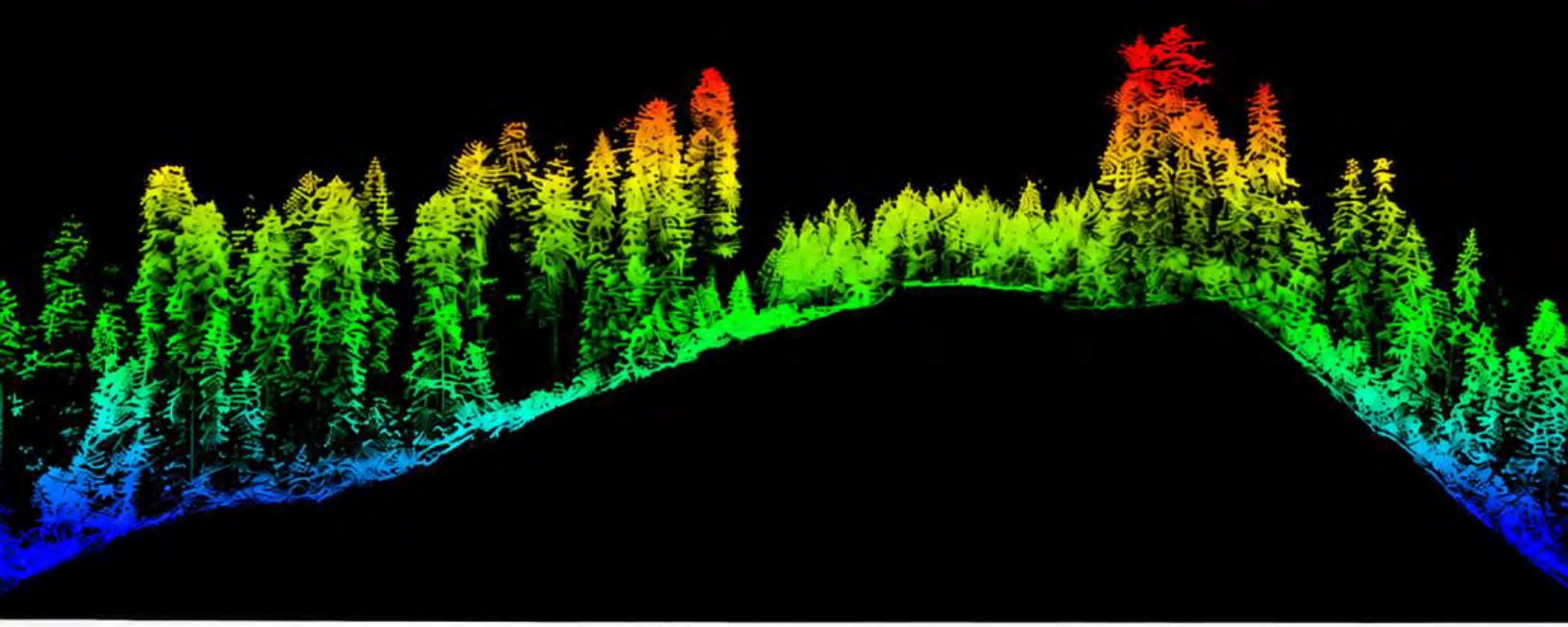

Marbled Murrelet
Habitat Conservation Plan

Green Diamond Resource Company

California Timberlands – Del Norte and Humboldt Counties

GREEN DIAMOND

FINAL | SEPTEMBER 2, 2026

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Prepared for:

U.S. Fish and Wildlife Service

Prepared by:

Green Diamond Resource Company

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MARBLED MURRELET HABITAT CONSERVATION PLAN

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Section 1. Introduction

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1.1 BACKGROUND

Green Diamond Resource Company (Green Diamond) owns and manages approximately 380,457 acres (153,965 hectares) of commercial timberland in Del Norte and Humboldt Counties in northern California (Map 1-1). Green Diamond's California timberlands consist of redwood forests located on the west slope of the Coastal and Klamath Mountains. The periphery of Green Diamond's California timberlands consists of Douglas-fir and mixed conifer forests located on higher elevation and interior lands in eastern Del Norte and Humboldt counties.

Map 1-1. Green Diamond Ownership in Eligible Plan Area of California

Portions of these California timberlands are used by marbled murrelets (*Brachyramphus marmoratus*), a species of Pacific seabird that is listed as threatened under the federal Endangered Species Act of 1973, as amended (ESA). The marbled murrelet is also listed as an endangered species under the California Endangered Species Act (CESA).

Green Diamond's commercial timberland management may cause the incidental take of marbled murrelets through operations in or near occupied nesting habitat. Under ESA Section 10, the U.S. Fish and Wildlife Service (Service, or USFWS) and the National Marine Fisheries Service (NMFS) may, upon the approval of a Habitat Conservation Plan (HCP) meeting certain criteria, issue an Incidental Take Permit (Take Permit) authorizing such take. An HCP must specify measures the applicant will take to minimize and mitigate to the maximum extent practicable the impacts of the proposed incidental take of the listed species. To be approved, an HCP must satisfy other standards such as a finding that implementation will not jeopardize the survival and recovery of the species, assurances of the applicant's capacity to implement the conservation measures, and other measures that the Service may prescribe as necessary and appropriate for the purposes of the HCP.

Green Diamond currently manages and operates its California commercial timberlands in accordance with two HCPs and their associated Take Permits:

- In 2007, the Service and NMFS approved the Green Diamond Aquatic Habitat Conservation Plan and Candidate Conservation Agreement with Assurances (AHCP/CCAA). The 50-year AHCP/CCAA provides for the conservation of anadromous salmonids and stream-associated amphibians across a Plan Area of approximately 363,100 acres of Green Diamond's California timberlands.
- In 2019, the Service approved the Forest Habitat Conservation Plan on the California Timberlands of Green Diamond Resource Company (FHCP). The 50-year FHCP replaces Green Diamond's previous northern spotted owl HCP and provides enhanced protection for the northern spotted owl, fisher, and red and Sonoma tree voles under the federal ESA, and it is consistent with requirements for protection of the northern spotted owl under the CESA. It covers the same area managed under the AHCP/CCAA.

In addition to the two HCPs, Green Diamond also manages its California timberlands subject to a Safe Harbor Agreement with the California Department of Fish and Wildlife (CDFW) for the

Conservation of the Humboldt Marten (Marten SHA). The Humboldt marten (hereafter marten) is listed as an endangered species under the CESA and the Marten SHA was approved by CDFW in 2018. The Coastal Distinct Population Segment of Pacific marten (is now listed as a threatened species under the ESA).

Over time, Green Diamond's implementation of former and current conservation plans such as the AHCP/CCAA, the FHCP, and the Marten SHA requires retention of specific habitat elements and forest stands that contribute to the development or improvement of suitable habitat for the marbled murrelet, but none of those plans explicitly provide for marbled murrelet conservation. This marbled murrelet HCP (MMHCP) establishes a new conservation program for the threatened marbled murrelet that builds on the conservation measures implemented by Green Diamond through its existing AHCP/CCAA, FHCP, and Marten SHA.

1.2 REGULATORY CONTEXT

1.2.1 Federal Endangered Species Act (16 U.S.C. §1531 et seq.)

1.2.1.1 Overview: ESA Sections 7, 9 and 10

The ESA was enacted in 1973 to provide a means for conserving endangered and threatened species and the ecosystems on which they depend, in order to prevent species extinctions. The ESA has three major components relevant to this MMHCP:

- **Section 7**: Requires federal agencies ensure, in consultation with the Service and the NMFS, that their actions are not likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of designated critical habitat
- **Section 9**: Prohibits take of listed fish and wildlife species
- **Section 10**: Provides for permit issuance to nonfederal entities authorizing the take of listed fish and wildlife species incidental to otherwise lawful activities

ESA Section 7 requires each federal agency to ensure, in consultation with the Secretary of the Interior or Commerce, that any actions authorized, funded, or carried out by the agency are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of areas determined to be critical habitat.[1] Section 7 requires federal agencies to engage in formal consultation with the Service for any proposed federal actions likely to adversely affect listed species or their designated critical habitat. A biological opinion is issued by the Service at the completion of formal consultation. The biological opinion can conclude that the project as proposed is either likely or not likely to jeopardize the continued existence of the species or result in the adverse modification of designated critical habitat. If the biological opinion concludes no jeopardy, the proposed action can proceed without modification. If the biological opinion concludes jeopardy, the Service will identify reasonable and prudent alternatives to the proposed action that would avoid jeopardizing the species. Included in the biological opinion is an incidental take statement that determines whether the action is likely to result in the incidental taking of any listed species, and if take is anticipated, the Service exempts a specified level of take resulting from the proposed action from the take prohibitions of section 9. The incidental take

[1] 16 United States Code (U.S.C.) Section (§) 1536(a)(2).

statement may include mandatory reasonable and prudent measures designed to minimize the level and degree of incidental take and require implementation as a condition of take authorization.[2] If the incidental take statement includes one or more such measures, those measures include mandatory terms and conditions that identify the means whereby such measures must be implemented as part of the project.

ESA Section 9(a)(1)(B) prohibits the take by any person of any endangered fish or wildlife species. Take is defined broadly to mean harass, harm, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct.[3] Harm is defined by regulation to mean an act that actually kills or injures wildlife, including activities causing significant habitat modification or degradation resulting in the killing or injuring of wildlife by significantly impairing essential behavior patterns, including breeding, feeding, or sheltering.[4] The take prohibition applies unless take is specifically authorized or permitted pursuant to ESA Section 7 or Section 10.

ESA Section 10 addresses the authorization of take by nonfederal entities. Under Section 10(a)(1)(B), the Service may permit the take of listed species that may occur incidental to otherwise lawful activity. To obtain a Section 10(a)(1)(B) permit, an applicant must prepare an HCP meeting the following five criteria:

- The taking is incidental to an otherwise lawful activity
- The applicant will, to the maximum extent practicable, minimize and mitigate the impacts of such taking
- The applicant will ensure that adequate funding is provided for HCP implementation
- The impacts of taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild; and
- Other measures, if any, which the Service requires as necessary or appropriate to meet HCP purposes[5]

The Service must conduct an internal Section 7 consultation and conclude that jeopardy will not occur before approving an HCP and issuing a Section 10(a)(1)(B) permit.

1.2.1.2 The Habitat Conservation Planning and Incidental Take Processing Handbook (2016)

In 2016, the Service and NMFS published new guidance on the development of HCPs in support of Take Permit applications (the HCP Handbook).[6] The updated HCP Handbook provides comprehensive guidance on the necessary components of an HCP, the substance that should be included in an HCP to satisfy ESA Section 10 criteria, and the development and approval process including measures to address other federal laws that apply to the decision-making process. The key components and procedures for HCP development and approval include:

- **Covered Lands and Activities:** The HCP should describe the lands, resources, and activities covered by the HCP.

[2] 50 *Code of Federal Regulations* (CFR) § 402.14(i)(5).
[3] 16 U.S.C. § 1532 (1988).
[4] 50 CFR § 17.3.
[5] 16 U.S.C. § 1539(a)(2)(A).
[6] Handbook for Habitat Conservation Planning and Incidental Take Permitting (2016).

- **Covered Species:** HCPs should provide a baseline understanding of the biology of a covered species including its behavior and life cycle, its habitat needs, its status within the HCP plan area and broader population and range context, and threats to its survival and recovery.
- **Biological Goals and Objectives:** HCPs must define biological goals for the covered species (broad guiding principles for the conservation program—the rationale behind the minimization and mitigation strategies) and biological objectives (the measurable targets for achieving the biological goals). Biological goals and objectives clarify the purpose and direction of the HCP's conservation program.
- **Incidental Take:** HCPs should provide an assessment of the type and degree of incidental take likely to occur due to the covered activities in the covered plan area, the impacts of such take on the species, how measures will be implemented to avoid, minimize, and mitigate take to the maximum extent practicable, and the net effect on the covered species based on implementation of the HCP.
- **Adaptive Management:** Adaptive management strategies are encouraged in appropriate circumstances. Adaptive management is an integrated method for addressing biological uncertainty, devising alternative strategies for meeting biological goals and objectives, and, if necessary, adjusting future conservation management actions according to new information.
- **Monitoring:** HCPs must include provisions for monitoring to measure the degree of incidental take, to gauge the effectiveness of the plan in meeting the biological goals and objectives, and to verify proper implementation of plan terms and conditions.
- **Permit Duration:** The Service considers several factors in determining the Take Permit term, including the applicant's proposed activity duration and the expected positive and negative effects on covered species associated with the proposed duration. The Service will also consider the scientific and commercial data underlying the proposed operating conservation program, the time necessary to implement and achieve operating conservation program benefits, and the extent to which adaptive management strategies are included in the conservation program.
- **Public Participation:** The policy increases public participation in the HCP process, with greater opportunity to assess, review, and analyze HCPs and associated National Environmental Policy Act (NEPA) documentation.

1.2.1.3 The MMHCP and ESA Section 10

The intention of the MMHCP is to meet all regulatory requirements necessary for the Service to issue to Green Diamond a Section 10 Take Permit authorizing incidental take of the "Covered Species" (defined in section 1.4.3 below) due to "Covered Activities" (defined in Section 2). The MMHCP also includes an assessment of direct and indirect effects on Covered Species that provides information and analysis for the Service to conduct internal ESA Section 7 consultation required for HCP evaluation.

Contingent on the satisfaction of decision-making requirements under federal law and approval of the MMHCP under ESA Section 10 criteria (the "Effective Date"), the Service will issue Green Diamond an Take Permit under ESA Section 10(a)(1)(B), authorizing incidental take by Green Diamond of the Covered Species resulting from Covered Activities in the Plan Area.

1.2.2 Migratory Bird Treaty Act (16 U.S.C. §703 et seq.)

The Migratory Bird Treaty Act implements various migratory bird protection treaties and conventions between the U.S. and Canada, Japan, Mexico, and the former Soviet Union. Under the Migratory Bird Treaty Act, taking, killing or possessing migratory birds is unlawful as is taking any such birds' parts, nests or eggs. The Migratory Bird Treaty Act defines take more narrowly than the ESA and includes only the death or injury of an individual bird from a migratory bird species or their eggs. 50 CFR. §10.13 includes a list of Migratory Bird Treaty Act-protected birds.

The Service has developed policy guidance regarding the incidental take of bird species that are listed as threatened or endangered under the ESA, and are also protected under the Migratory Bird Treaty Act. Under these guidelines, an ESA incidental take permit can function as a Special Purpose Permit under the Migratory Bird Treaty Act for the take of all ESA-listed covered species in the amount and/or number and subject to the terms and conditions specified in an HCP. Any such take will not be in violation of the Migratory Bird Treaty Act.

This MMHCP covers the marbled murrelet, which is listed under both the ESA and the Migratory Bird Treaty Act. Pursuant to Service guidance described previously, the ESA Section 10(a)(1)(B) permit Green Diamond seeks through this MMHCP would also serve as a Migratory Bird Treaty Act Special Purpose Permit for the marbled murrelet.

1.2.3 National Environmental Policy Act (42 U.S.C. § 4321 et seq.)

The purpose of NEPA is to ensure that federal agencies consider the environmental impact of their actions and decisions. To accomplish this purpose, NEPA requires a process and approach for analyzing the environmental impacts of proposed federal actions. This analysis is documented in either an Environmental Assessment (Environmental Assessment) and its accompanying Finding of No Significant Impact, or an Environmental Impact Statement (Impact Statement) and its accompanying Record of Decision.

Issuance of the Take Permit under ESA Section 10(a)(1)(B) for this MMHCP would constitute a federal action that is subject to NEPA. The Service will determine whether to prepare an Environmental Assessment or Impact Statement in order to analyze the environmental impacts associated with the issuance of the Take Permit and implementation of this MMHCP.

1.2.4 California Forest Practice Act (Pub. Res. Code §4511 et seq.)

The twin goals of the California Forest Practice Act are to:

- Restore, enhance, and maintain the long-term productivity of the state's timberlands, and achieve maximum sustained production of high-quality timber products
- Protect recreation, watershed, wildlife, range and forage, fisheries, regional economic vitality, employment and aesthetic enjoyment

The Forest Practice Act is implemented through regulations known as the Forest Practice Rules, which are applied through Timber Harvesting Plans (Harvest Plan) reviewed and approved by California Department of Forestry and Fire Protection (CalFire).

The Forest Practice Rules include standard prescriptions required in every Harvest Plan, including:

- Protection measures for watercourse zones (minimum buffer sizes, canopy closure requirements, and equipment exclusion)
- Restrictions on construction, use, and maintenance of roads, trails, landings, and watercourse crossings
- Snag retention requirements and measures providing for retention of late seral elements

The Forest Practice Rules also require a site- and area-specific assessment of potential individual and cumulative impacts of timber harvesting on the environment, including terrestrial resources. Any significant impacts remaining after application of the standard prescriptions require adoption of other measures to mitigate or avoid such impacts.

Under the Forest Practice Rules, when there is "evidence of an active murrelet site in or adjacent to the Harvest Plan area" or there is "evidence of a potential impact to a murrelet," CalFire shall consult with CDFW as to whether the proposed Harvest Plan will cause a "take" or "jeopardy" of a murrelet under the CESA before CalFire may approve the Harvest Plan.[7] This MMHCP should serve the purpose of a biological assessment and consultation with CDFW supporting a conclusion that activities conducted in compliance with the MMHCP will avoid jeopardy or take or will fully mitigate any take within the meaning of the CESA.

1.2.5 California Endangered Species Act and Other California Laws

Several other California environmental laws and associated regulations can apply to commercial timber operations. These include provisions in the California Fish and Game Code (including CESA[8]), and the California Water Code (including the Porter Cologne Water Quality Control Act).

The CESA lists and protects a number of species that inhabit Green Diamond's timberlands including the marbled murrelet, northern spotted owl, coho salmon, and Humboldt marten. Under the CESA, CDFW may determine that a federally issued Take Permit is consistent with CESA and no further authorization is necessary for incidental take under the CESA. A consistency determination under the CESA requires the avoidance of take or full mitigation of take, but the CESA definition of take is narrower than take under the federal ESA. Accordingly, both the ESA and CESA require the avoidance or mitigation of take that kills or injures listed animals, but the federal ESA also requires the applicant to minimize or mitigate take by activities that "harm" a species such as habitat modification or operations that interfere with essential behavior of a species.

In 2008, CDFW made a consistency determination under the CESA, finding that Green Diamond's activities under the AHCP/CCAA are also compliant with California's standards that protect coho salmon. For Green Diamond's FHCP, CDFW issued a consistency determination in 2019 finding that the FHCP complies with California's requirements for the protection of the northern spotted owl. Similarly, Green Diamond will seek a consistency determination from CDFW for this MMHCP, which will assure Green Diamond of compliance with the CESA and also serve as a programmatic consultation with CDFW that satisfies the California Forest Practice Rule

[7] Title 14, California Code of Regulations, Ch. 4, §919.11
[8] California Fish & Game Code §2050 et seq.)

requirement for consultation on marbled murrelet effects prior to approval of a Timber Harvest Plan.[9]

Under the California Fish and Game Code, Green Diamond must obtain a permit from CDFW for the construction, removal, or replacement of stream-crossing structures on forest roads. Based on AHCP/CCAA conservation commitments, CDFW provided long-term authorization for all stream crossing work on Green Diamond's California timberlands under a Master Agreement for Timber Operations, approved in 2010.

The California North Coast Regional Water Quality Control Board (Water Board) similarly approved a 2010 Waste Discharge Requirement for all storm water discharges from Green Diamond's forest roads within the AHCP/CCAA plan area based on the road management requirements of the AHCP/CCAA. And, in 2012, the same Water Board approved a Waste Discharge Requirement for all forest management activities on Green Diamond's California timberlands. The above-referenced CDFW and Water Board documents are available at https://greendiamond.com/responsible-forestry/california/.

1.3 CONSERVATION HISTORY CONTEXT

1.3.1 Green Diamond's 1992 Northern Spotted Owl HCP

In 1992, the Service approved Simpson Timber Company's Northern Spotted Owl (NSO) HCP, the first-ever HCP on private timberlands. As Simpson's successor, Green Diamond assumed responsibility for carrying out the NSO HCP on its California timberlands. The NSO HCP was approved with a 30-year term. Under the NSO HCP, Green Diamond precluded or limited timber harvest in large set asides, smaller habitat retention areas, and timber stands in close proximity to NSO site centers. Although the NSO HCP has been replaced, many of these retention areas now contain mature tree stands and legacy trees that may contribute to long-term development and improvement of suitable murrelet habitat.

1.3.2 Green Diamond's 2007 AHCP/CCAA

In 2007, the Service and NMFS approved the AHCP/CCAA (Green Diamond, 2007) for management of Green Diamond's core California timberlands. The AHCP/CCAA targets aquatic species and resource conservation and provides substantial protection of riparian forest stands and geologically unstable areas, resulting in little or no timber harvest in substantial portions of Green Diamond timberlands. Projections of future landscapes created through AHCP/CCAA implementation indicate that at least 25 percent of the lands managed under the AHCP/CCAA are in riparian management zones and geological protection areas. By the end of the 50-year AHCP/CCAA permit (2057), approximately two-thirds of the riparian management zone acreage will consist of the dominant and co-dominant trees in the 51-to 100-year-old age class, with the remaining third over 100 years old. This provides a well-distributed network of late seral habitat benefiting all aquatic species covered by the AHCP/CCAA and many other forest species like the marbled murrelet.

[9] See Title 14, California Code of Regulations, Ch. 4, §919.11 and discussion in Section 1.25 *supra*.

1.3.3 Green Diamond's 2019 FHCP

Green Diamond's NSO HCP was replaced in 2019 with the Service's approval of the Forest Habitat Conservation Plan on the California Timberlands of Green Diamond Resource Company (FHCP). The 50-year FHCP provides enhanced protection for the NSO, in addition to the Pacific fisher and red and Sonoma tree voles under the federal ESA. The FHCP adapts and improves the original conservation measures provided under the NSO HCP and includes major new conservation measures under the AHCP/CCAA. The NSO HCP was terminated upon approval of the FHCP, along with Green Diamond's Take Permit issued under the NSO HCP.

For planning and management purposes, the FHCP is the terrestrial species counterpart of the AHCP/CCAA, with a substantially equivalent term and Plan Area. For Green Diamond, the FHCP is a management tool that builds on and complements the AHCP/CCAA to conserve covered species in both aquatic and terrestrial forest ecosystems located on Green Diamond's core California timberlands. Like the AHCP/CCAA, the FHCP includes conservation measures that also contribute to the development and improvement of suitable marbled murrelet habitat.

1.3.4 Other Complementary Conservation Efforts

In addition to the NSO HCP, the AHCP/CCAA, the FHCP, and the Marten SHA, there are other recent and ongoing conservation efforts on or near Green Diamond lands that contribute to marbled murrelet conservation.

Other ongoing conservation efforts include:

- Implementation of the Yurok Habitat Conservation Plan based on assignment and assumption of responsibility for implementation of the Green Diamond AHCP/CCAA conservation measures on over 22,000 acres (8,903 hectares) of timberland, which has been conveyed by Green Diamond to the Yurok Tribe in the lower Klamath River Basin
- Green Diamond has conveyed over 24,500 acres (9,915 hectares) in the Blue Creek drainage to Western Rivers Conservancy for conservation purposes
- Memorandum of Understanding among the Service and seven other federal and state agencies, non-governmental organizations, and private resource owners regarding Humboldt Marten Conservation (2012)
- Memorandum of Understanding among the Service and 13 other federal and state agencies, non-governmental organizations, and private resource owners regarding California Condor Conservation (2016)
- Hoopa Tribal Forestry research and monitoring of spotted owls and fisher and the Forest Management Plan (2011–2025) that addresses forest management practices and other tribal activities that may affect forest species
- Late seral forest restoration projects implemented by the Redwood National Park and Del Norte Redwoods State Park within previously harvested areas of Mill Creek and Redwood Creek that are now intensively managed to accelerate mature forest stand regrowth
- A cooperative effort with Redwood National Park to monitor and study NSO and barred owl interactions

- California State Parks Department landscape management plan for the marbled murrelet in the southern end of its range
- Management of the nearby Six Rivers National Forest and Headwaters Forest Reserve subject to the Northwest Forest Plan amendments designed to promote conservation of the NSO and marbled murrelet and numerous additional late-successional forest species
- Collaboration and cooperation with the Willow Creek NSO demographic study conducted on Service lands east of the FHCP's Eligible Plan Area (EPA)
- Collaboration and cooperation with the CDFW on trapping fisher inhabiting Green Diamond timberlands and experimental relocation of those fisher on private timberlands in the Sierra Nevada subject to a Service-approved Candidate Conservation Agreement
- Humboldt Redwood Company's management of over 200,000 acres (80,937 hectares) of timberland adjacent to Green Diamond's timberlands pursuant to an HCP that addresses marbled murrelets and was assumed by HRC when it acquired Pacific Lumber Company timberlands
- Safe Harbor Agreement between Green Diamond and CDFW for Humboldt marten (2018)
- Memorandum of Understanding between the Service and Green Diamond on coastal marten conservation (2020)

To be clear, Green Diamond does not seek mitigation credit under this MMHCP for conservation measures and habitat conditions on adjacent lands that are beneficial to marbled murrelet. However, Green Diamond's conservation strategy may complement and support murrelet conservation on adjacent lands.

1.3.5 Green Diamond's Approach to Marbled Murrelet Conservation

After the marbled murrelet's listing for protection under the ESA in 1992, Green Diamond's predecessor, Simpson Timber Company, sought to develop a marbled murrelet HCP for the California timberlands now owned and managed by Green Diamond. The project sought incidental take authorization for the harvest of remaining old growth stands on Simpson's timberlands in exchange for mitigation in the form of several measures including assistance from Simpson on improved forest management within the adjacent Redwood National Park. The project was abandoned in 1998. Thereafter, Simpson implemented a no take policy for marbled murrelet that Green Diamond has followed to this day.

Under Green Diamond's no take policy, old growth forest stands that are known to be or presumed to be occupied by marbled murrelets as nesting habitat are not harvested and Green Diamond also uses a 300-hundred-foot limited/no harvest buffer around such stands (hereafter Occupied Reserves). Some of these stands are now subject to perpetual conservation easements; the remaining Occupied Reserves are still subject to Green Diamond's no take policy and are not subject to harvest.

Although Green Diamond's no take policy has been effective for nearly 30 years, large areas of Green Diamond's California timberlands are subject to no harvest and limited harvest retention standards under the former NSO HCP, the AHCP, the FHCP, and the Marten SHA. The cumulative result of these conservation measures is retention of many large residual wildlife trees scattered across the timberlands and the emergence of maturing forest stands in buffers for riparian

management zones, channel migration zones, unstable slope areas, and reserves for activity centers around northern spotted owl nests and denning areas for fisher and martens. As these habitat elements continue to develop across approximately 25 percent of Green Diamond's managed landscape, they have the potential to provide emergent, new suitable habitat for marbled murrelet that could also result in a broad, adverse regulatory impact on proposed timber harvesting operations within the matrix of working forests in between growing forest buffer stands. Those adverse impacts include delayed harvest planning and permitting, more costly surveying on a case-by-case basis, and additional tree retention conditions that could quickly eliminate the operating area necessary for the continued viability of Green Diamond's business. These impacts on Green Diamond as a business would be caused by Green Diamond's current conservation commitments that are producing more and more retention stands that may grow into suitable marbled murrelet habitat.

Green Diamond seeks regulatory assurances that it may continue to operate within a matrix of working forest lands between wildlife and tree retention areas in exchange for an HCP conservation program that derives mitigation credit from protection of presumed occupied marbled murrelet habitat and additional retention of maturing tree stands that are determined to be low suitable or better habitat (Suitable Habitat Reserves, 6.2.5) that may be occupied or will develop and improve into the older, larger, complex, multi-layered forest stands that provide platforms where marbled murrelets can be successful in nesting. Green Diamond's peer-reviewed model for identifying suitable marbled murrelet habitat and its use in estimating incidental take and mitigation is described in more detail in Sections 5 and 6 of this MMHCP. Green Diamond is also protecting forest stands with known occupancy by marbled murrelets at some time in the past based on audio-visual surveys and these stands are described as Occupied Reserves (6.2.2). The protection of the Occupied Reserves with past or current occupancy and vegetation buffers surrounding these areas (6.2.3) is consistent with the Service's Recovery Plan to protect occupied and suitable habitat through development of HCPs that contribute to conservation of the murrelet (USFWS 1997).

1.3.6 Role of HCPs on Nonfederal Lands in the Marbled Murrelet Recovery Plan

The Service's marbled murrelet Recovery Plan specifically includes the development of HCPs. In particular, the important role of HCPs on nonfederal land like Green Diamond is addressed by the Service in its Recovery Plan for the Marbled Murrelet (1997), which recommends HCPs on nonfederal lands to complement federal conservation strategy and describes them in Section 2.3.2 of the Recovery Actions. The Recovery Plan states, "Adequately designed and implemented HCPs will be very important in the conservation of marbled murrelets on . . . private lands and are likely to be the most effective and acceptable means of protecting most occupied sites on nonfederal lands in the near future and potentially providing replacement habitat in the long term" (USFWS, 1997). HCPs on nonfederal land "with appropriate measures to minimize and mitigate incidental take in the short term while providing for maintenance or creation of habitat for the long term probably offer the best means for conservation of the species" (USFWS, 1997).

1.4 PURPOSE, SCOPE AND ORGANIZATION OF THE MMHCP

1.4.1 Purpose

The primary purposes of the MMHCP are as follows:

- Provide for the conservation of the Covered Species (as defined herein below) and its habitat on commercial northern California timberlands owned and managed by Green Diamond
- Coordinate and facilitate Green Diamond's practicable and reliable compliance with the ESA to support long-term investment in and sustainable management of Green Diamond's California timberlands
- Provide assurances to Green Diamond that, pursuant and subject to the Service's "No Surprises" regulations, as long as the obligations of the MMHCP and Take Permit are performed, no additional mitigation shall be required of Green Diamond with respect to Covered Species
- Provide the Service with an appropriate basis for authorizing Green Diamond to incidentally take Covered Species pursuant to the Take Permit
- Provide CDFW with an appropriate basis for a consultation and finding that activities conducted in compliance with the MMHCP are consistent with the requirements of the CESA

The MMHCP describes conservation objectives Green Diamond will implement to meet the following objectives:

- Minimize and mitigate, to the maximum extent practicable, the impacts of any authorized taking of Covered Species that may occur incidental to Green Diamond's northern California timber management operations
- Ensure that impacts of any authorized take will not appreciably reduce the likelihood of survival and recovery in the wild of the Covered Species

The measures in the MMHCP are designed to be a comprehensive conservation program for the Covered Species on the Green Diamond timberlands managed under the MMHCP. The measures, supporting analysis, and related authorizations also help Green Diamond comply with any California Forest Practice Rules related to the ESA and the Covered Species.

1.4.2 Covered Species

The MMHCP provides a conservation program, and supports the issuance of an Take Permit, covering the marbled murrelet (*Brachyramphus marmoratus*), referred throughout this document as the Covered Species. The marbled murrelet is a species of Pacific seabird with inland habitat requirements for nesting (Section 3). It is currently listed under the federal ESA as a threatened species in California, Oregon, and Washington.

1.4.3 Covered Activities

The activities covered by the MMHCP and Take Permit (Covered Activities) include all of Green Diamond's timber operations and other forest management activities that could result in the incidental take of the Covered Species in the Plan Area defined below. Section 2 describes the Covered Activities, including those activities needed to execute all conservation measures identified in Section 6 (the Conservation Program).

1.4.4 Permit Term and Take Permit Extension

The MMHCP and associated Take Permit shall become operative on the Effective Date and shall remain in effect for a period of 50 years from the Effective Date. This term is necessary to fully implement a Conservation Program that can achieve meaningful progress in developing more suitable marbled murrelet nesting habitat and build momentum for renewal of the MMHCP to maximize its ecological benefits. If requested by Green Diamond and approved by the Service in compliance with all applicable laws, the Take Permit term may be renewed under regulations of the Service in force on the date of such renewal (Section 6.4.8).

1.4.5 Organization

- Section 1: Purpose and background, regulatory context, conservation history context, and scope and organization
- Section 2: Detailed description of the Covered Activities, including Green Diamond's timber operations and other forest management activities
- Section 3: Detailed description of the Covered Species and its habitat
- Section 4: Description and assessment of habitat conditions and occurrence of Covered Species in the MMHCP implementation area
- Section 5: Assessment of the potential for timber operations and other activities governed by the MMHCP to directly or indirectly influence Covered Species and potentially result in take
- Section 6: Description of:
    - Biological goals and objectives
    - Conservation Program fulfilling those biological goals and objectives with minimization and mitigation measures for take of Covered Species
    - Conservation Program compliance and effectiveness monitoring and reporting
    - Conservation Program adaptive management process, and contingent actions and assurances for foreseeable and unforeseen circumstances that may arise during MMHCP implementation
- Section 7: Assessment of how the Conservation Program minimizes and mitigates Covered Species take to the maximum extent practicable
- Appendices: Additional information, analysis, and details about HCP components, in addition to:
    - Glossary of terms and abbreviations
    - List of literature cited
- Atlas: Collection of large (11x17), foldout maps referenced in this document

1.4.6 Key MMHCP Implementation Area Definitions and Adjustment Procedures

The MMHCP, like the AHCP/CCAA and FHCP currently in effect, accommodates modest potential changes in Green Diamond land ownership, subject to certain restrictions, within an overall specified area of similar landscapes and habitat. Under this approach, the MMHCP covers certain specified lands upon approval. During the MMHCP term, some lands may be removed from coverage if Green Diamond sells them, while other lands within the broader analyzed area may be added to and covered by the MMHCP. The key definitions that implement this approach include:

- **Eligible Plan Area or "EPA":** All privately owned commercial timberlands and all roads within the geographic area described in Map 1-2. The EPA is further analyzed in Section 4.
- **Plan Area or "PA":** All commercial timberlands within the EPA which, at any point in time when the MMHCP is in effect, are owned by Green Diamond or upon which Green Diamond possesses perpetual harvesting rights if such lands or perpetual harvesting rights have been enrolled in the MMHCP as part of the PA or upon acquisition, and all roads used to access such lands. Map 1-2 displays the PA based on 2026 Green Diamond ownership and perpetual harvesting rights, which is approximately 380,457 acres (358,626 acres (145,131 hectares) used for estimating take[10]).
- **Perpetual Harvesting Rights:** Perpetual rights to conduct timber operations on lands owned in fee by another. Short-term harvesting rights generally expire upon the conclusion of timber operations, upon a certain date, or a combination of the two. Perpetual harvesting rights pertain to existing and subsequent crops of timber and continue without expiration. Lands on which Green Diamond holds Perpetual Harvesting Rights may be included in the Plan Area only where Green Diamond has sufficient legal control during the term of the Take Permit to implement the MMHCP. Currently Green Diamond holds perpetual harvesting rights on approximately 1,900 acres within the Plan Area and these acres are included in the incidental take analysis and in the considerations of the conservation strategy of this HCP.
- **Adjustment Area:** Commercial timberland acreage and associated roads within the EPA which, at any point in time while the MMHCP is in effect, are not within the Plan Area where the Service has authorized take and thus not covered by the Take Permit but are eligible for acquisition and inclusion in the Plan Area without amendment and are fully analyzed within the MMHCP.
- **Occupied Reserves:** The Occupied Reserves are the portions of the PA that are considered to be baseline occupied or presumed occupied marbled murrelet habitat that are not subject to timber harvesting during the term of the MMHCP. The Occupied Reserves may not be sold, conveyed, or otherwise transferred to a third party unless conveyance is subject to a restrictive covenant or conservation easement that prohibits timber harvest for the Term of the MMHCP. Green Diamond may sell and convey a perpetual conservation easement interest in any portion of the Occupied Reserves to the

[10] Our initial estimate of incidental take was based on timber harvest operations within a 358,626-acre (145,131 hectare) ownership. During development of the draft MMHCP, the Plan Area was adjusted to include all Green Diamond ownership within Del Norte and Humboldt Counties. The adjusted amount of incidental take based on the increased PA acreage (21,928 acres (8,874 hectares)) is discussed in Section 5.2.3.

federal government, State of California or a qualified land trust provided that the terms of the conservation easement prohibit harvest within the Occupied Reserves and are otherwise consistent with the MMHCP. Section 6 describes the Occupied Reserves within the PA.

