Central Valley Landscape Conservation Project

Climate Change Vulnerability Assessment (January 2017 version)

Cavity Nesters & Roosters

Vulnerability Assessment Summary

Overall Vulnerability Score and Components:

Vulnerability Component	Score
Sensitivity	Moderate-high
Exposure	Moderate-high
Adaptive Capacity	Moderate
Vulnerability	**Moderate**

Overall vulnerability of the cavity nesters and roosters species group was scored as moderate. The score is the result of moderate-high sensitivity, moderate-high future exposure, and moderate adaptive capacity ratings.

A key climate factor for cavity nesters and roosters is air temperature, which influences nest and roost site selection and may cause heat stress, especially in bats. Wildfire, disease, and insects are the primary disturbance regimes for this species group; wildfire and insects impact the availability of cavities, and cavity nesters may increase in the several years following a fire or insect outbreak.

A key non-climate factor for this species group is urban/suburban development, which may contribute to habitat fragmentation and loss; however, some cavity-nesting bird species may become more abundant near human activity. Bats are quite sensitive to disease, especially white-nose syndrome, which was recently discovered in the western United States.

Maintaining connectivity between habitat patches is important for cavity nesters and roosters, though the connectivity needs of this diverse species group are varied. Energy development and geologic barriers affect cavity nesters and roosters by causing direct mortality (in the case of wind farms) and limiting movement and dispersal.

Cavity nesters and roosters exhibit a moderate-high degree of specialization; they depend on snags and dead branches to provide natural cavities or sites suitable for excavated cavities. This species group exhibits moderate interspecific species diversity; many species have demonstrated behavioral and phenotypic plasticity that allows variable responses to habitat and climate conditions.

Management potential for cavity-nesting and rooster was scored as moderate-high. These species respond well to restored riparian habitats, and management options for cavity nesters and roosters are likely focused on maintaining healthy forest to provide nest sites and abundant insect prey.

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Introduction

Description of Priority Natural Resource

Cavity-nesting birds within the Central Valley primarily utilize riparian and oak woodland habitats; they include owls, woodpeckers (*Picus* spp., *Sphyrapicus* spp., etc.), nuthatches (*Sitta* spp.), chickadees (*Parus* spp.), wrens (*Thryomanes* spp.), tree swallows (*Tachycineta bicolor*), bluebirds (*Sialia* spp.), and wood ducks (*Aix sponsa*), among others (DiGaudio et al. 2015). They are typically divided into primary cavity nesters (e.g., woodpeckers), which excavate cavities in snags or dead branches, and secondary cavity nesters (e.g., wrens, nuthatches, owls), which use natural cavities or those previously excavated by other species (Scott et al. 1977). There are also seven species of cavity-roosting bats found in the Central Valley, including the Mexican free-tailed bat (*Tadarida brasiliensis*), big brown bat (*Eptesicus fuscus*), pallid bat (*Antrozous pallidas*), California myotis (*Myotis californicus*), Yuma myotis (*Myotis yumanensis*), western red bat (*Lasiurus blossevillii*), and hoary bat (*L. cinereus*) (Zeiner et al. 1990; Long et al. 2006). These typically hibernate in the winter and return to the roost annually to raise their young (Zeiner et al. 1990; Long et al. 2006).

As part of the Central Valley Landscape Conservation Project, workshop participants identified the cavity nesters and roosters 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 cavity nesters and roosters species group as a Priority Natural Resource included the following: the species group has high management importance, and the species group's conservation needs are not entirely represented within a single priority habitat. 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-high
Extreme events: drought	Moderate	Moderate-high
Extreme events: heat waves	Moderate	Moderate-high
Extreme events: storms	Moderate	High
Increased wildfire	-	Moderate-high
Precipitation (amount)	Moderate	Moderate
Precipitation (timing)	Moderate	Moderate
Overall Scores	**Moderate**	**Moderate-high**

Air temperature

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

Bats are sensitive to temperature, although they are able to respond to summer heat by moving to cooler areas and/or by increasing the distance between individuals in a roost (Licht & Leitner 1967). Some species appear to be more sensitive to heat than others; for instance, the Yuma myotis was more likely to move to a cooler but less sheltered roost than the Mexican free-tailed bat and the pallid bat (Licht & Leitner 1967). However, in a lab setting, the Mexican free-tailed bat was the most heat tolerant, followed by the Yuma myotis and then by the pallid bat, which was the most intolerant of heat (Licht & Leitner 1967). Flexible foraging strategies and habitat requirements may be associated with lower sensitivity to temperature (Adams 2010). Warm nights are associated with more insect activity, and may have some foraging benefits (though insect activity is also dependent on water availability)[1].

