
**APPENDIX D:
MARBLED MURRELET LITERATURE REVIEW
(2012-2025) (REVISED)**



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Big Basin Facilities Management Plan

Marbled Murrelet Literature Review: 2012–2025

prepared by

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September 2025

Revised January 2025

This literature review on the marbled murrelet (*Brachyramphus marmoratus*) was conducted as part of the background review during preparation of the Supplemental Environmental Impact Report (SEIR) on the Big Basin Facility Management Plan. The purpose of this literature review is to expand on the annotated bibliography contained in the 2013 General Plan and Final EIR for Big Basin Redwoods State Park (California State Parks 2013), under the master response on marbled murrelet from the Final EIR, which reviewed available data on the species from 1991 to 2012. This expanded review provides a compendium of scientific literature and other reports from 2012 to October 2025 and focuses on research and monitoring performed in central coastal California, identified as Conservation Zone 6 in the 1997 federal Recovery Plan for the species (U.S. Fish and Wildlife Service 1997).

The following provides a summary of the key findings from the literature review, consisting of 1) the current status of the marbled murrelet in Zone 6, 2) major findings related to corvid research and monitoring in Zone 6, and 3) results of recent research and observations of human-related disturbance on the marbled murrelet. This is followed by the results of the literature review, which includes a chronological listing of each source with a brief summary or excerpts of salient information.

Status of the Marbled Murrelet in Zone 6

Marbled Murrelets are a challenging species to monitor because of the difficulty in observing them, variability of information that can be obtained from each survey type, and the high degree of temporal variability in murrelet activity, such that no one survey method is able to paint the complete picture of murrelet status. Various types of monitoring of the Santa Cruz Mountains population of murrelets has been conducted in some form every year since the late 1980s,¹ and

¹ Patton, P. W. C. and C. J. Ralph. 1990. *Distribution of the Marbled Murrelet at inland sites in California*. *Northwestern Naturalist* 71:72–84.

rigorous monitoring beginning in the early 1990s documented higher inland murrelet activity levels than observed in the region today (Halbert and Singer 2017).

At-sea surveys between Half Moon Bay and Santa Cruz have provided annual population estimates based on adult abundance. There are no statistically significant trends in adult abundance since the inception of at-sea surveys in 1999, and adult abundance since 2012 appears to be stable, even after the CZU fire in 2020 (Felis et al. 2023b, White et al. 2024).

Inland monitoring since 1991 has included audio-visual (AV) surveys at many locations across the Santa Cruz Mountains, and more recently, passive acoustic monitoring. From the early 1990s to the early 2000s there was a significant long-term decline in inland murrelet activity where AV surveys were performed²; although since 2012, there appears to be no discernable trend in inland activity (Mori 2025). Beginning in 2022, inland activity at some locations has been lower than in previous years, and may be the first indication of change in the population as a result of habitat loss from the CZU fire (Mori 2023a, 2023b, 2025).

The effects of the CZU fire on murrelet nesting habitat are profound and lasting (Singer and Rinkert 2025), and its true impact on the population may take additional years to be clearly discerned. Passive acoustic monitoring is increasingly being relied upon for monitoring inland activity, although an analysis of trends using data collected with this technology has yet to be undertaken. An analysis of trends in passive acoustic data, continued AV and at-sea surveys, and further determination of the habitat loss incurred from the CZU fire and its effects on murrelet occupancy are needed to more conclusively determine the current status of the murrelet population breeding in the Santa Cruz Mountains.

Corvid Research and Monitoring in Zone 6

Corvid surveys, focusing on Steller's jay and common raven, first initiated in 1995 and performed on a regular basis since 2003, have been conducted within murrelet nesting habitat in the Santa Cruz Mountains in about half (43%) of the years since 2012. There is a long-term decline in Steller's jays, especially at campgrounds, as well as a less pronounced decline in adjacent low-impact areas (Rinkert 2021, 2022a, 2022b). Raven abundance has also declined significantly in some areas since 2003–2013, while American crows—a nascent threat to murrelets in the Santa Cruz Mountains—were recently documented breeding in murrelet habitat for the first time (Rinkert 2021, 2022a, 2022b).

Intensive research on Steller's jays in murrelet habitat from 2011–2019 revealed important information about their ecology, behavior, and space use that can be used to manage their populations to benefit murrelets. Numerous studies have now demonstrated how jay populations

² Suddjian, D. L. 2010. *Summary of 2009 Marbled Murrelet monitoring surveys in the Santa Cruz Mountains*. Unpublished report prepared for the Command Oil Spill Trustee Council.

benefit from food subsidies within campgrounds. Food subsidies in campgrounds were found to increase the reproductive output of jays (West and Peery 2017), and high densities of jays in campgrounds were maintained by dominant jays attempting to exclude subordinate birds (Brunk et al. 2022). Campgrounds also served as source populations for jays, which would breed at campgrounds and then disperse up to dozens of kilometers away to take advantage of human food subsidies outside of the park in fall and winter (West et al. 2019). Human food subsidies at campgrounds were shown to directly influence jays up to 2 km away (West et al. 2016). In response to inflated corvid populations, California State Parks implemented corvid management program that involved education, enforcement, and infrastructure improvements beginning in 2013; jays became less abundant and consumed less human food subsidies as a result (Brunk et al. 2021).

Conditioned taste aversion treatments to dissuade Steller's jays from predating murrelet eggs were implemented at various parks in the Santa Cruz Mountains from 2012–2016 (Gabriel et al. 2013, 2014a, 2014b, 2015, 2016). These studies documented a slight but significant decline in the predation of mimic eggs and apparent carryover of aversion to predation, especially where eggs were deployed across large, contiguous areas and where there were at least two deployments of mimic eggs in a season. While there were few actual documented predations of mimic eggs by Steller's jays, most predation of mimic eggs was attributed to this species.

