Marbled Murrelet (Brachyramphus marmoratus)

Climate Change Vulnerability Assessment for the Santa Cruz Mountains Climate Adaptation Project

This document represents an initial evaluation of mid-century climate change vulnerability for marbled murrelet in the Santa Cruz Mountains region based on expert input during an October 2019 vulnerability assessment workshop as well as information in the scientific literature.

Species Description

The marbled murrelet (Brachyramphus marmoratus) is a small seabird in the Alcidae family\(^1\), and populations are distributed from Santa Cruz, California north through the Aleutian Islands of Alaska\(^2,3\). In the Santa Cruz Mountains region, they occur across a 37-mile (60 km) range from the Pilarcitos Creek watershed in San Mateo County south to Henry Cowell State Park in Santa Cruz County\(^4\).

Marbled murrelets forage on small schooling fish and krill within the nearshore marine environment\(^5,6\). They are unique among seabirds in that they travel inland to reproduce in mature and old-growth forests dominated by coast redwood (Sequoia sempervirens) and Douglas-fir (Pseudotsuga heterophylla)\(^2,7–9\). Nest site requirements include platforms of moss, ferns, or other epiphytes located on branches or broken treetops in large-diameter trees; adequate canopy cover over the nest; and proximity to the marine environment\(^4,7–10\). Nesting sites are frequently located on gentle, low-elevation slopes or alluvial flats near streams\(^8,9\).

Vulnerability Ranking

Marbled murrelets are sensitive to changes in climate stressors and disturbance regimes (e.g., warmer air temperatures, changes in precipitation patterns, altered wildfire regimes, more frequent/intense storms) that reduce the quality and/or availability of nesting habitat within old-growth forests, which is likely to impact reproductive success and species distribution. Because they are dependent on both forest and marine habitats, marbled murrelets are also vulnerable to changes that impact prey availability within ocean environments. Non-climate stressors such as the presence of corvids, timber harvest, fire exclusion/suppression, and commercial fisheries can exacerbate sensitivity to changes in climate factors and disturbance regimes by decreasing reproductive success, increasing habitat loss and fragmentation, and reducing prey availability.

The Santa Cruz Mountains region supports a very small population of marbled murrelets, representing the southern extent of the species’ range. Nesting habitat has declined over the past century, and most remaining old-growth forests in the region are highly fragmented. Low reproductive rates and high site fidelity also increase vulnerability to population declines. Most management strategies for marbled murrelets focus on protecting and enhancing terrestrial nesting habitat, but actions focused on reducing nest predation by corvids could also increase population stability in this species.
Sensitivity and Exposure

**Sensitivity** is a measure of whether and how a species is likely to be affected by a given change in climate and climate-driven factors, changes in disturbance regimes, and non-climate stressors. **Exposure** is a measure of how much change in these factors a species is likely to experience.

### Sensitivity and future exposure to climate and climate-driven factors

The marbled murrelet is sensitive to climate stressors that reduce the quality and/or availability of nesting habitat, potentially impacting reproductive success and distribution.

<table>
<thead>
<tr>
<th>Climate Stressor</th>
<th>Trend Direction</th>
<th>Projected Future Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air temperature</td>
<td>▲</td>
<td>- 1.5–3.1°C (2.7–5.6°F) increase in annual mean temperature¹¹,¹²</td>
</tr>
<tr>
<td>Precipitation</td>
<td>▲▼</td>
<td>- Shorter winters and longer, drier summers likely, with higher interannual variability¹³,¹⁴</td>
</tr>
</tbody>
</table>

- **Increasing air temperatures** are likely to decrease nest platform availability by reducing epiphyte occurrence¹⁵,¹⁶. Studies suggest that warmer air temperatures could also impact redwood growth due to enhanced water stress¹⁷,¹⁸. The distribution of occupied marbled murrelet nesting sites is closely correlated with cooler maximum summer temperatures⁸. However, it is currently unknown whether marbled murrelets exhibit physiological sensitivity to temperature, or whether the association between temperature and occupied nesting sites is primarily due to indirect effects of cooler microclimates on nesting habitat quality⁸.

- **Changes in patterns of precipitation** are likely to alter plant moisture stress in coastal forests¹⁷,¹⁹,²⁰, which are characterized by frequent fog that relieves summer drought stress and closed canopies that create cool, moist microclimates¹⁹,²¹,²². These conditions support the growth of epiphytes that provide nest platforms for marbled murrelets²³, but drier future conditions may reduce the suitability of nesting habitat by impacting plant growth and mortality²⁴,²⁵. For instance, many epiphytes within coastal redwood forests are sensitive to desiccation, and changes in microclimate conditions due to reduced precipitation and/or increased drought would likely limit epiphyte growth and distribution¹⁵,²³.

