Central Valley Landscape Conservation Project

Climate Change Vulnerability Assessment (January 2017 version)

Breeding Waterbirds & Shorebirds

Vulnerability Assessment Summary

Overall Vulnerability Score and Components:

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

Overall vulnerability of the breeding waterbirds and shorebirds species group was scored as low-moderate. The score is the result of moderate sensitivity, moderate-high future exposure, and moderate-high adaptive capacity scores.

Key climate factors for breeding waterbirds and shorebirds include air temperature, heat waves, and the timing of precipitation. Warmer temperatures and heat waves decrease nesting success, and may also influence the timing of migration, nesting, and peak food availability. The timing of precipitation is closely tied to water availability and associated habitat loss, but also influences nesting success and food availability.

The key non-climate factor for this species group is predation, which accounts for a large proportion of nest losses and the majority of fledgling mortality. Breeding waterbirds and shorebirds are also sensitive to habitat loss and degradation in post-breeding and wintering habitat.

Key disturbance mechanisms for breeding waterbirds and shorebirds include flooding and grazing. Flooding is an important aspect of breeding and foraging habitat, although changes in water depth can inhibit foraging. Grazing may impact cover by reducing vegetation, but winter rotational grazing may have some benefits to breeding waterbirds. This species group exhibits a moderate degree of specialization due to their dependence on wetlands for breeding and foraging habitat.

Populations of breeding waterbirds and shorebirds in the Central Valley are limited by habitat availability; populations are patchily distributed in some areas, while in others bird density is high, contributing to increased disease and competition for resources. This species group exhibits moderate-high diversity, with many species exhibiting phenotypic and/or behavioral plasticity related to the timing of migration and breeding and nest site selection. This flexibility, as well as the ability to utilize agricultural habitats, increases the resilience of this species group, although high exposure to factors associated with human activity decreases nesting success and survival.

Management potential for breeding waterbirds and shorebirds was scored as moderate-high, and likely includes ensuring habitat availability, cover for nest sites and young, and water management practices that will maintain reliable water sources.

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Introduction

Description of Priority Natural Resource

Breeding waterbirds and shorebirds utilize wetlands and agricultural habitats (e.g., flooded rice fields, evaporation ponds, etc.) for breeding and foraging; ducks also use adjacent upland areas for nesting (Shuford et al. 1998; Central Valley Joint Venture 2006; Ackerman et al. 2011).

As part of the Central Valley Landscape Conservation Project, workshop participants identified the breeding waterbirds and shorebirds 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' 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.

Species included under the vulnerability assessment of the breeding waterbirds and shorebirds species group are mallard (*Anas platyrhynchos*), gadwall (*Anas strepera*), black-necked stilt (*Himantopus mexicanus*), American avocet (*Recurvirostra americana*), and killdeer (*Charadrius vociferous*).

The rationale for choosing the breeding waterbirds and shorebirds 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 it is a good indicator of ecosystem health. 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	-
Extreme events: heat waves	Moderate-high	-
Increased flooding	-	Moderate
Precipitation (timing)	Moderate-high	-
Overall Scores	**Moderate-high**	**Moderate-high**

Climate variables will likely contribute to a shift in the location or size of the breeding range of many bird species (Stralberg et al. 2009; National Audubon Society 2013; Galbraith et al. 2014). Species that are predicted to experience reductions in their breeding range include the American avocet (96% loss of summer range), gadwall (87%), and the black tern (35%; *Chlidonias niger*) (National Audubon Society 2013). For other species, such as the mallard, much of the current range may become unsuitable despite little or no loss of overall area.
Across the state, 10-57% of the land area will contain novel species assemblages by 2070 as species shift their ranges independently of one another in response to a combination of climate variables, including temperature and precipitation (Stralberg et al. 2009). The southern part of the Central Valley is one of the regions most likely to see the greatest changes in species composition, while the Delta is among the regions that will see the least change (Stralberg et al. 2009).

Air temperature

> ***Sensitivity:*** *Moderate-high (high confidence)*
> ***Future exposure:*** *Moderate-high (moderate confidence)*
> ***Potential refugia:*** *Delta, north-south gradient. Summer temperatures increase as you move north or south of the Delta (hottest areas are Redding in extreme north and Bakersfield in extreme south). Areas closer to Delta receive cooling from Bay/Delta breezes.*

Hatching success is expected to decline over the next 50 years in mallards and gadwalls, due in part to warming temperatures; impacts may include decreased clutch sizes, increased egg mortality and nest abandonment, and greater exposure of nests to predation as water levels recede (Ackerman et al. 2011).