Recent Research and Observations of Human-Related Disturbance on Marbled Murrelets

There is very limited information on how human-caused disturbance affects murrelets. Recent research and observations have focused on how noise (i.e., unwanted sound in an environment) can disturb murrelets by altering the behavior of nestlings and adults attending nests. Murrelets are generally sensitive to sound (Smith et al. 2023), and disturbance-causing noise could result in adverse impacts to murrelets when they are performing critical behaviors, such as feeding nestlings (USFWS 2020). If a nestling is fed an intermediate- or low-quality diet, it is estimated that just one missed feeding can adversely impact the nestling's development and survival (Nelson and Fitzgerald 2024).

Prior to the CZU fire, the ambient noise in murrelet nesting habitat at Big Basin Redwoods State Park was unusually elevated compared to noise levels in typical nesting habitat, and additional construction noise exceeded thresholds of acceptable noise near murrelet nests until modifications to equipment and work areas were implemented (Singer and Houston 2012). The U.S. Fish and Wildlife Service (2020) recently issued updated temporal and spatial noise restrictions in and near murrelet nesting habitat to avoid adverse impacts to the species, and based on a new analysis of local inland murrelet activity and noise attenuation, Halbert (2022) has recommended further refinement of temporal restrictions for restorative forest treatments following the CZU fire.

2012

Singer, S. and D. Houston. 2012. Investigation and mitigation of construction noise impacts on the Marbled Murrelet--facilities upgrade at Big Basin Redwoods State Park. Unpublished report prepared for California State Parks, Sacramento, CA.

“Pre-project noise levels at Big Basin Redwoods State Park were 53–123 dBC, measured in 2006,” while construction noises measured in 2012 were generally 80–100 dBA. The report also provides recommendations on how to modify work equipment and practices to produce less noise that could disturb murrelets.

2013

California Department of Parks and Recreation. 2013. *Big Basin Redwoods State Parks, Final General Plan and Environmental Impact Report*. State Clearinghouse No. 2001112104. Approved by the State Park and Recreation Commission May 2013.

The Final EIR contains a review of studies related to the Marbled Murrelet conducted from 1991 to 2012.

Gabriel, P. O., P. Halbert, and R. T. Golightly. 2013. Steller’s Jay conditioned taste aversion treatment in the Santa Cruz Mountains in 2012. Unpublished report prepared for the COSCO BUSAN Trustee Council.

“Deployment of murrelet-mimic eggs laced with carbachol in the forests surrounding high-visitor use areas of Butano State Park and Portola Redwoods State Park was effective at reducing predation by Steller’s jays on the murrelet-mimic eggs.”

“With an estimated decrease in predation of at least 44 to 80%, CTA can likely achieve the target reductions in corvid predation (40 to 70%; Peery and Henry 2010) to assist recovery of murrelets in this region.”

Halbert, P. 2013. Summary of 2013 corvid monitoring surveys in the Santa Cruz Mountains. Unpublished report prepared by California State Parks, Santa Cruz District, Felton, CA.

Corvid surveys conducted at Butano State Park, Big Basin and Portola Redwoods State Parks, and Memorial County Park found jays to be significantly more abundant in campgrounds than in control areas at all parks except Butano.

Singer, S.W. 2013. Results of 2013 Marbled Murrelet surveys at Gazos Mountain Camp and other sites. Unpublished report prepared by Steven Singer Environmental & Ecological Services, Santa Cruz, CA.

[The report presents the results of ten murrelet AV surveys conducted at Gazos Mountain Camp, and Big Basin and Portola Redwoods State Parks in July 2013. Most surveys at

Gazos had a moderate number of detections (28.1 average), while two surveys at Big Basin had 76 and 1 detection, and one survey at Portola had 11 detections.]

Vásquez-Carrillo, C., V. Friesen, L. Hall, and M. Z. Peery. 2013. Variation in MHC class II B genes in marbled murrelets: implications for delineating conservation units. *Animal Conservation* 17:244–255.

While previously determined to be a genetically distinct population, the murrelets breeding in the Santa Cruz Mountains did not differ in their MHC exon 2 alleles or peptides compared to other, more northerly breeding populations.

“. . . we recommend that central California be considered a separate conservation unit despite the lack of MHC differentiation.”

2014

Gabriel, P. O., P. Halbert, and R. T. Golightly. 2014a. Steller’s Jay aversion conditioning treatment in the Santa Cruz Mountains in 2013. Unpublished report prepared for the COSCO BUSAN Trustee Council.

“Deployment of murrelet-mimic eggs laced with carbachol for a second consecutive year in the forests surrounding high-visitor use areas of Butano State Park and Portola Redwoods State Park was effective at reducing predation by Steller’s jays on the murrelet-mimic eggs. Moreover, the initial predation rate on murrelet-mimic eggs in 2013 was similar to the predation rate after conditioning in 2012, suggesting a possible carry-over effect of conditioned aversion, where many jays that were treated in 2012 may still have retained their avoidance of mimic eggs in 2013.”

“The effectiveness of aversion achieved by the conditioning in 2013 was somewhat lower than in 2012 (Gabriel et al. 2013).”

Gabriel, P. O., P. Halbert, and R. T. Golightly. 2014b. Steller’s Jay aversion conditioning treatment in the Santa Cruz Mountains in 2014. Unpublished report prepared for the COSCO BUSAN Trustee Council.

“The initial predation rate on murrelet-mimic eggs in areas that had previously received treatment was similar to the predation rate after conditioning in 2013, suggesting that conditioned aversion persisted from one year to the next, where many jays that were treated in 2012 or 2013 may still have retained their avoidance of mimic eggs in 2014. In contrast to the two previous years, however, use of murrelet-mimic eggs for a third consecutive year in 2014 did not further reduce predation by Steller’s jays on the mimic eggs.”

“The absence of a detectable treatment effect specifically in newly treated, mostly small and isolated areas emphasizes that treatment is likely to be most effective if it is conducted in a mostly contiguous area, where it can reach the majority of a contiguous jay population.”