- **Suitable Habitat Reserves:** The Suitable Habitat Reserves are the portions of the PA that are suitable habitat for occupancy by marbled murrelets or areas possessing key habitat features that will continue to develop into suitable habitat during the permit term. The Suitable Habitat Reserves are next best on the suitability scale relative to the Occupied Reserves and are not subject to timber harvesting during the term of the MMHCP. The Occupied Reserves and Buffers, Adjacent Habitat Buffers, and Suitable Habitat Reserves may not be sold, conveyed, or otherwise transferred to a third party unless conveyance is subject to a restrictive covenant or conservation easement that prohibits timber harvest for the Term of the MMHCP. Green Diamond may sell and convey a perpetual conservation easement interest in any portion of the Occupied Reserves and Buffers, Adjacent Habitat Buffers, and Suitable Habitat Reserves to the federal government, State of California or a qualified land trust provided that the terms of the conservation easement prohibit harvest within such reserves and buffers and are otherwise consistent with the MMHCP. Section 6 describes the Suitable Habitat Reserves within the PA.

1.4.6.1 Eligible Plan Area Characteristics and Components

Map 1-2 displays the EPA of approximately 1,674,916 acres (697,027 acres original EPA) and its components: the PA 380,457 acres (153,965 hectares) and Adjustment Area 1,294,459 acres (523,848 hectares) (338,401 acre original AA).

Map 1-2. Eligible Plan Area in California

The acreage figures for the EPA and PA presented above reflect the Plan Area as most recently updated (see below). It is important to note that the geographic scope of the Plan Area itself changed during MMHCP development. Green Diamond's initial analysis of potential take and mitigation (Section 5) was based on the footprint of the land adjustment area associated with Green Diamond's existing AHCP/CCAA and FHCP, approximately 358,626 acres, referred to throughout this MMHCP as the pre-expansion Plan Area. During development of this MMHCP, Green Diamond elected to expand the Plan Area to include all Green Diamond ownership within Humboldt and Del Norte Counties, referred to as the expanded Plan Area, approximately 380,554 acres. The take and mitigation estimates presented in Section 5 account for this expansion, including the incremental take attributable to the additional acreage.

Consistent with Green Diamond's ordinary right to acquire and dispose of timberland (Section 1.4.6.2), the specific acreages of Marginal Habitat, Suitable Habitat Reserves, and Occupied Reserves used to calculate the take and mitigation estimates in Section 5 were fixed as of a 2023 dataset to allow completion of MMHCP drafting and analysis rather than continuous revision as Green Diamond's holdings changed through ordinary transactions. During the public comment period, Green Diamond provided the Service and CDFW updated acreages reflecting the Plan Area as of July 2026. As explained in Section 5, these updates were not used to recalculate the take and mitigation estimates because the changes move in a conservative direction, a net decrease in

Marginal Habitat available for harvest and a net increase in Suitable Habitat Reserve acreage available as mitigation, such that the original estimates in Section 5 continue to represent a conservative characterization of the Plan's impacts and mitigation. Except where specific figures are tied to the original take and mitigation calculations, acreage and other figures throughout this MMHCP have been updated to reflect the expanded Plan Area as of July 2026.

The scope of the EPA includes private and non-federal timberlands within the range of the marbled murrelet within Humboldt and Del Norte Counties as well as the EPA of the AHCP/CCAA and FHCP, which provides consistent and reliable commitments on long-term Plan Area management for conservation purposes. The EPA also provides an appropriate scale for analyzing habitat conditions and potential impacts and benefits for Covered Species from the combined effect of management under the MMHCP, the AHCP/CCAA, and the FHCP. The commercial timberlands in the EPA also have common characteristics directly related to habitat conditions for Covered Species. Section 4 describes these characteristics in detail, including:

- Forest ecosystems with conifer stands dominated by coastal redwood and Douglas-fir
- A pattern of forest stand structure produced by Green Diamond management and California Forest Practice Rules that consists of a mosaic of small patches of harvest and various ages of reproduction with intermittent closed-canopy mature stands where landowners elect to manage under a selective harvest regime
- A dendritic pattern of larger and older forest stands following riparian corridors and unstable geologic areas resulting from management under the AHCP/CCAA, the FHCP, the Marten SHA and, to a lesser degree, Forest Practice Rules
- Steep and rugged terrain, several highly unstable bedrock types, and extensive geologic folds and fault lines
- Seasonally intense precipitation
- More than a century of logging, mining, road building, and grazing

The EPA is bordered by national forests and wilderness areas on the north and east and abuts Redwood National Park and various state parks on the west. Other adjacent ownerships include industrial timberlands managed by Sierra Pacific Industries, Soper-Wheeler Company, Humboldt Redwood Company and other private holdings. The Hoopa Valley Indian Reservation is located east of the EPA, and lands administered by the Yurok Tribe or Bureau of Indian Affairs are located along the lower Klamath River. Adjacent land use varies by location but generally follows land ownership patterns. The federal and state land management supports multiple uses, including conservation and recreation, and various levels of timber harvesting allowed in designated areas. On adjacent private lands, commercial timber operations and ranching predominate, while other uses include gravel mining and residential development. Map 1-2 displays the Adjustment Area and includes adjacent commercial timberlands but excludes public and Indian lands, non-forested commercial timberlands and third party–owned commercial timberlands covered by an approved HCP.

The PA is that portion of the EPA owned and managed by Green Diamond at the time of MMHCP approval and Take Permit issuance. It is a substantial and cohesive block of forest habitat, representative of and well distributed throughout the EPA. The forest ecosystem habitat within the PA and EPA connects to forest ecosystem habitat in large blocks of national and state park land to

the north and west, large blocks of national forest and tribal lands to the north and east, and a large private commercial timberland ownership to the south managed under an HCP.

The Adjustment Area is the balance of the EPA that is not within the PA. The MMHCP may expand into the Adjustment Area through property acquisitions by Green Diamond. Based upon the analyses in the MMHCP, it is presumed that all commercial timberlands within the EPA share similar relevant characteristics and, therefore, that adding such lands to the Plan Area during the term of the Take Permit will not likely result in adverse effects on the Covered Species different from those analyzed in connection with the MMHCP.

The MMHCP's allowance for Plan Area adjustments is justified by the similarity of habitat conditions and the potential impacts of Covered Activities to Covered Species throughout the EPA. The EPA and Adjustment Area are further analyzed in Section 4. Because of these similarities, the Conservation Program may be applied with the same or substantially similar benefits on any Green Diamond timberlands or perpetual harvesting rights within the EPA during the MMHCP term. In addition, given the PA size and EPA location relative to forested habitat on federal, state, and tribal forest lands to the north and east and private timberlands managed under an HCP to the south, a net increase or decrease in the PA of no more than 15 percent will not significantly alter the effectiveness of the MMHCP for the conservation of Covered Species.

1.4.6.2 Land and Permit Area Adjustments

During the term of the MMHCP and Take Permit, Green Diamond may elect to add to the Plan Area any commercial timberlands within the EPA under the minor modification (administrative change) process by submitting to the Service and CDFW a summary and habitat analysis of the lands within the Adjustment Area that it intends to add, along with a summary of relevant biological and physical characteristics that such lands share with existing Plan Area lands. In addition, Green Diamond is free to remove commercial timberlands from the Plan Area through conveyances to third parties subject to notice, description, and enforceable conditions for the protection of Occupied Reserves and Buffers, Adjacent Habitat Buffers, and Suitable Habitat Reserves through the term of the Permit. The process and conditions for additions to and removals from the Plan Area are described in more detail in Section 6.4.7 of the MMHCP.

1.4.6.2.1 *Green Diamond's Right to Acquire and Sell Lands*

Subject to the conditions in Section 6.4.7, nothing in the MMHCP or Take Permit limits Green Diamond's right to acquire, sell, or otherwise transfer interests in lands within the EPA or elsewhere. However, unless commercial timberland acreage that Green Diamond acquires is included in the Plan Area or added to the Plan Area by operation of the MMHCP's land adjustment conditions, Green Diamond's activities that take place on those lands shall not be covered by the Take Permit.

1.4.6.2.2 *Reporting of Land Transactions*

Green Diamond shall notify the Service and CDFW of any transfer to a third party of ownership of real property or harvesting rights located within the Plan Area within sixty (60) days following such transfer, except where prior notification occurs pursuant to Section 6.4.7.2. Such notice shall describe the affected real property with particularity, identify the name and address of the

transferee, and include a detailed map showing the location of the transferred real property or harvesting rights.

1.4.6.2.3 Additions to the Plan Area

Green Diamond may elect to add to the Plan Area additional commercial timberlands consisting of fee lands and harvesting rights that it acquires within the EPA through the minor modification (administrative change) process pursuant to Section 6.4.7.1. As the first step, Green Diamond will provide the Service and CDFW with written notice and a summary habitat analysis of the land transaction prior to enrolling the land in the Plan Area. The Take Permit and MMHCP shall be effective for Covered Activities on all lands that meet the definition of Plan Area upon their inclusion as a minor amendment pursuant to Section 6.4.7.1 or a Major Amendment required under Section 6.4.6.

1.4.6.2.4 Removals from the Plan Area

Subject to the reporting requirements and conditions in Section 6.4.7, Green Diamond may remove property from the Plan Area through the minor amendment process with notification to the Service and CDFW. Where the property to be removed includes Occupied Reserves and Buffers, Adjacent Habitat Buffers, or Suitable Habitat Reserves, the notice of removal must be supported by documentation that the property will be either (i) managed by the new owner under an assumption of the MMHCP obligations in a new incidental take permit held by the transferee, or (ii) granted to the new owner subject to enforceable written covenants of record applying the MMHCP restrictions to those Reserves and Buffers. Upon such notification with documentation in compliance with the MMHCP, the Plan Area will automatically be reduced to reflect the sale, transfer, or conveyance, and the Take Permit and MMHCP shall cease to be effective as to the removed lands. Removals in compliance with Section 6.4.7 do not require a Major Amendment pursuant to Section 6.4.6. The sale or transfer of short-term harvesting rights (i.e., stumpage agreements rather than perpetual harvesting rights) to third parties in compliance with the MMHCP, and the expiration of short-term harvesting rights held by Green Diamond, shall not be considered deletions from the Plan Area.

1.4.7 Multiple Uses of the MMHCP

In addition to satisfying ESA requirements for authorization of marbled murrelet incidental take, the Conservation Program in Section 6 may produce other measurable ecosystem benefits such as benefits for wildlife species that are not Covered Species and carbon sequestration mitigation for emission of greenhouse gases and climate change. Green Diamond reserves the right to seek regulatory and mitigation credit for ecosystem benefits that are incidental to the conservation commitments provided by the MMHCP for the marbled murrelet. Green Diamond will ensure that these additional conservation commitments are in compliance with this MMHCP.

1.4.8 Alternatives to Taking

Section 5.6 of the HCP Handbook (USFWS and NMFS 2016) directs an HCP applicant to address the alternatives to taking that it considered in developing the plan. Green Diamond considered two alternatives to the proposed MMHCP conservation program: (1) No New Permit and Plan, the No Action alternative; and (2) Landscape Habitat Conservation with No Harvest in Murrelet Habitat

Reserves, which is the Proposed Action and Green Diamond's preferred alternative. Both are analyzed in Section 8.

Under the No New Permit and Plan alternative, Green Diamond would continue managing its timberlands without a new incidental take permit, relying on the case-by-case, no-take compliance strategy it has applied since the marbled murrelet was listed as threatened in 1992. This alternative encompasses two take-avoidance approaches – Intensive and Passive. Intensive Take Avoidance is the process that Green Diamond has been using for active forest management since the listing of the marbled murrelet as a threatened species in 1992. It is, in essence, the "No Action" alternative that Green Diamond would continue to implement if the MMHCP were not developed and approved. Intensive Take Avoidance complies with the ESA by avoiding harvest operations in known occupied marbled murrelet nesting habitat and operations in close proximity to such habitat during the nesting season when essential murrelet behavior might be seriously disrupted. But not all of Green Diamond's timberlands are clearly classified as either known, occupied murrelet habitat and areas that are not murrelet habitat. The murrelet habitat suitability and occupancy of some portions of Green Diamond's timberlands is uncertain. For these areas, Intensive Take Avoidance requires an investment in murrelet protocol surveys to determine with confidence that an area is not habitat used by murrelets and therefore available for harvest without take or, if occupied, harvest operations are excluded from a timber stand to avoid taking murrelets. Protocol surveys require at least two years of field work by trained biologists who observe and listen for murrelet behavior that may indicate habitat use and occupancy.

Intensive Take Avoidance is an expensive, inefficient, and ineffective approach to murrelet conservation. It is expensive because it requires case-by-case examination of proposed timber harvests to first determine whether there is a sufficient presence of murrelet habitat elements to warrant a protocol murrelet survey. Green Diamond foresters and representatives of regulatory agencies must determine, based on field observations and diverse perspectives, whether a given forest stand has a group of trees of sufficient size with a multi-layer forest canopy and supply of large nesting platforms to warrant protocol surveys for murrelets. If required, then Green Diamond must propose a nesting season protocol survey of the stand using an approved number and distribution of survey locations and schedule of sufficient duration to monitor for murrelet behavior in and around the stand and the surveys must be implemented for at least two seasons (i.e., two years). Depending on the results, another season (year) may be required.

It is a costly and time-consuming process for the identification of timber stands that either should not be harvested to avoid take or may be harvested without any risk of take. It is inefficient because it does not use scientific methods such as modeling to identify timber stands with higher suitability and likelihood of murrelet presence and risk of take, and it is inefficient because take avoidance does not allow for a rigorous identification of timber stands where timber harvest may proceed because habitat suitability is marginal and the risk of take is very low and improbable, but possible. It is also ineffective as a murrelet conservation strategy because the focus is not on a comprehensive assessment of the landscape to address a long-term strategy for protection and development of murrelet nesting habitat. Rather, Intensive Take Avoidance is driven by piece-meal harvest planning focused on identifying log inventory in timber stands that are ready to harvest contingent on harvest permitting. If take can be avoided, the harvest may proceed even if a timber stand exhibits suitable habitat characteristics that are scarce on a managed landscape and take a very long time to develop. Green Diamond is pursuing the MMHCP as a better alternative

to Intensive Take Avoidance because it uses a landscape approach to assessing habitat suitability and protects the very best murrelet habitat, occupied or not, while also providing for the development of more suitable habitat over time. By investing in habitat modeling and protection for the best murrelet habitat found on Green Diamond timberlands (the MMHCP), Green Diamond can more efficiently conserve murrelets by avoiding and minimizing take while also expeditiously planning and permitting timber harvest in areas where there is minimal or no risk of take.

Passive Take Avoidance is like Intensive Take Avoidance in that it sets a very high standard for compliance through confidence that no activities will take marbled murrelets. However, Passive Take Avoidance does not even attempt to invest more time and resources into field assessments and protocol surveys to reduce uncertainty and rule out murrelet occupancy so that timber stands may be permitted for harvest. Instead, Passive Take Avoidance simply avoids timber harvest in any areas where there is a perceived risk that there will be murrelet take because of some degree of suitable habitat potential. The Passive Take Avoidance approach is not a financially viable approach to investment in forest management because it places a timberland investment on a trajectory of progressive, cumulative set asides of forest stands for conservation without timber harvest. Green Diamond is unwilling to pursue this take avoidance alternative because it would render Green Diamond's forest management business unviable and cause severe economic disadvantage in its communities through the loss of jobs and income at Green Diamond and its customers and suppliers.

Section 2. Covered Activities

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2.1 INTRODUCTION

This Marbled Murrelet HCP (MMHCP) and the associated Incidental Take Permit (Take Permit) will cover and provide incidental take authorization for Green Diamond's timber operations and related land management activities in the Plan Area, further described in the following sections.

2.2 TIMBER-PRODUCT HARVEST

2.2.1 Felling and Bucking Timber

Timber felling is the first step in logging operations. It usually includes felling of the tree and may include bucking or cutting felled trees into predetermined log lengths specified by the timber owner to maximize tree value. Some felled trees may also be left "tree length" and manufactured into logs later in the process. Contractors ("timber fallers" sometimes working in pairs) are hired to fell and buck trees with chain saws. Mechanical felling machines (feller-bunchers) may be used to cut down trees where the tree size and hillslope allows for safe operations. These machines are structurally similar to tracked excavators; however, they have wider tracks and higher ground clearance. Using an articulated attachment, they grab, cut, and bunch the trees with other trees or logs to subsequently be moved to the landing. Feller-bunchers that are more complex have processor heads to delimb and buck trees into logs. Self-leveling mechanisms on some machines allow them to safely operate on steeper slopes. Some of the equipment is also capable of "tethered" operations where the equipment works in conjunction with a cable assist device to allow safe operation on steep slopes. Feller-bunchers have no blade or attachments capable of moving soil. Their wide track design and ability to travel on top of forest debris (limbs and chunks) minimize soil disturbance and compaction.

2.2.2 Yarding Timber

Yarding or skidding involves moving logs from the stump where they are felled to the landing. Major yarding system classifications include ground based, cable, and aerial. Section 2.4 describes biomass or slash debris yarding, an additional classification involving wood products not exclusively in log form.

2.2.2.1 Ground-Based Yarding

Ground-based yarding traditionally involves tracked or rubber-tired tractors (rubber-tired skidders) skidding logs to the landing. These machines grasp the log using either powered grapple attachments or wire rope winch lines. They require constructed skid trails to operate on all but the mildest terrain (generally under 35 percent slope). A related system, forwarder logging, is used only for small logs on mild terrain. It uses a specifically designed articulated skidder that includes log bunks and a small hydraulic boom loader. The forwarder travels into the logging unit and lifts logs onto bunks mounted on a rearward tractor frame extension. This specialized machine resembles a small self-loading truck designed with large low ground pressure tires, low gearing, and high ground clearance that allows off-road operation with minimal ground disturbance or soil compaction. Some forwarders are capable of tethered operations where they are equipped with a cable assist device to allow safe operation on steeper slopes.

Whenever possible, Green Diamond uses a more modern and technically improved ground-based yarding method called shovel logging. A shovel, or hydraulic boom log loader, resembles an excavator equipped with a log loading boom and grapple instead of an excavator boom and bucket. These machines are specially designed for yarding and provide more off-road mobility because they have additional horsepower and are mounted on tracked undercarriages with generous ground clearance and wider tracks with tall grousers. The shovel is capable of walking off the truck road, picking up felled logs in a unit, and passing them back toward the truck road using its upper structure 360-degree rotation or swing function. This system is efficient since the same machine that does the yarding can load the logs on trucks. It is not used over longer distances because increased distances from the truck road requires repeated log handling. As with feller-bunchers, shovels have no blade for moving soil and require no skid trail construction. Some shovel harvesting machines are capable of tethered operations where they are equipped with a cable assist device to allow for safe operations on steeper slopes. Shovel harvesters feature wide tracks that have low ground pressure that operate on top of the natural layer of residual slash debris and stumps. The tracks have tall grousers that improve traction and minimize track spin or churning. This provides significant additional protection by minimizing soil compaction and ground disturbance. Green Diamond prefers to use the shovel logging ground-based yarding method wherever feasible, rather than tractor or skidder logging. However, it can only be used in even-aged units and is not compatible with selection or thinning silviculture.

2.2.2.2 Cable Yarding

Cable yarding uses wire ropes to yard (winch) logs to a truck road or log landing. A yarder has a number of powered drums filled with wire rope, and a vertical tower or leaning boom that elevates the cables as they leave the machine. Wire rope guy lines hold the tower in position. With rare exception, cable systems yard logs uphill. Green Diamond utilizes cable yarding systems where the terrain is too steep to safely accommodate ground-based yarding systems such as shovel logging.

A variety of different cable yarding systems may be used depending on the terrain, yarding distance, and log sizes; on Green Diamond lands, the “skyline” yarding systems are the primary cable yarding systems. Harvest units and road locations are carefully designed and engineered to ensure that the cable yarding systems will operate efficiently and with a minimum of ground disturbance. Skyline logging uses a skyline cable that extends from the top of the tower to a point beyond the edge of the area to be logged. This anchor is usually a stump or a suitable tree at the perimeter of the logging area located to provide the necessary skyline elevation. Choker cables are used to attach logs to a drop line that leads to a carriage that rides on the skyline. The yarder pulls the carriage to the landing with its mainline.

Depending on the skyline variant used, the yarder lowers the skyline to attach the logs and then raises it for lift, or the carriage can unwind its own skidding line and then lift the logs toward the skyline. Either way, the yarding system typically provides enough lift to suspend the uphill end of logs above the ground. When carefully designed and planned, full suspension of logs across key control points can be accomplished. Green Diamond uses skyline cable yarding systems extensively throughout its lands, which minimizes overall ground disturbance and mid-slope road building.

2.2.2.3 Aerial Yarding

Aerial yarding (e.g., by helicopter or balloons) typically occurs when steep and/or unstable terrain or lack of road right-of-way prevents road construction for ground-based or cable yarding systems. Balloon aerial logging uses cables or grapples suspended from long cables with the balloon providing lift to the logs for transport to the landing. Aerial equipment lowers and releases logs to the loading area. In helicopter yarding, a cable extending from the helicopter is attached to the logs and transports the logs to the landing area. These types of yarding systems generate virtually no soil disturbance within the harvest units. However, both require large landings to safely accommodate concurrent log landing, log sorting, truck loading operations, and log decking during peak production hours. Helicopters also require a separate service landing that is free of debris to protect the engines from damage. The disadvantages of helicopter logging are its expense (roughly three times more expensive than cable yarding) and the fact that lack of vehicular access to the area compromises the landowner's ability to accomplish site preparation, reforestation, and other forest management activities in the future. Helicopter service landing areas are secondary to the Harvest Plan area.

2.2.2.4 Landing Construction, Maintenance and Loading

Log landings are cleared areas or wide spots in roads to which logs are yarded, swung, skidded, lowered, or forwarded for subsequent loading onto trucks for transport. They are constructed and maintained as part of the timber harvest and transport process. Landings must be located and constructed to complement the yarding system used to move the logs from the stump.

Logs yarded to a landing or roadside may need bucking into shorter segments, breakage removal, and delimbing by hand or mechanically. A mechanical delimber or processor is a tracked machine similar to an excavator with a long boom and cutting head that delimbs, accurately measures, and cuts trees into log-length pieces.

At the landing or roadside, a shovel or front-end loader (a wheeled bucket loader equipped with log loading forks instead of a bucket) then loads logs onto log trucks. Shovels (or heel-boom loaders) can operate on small landings or, if side slopes are suitable, they can deck logs on the roadside and load trucks without leaving the road grade. In contrast, front-end loaders have a longer turning radius and require larger landings. Shovels are Green Diamond's preferred loading equipment because they offer flexibility, utility, and lower ground pressure.

2.2.3 Salvaging Timber Products

Dead, dying, and wind thrown trees are periodically salvaged. This salvage is primarily related to road maintenance or fire damage resulting from prescribed burns. Dead or dying trees are removed along roads if they can be easily salvaged and yarded to the road. Salvage of timber products is conducted through the annual filing of a property wide Exempt Notice, i.e., subject to the Forest Practice Rules but exempt from Harvest Plan requirements and Harvest Plan processes. Removal of these products requires a licensed timber operator. Salvage harvesting is not permitted within floodplains or channel migration zones and is specifically limited in watercourse riparian management zones by Green Diamond's AHCP/CCAA (2007) and FHCP (2019). Older, decaying or defective logs are retained on the landscape to provide valuable wildlife habitat structure (Section 5.2.2.2 and Appendix E, TREE, FHCP 2019).

2.2.4 Transporting Timber and Rock Products

Timber products, biomass materials, and rock materials are most commonly transported along private and public roads via truck and trailer.

2.2.5 Road Construction, Maintenance, and Use

Roads on lands owned in fee by Green Diamond are constructed most commonly by felling and yarding timber along a predetermined road alignment that has been designated on the ground. This activity is followed by excavating or filling hillslope areas using tractors or excavators. Road construction also commonly involves construction of watercourse crossings that use culverts, bridges, and occasionally fords. Roads also include vehicle turnouts and log landings that are wide spots used for yarded logs and loading log trucks. Road construction may also involve surfacing soil roads with rock, lignin, pavement, or other surface treatments approved by NOAA Fisheries and the Service under the AHCP/CCAA (2007).

Road maintenance typically includes surface grading, clearing bank slumps, repairing slumping or sliding fills, clearing ditches, repairing or replacing culverts and bridges, adding surface material (rock), dust abatement, and installing or replacing surface drainage structures. Road maintenance for fire prevention, public access, and timber management may include mechanical control of roadside vegetation. Mechanical control may include grading, hand cutting, using a brush buster-type mechanical device, burning, steaming, and other experimental methods. Road construction and road maintenance activities are intended to provide for a well-designed and maintained transportation system used for long-term access to harvest timber, haul logs, and wood products, regenerate and maintain plantations, perform biological and geological study and assessments, and allow for the general administration and protection of the Plan Area. All activities associated with the construction, maintenance, and uses of roads serving the Plan Area (including roads over third parties where Green Diamond has a right or privilege of use) are Covered Activities.

2.2.6 Rock Pit Development and Use

Rock pits, also referred to as borrow pits, are locations where rock is excavated, crushed, blasted, or otherwise produced for eventual use as road surface, fill, or bank stabilization material. Activities associated with the use of rock pits also include loading crushed rock into trucks for hauling, hauling mined rock, and constructing and maintaining rock pit access roads (see previous section). Under the Harvest Plan process, Green Diamond also conducts an archaeological review for the development of any new rock quarry within the Plan Area to take account of any effects on historic properties under the National Historic Preservation Act.

2.2.7 Water Drafting and Storage

Water drafting involves direct drafting of stream flow from Class I and Class II watercourses or other drafting sites (e.g., Class I and Class II ponds and gravity fed storage tanks) into a water truck which is then periodically sprinkled or otherwise applied to roads for dust abatement, road maintenance, road construction, surfacing, or used for controlling prescribed fire or wildfire. Water may be diverted using gravity fed systems that provide water directly to storage reservoirs or tanks that are used to load water trucks. Occasionally, existing drafting locations within or adjacent to watercourses are excavated and cleaned of debris to increase their in-channel storage area for

drafting purposes. Water drafting and storage management is covered under Green Diamond's AHCP/CCAA (2007) in more detail and specificity under Green Diamond's Master Agreement for Timber Operations (MATO), approved by CDFW on May 20, 2010, and in the Waste Discharge Requirements for Discharges Related to Road Management and Maintenance Activities Conducted Pursuant to the Green Diamond Resource Company Aquatic Habitat Conservation Plan in the North Coast Region, approved by the California North Coast Region Water Quality Control Board on June 10, 2010.

2.2.8 Equipment Maintenance

The use of falling, yarding, loading, trucking, and road maintenance equipment requires fueling and maintenance. This maintenance is performed by Green Diamond and/or its contractors using maintenance trucks and generally occurs on or adjacent to roads and landings.

2.3 SILVICULTURAL METHODS

Green Diamond's silvicultural practices are designed to enhance the productivity of its timberlands by ensuring both prompt regeneration of harvested areas and rapid forest growth. Treatments vary by stand age, stand condition, site class and species composition. Green Diamond does not apply all treatments to every site. Table 2-1 summarizes the treatments in approximate chronological order that Green Diamond includes as part of its forest management regime.

Table 2-1. Green Diamond's forest management methods based on stand age.

Treatment	Stand Age (years)
Regeneration Harvest	45 and older
Site preparation	0 – 1
Tree Planting	0 – 1
Vegetation Management	0 – 10
Pre-commercial thinning	10 – 20
Commercial Thinning	25 – 40

Silvicultural activity involves specific methods used to harvest and regenerate forest stands over time to achieve desired management objectives. Typical management objectives include achieving maximum sustained yield, storage of carbon, and the maintenance, alteration, or creation of habitat. Examples of silvicultural methods for regeneration harvest include individual (single) tree selection, group selection, seed tree, shelterwood, and clear-cut. The first two methods regenerate uneven-aged stands and the latter three regenerate even aged stands.

2.4 TIMBER STAND REGENERATION AND IMPROVEMENT

Timber stand regeneration and improvement includes activities necessary to establish, grow, and achieve desired species composition, spacing and rate of growth of young forest stands. Associated activities described in this section include the following:

- Site preparation, prescribed burning and slash treatment
- Tree planting

- Controlling competing vegetation
- Precommercial thinning and pruning
- Commercial thinning
- Regeneration harvesting

Green Diamond manages timber in the Plan Area under a Maximum Sustained Production plan prepared and approved in accordance with California law. Under the Maximum Sustained Production plan, annual harvest levels are carefully scheduled to balance forest growth and timber harvest over a 100-year period and to achieve maximum sustained production of high-quality timber products while protecting resource values such as water quality and wildlife. Stands are ready for harvest once they enter the 50-year age class (45 to 55 years old). However, state laws that constrain both the size of even-aged management units and the timing of adjacent even-age harvesting operations can delay the harvest of many stands until they reach the 70-year age class. Green Diamond currently uses the Forest Projection and Planning System (Planning System), developed by the Forest Biometrics Research Institute, for inventory tracking, growth modeling, and long-term harvest scheduling. In 2008-9, this model was used to develop a 100-year projection of harvesting and growth to demonstrate Maximum Sustained Production as required by the California Forest Practice Rules under Title 14 California Code of Regulations 913.11(a). The rule requires the landowner to demonstrate achievement of Maximum Sustained Production by satisfying the following five requirements:

- "Producing the yield of timber products ... while accounting for limits on productivity due to constraints imposed from consideration of other forest values, including but not limited to, recreation, watershed, wildlife, range and forage, fisheries, regional economic vitality, employment and aesthetic enjoyment."
- "Balancing growth and harvest over time…."
- "Realizing ... adequate site occupancy…."
- "Maintaining good stand vigor."
- "Making provisions for adequate regeneration."

The modeling used spatially explicit simulation of harvesting and growth of individual stand components over more than one rotation for 100 years, based on the GIS mapping of the standing inventory for Green Diamond's California timberlands as of January 1, 2008. This stand mapping and its projections included both harvested and unharvested areas retained for wildlife and fisheries protection. This portrayed projected stand ages and structure across the whole property at various times, e.g., at decadal intervals, throughout the simulation period. The Maximum Sustained Production modeling resulted in a constant level of harvest for approximately 50 years, followed by an increase to a higher level for the last 50 years, with growth exceeding harvest at all times throughout the period, and with a concomitant increase in standing inventory throughout the whole period.

With the exceptions noted below, Green Diamond plans to practice even-aged management in the Plan Area, using clear-cutting as the harvest/regeneration method. Clear-cutting provides for prompt regeneration of redwood and Douglas-fir, the principal commercial tree species in these forests, and maintains these trees in a "free-to-grow" state that is not compromised by competition from older trees or by the possibility of damage from the repeated site disturbance that is implicit

in the application of other silvicultural systems. The growth potential inherent in the use of clear-cutting in these forest types was assumed in the calculation of yields for Green Diamond's sustained yield (Option (a) document).[1]

The primary exceptions to clear-cutting occur in the following situations:

- Areas where past use of selection or seed tree logging left residual mature timber that will be harvested in seed tree removal or overstory removal operations
- Areas where buffers along public roads or near urban development are harvested using the shelterwood or selection systems so that the visual impact of timber harvesting is ameliorated
- Overly steepened or unstable slopes where slope stability concerns take precedence over forest productivity
- Riparian management zones, habitat retention areas, single tree retention of trees possessing high value habitat features or other areas managed principally for fish and wildlife habitat.

As discussed in the FHCP (2019), clearcut management units will include the conservation measures designed to:

- Ensure that existing key habitat elements are retained on the landscape (snags, live legacy residual trees, key large residual hardwood trees, down old residual logs with rot and defect)
- Provide for the retention of vertical structure in the form of conifer and hardwood trees where existing key residual habitat elements do not presently exist

These retained trees, in conjunction with those left in riparian management zones, will cause a substantial portion of the area within even-aged harvesting units supporting post-harvest vertical structure to provide various habitat attributes for terrestrial and aquatic wildlife.

Because most of Green Diamond's property has been harvested at some time in the past, the progress of timber harvesting across the ownership will always reflect to some extent the pattern of age classes imprinted on the landscape by the timing of prior logging activity. In areas where large blocks were initially harvested in continuous logging operations during the railroad logging era (pre-WWII), harvesting operations will be more concentrated within these general watershed regions, although California Forest Practice Rule constraints will cause the dispersal of activities over time and space within these blocks during subsequent rotation periods. This is a product of the California Forest Practice Rules adjacency harvesting constraints that are applied to even-aged harvesting units resulting in retention of many stands past planned rotation age. If harvesting of a tract of mature timber is initiated around age 50, the harvesting of much of that tract will be constrained into the following decade, and the harvest of a few stands will be constrained past 70 years of age. This effect has been demonstrated in Green Diamond's long-term operating plan.

[1] The Option (a) document contains confidential proprietary information that is protected from public disclosure under California law. This reference to the Option (a) document is explanatory and the Option (a) document has not been provided to the Service and is not intended to be part of the administrative record for Service action on this MMHCP.

2.4.1 Site Preparation, Prescribed Burning, and Slash Treatment

Site preparation may be required where accumulations of slash following timber harvesting constitute a physical barrier to effective planting, or where weed species (brush or non-merchantable trees) remaining on the site significantly compromise establishment of planted seedlings. In either situation, Green Diamond may use prescribed burning, machine piling, mechanical scarification, biomass harvesting, or a combination of these methods to prepare the site for hand planting and reduce fuel concentrations for fire safety.

Green Diamond may retain slash created by logging activity on site without treatment if it does not prevent replanting or represent excessive fuel concentrations that pose an unacceptable fire risk or to comply with existing agreements such as the Marten Safe Harbor Agreement. The California Forest Practice Rules require removal of accidental deposits of slash within Class I and Class II watercourses. Slash deposited into Class III watercourses must be removed unless it is stable within the channel. In all logging areas, slash developed on log landings from yarding and truck loading activities may be piled and burned on the landing.

Site preparation occurs as soon as possible after completion of logging so that planting will not be delayed. Mechanical site preparation may occur concurrently with logging operations. If prescribed burning is required, it is scheduled during the first spring or fall following completion of timber harvesting.