### Sensitivity and future exposure to climate-driven changes in disturbance regimes

Marbled murrelets are sensitive to changes in disturbance regimes that directly impact survival as well as those that result in the loss of nesting habitat and increase habitat fragmentation.
Disturbance Regimes | Trend Direction | Projected Future Changes
--- | --- | ---
Wildfire | ▲ | • Slight to moderate increase in wildfire risk, particularly in areas of higher rainfall\(^{11,12}\)

| Storms | ▲ | • Increased storm intensity and duration, resulting in more frequent extreme precipitation events and flooding\(^{13,26,27}\)

- Although redwoods are adapted to survive fire\(^{28}\), climate-driven changes in wildfire regimes may result in uncharacteristically severe fires that result in the loss of nesting habitat in coastal old-growth forests\(^{4,24}\). The risk of severe fires is greater where old-growth stands are surrounded by dense forest dominated by small-diameter conifers and broadleaf trees, which increases fuel availability and continuity\(^{29}\).

- Climate-driven changes in the intensity and/or frequency of storm events may increase windthrow (i.e., uprooting or breaking of trees by the wind), particularly at the edge of clearcuts\(^{30}\) and/or in waterlogged soils\(^{21,28}\). This could cause the loss of mature trees or limbs used for nesting\(^{24,25,31}\).

Dependency on habitat and/or other species
Marbled murrelets are dependent on both marine foraging habitats and terrestrial nesting habitats, increasing their vulnerability to changes that affect habitat quality and/or availability in either environment\(^{24,25}\). They are considered habitat specialists due to their dependence on large-diameter trees with branches or broken tops that support nest platforms of moss, ferns, and other epiphytes\(^{10}\). Thus, marbled murrelets are very sensitive to the loss or fragmentation of their nesting habitat and changes in microclimate conditions that impact moss and epiphyte growth\(^{24,25}\). Because the development of a forest structure that includes the habitat elements required to support reproduction can take centuries, suitable habitat can be eliminated much faster than it is created\(^{25,32}\).

The dependence of marbled murrelets on marine foraging habitats increases their vulnerability to changes in ocean conditions (e.g., sea surface temperature, acidification, currents) that impact prey availability\(^{24,33}\). Years with abundant prey are generally associated with cooler waters and strong upwelling\(^{6,34}\), which likely increase murrelet survival and reproductive success\(^{6,35}\). During years with reduced prey availability, murrelets must spend more time foraging and travel farther to find sufficient food for themselves and their young\(^{36,37}\).

Sensitivity and current exposure to non-climate stressors
Non-climate stressors can exacerbate habitat sensitivity to changes in climate factors and disturbance regimes by decreasing reproductive success, increasing habitat loss and fragmentation, and reducing prey availability.

- Human activity and habitat fragmentation are associated with changes in the distribution and abundance of corvids (e.g., common ravens [Corvus corax], Steller’s jays [Cyanositta stelleri]), which prey on murrelet eggs and chicks\(^{4,38,39}\). Although they are native species, increases in Santa Cruz corvid populations since the 1980s\(^{39}\) have coincided with dramatic reductions in murrelet recruitment\(^{4}\). Corvid nest predators are attracted to supplemental food from recreational visitors around campgrounds and picnic areas\(^{40}\), and roughly half of known murrelet nests in the Santa Cruz Mountains region occur within 1 km (0.6 ft) of state and
county park campgrounds. Additionally, many remaining old-growth stands are small and surrounded by development and other anthropogenic land uses, which also increases the likelihood of high corvid populations within these areas.

- **Timber harvest** on private lands is a significant threat to marbled murrelets across their range due to the continued loss of old-growth coastal forests utilized as nesting habitat. Their remaining breeding habitat is highly fragmented, increasing vulnerability to wildfire and exposing murrelets to higher rates of nest predation. Increasing fragmentation as a result of timber harvest can also increase the rate of windthrow at stand edges and creates overall drier forest conditions, potentially altering epiphyte growth and composition and enhancing fire risk.

- Reduced fire frequency as a result of fire exclusion and suppression contributes to shifts in fuel structure and increased fuel loading in coastal old-growth forests, increasing the risk of more intense fires and associated losses in marbled murrelet nesting habitat in the future.

- The impacts of commercial fisheries have not been well-documented in marbled murrelets, but they could reduce prey by impacting food webs. Murrelets could also be displaced from foraging sites that are heavily fished. Finally, mortality due to bycatch in gill-net fisheries has been documented in Alaska and British Columbia, but those practices are banned in central California.