2015

Borker, A. L., P. Halbert, M. W. McKown, B. R. Tershy, and D. A. Croll. 2015. A comparison of automated and traditional monitoring techniques for marbled murrelets using passive acoustic sensors. *Wildlife Society Bulletin* 39:813–818.

“We found automated acoustic surveys and analysis had fewer detections per morning compared with audio–visual surveyors, but the rate of automated acoustic detections per morning was positively and strongly correlated with the rate of audio–visual detections per mornings ($r=0.96$, $P<0.01$). Furthermore, acoustic monitoring sampled 10 times more mornings per site ($\bar{x}=48$) than were monitored by human surveyors ($\bar{x}=4.4$) at a comparable cost.”

Halbert, P. 2015. Summary of 2012 corvid monitoring surveys in the Santa Cruz Mountains. Unpublished report prepared by California State Parks, Santa Cruz District, Felton, CA.

Steller’s Jay and Common Raven abundance remained considerably higher in campgrounds than in control areas at Big Basin and Portola Redwoods State Parks, Butano State Park, and Memorial County Park.

Singer, S. W. 2015a. 2014 forest survey results, Marbled Murrelets in the Santa Cruz Mountains. Unpublished report prepared for California State Parks, Santa Cruz District, Felton, CA.

“Simultaneous A-V survey were conducted at the Butano, Gazos Camp, Portola, Big Basin, and Memorial breeding areas on 3 days in 2014.”

“The highest murrelet activity levels were found at Gazos Camp and Butano, which had a record number of wing sound detections.”

“Five partial surveys on July 11, 12, 13, 15, and 19 had from 23 to 76 total detections with an average of 43 (Kuyper, pers. comm. cited in Singer, 2013). These values hinted at a possible recovery of murrelet activity levels at Big Basin.”

Singer, S. W. 2015b. 2015 forest survey results, Marbled Murrelets in the Santa Cruz Mountains. Unpublished report prepared for California State Parks, Santa Cruz District, Felton, CA.

“Simultaneous A-V survey were conducted at the Butano, Gazos Camp, Portola, and Big Basin breeding areas on 5 days in 2015.”

“A simple way of stating the findings, is that our four survey stations consist of two high activity stations – Butano and Gazos Camp, and two low activity level stations – Big Basin and Portola.”

2016

Gabriel, P. O., P. Halbert, and R. T. Golightly. 2016. Steller's Jay aversion conditioning treatment in the Santa Cruz Mountains in 2015. Unpublished report prepared for the COSCO BUSAN Trustee Council.

“The initial predation rate on murrelet-mimic eggs throughout all treatment areas was well below initial predation rates in previous years, especially compared to the first treatment year of 2012. In addition, no Steller's jays were detected on trail camera photos that documented a total of 45 wildlife interactions at mimic egg locations. These results suggested that conditioned aversion persisted across years, and the treatment effect on corvids in the area has now spread through the population.”

Henry, R. W., W. B. Tyler, and M. Z. Peery. 2016. Abundance and productivity of Marbled Murrelets off central California during the 2012 breeding season. Unpublished report prepared for the Luckenbach Oil Spill Trustees.

The central California population had an estimated 403–588 murrelets in the 2012 breeding season.

“These results indicate regional abundance has remain relatively similar since 2010, greater than the 2007/08 estimates, but less than estimates from 1999-2003 and 2009 (Figure 3A).”

West, E. H., W. R. Henry, W. Goldenberg, and M. Z. Peery. 2016. Influence of food subsidies on the foraging ecology of a synanthropic species in protected areas. *Ecosphere* 7(10):e01532.

“. . . campgrounds subsidize Steller's jays beyond their boundaries and potentially indicate that the quality of old-growth habitat surrounding campgrounds may be reduced for nesting marbled murrelets by these subsidies.”

“Based on space-use patterns of intermediate jays, we estimated that the “ecological footprint” of campgrounds extended 2 km beyond their spatial footprint.”

2017

Fleishman, A. B. and M. McKown. 2017. Automated acoustic surveys for Marbled Murrelets in the Santa Cruz Mountains – 2017. Unpublished report prepared by Conservation Metrics, Inc., Santa Cruz, CA for California State Parks, Santa Cruz District, Felton, CA and Steven Singer Environmental & Ecological Services, Santa Cruz, CA.

“Marbled Murrelet kee calls were detected at Gazos Mountain Camp and Berry Creek. There were no calls detected at the Fall Creek site (Figure 5).”

“Although the automated surveys detected fewer calls (typically ~60% of what human counters heard), there was a consistent relationship between counts from traditional and automated surveys.”

Gabriel, P. O., P. Halbert, and R. T. Golightly. 2017. Steller’s Jay aversion conditioning treatment in the Santa Cruz Mountains in 2016. Unpublished report prepared for the COSCO BUSAN Trustee Council.

“Predation rates on murrelet-mimic eggs both during the first and second treatments throughout all treatment areas were generally below initial predation rates in early treatment years, especially compared to the first treatment year of 2012. These results suggested that conditioned aversion persisted across years, and the treatment effect on corvids in the area has now spread through the population.”

Halbert, P. and S. W. Singer. 2017. Marbled Murrelet Landscape Management Plan for Zone 6. California Department of Parks and Recreation, Santa Cruz District, Felton, CA.

This plan summarizes current knowledge of the Marbled Murrelet population, their habitat, their predators, and threats to their population in Zone 6 through 2017. The plan analyzes this information and identifies gaps in knowledge and makes recommendations for future research, monitoring, and other work to conserve the murrelet population.

Henry, R. W. and W. B. Tyler. 2017. Abundance and productivity of Marbled Murrelets off central California during the 2013–2016 breeding seasons. Unpublished report prepared for The Luckenbach and Command Oil Spill Trustees and California State Parks, Santa Cruz District, Felton, CA.

The central California breeding population contained an estimated 152–1,063 murrelets during the 2013–2016 breeding seasons.

