Belted Kingfisher (*Megaceryle alcyon*)

Climate Change Vulnerability Assessment for the Golden Gate Biosphere Region

This document represents an evaluation of climate change vulnerability for belted kingfisher in the Golden Gate Biosphere (GGB) region of California. The following information is based on stakeholder input provided during and following a winter 2022 vulnerability workshop as well as sources from the scientific literature.

Species Description

The belted kingfisher (*Megaceryle alcyon*) is a medium-sized bird closely associated with freshwater wetlands, ponds, lakes, streams, riparian areas, coastal lagoons and estuaries, and marine shorelines, and is known for its loud, rattling call that carries across open water (Kelly et al. 2020). Belted kingfishers are vibrant blue on the back and neck with a white chest and neck ring and are sexually dichromatic, with the female displaying a rust-colored red "belt" across the lower chest (Kelly et al. 2020). Despite its widespread distribution in North America, the species remains surprisingly poorly studied (Kelly et al. 2020).

Belted kingfishers usually nest in burrows excavated by both sexes in sandy, vertical banks along streams or shorelines, generally near water (Brooks & Davis 1987). However, they occasionally select other sites such as cavities in trees or stumps, even those far from water (Kelly et al. 2020). Both parents feed their young, with males potentially contributing more to feeding than females (Hamas 1975). Their primary diet consists of small fish (<5 in. in length) and, to a lesser extent, aquatic invertebrates; however, they are also known to occasionally prey on amphibians, reptiles, birds, small mammals, and even mollusks, crustaceans, and berries (Hamas 1975; Forsell 1983; Kaufman 1996; Kelly et al. 2020). Kingfishers are visual hunters, and require clear, relatively shallow waters for fishing (Hamas 1975; Hadravová et al. 2020). The presence of perches is preferred, as these are known to lead to greater hunting efficiency compared to hovering over a waterbody (Forsell 1983).

Belted kingfishers are distributed across North America, although only as wintering birds in southern California, most of the southwestern states, and southern Florida (Kelly et al. 2020). Within California, they are found throughout most of northern and central California and south along the California coast (Figure 1; CDFW 1995). Birds in higher latitudes and inland, where water bodies freeze in winter, tend to be seasonal migrants (Kaufman 1996). In more temperate latitudes, kingfishers are likely to be present most or all of the year (Kaufman 1996), although movement of individuals may occur within these areas (Kelly et al. 2020). Males also appear to migrate shorter distances than females in temperate latitudes (Kelly et al. 2020). Within the Golden Gate Biosphere (GGB) region, many belted kingfishers are year-round residents, though some may make seasonal movements outside the breeding season (Vuln. Assessment Worksheets, pers. comm., 2022).