Prescribed burning introduces fire under controlled conditions in order to reduce slash concentrations, reduce vegetative levels, control species composition, and reduce fuel concentrations for fire hazard abatement, with little risk of catastrophic fire damage. It is facilitated using two main techniques:

- Broadcast burning, where a prescribed fire is ignited in the harvest unit (excluding riparian management zones and other resource protection areas)
- Pile burning, where logging debris and slash is accumulated and piled concurrent with harvesting operations and then ignited during the winter period under appropriate burning conditions

Piles of slash are accumulated by either cable yarders bringing logging debris to landings or by ground-based falling and shovel yarding equipment piling debris within the units or alongside adjacent roads and landings. The timing of prescribed burns is predicated upon temperature, wind, humidity, and fuel moisture conditions that will cause low intensity burns. Such conditions minimize the probability of escape and allow retention of large woody debris and the finer organic matter concentrated at the soil/litter interface. Ignition patterns are designed to keep fire from intruding into riparian management zones. The practice of using prescribed burning, especially broadcast burning, has been greatly diminished in recent years to comply with air quality regulatory standards.

With the development of specialized equipment, techniques, and new markets for biofuels, biomass harvesting has become a viable alternative in some areas to site preparation using broadcast burning. In areas where slash and other logging debris is accessible to ground-based equipment, a portion of the logging slash is removed (harvested) from harvest units and landings

as a site preparation and hazard abatement treatment. Where feasible and concurrent to harvesting operations, shovel logging operators are instructed to stack excessive slash into piles located along the roadway and in harvest units. Mechanized delimber or processor operators stack tops, limbs, and other debris in piles along the roadway, adjacent to landings and in units. After completing normal log harvesting operations, specialized biomass harvesting equipment (often a shovel loader with specialized tongs designed to pick up slash) gathers slash in untreated areas and deposits it into specialized articulated dump trucks capable of driving over uneven topography and slash. Alternatively, in areas with piles, the slash is loaded into the specialized dump trucks. These trucks deliver biomass to a centrally located landing where a mobile slash chipper grinds/chops the material into chips and then loads large trucks that deliver chips to conversion facilities such as paper chip utilizers or co-generation plants. The biomass that is harvested is in the form of unused woody material that was previously considered non-merchantable and uneconomical to retrieve from the landscape.

In areas where biomass operations occur, a residual layer of slash is retained throughout the unit to ensure needed ground cover is present for erosion prevention. All operational constraints associated with topography, seasonal restrictions, and resource protection and retention of important aquatic and terrestrial wildlife habitat elements are comprehensively identified and documented in Green Diamond's AHCP/CCAA and FHCP.

2.4.2 Tree Planting

Tree planting generally involves hand planting nursery-grown tree seedlings directly into the soil, ensuring good contact between the soil and roots. Tree seedlings are hand planted in even-aged management areas including landings during the first winter following completion of a Harvest Plan. In general, the tree species selected for planting are chosen to best fit the site-specific conditions of the area harvested.

Areas that exhibited pre-harvest high redwood composition are planted primarily with redwood seedlings. Some areas that are well stocked with redwood stump sprouts after harvest may be deemed unnecessary to replant except if it is necessary to fill areas void of regeneration. Areas exhibiting both redwood and Douglas-fir species before harvest will commonly be planted with a mix of both species often favoring one species over another depending upon the site-specific conditions. In areas that are dominated by hardwoods, conifers (either redwood or Douglas-fir, depending upon site conditions) are replanted with the purpose of increasing the conifer component while retaining important hardwood trees that provide benefits to wildlife species. In other locations on the ownership where elevation or growing site dictates, other tree species such as Ponderosa Pine or incense cedar may be selected for planting.

Planting will be postponed only if site preparation is necessary but cannot be completed before the planting season. The summer after initial planting, Green Diamond surveys planted areas to determine seedling survival rates and, where necessary to achieve desired stocking, will plant additional seedlings during the following winter. At age two, a more detailed stocking survey will be done, and if necessary, additional trees are planted. It is often common for some harvested sites to become stocked with additional volunteer tree species (western hemlock, Sitka spruce, red alder) that become established. Volunteers come from adjacent stands that provide seed sources. This is the most common process that allows for a wide variety of species across the landscape.

2.4.3 Control of Competing Vegetation

To provide successful establishment and continued, rapid growth of desired tree species, it is often necessary to control species that compete with desired species for water and sunlight. Control methods are mechanical cutting and chipping. Green Diamond is not seeking coverage of herbicide use for control of competing vegetation as a part of the Take Permit.

2.4.4 Precommercial Thinning and Pruning

Precommercial thinning involves thinning dense, young forest trees by mechanical means, including cutting individual trees or mechanically sawing or chipping rows or groups of trees. Pruning removes the lower limbs of desirable tree species to increase the eventual product value of the pruned trees. Between age 10 and 20, precommercial thinning may occur to remedy overstocked conditions in planted stands so that crop trees will achieve optimum diameter growth. Currently, Green Diamond does not remove precommercial stems from the site because they are too small to meet current merchantable standards. This operation is performed only once in the life of a stand and only in those stands with an excess number of trees per acre. Although chainsaws are used to cut the noncrop trees, progress in the development of feller-bunchers may eventually lead to machines capable of executing this operation more efficiently and with less risk of injury to workers. Alternatively, improvements in markets for small wood and in the machinery used to harvest small stems may allow economic harvesting of the excess trees, thus converting precommercial thinning to commercial thinning as described below.

2.4.5 Commercial Thinning

Commercial thinning involves removing selected trees that may contain commercial value, to create additional growing space for crop trees. Thinning a portion of the competing trees allows for the release of the selected crop tree by providing more light, and in some cases, more nutrients and soil moisture when they are limiting factors. In the Plan Area, a young forest's most significant limiting factor is typically sunlight. Commercial thinning on Green Diamond timberlands usually occurs when stands are identified as needing this treatment and when they are around the 25- to 40-year age class. The log size of these younger thinned stands is inherently smaller than those of an older stand ready for the final harvest stage of even-aged management. The harvesting systems, however, are fundamentally the same, except the size of the yarding equipment can be significantly reduced to correspond with smaller payloads and logs. Both cable and ground-based yarding systems are used to harvest the selected trees to be thinned with the goal of improving the growth potential of remaining stands and protecting residual trees from damage during the yarding process. During the planning and design stage of a thinning harvest, Green Diamond's registered professional foresters and professional biologists ensure key resource protection measures and mitigations included in a final clear-cut harvest also apply to intermediate thinning harvest.

2.4.6 Regeneration Harvest

Green Diamond uses clear-cut and selection harvest as the two primary methods of forest stand regeneration. Other silviculture approaches described in Section 2.3 are used in minimal amounts when site specific conditions warrant and will be applied in future harvests under similar circumstances. Clear-cutting provides for prompt regeneration of redwood and Douglas-fir, the

principal commercial tree species in these forests, and maintains these trees in a "free-to-grow" state that is not compromised by competition from a predominate residual overstory influence of older trees or by the possibility of damage from the repeated site disturbance that is implicit in the application of other silvicultural systems. The growth potential inherent in the use of clearcutting in these forest types was assumed in the calculation of yields for Green Diamond's sustained yield (Option A document).

Selection harvesting involves choosing either individual trees or small groups of trees for harvest. This silviculture retains a significant component of the original stand with the intention of reentry after a prolonged period (approximately 10 years) to select another component of individual trees for harvest after the stand experiences subsequent regrowth and natural regeneration. On the north coast of California and within Green Diamond's ownership, selection harvest occurs where competing resource values take precedence over even-aged harvesting. Selection harvesting is an ideal method used to ensure robust retention of stands and individual trees within riparian management zones, geologically unstable areas and in locations where protection of other resource values is the foremost management factor. Areas designated for selection harvest are managed within that prescription for long periods to ensure the specific retention that is desired continues to persist on the landscape. Because riparian management zones and geologically unstable areas are key elements of both aquatic and terrestrial resource protection strategies, the key retention guidelines for these features ensure that long-term retention and the development of mature forest stands with larger trees, multi-layer canopies, interior space, and marbled murrelet nesting platforms occur across the landscape.

2.5 MINOR FOREST-PRODUCT HARVEST

Minor forest products include burls, stumps, boughs, and greenery, which are collected, harvested, and transported on the Plan Area. These activities will comply with the measures in Section 6. These activities are conducted by third parties subject to Green Diamond's permits with conditions that protect sensitive habitats and minimize the risk of any incidental take of Covered Species.

2.6 ADMINISTRATION, IMPLEMENTATION AND MONITORING ACTIVITIES

The activities needed to carry out the various aspects of the Conservation Program described in Section 6 include:

- Use of all-terrain vehicles and passenger vehicles on roads
- Use of hand tools and power tools for clearing and maintaining roads for access
- Data collection
- Tree marking and habitat improvement activities
- Observation, surveys, capture, and marking of wildlife

Section 3. Biological Resources

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3.1 INTRODUCTION

Inhabiting the nearshore waters and mature and old-growth forests of the Pacific coast, the marbled murrelet (*Brachyramphus marmoratus*) is a small, elusive seabird with a unique life history: it forages for small fish and invertebrates in coastal waters until the nesting season, when it travels inland to seek forest cover along the west coast of the United States and British Columbia.

Beneath a multistoried canopy, a marbled murrelet will search for a large, mossy branch or platform on which to lay a single egg. Breeding success depends on a number of factors, including finding suitable habitat, avoiding predation, and ensuring adequate food for the chick. A breeding pair will take turns minding the nest and traveling back to ocean foraging areas, sometimes making several trips a day to feed a chick. If the nest is successful, the fledgling leaves the nest and flies alone, directly to the sea.

Fast-flying and not easily detected, the marbled murrelet has been a challenging species for scientists to study. In fact, the first nest was not found and formally documented in North America until 1974, after early ornithologists had searched for over a century (Nelson, 1997). Since then, efforts to survey marbled murrelets and learn more about their habits, diet, and life cycle have yielded important insights about the keys to the birds' survival.

3.2 SPECIES DESCRIPTION

The marbled murrelet is a plump, dove-sized seabird able to both fly overhead and swim underwater, with a short neck and tail feathers, a slender dark bill, and pointed wings. It measures about 9.25 to 9.5 inches, from bill to tail (McShane et al. 2004). Its smaller wing surface area relative to its body size reduces drag while swimming under water (McShane et al. 2004). That same feature also means it must fly at high speeds to maintain lift: Marbled murrelets fly at speeds of 43 miles per hour or faster and can rise directly from the water without first running across the surface (McShane et al. 2004).

The marbled murrelet's plumage does not vary between males and females but it does vary by season (USFWS, 1997). In the breeding season, adults appear dark brown with mottled brown underparts; during winter, the upperparts become grey and the underparts appear white, extending up the sides of the head almost all the way around the nape (USFWS, 1997). Juveniles look similar to winter adults, except that the underparts are more speckled (McShane et al. 2004).

The marbled murrelet is part of the Alcidae family, which is characterized by wing-propelled diving birds. Other birds in this family include razorbills, puffins, and auklets. The marbled murrelet is closely related to the long-billed murrelet, thought to be part of the same species until 1997, when the American Ornithologists' Union recognized the marbled and long-billed murrelets as distinct species (USFWS, 1997).

3.3 RANGE AND DISTRIBUTION

The marbled murrelet is found along the Pacific coast of the United States and British Columbia. Its range stretches from Alaska's Bristol Bay, along the Aleutian Archipelago, and south through British Columbia, Washington, and Oregon to central California (USFWS, 1997). The birds are not found continuously throughout that range; in California, the three main areas are largely separated by second-growth forest not used by marbled murrelets (USFWS, 1997).

The marbled murrelets' range includes both marine and terrestrial environments. Along the coast, marbled murrelets typically forage in nearshore waters, including estuaries, bays, and more open coastal waters, within 1.2 miles of shore (USFWS, 1997). They fly miles inland to nest in forests with trees old enough (typically at least 200 years) to have developed large, horizontal branches on which to lay their eggs (USFWS, 1996; USFWS, 1992). Marbled murrelets generally select nests within 50 miles of their ocean feeding grounds (USFWS, 1997). In California, marbled murrelet occupied sites have been reported up to 35 miles from the ocean (USFWS, 1996). The longest commute from the nest to foraging habitat was reported in Washington, at 90 miles (USFWS, 2019a).

In its Recovery Plan for the Marbled Murrelet (1997), the Service identified six conservation zones within the continental United States that cover the marbled murrelet's range. These zones correspond with large tracts of older forests near the coast, where marbled murrelets can be found in the breeding season and to some extent in the winter (USFWS, 1997). The six zones from north to south are as follows: Zone 1, Puget Sound; Zone 2, Western Washington Coast Range; Zone 3, Oregon Coast Range; Zone 4, Siskiyou Coast Range; Zone 5, Mendocino; and Zone 6, Santa Cruz Mountains (USFWS, 1997). Green Diamond's MMHCP plan area falls within Zone 4 (Figure 3-1).



Figure 3-1. Marbled Murrelet Habitat Conservation Plan Area in relation to six marbled murrelet conservation zones.

Marbled murrelet populations within this range are regularly reported in the Service's five-year status reviews. Data on Conservation Zones 1 through 5 come from the Northwest Forest Plan, a management plan for federal forestlands within the Pacific Northwest. The Northwest Forest Plan monitors marbled murrelet populations in order to evaluate the plan's effectiveness in conserving species associated with older forests; it has conducted at-sea population surveys during the breeding season since 2000 (USFWS, 2019a). Because each zone is not sampled annually but on even- or odd-year rotations, and because Northwest Forest Plan surveys only zones 1 through 5, the most current years in which data are available vary by zone.

Taking into account recent surveys by the Northwest Forest Plan for Conservation Zones 1 through 5 and others for Conservation Zone 6, the marbled murrelet population within the continental United States stands at approximately 23,260 as of 2016. As of 2021, Conservation Zone 4, which

includes southern Oregon and northern California where the MMHCP plan area is located, was estimated to contain 5,100 marbled murrelets (McIver et al. 2022).

No population trend, positive or negative, appears to exist for marbled murrelets at the listed-range scale (USFWS, 2019a). From 2001 to 2020, the population across Conservation Zones 1 through 5 increased at a rate of 0.30 percent per year, although the survey confidence intervals were low (-0.6 to 1.2 percent) (McIver et al. 2022). In Washington the trend was negative, with a population decrease of 4.1 percent per year; California and Oregon both saw significant positive trends in the years 2000 to 2020, with population increases of 3.8 percent and 2.0 percent per year, respectively (McIver et al. 2022).

In California, where the MMHCP area is located, marbled murrelets were at one time considered "plentiful" from Monterey County north to the Oregon border during the winter months (USFWS, 1997). Historically, it is estimated that at least 60,000 marbled murrelets may have been found along the California coast (USFWS, 1997).

3.4 LIFE HISTORY AND HABITAT

Marbled murrelets are a relatively long-lived seabird, with an estimated lifespan of approximately 10 years (USFWS, 1997). They reach sexual maturity in their second year but probably do not lay eggs until their third year, after which time it is typical to lay one egg per year (USFWS, 1997).

Research suggests that marbled murrelets are opportunistic foragers that consume a wide variety of small fish and invertebrate species depending on availability (USFWS, 1997). Spending most of their lives at sea, their primary food sources are Pacific sand lance (*Ammodytes hexapterus*), Pacific herring (*Clupea harengus*), northern anchovy (*Engraulis mordax*), and smelts (*Osmeridae*) (USFWS 1997).

To find suitable nesting habitat, marbled murrelets travel inland during the breeding season, which stretches from late March through late September (USFWS, 1997). They are sometimes detected inland during the winter as well, possibly while checking on previous nesting sites, forming or maintaining pair bonds, scouting future nests, or maintaining familiarity with flight paths (USFWS, 1996; USFWS, 1997). Like other alcids, marbled murrelets exhibit nest fidelity, typically returning each year to the same nest or nesting stand (USFWS, 1997). Although research and sample size are limited, marbled murrelets have shown fidelity at various spatial scales, including at the watershed (Burger et al., 2009; Hebert and Golightly, 2006), stand (Golightly and Schneider, 2011; Hebert and Golightly, 2006; Nelson and Wilson, 2002), and tree (Barbaree et al., 2014; Burger et al., 2009; Hebert and Golightly, 2006) level. Burger et al. 2009 also observed that marbled murrelets may exhibit higher nest site fidelity in areas with more limited suitable nest features and less continuity due to past harvest or wildfire.

A breeding pair of marbled murrelets nests solitarily and not within a colony, although nests have sometimes been detected in close proximity to each other (USFWS, 1997). The only alcid known to nest in trees, marbled murrelets do not build nests but instead seek a large tree limb with epiphytes (plants such as moss) or forest debris that forms a platform in which to lay a single egg. The male and female birds take turns incubating the egg over an approximately 30-day period, taking 24-hour shifts (USFWS, 1997). When not incubating the egg, they return to ocean feeding

grounds to forage, typically departing and returning to the nest under the cover of low light (dawn and dusk) and often in small groups (USFWS, 1997).

After hatching, the chick is tended in the nest for an additional 27 to 40 days (USFWS, 1996). Chicks are fed up to eight times daily, usually a small fish at a time. Rates of nest failure are high, possibly due to predation, low food supply, or lack of suitable nest sites (USFWS, 1997). If nesting and fledging are successful, the chick molts into distinctive juvenile plumage and takes its first flight from the nest directly to ocean feeding grounds (USFWS, 1992; USFWS, 1996).

Nesting habitat is of critical importance to marbled murrelets. In their inland environment, they nest almost exclusively in older forests, or in mature second-growth forests when they are adjacent to near to older stands (USFWS, 1997). The trees must be old and tall enough to have developed large branches or deformities that form a platform on which an egg can be laid, with sufficient canopy cover and distance from the forest edge to offer protection from predators. The site must also be near enough to the ocean for daily foraging trips (USFWS, 1997; USFWS, 2019a).

Marbled murrelets exhibit selection in nest site characteristics at the landscape level, stand level, tree level, and platform level. Habitat selection, therefore, occurs at multiple scales, and marbled murrelets' nest selection can vary by geographic location due in part to regional differences in forest composition and structure, climate, and other variables (Meyer et al., 2004; Baker et al., 2006; Plissner et al., 2015).

In California, the trees most used by marbled murrelets for nests are Douglas-fir (*Pseudotsuga menziesii*) and coastal redwood (*Sequoia simpervirens*) (USFWS, 1997; Baker et al., 2006; Golightly et al., 2009). Because it takes approximately 200 to 250 years for northwest trees and forests to develop suitable nest attributes (USFWS, 1996), old-growth forests and mature forests with old-growth components provide the characteristics necessary for nesting habitat (Baker et al., 2006; USFWS, 1996; Hamer and Nelson, 1995a). In California studies, the greatest predictors of murrelet presence were the density of old-growth cover and the presence of coastal redwood (USWS, 1997; Miller and Ralph, 1995).

Marbled murrelets in California tend to look for nest sites low on slopes, close to streams, in a large area of contiguous forest, and in stands with a high basal area of very large trees (Baker et al., 2006; Golightly et al., 2009). In a 2006 study, Baker et al. found that unharvested or lightly harvested (individual tree selection with 4-6 trees >120 centimeters dbh within a 25-meter-radius plot post-harvest) old-growth forest stands are the primary sources of nesting habitat in central California. Marbled murrelets in that study selected old-growth forests, sites close to streams (possibly because they afforded better access), and very large trees (possibly because they have more limb and tree deformities to serve as platforms). Mean limb diameter was 24 inches, and the smallest nest limb diameter was 11 inches (Baker et al., 2006). In another California study, Golightly et al. (2009) found that nest trees were tall (mean height 217 feet) and large (mean diameter at breast height [DBH] 105 inches)—larger on average than the other trees in the plot but not the largest. Nest trees with numerous platforms were important nesting habitat characteristics (Golightly et al., 2009). The study concluded, "It is important to protect stands of old-growth redwoods that contain natural openings in the stand and at individual trees, characteristics that are likely naturally present in areas of undisturbed and unmanaged old-growth forest" (Golightly et al., 2009). Various other studies throughout the species range have also acknowledged the

importance of conserving old-growth stands and stands with old-growth characteristics (Hamer and Nelson, 1995a; Nelson and Wilson, 2002; Baker et al., 2006).

Along their range, marbled murrelet nests are typically found in the top half of the tree; canopy closure directly above the nest site by the nest tree or adjacent trees appears to be preferred as protection from potential predators (USFWS, 2016). In a study of nests in the Pacific Northwest and British Columbia, all nest trees had a DBH of at least 30 inches (7.6 decimeters), with an average of 63 inches (16.0 decimeters) (USFWS, 1997). Stands in which nests were located ranged from 7 acres to 2,718 acres (2.8 to 1,100 hectares), with an average of 509 acres (206 hectares) (Hamer and Nelson, 1995a). The average forest stand age in a sample of 16 nests in the Pacific Northwest and British Columbia was 522 years (Hamer and Nelson, 1995a), and old-growth characteristics were observed in stands as young as 180 years.

One source that illustrates the regional differences in habitat suitability for marbled murrelets is Falxa and Raphael's 20-year report on the status and trends of marbled murrelet populations and nesting habitat (2016b). The researchers developed a model of nesting habitat for marbled murrelets because the species was selected for monitoring under the Northwest Forest Plan due to its nesting association with late successional and old-growth forests. The murrelet was selected as a species for habitat monitoring based on the underlying assumption that murrelets are responding to habitat characteristics used in the models as predictors of nesting habitat. They used species distribution models with presence-only data from known nest locations and a subset of occupied habitat (presumed nesting) to model the distribution and relative suitability of forests within the Northwest Forest Plan area. In California, 126 known points, including known nests and occupied habitat, were used to train the model for predictive purposes. The habitat attributes most important to known nest and occupied sites in California were canopy cover for all conifers, nesting platforms per acre, percentage of a 124-acre (50.2 hectare) circle comprised of large and giant conifer, an old growth index variable, and number of trees per acre greater than 39 inches (9.9 decimeter) DBH. California's modeling results for nesting platforms differed from Washington's and Oregon's, suggesting that the relationship in California may be unique due to redwoods dominating forests (and nesting habitat) and platforms in redwoods having different characteristics than tree species used to the north. The researchers found that the model differentiated nest and occupied sites from other available habitat strongest with California data, indicating a greater degree of predicting habitat suitability when using the above-listed attributes. These results add to the evidence that regional differences in habitat suitability exist, and in California marbled murrelets appear to avoid forested areas lacking key attributes of nesting habitat.

It is important to note that some habitat studies have identified marbled murrelet nesting characteristics outside of the range of what has been observed in California studies. For example, in an unpublished study of marbled murrelet nests in Oregon, Nelson and Wilson (2002) found marbled murrelet nests on limbs as small as 4 inches in diameter at the nest. However, this measurement did not include the diameter of the platform—the portion of tree where murrelets may build an egg cup, usually consisting of epiphytes like moss. In contrast, the smallest limb size in California (11 inches at the nest) did include epiphyte cover in its diameter measurement (Baker et al., 2006). A measurement that includes the platform/epiphyte diameter is a more appropriate metric for forest management purposes, because in the absence of a suitable platform or enough limb structure, a murrelet egg cannot be supported on the limb. Subsequent research has concluded that geographic variation exists in mean nest limb size (Plissner et al., 2015). Another Oregon

study that looked at marbled murrelet nesting habitat found that murrelets occupied stands with scattered trees and that tree density was lower and tree size smaller than "classic" old growth (typically greater than 200 years); its conclusions included that stand structure was more important than stand age (Grenier and Nelson, 1995). Notably, both the Nelson and Wilson (2002) and Grenier and Nelson (1995) studies occurred in Oregon, and they capture the lower end of the spectrum of documented suitable marbled murrelet nesting habitat. In coastal areas of California, however, there are examples of marbled murrelet detections in small stands of residual old-growth trees and in younger stands with residual old-growth trees (Appendix C).

The Pacific Seabird Group (PSG) publication "Methods for surveying Marbled Murrelets in forests: a revised protocol for land management and research" (PSG protocol; Evans Mack et al. 2003) has been widely used from 2003 through 2023 for identifying potential marbled murrelet nesting habitat that is then subject to surveying. Notably, the Pacific Seabird Group protocol uses a filter for suitable marbled murrelet habitat that is driven by empirical and anecdotal possibility rather than scientific probability (Evans Mack 2003). The Pacific Seabird Group protocol provides in part:

> "[P]otential habitat that should be surveyed for murrelets is defined as (1) mature (with or without an old-growth component) and old-growth coniferous forests; and (2) younger coniferous forests that have platforms. A platform is a relatively flat surface at least 10 cm (4 in) in diameter and 10 m (33 ft) high in the live crown of a coniferous tree. Platforms can be created by a wide bare branch, moss or lichen covering a branch, mistletoe, witches' brooms, other deformities, or structures such as squirrel nests. It is important to note that murrelets have occupied small patches of habitat within larger areas of unsuitable habitat (Nelson and Wilson 2001). Some occupied sites also have included large, residual trees in low densities, sometimes less than one tree per acre (0.4 per hectare) (Grenier and Nelson 1995, Ralph et al. 1995). The presence of platforms appears to be the most important stand characteristic for predicting murrelet presence in an area (Hamer et al. 1994). Platform presence is more important than tree size, which alone is not a good indicator of platform abundance (Hamer 1995; S. K. Nelson, pers. comm.). Therefore, any forested area with a residual tree component, small patches of residual trees, or one or more platforms should be considered potential murrelet nesting habitat" (Evans Mack et al. 2003)."

In 2024, The Pacific Seabird Group published a revised protocol (Pacific Seabird Group, 2024) that retained the platform descriptions quoted above. The revised protocol further defined potential marbled murrelet nesting habitat as "coniferous forest stands within the inland limits….with one or more platform trees, where the surrounding forest canopy (surrounding trees or within the platform tree itself) provides some cover and functional protections. Nesting habitat (hereafter called habitat), therefore, has the following components, at a minimum: coniferous stand; one or more platforms in one or more trees; and forest canopy (surrounding trees or within the platform tree itself) that provides cover and functional protection for nest platforms" (Pacific Seabird Group, 2024).

As quoted above and compared with existing literature, the Pacific Seabird Group protocol (2003 and revised 2024) uses a very low threshold for potential marbled murrelet nesting habitat that is based on the mere presence of one or more platforms in a forested area that is not necessarily comprised of old or large trees or stands of trees. The Pacific Seabird Group protocol definition

for platforms is a standard at the low end of the range of potential habitat documented for nesting marbled murrelets (4-inch diameter platform, even though the Nelson and Wilson (2002) study on which the definition is based did not include platform/epiphyte diameter, just limb diameter at nest). The Pacific Seabird Group protocol uses a threshold definition of possible marbled murrelet habitat based on exceptions to the body of science that describes suitable marbled murrelet habitat where higher occupancy and nesting success are based on the quality and probable use of forest stands with larger, older trees and larger platforms at a density that is unrecognized in Pacific Seabird Group's formula of "one or more platforms" in a forested area.

The Pacific Seabird Group protocol (Evans Mack et al. 2003 or Pacific Seabird Group 2024) that is used as a guide to identify potential habitat to survey within the range of the marbled murrelet, may be inadequate for identifying suitable habitat in California because it is based on conditions (i.e., unfragmented old-growth, 180-year-old stands of mature second-growth, hemlock forests, etc.) not observed in California or the Plan Area and is not supported by the latest research from California (Golightly et al., 2009; Baker et al., 2006). Marbled murrelets incorporate many factors into nest site selection (Meyer et al., 2004; Golightly et al., 2009). In California, the selection shown for old-growth forests at the nest tree and stand scales demonstrate that older forests provide the characteristics essential for nesting habitat, while younger forests are less likely to provide the essential characteristics for suitable habitat and nesting success at the stand, tree, and nest levels.

The best available research continues to show that the important attributes of the marbled murrelet nesting habitat are the presence and abundance of mature and old-growth forests, stands of old-growth with undisturbed interior space, low amounts of forest-edge habitat, reduced forest fragmentation, proximity to the marine environment, and forests that are increasing in stand age and height (USFWS, 2019a).

3.5 LISTING STATUS AND THREATS

The marbled murrelet was listed as a federally threatened species under the Endangered Species Act in California, Oregon, and Washington as of September 28, 1992 (USFWS, 1992). State laws offer protections for the marbled murrelet as well: it is listed as endangered in California and Washington, and as threatened in Oregon (USFWS, 2019a). In 2018, the Oregon Fish and Wildlife Commission voted to reclassify the marbled murrelet to endangered, but this decision was subsequently reversed and its status remains as threatened (USFWS, 2019a). In Canada, the marbled murrelet is listed as threatened. It has not been listed in Alaska (USFWS, 2019a). The Service's latest five-year status review in 2019 recommended no change to the marbled murrelet's status (USFWS, 2019a).

The Service originally designated 3,887,800 acres (5,620,215 hectares) of land in California, Oregon, and Washington as critical habitat for the marbled murrelet in 1996. However, approximately 189,671 acres (76,757 hectares) were found to not meet the critical habitat definition in California and southern Oregon in 2011 and were removed, resulting in a final designation of approximately 3,698,100 acres (1,496,574 hectares) of critical habitat. In 2016, the USFWS affirmed that the 1996 designation, as revised in 2011, meets the statutory definition of critical habitat (81 FR 51348) (USFWS, 2019a). In California, 333,813 acres (135,090 hectares) are now designated as critical habitat and approximately 1,400 acres (567 hectares) designated in the MMHCP plan area. The Service's Recovery Plan for the Marbled Murrelet was completed on

September 24, 1997. The Service regularly releases status reviews, with its 2019 version being the most recent.

Marbled murrelets are threatened on a variety of fronts, but the greatest threats to their survival continue to be loss of nesting habitat in old-growth forests, poor reproductive success in the habitat that remains, and variability in ocean conditions.

In the pre-logging era of the early to mid-1800s, millions of acres of old-growth conifer forests blanketed the western portions of California, Oregon, and Washington. Only a small percentage (5 to 20 percent) of original old-growth forests in those states remain (Raphael et al., 2016a). In 2012, 20 years after the marbled murrelet's listing as threatened in 1992, remaining marbled murrelet nesting habitat in California, Oregon, and Washington stood at a total of 2.23 million acres (902,453 hectares) (USFWS, 2019a, citing Raphael et al. 2016a).

In northwestern California, an estimated 1.3 to 3.2 million acres (0.53 to 1.3 million hectares) of old-growth Douglas fir/mixed conifer forest and approximately 2.2 million acres (0.89 million hectares) of old-growth coastal redwood forest once existed in the pre-logging era (USFWS, 1996). At the time of the marbled murrelet's listing in 1992, old-growth coastal redwood forests had been reduced by 85 to 96 percent (USFWS, 1997). At the time of first designation of critical habitat in 1996, approximately 70,000 acres (28,328 hectares) of old-growth coastal redwood forest remained in California (USFWS, 1996). Of the marbled murrelet habitat remaining in California, 66 percent occurs on federal lands and 34 percent occurs on non-federal lands as of 2012 (USFWS, 2019a). In California, higher probability nesting habitat was estimated at 38,564 acres (15,606 hectares) in 2017, an estimated loss of 7.83 percent since 1993 (Lorenz et al. 2021).

This decline in old-growth forest is primarily due to commercial logging and land conversion practices, although natural occurrences such as wildfire and windthrow have also contributed to the loss of habitat (USFWS, 1992; Lorenz et al. 2021). Harvesting of older forest has been concentrated at the lower elevations and along the coastal ranges, generally corresponding with marbled murrelet's range (USFWS, 1992). Certain forest management practices also have resulted in habitat loss: When young-growth forests are managed for timber production on harvest rotations of 40 to 60 years, the trees do not live long enough to develop the characteristics of old-growth trees—namely the large, horizontal limbs that marbled murrelets require for nesting. Such platform characteristics can take at least 200 years to develop (USFWS, 1992).

In addition to loss through direct habitat removal, timber harvest and natural disturbances such as fire can also break up native forest into small, isolated forest patches, causing detrimental fragmentation of marbled murrelet habitat. Fragmentation reduces the amount of interior habitat, isolates remaining habitat patches, and reduces the contiguous nature of the habitat (USFWS 2019a, citing McShane et al. 2004).

Marbled murrelets are believed to be one of the Pacific Northwest seabirds most sensitive to forest fragmentation (USFWS, 1996), which reduces populations and adult survival, increases displacement and predation, and results in fewer nesting attempts, failure to breed, and lower nesting success (USFWS, 2019a). Fragmentation is also an important issue because mature second-growth trees and forest appear to support murrelet nesting only when they occur adjacent to or in close proximity to older forest or residual older forest stands (USFWS 1992).

Further, forest that is fragmented and exposed along its edges leads to changes in the forest environment known as "edge effects," that could adversely affect marbled murrelets through decreased moisture and greater penetration of light, heat, and wind. Small patches of habitat have a greater proportion of edge than do large patches of the same shape (USFWS, 1996). Epiphytes, plants that murrelets use to make their nests, are also less common in edge habitat, and those that remain are more prone to being thrown by wind, as is other forest debris used for nests (USFWS, 2019a; Van Rooyen et al., 2011; Burger et al., 2010). Soft, natural, or "feathered" edges, rather than hard or abrupt edges found around fields or clear-cut, appear to be more beneficial for marbled murrelets, possibly because the vegetative complexity of a feathered edge may better simulate natural edge conditions than abrupt edges (USFWS, 1997). Scientists have observed lower rates of predation near feathered edges compared to abrupt edges (USFWS, 1996). Soft edges also have more epiphytes on branches used as murrelet nest sites than hard edges, although epiphyte presence at hard edges has been shown to increase as forests regenerate (USFWS, 2019a; Van Rooyen et al., 2011).

Perhaps the most significant harmful effect of edge habitat for marbled murrelets is that it makes them more prone to predation. Studies have shown that nests were preyed on more when edge habitat increased (USFWS, 1992). Without the protection of the forest interior, marbled murrelets exposed to edge habitat are closer in proximity to and likely more visible to predators. Potential nest predators include the common raven (*Corvus corax*), Stellar's jay (*Cyanocitta stelleri*), American crow (*Corvus brachyrhynchos*), gray jay (*Perisoreus canadensis*), great horned owl (*Bubo virginianus*), sharp-shinned hawk (*Accipiter striatus*), Cooper's hawk (*Accipiter cooperii*), northern goshawk (*Accipiter gentilis*), and peregrine falcons (*Falco peregrinus*). Addition predators are raccoon (*Procyon lotor*), marten (*Martes caurina*), Townsend chipmunk (*Eutamias townsendii*), northern flying squirrel (*Glaucomys sabrinus*), Douglas squirrel (*Tamiasciurus douglasi*), and fisher (*Pekania pennanti*). Ravens, Steller's jays, peregrine falcons, sharp-shinned hawks, and great horned owls are known predators of eggs or chicks (USFWS, 1992; USFWS, 1996).

Edges are also associated with more human presence and activity, which causes disturbance for marbled murrelets in their nesting habitat and increases the chance of predation. Increased human activities in forests, such as picnic grounds, can attract corvids such as crows and ravens and increase their survival and populations, leading to greater chances of predation on marbled murrelets (USFWS, 2019a). Interior forest nests in contiguous stands of trees far from human activity appear to experience the least predation (USFWS, 1997). Notably, studies have found that while initial edge effects on marbled murrelet predation are negative, those negative effects decrease back toward interior levels of predation as forests regenerate (Malt, 2009; Malt, 2007).

