4.4 CLIMATE

California's climate conditions are changing, and those changes are predicted to accelerate over the next century. Extreme weather events are likely to significantly affect bird and human communities alike in the Central Valley. These changes could include increasing air temperatures, decreasing water availability, and more frequent floods and droughts, all of which will negatively affect many bird species. For example, a previous study documented that an increase in mean daily temperature caused a decline in nest survival of Central Valley mallards and gadwalls (Ackerman et al. 2011).

These climate-induced stressors will add to the already-significant existing threats to bird populations and, in many cases, are likely to become the most significant factors influencing bird populations in the Central Valley. Hence, there is an urgent need for natural resource managers to incorporate projected changes in climate patterns into conservation planning efforts to provide for bird populations in a changing future. Managers must consider how these patterns could affect the environment of the Central Valley, how human populations might respond to those changes, and what impact these combined factors could have on bird populations.

This subchapter describes the major changes in climate projected to occur over the next century in the Central Valley and summarizes the vulnerability of the region's bird populations to a shifting climate.

(1) Flooding in the Yolo Bypass - Daniel Nylen, American Rivers (2) Least Bell's vireo, a federally endangered species, collecting nesting material - Robert A. Hamilton

Shifting Climate Conditions

Increasing temperatures

Mean annual temperatures in the Central Valley increased by nearly 2°F since the start of the 20th century (Bureau of Reclamation 2016), though mean annual maximum temperatures decreased in the San Joaquin Valley (Rapacciuolo et al. 2014). In California, average temperatures are projected to increase significantly over the next century (Figure 4.4.1). Climate models project average annual temperatures in California to increase by 1.8°F to 5.4°F by mid-century, and by 3.6°F to 9°F by the end of the century (Cayan et al. 2012).

Increasing air temperatures will lead to increasing water temperatures of rivers, reservoirs, and ephemeral or vernal pools (Bureau of Reclamation 2016).

