Urban/suburban development destroys and fragments habitat for large wide-ranging mammals, degrading overall habitat quality and potentially affecting gene flow (Ernest et al. 2003; Ordeñana et al. 2010). Even for those species able to disperse through highly altered landscapes, decreased habitat suitability as a result of modification can undermine survival, reproduction (Schloss et al. 2012), and genetic exchange (Ernest et al. 2003). Urban/suburban development can also increase exposure to disease agents, including domestic cats and dogs (Foley et al. 2013), although most large wide-ranging mammals naturally avoid urban/suburban areas (McKinney 2002). In addition, urban/suburban development often increases other non-climate factors linked with human activity and interests, including road construction, vehicular strikes, poisons and pollution, and human harassment (Ordeñana et al. 2010), further limiting animal movement through landscapes that might otherwise be suitable (Huber et al. 2012). Studies in other urbanized California landscapes indicate that gray fox, mountain lion, and bobcat occurrence declines with increasing urbanization proximity and intensity (Ordeñana et al. 2010).

Continued development is likely in the Central Valley due to a growing human population (Huber et al. 2014). Areas most at risk for urban conversion and related negative impacts on large wide-ranging mammal habitat connectivity include current agricultural areas near Riverbank and Modesto, and land near Oakdale (Huber et al. 2012).

Pollutions & poisons

Sensitivity: *Moderate (high confidence)*

Current exposure: *High (high confidence)*
Pattern of exposure: *Localized; poison baits in urban and agricultural areas and illegal marijuana farms.*

Predator species, such as mountain lion and gray fox, may experience mortality due to targeted and non-targeted poison baits (e.g., see Riley et al. 2007). Pollution and poisons include rat poison in urban/agricultural areas and illegal marijuana farming[1].

Invasive & other problematic species

Sensitivity: *Low-moderate (high confidence)*
Current exposure: *Moderate (high confidence)*
Pattern of exposure: *Localized and patchy; depends strongly on land practices.*

Yellow starthistle (*Centaurea solstitialis*) is a wide-spread and highly invasive non-native plant that has degraded grassland habitats of the Sacramento and San Joaquin valleys and surrounding foothills. The plant interferes with grazing and lowers yield and forage quality of grasslands and rangelands. (Bossard, et. al. 2000).

Other factors: Poaching

Sensitivity: *Moderate (high confidence)*
Current exposure: *Low-moderate (moderate confidence)*
Pattern of exposure: *Localized; rural areas.*

Poaching is a major source of large wide-ranging mammal mortality in some areas[1].

Disturbance Regimes

Workshop participants scored the resource's sensitivity to disturbance regimes, and these scores were used to calculate climate change sensitivity.

Overall sensitivity to disturbance regimes: *Moderate (moderate confidence)*

Large wide-ranging mammal sensitivity to disturbance regimes is increased by the severe reduction of connected habitat[1].

Wildfire

Future exposure: *Low-moderate (moderate confidence)*
Potential refugia: *Riparian areas.*

Large wide-ranging mammals exhibit localized sensitivity to fire[1], particularly since high vagility and mobility may make large mammals less vulnerable to direct fire mortality than other species (Esque et al. 2003). Wildfires can temporarily reduce thermal cover and prey availability for carnivores (Cunningham et al. 2006), as well as browse, thermal cover, and predator cover for herbivores (Updike et al. 1990). Current studies have documented few long-term wildfire impacts for carnivores (Cunningham et al. 2006; Schuette et al. 2014), while wildfire impacts on ungulates are intertwined with precipitation (i.e., impacts on post-fire herbaceous forage) and other environmental variables (Updike et al. 1990).

Disease

Many large wide-ranging mammals are vulnerable to disease, and habitat fragmentation may increase disease exposure by increasing local population densities and forcing more frequent contact with domestic disease carriers (Bevins et al. 2012; Foley et al. 2013). For example, mountain lions and bobcats are vulnerable to several diseases transmitted by domestic dogs and cats (Foley et al. 2013). Alternatively, native ungulates can serve as disease sources for domestic livestock (Miller et al. 2013). Disease is a region-wide issue for large wide-ranging mammals[1].

Flooding

Future exposure: *Low-moderate (moderate confidence)*
Potential refugia: *Riparian areas*.

Large wide-ranging mammals exhibit localized sensitivity to flooding[1].

Grazing

Large wide-ranging mammals exhibit localized sensitivity to grazing[1]. Riparian areas are ideal foraging locations for both native ungulates and cattle, increasing competition (Gogan & Barrett 1987; Vallentine 1989; Zeiner et al. 1990). Additionally, fences used in ranching operations can influence large wide-ranging mammal movement and access to critical resources, as well as contribute to adult/young ungulate separation, injury, or mortality (Gates et al. 2012).

Dependency on habitat and/or other species

Workshop participants scored the resource's dependency on habitat and/or other species, and these scores were used calculate climate change sensitivity.