Marbled murrelets' forest habitat is also affected by climate change. Recent research has shown that coastal redwoods have experienced higher-than-expected growth in the past few decades, as decreased fog and cloud cover has allowed more sunlight to penetrate the forest and accelerate wood production (Sillett et al., 2015). Other research suggests that increased concentrations of atmospheric carbon dioxide may initially lead to increased growth and productivity of northwest forests, but some forests may also be challenged by rising temperatures and less precipitation, leading to drought, more severe wildfires with extended fire season, insect infestations that reduce tree vigor and increase mortality, and shifting forest composition (USFWS, 2019a, citing Chmura et al., 2011). In particular, the coast redwood forests, the forest type common in northern

California, are projected to experience a reduction of nearly one-fourth of their range by the late 21st century due to climate change (USFWS 2019a). In short, climate change is expected to exacerbate detrimental loss of nesting habitat and forest fragmentation (USFWS 2019a).

While much attention has focused on the loss of nesting habitat as a threat to marbled murrelets' survival, declining conditions in their marine environment may also be detrimental. Shifts within the ocean due to climate change threaten marbled murrelets' survival in the form of ocean acidification, decreased prey availability, and deadly toxin events. Increasing carbon dioxide emissions causes acidification of the ocean, as a result of carbon dioxide in the air dissolving in surface water; both the surface and upwelled waters of North Pacific Ocean have become more acidic due to carbon dioxide emissions (UWFWS, 2019a). This acidification contributes to harmful algae blooms (HABs), which produce toxins that pose health risks to marbled murrelets (USFWS, 2019a).

In addition, climate change is projected to alter the marine food web, likely reducing murrelet prey quality and quantity, which can negatively impact the birds' health and result in poor breeding success (UWFWS, 2019a). In 2013, a patch of warm water known as "the Blob" formed near Alaska and by 2015 stretched to southern California. With average surface water temperatures 1 to 4 degrees Celsius above average, this warm water anomaly coincided with a devastating harmful algae bloom (HAB). As a result, typical prey species of marbled murrelets saw reduced populations or migrated to cooler water; the lack of high-quality food caused population declines for many fish and seabird species (Cavole et al., 2016). As ocean temperatures continue to increase, more numerous and longer lasting HABs are predicted to occur, and increased temperatures could alter the geographic range of species including seabirds. For opportunistic feeders like marbled murrelets, decreasing prey availability can cause redistribution to different geographic locations and poor reproduction. Another study looked specifically at marbled murrelets and found that variability in ocean temperatures affected prey availability, murrelet dietary composition, and, as a result, murrelet reproductive success (Becker et al., 2007). The study concluded that a warmer marine environment due to climate change would likely reduce marbled murrelets' reproductive success, especially when combined with the effects of overfishing on marine food webs. The study noted that marbled murrelet conservation has been focused on "forest habitats that marbled murrelet use for nesting, with little attention to the effects of marine resources on population dynamics and persistence" (Becker et al., 2007).

Clean, unpolluted water is essential for the survival of the species, as is important for maintaining the health of individual marbled murrelets and their prey species (USFWS, 1996). Because of their extensive use of nearshore waters for foraging and social interaction, marbled murrelets have a high vulnerability to the impacts of oil spills and have been given one of the highest oil spill vulnerability index values among seabirds (USFWS, 1997). Oil pollution has been highlighted as a significant threat or conservation problem for marbled murrelets in areas of its range, including California (USFWS, 1997). Large oil spills result periodically from mishaps by oil tankers and other large ocean-going vessels, offshore oil wells, unloading and loading cargo from onshore and offshore facilities, and onshore facility spills that enter the ocean (USFWS, 1997). In addition to large and medium oil spills, chronic oil pollution (for example, small oil spills and seeps) has been known to occur in coastal areas, and oiled marbled murrelets have been reported separate from larger spills (USFWS, 1997). The dumping of other contaminants and chemicals, including

effluent from onshore sources and direct dumping of chemicals at sea, may also be a source of marine pollution affecting seabirds (USFWS, 1997).

Northern California's population of marbled murrelets in particular faces threats from marine pollution, as Humboldt Bay occurs within this area and has a moderate amount of industrial development and tanker trips; future spills of any size could have a significant impact on this population (USFWS, 1997). The threat of oil and marine pollution in this area and elsewhere along the west coast is likely to increase in the future, although the frequency of spills is difficult to predict (USFWS, 1997).

Fishing nets have also been shown to trap and kill marbled murrelets, although mortality has declined in recent years, due in part to regulations implemented to avoid such outcomes (USFWS, 1996). Since gill net fisheries no longer occur in California, this particular kind of netting is not a major threat to marbled murrelets there (USFWS, 1996). Research has also shown that marbled murrelets may be vulnerable to El Nino events, which may affect prey availability and lead to increased mortality and decreased reproductive efforts (USFWS 1996). Marbled murrelets' particular life strategy (for example, being opportunistic foragers and relatively long lived) help them withstand environmental fluctuations. However, cumulative impacts of ocean pollution and weather events can cause serious impacts on their survival (USFWS, 1996).

In summary, the best scientific information indicates the threats to marbled murrelets show no signs of abating and that the recovery of the species will depend in large part on the maintenance and development of suitable nesting habitat with priority given to unfragmented stands of mature and old-growth forest in proximity to unpolluted marine waters.

3.6 OCCURRENCE IN THE PLAN AREA

In the early- to late-1990s, Arcata Redwood Company (ARCo), a subsidiary owned by Green Diamond Resource Company (formerly Simpson Timber Company) conducted a comprehensive assessment of potential marbled murrelet habitat within an approximately 142,000-acre (57,465-hectare) area considered for inclusion in a habitat conservation plan (HCP) for marbled murrelets. Green Diamond's GIS and forest inventory database were used to identify all areas with various densities of residual trees per acre. These areas were then inspected by representatives from ARCo, Service, and CDFW. Areas identified as potential habitat and scheduled for timber harvest were surveyed. Stands determined to be potentially occupied habitat were protected, and all other stands were harvested. From 1991 through 1996, approximately 1,092.5 acres (442 hectares) of potential habitat were surveyed resulting in 21 occupied stands. One stand of potential habitat, the "Pisgah View" stand (formerly named "R-3") was not surveyed by ARCo biologists, but this 3.9-acre (1.6 hectare) stand was contiguous with a stand owned by the U.S. Bureau of Outdoor Recreation (administered by the U.S. Forest Service) with occupied behaviors observed during surveys in 1993. Therefore, the "Pisgah View" stand was also considered occupied.

Surveys continued through 2001 primarily focusing on stands with prior detections or previously documented occupied behaviors. One stand ("T630") received 40 surveys between 1991 and 1996 resulting in 11 detections but no occupied behaviors. Additional surveys in this stand resulted in occupied behaviors in 1998 bringing the total number of occupied stands to 23. Prior to Green Diamond's acquisition of the former Louisiana-Pacific ownership in 1998, Louisiana-Pacific

conducted murrelet surveys in several watersheds in Humboldt County. The only area of the Louisiana-Pacific ownership where murrelets were detected was in the Maple Creek watershed adding one additional occupied stand to the previous total (n=24).

From 2002 through 2014, Green Diamond and agency representatives continued to apply similar criteria for identifying areas of potential habitat as those procedures implemented 1991 through 2001. Agency field inspections and consultations were focused on larger (> 5 acres, > 2.0 hectare) areas of older forests or mature forests with a high residual component plus field inspections to confirm the presence of platform structures. Some new areas of potential habitat were identified in 2002 through 2014 primarily associated with adjacent federal and state lands, but no additional occupied areas were identified on the Green Diamond ownership. Starting in 2015, agency representatives began applying a different set of criteria to identify areas of potential habitat based on new interpretations of information presented in the revised Pacific Seabird Group protocol (Evans Mack 2003). From 2015 through 2020, identification of potential habitat relied heavily on determinations made by agency representatives during field inspections since the new criteria was not easily observed through traditional remote sensing techniques. This new definition of habitat resulted in a significant increase in areas on the Green Diamond ownership considered potentially suitable for nesting murrelets, and audio-visual surveys were conducted over large portions of the ownership between 2017 and 2021.

In 2020, Green Diamond developed a proprietary habitat suitability model (Appendix A) to help identify areas of potential habitat based on objective criteria derived from known occupied areas on or directly adjacent to the Green Diamond ownership. Areas identified through the habitat model were inspected in the field for potential platform trees, and determinations on habitat potential were made in collaboration with agency representatives.

From 2015 through 2022, ground-based habitat assessments were conducted on greater than 3,000 acres (1,214 hectares), and approximately 1,600 acres (647 hectares) were determined to be potential habitat. Of the approximately 1,600 acres of potential habitat, 628.57 acres (254.4 hectares) received audio-visual surveys resulting in three additional stands considered potentially occupied by marbled murrelets. Thus, a total of 29 occupied stands (755.4 acres, 305.7 hectares) are located within the Plan Area. Detailed stand descriptions and survey summaries are provided in Appendix C.

3.7 OCCURRENCE OF OTHER SPECIAL STATUS WILDLIFE SPECIES IN THE PLAN AREA

This section describes other special status wildlife species that may potentially occur within the Plan Area or Adjustment Area (excluding the proposed Covered Species, the marbled murrelet). Special status species potentially occurring within the Plan Area or Adjustment Area were identified through a query of the California Natural Diversity Database (Diversity Database), Green Diamond resource staff monitoring and observations, and discussions with Service and CDFW. Special status species include:

- Species currently listed, proposed for listing, or candidates for listing under the federal ESA and/or CESA
- Species considered by CDFW as a Species of Special Concern (SSC)

- Species listed as Fully Protected (FP) under California Fish and Game Code
- Species considered sensitive by the California Department of Forestry and Fire Protection (CDF_S)

3.7.1 Special Status Bird or Mammal Species

Thirty-two special status bird and mammal species were identified that have the potential to occur within the Plan Area and/or Adjustment Area (Table 3-1 and 3-2). Three of these species are Covered Species under Green Diamond's Forest Habitat Conservation Plan (FHCP), and the Humboldt marten is a Covered Species under Green Diamond's Marten Safe Harbor Agreement.

3.7.1.1 California Condor Nonessential Experimental Population

The California Condor (*Gymnogyps californianus*) is listed as endangered under the ESA and CESA. On March 24, 2021, the reintroduced California Condor population in the Pacific Northwest was designated as a Nonessential Experimental Population under Section 10(j) of the ESA (16 U.S.C. §1539(j) et seq.) and title 50 of the Code of Federal Regulations (50 CFR 17.81). On November 30, 2021, CDFW determined that the federal ruling was consistent with Fish and Game Code Sections 2080.6 and 3858 allowing incidental take of the experimental population in compliance with the 10(j) regulation adopted for the California Condor population in the Pacific Northwest. This species has been documented within the Plan Area, but no nest sites have been documented. Trees capable of supporting a California Condor nest are present but rare in the Plan Area. Green Diamond is not seeking incidental take coverage for the California Condor population in the Pacific Northwest under this MMHCP. However, Covered Activities (Section 2) will comply with the Service 10(j) rule for this species as implemented through the California Forest Practice Act (Section 1.2.5).

3.7.1.2 Bald Eagle

Western breeding and wintering territories for the bald eagle (*Haliaeetus leucocephalus*), listed as endangered under CESA, includes the Pacific Coast from Alaska to Baja California. Ocean shorelines, lake margins, and other larger watercourses in northwestern California provide essential breeding areas. Nest sites within the Plan Area are typically associated with large live trees or snags with structure above the surrounding canopy. Nesting pairs have been observed along the Mad River, Klamath River, and near other major bodies of water in or adjacent to the Plan Area. Nine nest sites are known to occur in the Plan Area. Similar to the Migratory Bird Treaty Act, Bald and Golden Eagle Protection Act (16 U.S.C. §§ 668-668c) prohibits the "taking" of bald eagles including their parts, nests, or eggs. Green Diamond is not seeking incidental take coverage for bald eagles under the MMHCP, but take avoidance measures for this species are implemented through the California Forest Practice Act (Section 1.2.5).

3.7.1.3 Golden Eagle

Golden eagles *(Aquila chrysaetos)* nest in trees or on cliff ledges and forage in open and semi-open areas. This species has been observed within the Plan Area in association with upland prairie habitat used for foraging. Although trees large enough to support a golden eagle nest are present within the Plan Area, these trees are rare, and no nests sites have been documented. The Bald and Golden Eagle Protection Act (16 U.S.C. §§ 668-668c) prohibits the "taking" of golden eagles including their parts, nests, or eggs. Green Diamond is not seeking incidental take coverage for golden eagles under the MMHCP, but take avoidance measures for this species are implemented through the California Forest Practice Act (Section 1.2.5).

3.7.1.4 Bank Swallow

The bank swallow (*Riparia riparia*) is listed as threatened under CESA. It breeds across North America from Alaska to California, but it winters in the tropics. This species breeds in colonies near riverbanks and creeks and requires vertical banks or bluffs with fine-textured, friable soils to dig nesting holes. Near the Plan Area or Adjustment Area, breeding sites are known near the Mad River at Moonstone Beach, Clam Beach, near the mouth of Luffenholtz Creek, and near Essex Rock along the banks of the Mad River. One colony was observed near Freshwater Lagoon. Several colonies have been observed along the banks of the Eel River, the Van Duzen River, and the Smith River. Colonies have also been observed on coastal bluffs within lands owned by the Smith River Rancheria downstream of the mouth of Rowdy Creek. Nesting colonies for this species have not been identified within the Plan Area, but this species has a moderate potential for occurrence in association with riparian areas within the Plan Area. Green Diamond is not seeking incidental take coverage for bank swallows under the MMHCP, but take avoidance measures for this species are implemented through the California Forest Practice Act and through riparian protection measures implemented through Green Diamond's Aquatic HCP.

Table 3-1. Special Status bird species evaluation table.

Scientific Name	Common Name	Federal Status	State Status	Occurrence in the Plan Area	Occurrence in the Adjustment Area	Comments
Accipiter gentilis	Northern Goshawk	None	SSC, CDF_S	None	Yes	This species nests in mature and old-growth coniferous forests with sparse ground cover. This species is rare or absent from the Plan Area with documented nests in eastern Humboldt County.
Agelaius tricolor	Tricolored Blackbird	None	T, SSC	None	Yes	This species requires open water with protected areas for nesting and is a rare local breeder in Humboldt County. Low to moderate potential for occurrence in the Plan Area.
Ammodramus savannarum	Grasshopper Sparrow	None	SSC	None	Yes	This species is associated with coastal prairies and pastures consisting of short to middle-height, moderately open grasslands with scattered shrubs. This species is known to breed along the coast in Humboldt and Del Norte Counties but is likely rare or absent from the Plan Area given habitat associations.
Aquila chrysaetos	Golden Eagle	None	FP, CDF_S	None	Yes	This species is associated with upland prairie habitat adjacent to forested areas and has been observed foraging in the Plan Area, but no nests documented. Low potential for occurrence in the Plan Area.
Ardea alba	Great Egret	None	CDF_S	None	Yes	Colonial nester in large trees near marshes, tidal flats, rivers and lakes. Moderate potential for occurrence in Plan Area primarily foraging.
Ardea herodias	Great Blue Heron	None	CDF_S	Yes	Yes	Colonial nester in large trees near wet meadows, marshes, lakes, rivers, and streams. Foraging is known to occur in the Plan Area. Five documented rookeries occur in the Plan Area.
Asio flammeus	Short-eared Owl	None	SSC	Yes	Yes	This species requires marshlands, grasslands, or forest clearings. This species has been incidentally observed within the Plan Area, but no known breeding sites. Low to moderate potential for occurrence in the Plan Area.
Athene cunicularia	Burrowing Owl	None	SSC	None	Yes	This species is associated with grasslands or open areas and nests in burrows. This species has been documented in the Adjustment Area but no known breeding sites. Low potential for occurrence in the Plan Area.

Scientific Name	Common Name	Federal Status	State Status	Occurrence in the Plan Area	Occurrence in the Adjustment Area	Comments
Chaetura vauxi	Vaux's Swift	None	SSC	Yes	Yes	This species is associated with conifer forests with large snags. Nesting and/or roosting sites have been observed within the Plan Area with moderate potential to occur in other areas.
Charadrius nivosus nivosus	Western Snowy Plover	T	SSC	None	Yes	This species is associated with sandy beaches, salt ponds, levees, and gravel bars along coastal rivers. Low potential for this species to occur in the Plan Area given the habitat associations.
Circus hudsonius	Northern Harrier	None	SSC	Yes	Yes	This species is associated with open habitats with moderate potential to occur in the Plan Area. This species has been incidentally observed in the Plan Area but no known nest sites.
Coccyzus americanus occidentalis	Western Yellow-billed Cuckoo	T	E	None	Yes	This species is associated with deciduous riparian woodlands and is rare in the Adjustment Area with one occurrence documented in the Diversity Database along the Salt River near the city of Ferndale.
Contopus cooperi	Olive-sided Flycatcher	None	SSC	Yes	Yes	This species is associated with forest and woodland riparian areas and is commonly seen throughout the Plan Area.
Cypseloides niger	Black Swift	None	SSC	None	Yes	This species breeds in small colonies adjacent to waterfalls in deep canyons and coastal bluffs. Low potential for occurrence in the Plan Area as a result of limited habitat availability.
Elanus leucurus	White-tailed Kite	None	FP	None	Yes	This species nests along rivers and marshes and forages in open meadows and grasslands. This species has been observed foraging in areas adjacent to the Plan Area but no documented nests.
Empidonax traillii brewsterii	Little Willow Flycatcher	None	E	None	Yes	Breeding habitat for this species includes riparian areas with extensive monotypic willow meadows associated with large, low-gradient streams and rivers and mixed shrub vegetation in riparian areas associated with streams. Two occurrences are documented in the Diversity Database: one along Rowdy Creek in Del Norte County, and one along the Eel River in Humboldt County. Habitat for this species is present within the Plan Area but no known occurrences have been documented.
Falco peregrinus anatum	American Peregrine Falcon	D	D, CDF_S	Yes	Yes	This species breeds on coastal cliffs or cavities with flat ledges in large diameter snags. Two cliff nests and seven nests in snags are known to occur within the Plan Area.

Scientific Name	Common Name	Federal Status	State Status	Occurrence in the Plan Area	Occurrence in the Adjustment Area	Comments
Gymnogyps californianus	California Condor	E	E, FP, CDF_S	Yes	Yes	The reintroduced California Condor population in the Pacific Northwest was designated as a Nonessential Experimental Population under Section 10(j) of the ESA allowing for incidental take. This species requires large, open areas for foraging and may nest in caves, cliffs, natural cavities, and broken tops of large trees. At least one documented roost site occurs within the Plan Area. Breeding habitat for this species is rare in the Plan Area, but if discovered would be protected through implementation of the California Forest Practice Act.
Icteria virens	Yellow-breasted Chat	None	SSC	Yes	Yes	This species is associated with riparian thickets and early seral forests. Rare occurrences documented in the Mad River area in 1996.
Pandion haliaetus	Osprey	None	CDF_S	Yes	Yes	This species nests in trees/snags near bodies of water. Known nest sites occur throughout the Plan Area.
Progne subis	Purple Martin	None	SSC	Yes	Yes	This species is associated with tree cavities near riparian areas and is occasionally seen in the Plan Area with nests documented in the Korbel area.
Riparia riparia	Bank Swallow	None	T	Yes	Yes	This species is a colonial nester in riparian areas with sandy banks/friable soils. Some nest sites documented along major rivers within the Plan Area.
Setophaga petechia	Yellow Warbler	None	SSC	Yes	Yes	Species associated with riparian woodlands and commonly observed in the Plan Area, but no documented nest sites.
Strix occidentalis caurina	Northern Spotted Owl	T	T, CDF_S	Yes	Yes	Established, monitored sites within and adjacent to the Plan Area. Species is covered by Green Diamond's Forest HCP.

Key to Abbreviations:

State

CDF_S = California Department of Forestry and Fire Protection Sensitive
D = Delisted
E = Endangered
FP = Fully Protected
SSC = Species of Special Concern
T = Threatened

Federal

D = Delisted
E = Endangered
T = Threatened

Table 3-2. Special Status mammalian species evaluation table.

Scientific Name	Common Name	Federal Status	State Status	Occurrence in the Plan Area	Occurrence in the Adjustment Area	Comments
Antrozous pallidus	Pallid Bat	None	SSC	Yes	Yes	Roosts in trees, caves, crevices, and buildings and forages in a variety of open habitats. Species has been observed in the Plan Area and commonly occurs throughout the region.
Arborimus albipes	White-footed Vole	None	SSC	Yes	Yes	Species is associated with mature conifer forests with small streams and dense alder and shrub cover. Rare occurrences within and adjacent to the Plan Area.
Arborimus pomo	Sonoma Tree Vole	None	SSC	Yes	Yes	Species documented throughout the Plan Area and covered by Green Diamond's Forest HCP.
Corynorhinus townsendii	Townsend's Big-eared Bat	None	SSC	Yes	Yes	Species associated with large tree cavities, basal hollows, caves or buildings. Potential Diversity Database occurrences within the Plan Area (non-specific locations from 1945-1949). No confirmed contemporary occurrences.
Martes caurina humboldtensis	Humboldt Marten	T	E, SSC	Yes	Yes	This species has been documented within the Plan Area but no confirmed den locations. This species is covered under Green Diamond's Marten Safe Harbor Agreement and federal MOU.
Pekania pennanti	Fisher	None	SSC	Yes	Yes	This species is common throughout the Plan Area and is covered under Green Diamond's Forest HCP.
Taxidea taxus	American Badger	None	SSC	None	Yes	Species occurs in burrows in friable soils in drier open areas of shrub, forest, or herbaceous habitats. One occurrence record in the Diversity Database in the Adjustment Area. Species is rare with low potential to occur within the Adjustment Area.

Key to Abbreviations:

State
E = Endangered
SSC = Species of Special Concern

Federal
T = Threatened

3.7.2 Special Status Invertebrate Species

Six special status invertebrate species were identified that have the potential to occur within the Plan Area and/or Adjustment Area (Table 3-3).

3.7.2.1 Monarch Butterfly

The Monarch (*Danaus plexippus*) was petitioned for listing under the ESA on August 26, 2014. In December 2014, the Service determined that listing may be warranted and initiated a status review. In December 2020, the Service found that the listing was warranted but precluded under ESA Section 4 (16 U.S.C. §1533 et seq.) due to other listing actions on the National Priority List. The monarch is scheduled to be listed in 2024. Adult monarch butterflies require a diversity of blooming nectar resources during migration and breeding. Monarchs also require milkweed (for both oviposition and larval feeding) embedded within this diverse nectaring habitat. In this region, nectar resources and milkweed are often associated with riparian corridors. Occurrences for this species have not been confirmed within the Plan Area, but migrating species have been observed in coastal areas near the Plan Area. Potential foraging habitat for this species is present within coastal areas of the Plan Area and Adjustment Area, and potential breeding habitat (milkweed) is potentially present further inland within the Adjustment Area. Use of herbicides/pesticides is not a Covered Activity under the MMHCP. Protection to riparian areas is provided through implementation of Green Diamond's AHCP. Additionally, the MMHCP Covered Activities likely create foraging habitat for this species. Green Diamond is not seeking incidental take coverage for the monarch butterfly under this MMHCP. However, the Covered Activities will comply with federal and state regulations or future state and federal permits for this species.

3.7.2.2 Oregon Silverspot Butterfly

The Oregon silverspot butterfly (*Speyeria zerene hippolyta*) is listed as threatened under the ESA and inhabits coastal terrace and headland "salt spray" meadows, coastal dune systems, and montane grasslands where its larval host plant (*Viola* spp.) is found. This species is also commonly referred to as the *Hippolyta frittilary*. One known population is located at Point St. George in coastal Del Norte County near Crescent City. A second occurrence was reported in 1990 from a *Viola adunca* patch in northern coastal dune scrub habitat in Kamph Memorial Park west of Highway 101 and one mile north of the mouth of the Smith River. The third occurrence is located within northern coastal bluff scrub habitat at the northwest side of Lake Earl, about six miles north of Crescent City. This species is not known to occur on the Green Diamond ownership and has a low potential for occurrence in the Plan Area. Green Diamond is not seeking incidental take coverage for the Oregon silverspot butterfly under this MMHCP. However, the Covered Activities will comply with federal and state regulations or future state and federal permits for this species.

Table 3-3. Special Status invertebrate species evaluation table.

Scientific Name	Common Name	Federal Status	State Status	Occurrence in the Plan Area	Occurrence in the Adjustment Area	Comments
Bombus crotchii	Crotch Bumble Bee	None	C	None	Yes	This species is associated with open meadows, grasslands, and shrublands, and wet areas associated with these habitat types. This species primarily persists in southern coastal habitats, but the historic distribution includes Humboldt County. This is not a covered species under this MMHCP, but Covered Activities will promote the development of a mosaic of forest openings mixed with forested riparian areas to support this species and an increasing abundance of flowering plants.
Bombus franklini	Franklin's Bumble Bee	E	C	None	Yes	This species is associated with meadows and grasslands with abundant flowering resources and wet areas associated with these habitat types. The historic range for this species includes northeastern Del Norte County. This is not a covered species under this MMHCP, but Covered Activities will promote the development of a mosaic of forest openings mixed with forested riparian areas to support this species and an increasing abundance of flowering plants.
Bombus occidentalis	Western Bumble Bee	None	C	Yes	Yes	This species is associated with meadows and grasslands with abundant flowering resources. This species historically occupied large portions of California and is now thought to be limited to mostly high elevation meadows and coastal areas. This is not a covered species under this MMHCP, but Covered Activities will promote the development of a mosaic of forest openings mixed with forested riparian areas to support this species and an increasing abundance of flowering plants.

Scientific Name	Common Name	Federal Status	State Status	Occurrence in the Plan Area	Occurrence in the Adjustment Area	Comments
Bombus suckleyi	Suckley's Cuckoo Bumble Bee	None	C	None	Yes	This species is associated with meadows and grasslands with abundant flowering resources and wet areas associated with these habitat types. The historic range for this species includes northeastern Del Norte County. This is not a covered species under this MMHCP, but Covered Activities will promote the development of a mosaic of forest openings mixed with forested riparian areas to support this species and an increasing abundance of flowering plants.
Danaus plexippus plexippus	Monarch (overwintering population)	C	None	None	None	Migrating species may be found along the coast near the Plan Area while potential breeding habitat (milkweed) may be present further inland within the Adjustment Area. No documented occurrences of monarchs or milkweed are known in the Plan Area. Use of herbicides/pesticides is not a Covered Activity under the MMHCP. Although this species is rare and has a low potential to occur in the Plan Area, Covered Activities likely create foraging habitat for this species.
Speyeria zerene hippolyta	Oregon Silverspot Butterfly	T	None	None	Yes	This species is associated with coastal meadows in Del Norte County. The larvae feed only on the foliage of violets, and this species has a low potential to occur within the Plan Area. Extant populations are only known in the vicinity of Lake Earl and Kamph Memorial Park.

Key to Abbreviations:

State
C = Candidate

Federal
C = Candidate
E = Endangered
T = Threatened

3.7.3 Special Status Fish Species

Twelve special status fish species were identified that have the potential to occur within the Plan Area and/or Adjustment Area (Table 3-4).

Table 3-4. Special Status fish species evaluation table.

Scientific Name	Common Name	Federal Status	State Status	Occurrence in the Plan Area	Occurrence in the Adjustment Area	Comments
Acipenser medirostris	Green Sturgeon - Northern DPS	None	SSC	Yes	Yes	Species is associated with coastal watersheds north of the Eel River and known to spawn in the Klamath River.
Cottus klamathensis polyporus	Lower Klamath Marbled Sculpin	None	SSC	Yes	Yes	Species associated with cold, spring-fed streams that have low gradient and adequate aquatic vegetations. Rare or absent in the Klamath River drainage downstream of the Trinity River but one occurrence from 1998 in McGarvey Creek.
Entosphenus tridentatus	Pacific Lamprey	None	SSC	Yes	Yes	Found in stream and river reaches that have relatively stable flow conditions and a mix of deep pools, low velocity rearing areas with fine sand/silt, and silt-free cobble areas upstream of rearing areas.
Lampetra richardsoni	Western Brook Lamprey	None	SSC	Yes	Yes	Associated with coastal rivers and their tributaries with clean gravel near cover for spawning and areas with low flow velocities and fine sediments for rearing that are not excessively scoured under high flows.
Oncorhynchus clarkii clarkii	Coast Cutthroat Trout	None	SSC	Yes	Yes	Occurs within the Plan Area and is a covered species under the Aquatic HCP.
Oncorhynchus kisutch	Coho Salmon - Southern Oregon / Northern California ESU	T	T	Yes	Yes	Occurs within the Plan Area and is a covered species under the Aquatic HCP.
Oncorhynchus mykiss irideus	Steelhead - Northern California DPS Summer-Run	T	E	Yes	Yes	Occurs within the Plan Area and is a covered species under the Aquatic HCP.
Oncorhynchus mykiss irideus	Steelhead - Northern California DPS Winter-Run	T	None	Yes	Yes	Occurs within the Plan Area and is a covered species under the Aquatic HCP.
Oncorhynchus tshawytscha	Chinook Salmon - California Coastal ESU	T	None	Yes	Yes	Occurs within the Plan Area and is a covered species under the Aquatic HCP.
Oncorhynchus tshawytscha	Chinook Salmon - Upper Klamath and Trinity Rivers ESU	C	T	Yes	Yes	Occurs within the Plan Area and is a covered species under the Aquatic HCP.

Scientific Name	Common Name	Federal Status	State Status	Occurrence in the Plan Area	Occurrence in the Adjustment Area	Comments
Spirinchus thaleichthys	Longfin Smelt	None	T	Yes	Yes	Associated with nearshore waters, estuaries, and lower portions of freshwater streams
Thaleichthys pacificus	Eulachon	T	None	Yes	Yes	Associated with the lower reaches of coastal rivers and streams including the Klamath River, Smith River, Mad River, Little River and Redwood Creek.

Key to Abbreviations:

State
E = Endangered
SSC = Species of Special Concern
T = Threatened

Federal
C = Candidate
T = Threatened

3.7.4 Special Status Amphibian and Reptile Species

Five special status amphibian species and one special status reptile were identified that have the potential to occur within the Plan Area and/or Adjustment Area (Table 3-5).

3.7.4.1 Northwestern Pond Turtle

The Northwestern pond turtle (*Actinemys marmorata*) was petitioned for listing in July 2012. On April 10, 2015, the Service published a 90-day finding that listing may be warranted. On October 3, 2023, the Service proposed to list the species as threatened along with rules listed under section 4(d) of the ESA. This species is semi-aquatic using aquatic habitat for breeding, feeding, overwintering, and sheltering and upland habitat for nesting, overwintering/aestivation, and dispersal. This species is present within the Plan Area along portions of the Mad River, Smith River, Klamath River, Van Duzen River, and Redwood Creek areas. Green Diamond is not seeking incidental take coverage for northwestern pond turtles under the MMHCP, but take avoidance measures for this species are implemented through the California Forest Practice Act and through riparian protection measures implemented through Green Diamond's Aquatic HCP.

Table 3-5. Special Status amphibian and reptile species evaluation table.

Scientific Name	Common Name	Federal Status	State Status	Occurrence in the Plan Area	Occurrences in the Adjustment Area	Comments
Actinemys marmorata	Northwestern Pond Turtle	PT	SSC	Yes	Yes	This species is associated with ponds and slow-moving riverine reaches within the Plan Area. Several known occurrences from the Mad River, Smith River, Lower Klamath, Van Duzen River, and Redwood Creek Areas. This species also occurs within the Adjustment Area in southern Humboldt County.
Ascaphus truei	Coastal Tailed Frog	None	SSC	Yes	Yes	This species is associated with cold, fast-flowing, perennial streams with dense vegetation cover or streams in steep-walled valleys in non-forested areas. Larval tailed frogs require suitable gravel and cobble for attachment sites and diatoms for food. This species is common in the Plan Area in permanent streams with suitable substrate and is covered under Green Diamond's Aquatic HCP.
Rana aurora	Northern Red-legged Frog	None	SSC	Yes	Yes	This species is associated with quiet, permanent pools of streams, marshes, and ponds, as well as riparian areas. This species is also found occupying drainage ditches. This species is common throughout the Plan Area and region.
Rana boylii	Foothill Yellow-legged Frog - North Coast DPS	None	SSC	Yes	Yes	This species is associated with gently flowing, low-gradient stream sections with variable substrates. Known to occur in most Class I and Class II watercourses in the Plan Area. Not a covered species under the Aquatic HCP but Aquatic HCP riparian protection measures benefit this species.

Scientific Name	Common Name	Federal Status	State Status	Occurrence in the Plan Area	Occurrences in the Adjustment Area	Comments
Rhyacotriton variegatus	Southern Torrent Salamander	None	SSC	Yes	Yes	This species is associated with cold, well-shaded permanent streams with loose gravel substrate, springs, headwater seeps, waterfalls, and moss covered rock rubble with flowing water. This species is common in the Plan Area and a covered species under the Aquatic HCP.
Taricha rivularis	Red-bellied Newt	None	SSC	None	Yes	This species is associated with rapid-flowing, permanent streams (breeding and egg-laying) within redwood forests, mixed conifer forests, valley-foothill woodland, montane hardwood, and hardwood-conifer habitats. This species is not known to occur within the Plan Area. Within the Adjustment Area, this species occurs in southern Humboldt County.

Key to Abbreviations:

State
SSC = Species of Special Concern

Federal
PT = Petitioned for Listing as Threatened

Section 4. Physical Setting and Forest Habitat Conditions of the Plan Area

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4.1 INTRODUCTION

This Section describes the physical setting and general climatic conditions of the Eligible Plan Area (EPA). We then describe marbled murrelet habitat within the Plan Area (PA) as defined by a habitat suitability model (HSM) developed by Green Diamond to characterize forested areas known or presumed occupied by marbled murrelets. We describe predictions of potential habitat based on the HSM for the Plan Area and use that information as a basis for analyzing other commercial timberlands in the Eligible Plan Area using available remote sensing information on forest habitat conditions.

4.2 PHYSICAL SETTING OF THE PLAN AREA

The Plan Area is proximal to the Pacific Ocean within Del Norte and Humboldt Counties of northwestern California. The two-county area covers approximately 4,596 square miles (11,903 km^2), extends up to 45 miles inland from the coast, and spans 135 miles north to south from the California-Oregon border to the Humboldt and Mendocino County line. The area is generally referred to as the Six Rivers region due to the major river systems flowing in a geologically influenced northwesterly direction to the Pacific Ocean. The six major river systems from north to south include the Smith River, Klamath River, Trinity River, Mad River, Van Duzen River, and Eel River. Other major watershed areas include Redwood Creek and the Mattole River. The area encompasses significant Native American ancestral lands and is home to numerous Native American Tribes within the region[1]. The Plan Area is home to the tallest tree canopies in the world, the coast redwood (*Seqouia sempervirens*) forests, and is among the most productive forest ecosystems in the United States. The region is also well known for the forest resources and recreational opportunities provided by both public and private lands.

4.2.1 Climate, Precipitation, and Temperature within the Eligible Plan Area

Analysis of climate conditions within the Eligible Plan Area is constrained to the Plan Area and Adjustment Area (AA). Thirty-year normal precipitation and air temperature minimum, mean, and maximum values (PRISM 2023) are compared between the PA and AA. Localized variation exists and is visible in the variation in the minimum and maximum values, but overall, the strong similarities between the PA and AA are evident.