“While still remaining below historic population estimates from the 1999-2003, results presented in this report may signify a positive population response to CADPR [California Department of Parks and Recreation] actions.”

Singer, S. W. 2017a. 2016 forest survey results - Marbled Murrelets in the Santa Cruz Mountains. Unpublished report prepared for California State Parks, Santa Cruz District, Felton, CA.

“Simultaneous A-V surveys were conducted at the Butano, Gazos Camp, Portola, Big Basin, and, for the first time, Pescadero Creek County Park breeding areas on 5 days in July 2016.”

“There was a decrease in the number of detections at Butano and an increase at Portola and Big Basin.”

Singer, S. W. 2017b. 2017 forest survey results - Marbled Murrelets in the Santa Cruz Mountains. Steve Singer Environmental & Ecological Services. Unpublished report prepared for California State Parks, Santa Cruz District, Felton, CA.

“Simultaneous A-V surveys were conducted at the Butano, Gazos Camp, Big Basin, and at Pescadero Creek County Park (new location) survey stations on 5 days in July 2017.”

“Total detection numbers for all three stations combined in 2017 were similar to the 2016 value. Of interest was the fact that the number of detections at Big Basin, although relatively small, reached an all-time high for recent years.”

Webb, W. C. 2017. Corvid density and population trends inside and outside campgrounds at Big Basin Redwoods State Park. Unpublished report prepared for California State Parks, Santa Cruz District, Felton, CA.

“Jays and ravens occurred at greater densities and were detected more frequently in campgrounds compared to control plots.”

“The absence of observations of successful foraging by corvids in campsites suggests a high level of compliance by campers with management efforts to reduce human food subsidies.”

West, E. H. and M. Z. Peery. 2017. Behavioral mechanisms leading to improved fitness in a subsidized predator. *Oecologia* 184:787–798.

In a study of Steller’s Jays in campgrounds and surrounding low-impact areas at Big Basin Redwoods State Park, jays were found at campgrounds to consume more anthropogenic foods, occur in higher densities, be in better body condition, and have greater reproductive output than jays in low-impact areas.

2018

Felis, J. J., J. Adams, and E. C. Kelsey. 2018. Abundance and productivity of marbled murrelets (*Brachyramphus marmoratus*) off central California during the 2017 breeding season. U.S. Geological Survey Data Series 1093. <https://doi.org/10.3133/ds1093>.

The central California breeding population contained an estimated 384–732 murrelets during the 2017 breeding season.

“Estimated abundances from 2017 are comparable to most prior years of study, except for 2008 and 2015, which had anomalously low abundances (table 3, fig. 3).”

Gondek, N., A. Fleishman, and M. McKown. 2018. Automated acoustic surveys for Marbled Murrelets in the Santa Cruz Mountains – 2018. Unpublished report prepared by Conservation Metrics, Inc., Santa Cruz, CA for California State Parks, Santa Cruz District, Felton, CA and Steven Singer Environmental & Ecological Services, Santa Cruz, CA.

“Marbled Murrelet keer calls were detected at Gazos Mountain Camp and Redwood Meadows. For the second consecutive year, there were no calls detected at the Fall Creek site (Figure 4, Figure 5).”

Singer, S. W. 2018 forest survey results – Marbled Murrelets in the Santa Cruz Mountains. Unpublished report prepared for California State Parks, Santa Cruz District, Felton, CA.

“Simultaneous A-V surveys were conducted at the Butano, Gazos (Gazos Camp), and Big Basin survey stations on 5 days in July 2018 using the PSG Forest Survey protocol.”

“Over the 2014 – 2018 period, the results from all three stations combined did not show any significant trend. However, over this same short-term period, total detections numbers at Butano and at Gazos have declined. In contrast, total detection numbers at Big Basin have increased.”

2019

Felis, J.J., E. C. Kelsey, and J. Adams. 2019. Abundance and productivity of marbled murrelets (*Brachyramphus marmoratus*) off central California during the 2018 breeding season: U.S. Geological Survey Data Series 1107. <https://doi.org/10.3133/ds1107>.

The central California breeding population contained an estimated 250–546 murrelets during the 2018 breeding season.

“Estimated abundance from 2018 was below the long-term mean (2001–18: 497 murrelets) but is comparable at the 95-percent CI level to most prior years of study, except for 2001–03, which had greater estimated abundances.”

Fleishman, A. and M. McKown. 2019. Automated acoustic surveys for Marbled Murrelets in the Santa Cruz Mountains – 2019. Unpublished report prepared by Conservation Metrics, Inc., Santa Cruz, CA for California State Parks, Santa Cruz District, Felton, CA and Steven Singer Environmental & Ecological Services, Santa Cruz, CA.

“The primary goals of the survey were to search for Marbled Murrelet acoustic activity at three monitoring sites in the Santa Cruz Mountains: Gazos Mt. Camp, Redwood Meadows in Big Basin State Park, and Girl Scout Creek in Butano State Park.”

Murrelets were regularly detected at Gazos Mountain Camp and Redwood Meadow at Big Basin Redwoods State Park between April and July/August, but only a few call bouts were recorded at Girl Scout Creek in Butano State Park.

Singer, S. W. 2019 forest survey results – Marbled Murrelets in the Santa Cruz Mountains. Unpublished report prepared for California State Parks, Santa Cruz District, Felton, CA.

“Simultaneous A-V surveys were conducted at the Butano, Gazos (Gazos Camp), Big Basin, and Portola survey stations on 5 days in July 2019 using the PSG Forest Survey protocol.”

“Combined data from these three stations [Gazos, Big Basin, and Butano] reveal that total detections, occupied behavior detections, and below one canopy detections all show no trend since 2014, either decreasing or increasing (Table 4 and Graph 1).”

West, E. H., K. Brunk, and M. Z. Peery. 2019. When protected areas produce source populations of overabundant species. *Biological Conservation* 238:108220.

“Our study suggests that heavily-visited sites in a protected area promoted a source population of an overabundant nest predator that “seeded” the surrounding landscape within the park with recruiting breeders, potentially exacerbating risk to a threatened species that is at the heart of the park's conservation mission.”