Overall degree of specialization*: Moderate (high confidence)*
Dependency on one or more sensitive habitat types: *Low-moderate (high confidence)*
Description of habitat: *Not dependent on specific habitats except for pronghorn, which need grasslands. Elk are associated with wetlands to some degree, but not dependent upon them.*
Dependency on specific prey or forage species: *Low (high confidence)*
Dependency on other factors that influence sensitivity: *High (high confidence)*
Description of other dependencies: *Habitat connectivity/geometry*

Large-wide ranging mammals are largely habitat generalists, utilizing a variety of habitat types as they move across the landscape. Pronghorn prefer open sagebrush and grassland, and mule deer are commonly found along riparian corridors. Elk prefer shrublands and forage in riparian and meadow areas (Zeiner et al. 1990); elk also utilize wetlands (Zeiner et al. 1990), which are vulnerable to climate change due to their dependence on allocated water (CA Natural Resources Agency 2010). Similarly, grey fox, mountain lion, and bobcat utilize a variety of shrubland, riparian, forest, and woodland habitats depending on what is available. Gray foxes have also been documented to den below human structures (Zeiner et al. 1990). Although they are ecosystem generalists, large wide-ranging mammals generally require large, connected

habitat areas (Zeiner et al. 1990), and habitat connectivity/geometry is affected by cultural activities more than climate change[1].

Large wide-ranging mammals are also largely prey/forage generalists. For example, herbivores utilize various vegetative resources depending on season and location, including forbs, sagebrush, and grasses, as well as cultivated crops such as alfalfa on occasion. Carnivores prey on a variety of species including small and large mammals, birds, rodents, reptiles, invertebrates, and rabbits; bobcats and gray foxes have also been documented to eat fruits, nuts, insects, and carrion (Zeiner et al. 1990).

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, Status, and Dispersal Ability	Low
Landscape Permeability	Low-moderate
Intraspecific Species Group Diversity	Moderate
Resistance & Recovery	Moderate-high
Other Adaptive Capacity Factors	Moderate-high
Overall Score	**Moderate**

Extent, status, and dispersal ability

Overall degree extent, integrity, connectivity, and dispersal ability: *Low (high confidence)*
Geographic extent: *Occurs beyond small area but still quite limited (high confidence)*
Health and functional integrity: *Degraded (high confidence)*
Population connectivity: *Isolated and/or quite fragmented (high confidence)*
Dispersal ability: *Low-moderate (high confidence)*

The large wide-ranging mammals considered here are isolated, locally threatened sub-populations of widespread species. For example, pronghorn are generally found only in the northeastern part of California, mule deer have a limited distribution in the Central Valley relative to the rest of state (Pease et al. 2009), and tule elk now exist only in dedicated wildlife reserves within the study area, including the Tule Elk State Reserve in Kern County and in Grizzly Island in Solano County (Gogan & Barrett 1987). Mountain lions, gray foxes, and bobcats are more widespread throughout California but require fairly large home ranges (Zeiner et al. 1990; Ernest et al. 2003). Large wide-ranging mammals are highly mobile (Zeiner et al. 1990; Ernest et al. 2003; Pease et al. 2009), but current and expected habitat fragmentation limits

dispersal (Huber et al. 2012) and gene flow between sub-populations in the study area (Ernest et al. 2003).

Landscape permeability

Overall landscape permeability: *Low-moderate (high confidence)*
Impact of various factors on landscape permeability:
Urban/suburban development: *High (high confidence)*
Roads, highways, & trails: *High (high confidence)*
Dams, levees, & water diversions: *High (high confidence)*
Lack of riparian zone: *High (high confidence)*
Agricultural & rangeland practices: *Moderate (moderate confidence)*
Land use change: *Moderate (moderate confidence)*
Energy production & mining: *Moderate (moderate confidence)*

In some cases, extensive human land use may eliminate mammal migration options in the face of climate change (Schloss et al. 2012). Several land uses in the Central Valley restrict passage for large wide-ranging mammals; urban landscapes and heavily roaded areas are the least permeable, agricultural areas are slightly more permeable, and pasture areas provide the highest permeability within areas of human land use (Huber et al. 2012). However, the permeability of these zones is still less than that of natural habitat types (Huber et al. 2012, 2014). Additionally, solar farms in the San Joaquin Valley have a locally high impact on the species group, and more facilities are going to be added in the future[1].

Riparian areas and zones with high cover (e.g., woodland) are important connectivity thruways for large wide-ranging mammals (Huber et al. 2012, 2014), but a lack of riparian habitat on most of the tributaries to the Sacramento and San Joaquin Rivers prevents the species group from migrating in and out of the Central Valley [1]. Additionally, some riparian area modifications (e.g., concrete-lined canals) create impermeable barriers to large mammal dispersal[1].Different species require different modifications (e.g., bridges vs. culverts) to facilitate landscape permeability (Spencer et al. 2010).