Nest survival decreases as temperatures increase in both mallards and gadwalls (Ackerman et al. 2011). Mallards nested earlier when spring temperatures were warm (about 2 days earlier for every 1°F change in temp), and warm temperatures may allow more time for birds to re-nest if their initial attempts fail (Ackerman et al. 2011). Larger temperature increases may be associated with declining hatch success due to increased egg mortality, nest abandonment, and exposure to predation (Ackerman et al. 2011).

Warming temperatures may also cause shifts in the timing of seasonal patterns related to migration and reproduction in breeding birds (Both et al. 2006; Ackerman et al. 2011; Charmantier & Gienapp 2014), as well as changes in the timing of invertebrate development and emergence (Bale et al. 2002). Temperature interacts with other factors to determine phenology, including photoperiod (Bale et al. 2002; Visser et al. 2010).

Heat waves

Sensitivity: *Moderate-high (high confidence)*

Summer heat waves have been associated with decreased hatch rates, although the impact can be site-specific (Ackerman et al. 2011). In Yolo County, there was a 17% decrease in hatch rate for mallards after a season that included 13 days of heat over 95°F (Ackerman et al. 2011).

Flooding

Future exposure: *Moderate (low confidence)*

Breeding waterbirds and shorebirds depend on flooded habitat for foraging and raising their young, and reductions in the amount of flooded habitat available reduces the amount of food resources (Central Valley Joint Venture 2006; Reiter et al. 2015). Because wetland and cropland flooding is typically controlled in the Central Valley, nests and young are rarely harmed by large flood events. Chouinard and Arnold (2007) found that only 3 out of 74 radiomarked mallard hens lost their nests due to flooding. However, many species are sensitive to water depth and precipitation events may reduce their ability to forage. For instance, dabbling ducks (Anatinae) are found in deeper water, while wading birds and shorebirds are typically found in areas with shallow flooding that allows them to reach seeds (Elphick 2000; Strum et al. 2013; Sesser et al. 2016). It may be possible for atmospheric river events and spring flooding to change nest placement[1].

Precipitation (timing)

Sensitivity: *Moderate-high (moderate confidence)*

Changes in the timing of precipitation may to alter the hydrology and/or reduce the availability of wetland habitat used by breeding waterbirds and shorebirds. For instance, precipitation shortly before and during the breeding season creates more flooded habitat, including flooded croplands and seasonal wetlands, and this may increase foraging habitat and cover for ducklings (Ackerman et al. 2011).

The timing of rainfall also affects nesting behavior in mallards and gadwalls (Ackerman et al. 2011). Nests have initiated later in both species when there was more winter precipitation

(1.93 and 0.84 days later, respectively, for each additional 1” of winter rain), and nests that were initiated later in the season had a smaller clutch size. However, longer nesting season lengths were associated with more precipitation in the winter and late spring, especially in mallards, which increased their season length by 1.75 days for each additional 1” of late spring rain (Ackerman et al. 2011).

Drought

Sensitivity: *Moderate (moderate confidence)*

Flooded habitat for breeding birds is drastically reduced during the dry season and drought years, especially in the Tulare and San Joaquin basins (Reiter et al. 2015). Drier conditions reduce food availability (e.g., seeds, insects) and nesting substrate for waterbirds and shorebirds that depend on wetland habitat (Naylor 2002; Moss et al. 2009), and young mallards are less likely to breed in dry years (McLandress et al. 1996).

Water availability and cost is a limiting factor for wetland irrigation (Naylor 2002; Central Valley Joint Venture 2006), and changes in the timing of precipitation may reduce water storage and availability during the growing season (Kiparsky & Gleick 2003).

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
Other factors: predation	Moderate-high	Moderate-high
Overall Scores	**Moderate-high**	**Moderate-high**

Predation

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

Breeding shorebirds are vulnerable to predation, which may be increased by wetland design, habitat patch configuration, and agricultural practices (Shuford et al. 2004). Rapid water drawdown in rice croplands may expose nests to rat (*Rattus* spp.) predation (Lee 1984 cited in Shuford et al. 2004), although species that place their nests on higher ground (e.g., slopes on the edges of ponds, levees separating rice fields) are less vulnerable to rats (Shuford et al. 2004). Nests placed on levees have very high rates of loss to coyotes (*Canis latrans*; Shuford et al. 2004). Additional nest predators can include red-tailed hawks (*Buteo jamaicensis*), great horned owls (*Bubo virginianus*), black-crowned night herons (*Nycticorax nycticorax*), bullfrogs (*Rana catesbeiana*), and gopher snakes (*Pituophis melanoleucus*; Shuford et al. 2004).