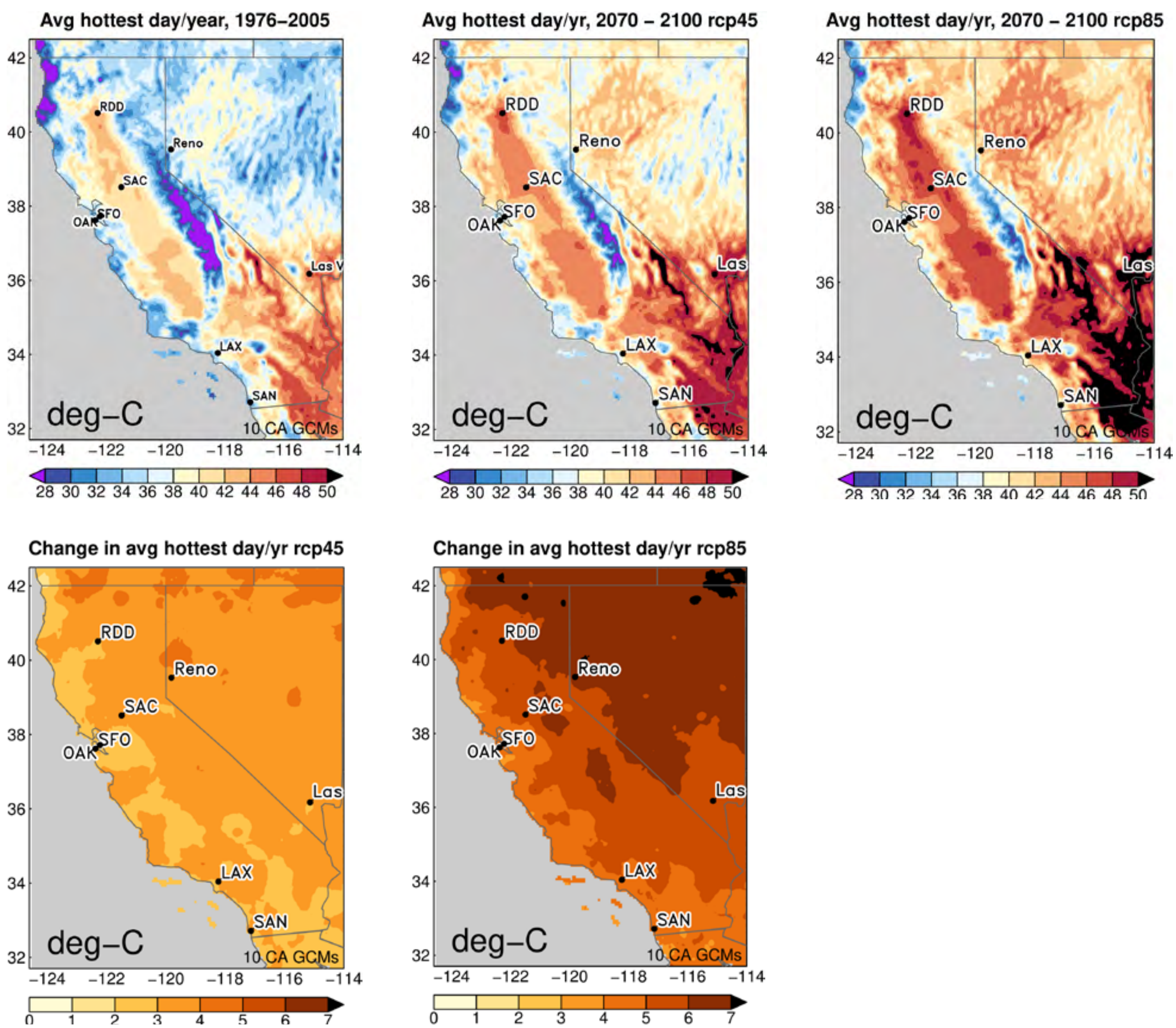

FIGURE 4.4.1 Predicted 21st century temperature increases in California. GCM = Global Circulation Model; RCP = Representative Concentration Pathways. Top row: Average hottest day of the year (°C), averaged over 10 GCMs, for the historical period (top left) and for late-21st century for RCP 4.5 (top middle) and RCP 8.5 (top right) emissions scenarios. Bottom row: the increase (°C) of the late-21st century over the historical values, for RCP 4.5 (bottom center) and RCP 8.5 (bottom right). Results are from the 10 California GCMs (Pierce et al. 2018).

Uncertain changes in average precipitation

Whether the average annual precipitation will increase or decrease in California over the coming century is not clear. Model projections indicate a wide range of potential future changes in precipitation for California and the Central Valley. Despite a drying trend in California since the late 1970s, there is no appreciable trend towards either wetter or drier winters over the full record beginning in 1895 (Funk et al. 2014; Seager et al. 2014). A slight trend toward decreasing and more variable precipitation has been detected in central and southern California over the last 100 years (Hunsaker et al. 2014). The north-south gradient from higher to lower annual precipitation is predicted to continue in the Central Valley (Cayan et al. 2009). Despite this uncertainty, there are other changes expected in the hydrological conditions of the Central Valley as described below.

Decreasing water availability in the dry season

The Central Valley receives most of its annual precipitation during the rainy, cooler season between November and March (Scanlon et al. 2012). During the typically dry months (April – October), the Sierra Nevada snowpack serves as the primary source of water for irrigation and for wetland management (Domagalski et al. 2000; Scanlon et al. 2012). However, the availability of this source of water during the dry season is projected to change. Despite the uncertainty in projections of average annual precipitation, there is relatively high confidence that overall landscape aridity will increase with warmer temperatures (Flint et. al. 2013). In short, the dry season will become drier. Several factors will cause this shift, including warmer summer temperatures that will cause drier conditions, warmer winter temperatures that will decrease accumulated snowpack, and warmer winter and spring temperatures that will lead to earlier snowmelt.

The warming trend projected during the dry season will further increase evapotranspiration: evaporation of water from the soil and transpiration of water from plants to the atmosphere. This process will increase the aridity of soils in most areas and will cause drier conditions overall (Cook et al. 2015).

Historically, the Sierra Nevada snowpack has released meltwater gradually, refilling reservoirs, recharging aquifers, and flowing downstream into the Central Valley during the spring and summer. Projections using the best available climate models show that, even during years with an average amount of snowpack in the winter, increasing spring temperatures will cause earlier snowmelt. Warmer temperatures are already leading to earlier spring snowmelt in the Sierra Nevada (Hayhoe et al. 2004; Thorne et al. 2015), changing the timing of water availability in lowland regions that receive much of their water from snowmelt (Moser et al. 2009; Yarnell et al. 2010; Thorne et al. 2015). With earlier snowmelt, April to July runoff volume has already decreased over the last 100 years by 23 percent and 19 percent in the Sacramento and San Joaquin Basins, respectively (Anderson et al. 2008). The earlier and higher spring peak flows are typically followed by reduced summer flows and longer periods of summer aridity (Yarnell et al. 2010).

In addition, higher peak flows are likely to increase spring flooding risk (Jackson et al. 2011), which requires dam managers to release more stored water from reservoirs earlier in the season to minimize risk of a catastrophic flood (Kiparsky and Gleick 2003; Anderson et al. 2008).