The North Coast of California averages a temperate Mediterranean climate. Along the Pacific Ocean, winters are generally mild and rainy, and summers mild, cool, and dry. Further inland, weather varies from the oceanic climate and temperatures increase throughout the year into a hot summer. Variation is generally low along the coast as maritime influences dominate, with decreasing affect inland.

Normal annual precipitation varies spatially across the PA and AA from a 30-year average minimum of 40.0 inches (101.6 centimeters) to an average maximum of 150.9 inches (383.3 centimeters), and an area weighted mean of 70.2 inches (178.3 centimeters) (Figure 4-1). This

[1] Native American tribes within the Plan Area published from the CalFire Native American Contact list https://www.fire.ca.gov/what-we-do/natural-resource-management/environmental-protection-program/cultural-resource-management

variation typically results in higher rainfall in the north and along the major ridgelines extending from the northwest to southeast as orographic effects dominate high precipitation rate events. Precipitation within the year is concentrated in the winter months from October through March with fog concentrating along the coastline in the summer months. Variation between the PA and AA is low (3.4 inches, 8.6 centimeters) for the minimum and moderate (8.0 inches, 20.3 centimeters) for mean rainfall values, however the average maximum rainfall difference is much higher, with the AA receiving more than 24.9 inches (63.2 centimeters) more than the PA.

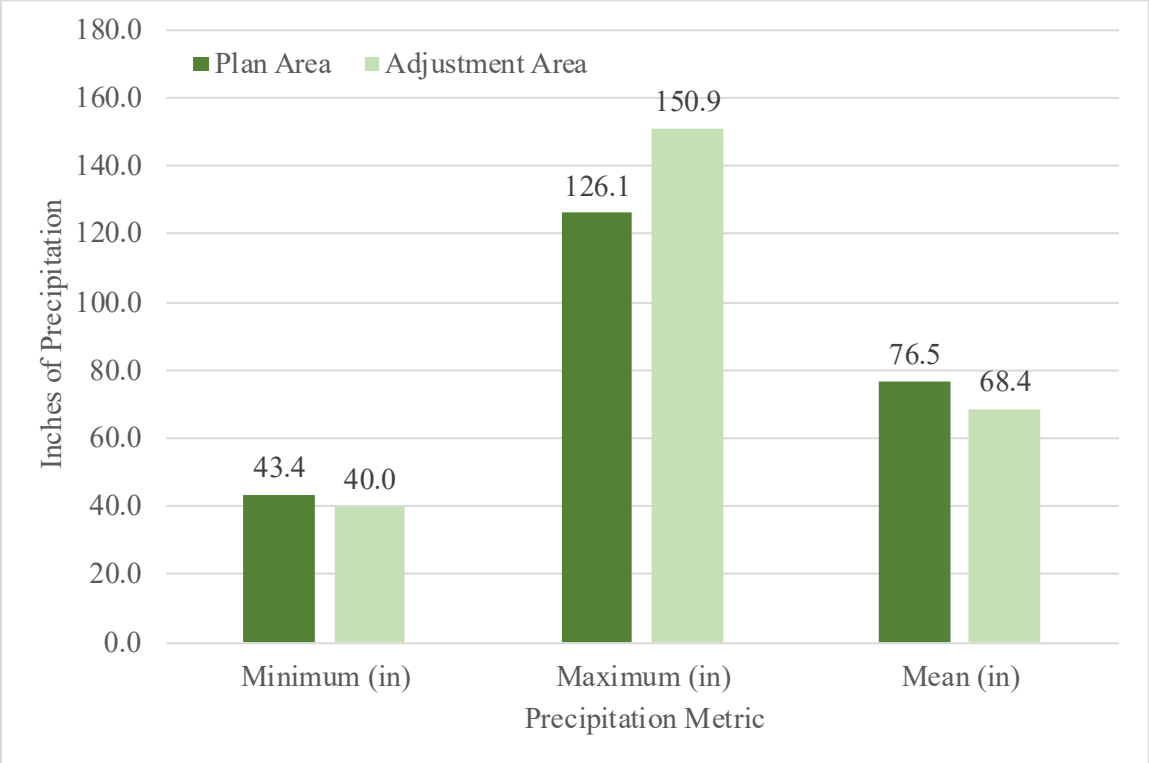


Figure 4-1. Normalized 30-year minimum, maximum, and mean precipitation values within the Plan Area (PA) and Adjustment Area (AA).

Normal annual air temperature varies spatially across the PA and AA from a minimum of 29.1 °F to a maximum of 90.7 °F with cooler extreme minimum temperatures concentrated inland and in the north and warmer extreme maximums found further inland from the coast. Overall, mean yearly minimum, mean, and maximum normal temperature show minor variation between the PA and AA.

The mean yearly minimum air temperature differs between PA (38.3 °F) and AA (37.8 °F) by 0.5 °F with warmer minimum temperatures concentrated coastally due to the oceans ameliorating winter's effect on climate extremes (Figure 4-2). The mean yearly maximum air temperature differs between PA (77.0 °F) and AA (80.5 °F) by 3.5 °F with warmer minimum temperatures concentrated inland due to the oceans ameliorating summer's effect on climate extremes. The mean yearly mean air temperature differs between PA (54.3 °F) and AA (54.7 °F) by 0.4°F with warmer mean temperatures concentrated coastally due to the oceans ameliorating overall effect on climate extremes. Overall mean differences in the yearly minimum and mean temperatures between the PA and AA are low (0.4-0.5 °F), with a difference of 3.5 °F in the mean maximum.

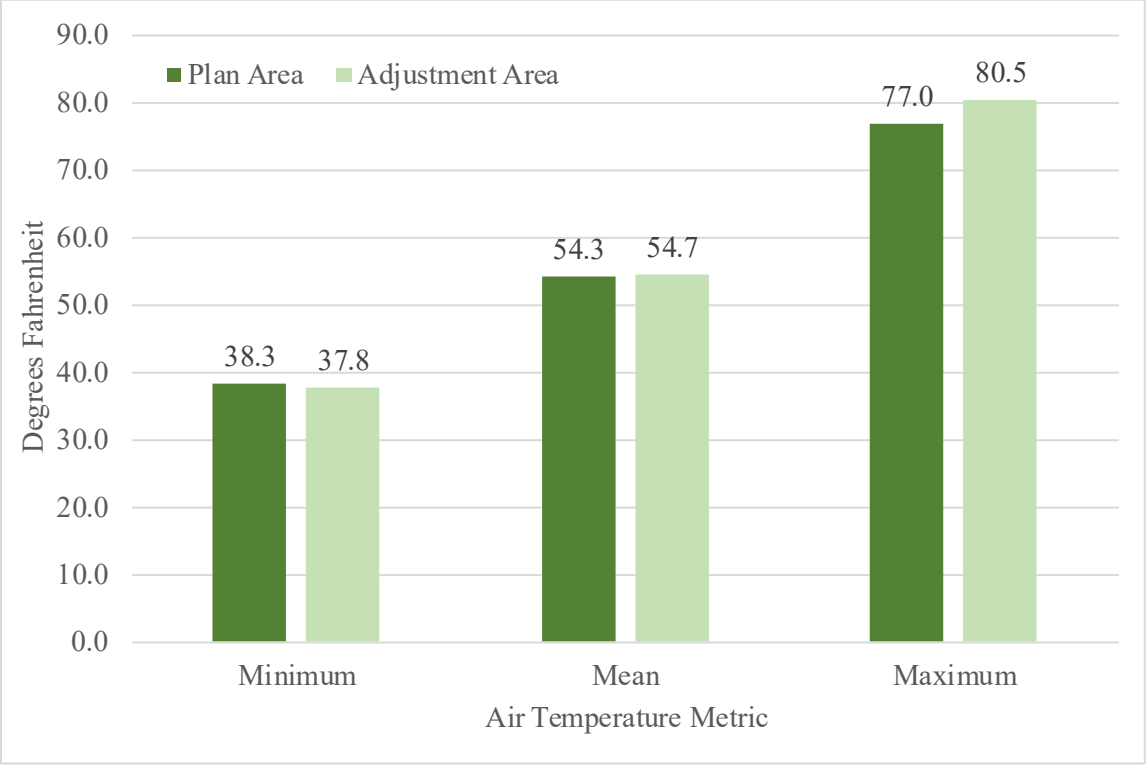


Figure 4-2. Normalized 30-year air temperature minimum, mean, and maximum values within the Plan Area (PA) and Adjustment Area (AA).

4.2.2 Climate Change, Forest Management, and Effects on the Marbled Murrelet

Climate conditions in the Eligible Plan Area are subject to long-term change that may affect the habitat and population of the marbled murrelet. A robust scientific debate exists concerning the natural and anthropogenic causes of climate change, the rate of change, and the response of plant and wildlife communities across and within specific landscapes such as the Eligible Plan Area. The causes and rates of climate change are uncertain (IPCC 2007). It is certain that the earth's climate has changed in the past with variable cooling and warming trends. It is likely that climate change will continue in the future, but it is very difficult to reliably predict the rate of climate change or the regional or localized effects on temperatures, precipitation, growing seasons, drought, vegetation, habitat and wildlife (IPCC 2007), including regional or localized effects within the Eligible Plan Area.

Potential natural causes of climate change include solar activity and extraordinary volcanic eruptions. The Earth's climate has changed and warmed due to natural causes since the end of an "ice age" in the past 10,000 years. Forests and marbled murrelets apparently have evolved and adapted to such natural climate changes. There is now a growing body of research about how global warming and the rate of climate change may be driven by human activity. A leading theory of anthropogenic climate change is that human-caused emissions of greenhouse gases (GHGs) that promote warming in the Earth's atmosphere have resulted, and will continue to result, in changes to global climate patterns (IPCC 2013). GHGs are defined as any gases that absorb infrared radiation in the atmosphere including water vapor, carbon dioxide (CO_2), methane, nitrous oxide,

hydrochlorofluorocarbons, ozone, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride (CARB 2017). Forest management is a human activity that can contribute to and mitigate or reduce atmospheric GHGs that contribute to climate change.

Notwithstanding the difficulty and uncertainty of forecasting climate change and predicting physical and biological responses, in Section 3.5 and in this Section 4.2.2 of the MMHCP we assess how climate change could affect marbled murrelets and how management of the Plan Area by Green Diamond may contribute to GHG emissions while also buffering against climate change and its effects on marbled murrelets. We conclude that Green Diamond's forest management in the Eligible Plan Area is beneficial as a buffer against the threats and impacts of climate change, and implementation of the proposed MMHCP would have a small but beneficial effect in mitigating GHG emissions that may contribute to climate change and its threats to the marbled murrelet.

4.2.2.1 Climate Change as a Threat to Marbled Murrelets

Scientific research on the consequences of anthropogenic climate change focuses on how accelerated warming of the atmosphere and corresponding changes in climatic conditions may affect marine and terrestrial systems. In the long term, climate change may affect the habitat and population of marbled murrelets in two primary ways: changes in ocean conditions and disturbance of nesting habitat (USFWS 2024). The climate change threats to murrelets caused by changes in ocean conditions and loss of nesting habitat are described below, in Section 3.5 of this MMHCP, and in a comprehensive summary with supporting references in the Species Biological Report for Marbled Murrelet (USFWS 2024), which this HCP incorporates by reference.

Significant, long-term changes in ocean currents, acidity, and temperatures could alter the nutritional quality, availability and abundance of fish species that murrelets rely on for forage at particular times and locations in their life cycle (Hyrenbach and Veit 2003, Peery et al. 2004, Hedd et al. 2006, Piatt et al. 2020, Cushing et al. 2023, USFWS 2024). Generally, increased foraging opportunities are beneficial to murrelet survival and recovery and decreased foraging opportunities are detrimental to their survival and recovery (USFWS 2024). But it is also particularly important that healthy forage conditions exist close to murrelet nesting habitat during the nesting season when breeding murrelets are making daily flights between the ocean and nesting stands to feed their chicks. The better the availability of proximate, high-quality forage, the better the reproductive success (USFWS 2024). When forage close to nesting stands is scarce or of poor quality during the nesting season, the success of murrelet reproduction can be expected to decrease (USFWS 2024). However, forecasting predicted climate change impacts on ocean currents, pH, and temperatures, and corresponding changes to prey availability and abundance, in the immediate vicinity of the Eligible Plan Area over a particular period of time is not feasible based on available scientific literature. Studies are not available that directly project the effects of marine climate change on murrelets (USFWS 2024).

Because optimal marbled murrelet nesting habitat requires old growth and mature forest stands with old and large trees and a multi-layered canopy, optimal nesting habitat requires centuries to develop. Historic logging and other land uses previously removed a good deal of marbled murrelet nesting habitat, and the remaining occupied and suitable nesting habitat stands are somewhat rare, particularly within the landscape of managed forests. Such remnant stands are resilient enough to

persist and grow for centuries, but they are vulnerable to degradation when disturbed by wildfire, floods, pests, landslides, development, and logging (USFWS 2024). Any disturbance that substantially damages or eliminates these marbled murrelet nesting stands may adversely affect marbled murrelet reproduction (USFWS 2024). Climate change leading to long-term changes in temperature and precipitation may also adversely affect the reproductive success of marbled murrelets (USFWS 2024) through changes to nesting habitat (i.e. coastal old growth forests and structurally complex mature coastal conifer forest stands (Divoky and Horton 1995, Raphael et al. 2002).

Warming temperatures and reduced precipitation due to climate change may degrade and destroy existing nesting habitat and retard the development of new nesting habitat through drought and reduced coastal fog that stresses trees and erodes forest health by slowing growth, reducing resistance to pests and disease, and enhancing the risk of stand replacing wildfire (Johnstone and Dawson 2010, USFWS 2019b, USFWS 2024). Modeling climate change effects on coastal redwood forests on the southern extent of the range of the marbled murrelet in California predicts that those forests are particularly vulnerable to drought and stand-replacing wildfire that will degrade and remove murrelet nesting habitat in that geography (EcoAdapt 2021, EcoAdapt 2024). A modeling exercise for climate change effects on all coastal redwood forests in California and southern Oregon predicts a small and temporary northern expansion of 3 percent in the range of redwood by 2050 followed by a 23 percent reduction in the range of coastal redwood forests by 2080 (USFWS 2024 *citing* DellaSala et al. 2018, p. 237). However, most of this predicted reduction in range affects redwood forests at the southern margin of their range, which is south of the Eligible Plan Area (DellaSala et al. 2018). A smaller portion of the predicted reduction in the range of redwood by 2080 occurs along the eastern margin of the Eligible Plan Area, which would affect redwood forests that are the most distant from the coast and already at the margin of murrelet nesting habitat.

Notwithstanding these evolving studies, there is uncertainty about how climate change will affect forest habitat in all forest landscapes—at both the local and regional scales (Petr et al. 2019, Maxwell et al. 2022, Djahangard et al. 2024). There is even the possibility that certain forest stands are more resilient in responding to climate change or benefit from localized effects of climate change (Baker et al. 2023). Research on the response of old growth and mature redwood forests in the heart of the redwood forest range on the north coast of California finds that global warming has increased the rate of growth for some redwood trees or sustained their growth even through periods of periodic drought (Save the Redwoods League 2013, Brodrick 2019, Sillett et al. 2022, Phys. Org 2023, USFWS 2024). Redwood trees are well adapted for survival of climate-related disturbances such as wildfire, pests, flooding and extraordinary sediment deposition (O'Hara et al. 2017). Research has also shown that coastal redwoods have experienced higher-than-expected growth in the past few decades, as decreased fog and cloud cover has allowed more sunlight to penetrate the forest and accelerate wood production (Sillett et al. 2015). Thus, while the impacts of climate change on habitat availability within the Eligible Plan Area for a particular period of time cannot be accurately predicted, these findings support a more optimistic view of the long-term resilience and recruitment of old growth and complex, mature forest nesting habitat within the northerly portions of the murrelet's range in California—including the Eligible Plan Area—notwithstanding climate change impacts.

4.2.2.2 The Direct and Indirect Effects of Forest Management on Climate Change

Green Diamond does not manage the Earth's atmosphere, and the effects of Green Diamond's forest management on climate change are insignificant at the global scale. Green Diamond has no ability to directly alter global climate change effects that may impact the murrelet, such as changes in ocean currents, temperatures, or precipitation, through its covered activities. Nevertheless, Green Diamond's management at the landscape scale may contribute to or buffer against climate change and related effects on marine or terrestrial habitat for the murrelet. Green Diamond's management of forests in the Plan Area may directly affect climate change through the emission of GHGs that promote climate change, but its management may buffer and slow climate change through the removal of CO_2 from the atmosphere via photosynthesis and sequestration of carbon in forest plants, forest soil, and forest products (Environmental Protection Agency 2024, OFRI 2007).

Forest management activities that generate GHG emissions into the atmosphere are primarily associated with fossil fuel combustion for timber harvesting and site preparation, prescribed burning, and fertilization (Sonne 2006, Han et al. 2015). Forest management activities that remove GHGs (primarily carbon dioxide) from the atmosphere are the growing of trees and other vegetation, the retention of standing timber, conservation of forest soil, and the conversion of timber into long-lived wood products that store carbon at the same time that a new generation of trees is planted and grown using more atmospheric carbon. This cycle of sustainable forest management is a form of carbon sequestration. The life cycle of forest products and byproducts also reduces GHG emissions when wood products and byproducts are substituted for more GHG-intensive building products like concrete and steel, or more GHG-emitting energy sources like fossil fuels.

Following each timber harvest in the Plan Area, Green Diamond manages slash to reduce fire risk and enhance forest soils that will host the next rotation of forest growth. Timber stands are promptly replanted and regenerated with healthy seedlings that combine with coppice regeneration of tree sprouts from each harvested redwood and some hardwoods to immediately begin to fix carbon through photosynthesis. Because the seedlings require a substantial investment by Green Diamond, there is a strong financial incentive to efficiently and effectively re-establish growing forests and timber production on harvested areas. For the same reason, there is a strong incentive to protect growing tree stands from mortality that adds to forest fuels and to aggressively prevent and suppress wildfires. Intensive management of Green Diamond timberlands provides a cumulative climate benefit of reducing the risk of catastrophic fire and related adverse impacts of reduced carbon sequestration and increased GHG emissions.

After timber harvest, tree fibers such as branches and tops are left in the forest where they are sometimes burned to reduce fire hazard. However, the vast majority of this material is left to decay and will emit CO_2 over time even as it supplements the forest soils and forest duff layer where carbon is stored and serves as a substrate and nutrient for more tree growth. In addition, redwood is a dominant tree species in the Plan Area and redwood slash decays more slowly than slash from hardwood and whitewood species. Further, when CO_2 is released by decaying slash, it is offset by rapid regeneration of tree stands (including sprouts from redwood and hardwood species) and other vegetation that sequesters carbon. Some of the carbon-filled tree fibers, such as bark, shavings, and chips, are by-products of converting a tree to lumber and they are used in other engineered

building products or as fuel used to generate electricity or steam to dry lumber. When bark, shavings, and wood chips are burned to generate electricity or steam, there are CO_2 emissions that would nonetheless occur if the bark and chips were allowed to simply decay. When wood waste is used to generate electricity, these inevitable emissions are then substituted for avoidable emissions from the combustion of fossil fuels such as coal and oil to generate electricity (Bergman et al. 2014). The substitution effect of using biogenic emissions from wood fuel combustion involves the cycling of carbon already available to the atmosphere rather than the use of fossil fuels, which releases CO2 that would otherwise remain sequestered in mineral, oil, and gas deposits that remain in the earth's crust and unavailable to the atmosphere (Bergman et al. 2014).

Several studies have rigorously examined the net atmospheric effects of GHG emissions, carbon sequestration, and resource substitution across the entire life cycle of forest management and lumber manufacturing sourced from sustainable timber harvest and planting. These studies have concluded that the direct and indirect climate effects of forest management combined with softwood lumber manufacturing for all conifer species on the U.S. Pacific Coast are at the very least carbon neutral (American Wood Council 2024). More often, managed forests are considered to be a carbon sink (Gregor et al. 2024). Managed forests therefore help mitigate climate change by reducing atmospheric GHG concentrations through the carbon sink in the forest and in wood products, and substitution effects when wood products replace carbon-intensive materials and fuels (California Forest Climate Action Team 2018, World Resources Institute 2021). Research on redwood lumber production representative of the Eligible Plan Area in California finds that the redwood forest products system removes substantially more GHG from the atmosphere than it emits over its management and manufacturing life cycle (Sahoo et al. 2021). Redwood lumber production acts as a carbon sink: over the life cycle, final products store about 4 (range 3–5) times more GHG than is released (Sahoo et al. 2021). The amount of carbon stored in redwood decking is approximately 10 times the total CO_2 emissions released during its manufacturing (Bergman et al. 2014). Notably, these assessments have specifically examined the carbon footprint over the lifecycle of the redwood forest products industry, which is centered in the Eligible Plan Area and uses data and assumptions on sustainable management, manufacturing, and by-products that are particular to Green Diamond's forest management regime and markets (Bergman et al. 2014, Han et al. 2015). Green Diamond's forest management regime provides a substantial climate benefit that is a sustainable, annual, and long-term net reduction in atmospheric GHG.

4.2.2.3 Green Diamond Forest Management Contributes to Enhanced Carbon Sequestration and Forest Resilience

Green Diamond's current management framework for forests in the Plan Area is sustainable and provides enhanced net carbon sequestration and forest resilience benefits that buffer and mitigate the effects of climate change. Key elements of the management framework include California laws governing land use, forest practices, and reduction of GHG emissions, as well as Green Diamond's voluntary, enforceable, long-term commitments to carbon sequestration and fish and wildlife conservation.

California law promotes and requires sustainable forest management through land use regulation, tax policy, and forest practices regulations. Most of the forest land in the Eligible Plan Area is zoned and regulated as Timber Production Zone. Timber Production Zone land cannot be de-forested and converted to other land uses without exceptional local government actions such as

rezoning, which is very difficult to obtain and would only be allowed on a small scale near urban boundaries. By maintaining forest lands in Timber Production Zone status, the State of California is promoting long-term sustainable management of forests as a preferred land use. This is further promoted by California tax policies that reduce the property tax incident on forest lands dedicated to long-term timber growth and recoup tax revenue through excise taxes on timber when it is harvested. The sustainable management of commercial forests is further guaranteed by California Forest Practice Rules (Forest Practice Rules), which require responsible forestry that conserves soils and protects water quality, fish, and wildlife. Key among the Forest Practice Rules requirements is long-term planning for Maximum Sustained Production. Green Diamond's Option A plan demonstrates compliance with the Forest Practice Rules requirements for achieving Maximum Sustained Production. The Option A plan establishes that growth will match or exceed harvest in Green Diamond's ownership over a 100-year planning horizon and during each 10-year period. California's legal requirements for forest management are the foundation for the studies discussed in Section 4.2.2.2 above, which find that California's forest industry delivers a net carbon sequestration result that more than offsets emissions associated with timberland management, timber harvest and forest products manufacturing.

The cumulative beneficial climate impact of Green Diamond's current forest management framework has been previously recognized by the Service in section 4.2.3.2 (Cumulative Effects on Climate Change) of the Final Environmental Impact Statement for the FHCP approved by the Service, which provides:

> *The accumulation of GHG in the atmosphere is thought to be the product of both natural processes and anthropogenic sources that have emerged over several centuries and become detectable at a global scale. Human activities in the region, including the covered activities, probably contribute to the accumulation of GHG in the earth's atmosphere, but the contribution is negligible in comparison to other regions of human activity and significant natural sources. Public, tribal, and private timberlands in the region make a significant contribution to carbon sequestration . . . . The result is more carbon being sequestered on these lands than being released to the atmosphere. To the degree that forest ecosystems can be maintained over other land uses, carbon sequestration will continue to occur in the area. Under the No Action Alternative, maintaining forest ecosystems is enhanced through the continued management of timberlands for the sustained yield of forest products and the continued restrictions on forestland conversions as a result of the TPZ and other zoning. In addition, other efforts to mitigate GHG generation (e.g., use of forests as carbon offset mitigation banks) may further contribute to the long-term sustainability of the forestry sector. Maintaining the forest landscape in the region under all alternatives, including the No Action Alternative, is expected to positively contribute to overall trends in sustaining the forest landscape for carbon sequestration. This trend would result in a beneficial cumulative effect. (USFWS 2019b)*

California law also promotes reduced GHG emissions through policies that reduce the carbon footprint of energy and technology used in forest management by Green Diamond. The California Global Warming Solutions Act of 2006 (AB 32) is California's legislative effort aimed at reducing GHG emissions. Pursuant to AB 32, the California Air Resources Board (CARB) must develop

an implementation program and adopt control measures to achieve the maximum technologically feasible and cost-effective GHG reductions. California has established a GHG reduction target of 40 percent below 1990 levels by 2030 leading to carbon neutrality no later than 2045 and maintenance of net negative emissions thereafter. As a result of these policies, the GHG emissions from Green Diamond's operations in California will continue to decline. For example, California law requires the phasing out of older internal combustion engines used in commercial trucks and other motorized equipment so that businesses invest in newer engines that are more efficient and emit less GHGs per unit of operating time. In addition, the electric power supply used by Green Diamond and all of its suppliers and customers continues to emphasize renewable sources and reduced reliance on fossil fuels for power generation.

Compliance with California law undergirds the finding that commercial forest management and forest products manufacturing provide cumulative, long-term carbon sequestration benefits in excess of GHG emissions. But there is more that Green Diamond currently incorporates into its management that enhances carbon sequestration and forest resilience to buffer and mitigate the adverse effects of climate change. Currently, Green Diamond is implementing three improved forest management carbon offset compliance projects on its California Timberlands within and near the Eligible Plan Area: Humboldt (33,218 acres), Willits Woods (17,682), and Lord Ellis (1,933 acres). Each of these projects have been approved by CARB for the issuance of carbon offset credits that may be acquired to offset regulated GHG emissions in California. The projects reflect an enforceable commitment by Green Diamond to maintain credited forest carbon sequestration stored in these portions of the Plan Area for at least 100 years. Further, Green Diamond has committed to sustainably manage its forests subject to third party verification and auditing to maintain sustainable management certification under the Forest Stewardship Council (FSC) criteria. As a result, Green Diamond goes beyond compliance with the Forest Practice Rules to retain additional standing trees in and around harvest units and to manage for resources other than harvested trees.

Not all of the Green Diamond timberlands are dedicated to timber harvest and regrowth under intensive forest management. Over 25 percent of the Plan Area remains unharvested or lightly harvested to provide various fish, wildlife, and ecosystem benefits. Under Green Diamond's Aquatic Habitat Conservation Plan, extensive riparian management zones extend like a web across Green Diamond's property, and within those zones, most trees will grow into older stands with large trees and a multilayer canopy. Likewise, there are channel migration zones and areas of unstable slopes caused by a variety of geological features that will also experience little or no harvest such that more trees will grow old and large in many locations. Under Green Diamond's Forest HCP, dynamic core areas protect many northern spotted owl nesting stands beyond normal harvest rotation age, and large areas of the property remain unharvested for decades beyond an intensive forest management rotation because they provide additional northern spotted owl nesting and roosting habitat. The Humboldt Marten Safe Harbor Agreement approved by the California Department of Fish and Wildlife sets aside a no-harvest marten reserve and requires operating buffers around marten dens located in the Plan Area. The impact of these reserve areas with little or no harvest is a diversification of Green Diamond's timber portfolio that provides additional carbon sequestration and forest resilience.

There are several indications that Green Diamond's timberlands have been and continue to be resilient. After more than a century of timber harvest, most of which occurred without the benefits

of modern forest practices regulations and best management practices, Green Diamond's timberlands remain among the most productive forest lands in the world. A key tree species on Green Diamond timberlands is the California redwood (*Sequoia sempervirens)*, which is the epitome of resilience, having persisted for millennia in the coastal climate of northern California (O'Hara 2017). Redwood trees are equipped by evolution with an array of biological defenses to pests and wildfire risks that may increase with global warming (O'Hara 2017, Sillett 2021). Most of Green Diamond's Plan Area lies at the northern heart of the redwood range where redwood trees are least vulnerable to higher temperatures and reduced precipitation (Save the Redwoods League 2013, Brodrick et al. 2019, Sillett et al. 2022, Phys.Org 2023, USFWS 2024).

The redwood tree also benefits from coppice regeneration, which means that it regenerates from the stump after a tree has been harvested (O'Hara 2017). As such, much of the living root system of redwood trees persists and the genetic diversity of each individual tree is preserved on the landscape as cut trees are replaced by genetically identical sprouts that grow from the same root system (O'Hara 2017). For the same reason, the regeneration and growth of redwood forests after harvest occurs quickly and with more certainty because young trees have the benefit of mature root systems. The resilience of these lasting forests is also supplemented by required planting of seedlings to promote healthy stocking levels on every harvested area.

In addition to redwood, Green Diamond's timberlands grow hearty and resilient tree species such as Douglas-fir that thrive in open stands following even-age harvest. Douglas-fir grow in a variety of climates throughout western North America and are believed to be highly adaptive based on rapid colonization that established vast forestlands following the end of the last Ice Age. The genetic makeup of Douglas-fir "offers considerable potential for adaptive differentiation and acclimation to a variable climate" (Leuschner and Meinzer 2024). Through its substantial and continuous investment in reforestation and productive regeneration of forest stands, Green Diamond has a strong incentive to nurture healthy and resilient forest stands on its property. The resilience of Green Diamond's timberlands is also apparent in the thriving wildlife populations that inhabit the property. More than a century of active forest management has produced a mosaic of timber stands where sensitive species such as the northern spotted owl and fisher thrive at densities that surpass almost any other habitat in North America. The resilience of Green Diamond's Plan Area forests is also seen in the reliable flow of cool water from these timberlands despite the absence of glaciers or substantial high-altitude snowpack to store and slowly release water. Regardless of observed global warming trends and through decades of commercial timber production, the rivers and streams flowing from Green Diamond's California Timberlands remain cold and beneficial to sensitive salmonids.

4.2.2.4 Recommendations for Forest Management in Response to Climate Change

Federal forestlands proximate to the marine coastline in the Pacific Northwest are now managed with a system of reserves that protect and recruit old growth forest stands to promote the conservation and recovery of the marbled murrelet (USDA and USDI 1994). However, the threat of disturbance to nesting habitat caused by climate change may warrant the addition of protective reserves for murrelet nesting on non-federal lands (Gaines et al. 2022) ("murrelet conservation might better focus on reducing losses to high suitability nesting habitat on all lands, including nonfederal lands, and recruiting replacement habitat, especially where federal lands are limited"). Indeed, scientists who have studied the effects of climate change on redwood forests in the Plan

Area have recommended "intentional forestry" to mitigate the effects of climate change by enhancing carbon sequestration, biodiversity, and forest resilience through the protection of "Elder Trees" or ETs and the recruitment of "Potential Elder Trees" or PETs. (Antione and Sillett 2021, Sillett et al. 2022, Sillett et al. 2025).

The proposed Conservation Program described in Section 6 is consistent with these recommendations. The proposed MMHCP will protect all old growth ET forest stands in the Plan Area as Occupied Reserves with management buffers (see Sections 6.2.2 and 6.2.3), and it will designate and protect Suitable Habitat Reserves consisting of ETs or PETs that are expected to develop improved nesting habitat over time (see Section 6.5). The MMHCP protects and develops the best marbled murrelet nesting habitat in the Plan Area to retain all old growth forest stands with management buffers and to develop mature forest stands with high murrelet nesting habitat suitability characterized by large trees and an emerging multi-layered canopy. The protection and development of high-quality nesting habitat is the best response to climate change because it secures protection for nesting habitat that only develops over centuries and is relatively rare in managed forest landscapes (USFWS 1997, Gaines et al. 2022). Productive nesting habitat provides demographic support for marbled murrelets in response to the threats of terrestrial habitat loss and changes in ocean conditions caused by climate change (USFWS 2024). The carbon sequestered in these protected reserves and buffers will also provide an incremental climate change mitigation benefit by reducing GHG in the Earth's atmosphere.

4.2.3 Ecological Regions within the Eligible Plan Area

We begin by describing the constituents of the Eligible Plan Area (EPA) of the MMHCP using the Ecological Sections of California (Miles and Goudy 1997). For purposes of this document, the EPA is the overall area of analysis and mapping and includes three component areas: the Plan Area, Adjustment Area, and Remainder (Map 4-1). Eligibility for inclusion is evaluated at the component-area level (Plan Area and Adjustment Area); the Remainder is included in the EPA for context and comparison only. The Plan Area represents the covered ownership at the time of analysis; the Adjustment Area is comprised of lands that could be added to the Plan Area during the permit term; and the Remainder is comprised of lands within the EPA that are not eligible for addition to the Plan Area (e.g., State or National Park ownership). The forest conditions of the EPA are described as a whole and for comparison by the component areas including the conservation zone. The EPA occurs within three major Ecological Sections:

Klamath Mountains – This Section is located between the Southern Cascades and Coast Range Mountains. The predominant forest community types are Douglas-fir, Douglas-fir/tanoak, Douglas-fir/pine, mixed conifer, white fir, Jeffrey Pine, red fir, canyon live oak, and Oregon white oak series. It is characterized by greater temperature extremes and elevations from 200 to over 9,000 feet (61 to over 2,743 meters) above sea level and precipitation varies from 18 to 120 inches (45.7 to 304.8 centimeters). The growing season is 25 to 225 days long.

Northern California Coast – This Section is characterized by mountains, hills and valleys of the northern Coast Ranges and portions of the Klamath Mountains that are close enough to the Pacific Ocean for the climate to be greatly modified by the marine influence. Summers are characterized by fog, cool temperatures, and higher humidity than inland. The

predominant forests communities include redwood, Douglas-fir/tanoak, Oregon white oak, tanoak, and Coast live oak series. Elevations range from zero to 3,000 feet (914 meters) above sea level and precipitation varies from 20 to 120 inches (50.8 to 304.8 centimeters). The area has a long growing season of 225 to 310 days, with fog very common during summer and winter.

Northern California Coast Ranges – This Section includes the interior part of the California Coast Ranges, located north of the Carquinez Strait. Marine air modifies winter and summer temperatures, but the section is inland from the coast far enough that oceanic effects are greatly diminished. The predominant forest communities include Douglas-fir/tanoak, blue oak, Oregon white oak, mixed conifer, and White fir series. Elevations range from just above sea level to 8,000 feet (2,438 meters). The growing season is 80 to 250 days, and summer fog is generally limited to low elevations and major watercourses.

Map 4-1. Green Diamond Ownership and Marbled Murrelet Conservation Boundaries in Eligible Plan Area of California

4.2.3.1 Ecological Subsections within the Eligible Plan Area

Analysis of Ecological subsections within the EPA is constrained to the Plan Area and Adjustment Area without additional sub-setting of the forested portion of the AA. Within the PA, the Northern Franciscan Redwood Forest, Central Franciscan, and Wiregrass Ridge Subsections dominate covering a combined area of 83.6% (39.4%, 31.9%, and 12.3% respectively). Within the AA, the Central Franciscan and Coastal Franciscan dominate covering a combined area of 79.3% (39.7%, and 39.6% respectively). The listing of Subsections is shown in Table 4-1.

Table 4-1. United States Forest Service ecological regions used to describe forest habitat conditions within this MMHCP Eligible Plan Area.