Resistance and recovery

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

As prey/forage and habitat generalists (Zeiner et al. 1990), large wide-ranging mammals are generally resistant to climate-driven changes and disturbance regimes. However, extensive land use alteration undermines the resilience of this species group by limiting migration and dispersal in response to variable climate conditions (Schloss et al. 2012) and habitat loss to human uses (Huber et al. 2012).

Species group diversity

Overall species group diversity: *Moderate (high confidence)*
Diversity of life history strategies: *Moderate (moderate confidence)*
Genetic diversity: *Low-moderate (high confidence)*
Behavioral plasticity: *High (high confidence)*
Phenotypic plasticity: *Moderate (moderate confidence)*

Reproductive rates among large wide-ranging mammals are typically low, with most species reproducing only once per year and having a small number of young (1-2 for ungulates, 2-7 for carnivores; Zeiner et al. 1990). Members of this species group typically take 1-2 years to reach reproductive maturity (Zeiner et al. 1990). Genetic diversity varies amongst species; tule elk diversity is quite low (Williams et al. 2004), mule deer diversity is higher but current gene flow is likely limited relative to historic interactions (Pease et al. 2009), and mountain lion diversity exhibits differences by sub-region in California (Ernest et al. 2003). Genetic exchange can be inhibited by fragmented landscapes and populations (Ernest et al. 2003). Species in this group exhibit some behavioral plasticity in response to changing conditions and altered habitat availability and quality, including utilizing cultivated crops for forage (Zeiner et al. 1990).

Other Factors

Overall degree to which other factors affect habitat adaptive capacity: *Moderate-high (moderate confidence)*

Assisted migration

Assisted migration

Assisted migration is a current management tool (Zeiner et al. 1990) whose use will likely increase in the future as connectivity declines on the landscape; the degree to which the technique is successfully used will affect gene flow (Williams et al. 2004). Pronghorn translocation efforts have occurred in Kern, San Lois Obispo, and San Benito Counties to attempt the reestablishment of this mammal across larger parts of its historic range (Zeiner et al. 1990). Similar translocations have occurred with tule elk (Zeiner et al. 1990), and assisted migration may be an important tool in building genetic diversity between highly fragmented populations of this species (Williams et al. 2004). However, large mammal introductions into new areas could increase the occurrence of genetic bottlenecks via the founder's effect (e.g., see Stephen et al. 2005) or pose extinction risks in cases where not enough is known about the species' biology and suitable habitat requirements (Mawdsley et al. 2009).

Management potential

Workshop participants scored the resource's management potential.

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

Value to people

Value to people: *High (high confidence)*
Description of value: *Charismatic species, harvest species (hunting).*

Support for conservation

Degree of societal support for management and conservation: *High (high confidence)*
Description of support: *Charismatic species, harvest species (hunting). Support suffers somewhat with conflicts at the wildland-urban interface (e.g., mountain lions eating pets, attacking people).*

Degree to which agriculture and/or rangelands can benefit/support/increase resilience: *Moderate (moderate confidence)*
Description of support: *Managed rangelands can be important, intensive agriculture not so much.*

Degree to which extreme events (e.g., flooding, drought) influence societal support for taking action: *Low-moderate (moderate confidence)*
Description of events: *Reduced support for water in wetlands (due to water scarcity/drought) would impact tule elk, however public awareness is already high so there would not be much change.*

Likelihood of converting land to support species group

Likelihood of (or support for) converting retired agriculture land to maintain or enhance species group: *Moderate-high (moderate confidence)*

Description of likelihood: *The conversion of some of the islands south of the Yolo Bypass is an example. Riparian restoration has good support; there is a movement toward acquiring land along creeks as parkways.*

Likelihood of managing or alleviating climate change impacts: *High (high confidence)*
Description of likelihood: *This is a behaviorally adaptive group with minimal direct impacts from climate change. Riparian corridors mitigate the effect of high temperatures (provide thermal refugia), and are likely to receive restoration attention.*

Maintaining riparian corridors and adjacent rangelands will likely be important for maintaining remnant landscape permeability, dispersal corridors (Huber et al. 2012), and thermal refugia for large wide-ranging mammals in the Central Valley (Zeiner et al. 1990). Targeted valley oak and other native tree plantings along fragmented dispersal corridors and riparian areas could provide refugia and connectivity opportunities for these species (Huber et al. 2014). Agricultural and rangeland areas, urban zones, and critical road crossings across the study area can also be modified and managed to promote maximum permeability and ecological function for mammals and other native species (Huber et al. 2014). Improving and modifying human land use areas may provide greater overall landscape permeability for native species relative to protecting isolated corridors, which may or may not be suitable for large mammal dispersal (Huber et al. 2014). However, conservation efforts, particularly for carnivores, may be undermined by human safety concerns and loss of human property (e.g., livestock) to carnivore activity (Torres & Mansfield 1996; Löe & Röskaft 2004).

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