This shift will further constrain water management by hampering the ability to refill reservoirs after the season of highest runoff has passed, thereby reducing the amount of spring runoff that is normally stored. In turn, this will decrease the availability of water for the summer growing season and for postharvest flooding of rice fields to promote stubble decomposition and provide seasonal habitat for birds and other wildlife (Anderson et al. 2008).

Increase in severe storm and flooding events

Climate shifts are likely to increase flooding from severe storms (Swain et al. 2018). Natural formations called “atmospheric rivers” transport huge volumes of condensed water vapor through the atmosphere; these atmospheric rivers can create extreme precipitation. An analysis of climate projections for California indicates that the average intensity of atmospheric river events will not increase. However, there may be more years with many such events and occasionally much stronger events than seen in the historical record. Moreover, the length of the season over which atmospheric river events may occur is predicted to increase. These changing patterns are likely to result in more frequent and more severe floods in California (Dettinger 2011). Hydrological models project larger, more frequent winter floods as rain-on-snow events and winter snowmelt become more common in the headwaters of major river systems in the West (Hamlet and Lettenmaier 2007).

Regardless of variation among specific precipitation projections, all models project that by the end of the century, large discharges from the northern Sierra Nevada that were previously classified as probable only once every 50 years (“50-year floods”) will increase in likelihood by 30 to 90 percent compared to historical values. Corresponding flood flows from the southern Sierra are projected to increase in likelihood by 50 to 100 percent (Das et al. 2013). Overall higher peak flows, caused by earlier and more rapid snowmelt, are likely to increase spring flooding in the Central Valley (Jackson et al. 2011).

Increased frequency and severity of droughts

The combined effect of the changes in the hydrological cycle described above will magnify the impacts of severe droughts in the Central Valley. Compared to the preceding century, drought years in California have occurred twice as often in the last 20 years (Diffenbaugh et al. 2015). Additionally, the 2010–2015 drought was the most severe on record in the Central Valley (Williams et al. 2015), with record high temperatures that worsened its effects. A warming climate is likely to increase the frequency and severity of California droughts (Hayhoe et al. 2004; Cook et al. 2015; Diffenbaugh et al. 2015; Williams et al. 2015; Swain et al. 2018). Severe drought years reduce the open surface water and waterbird habitat in flooded agriculture and managed wetlands across the Central Valley (Reiter et al. 2015; Reiter et al. 2018) and can increase food deficits for waterfowl (Petrie et al. 2016).

Dry seasonal wetland, Yolo Bypass Wildlife Area - Wayne Tilcock, California Waterfowl Association

Effects of a Shifting Climate on Central Valley Bird Populations

General threats

The predominant effects of a shifting climate on bird populations will likely be from changes in water availability. Climate directly determines water availability. Management actions designed to capture and store water for human use indirectly affect it; these management actions are likely to change as climate-related water stressors increase. At particular risk are species sensitive to the timing, amount, and reliability of water. For example, some bird species have come to rely on certain types of agriculture. These species may be affected if management reduces the extent of wetlands and key agricultural crops (rice, corn, alfalfa, irrigated pasture) used by these birds (PRBO Conservation Science 2011).

Estuarine habitats in the Sacramento-San Joaquin Delta are likely to be degraded because of sea level rise and increasing salinity, but the degree of this loss is not yet well understood (PRBO Conservation Science 2011; Achete et al. 2017).

High temperature events, which are predicted to become more common in summer, are likely to result in thermal stress for species with a narrow range of temperature tolerance (e.g., Ackerman et al. 2011; PRBO Conservation Science 2011).

Vulnerability

Evaluations by Gardali et al. (2012) and Galbraith et al. (2014) of the vulnerability of various species of birds to a shifting climate are relevant to bird populations in California's Central Valley.

Gardali et al. (2012) ranked a subset of the state's birds for vulnerability in California. Of the 358 taxa (species, subspecies, and distinct populations) ranked, 230 were not considered vulnerable. The remaining 128 were considered climate-vulnerable and were ranked for three categories of priority: low (80), moderate (35), and high (13). Of these 128 taxa, 31 pertain to the Central Valley (Table 4.4.1). In general, birds associated with wetlands had the largest representation on the list relative to other habitat groups, a pattern that also appears to hold for the Central Valley.

Combined effects of climate and other human stressors

Shifting climate conditions are not the sole determinant of how Central Valley bird populations will fare in the future. Human choices will be important in driving bird population responses to a shifting climate.