Bat reproduction rates likely decline in higher temperatures, although low precipitation may play a larger role than temperature in reproductive rates, and the two factors have a strong inverse correlation (Adams 2010). Young bats may experience more heat stress than adults because they cannot move around[1].

There is limited evidence that tree swallows and northern flickers may prefer nesting sites with in larger trees and with a south-facing orientation, suggesting that warmer cavities may provide a fitness benefit (Wiebe 2001; Ardia et al. 2006).

Heat waves

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

Drought

Sensitivity: *Moderate (low confidence)*
Future exposure: *Moderate-high (high confidence)*
Potential refugia: *Bat refugia may include riparian habitat along larger rivers because they are more likely to maintain water availability; wildlife programs are working with rangers in the foothills to keep open water sources to provide refugia.*

Precipitation (amount)

Sensitivity: *Moderate (low confidence)*
Future exposure: *Moderate (low confidence)*
Potential refugia: *Bat refugia may include riparian habitat along larger rivers because they are more likely to maintain water availability; wildlife programs are working with rangers in the foothills to keep open water sources to provide refugia.*

Precipitation affects the success of maternity colonies, which are sensitive to water availability (Adams & Hayes 2008). Nursing mothers visit streams more often than non-lactating females, and are more vulnerable to water loss through wing membranes (Adams & Hayes 2008). Precipitation also affects roosts and prey production, with late precipitation contributing to low insect production and decreased reproductive success (Adams 2010). Conversely, increased precipitation could increase prey production, depending on the timing and availability of water in streams[1]. In the Central Valley, changes in precipitation may have a larger effect on bats living near small streams, which have more variable water availability and therefore more variable prey production[1].

Precipitation (timing)

Sensitivity: *Moderate (low confidence)*
Future exposure: *Moderate (low confidence)*
Potential refugia: *Bat refugia may include riparian habitat along larger rivers because they are more likely to maintain water availability; wildlife programs are working with rangers in the foothills to keep open water sources to provide refugia.*

Storms

Sensitivity: *Moderate (low confidence)*

Future exposure: *High (high confidence)*

Storms reduce foraging time and could disturb prey populations that have to rebound afterwards[1].

Increased Wildfire

Workshop participants did not further discuss this factor beyond assigning an exposure score.

Future exposure: *Moderate-high*

Climatic changes that may benefit the species group:

- Drought would create a short-term increase in cavities
- Less snowpack and more rain could mean more insects
- Increased temperatures could cause faster fetal development
- More storms may increase water availability

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
Invasive & other problematic species	Low-moderate	Moderate
Land use change	Moderate	Moderate-high
Pollution & poisons	Moderate	-
Urban/suburban development	Moderate-high	Moderate-high
Overall Scores	**Moderate**	**Moderate-high**

Urban/suburban development

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

Tewksbury et al. (2002) found that, across the western United States, house wrens (*Troglodytes aedon*), downy woodpeckers (*Picoides pubescens*), and northern flickers were more common around human habitation and agriculture, while red-naped sapsuckers were less abundant.

Urban/suburban development also leads to the loss of many bat roosts[1]. Maternity colonies are more sensitive to this stress than other bat demographics, primarily because people may be averse to large groups of bats[1]; they also require larger habitat patches[1].

Agricultural & rangeland practices

> ***Sensitivity:*** *Moderate (low confidence)*
> ***Current exposure:*** *High (high confidence)*
> ***Pattern of exposure:*** *Widespread across the landscape.*

Water availability in rangelands has a large impact on this species group[1]. Agricultural practices that produce insects and maintain trees may be beneficial [1].