Section	Subsection (Code)	Plan Area (acres/hectares)	Adjustment Area (acres/hectares)	Plan Area (Percentage)	Adjustment Area (Percentage)
Klamath Mountains	Gasquet Mountain Ultramafics (M261Ab)	2,422/980	6,599/2,671	0.6	0.5
Klamath Mountains	Lower Salmon Mountains (M261Af)	0	714/289	0.0	0.1
Klamath Mountains	Rattlesnake Creek (M261Au)	0	18,127/7,336	0.0	1.4
Klamath Mountains	Siskiyou Mountains (M261Ad)	0	797/323	0.0	0.1
Klamath Mountains	Siskiyou Serpentine (M261Aa)	5,124/2,074	22,052/8,924	1.3	1.7
Northern California Coast	Central Franciscan (263Af)	121,298/49088	338,110/136,828	31.9	26.1

Section	Subsection (Code)	Plan Area (acres/hectares)	Adjustment Area (acres/hectares)	Plan Area (Percentage)	Adjustment Area (Percentage)
Northern California Coast	Coastal Franciscan (263Ag)	25,649/10,379	512,850/207,544	6.7	39.6
Northern California Coast	Humboldt Bay Flats and Terraces (263Ae)	19,801/8,013	126,402/51,153	5.2	9.8
Northern California Coast	Northern Franciscan Redwood Forest (263Ab)	150,119/60,751	46,081/18,648	39.4	3.6
Northern California Coast	Wiregrass Ridge (263Ad)	46,627/18,060	26,544/10,742	12.3	2.1
Northern California Coast Ranges	Central Franciscan (M261Bb)	446/180	175,601/71,063	0.1	13.6
Northern California Coast Ranges	Eastern Franciscan (M261Ba)	9,066/3,669	20,065/8,120	2.4	1.6
Undefined	Undefined	0	419/170	0.0	0.0

Klamath Mountains

Within the Klamath Mountains ecological section lie five subsections including the Siskiyou Serpentine, Gasquet Mountain Ultramafics, Siskiyou Mountains, Lower Salmon Mountains and Rattlesnake Creek.

Siskiyou Serpentine (M261Aa)

The Siskiyou Serpentine subsection is in the Western Jurassic Belt. It is along the western edge of the Klamath Mountains. Marine air moderates the climate of the western part of the subsection. It has a temperate and humid climate. This subsection is dominated by clastic Jurassic marine sedimentary rocks and greenstone of the Galice and Rogue formations. The sedimentary rocks have been slightly metamorphosed to form metagraywacke and slate. In the northern part of the subsection there are some serpentinized peridotite, gabbro, diabase, and volcanic rocks. The rocks are moderately to intensely folded and faulted. The predominant natural plant communities are Douglas-fir - tanoak series and Douglas-fir series. Canyon live oak series is common on very steep rocky slopes with stony soils. Port Orford cedar series occurs on wet mountain sideslopes and along streams. Arroyo willow series and Mixed willow series occur in riparian areas along streams. Jeffrey pine series occur on soils formed from serpentinized peridotite. The mean annual precipitation is about 50 to 120 inches. Most of the precipitation is rain at lower elevations, with alternating rain and snow at higher elevations. Mean annual temperature is about 45° to 57° F. The mean freeze-free period is about 100 days at higher elevations to 225 days at lower elevations (USDA, Forest Service, 1998).

Gasquet Mountain Ultramafics (M261Ab)

The Gasquet Mountain Ultramafics subsection encompasses ultramafic rocks in the Josephine ophiolite and from the Josephine ophiolite southward along the east side of a thrust fault that separates the Coast Range mountains from the Klamath Mountains. It ends at Burrill Peak, just north of the Klamath River. Marine air moderates the climate of most of the subsection. It has a temperate and humid climate. This subsection is dominated by partially to completely serpentinized peridotite of a Jurassic-aged ophiolite, called the Josephine ophiolite. Some gabbro and diabase are included in the subsection. This is a subsection of mountains with rounded ridges, steep sides, and narrow canyons. Some of the mountains have broad summits. Landslides are common, particularly where the peridotite has been completely serpentinized and sheared. The elevation range is about 200 to 4800 feet. Mass wasting and fluvial erosion are the main geomorphic processes. The predominant natural plant communities are Jeffrey pine series and Lodgepole pine series. Port Orford-cedar series is common on wet mountain side slopes and along streams. Douglas-fir series and Western white pine series occur on old land surfaces where most of the magnesium (Mg) has been leached from the soil. Darlingtonia series is common in small bogs and fens. The mean annual precipitation is about 80 to 120 inches. Most of the precipitation is rain at lower elevations, with some snow at higher elevations. Mean annual temperature is about 46° to 57° F. The mean freeze-free period is about 100 days at higher elevations to 225 days at lower elevations (USDA, Forest Service, 1998).

Siskiyou Mountains (M261Ad)

The Siskiyou Mountains subsection is in the Siskiyou Mountains where they are centered along a north-south aligned drainage divide east of the Smith River. It is in the Western Paleozoic and Triassic Belt. The climate is temperate to cold and humid. This subsection

is dominated by serpentinized peridotite, gabbro, diabase, and Paleozoic to Jurassic metavolcanic and metasedimentary rocks of Rattlesnake Creek terrane and by Mesozoic gabbro and granitic rocks. The granitic rocks are generally quartz diorite to slightly more silicic rocks. Quaternary glacial till and outwash occur in many small areas. At lower elevations, the predominant natural plant communities are Douglas-fir-tanoak series and Douglas-fir series, and, on ultramafic rocks, Jeffrey pine series. Canyon live oak series is common on very steep rocky slopes with stony soils. The higher elevations are mostly White fir series, with some Red fir series and Mixed subalpine forest series. Port Orford-cedar series occurs on some wet mountain side-slopes and along streams. There are also some unique plant communities in the Siskiyou Mountains called "Enriched stands in the Klamath Mountains" (Sawyer and Keeler-Wolf, 1995). The mean annual precipitation is about 60 to 100 inches. Most of the precipitation is rain at lower elevations, but much of it is snow at higher elevations. Mean annual temperature is about 40° to 53° F. The mean freeze-free period is about 50 days at higher elevations to 175 days at lower elevations (USDA, Forest Service, 1998).

Lower Salmon Mountains (M261Af)

The Lower Salmon Mountains subsection is in the Western Paleozoic and Triassic Belt, near the Klamath River from Thompson Creek to south of the Salmon River. The climate is temperate and humid. This subsection contains a variety of Paleozoic to Jurassic metavolcanic and metasedimentary rocks, including components of ophiolitic sequences, of mostly Western Hayfork and Rattlesnake Creek terranes, and some Sawyers Bar terrane up Wooley Creek. The rocks were intruded by Mesozoic granitic rocks, generally quartz diorite to slightly more silicic rocks. The predominant natural plant communities are Douglas-fir - tanoak series, Douglas-fir series, and Mixed conifer series, and, on ultramafic rocks, Jeffrey pine series. Canyon live oak series is common on very steep rocky slopes with stony soils. White fir series occurs at higher elevations. The mean annual precipitation is about 50 to 80 inches. Most of the precipitation is rain at lower elevations, with some snow at higher elevations. Mean annual temperature is about 45° to 57° F. The mean freeze-free period is about 100 days at higher elevations to 200 days at lower elevations (USDA, Forest Service, 1998).

Rattlesnake Creek (M261Au)

Rattlesnake Creek is an arcuate subsection aligned from north-northwest to east-southeast along the southwest edge of the Klamath Mountains. It is the Western Paleozoic and Triassic Belt, bound on the southwest by the South Fork Mountain and Bear Wallow faults and on the northeast by the Salt Creek fault. The climate is temperate and humid. This subsection is dominated by Paleozoic to Jurassic metavolcanic and metasedimentary rocks and serpentinized peridotite of Rattlesnake Creek terrane. These rocks are intensely faulted. There are small areas of Mesozoic granitic rocks in the subsection. There is a small area of Oligocene nonmarine sedimentary rocks of the Weaverville Formation in Hyampom Valley and Quaternary alluvium occurs there and elsewhere along the South Fork Trinity River. The predominant natural plant communities are Douglas-fir series, Mixed conifer series, Douglas-fir - ponderosa pine series, and Ponderosa pine series. The Jeffrey pine

series occurs on serpentinized peridotite. Canyon live oak series is common on very steep rocky slopes with stony soils. The mean annual precipitation is about 40 to 60 inches. Most of the precipitation is rain. Mean annual temperature is about 45° to 57° F. The mean freeze-free period is about 100 days at higher elevations to 225 days at lower elevations (USDA, Forest Service, 1998).

Northern California Coast

Within the Northern California Coast ecological section lie five subsections including the Northern Franciscan Redwood Forest, Wiregrass Ridge, Humboldt Bay Flats and Terraces, Central Franciscan, and Coastal Franciscan.

Northern Franciscan Redwood Forest (263Ab)

The Northern Franciscan Redwood Forest subsection is in a steep mountainous area of the northern California Coast with substantial oceanic influence on climate, including summer fog. It is bounded by the South Fork Mountain Thrust fault and a branch of it on the east, by the Pacific Ocean on the west, and by the Grogan fault on the southwest. The climate is temperate and humid. This subsection is dominated by Jurassic and Cretaceous Franciscan sedimentary, minor volcanic, and metamorphic rocks of the Eastern Belt. They are intensely folded and faulted. Plio-Pleistocene marine and nonmarine sediments are the predominant strata between the Lost Man fault and the ocean, south of the Klamath River. There are small areas of recent alluvium along the Klamath and Smith Rivers and Pleistocene gravels on mountain ridges between the Klamath River and the Lost Man fault. The predominant natural plant community is Redwood series. Douglas-fir - tanoak series occurs on upper slopes and ridges. Sitka spruce occurs along the coast. There are patches of Black oak series, Oregon white oak series, and Pacific reedgrass series on south-facing slopes and ridges. Red alder series is common in riparian areas. The mean annual precipitation is about 60 to 120 inches consisting of rain at lower elevations and some snow at higher elevations. Mean annual temperature is about 45° to 53° F. The mean freeze-free period is about 250 to 300 days (USDA, Forest Service, 1998).

Wiregrass Ridge (263Ad)

The Wiregrass Ridge subsection is a steep mountainous area south-southeast of Orick. It is a narrow strip bounded on the east-northeast by the Grogan fault, which is along Redwood Creek, and on the west-southwest by the Bald Mountain fault. It has a temperate, humid climate. There is substantial oceanic influence on climate, including summer fog. This subsection is dominated by Jurassic and Cretaceous Franciscan sedimentary, minor volcanic, and metamorphic rocks, including the schist of Redwood Creek. They are intensely folded and faulted of the Eastern Belt. There are small areas of recent alluvium along Prairie and Redwood Creeks. The predominant natural plant community is Redwood series. Red alder series is common in riparian areas. The mean annual precipitation is about 60 to 80 inches consisting of rain at lower elevations and some snow at higher elevations. Mean annual temperature is about 40° to 53° F. The mean freeze-free period is about 225 to 300 days (USDA, Forest Service, 1998).

Humboldt Bay Flats and Terraces (263Ae)

The Humboldt Bay Flats and Terraces subsection is on a coastal plain and terraces between mountains of the northern California Coast Ranges and the Pacific Ocean. The mouths of the Mad, Van Duzen, and Eel Rivers, which drain much of the northern California Coast Ranges, are on this coastal plain. The subsection climate is temperate and humid. There is substantial oceanic influence on climate, including summer fog. This subsection is predominantly Quaternary nonmarine and marine terrace deposits and recent alluvium. Also, there are some Plio-Pleistocene nonmarine sediments and, along the ocean shoreline, substantial areas of beach and dune deposits. The predominant natural plant communities on the plain and on marine terraces around Trinidad Head and Patrick's Point are Sitka spruce series on the outer edge and Redwood series inland. Much of the area has successional cover of shrubs or Red alder series. The dunes support a succession of plant communities, from bare dune through Native dunegrass series, Sand - verbena - beach bursage series, and Beach pine series or Bishop pine series to Sitka spruce series. Pickleweed series is present, but not extensive, in this subsection. The mean annual precipitation is about 30 to 50 inches. There is summer fog. Mean annual temperature is about 50° to 53° F, and there is less than 12° F difference between lowest and highest monthly means. The mean freeze-free period is about 300 days (USDA, Forest Service, 1998).

Central Franciscan (263Af)

The Central Franciscan subsection is a steep mountainous area of the northern California Coast, south-southeast of Patrick's Point. Most of it is between the Bald Mountain fault on the east-northeast and the Freshwater fault on the west-southwest. The climate is temperate and humid. There is substantial oceanic influence on climate, including summer fog in the northern part of the subsection. This subsection is dominated by Jurassic and Cretaceous Franciscan sedimentary, minor volcanic, and metamorphic rocks of the Central Belt; some Franciscan rocks of the Coastal Belt are present. They are intensely folded and faulted. There are small areas of Tertiary marine sedimentary rocks and ultramafic rocks are sparsely scattered through the Franciscan Complex. The predominant natural plant communities are Redwood series in the northern one-third and Douglas-fir - tanoak series in the southern two-thirds of the subsection. Needlegrass grasslands are common in the southern part of the subsection, and Oregon white oak series is also common. Common in riparian areas are red alder series in the northern part and Black cottonwood series in the southern part of the subsection. The mean annual precipitation is about 40 to 80 inches consisting of rain at lower elevations and some snow at higher elevations. Mean annual temperature is about 40° to 53° F. The mean freeze-free period is about 225 to 300 days (USDA, Forest Service, 1998).

Coastal Franciscan (263Ag)

The Coastal Franciscan subsection is a steep mountainous area of the northern California Coast Ranges, near the coast, south from Humboldt Bay to the Russian River. There is

substantial oceanic influence on climate, including summer fog. This subsection is dominated by Cretaceous, Jurassic, and early Tertiary Franciscan marine sedimentary rocks of mostly the Coastal Belt but includes some of the Central and Eastern Belts. There are relatively small areas of upper Pliocene marine sediments at the north and south ends of the subsection and Tertiary marine sediments in and around the Kings Range. Ultramafic rocks are scattered through the Franciscan Complex. The predominant natural plant communities are Redwood series, Douglas-fir tanoak series, and Needlegrass grasslands in the King Range, and Douglas-fir - tanoak series in the central and southern interior parts of the subsection. Canyon live oak series is common on very steep slopes. Sergeant cypress series is common on serpentinitic soils. Black cottonwood series is common in riparian areas. The mean annual precipitation is about 40 to 110 inches. Most is rain at lower elevations, and some is snow at higher elevations. Mean annual temperature is about 40° to 53° F. The mean freeze-free period is about 225 to 300 days (USDA, Forest Service, 1998).

Northern California Coast Ranges

Within the Northern California Coast Ranges ecological section lie two subsections including the Eastern Franciscan, and Central Franciscan.

Eastern Franciscan (M261Ba)

The Eastern Franciscan subsection is in the higher elevation part of the northern California Coast Ranges that is far enough inland to have little oceanic influence on climate. It has a temperate to cold, humid climate. This subsection is dominated by Jurassic and Cretaceous Franciscan metaclastic rocks of the Eastern Belt. They are intensely folded and faulted. Ultramafic rocks are minor components in this subsection. The predominant natural plant community is Mixed conifer series, except in the northern part of the subsection where Douglas-fir - tanoak series is the predominant plant community. Red fir series and White fir series are common in areas of frigid soil temperature regimes. The mean annual precipitation is about 40 to 120 inches. Most of the precipitation is rain at lower and snow at higher elevations. Mean annual temperature is about 35° to 55° F. The mean freeze-free period is in the range from 100 days at higher elevations to 200 days at low elevations (USDA, Forest Service, 1998).

Central Franciscan (M261Bb)

The Central Franciscan subsection is in the central part of the northern California Coast Ranges that is influenced somewhat by marine air but lacks summer fog. It has a temperate and humid climate that is cooler during summer and wetter than the Eastern Franciscan subsection. This subsection is dominated by Jurassic and Cretaceous Franciscan graywacke, greenstone, chert, mélange, and serpentinite of the Central and other Belts, and, in the southwestern part of the subsection, Cretaceous marine sedimentary rocks other than those of the Franciscan Complex. They are intensely folded and faulted. Nonmarine Pliocene sedimentary rocks are present in some low areas and Quaternary alluvium is present in the valleys. The predominant natural plant communities are Douglas-fir - tanoak

series with Needlegrass grasslands and Oregon white oak series in the northern part; and a mosaic of Mixed conifer series, Needlegrass grasslands, Blue oak series, and Chamise series in the southern part of the subsection. The mosaic is controlled by slope aspect, lithology, and soils. Blue oak series is most common on south-facing slopes and at lower elevations. Needlegrass grasslands are present in areas of Franciscan mélange, which are quite susceptible to mass wasting by slide and flow. The Chamise series prevails on south-facing slopes with shallow soils. The mean annual precipitation is about 35 to 110 inches. Most of the precipitation is snow at higher and rainfall at lower elevations. Mean annual temperature is about 40° to 58° F. The mean freeze-free period is from 125 days at higher elevations to 250 days at lower elevations.

4.3 MARBLED MURRELET HABITAT AND STATUS WITHIN THE PLAN AREA

4.3.1 Forest Age Class Distribution within the Plan Area

The ages of forest stands within the Plan Area range from recent clearcut (0 yrs) age stands through Old Growth (200+ yrs) primarily found within the Occupied Reserves (Table 4-2). The age class distribution is spatially dominated by mid-age 30-70 year old stands with the largest area represented in 50-59 year old class. The primary contribution to this class comes from approximately 24% of the Plan Area in perpetually aging Riparian Management Zones with a current area weighted average age of 56.2 years old. An equivalent measure for the Adjustment Area is unavailable given that forest stand level information on forest age requires specific timber inventory data at the ownership level. In the absence of this information, we have presented surrogate data on forest age as represented by forest canopy height (Section 4.4.1).

Table 4-2. Forest age class percentage within the Plan Area.

Forest Age Class (years)	Plan Area (Percentage)
0-9	12.2
10-19	9.8
20-29	8.4
30-39	13.8
40-49	13.5
50-59	18.9
60-69	12.0
70-79	4.4
80+	4.0
Non-Forest	1.8
Undefined	1.2

4.3.2 A Habitat Suitability Model for Predicting Occupied Habitat

We developed a marbled murrelet HSM using Maxent software (Phillips et. al. 2004, version 3.4.1) that estimates the relative habitat suitability index (HSI) for marbled murrelets from a two-sample resource selection function (Manly et al. 2002; Warton and Aarts, 2013), often called the presence/background model in Maxent literature (Guillera-Arroita et al. 2015). The presence/background model compares environmental conditions (i.e., habitat characteristics) at a sample of presence locations to background environmental conditions extracted from a dense spatially balanced sample of locations. We estimated a presence/background model due to a lack of definitive absence records within the study area (Appendix A).

We developed the HSM based on environmental covariates derived from high resolution light imaging detection and ranging (LiDAR) data to identify, at the patch and study area scale, forested areas that reflected habitat where marbled murrelets have exhibited indirect evidence of nesting ("occupied behaviors"; Evans-Mack et al. 2003) or where other observations and research provided direct evidence of nesting. We developed this correlative HSM following two key concepts (Bahn and Newsom 2002) where 1) habitat suitability refers to the potential of an area to support successful marbled murrelet nests and, 2) marbled murrelet occupancy is defined as a subset of detections indicative of nesting behavior (e.g., subcanopy flights, circling below canopy) or the known occurrence of nest sites within occupied habitat. As far as we are aware, this is the first time that height and density of individual trees derived from LiDAR data have been applied directly to marbled murrelet habitat modeling. We built our HSM using Maxent software and selected covariates to include in the final model using a four-step objective and repeatable variable selection procedure. We validated the model by inspecting the magnitude and variation of performance measures over bootstrap replicates drawn from the raw data.

Phase 1 of model selection yielded six covariates based on Tree Approximate Objects (TAOs), two biogeographic variables, and one covariate from each of the percentiles, canopy metrics, and climate groups (Appendix A, Table S2). After separating correlated covariates, we advanced five of the six covariates based on TAOs from Phase 2 to 3 (Table 2). The covariates that advanced from Phase 2 measured TAO density, TAO total height, and standard deviation of height for TAOs $\geq$ 50 and $\geq$ 60 meters. Simpsons' Diversity Index based on three height classes within a 5-acre moving window (i.e., SDI_3cl_5ac) initially showed strong predictive abilities; but we discovered computational inconsistencies in the Simpsons' Diversity computation routine and dropped it in favor of the next best covariate, the standard deviation in tree heights $\geq$ 50 meters at both the 5-acre and 1-acre moving window scale. All climate, geographic, canopy, and height percentiles failed to advance from Phase 2, highlighting that they contributed little to the HSM after considering tree density, height, and height variability.

We fitted four models during Phase 3 that represented all possible models of uncorrelated covariates (Table 2). Model C contained density of TAOs $\geq$ 60 meters, total height of TAOs $\geq$ 50 meters, and the standard deviation TAO height, all measured on the surrounding 5 acres, and produced the lowest AIC (Akaike, H. 1974) (ΔAIC to next best model = 39.3). Box plots of AIC over 10 bootstrap replicates for each Phase 3 model (Appendix A, Table S3, Figure 5) showed Model C also produced the lowest variability in AIC, suggesting stability and consistency among

random replicates. Among covariates in Model C, tree density (TAOs ≥ 60 meters) and total height (of TAOs ≥ 50 meters) exhibited stronger predictive abilities than the standard deviation of tree height (of TAOs ≥ 50 meters).

We constructed a predicted-to-expected (P/E) ratio curve following the methods of Boyce et al. (2002) and Hirzel et al. (2006) by partitioning habitat suitability predicted by Model C into bins and calculating the area-adjusted predicted frequency of evaluation points in each bin relative to the total expected frequency of evaluation points. Ultimately, we classified forested areas in the study area as "unsuitable", "marginal", "low", "medium", and "high" suitable habitat. The model was used to identify potentially suitable habitat at the forest stand and study area scales for purposes of conservation planning and forest management. This method provides a visual illustration of the continuous habitat selection curve over the range of Maxent model values and a quantitative basis to assess the final habitat suitability model results and estimate thresholds for habitat classification. The Green Diamond Plan Area is heavily dominated by areas classified as unsuitable (98.08%) due to the scarcity of TAOs ≥ 50 meters (Table 5). The Remainder of the Plan Area is mostly marginal (1.63%), with less than 0.30% classified as low suitable and better according to the HSM.

4.3.3 Potential Nesting Habitat within the Plan Area

Based on the results of the HSM modeling and predictions, three levels of habitat exist within the Plan Area; Occupied Reserves, Suitable Habitat Reserves, and Marginal Habitat (Section 6.2), distinguished primarily by their ability to support murrelet occupancy and potential nesting. The modeled quality of these habitat areas is positively affected by the density of very tall (≥ 60m) trees, combined height of the tall (≥ 50m) trees, and an increase in the variability (standard deviation) of tall tree heights. The current HSM uses measures of tree heights and densities as surrogates for forest age and canopy structure that indirectly incorporates a measure of nesting platforms based on the assumption that suitable nesting platforms increase with tree and forest age and tree height, particularly in the coastal redwood zone of northern California. The Occupied Reserves, which are primarily composed of small remnant patches of old growth from past harvesting practices, are concentrated in Del Norte County with several known occupied stands in Humboldt County. Green Diamond has identified 30 discrete patches of habitat totaling approximately 772 acres that are considered occupied by marbled murrelets within the past 30 years based on observations during audio-visual surveys (Evans Mack 2003, Appendix C). One patch ('Oil Creek') was located on lands acquired by Green Diamond during the development of this MMHCP. Two of the 30 patches are smaller, satellite patches adjacent to larger, main patches. For analysis purposes in Appendix A, these two satellite patches were included with the adjacent main patches and the 'Oil Creek' patch was identified after analyses were completed for a total of 27 occupied patches. Six of the 30 patches are associated with Conservation Easements, and the forest stands and vegetation buffers for these stands are not included as a component of the Conservation Program for this MMHCP (Section 6.2.2). These 24 patches and vegetation buffers are identified in Green Diamond's Geographic Information System (GIS) and are hereafter referred to as Occupied Reserves in the context of the Conservation Program in this MMHCP (Maps 4-2, 6-1-1, 6-1-2, 6-1-3).

Map 4-2. Marbled Murrelet Habitat on the Plan Area

Because old forests and trees are rare, the retention and protection of the older and most structurally suitable habitat provides assurance that forest areas potentially occupied by marbled murrelets will be maintained, and habitat will continue to develop in these areas. The growth and development of forest habitat and trees for murrelets is a process that occurs over a period of 200 years or more and is rare on the managed forest landscape of the Plan Area where >99% of the area is composed of young or immature second and third growth forests less than 100 years of age. Green Diamond has identified 96 forest stands within the Plan Area totaling approximately 946.4 acres that are next best on the suitability scale relative to the Occupied Reserves based on the HSM (Map 4-2). These areas are classified as Suitable Habitat Reserves and will be conserved during the permit term (Section 6.2.5).

The final category of potential habitat within the Plan Area is classified as Marginal Habitat based on the HSM. This category of habitat is the least suitable nesting habitat within the Plan Area and timber harvest within potentially occupied areas of these forest patches is identified as the primary form of incidental take under this MMHCP (Section 5.1.1, Appendix B). Green Diamond has identified approximately 7,180 acres (as of 2023) of Marginal Habitat within the Plan Area with approximately 2,199 acres removed through timber harvest over the Permit term.

4.4 FOREST STRUCTURE AND AGE CLASS DISTRIBUTIONS WITHIN THE ELIGIBLE PLAN AREA

The results of the Habitat Suitability Modeling (HSM) for marbled murrelets (Appendix A) prompted us to use available remote sensing data on forest structure within the Eligible Plan Area. Recall that the three important covariates for the Green Diamond HSM for marbled murrelets were related to LiDAR point statistics and point density data for trees, or tree approximate objects, 50 meters and greater in height. A majority of the Eligible Plan Area has publicly available LiDAR data (OCM Partners, 2023: 2018) or data that will be available in the near future; however, that data requires downloading and analysis using the HSM prior to comparisons with the Plan Area LiDAR data and HSM, or prior to any HSM based predictions within the Adjustment Area. We used California Forest Observatory data (California Forest Observatory 2020.) to characterize forest canopy characteristics across the Eligible Plan Area (EPA). This dataset provides unprecedented and continuously updated views of wildfire hazard and forest health for California. The data are based on artificial intelligence methods applied to satellite imagery and airborne LiDAR to produce detailed 10-meter resolution raster data on vegetation fuels including tree heights and canopy cover. This data was used as a best approximation proxy until county-wide LiDAR data is available for use in the HSM. The California Forest Observatory data provides a useful measure of tree canopy height and comparison for lands within the Plan Area and Adjustment Area.

4.4.1 Forest Canopy Height within the Eligible Plan Area

Canopy Height ranges from less than 1 meter (Shrubs and grasslands) to 80 meters (residual old forest) across the Forested EPA. Dividing the range of canopy heights into 10-meter classes provides strong evidence for the similarities between the PA and AA. A review of the forest height class between the PA and AA reveals that the largest areal difference (3.8%) occurs in the 20–30-

meter (65.6–98.4 foot) class with a higher percentage of this class in the PA (42.6%) versus the AA (38.8%). This rather small difference is followed by a 2.2% areal difference in the 0-10-meter class with the AA (15.0%) larger than the PA (12.8%). All other areal differences within height class range from 0.0% to 0.8% and average less than 0.3% (Figure 4-3). The majority of both the PA and AA are in the 20–30-meter class representing coniferous forest stands that average 43.2 years old (SD = 15.22, N = 152,171) based on a sample of TAOs within stands of known age. Examining the combined height classes within the PA, AA, and Remainder above 50 meters (164 feet), which represent the trees selected for modeling Murrelet nesting habitat, reveals that a very small percentage of the EPA are represented in these forest height classes (0.4%, 0.5%, and 1.0% respectively). The larger percentage within the Remainder is likely due to State and National Park lands including Redwood National and State Parks and the Bureau of Land Management Headwaters Forest Reserve.

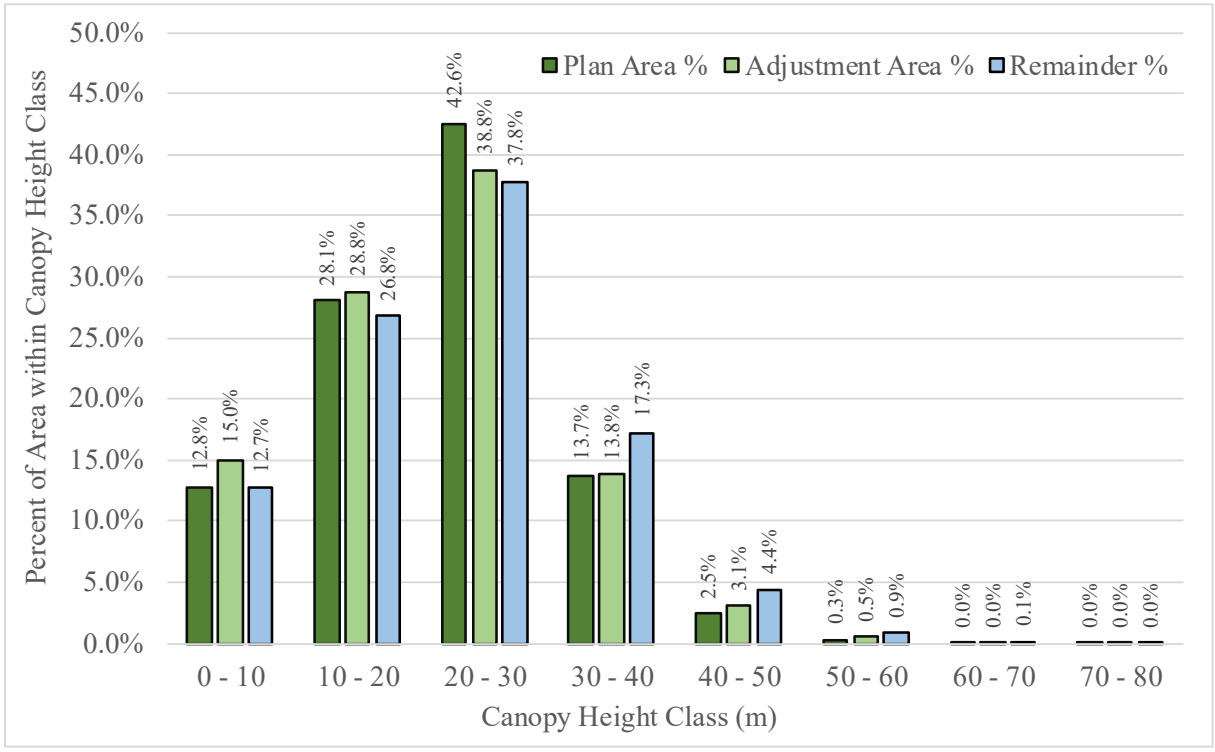


Figure 4-3. Percent of forested Plan Area (PA), Adjustment Area (AA), and Remainder by canopy height class (meters).

4.4.2 Forest Canopy Closure within the Eligible Plan Area

Canopy Closure ranges from approximately 0% (interspersed grasslands, nonforest, and recent clear-cuts) to 100% in both young and old forests across the forested EPA. A reporting of the range of canopy closure values into percentile classes provides additional evidence of the similarities between the PA and AA (Figure 4-4). An evaluation of the percent areal differences between PA and AA by closure class reveals the largest differences occurring in the 70-80% (3.2%) and 90-100% (9.5%) canopy closure classes, with a higher percentage of 70-80% class in the AA and a higher percentage of 90-100% class in the PA. All other differences between PA and AA by closure class range from 0.2% to 2.4% with an average of 1.0% (Figure 4-4). The majority of both

the PA and AA are in the 80-90% and 90-100% canopy closure classes comprising 76.6% and 66.1% of the PA and AA, respectively.

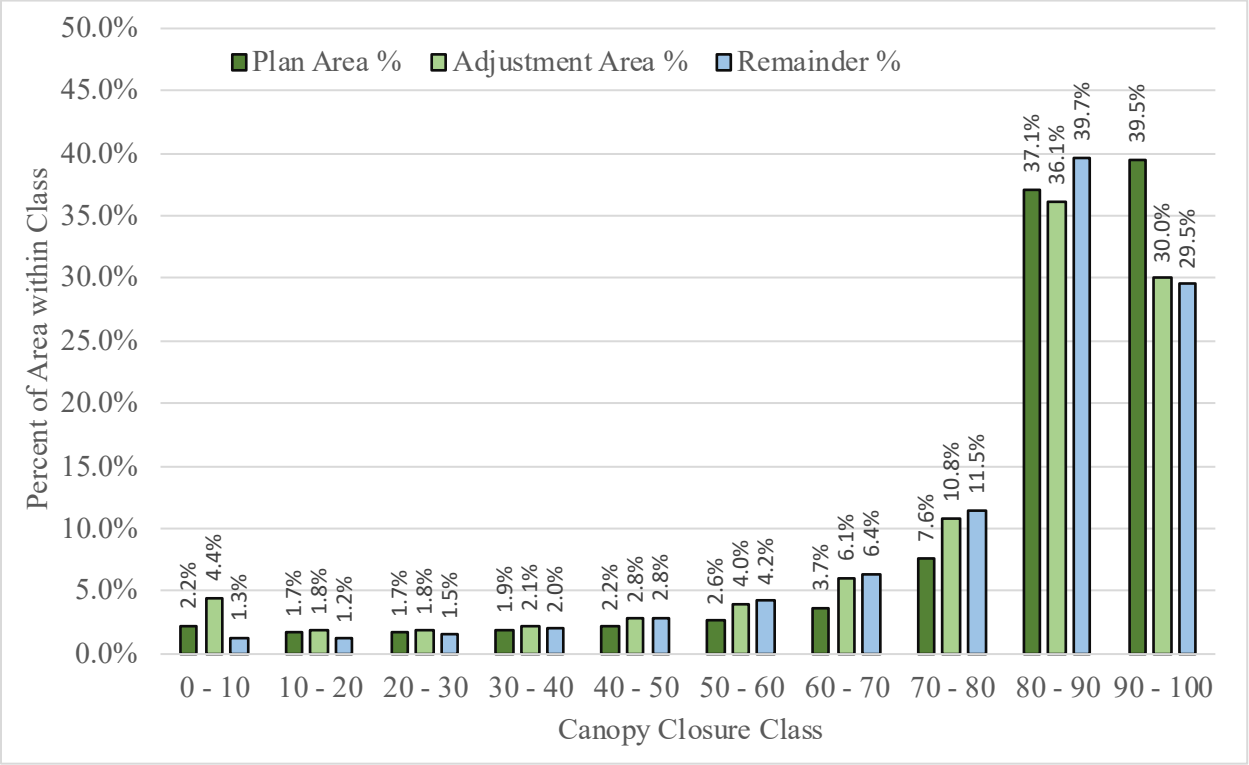


Figure 4-4. Percent of Plan Area, Adjustment Area, and Remainder by canopy closure class (%).