Waterbirds also lose many nests and young to predation. Out of 74 nests from radiomarked mallard hens, 10 were lost to predation; among mallard ducklings, the primary cause of death was predation by birds (39% of total duckling mortality) and mammals (22% of duckling mortality; Chouinard and Arnold 2007).

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:*** *Low (high confidence)*

Grazing

Actively grazed areas have shorter vegetation, resulting in less cover for nesting birds (Carroll et al. 2007). However, rotational grazing practices may have some benefit in summer nesting habitat; for instance, fields grazed from July-October had shorter vegetation during the winter compared to ungrazed fields, but by March there was no difference and by late May (the end of nesting season) the vegetation was taller in grazed fields (Carroll et al. 2007). Duck nest density was three times higher in fields one-year post-grazing, but no differences were found the second year (this finding may reflect additional factors that were impacting nest density). There was no difference in nest success between grazed and ungrazed fields (Carroll et al. 2007). Seasonal grazing in and around wetlands inhabited by California black rails (*Laterallus jamaicensis coturniculus*) did not impact occupancy at irrigated sites, but occupancy was lower at sites fed by natural springs and streams (Richmond 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:*** *High (high confidence)*
> > ***Description of habitat:*** *Wetlands*
>
> ***Dependency on specific prey or forage species:*** *Low-moderate (high confidence)*
> ***Dependency on other critical factors that influence sensitivity:*** *Moderate (moderate confidence)*
> > ***Description of other dependencies:*** *Forage availability on agricultural land*

Breeding waterbirds and shorebirds have a generalized diet and are opportunistic nesters[1]. However, they are very dependent on wetland habitat, which provide cover and food (e.g., aquatic invertebrates). Many ducks nest in upland vegetation, but require nearby wetlands for foraging while incubating and to lead ducklings to when they hatch (Ackerman et al. 2011). Due to the decline of wetland area in the Central Valley, breeding waterbirds and shorebirds have become increasingly dependent on agricultural habitats, such as rice fields, evaporation ponds, levees and ditches, and water storage infrastructure (Shuford et al. 2004). While these can provide nesting and foraging habitat in the absence of adequate wetland area (Elphick 2000), birds can be exposed to high levels of disturbance, toxins, predation, and other dangers associated with human activity (Shuford et al. 2004).

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
Intraspecific Species Group Diversity	Moderate-high
Resistance & Recovery	Low-moderate
Overall Scores	**Moderate-high**

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 (moderate confidence)*
Population connectivity: *Robust (high confidence)*
Dispersal ability: *Moderate (moderate confidence)*

Over 95% of the four million wetland acres historically present in the Central Valley have been lost since the mid-1800s, and habitat loss for this species group has been highest in the Tulare Basin, which used to provide over 500,000 acres of seasonal and semi-permanent wetlands (Frayer et al. 1989). Despite these losses, waterbirds and shorebirds are highly mobile, which increases population connectivity and the ability to travel between habitat patches (Newton 2010). However, more continuous habitat reduces energy requirements for foraging and travel (Elphick 2000; Ackerman et al. 2006). Habitat availability has been associated with health, body condition, daily flight distances, and shifts in density and regional distribution in waterbirds (Fleskes et al. 2005; Ackerman et al. 2006; Hénaux et al. 2012). Available habitat is quickly reduced by water shortages and results in higher bird density, which may increase disease transmission and competition for food and nest sites (Duffy and Kahara 2011).

Landscape permeability

Overall landscape permeability: *No landscape barriers were identified by workshop participants, and landscape permeability was not assessed.*

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)*

The high mobility of wintering waterbirds and shorebirds is closely tied to their resistance to climate-related stresses, potentially allowing them to shift their range and/or migration strategy (Dolman & Sutherland 1995) and reach foraging and breeding habitat patches across a fairly wide area (Ackerman et al. 2006). Jiguet et al. (2006) also found that avian species that are adapted to a wide range of temperatures are more resilient to heat waves and warming patterns.

Flexibility in habitat use (e.g., the ability to use agricultural habitats), migration and breeding timing, and nest site selection allow breeding waterbirds and shorebirds to resist some negative changes in their environment (Elphick 2000; Shuford et al. 2004; Ackerman et al. 2011). However, their dependence on reliable water sources makes them vulnerable to drier conditions, when management decisions and agricultural practices largely determine habitat availability, and, indirectly, the availability of food resources, breeding success, and survival (Shuford et al. 2004; Central Valley Joint Venture 2006; Duffy & Kahara 2011; Kahara et al. 2012).