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**Adaptive Capacity**

**Adaptive capacity** is the ability of a species to accommodate or cope with climate change impacts with minimal disruption.

**Species extent, integrity, connectivity, and dispersal ability**

The Santa Cruz Mountains support a very small population of murrelets (~650 individuals) representing the southern extent of the species’ range, and nests have been documented within just seven coastal watersheds in San Mateo and Santa Cruz counties. Over the past century, marbled murrelet nesting habitat in the region has declined due to the logging of mature and old-growth forests. Only about 10,000 acres of old-growth habitat remains with the region, with almost half of that found within Big Basin Redwoods State Park and much of the remaining area fragmented in stands of less than 150 acres. An additional ~5,000 acres of mature second-growth habitat has also been identified, occurring on both public and private lands. Marbled murrelets do not typically disperse very far inland for nesting (17.7–35.4 km [11–22 miles]), so they are heavily dependent on coastal old-growth habitat.

Very low reproductive rates observed in the region suggest that recruitment is currently inadequate to support the population. It is likely that marbled murrelets in the Santa Cruz Mountains region represent a sink population that would decline rapidly in the absence of immigration from northern populations. Because the population is too small to be limited by nest site availability, it is likely that limited food availability in some years and high rates of nest predation are the most important factors limiting reproductive success in this region.

The small size of this population also increases
vulnerability to stochastic events (e.g., uncharacteristically severe fires), because even relatively low levels of adult mortality could cause significant population declines or extirpation.4,48

**Intraspecific/life history diversity**

Marbled murrelets have adapted several characteristics that reduce the risk of detection by nest predators, including effective camouflage and secretive behavior1. For instance, murrelets are primarily active around their nests when the light is low at dawn and dusk1. While incubating, they switch off every 24 hours and they stay completely motionless for over 98% of the time while on their nest1,49. Marbled murrelets exhibit very strong site fidelity24,49, increasing the potential for breeding disruption as a result of nesting habitat degradation or loss. The loss of nesting habitat may also limit the ability of this species to respond to shifts in prey availability near their nesting site24.

The Santa Cruz Mountains population of murrelets appears to be genetically distinct from the those to the north50. However, the very small size of this population increases the risk of inbreeding due to genetic bottlenecks48.

**Resistance and recovery**

Marbled murrelets have low resistance to loss or fragmentation of nesting habitat, such as might occur following large, uncharacteristically severe fires24,25. However, old-growth forests are relatively resistant to wildfire due to their cool, moist microclimate29, and the thick, fire-resistant bark of large redwoods reduces the risk of severe damage or mortality in nest trees28.

Recovery from disturbance events or population declines is very slow due to low reproductive rates1,32. Marbled murrelet clutches are usually just a single egg10. Additionally, they do not breed every year, further reducing their reproductive rate and increasing vulnerability to population declines1,32. Within the small Santa Cruz Mountains population, nesting success rates since 1991 may be as low as 16%4,7,9.

**Management potential**

Although they are not well-known by the general public, marbled murrelets are an enigmatic species with a loyal following among those who are aware of them. Birders and other conservation interest groups are generally strong supporters of protection for this species48. Marbled murrelets receive regulatory protection through the federal Endangered Species Act which lists them as a threatened species45; they are also state-listed as endangered in California51. Overall, there is strong public and societal support for old-growth forest protection, though continued outreach is needed to raise visibility of this unique species and their connection to old-growth redwood forests48. However, there is a relative lack of information on this species compared to many other old-growth specialists, largely because characteristics that make marbled murrelets difficult to detect by nest predators also make them difficult to study4,48.

Because many stressors that affect marbled murrelets are difficult to control (e.g., prey availability within marine habitats), management of marbled murrelets focuses heavily on protecting nesting habitat within old-growth redwood forests48. It is also critical to protect older second-growth and regenerating stands that represent potential nesting habitat, including those on privately-owned land that are at risk of harvest or development4,24,25. In these areas, management strategies that accelerate the development of old-growth forest structure could benefit murrelet populations31,52. Reducing nest predation by corvids is also an important management focus; although it is not directly related to climate change, studies suggest that successful management of this factor could increase population
stability in the region\(^3\). Most corvid management strategies to date have focused on a combination of reducing the availability of anthropogenic food sources in recreational areas and public education efforts to increase awareness of the problem among recreational users\(^4\). Surrounding clusters of old-growth and/or mature second-growth stands with regenerating forest may also help reduce the predation risk associated with hard edges\(^42\).

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**Recommended Citation**

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Further information on the Santa Cruz Mountains Climate Adaptation Project is available on the project page (http://ecoadapt.org/programs/awareness-to-action/santa-cruz-mountains).

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