Land use change

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

Land use change refers to conversion of land to permanent crops[1].

Pollution & poisons

> ***Sensitivity:*** *Moderate (high confidence)*

Pollution and poisons includes pesticide use, which impact this species group indirectly because they have negative effects on insects[1].

Invasive & other problematic species

Workshop participants did not further discuss this factor beyond assigning scores.

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

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-high (moderate confidence)*

Wildfire

> ***Future exposure:*** *Moderate-high (high confidence)*

Wildfire increases the availability of snags and dead branches for cavity nesters (Dudley & Saab 2003). In the first few years after a fire, trees with soft wood that is easily excavated (e.g., aspen) and treetops that were dead before the fire are heavily used (Dudley & Saab 2003).

Disease

The greatest threat of disease is to bats, which are vulnerable to fungal diseases; these can have extremely high mortality rates, and transmission can continue after death through fungal spores remaining in the soil (Fisher & Shaffer 1996). White-nose syndrome, which is caused by the *Pseudogymnoascus destructans* fungus, emerged in New York in 2006 and has led to the rapid decline of eastern U.S. bat populations (Frick et al. 2010). In March 2016, the first case of white-nose syndrome was reported on the west coast in North Bend, Washington, and it will likely spread throughout the western United States (WDFW 2016).

Insects

Outbreaks of insect pests may increase the availability of snags and available cavities; Drever and Martin (2010) found that woodpecker richness increased following insect outbreaks, although the species richness of other forest birds decreased.

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 (high confidence)*
> ***Dependency on one or more sensitive habitat types:** High (high confidence)*
> > ***Description of habitat:** Large trees with cavities (primarily oak woodlands and large riparian trees).*
>
> ***Dependency on specific prey or forage species:** Low-moderate (low confidence)*
> ***Dependency on other critical factors that influence sensitivity:** Moderate-high (high confidence)*
> > ***Description of other dependencies:** Host plants, cavities excavated by other species*

Cavity-nesting birds are dependent on medium-large trees, which are primarily found within riparian or oak woodland habitats in the Central Valley. They may be vulnerable to the impacts of climate change on tree recruitment; for instance, drought and long periods of low precipitation are likely to significantly decrease cottonwood (*Populus* spp.) recruitment (Mahoney & Rood 1998). Secondary cavity nesters are additionally dependent on existing cavities, and some studies have demonstrated density-dependent reproductive rates in Eurasian nuthatches, which may be linked to heavy competition for available cavities (Nilsson 1987; Maícas et al. 2012). Northern flickers (*Colaptes auratus*) and white-breasted nuthatches (*Sitta carolinensis*) were more abundant in deciduous riparian habitat, and the northern sapsucker was found exclusively in deciduous habitat (Tewksbury et al. 2002).

Dependence on specialized prey varies widely among bat species (Denzinger & Schnitzler 2013), with some species foraging opportunistically (e.g., Mexican free-tailed bat*)* and others on specific types of insects (e.g., western red bat; Long et al. 2006).

Bats require separate roosting and foraging locations, and changing climate factors could affect their ability to make this foraging journey daily[1]. They also depend on other cavity nesters or environmental decay for nest sites; they can use bark fluffing and cracks and crevices that most people might not think as cavities, as well as riparian vegetation[1]. Dependence on specialized prey varies widely among bat species (Denzinger & Schnitzler 2013), with some species foraging opportunistically (e.g., Mexican free-tailed bat*)* and others on specific functional types of insects (Long et al. 2006). Larger species cannot maneuver as much so will not go after small fast insects[1].