4.4.3 Percent Forested Habitat within Eligible Plan Area

The forested percentage of the Plan Area (PA), Adjustment Area (AA), and Remainder within the MMHCP Eligible Plan Area (EPA) were assessed using data from the California Timberland Task Force (Timberland Task Force, 1993). Timberland Task Force vegetation data resulted from California Assembly Bill 1580 in 1989 with the objective of developing a comprehensive information system on California's forest ecosystems, including old growth forests. This raster-based system, utilizing Landsat satellite imagery, contains the California Wildlife Habitat Relationships Classification System (California Department of Fish and Wildlife 2014). The California Wildlife Habitat Relationships Tree Type code was used to identify forested areas within the EPA (Table 4-3).

A reclassification was performed on the Timberland Task Force raster data using the listed Tree Cover Types below. This classification represents the best EPA-wide representation of forested areas available.

Table 4-3. California Wildlife Habitat Relationships tree cover types used to distinguish between forested and non-forested lands.

Tree Type	Code
Subalpine Conifer	SCN
Red Fir	RFR
Lodgepole Pine	LPN
Klamath Mixed Confer	KMC
Closed-Cone Pine-Cypress	CPC
Montane Hardwood Conifer	MHC
Redwood	RDW
Juniper	JUM
Douglas-fir	DFR
White Fir	WFR
Montane Hardwood	MHW

An intersection between Timberland Task Force forested areas and the EPA produced the following results. Of the total 2,941,350 acres (1,190,326 hectares) within Humboldt and Del Norte Counties, 82.6% of the area is estimated to be forested. Non-forested areas (17.4%), primarily within the AA and Remainder include both natural and man-made types including grasslands, water, urban, etc. Further evaluation by sub-areas of the EPA, resulted in forested area percentages in the Plan Area of 88.8%, Adjustment Area of 74.8%, and the Remainder of 88.8% (Figure 4-5). As the majority of 11.2% ‘non-forest’ areas within the PA are in fact recently harvested forests, the Plan Area will be considered entirely forested for further analyses.

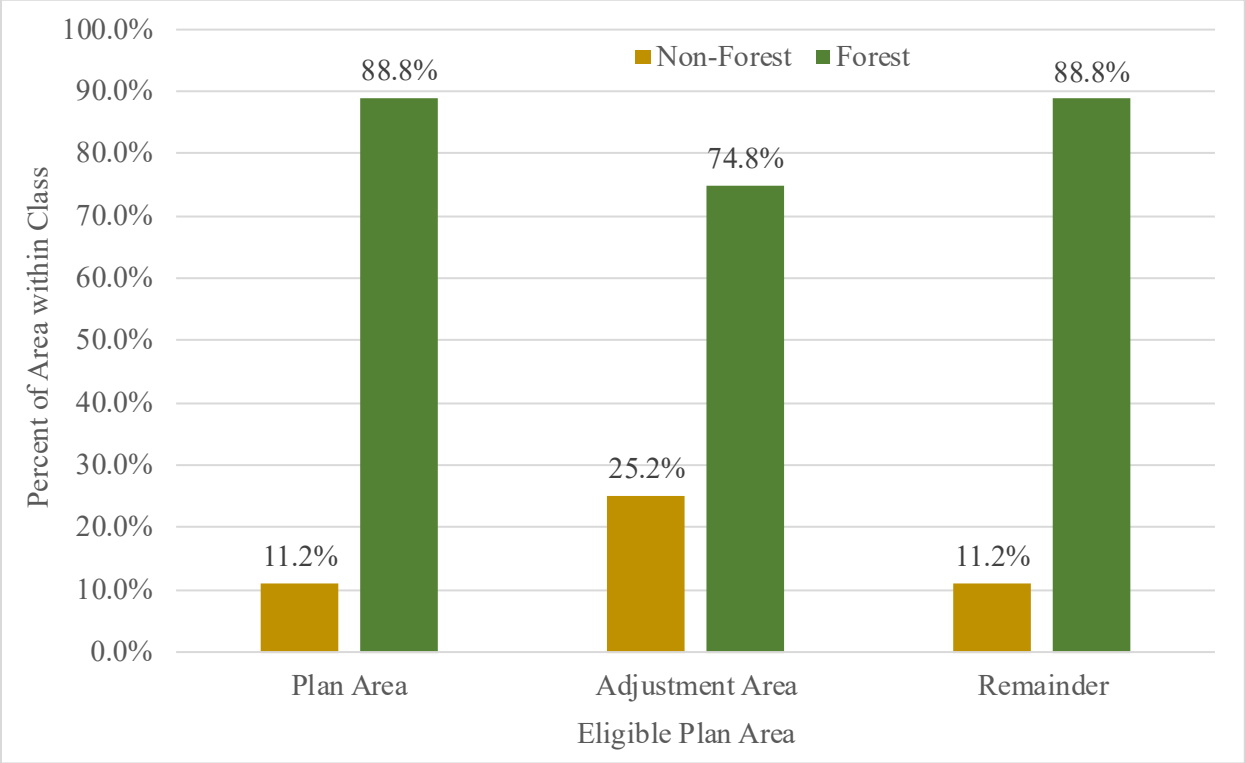


Figure 4-5. Percent forested composition of Plan Area (PA), Adjustment Area (AA), and Remainder within Humboldt and Del Norte Counties.

4.5 FEDERAL CRITICAL HABITAT

Section 4 (a)(3) of the ESA requires the FWS to designate critical habitat for species listed as threatened or endangered. Critical habitat is defined in section 3(5)(A) of the ESA as: (1) The specific areas within the geographical area occupied by the species, at the time it is listed, on which are found those physical or biological features (a) Essential to the conservation of the species, and (b) Which may require special management considerations or protection; and (2) Specific areas outside the geographical area occupied by a species at the time it is listed, upon a determination that such areas are essential for the conservation of the species. In its designation of critical habitat for the marbled murrelet, the FWS explains the purpose of critical habitat under the ESA:

> *The role of critical habitat is to support the life-history needs of the species and provide for conservation. Activities that may destroy or adversely modify critical habitat are those that would alter the physical or biological features to an extent that appreciably reduces the conservation value of critical habitat for the marbled murrelet.*

76 Fed. Reg. 61599, 61605 (October 5, 2011)

Critical habitat receives protection under section 7 of the ESA through the requirement that federal agencies ensure, in consultation with the FWS, that any action they authorize, fund, or carry out is not likely to result in the destruction or adverse modification of critical habitat. Such designation does not require implementation of restoration, recovery, or enhancement measures by non-Federal landowners. Where a landowner seeks or requests Federal agency authorization for an action that may affect a listed species or critical habitat, the consultation requirements of section 7(a)(2) of the ESA are triggered to determine whether the authorization would result in destruction or adverse modification of critical habitat. This portion of the MMHCP provides information for that purpose.

We begin with a description of the size and location of designated critical habitat for the marbled murrelet in the Plan Area and the Eligible Plan Area relative to designated critical habitat on adjacent lands and throughout the range of the species. We then describe the physical and biological features ("PBFs" also known as "primary constituent elements") that the FWS used to define the conservation value of critical habitat and we assess the conservation role of the designated critical habitat in the Plan Area. Finally, we describe the potential effects of the MMHCP on the conservation role of designated critical habitat in the Plan Area and critical habitat that is immediately adjacent to the Plan Area.

4.5.1 Critical Habitat Designation in the Eligible Plan Area

Critical habitat for the marbled murrelet was first designated in 1996 with minor adjustments made by the FWS in 2011. 76 Fed. Reg. 61599 (October 5, 2011). After adjustment, approximately 3,698,100 acres (1,497,000 hectares) of critical habitat were designated in Washington, Oregon, and California. Initially and after adjustment, the designation included an approximately 1,400-acre portion of the Plan Area located in the Elk River and Salmon Creek drainages of Humboldt County, California (within FWS-designated critical habitat unit CA-03-a). See Map 4-3-1. The critical habitat portion of the Plan Area is six miles (9.6 km) east of the marine waters of Humboldt Bay and approximately 8 miles from murrelet foraging areas of the Pacific Ocean. Critical habitat unit CA-03-a primarily consists of private lands, but it also includes the federal Headwaters Forest Reserve, which borders the Plan Area critical habitat on its northern, eastern, and southern boundaries (Map 4-3-1).

Map 4-3-1. Designated Critical Habitat in the Plan Area

Within the Eligible Plan Area (EPA), 400,633 acres (162,131 hectares) of designated critical habitat are distributed across the EPA (Map 4-3-1) with the majority in the Remainder (359,781 acres, 145,599 hectares), followed by the Adjustment Area (31,255 acres, 12,648 hectares), and the Plan Area (1,400 acres, 567 hectares). See Figure 4-6. Under the Marbled Murrelet Recovery Plan, all of the critical habitat in the EPA is located within Conservation Zone 4 (See Map 4-3-2.

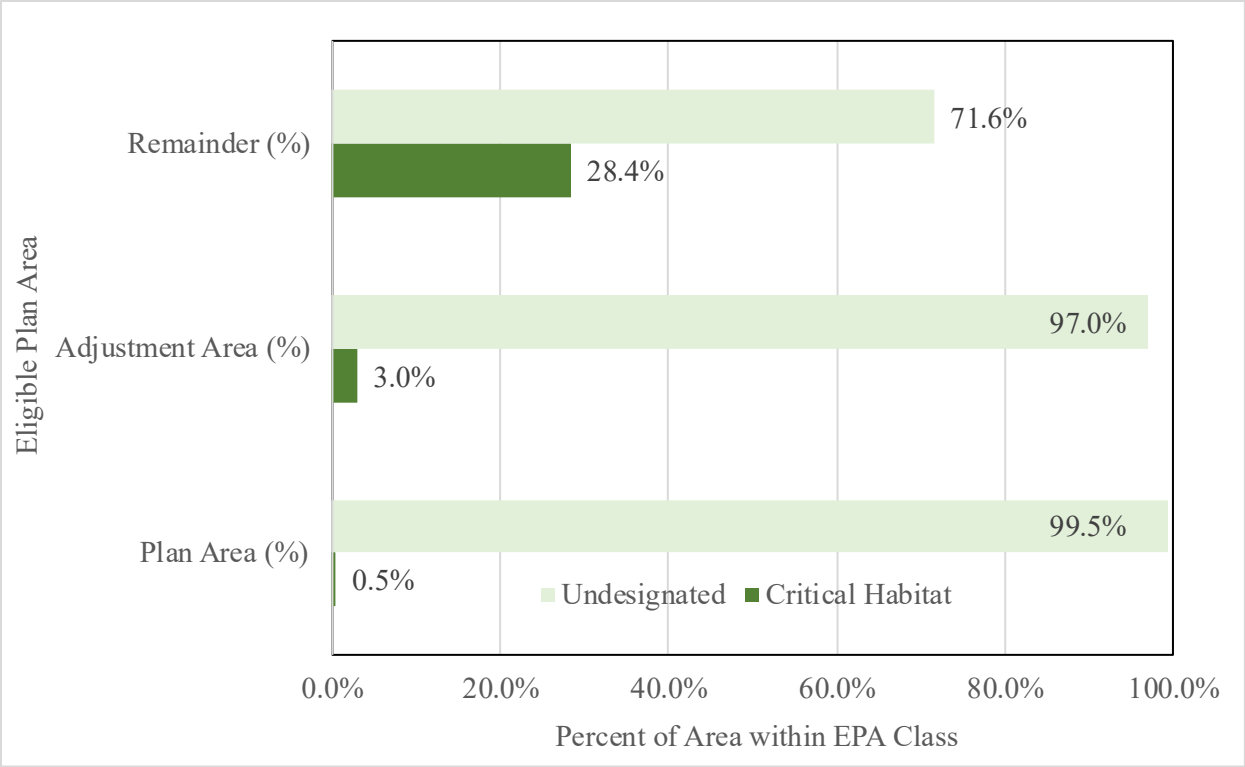


Figure 4-6. Federally designated critical habitat for Marbled Murrelet within the Eligible Plan Area composed of Plan Area, Adjustment Area and Remainder within Humboldt and Del Norte Counties, California.

Forest management activities with incidental take authorization under the proposed MMHCP likely would occur within portions of the 1,400 acres of designated critical habitat in the Plan Area and may affect portions of the 31,255 acres of designated critical habitat in the Adjustment Area contingent on acquisition by Green Diamond during the term of the MMHCP and enrollment as Covered Lands of the MMHCP that are not placed in Occupied Reserves, Suitable Habitat Reserves, or Adjacent Habitat Reserve Buffers under the criteria and process for adding lands to the MMHCP.

The Plan Area designated critical habitat area of approximately 1,400 acres is approximately 0.2 percent of all designated critical habitat in Marbled Murrelet Recovery Plan Conservation Zone 4 (~883,173 acres) and approximately 0.04 percent of the total designated critical habitat for marbled murrelets in California, Oregon, and Washington (See Map 4-3-2). The Adjustment Area critical habitat areas are approximately 4 percent of all designated critical habitat in Marbled Murrelet Recovery Plan Conservation Zone 4 and approximately 1 percent of the total designated critical habitat for marbled murrelets in California, Oregon, and Washington. Most of this assessment of MMHCP critical habitat effects will focus on the currently known acres of critical habitat located within the Plan Area. It is possible, but not probable, that Green Diamond would acquire portions of the Adjustment Area that are designated critical habitat, some of which could be subject to timber harvesting activities or managed under the MMHCP as Occupied Reserves, Suitable Habitat Reserves, or buffers on Adjacent Habitat Reserves. At this time, it is not possible to offer a site-specific assessment of any contingent scenarios, but the FWS would be provided with notice

and site-specific information for any acquisitions in the Adjustment Area that are added to the MMHCP.

Map 4-3-2. Plan Area Critical Habitat Relative to Conservation Zone and Range-Wide Critical Habitat

4.5.2 The Conservation Value of Designated Critical Habitat in the Plan Area

To assess the effects on critical habitat from Covered Activities with incidental take authorization under the MMHCP, it is important to first understand the conservation value of the designated critical habitat, which is its location on the landscape and the habitat characteristics of that area that play a role in the conservation of the species. Within mapped critical habitat boundaries, the conservation function is expressed through the presence, condition, abundance, and spatial arrangement of physical and biological features or PBFs that are the basis for designation.

When the FWS designated critical habitat for the marbled murrelet in 1996 and when it adjusted the designation in 2011, the FWS described the specific PBFs essential for conservation as "individual nest trees with potential nesting platforms" (PBF Type 1) and "forested areas within 0.8 kilometers (0.5 miles) of individual nest trees with potential nesting platforms that had a canopy height of at least one-half the site potential tree height . . . ." (PBF Type 2). 76 Fed. Reg. at 61607. The FWS explained that it determined that "these features were essential because they provided suitable nesting habitat for successful reproduction." Id. The individual nest trees (PBF Type 1) are typically very large, old growth trees that develop nest platforms that are obviously essential for reproduction, but suitable nesting habitat requires that these nest trees also be surrounded by forest stands with other mature trees (PBF Type 2) that may develop into nest trees and also provide a multi-layered canopy and buffer against adverse edge effects on nesting stands such as weather, predation, and other disturbances that interfere with successful nesting. Id. at 61609.

Although these PBFs are defined with some precision, it is difficult to obtain the data and model the PBF relationships that accurately identify the threshold size and quality conditions for suitable habitat on the landscape. The FWS states that it used general criteria to identify critical habitat; "suitable nesting habitat, information on presence/absence and occupancy, proximity to marine foraging habitat, large continuous blocks of nesting habitat, rangewide distribution, and adequacy of existing protection and management." Id. at 61606-607. These general criteria work well for identification of the obvious large stands of old growth forests where protocol surveys have confirmed murrelet nesting behavior. However, it is far more difficult to consistently delineate where the size and internal qualities of a forest stand make it unsuitable for murrelet nesting even when it has been designated as critical habitat. The FWS conceded that the components of suitable habitat were generally known, but more refined definitions or models of suitable habitat should be developed to map and manage suitable habitat. Id. at 61603, 61607.

As the FWS explained in its critical habitat designation, PBFs are used to identify "suitable nesting habitat for successful reproduction." Id. at 61607. In the course of developing the MMHCP, Green Diamond developed a peer-reviewed habitat suitability model that uses murrelet presence/absence data and habitat data specific to the Plan Area to map the location and degree of suitability for marbled murrelet nesting habitat in the Plan Area. See MMHCP Section 4.3.2 and Appendix A. Green Diamond's habitat suitability model is now an important part of the best available science

that can be used to understand the conservation value and role of the critical habitat that has been designated in the Plan Area.

Map 4-3-3 shows the Green Diamond habitat suitability model applied to the forest stands in the critical habitat portion of the Plan Area and on adjacent ownership including the Headwaters Forest Reserve. According to Green Diamond's model, nearly all of the Plan Area that has been designated as critical habitat is unsuitable as murrelet nesting habitat due to the young age of forest stands and the relative scarcity of large, older trees that are grouped in stands that have or might develop the properties conducive to murrelet nesting. In contrast, large portions of the Headwaters Forest Reserve on the eastern boundary of the Plan Area are shown as moderate to high suitability for marbled murrelet nesting with some marginal nesting habitat along the eastern boundary of the Plan Area critical habitat.

Map 4-3-3. Habitat Suitability of Designated Critical Habitat

The Headwaters Forest Reserve is approximately 7,472 acres of coastal redwood forest managed by the Bureau of Land Management (BLM) in consultation with California Department of Fish and Wildlife. The Reserve is designated as critical habitat because it protects approximately 3,000 acres of old growth redwood forest that is high quality, occupied marbled murrelet nesting habitat. The Reserve is also designated as critical habitat because it is important to the distribution of nesting habitat within Marbled Murrelet Recovery Plan Conservation Zone 4 by maintaining a federally-managed reserve within a landscape dominated by younger forests on private managed timberlands.

As an occupied murrelet nesting area with large, contiguous stands of old growth redwood forest, the Headwaters Reserve undoubtedly contains the PBFs that are conducive to murrelet nesting and successful reproduction. It has many individual trees with potential nesting platforms (PBF 1) and they are surrounded by stands of mature trees (PBF 2) that serve as a disturbance buffer around nest trees and also serve as a supply of trees that may develop into nest trees. For purposes of the conservation program in the MMHCP, the portions of the Reserve that are nesting stands are considered an Adjacent Habitat Reserve that warrants the imposition of Adjacent Habitat buffers for management of adjacent stands in the Plan Area (MMHCP Section 6.2.3). The areas where these buffers would be implemented are shown on Map 4-3-3.

To the west of the Headwaters Forest Reserve and the proposed Adjacent Habitat buffers of the MMHCP, the Plan Area that is designated as critical habitat is a managed forest that has been harvested and is now reforested with younger forests of varying ages. Green Diamond has no data that confirms or even suggests that there is murrelet nesting in this portion of the Plan Area, which is consistent with Green Diamond's habitat suitability model that classifies nearly all of this area as unsuitable habitat. The model does show that there are limited areas of marginal murrelet habitat located on the eastern boundary of the Plan Area, along the western edge of the Headwaters Forest Reserve. This may be a modeling shadow effect of the concentrations of large trees in the Headwaters Reserve, but there are also some large trees in the Plan Area along the boundary and some of these larger trees may have or develop forks and branches that could be classified as potential nesting platforms.

The actual forest conditions in the Plan Area, as reflected by the habitat suitability model support a conclusion that the primary conservation value of the Plan Area critical habitat is to serve as a forested buffer (PBF 2) along the western edge of the Headwaters Reserve. The mature trees located along the edge of the nesting stands in the Headwaters Reserve help to provide a textured, multi-layered canopy edge for the nesting stands in the Reserve as a buffer against adverse forest edge effects such as windthrow and predation.

In the broader context of murrelet conservation and recovery, the Headwaters Forest Reserve is the essential nesting habitat that the FWS seeks to preserve (PBF 1) and buffer (PBF 2) through designation of critical habitat shown in Map 4-3-3. Alone, the portion of the Plan Area designated as critical habitat makes a negligible contribution to murrelet conservation at the scale of Conservation Zone 4 and the range of the species because it does not have nesting stands or large stands of suitable habitat with potential to become nesting stands. In the context of adjacency to the Headwaters Reserve, however, the forest stands on the eastern boundary of the Plan Area critical habitat make a contribution to murrelet conservation at the local scale as a forested buffer against adverse edge effects on the Headwaters Reserve nesting stands.

4.5.3 The Effects of the MMHCP on Critical Habitat

The FWS must determine whether issuance of an incidental take permit to Green Diamond based on approval of the proposed MMHCP will destroy or adversely modify designated critical habitat in the Plan Area or Eligible Plan Area. It is not merely a determination whether the activities covered by the incidental take permit will directly or indirectly modify or remove any of the trees within the designated critical habitat. Rather, it is a broader assessment of how the localized impacts affect the conservation of the species in the context of the intended function and current condition of critical habitat at the Conservation Zone and range-wide scales.

The key factor related to an adverse modification determination is whether, with implementation of a proposed Federal action, the affected critical habitat would continue to serve its intended conservation role for the species. 76 Fed. Reg. 61599, 61609 (October. 5, 2011). As the FWS has explained, "[A]ctivities that may destroy or adversely modify critical habitat are those that alter the physical or biological features to an extent that appreciably reduces the conservation value of critical habitat for the marbled murrelet." Id.

To determine whether there is destruction or adverse modification of critical habitat, it is first necessary to determine effects at the local level and then proceed to the broader inquiry whether those localized effects would appreciably impair the capacity of the designated critical habitat to remain functional to serve its identified conservation role at the Conservation Zone and range-wide levels. Id. at 61609. For a wide-ranging species such as the marbled murrelet, where multiple critical habitat units are designated, each unit has a Conservation Zone role and range-wide role in contributing to the conservation of the species. Generally, the conservation role of marbled murrelet critical habitat units is to protect nesting habitat that supports viable marbled murrelet populations that are well distributed throughout the respective Conservation Zones. For the murrelet, the FWS has summarized the destruction or adverse modification test as follows:

The basis for an adverse modification opinion would be whether a proposed action appreciably reduces the ability of critical habitat to remain functional to serve its identified conservation role

at the Conservation Zone and range-wide levels. In evaluating the effect of a proposed action, the FWS will analyze the impacts to individual units in light of their overall contribution to the conservation of murrelets in the conservation zone, and the overall range of the marbled murrelet in Washington, Oregon, and California. Thus, an adverse modification determination would be based upon a broader inquiry than an assessment of adverse effects at the local unit level. Id.

At the local level, forest management activities may contribute to destruction or adverse modification of critical habitat through: (1) removal or degradation of individual trees with potential nesting platforms (PBF type 1), or (2) removal or degradation of trees adjacent to trees with potential nesting platforms that provide habitat elements essential to the suitability of the potential nest tree or platform, such as trees providing cover from weather or predators (also known as edge effects). (PBF type 2).

Under the proposed MMHCP (see Covered Activities in Section 2 of the MMHCP), the forest management activities that may directly or indirectly affect critical habitat are even-age and selection timber harvesting and thinning and related construction, maintenance, and use of roads for harvesting and reforestation. These activities occur infrequently and only in portions of the Plan Area critical habitat where previously harvested younger forest stands grow into merchantable timber. Under California Forest Practices Regulations and Green Diamond's management framework, timber harvesting occurs in patches with substantial retention of forested buffers on streams and retention of other forest stands and exceptional trees for the benefit of fish and wildlife (Green Diamond 2007, Green Diamond 2019). In addition, under the MMHCP, several conservation measures are added for the benefit of marbled murrelets. Key among them is the prescription of a 300-foot forested buffer on Adjacent Habitat Reserves such as the murrelet nesting stands in the Headwaters Reserve (Section 6.2.3). All of the large trees within that buffer will be retained, and the only harvest that may occur must be approved by the FWS as a treatment that will enhance and accelerate the development of murrelet habitat within the buffer area. Id. In addition, the MMHCP prescribes seasonal restrictions for forest management activities within Adjacent Habitat buffers to avoid and mitigate indirect effects of noise that might disturb murrelet nesting habitat in Adjacent Habitat Reserves like the Headwaters Forest (Section 6.2.4).

As a consequence of the approval and implementation of the MMHCP, it is unlikely that there will be degradation of forest habitat within designated areas to the extent that it would destroy or adversely modify habitat and function of the critical habitat within Conservation Zone 4 or at the range-wide scale. At the local scale of analysis, there will be removal of trees and modification of forest stands within portions of the Plan Area designated critical habitat, but most of that impact will occur within areas that are modeled as unsuitable habitat without any significant contribution of PBFs beneficial to murrelet conservation. In fact, a significant portion of the designated critical habitat in the Plan Area is located more than 0.5 miles west of the Headwaters Reserve and Adjacent Reserve buffer area. As the FWS explained in its critical habitat designation, "[a]ctions that impact forest stands that are not within 0.5 mile (0.8 km) of individual trees with potential nesting platforms would probably not adversely modify critical habitat, even if they occur within the boundaries of the area designated as critical habitat." Id. at 61609.

Under the MMHCP, the portions of the Plan Area critical habitat that contribute conservation value for murrelets are protected and may be enhanced. The MMHCP prescribes Adjacent Habitat Reserve buffers to prevent the removal or degradation of forest stands adjacent to nesting stands

that eliminate and mitigate against forest edge effects that are harmful to nesting (e.g. wind disturbance and predation). These buffers may only be managed within seasonal restrictions to prevent disturbance and solely to enhance their quality as suitable habitat with retention of all large trees. These prescribed buffers are implemented along the western boundary of the Headwaters Reserve (see Map 4-3-3) and in other locations where the Plan Area shares a boundary with designated critical habitat that is occupied nesting habitat (see Map 4-3-1).

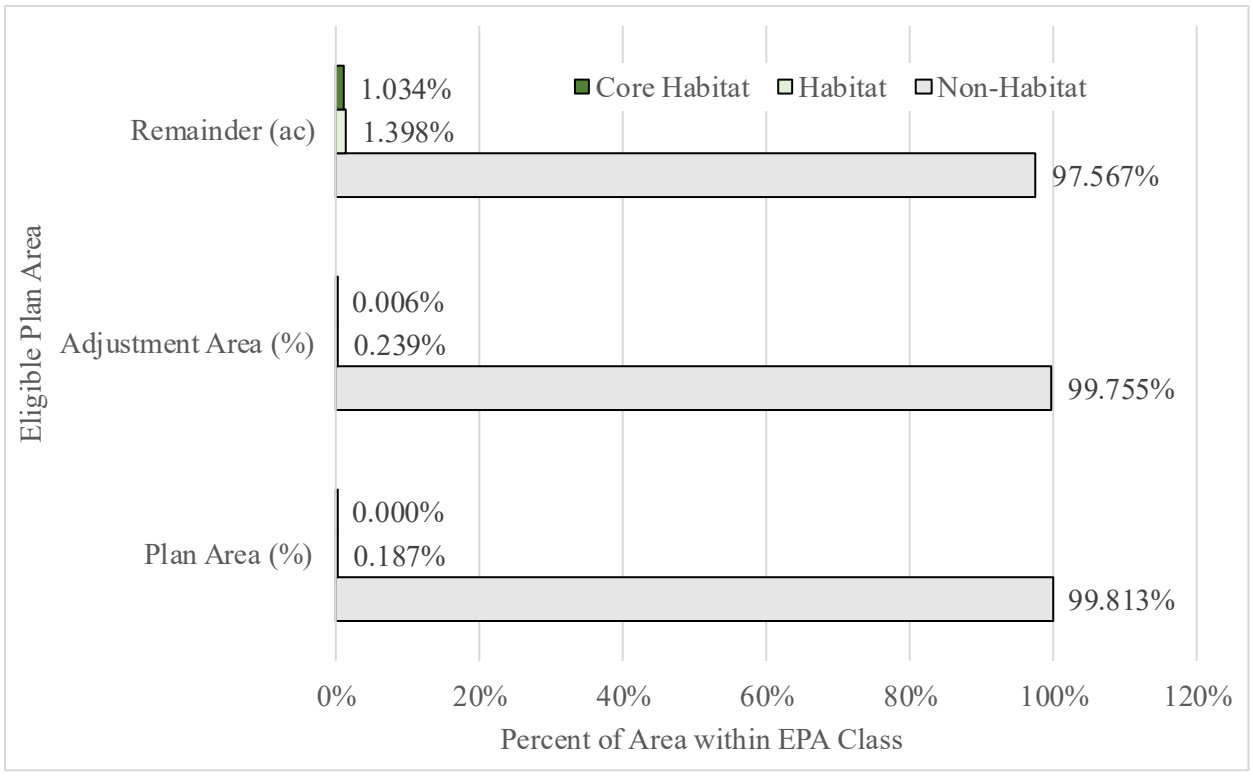
Because the conservation value of designated critical habitat in the Plan Area will be sustained by the MMHCP at the local scale, the conservation role of the designated critical habitat in the Plan Area will also be sustained for the benefit of Conservation Zone 4 and the range-wide Marbled Murrelet Recovery Plan. The forest management activities within the Plan Area critical habitat will occur in the previously harvested and younger forest stands that are not suitable nesting habitat and are separated from nesting habitat by a forested buffer that is prescribed by the MMHCP. Moreover, the forest management activities covered by the MMHCP will occur infrequently and on only a portion of the 1,400 acres of critical habitat in the Plan Area. In the broader context of murrelet conservation, Green Diamond's forest management under the MMHCP will affect less than 0.2 percent of the critical habitat designated for Conservation Zone 4 and less than 0.04 percent of all critical habitat designated for the marbled murrelet. Forest management under the MMHCP is expected to conserve the marbled murrelet, but to the extent that there are any localized impacts on designated critical habitat, they are unlikely to appreciably reduce the conservation value of critical habitat at the local, regional, and range-wide scale.

The cumulative effects of non-federal third-party activities are unlikely to diminish the benefits of designated critical habitat in the Plan Area. As discussed in Section 4.2.2, murrelet nesting habitat may be threatened by the impacts of climate change, but the portion of the Plan Area that is designated as critical habitat is located in the heart of the range of the marbled murrelet, very close to the ocean, and in an area that is likely to be most resilient due to fog, moisture, soil conditions, and the low risk of drought, wildfire, and disease. In addition, although most of the designated critical habitat in the Plan Area is not currently suitable habitat, in the long term, the marginal habitat along the western boundary of the Headwaters Forest Reserve likely will improve as suitable habitat with more PBFs and a significant portion of the unsuitable murrelet habitat in the Plan Area that is retained without timber harvest to satisfy forest practices regulations and conservation plans for aquatic species and the northern spotted owl will also develop the PBFs of significance to the marbled murrelet in the long term.

4.6 HABITAT IN THE NORTHWEST FOREST PLAN

Habitat designated under the Status and Trend of Nesting Habitat for the Marbled Murrelet Under the Northwest Forest Plan, 1993 to 2017 (Lorenz et al. 2021), commonly known as the 25-year report, falls into two categories, Core and 'Edge' Habitat. Core habitat was identified as habitat, consisting of intact patches of higher probability nesting habitat > 5.56 acres (2.25 hectares) in size. Approximately 383,539 acres (155,213 hectares) of designated Core and Edge habitat exists in the States of Washington, Oregon, and California (77.1%, 17.4%, and 5.6% respectively by state). Although California has the lowest amount of Core and Edge habitat, it has the highest and only Core to Edge ratio greater than 1 at 1.6:1. Washington and Oregon Core to Edge ratios are 0.62:1 and 0.28:1 respectively. This suggests California habitat is less fragmented with larger core areas in general. Within the EPA, there are 34,692 acres (14,039 hectares) of designated Edge and

Core habitat. Much of that habitat (30,810 acres, 12,468 hectares) is in the Remainder Area, leaving 3,882 acres (1,571 hectares) within the Plan Area (714 acres, 289 hectares) and Adjustment Areas (3,169 acres, 1,282 hectares). When viewed as a percentage of the EPA constituent areas (PA, AA, and Remainder), Core and Edge habitat combined accounts for 0.19%, 0.24%, and 2.43% respectively and a mere 1.8% of the entire EPA (Figure 4-7).



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Section 5. Assessment of Potential Effects of Take on the Covered Species and Its Habitat

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5.1 INTRODUCTION

The purpose of this MMHCP is to manage the Covered Lands under a conservation strategy that:

- Avoids or minimizes and mitigates, to the maximum extent practicable, the impacts of incidental take by Green Diamond's Covered Activities on marbled murrelets
- Does not appreciably reduce the likelihood of survival and recovery of marbled murrelet as a species
- Contributes to conservation and long-term recovery of the marbled murrelet as a species

To evaluate the MMHCP under these criteria, it is first necessary to define and estimate the take of marbled murrelets that may occur incidental to Covered Activities during the Permit term. The estimates of take may then be used by Green Diamond and the Service to assess the means to avoid, minimize and mitigate such take and the impacts of such take on the survival and recovery of the marbled murrelet as a species. To facilitate the evaluation of this MMHCP by the Service, this Section: (1) defines take and the direct and indirect pathways by which the Covered Activities may incidentally take marbled murrelets; (2) estimates the quantity of take that may occur over the life of the Permit; (3) estimates the offsetting and mitigating benefits of the MMHCP conservation strategy; and (4) provides an assessment of the potential effects of take incidental to Covered Activities when those activities are implemented in accordance with the Conservation Program described in Section 6 and the attendant benefits of that program.

For purposes of an incidental take permit application and habitat conservation plan, the Service must assess the impacts of incidental take and ultimately determine the quantity and nature of authorized taking based on an estimate of taking that is reasonably certain to occur incidental to Covered Activities implemented in accordance with this MMHCP. The amount of take and impacts of take are necessary information for the Service to determine the amount of incidental take that is authorized and the impacts that such take will have on the Covered Species.

An estimate of potential take requires a thorough evaluation of the direct and indirect pathways by which Covered Activities and associated habitat modifications may individually or cumulatively result in taking of the Covered Species over the life of the Permit and Plan. We need to know where, when, and how take is reasonably certain to occur.

5.1.1 Defining Take and Pathways for Take

Under the ESA, the term "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or to attempt to engage in any such conduct (16 U.S.C. section 1532(19)).

Harm in the definition of take means an act which actually kills or injures wildlife. This may include significant habitat modification or degradation that actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering.

For purposes of this MMHCP, the Covered Activities do not include actions that are intended to pursue, hunt, shoot, kill, trap, capture, or collect marbled murrelets, but the Covered Activities could cause incidental take in the form of harm to marbled murrelets through otherwise lawful

activities that kill or injure murrelets or significantly disrupt essential murrelet behavior to the extent that injury or death is likely to occur.

Not all instances of habitat modification or behavioral disruption for a listed species result in take. For purposes of this MMHCP, an estimate of take and the impacts of take require that we identify where Covered Activities will cause habitat modifications or interference with essential behavior that is "reasonably certain" to cause take. This requires a thorough evaluation of the direct and indirect pathways by which Covered Activities and habitat modifications may result in taking of Covered Species over the life of the Plan.

A Note on Take Under the California ESA

Consistent with guidance from the Service's Habitat Conservation Plan Handbook (USFWS and NMFS 2016), Green Diamond has invited the California Department of Fish and Wildlife to participate in the development of this MMHCP so that the MMCHP can be found to be consistent with the requirements of the California Endangered Species Act (CESA), which also applies to and protects the marbled murrelet as a CESA-listed species.

Under California Fish & Game Code Section 2080.1(b), CDFW may find the MMHCP and Green Diamond's activities covered by the MMHCP to be consistent with the requirements of the CESA, which prohibits the "take" of listed species such as the marbled murrelet. Under the CESA, "take" means hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill. Fish & Game Code Section 86. It is noteworthy that the CESA definition of "take" is narrower than the ESA definition of take and does not include broader prohibition against harm and harassment as forms of take. In the examples of take provided above, only example 1 – the direct killing of murrelets during a timber harvest – falls firmly within the scope of take that is prohibited under the CESA.