2020

Felis, J. J., E. C. Kelsey, J. Adams, C. Horton, and L. White. 2020a. Abundance and productivity of Marbled Murrelets (*Brachyramphus marmoratus*) off central California during the 2019 breeding season. U. S. Geological Survey Data Series 1123. Unpublished report prepared by U. S Geological Survey, Western Ecological Research Center.

The central California breeding population contained an estimated 272–601 murrelets during the 2019 breeding season.

Felis, J., J. Adams, and E. C. Kelsey. 2020b. Summary of Marbled Murrelet at-sea survey results in USFWS Conservation Zone 6, central California, during the 2020 breeding season. Unpublished report prepared by U.S. Geological Survey, Western Ecological Research Center.

The central California breeding population contained an estimated 313–707 murrelets during the 2020 breeding season.

United States Fish and Wildlife Service. 2020. Revised transmittal of guidance: estimating the effects of auditory and visual disturbance to Northern Spotted Owls and Marbled Murrelets in northwestern California. Arcata Fish and Wildlife Office, U. S. Fish and Wildlife Service, Arcata, CA.

This memo outlines the thresholds for disturbance of murrelets and Northern Spotted Owls in northwestern California. Disturbance is defined by the U. S. Fish and Wildlife Service as flushing an adult or juvenile from an active nest, or precluding feeding of young during the daily feeding cycle or during part of multiple feeding cycles.

“We interpret the best available published data on owls, murrelets and appropriate surrogate species as indicating that the above behaviors may manifest when: (a) the action-

generated sound level substantially exceeds (i.e., by 20-25 dB or more as experienced by the animal) ambient conditions existing prior to the project; (b) when the total sound level, including the combined existing ambient and action-generated sound, is very high (i.e., exceeds 90 dB, as experienced by the animal); or (c) when visual proximity of human activities occurs close to (i.e., within 330 feet) of an active nest site.”

2021

Brunk, K. M., E. H. West, M. Z. Peery, and A. M. Pidgeon. 2021. Reducing anthropogenic subsidies can curb density of overabundant predators in protected areas. *Biological Conservation* 256:109081.

A study of Steller’s Jay response to corvid management (education, compliance, and infrastructure improvements) at Big Basin Redwoods State Park found jays consumed less anthropogenic food and were less abundant following the implementation of corvid management at the park in 2013.

“Indeed, we observed a substantial reduction in the consumption of anthropogenic foods by jays following the implementation of the visitor education program that led to changes that supported our second hypothesis, specifically that jay density would decrease while body condition and fecundity would remain reasonably stable in subsidized areas.”

Himmelwright, C. and A. Rinkert. 2021. Peregrine Falcon nest monitoring and prey remains analysis in the Santa Cruz Mountains from 2018–2021. Unpublished data collected for California State Parks, Santa Cruz District, Felton, CA.

Two Peregrine Falcon nest sites located at Big Basin Redwoods State Park and near Butano State Park, both within major flyways of the Marbled Murrelet, were monitored from 2018–2021. Both nest sites were occupied most of the four years they were monitored, and three successful nesting attempts produced a total of six fledglings. Prey remains were collected and identified to lowest taxonomic rank in three of the four years at each of the two nest sites. At least 44 bird species were identified in prey remains; Band-tailed Pigeon, Eurasian Collared-Dove, and Red-winged Blackbird were identified from remains at both nest sites in most years. Shorebird and passerine species were also well-represented in prey remains at both nest sites in all years. Marbled Murrelet remains were only detected in one year at one nest site, and the remains comprised two or three individual murrelets.

Mahdizadeh, M. and W. Russell. 2021. Initial floristic response to high severity wildfire in an old-growth coast redwood (*Sequoia sempervirens* (D. Don) Endl.) forest. *Forests* 12:1135.

Coast redwoods had the highest survival rate and canopy retention of trees in old-growth forest at Big Basin Redwoods State Park immediately (0.5 years) after the CZU fire, while Douglas-firs had the lowest survival rate and low canopy retention.

Mori, B. 2021. Marbled Murrelet inland monitoring program, Santa Cruz Mountains region, 2020 progress report. Unpublished report prepared for California State Parks, Santa Cruz District, Felton, CA.

In 2020, the level of murrelet activity was noticeably higher than over the previous 6 years of the monitoring program. Mean total detections were up significantly, for the region (e.g., Big Basin, Butano and Gazos combined) and for Butano, Gazos and Portola individually. This increase also was mirrored at Memorial County Park and Pescadero Creek County Park (H. Ormshaw, pers. comm.).

Rinkert, A. 2021a. Corvid surveys in the Santa Cruz Mountains: 2020 summary. Unpublished report prepared for California State Parks, Santa Cruz District, Felton, CA.

“Steller’s Jays were more abundant in treatment areas than in control areas at all parks combined and Big Basin, but not at Butano or Portola. This was the first year there was no significant difference in abundance between treatment and control areas at Portola, and the first year there was no difference at multiple parks (Portola and Butano).”

“Raven abundance was higher in treatment areas than in control areas in 2020. Their abundance in 2020 did not significantly differ from previous years of corvid surveys.”

Rinkert, A. 2021b. Initial observations of a Marbled Murrelet (*Brachyramphus marmoratus*) nest found at Big Basin Redwoods State Park in July 2021. Unpublished report prepared for California State Parks, Santa Cruz District, Felton, CA.

The finding of a murrelet nest and the chick’s response to construction and predator activity near the nest is described. The nest was located in a patch of old growth forest burned at low intensity by the CZU fire at Big Basin Redwoods State Park.

The chick became visibly alert by the presence of ravens near the nest, a repeatedly sounded vehicle horn, and loud scraping noises from construction activity, but did not respond to vehicles driving directly below the nest or the ambient construction noise.