Species group diversity

Overall species group diversity: *Moderate-high (high confidence)*
Diversity of life history strategies: *Moderate-high (high confidence)*
Genetic diversity: *Moderate-high (high confidence)*
Behavioral plasticity: *Moderate-high (moderate confidence)*
Phenotypic plasticity: *Not assessed.*

The timing of migration and breeding has advanced over the past ~50 years for many bird species, although it is unclear whether this is related to evolutionary (e.g., genetic) changes in populations, or phenotype and behavior at the individual level (Charmantier & Gienapp 2014). For instance, some flexibility in breeding behavior has been noted in Arctic shorebirds, which respond to annual weather variations (Meltofte 2007); range shifts may also be influenced by behavioral plasticity as birds respond to variations in food availability, nest sites, and territories (Tingley et al. 2012).

Gene flow may be very low amongst some small populations, such as the federally-protected California black rail, which has low gene flow amongst discontinuous populations located in small marshes located with a matrix of unsuitable habitat (Richmond 2010).

Other Factors

Overall degree to which other factors affect adaptive capacity:

Reliance on additional outside habitats: *Low-moderate (low confidence)*

Reliance on additional outside habitats

Migratory birds are additionally vulnerable to climate and non-climate stresses (e.g., habitat loss) because they are dependent on conditions in both their breeding and wintering habitats, as well as in stopover locations (Dolman & Sutherland 1995; Small-Lorenz et al. 2013; Galbraith et al. 2014). Ducks dispersing from the Central Valley rely on large permanent wetlands for molting, a time in which they are unable to fly and so are more vulnerable to food shortages, disease, and predation (Yarris et al. 1994; Fleskes et al. 2010). Post-breeding ducks appear to have site fidelity, returning to the same area in consecutive years (Yarris et al. 1994).

Management potential

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

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

Value to people

Value to people: *Moderate-high (moderate confidence)*
Description of value: *Except geese.*

Support for conservation

Degree of societal support for management and conservation: *Moderate-high (moderate confidence)*

Degree to which agriculture and/or rangelands can benefit/support/increase resilience: *Moderate-high (high confidence)*

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

Likelihood of converting land to support species group

Likelihood of (or support for) converting retired agriculture land to maintain or enhance species group: *Moderate (moderate confidence)*
Description of likelihood: *There are several programs (national and state) that have been developed to convert marginal/less productive agricultural land to wetlands. In a sense, there is already support for this because the policies reflect it; there may be resistance from the Farm Bureau.*

Likelihood of managing or alleviating climate change impacts: *Moderate (moderate confidence)*
Description of likelihood: *Because habitat used by breeding wetlands birds is managed, the water levels can be manipulated to provide optimal conditions. However, because competition for water is greatest during spring and summer, there might not be enough water to flood these wetlands in the future if other needs (agriculture, urban, river flows for fish) are deemed more important.*

While waterfowl are likely to be impacted by future climate change, management actions can ameliorate some of the effects (Ackerman et al. 2011). Managers may be able to minimize the impact of increasing temperatures and heat waves by emphasizing dense cover that can provide shade, and by selecting plant species that leave standing vegetation over the winter to provide protection early in the season (Ackerman et al. 2011). Management considerations should include the relative location of wetlands and upland nesting habitat, predation, and habitat structure (e.g., heterogeneous habitats will allow more flexible behavior in nest site selection; Ackerman et al. 2011). Agricultural habitat should be managed to minimize the impacts of pollution/poisons, predation, and habitat loss by flooding rice croplands late in the season, reducing the use of insecticides, and leaving weeds to provide cover (or planting a cover crop), among other strategies (Shuford et al. 2004; Central Valley Joint Venture 2006). Water management practices may be the most important consideration for both managed wetlands and agricultural lands, and will likely become even more important under future climate conditions (Central Valley Joint Venture 2006; Kahara et al. 2012).

Incentive programs pay farmers and landowners to provide habitat for waterbirds and shorebirds, either by using agricultural practices that are beneficial (e.g., flooding post-harvest rice fields), or by removing environmentally sensitive habitat from active agricultural use (Duffy & Kahara 2011; DiGaudio et al. 2015). Wetlands restored through these efforts have been successful at providing habitat for diverse bird species, including many special status species (DiGaudio et al. 2015).

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