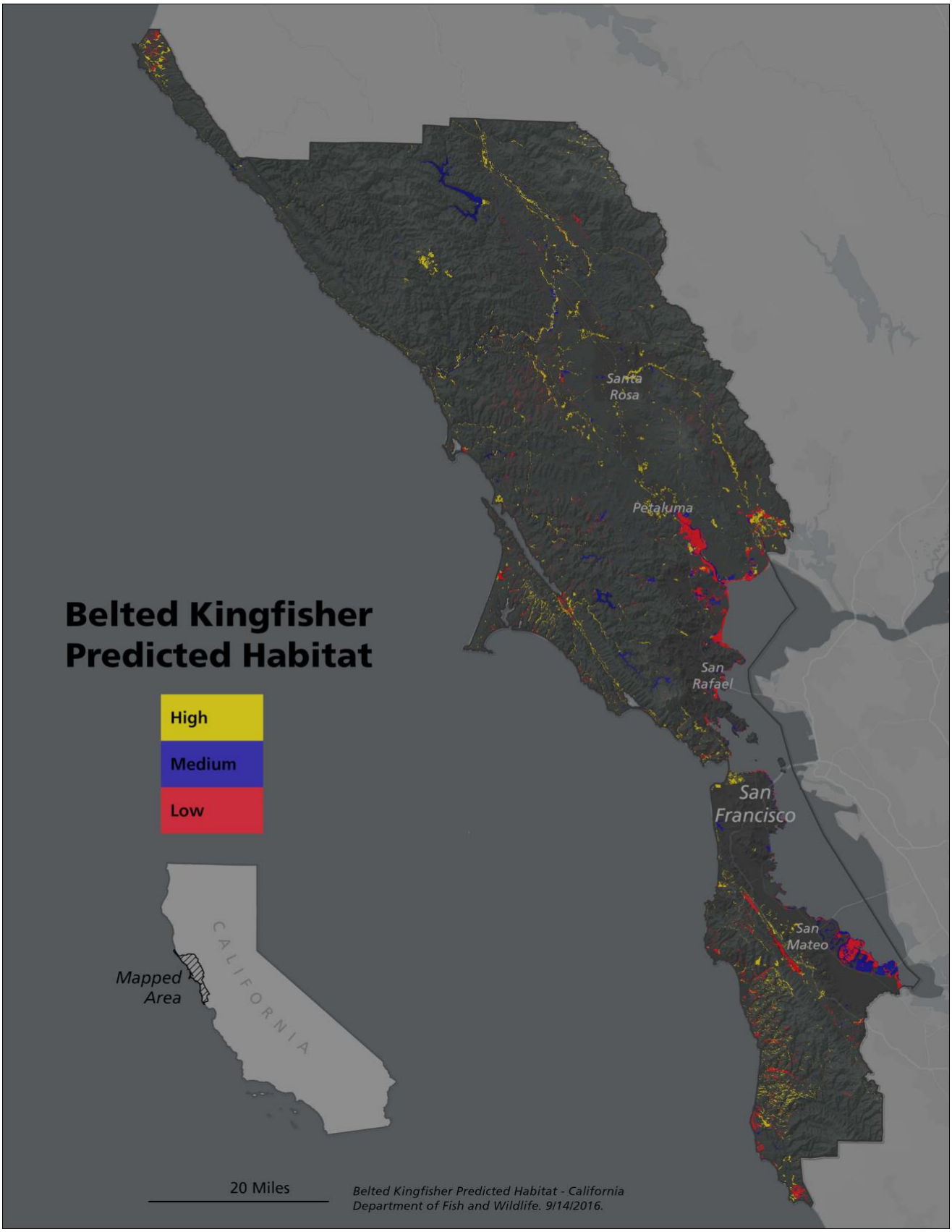

Figure 1. Belted kingfisher predicted habitat within the GGB region (map provided by the National Park Service).

Species Vulnerability → Moderate *(moderate confidence)*

Vulnerability is evaluated by considering the species' sensitivity and exposure to various climate and non-climate stressors as well as the species' adaptive capacity (i.e., ability to cope with these stressors), and is given a ranking of low, moderate, or high. The confidence ranking represents confidence in the accuracy of the ranking based on available scientific knowledge, and is similarly ranked on a scale from low to high.

Summary of species vulnerability

Belted kingfishers are sensitive to climate stressors that impact prey availability, including warmer water temperatures, changes in precipitation patterns, and altered streamflow. Increased flooding and associated erosion of stream banks can wash away nests, drown eggs and nestlings, or cause a female to abandon a nest if eggs settle in mud. Alternatively, these conditions may create additional nesting habitat through flood-induced scouring that exposes banks. Non-climate stressors, including development, dams and water diversions, and pollutants, primarily threaten the food resources on which kingfisher rely. Depending on their burrow placement, eggs and nestlings can be vulnerable to predation by cats, rats, and raccoons.

The belted kingfisher is a charismatic species widely recognized by the public and admired by birders, and there is significant public and regulatory support for protecting and restoring the aquatic and riparian habitats and associated resources on which the species depends. Many existing restoration and protection activities are likely to increase the resilience of this species to climate change, including regulatory mechanisms that protect habitat; land management actions that reduce habitat fragmentation, degradation, and loss; and restoration activities to support clean, clear water with natural flow regimes and complex stream channels that support abundant small fish populations needed by this species.

Sensitivity and Exposure → Moderate *(low confidence)*

***Sensitivity** is a measure of whether and how a species is likely to be affected by a given change in climate factors, climate-driven changes in disturbance regimes, and non-climate stressors. By contrast, **exposure** is a measure of how much change in these factors a species is likely to experience. Sensitivity and exposure are combined here into one score representing both components of vulnerability, with high scores corresponding to increased vulnerability and low scores suggesting a species is less vulnerable.*

A recent analysis of the climate vulnerability of the belted kingfisher suggests that under warming scenarios at or above 2°C, kingfishers will lose a substantial amount of their climatically-suitable habitat in the GGB region, particularly on the west side of the Coast Range (Audubon Society 2023). However, a multi-factor analysis of climate sensitivity and exposure of California birds ranked belted kingfishers as having low vulnerability to climate change, though it was still higher than for hundreds of

other bird species assessed in the study (230 species are in the "unprioritized" category, below the category into which belted kingfisher falls; Gardali et al. 2012).