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	Moderate-high
Landscape Permeability	Moderate
Intraspecific Species Group Diversity	Moderate
Resistance & Recovery	Moderate-high
Overall Score	**Moderate**

Extent, status, and dispersal ability

Overall degree extent, integrity, connectivity, and dispersal ability: *Moderate-high (high confidence)*
Geographic extent: *Transboundary (high confidence)*
Health and functional integrity: *Moderately healthy (high confidence)*
Population connectivity: *Continuous (high confidence)*
Dispersal ability: *High (high confidence)*

Populations of many species of birds have been significantly reduced as portions of their breeding range are lost and fragmented; listed species include yellow-billed cuckoo (*Coccyzus americanus*), Least Bell's vireo, and yellow warbler (RHJV 2004). It is likely that habitat loss and fragmentation is the primary driver of declining populations in most riparian birds (RHJV 2004). Patch size, density, heterogeneity, and spatial configuration determine the impact of habitat fragmentation on nesting success in birds (Stephens et al. 2003), with some populations experiencing greater impacts than others (RHJV 2004). The impacts of habitat fragmentation are clearer when evaluated at large spatial scales (e.g., landscape), due to the number of additional factors that influence nesting success and population dynamics at the local level (Stephens et al. 2003). Large-scale analysis also takes into account complex interactions with other factors, such as how multiple predator types that are also responding to habitat loss and fragmentation at different levels of intensity and scale [e.g., squirrels, raccoons (*Procyon lotor*), coyotes (*Canis latrans*); Stephens et al. 2003].

Landscape permeability

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

Energy production & mining: *Moderate-high (high confidence)*
Agricultural & rangeland practices: *Moderate (high confidence)*
Dams, levees, & water diversions: *Moderate (moderate confidence)*
Roads, highways, & trails: *Moderate (moderate confidence)*

Riparian habitats act as movement corridors and stopover habitat for riparian birds, as well as many upland species (Tewksbury et al. 2002; RHJV 2004). Habitat fragmentation caused by development and associated infrastructure, energy production (e.g., utility lines), and agriculture (especially vineyards) can alter patterns of movement; changes in land use practices that result in habitat loss or degradation can also act as barriers (RHJV 2004). Both patch size and spatial configuration are important components of connectivity, contributing to the degree of isolation of bird populations utilizing the patch (Bélisle & St. Clair 2001; Stephens et al. 2003; RHJV 2004). Fragmentation due to development, agriculture, and grazing significantly increase the abundance of brown-headed cowbirds, house sparrows, and many predators (Tewksbury et al. 2002; RHJV 2004).

Roads may be a significant barrier to riparian birds, and can cause changes in dispersal and movement patterns, body condition, mortality, and population declines (Bélisle & St. Clair 2001; McClure et al. 2013; Ware et al. 2015). McClure et al. (2013) found that, even in roadless areas, the sound of traffic being played was associated with a 25% decrease in bird abundance, confirming that noise is one of the primary negative impacts of roads.

More research needs to be done on dams and levees[1]. Light pollution affects insect populations[1].

Resistance and recovery

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

There is little ecological information that directly addresses the ability of riparian birds to resist the climate-related stresses and/or to recover from stresses. However, many species are able to respond quickly to habitat improvements, including the spotted sandpiper, which nests on gravel bars exposed during flood events (RHJV 2004). Restoration projects, such as those occurring along the Sacramento River, have successfully increased riparian bird diversity within the last 10 years (DiGaudio et al. 2015).

Species group diversity

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

Over 130 species of riparian birds are present in the Central Valley, including many rare species such as Cassin's vireo, black-throated gray warbler, western yellow-billed cuckoo, bank swallow, and pine siskin (Dybala et al. 2015; DiGaudio et al. 2015). While population size has declined for many species within this group, species diversity has not changed significantly, and most riparian species that are thought to have been present historically are still present[1]. Species richness remains high in the winter, when riparian habitats are used by neotemperate migrants; winter phylogenetic diversity (and thus, avian genetic diversity) is higher than during the breeding season (Dybala et al. 2015).