2022

Brunk, K. M., E. H. West, M. Z. Peery, and A. Pidgeon. 2022. Failed despots and the equitable distribution of fitness in a subsidized species. Behavioral Ecology 33:979–988.

A study of Steller’s Jay behavior at Big Basin Redwoods State Park campgrounds found high jay densities are attained because dominant jays do not exclude subordinates from human food subsidies, and dominant jay territories overlap more with campgrounds than subordinate jay territories. Jays of all dominance categories had similar fitness and fecundity, and consumed similar amounts of human food subsidies.

Felis, J., J. Adams, C. A. Horton, E. C. Kelsey, and L. M. White. 2022. Abundance and productivity of Marbled Murrelets (*Brachyramphus marmoratus*) off central California

during the 2020 and 2021 breeding seasons. U.S. Geological Survey Data Report 1157. <https://doi.org/10.3133/dr1157>.

The central California breeding population contained an estimated 219–737 murrelets during the 2021 breeding season.

“The abundance estimated for the entire study area was 470 birds (95-percent confidence interval, 313–707 birds) in 2020 and 402 birds (95-percent confidence interval, 219–737 birds) in 2021. Estimated abundances for both years are comparable with most prior years of study.”

“Despite the significant loss of breeding habitat due to the CZU fire, estimated abundance and productivity results for 2021, as well as the spatial distribution of murrelet sightings, were not dramatically different than results from recent years; . . .”

Gustafson, Z. and J. Schlueter. 2022. Automated acoustic surveys for Marbled Murrelet and Spotted Owl in the Santa Cruz Mountains – 2021. Unpublished report prepared by Conservation Metrics, Inc., Santa Cruz, CA for California State Parks, Santa Cruz District, Felton, CA.

“We analyzed data from eight sites for vocalizations of Marbled Murrelet (*Brachyramphus marmoratus*), Barred Owl (*Strix varia*), and Northern Spotted Owl (*Strix occidentalis caurina*). Marbled Murrelets were detected at six of the eight sites, with the highest activity at Gazos Mt. Camp and Portola Ramada. No Barred Owl or Northern Spotted Owl vocalizations were detected.”

Halbert, P. 2022. Avoidance measure recommendations for Marbled Murrelets in the Santa Cruz Mountains following the CZU Lightning Complex. Unpublished report prepared by California State Parks, Santa Cruz District, Felton, CA.

The report recommends modifying the temporal restrictions when high decibel activities can occur in and near suitable habitat for murrelets in the Santa Cruz Mountains.

“The localized marbled murrelet behavioral data outlined in this report are supportive of wider operational windows; April 1 – August 5 are dates that better reflect known time of use based on AV and ARU surveys, except for the marbled murrelet important areas within Portola State Park and Pescadero Creek County Park or Gazos Mountain Camp where September 1st is appropriate.”

The modifications the report recommends are summarized below.

1. Expands the operational window for high decibel work near or within occupied or important habitat areas for murrelets to be between August 5 and March 24. Work in prime unburned habitat for murrelets in Pescadero Creek County Park and Portola Redwoods State Park can begin August 15, and at Gazos Mountain Camp by September 1. Work in

moderate-high and high severity burned forest can be conducted year-round with no noise restrictions.

2. Work should be conducted between 1.5 hours after sunrise and 1 hour before sunset.
3. Noise buffers can be reduced to 330 feet in forest burned at low to moderate severity.
4. Forestry work should be strategically planned to be conducted as far as possible from murrelet habitat in July.
5. AV and ARU monitoring will continue in areas where these recommendations are applied, survey data will be shared with agencies as it becomes available, and adaptive management will be implemented based on survey results.

Mori, B. 2022. Marbled Murrelet inland monitoring program, Santa Cruz Mountains region, 2021 progress report – post CZU fire results. Unpublished report prepared for California State Parks, Santa Cruz District, Felton, CA.

“From a regional perspective (i.e., Big Basin, Butano and Gazos combined), total detections dropped from a record high in 2020, but was still greater than the long-term average, prior to the 2020.”

“The drop in overall detections at Memorial and Pescadero County Parks in 2021 did not support the idea that detection levels would be similar to or higher in these two parks than in 2020, given the extensive fire damage to MAMU habitat in the Santa Cruz Mountains, south of Pescadero Creek.”

Rinkert, A. 2022a. Corvid surveys in the Santa Cruz Mountains: 2021 summary. Unpublished report prepared for California State Parks, Santa Cruz District, Felton, CA.

“For the first time since corvid surveys began in 2003, there was no significant difference in Steller’s Jay and Common Raven abundance between treatment and control areas at multiple state parks in consecutive years.”

“The CZU fire reduced the population of jays at Big Basin, and likely changed the distribution of ravens but did not directly reduce their population. There was little indication corvid populations changed at Butano, perhaps because it was less severely burned than Big Basin.”

Rinkert, A. 2022b. Corvid surveys in the Santa Cruz Mountains: 2022 summary. Unpublished report prepared for California State Parks, Santa Cruz District, Felton, CA.

“After accounting for differing burn severities, there was no significant difference in jay abundance between treatment and control areas at Big Basin, Butano, and Portola. This is the second consecutive year that abundance between treatment and control areas did not differ at these three parks.”

“Jay abundance remained low in high severity burn areas at Big Basin in the second year following the CZU Lightning Complex Fire. There was still no indication the fire had any

impact on the raven population in these two parks, or that jays were less abundant at Butano, which burned at low severity.”

United States Fish and Wildlife Service. 2022. Programmatic biological and conference opinion, California statewide programmatic restoration effort, FWS Reference: 2022-0005149-S7. Pacific Southwest Regional Office, U. S. Fish and Wildlife Service, Region 8, Sacramento, CA.

The U. S. Fish and Wildlife Service issues protections on listed species and their habitats. Murrelets are protected by the following restrictions to project activities:

“MAMU-1-a: damage or removal to potential nest trees or trees with potential nesting platforms shall be avoided. Project activities shall not alter suitable habitat to the extent that it is no longer functioning. No nest loss of critical habitat shall occur as a result of project activities.