Sensitivity and future exposure to climate factors → Moderate *(low confidence)*

- Increasing **freshwater temperatures** may negatively impact small fish and other aquatic organisms on which belted kingfishers depend for food. Warming stream temperatures can curtail fish distribution and abundance as stream volume and dissolved oxygen decline (Ebersole et al. 2001; Obedzinski et al. 2018). Warmer temperatures may also cause fish to seek thermal refugia in deeper or less accessible areas (e.g., under logs, banks, between larger rocks) where they are more difficult for kingfishers to catch (Kelly 1996).
- Changes in **precipitation amount and timing** are closely associated with **altered stream flows**, which can negatively impact kingfishers by decreasing the abundance and diversity of their prey. Both intensity and variability in the timing of high flows are likely to increase in California as a result of climate change (Grantham et al. 2018), increasing risks including washout of fish eggs and mortality of juvenile fish during severe flooding (Moyle et al. 2013; Crozier et al. 2019). Drier conditions can also lead to loss of kingfisher prey as stream habitats shrink and in-stream temperatures increase, stressing fish. For example, low and disconnected streamflow has been shown to negatively impact survival of juvenile salmon in the Russian River (Obedzinski et al. 2018).
- Kingfishers' behavior of burrowing in earthen banks to construct their nests may afford their eggs and nestlings some measure of protection from **warmer or more variable air temperatures** because underground burrows tend to maintain a fairly consistent internal temperature regardless of air temperature fluctuations (Hamas 1975).

Sensitivity and future exposure to climate-driven changes in disturbances → High *(low confidence)*

- **Increased flooding** can impact the prey on which kingfishers rely. Flooding can lead to declines in macroinvertebrates in both wetland and stream habitats (Neckles et al. 1990; Giller et al. 1991). Extreme river flooding has also been shown to reduce fish taxa diversity and increase fish size in the diet of the related common kingfisher (*Alcedo atthis*) after declines in preferred prey (Hadravová et al. 2020). Kingfishers do have the potential to benefit from erosion and scouring of streambanks that can expose vertical faces into which they can burrow (Brooks & Davis 1987; Vuln. Assessment Worksheets, pers. comm., 2022). However, excessive erosion associated with frequent, severe flooding may lead to bank failure and loss of burrows, and flood waters can directly inundate kingfisher burrows and drown chicks (Rubáčová et al. 2021). Females may also abandon nests if eggs settle in mud (Davis 1980).

Dependency on habitat and/or other species → Low *(moderate confidence)*

Belted kingfishers rely on open aquatic habitat with clean, clear water, and these areas tend to be vulnerable to climate change as well as multiple anthropogenic stressors (Craig et al. 2017). Intact riparian habitat is particularly important for belted kingfishers, offering protection from predators, support of fish and macroinvertebrate populations, and provision of perches for hunting (Sullivan et al. 2006; Vuln. Assessment Worksheets, pers. comm., 2022). However, many riparian ecosystems in California have been seriously degraded (RHJV 2004), although extensive restoration efforts have improved habitat for kingfishers and other riparian birds in some areas. Kingfishers can also make use of a wide variety of other aquatic habitats, including streams, ponds, lakes, lagoons, and reservoirs (Vuln. Assessment Worksheets, pers. comm., 2022), and this flexibility likely reduces their vulnerability to climate-driven loss of particular sites or habitat types. Within their habitat, belted kingfishers require suitable substrate for nesting (i.e., exposed banks with soft soil for excavating burrows), and availability of nesting sites can be a limiting factor for populations (Hamas 1975). Kingfishers do appear to be somewhat flexible in nest site selection and have been observed using disturbed sites such as gravel pits and road cuts in areas where natural nesting sites are limited (Hamas 1975). However, they are also sensitive to disturbance and may abandon nests because of proximate human activity (Cornwell 1963).