Jongsomjit et al. (2013) compared projected spatial impacts of shifting climate patterns and housing development on breeding birds in California. Areas of decreasing climatic suitability for birds and increasing housing density were largely concentrated within the Central Valley. This work suggests that the cumulative effects of future housing development and shifting climate patterns will be significant for many bird species, and that some species otherwise projected to expand their distribution may actually lose ground to development.

Matchett and Fleskes (2017) examined 17 future scenarios for characterizing potential interactions among land use (especially urbanization), water supply management, and shifts in climate conditions with their collective impacts on waterbird habitat. Specifically, they looked at the capacity for the Central Valley to provide additional wetlands to offset modeled impacts of a shifting climate on waterbirds. Most scenarios examined pointed to a loss of options for adequately conserving wetland-dependent birds through wetland restoration after 2065.

The combined impacts of higher temperatures, lower water availability, extreme weather events, and the responses of human populations to these stressors are likely to dramatically impact bird populations in the Central Valley over the next century. It is critically important for natural resource managers to consider these impacts as they develop and enact plans for bird population and habitat conservation.

BIRD SPECIES ORGANIZED BY CLIMATE PRIORITY	CONSERVATION STATUS[a]
High priority	
Yellow rail (winter) (*Coturnicops noveboracensis*)	BCC, BSSC
California black rail (*Laterallus jamaicensis coturniculus*)	BCC, ST
Suisun song sparrow (*Melospiza melodia maxillaris*)	BCC, BSSC
Moderate priority	
Snowy plover (interior population) (*Charadrius nivosus*)	BCC, BSSC
Black tern (*Chlidonias niger*)	BSSC
American white pelican (*Pelecanus erythrorhynchos*)	BSSC
Swainson's hawk (*Buteo swainsoni*)	ST
Yellow-billed cuckoo (western distinct population segment) (*Coccyzus americanus*)	FT, SE
Least Bell's vireo (*Vireo bellii pusillus*)	FE, SE
San Joaquin LeConte's thrasher (*Toxostoma lecontei macmillanorum*)	BCC, BSSC
Song sparrow (Modesto population) (*Melospiza melodia mailliardi*)	BSSC-
Lower priority	
Bufflehead (*Bucephala albeola*)	-
Eared grebe (*Podiceps nigricollis*)	-
Western grebe (*Aechmophorus occidentalis*)	BCC
Clark's grebe (*Aechmophorus clarkii*)	-
Whimbrel (*Numenius phaeopus*)	BCC
Wilson's phalarope (*Phalaropus tricolor*)	-
Red-necked phalarope (*Phalaropus lobatus*)	-
Caspian tern (*Hydroprogne caspia*)	BCC
Forster's tern (*Sterna forsteri*)	-
Double-crested cormorant (*Phalacrocorax auritus*)	-
American bittern (*Botaurus lentiginosus*)	-
Least bittern (*Ixobrychus exilis*)	BCC, BSSC
White-faced ibis (*Plegadis chihi*)	-
Osprey (*Pandion haliaetus*)	-
Greater roadrunner (*Geococcyx californianus*)	-
Lesser nighthawk (*Chordeiles acutipennis*)	-
Rufous hummingbird (*Selasphorus rufus*)	-
Belted kingfisher (*Megaceryle alcyon*)	-
Yellow-billed magpie (*Pica nuttalli*)	BCC
Bank swallow (*Riparia riparia*)	ST

[a] *Conservation Status designations: **FE**, federally endangered species; **FT**, federally threatened species; **BCC**, U.S. Fish and Wildlife's Birds of Conservation Concern (USFWS 2008); **SE**, state endangered species; **ST**, state threatened species; **BSSC**, California Bird Species of Concern (Shuford 2008).*

TABLE 4.4.1 Conservation status of Central Valley bird taxa classified as vulnerable to the impacts of a shifting climate. These species, subspecies, and distinct populations of birds occur regularly in the Central Valley Joint Venture's Primary Focus Area or Secondary Focus Area up to 3,000 feet elevation (adapted from Gardali et al. 2012).

Galbraith et al. (2014) assessed all North American shorebirds for vulnerability to changes in climate conditions using life history factors such as migration distance and specialized habitat requirements. They ranked the whimbrel *(Numenius phaeopus)* and the long-billed curlew *(N. americanus)* as critically vulnerable. Other highly climate-vulnerable shorebird species were the mountain plover *(Charadrius montanus)*, dowitcher species *(Limnodromus* spp.*)*, western sandpiper *(Calidris mauri)*, dunlin *(C. alpina)*, and Wilson's phalarope *(Phalaropus tricolor)*. Each of these shorebird species relies on Central Valley habitat during migration or winter, but the most intense climate-related stressors for these species may occur outside the Central Valley.