MAMU-1-b: in occupied habitat.

- i. No proposed activity generating sound levels 20 or more decibels above ambient sound levels, or with maximum sound levels (ambient sound levels plus activity generated sound levels) above 90 decibels (excluding vehicle back-up alarms), may occur in confirmed marbled murrelet nesting habitat during the majority of the murrelet nesting season (i.e., March 24 through August 5) (USFWS 2020a).
- ii. Between August 6 (date when most murrelets have fledged in coastal northern California) and September 15 (end of murrelet nesting season) of any year, project activities, with adjacent suitable nesting habitat, that will generate sound levels ≥ 10 dB above ambient sound levels will observe a daily work window beginning 2 hours post-sunrise and ending 2 hours pre-sunset. However, prep work that does not generate sound levels above ambient sound levels, including street sweeping and manual removal of pavement markers, can occur during all hours.
- ...
- iv. No human activities shall occur within visual line-of-sight of 100 meters or less from a known nest location within the Action Area (USFWS 2020a), or from unsurveyed suitable nesting habitat containing potential murrelet nest trees within 100 meters of proposed activities.”

2023

Felis, J. J., J. Adams, C. Horton, E. C. Kelsey, and L. M. White. 2023a. Abundance and productivity of marbled murrelets (*Brachyramphus marmoratus*) off central California during the 2022 breeding season. Summary provisional data report to Luckenbach Trustee Council and California State Parks, Santa Cruz District, Felton, CA.

The central California breeding population contained an estimated 277–568 murrelets during the 2018 breeding season.

“The abundance estimate for 2022 was similar to the long term (1999–present) average of 379 murrelets (range 163–585 annually; Table 2).”

Felis, J. J., J. Adams, and B. Becker. 2023b. Status, trend, and monitoring effectiveness of Marbled Murrelet (*Brachyramphus marmoratus*) at sea abundance and reproductive output off central California, 1999–2021. U.S. Geological Survey Open-File Report 2023–1065. <https://doi.org/10.3133/ofr20231065>.

“Abundance of murrelets has been estimated at sea along an 85-km length of coastline adjacent to the Santa Cruz Mountains in Zone 6 since 1999 (excluding 2004–06), with annual estimates of 174–699 individuals at sea (Felis and others, 2022a).”

“The long-term AHY [after hatch-year, or “adult”] murrelet abundance at sea in Zone 6 seemed stable, and we did not detect any statistically significant trend for 23 years”

“The current survey design for estimating reproductive output by counting HY [hatch-year, or “juvenile”] birds at sea may not be effective given the high CVs [coefficient of variances] and large confidence limits associated with annual estimates, regardless of which metric is used.”

Mori, B. 2023a. Marbled Murrelet inland monitoring program, Santa Cruz Mountains region, 2022 progress report. Unpublished report prepared for California State Parks, Santa Cruz District, Felton, CA.

“On a regional level, all three detection categories dropped in 2022. Although total detections were within the variability seen in previous years, occupied behavior and SSBBC [Single Silent Birds Below Canopy] matched lows not seen since 2014 (see Figure 2) and are consistent with expectations following a severe burn.”

Mori, B. 2023b. Marbled Murrelet inland monitoring program, Santa Cruz Mountains region, 2023 progress report. Bryan Mori Biological Consulting. Unpublished report prepared for California State Parks, Santa Cruz District, Felton, CA.

“From a regional perspective (i.e., surveys at Big Basin, Butano, Gazos and Portola combined), mean total detections (TD), occupied behavior (OB) and single-silent birds-below-canopy (SSBBC) all gradually declined from 2022, with OB and SSBBC detections recorded at their lowest values since 2014.”

Ng, E. M., A. Pidgeon, E. H. West, M. Z. Peery, and K. M. Brunk. 2023. Garbage in may not equal garbage out: sex mediates effects of 'junk food' in a synanthropic species. *Journal of Urban Ecology* 9(1): juad014.

In a study of Steller's Jay diet and fitness consequences in campgrounds at Big Basin Redwoods State Park, researchers found male jays consumed more human food subsidies compared to females, but the amount of human food subsidies consumed did not impact body condition or fecundity.

Potter, C. 2023. Impacts of the CZU Lightning Complex Fire of August 2020 on the forests of Big Basin Redwoods State Park. California Fish and Wildlife Journal 109:e1.

“The unprecedented intensity of the CZU Fires together with two successive years (2021 and 2022) of extreme drought and summer heat has inflicted severe damage on the majority of old-growth trees in BBRSP [Big Basin Redwoods State Park].”

Rinkert, A. and S. W. Singer. 2023. Nesting status of the Marbled Murrelet at Big Basin Redwoods State Park in 2022. Unpublished report prepared for California State Parks, Santa Cruz District, Felton, CA.

A murrelet nest search was undertaken at Big Basin Redwoods State Park two years after the CZU fire. One probable murrelet nest site was found in an unburned area of the park, but the nest was suspected to have failed.

“Dawn murrelet activity in June 2022 was generally very low where suitable habitat still exists at the park after the 2020 CZU Lightning Complex Fire.”

Smith, A. B., M. Kissling, A. M. Capuano, S. B. Lewis, and T. A. Mooney. 2023. Aerial hearing thresholds and ecoacoustics of a threatened pursuit-diving seabird, the marbled murrelet *Brachyramphus marmoratus*. Endangered Species Research 50:167–179.

“We conclude marbled murrelets exhibit generally sensitive aerial hearing despite their amphibious lifestyle. Moreover, short-term acoustic recordings indicate this solitary and inland nesting seabird nests in a relatively quiet environment which may permit heightened incursion of nearby anthropogenic sounds.”

2024

Nelson, S. L. and K. Fitzgerald. 2024. Potential nutritional effects of missed feedings to Marbled Murrelet (*Brachyramphus marmoratus*) chicks due to disturbance. Northwest Science 97:2–14.