Genetic and phenotypic diversity can prompt shifts in species' migration strategies, which is a vital part of species' adaptation to changing environmental conditions (including both climate changes and habitat loss; Dolman & Sutherland 1995). Although little research exists on the link between genetics and migration strategies for most species, there is some evidence that assortative mating (i.e., a tendency for individuals to mate with others that share their own traits) may contribute to shifts in migration strategies; for instance, individuals that pair off in their wintering grounds could be more likely to increase the frequency of genetic coding that is tied to wintering in that particular location (Dolman & Sutherland 1995). Migration strategies are less likely to have a genetic component when birds migrate in large family groups, where young birds are able to learn the route rather than depending entirely on internal cues (Dolman & Sutherland 1995; Newton 2010). However, no studies have provided direct evidence for a link between climate change and genetic adaptation in bird phenology (Charmantier & Gienapp 2014).

There is some evidence of behavioral plasticity among neotropical migrants in response to variation in environmental conditions; for instance, barn swallows arrive later during El Niño years, while black-headed grosbeaks arrive earlier (Ackerman et al. 2011). Song sparrows exhibit flexibility in nest-site preferences, with some nest sites leading to improved nesting success (Chase 2002).

Management potential

Workshop participants scored the resource's management potential.

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

Value to people

Value to people: *Moderate-high (high confidence)*
Description of value: *Bird watching is the most popular sport.*

Support for conservation

Degree of societal support for management and conservation: *Moderate-high (high confidence)*
Description of support: *Culture and social attitudes shift over time. The Lacey Act and the Migratory Bird Treaty Act play into protecting areas.*

Degree to which agriculture and/or rangelands can benefit/support/increase resilience: *High (high confidence)*
Description of support: *There is major potential for benefit to riparian habitat and riparian birds if appropriate changes are made in agricultural and rangeland management, such as: (1) excluding grazing from riparian areas, (2) moving cropped areas away from stream margins and restoring riparian corridors, and (3) reconnecting fragmented riparian corridors within agricultural landscapes. These potential benefits will not be achieved unless the current practices used in managing agricultural and rangeland areas are good (for example, Point Blue Conservation Science programs).*

Degree to which extreme events (e.g., flooding, drought) influence societal support for taking action: *Moderate (moderate confidence)*
Description of events: *The real impacts to riparian areas related to flooding are the management practices used to "prevent" flood-related impacts. This often includes removing and/or simplifying riparian habitat areas significantly. There does seem to be a moderate level of public support for moderating impacts of flood-prevention practices and not destroying riparian habitat areas.*

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 (high confidence)*

Likelihood of managing or alleviating climate change impacts: *Moderate (high confidence)*
Description of likelihood: *Multi-purpose projects as part of habitat restoration.*

Habitat restoration activities should prioritize restoration of stream hydrology; flow management and dam releases should try to imitate natural flooding cycles to restore natural hydrology and scouring/sedimentation processes (RHJV 2004). Bypasses and levee setbacks can be an alternative to traditional flood control infrastructure, which protects agriculture and urban areas while also maintaining flow variation within riparian habitats (RHJV 2004). Restoring riparian corridors will allow dispersal and migration of riparian bird communities, increasing genetic diversity and the opportunity for phenotypic and behavioral plasticity to allow flexible responses to changing climate conditions (Seavy et al. 2009; Dybala et al. 2015). Habitat restoration activities should prioritize areas that are within 7-12 kilometers of protected land, and those that are within dispersal range of source populations (RHJV 2004). Management options may also include the protection of adjacent upland areas that can serve as foraging habitat and flood refugia; for instance, yellow-billed cuckoos utilize upland refugia to forage when their usual prey is wiped out during spring floods (RHJV 2004).

Land managers should focus on providing habitat for both breeding and wintering riparian birds by considering resource availability (e.g., food, nest sites), microclimate conditions, predation risk, and habitat structure (Dybala et al. 2015). Land managers may consider non-invasive exotic species as potentially beneficial where they may maintain ecological functions and services, and these could be maintained in areas where native plants may be unlikely succeed in the future[1]. Considering habitat loss and fragmentation at the landscape level will enable planning processes to capture more complex dynamics that could be impacted by climate change and human activities, such as changing predator/prey dynamics as the abundance and distribution of both riparian birds and predators shift (Stephens et al. 2003). Habitat protection efforts should focus on large blocks of habitat and/or corridors, and encourage more concentrated development rather than expansion (Stephens et al. 2003).

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