Although belted kingfishers consume a range of prey including amphibians and macroinvertebrates (Kaufman 1996), their primary prey is small fish (Hamas 1975; Forsell 1983; Kelly et al. 2020). Kingfishers feed on a wide variety of fish species of an appropriate size class for feeding themselves and their young (Cornwell 1963; Brooks & Davis 1987); presumably smaller or juvenile non-native fish could fill this role, although this has not been explicitly studied. Freshwater fish in central coastal California are threatened by multiple climate-driven and anthropogenic stressors (Moyle et al. 2013; Quiñones & Moyle, Peter 2014; Howard et al. 2015).

Sensitivity and current exposure to non-climate stressors → Moderate *(moderate confidence)*

Non-climate stressors can exacerbate ecosystem sensitivity to changes in climate factors and disturbance regimes, and/or can be exacerbated by these changes.

- **Residential and commercial development** is associated with reduced water quality and drives fragmentation and loss of riparian and wetland habitat on which kingfishers depend (Duffy et al. 2016). Development increases impervious surfaces, enhancing runoff and delivery of sediment and pollutants into streams as well as erosion, scouring, and incision of the stream bed that can eliminate fish and macroinvertebrate food sources (Moscrip & Montgomery 1997). **Flood control measures** designed to protect developed areas are widespread throughout the GBB region (Baumgarten et al. 2018, 2021) and are associated with simplification and reduction of stream habitat that impacts prey populations, altered instream flows and increased stream velocity that leads to scouring and erosion, and hardening of streambanks that reduces available nesting habitat (Schoof 1980; Scott et al. 2016). Kingfishers

nesting in and around developed areas may also be more vulnerable to egg and nestling predation from human-associated species such as feral cats, rats, and raccoons (Vuln. Assessment Worksheets, pers. comm., 2022). However, nest mortality overall is low for this species due to their placement of nests in vertical banks (Kelly et al. 2020). Anecdotally, a domestic cat was observed attempting to ambush breeders at their burrow and the nest failed shortly thereafter (Kelly et al. 2020), but the impacts of these and other human-associated predators on kingfishers has not been quantified.

- **Dams and diversions** are abundant throughout the GGB region (Nicely et al. 2007; Baumgarten et al. 2018, 2021). Dams introduce physical barriers to movement of aquatic organisms and alter thermal regimes, flow volume and timing, and sediment transport processes, all of which impact fish populations on which belted kingfisher depend (Power et al. 1996; Yarnell et al. 2015). One possible benefit of dams for kingfishers could be the regulation of downstream flows which reduces flooding potential that could impact nesting habitat. However, the impacts of dams and diversions to their prey base may outweigh potential benefits, and there may also be negative impacts to available bank habitat due to dams. Kingfishers appear to be adaptable in their habitat requirements and will use reservoirs and other water control structures for foraging (Vuln. Assessment Worksheets, pers. comm., 2022).
- **Pollution and poisons** are abundant in stormwater and runoff in the GGB region, resulting in excess nutrients, metals, pesticides, PCBs, and several classes of emerging chemicals entering streams and wetlands where they have the potential to impact macroinvertebrates and fish on which belted kingfisher depend (McKee et al. 2003; Brooks et al. 2012). Research has identified reduced coloration in kingfishers (White & Cristol 2014) and skewing of nestling sex ratios (Bouland et al. 2012) following ingestion of prey containing high concentrations of mercury. However, most studies have not found that bioaccumulative contaminants significantly impact kingfishers, even in areas with fairly high levels of chemicals such as PCBs (Baron et al. 1997; Bridge & Kelly 2013). It is possible that kingfishers are less vulnerable to some contaminants than other piscivorous birds because they feed primarily on smaller fish which bioaccumulate fewer contaminants compared to larger individuals (Kelly et al. 2020; Vuln. Assessment Worksheets, pers. comm., 2022).

  Kingfishers may also be vulnerable to oiling, or more likely, impacts of oil to foraging areas, where marine spills may enter lagoons or inland spills may enter inland waterways (Day et al. 1997; Vuln. Assessment Reviewer, pers. comm., 2023). For instance, following the *Exxon Valdez* spill, the presence of oil was correlated with reduced habitat us by belted kingfisher in the first year following the spill (Wiens et al. 2004).