“Six dietary scenarios were developed to simulate murrelet chick feeding: a high-quality, intermediate, and low-quality diet, with one or two feedings missing from each diet. Five of the six scenarios resulted in insufficient energy for marbled murrelet chicks, with only the high-quality diet able to provide sufficient energy with one missed feeding.”

“Therefore, caloric insufficiency, as seen with the loss of even one fish meal within the intermediate and low-quality diet, occurring within the first 15 days of the nesting period

would be much more influential to chick development and stature than if it occurred in the second 15-day period of nesting.”

Pacific Seabird Group. 2024. Terrestrial habitat management recommendations for Marbled Murrelets. Pacific Seabird Group Technical Publication Number 7. Available at: <https://pacificseabirdgroup.org/psg-publications/technical-publications/>.

This publication provides recommendations for delineating, protecting, managing, and enhancing existing suitable habitat and developing new suitable habitat; reducing threats and impacts from megafires and human activities; and guidelines for hazard tree removal and infrastructure and energy projects (e.g., wind power, roads, and power lines) that can impact murrelets in their terrestrial habitat.

Overall recommendations for forest management include the following:

- delineate occupied areas;
- protect all habitat;
- maintain and enhance forested areas adjacent to habitat;
- maintain and enhance large blocks of contiguous forest cover;
- minimize predation and predator numbers in and near habitat;
- minimize the effects of disturbance near habitat;
- avoid or minimize adverse impacts to murrelet habitat due to forest fires.

Additional recommendations for protecting and conserving murrelets in forests are provided for the following:

- methods for delineating an occupied area;
- creating and maintaining buffers around occupied areas;
- reducing the threat of megafires;
- reducing impacts from human impacts;
- hazard tree removal and utility work;
- minimizing noise and other types of disturbance.

White, L. M., J. Adams, E. C. Kelsey, A. Rinkert, and G. Haight. 2024. Abundance of marbled murrelets (*Brachyramphus marmoratus*) off central California during the 2024 breeding season. Summary provisional data report to California State Parks, Santa Cruz District, Felton, CA.

The murrelet abundance estimate for the 2024 season was similar to previous years, and no statistically significant trends in abundance were found between 1999–2024 and 2007–2024.

2025

Leal, M. 2025. Post-CZU fire conditions and changes to habitat suitability for Marbled Murrelets at Huckleberry Campground in Big Basin Redwoods State Park. Unpublished report prepared by Santa Cruz District, California State Parks, Felton, CA.

Several PNTs were identified at Huckleberry Campground in Big Basin Redwoods State Park in 2025, but most that were known there prior to the CZU fire were lost. Six protocol-level murrelet surveys were conducted there in July and August 2025; one survey recorded at least one detection of distant, heard-only murrelets. An ARU deployed at the campground from mid-May to early September 2025 recorded a total of 21 call bouts across six days.

Mahdizadeh, M. and W. Russell. 2025. Post-fire succession in an old-growth coast redwood (*Sequoia sempervirens*) forest. *Fire* 8:322.

Vegetation characteristics and forest structure were compared between one and four years following the CZU fire in old-growth forest at Big Basin Redwoods State Park.

“While *Ceanothus* can enrich soils with nitrogen, its proliferation may delay or suppress Douglas fir seedling establishment by competing for space and light that can potentially outcompete Douglas fir seedlings and alter the forest composition in the short to medium term.”

“Although overall canopy cover increased slightly from 2021 to 2024, the change was not statistically significant, likely due to the inherently slow growth of upper canopy trees and stressors such as drought.”

Mori, B. 2025. Marbled Murrelet inland monitoring program, Santa Cruz Mountains region, 2024 progress report. Bryan Mori Biological Consulting, Watsonville, CA. Unpublished report prepared for California State Parks, Santa Cruz District, Felton, CA.

“The overall downward trend of MAMU activity regionally and at specific stations may be starting to reveal changes in behavior due to habitat loss from the CZU Fire. Of special concern is the absence of single-silent birds-below-canopy (SSBBC) at Big Basin for the first time since 2014 and the pronounced decline of MAMU activity at Butano.”

Singer, S. W. 2025. The 1904 crown fire in Big Basin Redwoods State Park - and the implications of epicormic branching for nesting Marbled Murrelets. Unpublished report prepared for California State Parks, Santa Cruz District, Felton, CA.

The boundary of the 1904 crown fire at Big Basin Redwoods State Park was estimated from observations of limb characteristics of old-growth coast redwoods. Limbs that formed as a result of the 1904 crown fire reportedly had a more swirly or curved growth pattern compared to a flatter, more horizontal growth pattern of trees with their original limbs.

Singer, S. W. and A. Rinkert. 2025. Impact of the 2020 CZU Fire on Marbled Murrelet nesting habitat in Big Basin Redwoods State Park. Unpublished report prepared by Steven Singer Environmental & Ecological Services, Santa Cruz, CA.

The status of 107 platform trees was monitored at Big Basin Redwoods State Park before the CZU fire and at various intervals afterward to determine their suitability for murrelets. A substantial number of platform trees were lost and the fire caused major changes to the structure and composition of the old-growth forest. Only 11% of Douglas-firs and 40% of coast redwoods were still alive within two years after the fire. However, many of these trees were so severely burned that they are no longer suitable for marbled murrelet nesting in the near term. Both tree species fared significantly better in areas burned at moderate and low severity compared to areas burned at extreme and high severity.

White, L. M., E. C. Kelsey, G. Haight, A. Rinkert, and J. Adams. 2025. Abundance of Marbled Murrelets (*Brachyramphus marmoratus*) off central California during the 2025 breeding season. Unpublished report prepared by U.S. Geological Survey - Western Ecological Research Center, Santa Cruz CA for California State Parks, Santa Cruz District, Felton, CA.

The central California breeding population contained an estimated 149–322 murrelets during the 2025 breeding season, which is one of the lowest annual estimate of the population since surveys began in 1999.

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