Adaptive Capacity → High *(high confidence)*

Adaptive capacity *is the ability of a species to respond to or cope with climate change impacts with minimal disruption. High adaptive capacity corresponds to lower overall climate change vulnerability, while low adaptive capacity means that the species will be less likely to cope with the adverse effects of climate change, thus increasing the vulnerability of the species.*

Species extent, status, connectivity, and dispersal ability → High (high confidence)

Belted kingfishers are known to occur throughout the GGB region on a year-round basis (Vuln. Assessment Worksheets, pers. comm., 2022). Although robust monitoring data for population abundance and trends do not exist, small but significant declines (less than 1.5% decrease in summer populations) have been observed through Breeding Bird Survey (BBS) data (Kelly et al. 2020). However, kingfishers in riparian areas with large linear territories are poorly monitored by roadside counts such as the Breeding Bird Survey (Kelly et al. 2020).

Belted kingfishers are highly mobile and can move between aquatic habitats for foraging. Roads and highways may be a source of mortality, but otherwise this species is not greatly constrained by physical barriers (Vuln. Assessment Worksheets, pers. comm., 2022). Rather, it is likely that loss of foraging and nesting habitat due to climatic and anthropogenic factors are the primary drivers of risk to this species (Vuln. Assessment Worksheets, pers. comm., 2022). In fact, a recent analysis suggests that climatically-suitable habitat for belted kingfishers is likely to decline significantly within the GGB region under warming scenarios at or above 2°C, which could significantly restrict their regional distribution (Audubon Society 2023). Overall, populations are believed to exhibit high connectivity, and migratory individuals likely overlap with resident birds in the non-breeding season (Vuln. Assessment Worksheets, pers. comm., 2022).

Intraspecific/life history diversity → Moderate (moderate confidence)

Most of the information about belted kingfisher is limited to studies of individual populations (Hamas 1975; Brooks & Davis 1987; Baron et al. 1997), and there is little information available about the genetics or diversity of this species across populations. Kingfishers are territorial birds, and territory sizes may increase or decrease depending on the quality of foraging habitat available (Sullivan et al. 2006). Belted kingfishers are known to display a range of migratory strategies depending on sex and on whether local climate drives them from areas on a seasonal basis (Kaufman 1996; Kelly et al. 2020).

Resistance and recovery → Moderate (moderate confidence)

Belted kingfishers are resistant to changes in their aquatic habitat in that they can make use of a wide variety of aquatic habitats for foraging. However, they do require open, clear water with abundant fish and other aquatic prey, and these conditions are increasingly challenged by climate and anthropogenic stressors (Moyle et al. 2012; Quiñones & Moyle, Peter 2014; Howard et al. 2015; Craig et al. 2017). Belted kingfishers tolerate some proximity to human development, and would likely take to restored

aquatic habitat fairly readily (Vuln. Assessment Worksheets, pers. comm., 2022). Fortunately, nest predation and even overall nest mortality is relatively low in this species due to the placement of their nests in vertical banks (Kelly et al. 2020).

Management potential → High (moderate confidence)

With their bright colors, large size, and highly recognizable call, belted kingfishers are a charismatic species easily recognized by the general public and admired by birders (e.g., Richie 2022). Because they depend on aquatic habitats for both foraging and nesting, kingfishers have the potential of benefiting from federal and state regulations encouraging protection and recovery of aquatic ecosystems and the significant investments going into those efforts (Kondolf et al. 2007; Callaway et al. 2011). Despite these investments, the habitat and the small freshwater fish on which kingfishers rely face steep challenges from climate change and multiple anthropogenic stressors (Light & Marchetti 2007; Quiñones & Moyle, Peter 2014; Sturrock et al. 2020).

There are many management options that support healthy aquatic habitats with characteristics that support the foraging and nesting requirements for kingfishers (i.e., clear, open water, intact riparian vegetation, and abundant small fish). For instance, addressing artificial barriers and increasing floodplain connectivity, natural flow regimes, and in-stream complexity to support small and juvenile fish species and their food web would support foraging opportunities for kingfishers (Power et al. 1996; Sullivan et al. 2006; Herbold et al. 2018). Efforts to restore natural flow regimes and remove or prevent riparian and shoreline hardening would also increase the availability of soft streambanks and shorelines that this species requires for nesting (Cornwell 1963; Hamas 1975). Efforts to protect and restore the habitats and prey resources needed by kingfishers are some of the most important ways to support this species and build greater resilience to stressors.

Recommended Citation

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Further information on the Golden Gate Biosphere Region Climate Adaptation Project is available on the project page (www.ecoadapt.org/goto/GGBRClimateProject).

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