CDFW may find that the MMHCP is consistent with the requirements of the CESA. Such a finding by CDFW would provide programmatic satisfaction of the biological assessment and consultation requirement under California Forest Practices Regulation, 14 CCR 919.11, whereby the California Department of Forestry and Fire Protection consults with CDFW to ensure that any timber harvesting plan with potential impact to marbled murrelet will not cause unmitigated take or jeopardy to the species.

5.1.1.1 Where and When? Location and Time Limits for Incidental Take in the Forest Environment

We begin our assessment of incidental take by reference to the life cycle of the marbled murrelet to determine where and when incidental take may occur. In Section 3, we described the marbled murrelet as a seabird that uses terrestrial forest habitat that is in a condition that is uniquely suited for murrelet nesting, and it does so during a nesting season that is broadly defined to begin around March 24 and end around September 15 of each year. This means that the potential for incidental take of marbled murrelets in the forest environment is subject to certain spatial and temporal limitations on effects to suitable habitat. Covered Activities that occur in locations where marbled murrelets are not nesting or during times when marbled murrelets are not present in the forest environment do not have the potential to kill, injure or disrupt breeding behavior such that actual

death or injury to murrelets is likely to occur. However, we assumed in our assessment of incidental take that the entirety of Covered Activities that may affect murrelets where habitat is likely to be used for nesting would occur during the breeding season in any given year of the Permit Term. Accordingly, our assessment focuses on Covered Activities that incidentally take marbled murrelets through otherwise lawful habitat modification that unintentionally kills or injures murrelets or otherwise harms murrelets through disturbance and interference with essential behavior. This approach likely results in an overestimate of the risk of take and impacts of taking.

To solve for the spatial component of marbled murrelet take exposure in the Plan Area, Green Diamond identified suitable habitat for murrelet nesting using two methods. First Green Diamond mapped forest stands that are known or presumed to be occupied by marbled murrelets based on past field survey results or other evidence of nesting (Appendix C). Hereafter, these forest stands are referred to as Occupied Reserves. Then, Green Diamond created a landscape-specific model that identifies the location and extent of other forest stands in the Plan Area that contain habitat elements with the potential for suitable marbled murrelet nesting habitat. The model also provides a qualitative classification of whether such suitable habitat is of high, medium, low, or only marginal suitability, or simply unsuitable (Figure 5-1). The habitat model is described in Appendix A of this MMHCP.

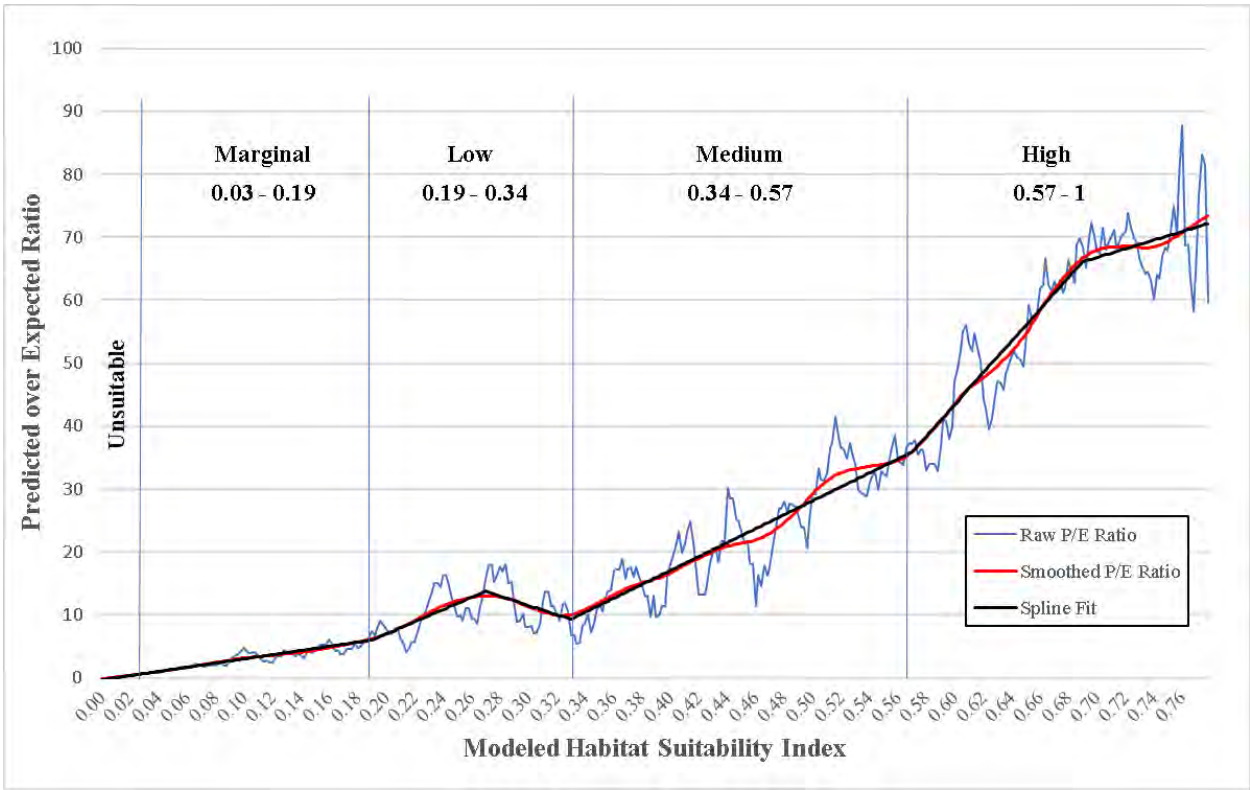


Figure 5-1. Predicted-to-expected (P/E) ratio curve showing the continuous Boyce (raw P/E ratio) curve, smoothed curve (Friedman 1984 SuperSmoother, R-Package supsmu), fitted slope lines from a spline fit model, and habitat classification breaks for a habitat suitability model (HSM) of marbled murrelet (Brachyramphus marmoratus) on Green Diamond Resource Company ownership and adjacent lands in northern California. The P/E curve for the model depicts relative likelihood of habitat selection across the range of conditions predicted by the best three-variable habitat model for Green Diamond lands consisting of the point density of tree approximate objects (TAO) ≥ 60 meters (197 feet) within a 5-acre circular buffer, the sum of heights of TAO ≥ 50 meters (164 feet) within a 5-acre (2.02 hectare) circular buffer, and the standard deviation of TAO ≥ 50 meters within a 5 acre circular buffer. The relative probability of habitat selection by marbled murrelets, in this case observation of occupied behaviors, increases as the value of habitat suitability (x-axis) increases from left to right.

The continuum of habitat suitability on Green Diamond timberlands is important because it corresponds with the relative likelihood that such habitat is occupied by marbled murrelets and used for nesting and can be protected and improved during the term of the Plan to benefit marbled murrelets or such habitat is of marginal or unsuitable quality and provides little or no conservation benefit. Naturally, the habitat suitability model aids in the estimation of take of marbled murrelets based on the relative likelihood of presence in an area affected by Covered Activities. The relative habitat suitability value of forest stands also helps to estimate the conservation benefits and population effects when forest stands are retained or harvested.

For purposes of our assessment of take, Green Diamond will assume that management under the MMHCP will protect and not remove any of the forest stands that are: (1) Occupied Reserves, or (2) Suitable Habitat Reserves (Section 6). The Suitable Habitat Reserves are forest stands with a

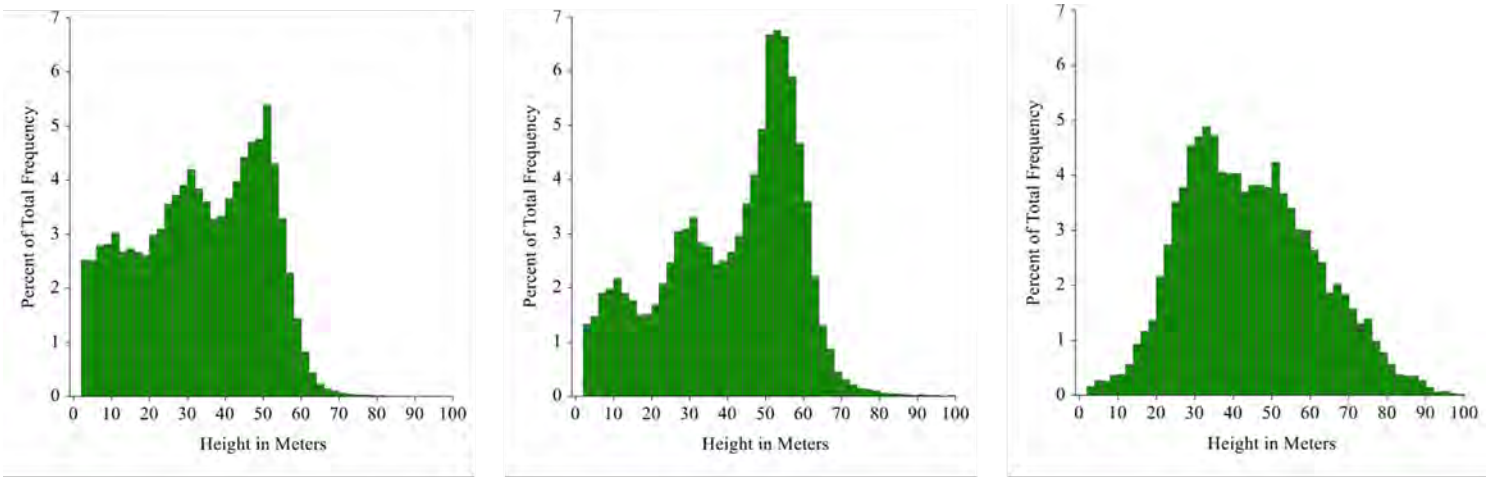
habitat suitability value of at least 0.19 (Figure 5-1) and fall into a habitat classification rating of low, medium or high based on the modeled habitat suitability value. From the perspective of conservation value to murrelets, these stands are considered the second most important habitats relative to the Occupied Reserves because they are more likely to provide important nesting structure and may be used for nesting. The Occupied Reserves and Suitable Habitat Reserves consist of taller and older trees represented in the Habitat Suitability Model (HSM) (Appendix A) by the variables defined as tree approximate objects (TAOs). The TAO variables derived from LiDAR included density of TAOs ≥ 60 meters in height, the sum of heights of TAOs ≥ 50 meters, and the standard deviation of TAO heights ≥ 50 meters. The Occupied Reserves are unharvested or lightly harvested old growth stands and are mainly comprised of exceptionally large diameter and tall centuries-old trees. These areas represent the highest suitability habitat in the Plan Area. These centuries old stands provide the density of large trees and abundance of large nesting platforms required by marbled murrelets due to tree age. The Occupied Reserves are small and isolated stands of old-growth conifer forests on these privately managed lands that represent remnants of the typical habitat for marbled murrelets found in larger extents on federal and state lands. The Suitable Habitat Reserves are primarily second growth forest (< 70 years old) with scattered remnant old trees or slightly aggregated old growth trees (> 200 years old) retained from the prior timber harvest. As the density of the scattered old growth trees increases within an area as measured by the HSM, the habitat suitability increases because these areas begin to acquire attributes of the Occupied Reserves (Figure 5-2). The true old growth trees (> 200 years old and > 60 meters in height) within these areas represent the potential nesting trees due to the time (age) required for large limbs, deformities, and other attributes of nesting platforms to develop. The patches or clumps of older trees also provide the increased vertical and horizontal heterogeneity and canopy gaps necessary for murrelets to aerially negotiate these areas for flight, landing, and nesting.

Our assessment also assumes that all forest stands within the portions of the Plan Area that are determined to be marginal or unsuitable marbled murrelet habitat are subject to harvest and removal (Maps 5-1-1, 5-1-2, and 5-1-3). The Marginal Habitat stands have a suitability index value of 0.03 - 0.189 and are of marginal conservation value to murrelets due to limited or non-existent nesting structure and very low probability of use by murrelets. The unsuitable areas are of no current conservation value to murrelets because nesting habitat does not exist at a level suitable for use by murrelets. As the density of the scattered old growth trees decreases within an area as measured by the HSM, the habitat suitability decreases because these areas exhibit fewer of the attributes of the Occupied Reserves. The Marginal Habitat areas contain fewer old growth trees or are completely lacking in this stand component. The Marginal Habitat areas also have a greater density of the 50 meter and shorter trees due to the relatively young age (< 70 years old) of the forest and insufficient time required for the density of tree stems to reduce over time from maturation of the forest stand and natural thinning from mortality, competition, and weather-related events. The 50 meter height class generally represents younger trees that support fewer or lack nesting platforms and reduced vertical and horizontal heterogeneity that limits flight, landing and nesting by marbled murrelets.

Map 5-1-1. Modeled Habitat

Map 5-1-2. Modeled Habitat

Map 5-1-3. Modeled Habitat



Marginal Habitat | Suitable Habitat Reserves | Occupied Reserves

Figure 5-2. Percent of total frequency histogram of LiDAR developed tree approximate objects (TAO) defining patches of forest within three categories of habitat on the California ownership of Green Diamond Resource Company. A habitat suitability model (HSM) for marbled murrelets was defined by three LiDAR derived covariates at 5-acre scales including sum of heights of TAO ≥ 50 meters, point density of TAO ≥ 60 meters, and standard deviation of TAO heights ≥ 50 meters. The ≥ 50 meters TAO from the HSM were used to delineate patches of habitat into three categories of habitat suitability index values. The histograms of percent total frequency of TAO on the Y-axis and TAO height in meters on the X-axis are shown within the three categories including Marginal Habitat (left), Suitable Habitat Reserves (middle), and Occupied Reserves (right) identified under the marbled murrelet Habitat Conservation Plan. The TAO height is positively related to tree age, and over hundreds of years, nesting platforms and other structural attributes of trees and forest patches develop into nesting habitat for marbled murrelets, particularly for redwood and Douglas-fir in northern California. When evaluating habitat for marbled murrelets based on the three variables in the predictive HSM, TAO ≥ 50 meters are the important metric, and the relative habitat suitability among the three classes increases from left to right (low to high).Marginal is the lowest suitability habitat due to the low percent total frequency (~20%) of TAO in this height class followed by Suitable Habitat Reserves and Occupied Reserves (both ~40% total frequency). The Occupied Reserves (right) contain the greatest percent total frequency of exceptionally tall, old, and structurally complex trees and the TAO in Suitable Habitat Reserves are of greater conservation value compared to Marginal Habitat given the percent total frequency of TAO ≥ 50 meters and the recruitment, over time, of TAO into height classes from 50-100 meters as observed in the Occupied Reserves.

To solve for the temporal component of marbled murrelet take exposure in the Plan Area, we use the broadly defined breeding season of marbled murrelets. In truth, a given pair of adult murrelets will complete their nesting activities in a shorter time frame than the range of possible murrelet nesting in the forest environment (Figure 5-3). Take of marbled murrelets by Covered Activities

cannot occur when murrelets are not present in the forest environment, but we have conservatively assumed and estimated take under a scenario that Covered Activities would occur when murrelets are present even though we know that there are months when murrelets will not be using suitable habitat in the Plan Area when Covered Activities with potential impacts occur.

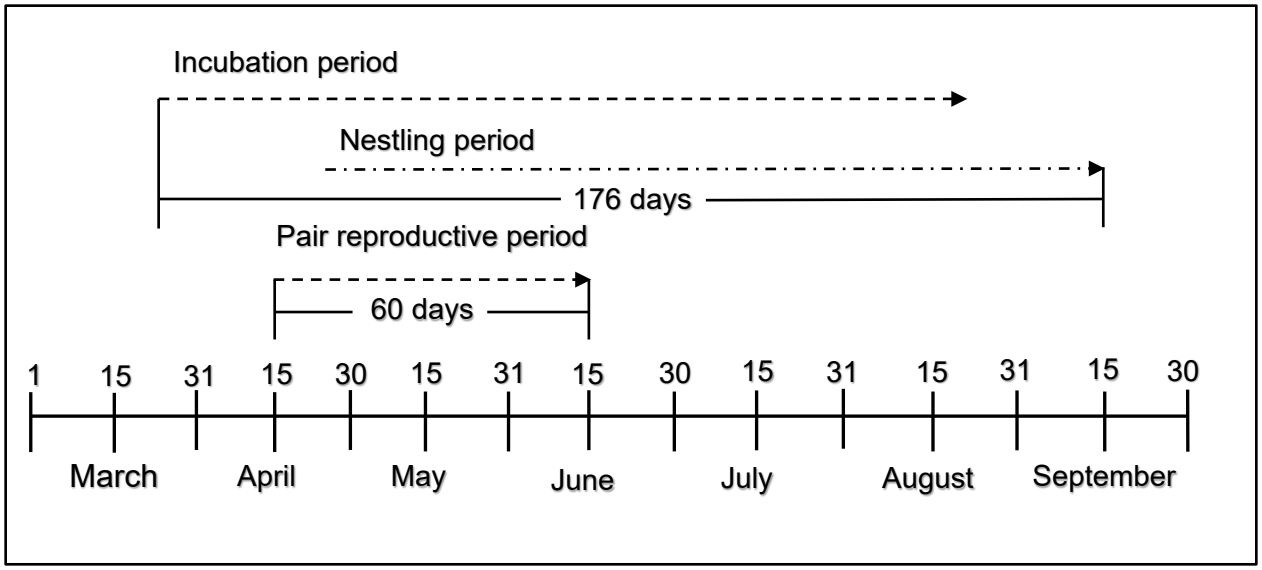


Figure 5-3. Breeding phenology of marbled murrelets in northern California based on data presented in Hamer and Nelson 1995b. The breeding season for murrelets in California commences on March 24 and ends on September 15, or 176 days. The typical reproductive period for a pair of murrelets is 60 days, or 30 days for egg laying and incubation followed by approximately 30 days of nestling development prior to date of fledging when the juvenile makes its first flight to the Pacific Ocean (the 60-day period for any pair could occur within the duration of the 176-day period). Both members of the pair share incubation duties with switching happening at pre-dawn or just after dawn. Members of the pair may feed the nestling several times per day with dawn and dusk feedings more common, but mid-day feeding bouts occur especially later in the breeding season.

5.1.1.2 How? Habitat Modification and Disturbance of Essential Behavior

Green Diamond's Covered Activities may incidentally take marbled murrelets through otherwise lawful habitat modification that unintentionally kills or injures murrelets or otherwise harms murrelets by interfering with their essential behavior, and through visual and auditory disturbance from activities that harm murrelets to the extent of interference with essential behavior. To harm murrelets, such habitat modification or disturbance must be reasonably certain to result in injury or death of murrelets.

Not all instances of habitat modification or behavioral disturbance result in take. For purposes of this MMHCP, an evaluation of take and the influences of take require us to identify potential incidental take scenarios and conditions where Covered Activities are reasonably certain to cause death or injury to marbled murrelets over the life of the Permit. Individual minor effects themselves

may not cause take but combined temporally and spatially with other similar closely related activities and effects could culminate in the take of marbled murrelets.

Green Diamond's Covered Activities (described in Section 2 of this Plan) have the potential to individually and cumulatively cause incidental take in two scenarios: (1) direct take of murrelets that are killed or injured when Covered Activities culminate in the removal and replacement of forest stands that are Marginal Habitat (i.e. harvest of suitable nesting habitat when it is actually occupied); and (2) indirect take when Covered Activities occurring outside the boundaries of suitable murrelet habitat cause significant impairment of essential behavior leading to actual death of or injury to murrelets.

A more detailed description of each scenario helps to illustrate how Covered Activities could directly or indirectly harm and take marbled murrelets.

Scenario 1 - Direct Harm and Take from Modification or Removal of Marginal Habitat: Timber harvest is a form of habitat modification that could directly harm and therefore take a marbled murrelet when the timber harvest occurs in a timber stand that is occupied by marbled murrelets during the nesting season and a nest tree is disturbed to the extent that a nestling in a nest or an adult that will not leave the nest is directly injured or killed by timber falling.

Scenario 2 - Indirect Harm and Take from Covered Activities Adjacent to Suitable Habitat through Edge-Effects. Both habitat modification and disturbance of essential behavior through timber harvesting can cause indirect take when, for example, it occurs outside and adjacent to a forest stand used by murrelets for nesting and the harvest causes edge-effects. There are two types of take from edge-effects: habitat modification and disturbance.

a. Edge-Effects from Habitat Modification. Timber harvest adjacent to suitable habitat may result in cutting and removal of most trees followed by many years of young forest conditions along a boundary with a mature forest stand used by murrelets for nesting. Regardless of whether the timber harvest occurs within or outside the nesting season, the resulting hard edge of forest canopy may reduce the suitability of an existing nesting site. The decrease in suitability of a particular nesting platform may occur from changes in microclimate that alter temperature and moisture regimes or through increased risk of predation on murrelet nestlings because nesting activity is more easily detected by predators around the forest edge created by harvest. Those risks are reduced as the adjacent young forest regenerates and provides cover. We do not attempt to distinguish between take that reduces nest success due to exposure from climatic effects and that from increased rates of predation. We simply acknowledge that take from edge-effects may occur from individual or combined pathways.

b. Edge-Effects from Disturbance. Timber harvesting adjacent to a suitable habitat stand not only alters the physical habitat structure of the forest edge, it also causes a period of above-baseline noise and activity that may disturb the essential behavior of nesting murrelet adults and nestlings that are nearby. Such a disturbance may result in take (i.e., death or injury) when, for example, it causes a murrelet nestling to startle and fall from a nest, reveal itself to a predator, or adult murrelets avoid a nest site where they are caring for an egg or nestling and that changed behavior results in death or injury.

It is possible, but exceedingly rare, for Covered Activities outside the scope of timber harvesting to cause a significant auditory or visual disturbance that results in the destruction of an egg or loss of a nestling. An example of such an activity is the replacement and installation of a culvert or bridge at a watercourse that requires stationary activity by heavy equipment over several hours or days. Many such activities are required by existing permits and agreements to benefit other protected resources and are only possible during the murrelet breeding season. Routine Covered Activities such as wildlife management surveys, forest inventory surveys, road maintenance activities, timber harvest plan layout, or vehicle traffic on an existing road network may be heard or seen by murrelets, but are not reasonably certain to cause death or injury to a murrelet, particularly when those activities are transitory in nature.

To understand these two scenarios, it is also helpful to understand the scope of where direct and indirect take may or may not occur under the proposed Conservation Program (Section 6). Based on the Conservation Program we have identified two essential scenarios where Covered Activities can cause murrelet take – (1) harvest and removal or significant alteration of Marginal Habitat stands; and (2) harvesting operations adjacent to forest stands that are determined to be low suitable and better habitat, hereafter Suitable Habitat Reserves (Section 6). Table 5-1 below helps to explain why these two scenarios are key to estimating the take that may occur under the MMHCP.

Table 5-1. Direct and indirect take effects to Plan Area forest stand murrelet habitat suitability.

Plan Area Forest Stand Murrelet Habitat Suitability	Conservation Prescription	Take Effect
Occupied Reserves (Murrelet Stands Known and Presumed Occupied plus other recently Occupied stands[1])	No harvest and 300-foot operational buffer, limited seasonal restrictions[2]	No direct take through habitat removal and no indirect take through edge effects
Suitable Habitat Reserves (Predicted Low and Better Suitability within model classified habitat patch)	No harvest within model classified habitat patch and no operational buffer outside boundary or seasonal restrictions	No direct take through habitat removal, but potential indirect edge-effect take estimated because of no operational buffer
Marginal Habitat (Suitability within model classified habitat patch)	Free to harvest	Direct take estimated based on removal or alteration of forest stand. Potential indirect take through edge effect on Marginal Habitat when it is not removed.
Unsuitable (no patch delineation)	Free to harvest	Direct or indirect take highly improbable

Green Diamond will provide estimates of take and the impacts of take based on intersection of Conservation Program prescriptions the degree of habitat suitability for all forest stands and these two scenarios: (1) potential direct take from modification and removal of Marginal Habitat; and

[1] Forest stands where occupied behaviors were observed.
[2] See Appendix D for take avoidance and minimization measures

(2) potential indirect take caused by the edge effects of habitat modification adjacent to Marginal and Suitable Habitat and disturbance associated with timber harvests near potentially nesting murrelets in these habitats. A more detailed description of the Covered Activities and pathways for take under these two scenarios is provided below.

5.1.2 A Description of Green Diamond's Covered Activities that are Reasonably Likely to Cause Take

Green Diamond's Covered Activities may incidentally take marbled murrelets (hereafter murrelet) through habitat modification, edge-influenced impacts (e.g., increased predation), and noise disturbance-related impacts that result in injury, death, or impairment of essential behaviors resulting in death or injury of nesting adult murrelets and nestlings.

Green Diamond seeks a Take Permit for murrelets primarily due to timber harvest-related impacts. Each timber harvest event is comprised of a series of Covered Activities that are considered in this assessment of take. The series of Covered Activities begins with harvest planning when vehicles and personnel may visit a forested site occupied by murrelets to initiate activities associated with timber harvest plan reconnaissance and layout such as inventory of timber, identification of protected areas, wildlife surveys, tree marking/flagging, archaeological surveys, and site inspections by regulatory agencies. Next, roads may be built, reconstructed, or maintained using heavy equipment, rock hauling, installation or upgrading of stream crossings, and in some cases, limited timber falling may be conducted to facilitate these activities. The actual timber harvest follows with timber falling, yarding, loading, and hauling from the harvest unit across a portion of the Plan Area to market. When harvest is concluded, more Covered Activities ensue such as piling and burning of slash, reforestation, manual management of competing vegetation (i.e., non-herbicide treatments), and in some instances, pre-commercial thinning of young stands. In limited instances, Covered Activities occur without any association with a particular timber harvest event. For example, monitoring and research activities and forest road traffic occurs across the Plan Area on a regular basis. Covered Activities of this nature do not modify habitat but result in common (baseline) noise that is experienced by murrelets in a working forest setting. Murrelets within the Plan Area are acclimatized to noise from these dispersed Covered Activities and are unlikely to modify their essential behavior in response to this baseline commercial and non-commercial human activity distributed throughout the Plan Area over time. Nonetheless, this assessment of potential take also considers the effect on murrelets from noise generated by Covered Activities.

5.1.2.1 Direct Take from Alteration or Removal of Marginal Habitat

Removal or significant disturbance of a potential nest tree and nest during the nesting season is the primary risk of taking that may occur during implementation of the Plan. Such incidental take may occur through habitat modification by timber harvesting that removes or disturbs a nest structure containing an active nest (incubating adult, eggs, or dependent nestlings). Take will result if eggs and nestlings are abandoned or removed from the nest and crushed or injured and killed. Take of an adult may also occur if it is killed or injured during the destruction of a nest. Although it is extremely unlikely that an adult would fail to flush from a nest tree prior to the tree being cut, this scenario has been accounted for in the estimates of take.

Direct take of nesting murrelets is avoided and minimized in several ways. Under the Conservation Program of this Plan, Occupied Reserves and Suitable Habitat Reserves will be retained and allowed to develop without harvest. Only forest stands that are unsuitable or identified as Marginal Habitat may be altered or removed through sustainable timber harvesting. When Marginal Habitat is altered or removed by timber harvest, there is a potential for incidental take to occur. Unsuitable habitat is not expected to result in take, but contingencies are in place if confirmed nesting is documented in model-classified unsuitable areas (Section 6.3.2.5).

Potential direct take from timber harvest is further reduced by the fact that some timber harvest within Marginal Habitat will occur outside the murrelet nesting season. Removal and destruction of a nest or nest tree will only result in injury or death of eggs or dependent young if the removal occurs during the murrelet breeding season and in a year when the nest is active, which varies from year to year based on offshore conditions (Peery et al. 2004, Lorenz et al. 2017). Based on past harvest patterns (2016–2020) and analyses of prior timber felling events in the Plan Area, approximately 34% of Green Diamond's harvest units were harvested outside of the murrelet breeding season. Similarly, removal of a nest tree will only result in injury or death of an adult murrelet if the tree removal occurs during the incubation period in a year when the nest is active. The breeding season for murrelets in the Plan Area is from March 24 through September 15, and this period is conservative to account for early nesting and late fledging. We assumed a conservative approach with the potential for take to be constant during the entire breeding season and population impacts through loss in productivity are described in Section 5.2.2. Given the low probability of occupancy in Marginal Habitat, directly killing or injuring murrelets is highly unlikely. However, isolated unintentional or inadvertent instances of direct take are not zero and are therefore estimated below. When the entire cycle of Covered Activities for sustainable timber harvesting results in significant alteration or removal of a stand of timber that is suitable habitat for nesting, take is estimated based on harvest as the culmination of all Covered Activities in the likelihood of an event that directly injures or kills adult murrelets and nests with eggs or nestlings. When an area of suitable habitat is removed by timber harvesting, it becomes a younger forest that is no longer habitat that is suitable for nesting nor is it susceptible to further take from Covered Activities that occur in or near the suitable habitat that has been removed. However, the estimated loss of individual marbled murrelets that are taken does have a second-order impact of take that will affect the murrelet population -- a loss of future reproduction by the taken individuals. This impact of take is not additional take (i.e., actual death or injury), but the adverse future population effect of such take is estimated for consideration by the Service in its determination whether such taking will appreciably reduce the likelihood of survival and recovery of the marbled murrelet species.

5.1.2.2 Indirect Take from the Edge Effects of Harvest Near Suitable Habitat

Covered Activities occurring outside stands of suitable murrelet habitat (Marginal Habitat and Suitable Habitat Reserves) may also cause take when such activities cause significant impairment of essential behavior within the suitable habitat and lead to actual death of or injury to murrelets. Indirect take may result from habitat modification or above-baseline noise disturbance caused by timber harvest outside of suitable nesting habitat, but in close proximity (within 50 meters) to nest trees. Timber harvest outside of suitable habitat may create a hard edge of young forest on a suitable habitat stand that makes it more susceptible to predation on nesting murrelets. Also, above-baseline noise disturbances originating outside of occupied nesting habitat may, in limited

instances, interfere with essential behavior to the degree that it causes actual death or injury to murrelets. In close proximity, extraordinary loud noises may harm murrelets through changes in essential behaviors such as flushing a murrelet nestling from its nest or causing adult murrelets to avoid or neglect an active nest due to increasing stress and elevated corticosteroid levels. These situations have the potential to result in take due to possible neglect and death of eggs or nestlings. Murrelets may experience reduced nesting success within close proximity to human-induced forest edges due to increased nest predation risk (Nelson and Hamer 1995, Manly and Nelson 1999) or changes in microclimate (McShane et al. 2004, van Rooyen et al. 2011). Avian disturbance (predation risk) appears to be the strongest at hard edges such as recent clearcut harvest areas, but the risk is reduced over time as the younger stands regenerate and soften the edge of suitable habitat with more canopy and cover (Malt and Lank 2009). Hard edges may increase predator densities by temporarily increasing preferential foraging opportunities (i.e., increased berry production and insects) (Marzluff et al. 2004). While overall predator densities may decline as forests regenerate, jay abundance may not be reduced because new clearcuts that attract these generalist predators are continually created and remain common (Malt and Lank 2009). However, the relative percentages of edge across the Plan Area will remain generally constant throughout the Permit term because Green Diamond will continue to manage its forests for sustainable harvest through existing regulations, permits, and policies. Additionally, cryptic coloration of the egg/nestling/adult, crepuscular activity patterns, selection of hidden nest sites with high vertical and horizontal cover, retention of down by the nestling, fledging after dusk, minimal or muted vocalizations from nests, remaining still or flattening against tree branches in response to predators, and other behavioral and breeding habits of murrelets likely indicates that the species evolved under immense predation and nest site competition pressure (Nelson and Hamer 1995, Burger 2002).

Hard edges may also reduce nest success by increasing windthrow and altering microclimate regimes (i.e., sunlight, temperature, and moisture) that may reduce epiphyte growth and survival important for murrelet nest platforms (van Rooyen et al. 2011). Van Rooyen et al. (2011) found that platform abundance within 0-50 meters (0–164 feet) from stands 0-20 years (“hard edges”) was reduced by 75% in comparison with interior forests, and platform abundance within 0-50 meters from stands 21-40 years old (“soft edges”) was reduced by 60% in comparison with interior forests. Other studies have observed that most microclimate-related edge effects are captured within 100 meters (328 feet) of an edge (Paton 1994, Chen et al. 1992, Raphael et al. 2002). However, changes in habitat function due to microclimate shifts from edges are transitory and are unlikely to result in death or injury to murrelets. Increased risk of predation is a function of whether murrelets choose to nest in habitat patches near edges in a landscape where this feature is relatively common. The association of timber harvest, the probability of increased predation risk or other edge effects, and actual take of murrelets is not well understood. Potential take of murrelets due to edge effects of suitable habitat may be difficult to reliably quantify or be accounted for in a working forest landscape where this feature is common. Although the amounts of edge are unlikely to change substantially from baseline over the Permit term, potential indirect take through edge effects has been accounted for in the overall calculations through a cautious approach to estimate potential negative effects from Covered Activities.

Covered Activities occurring adjacent to an occupied marbled murrelet nest during the breeding season may result in noise disturbance with the potential to cause take of the Covered Species if the activity “actually kills or injures wildlife by significantly impairing essential behavior patterns including breeding, feeding, or sheltering.” (50 C.F.R. §17.3). Impairment of essential behaviors

may include an adult murrelet being flushed from a nest during the incubation period that results in egg failure. Murrelets and other seabirds are known to neglect their eggs for short periods to maximize foraging time (Nelson and Hamer 1995). Adult murrelets have been documented to neglect their egg during incubation for periods of 24 hours without resulting in egg failure (Golightly and Schneider 2009); however, unattended eggs may be more vulnerable to predation (Nelson and Hamer 1995). Additionally, hatched young are only brooded for one or two days by the adults and then left alone at the nest for most of the nestling-rearing period (McShane et al. 2004). Although a variety of physical and biological factors may influence timing of incubation (Nelson and Hamer 1995), the incubation period for murrelets in northern California has been documented late-April through late-July, including re-nesting attempts, with mean nest initiation occurring from late-May through early June (Hébert and Golightly 2006). For noise disturbance to result in egg failure, the disturbance would need to occur during the incubation period and cause the adult to flush leaving the egg vulnerable to predation (more than what is experienced through typical egg neglect) or result in nest abandonment.

In addition to noise disturbance causing potential egg failures or nest abandonment, concerns have also been raised about noise disturbance causing delayed or aborted feeding attempts that could potentially result in starvation of the young or malnutrition of the young that reduces likelihood of survival. However, very few observations have been made of delayed or aborted feeding attempts resulting from noise disturbance. As reported by Long and Ralph (1998), instances where investigator disturbance (researchers near a nest tree or in the nest tree) caused delayed or aborted feeding attempts have been observed, but none resulted in abandonment or reduced success. Likewise, many of these investigations did not result in disturbance of any kind to nestlings or adults. Long and Ralph (1998) also summarized other forms of noise disturbance including hikers, campgrounds, vehicles, sharp/loud noises (gun shots, car doors slamming, horns/jake brakes) and murrelets nesting in areas where these noises or similar noises were common showed no signs of disturbance. However, in remote areas away from anthropogenic noises, nesting murrelets were more likely to react, mostly by flinching. Long and Ralph (1998) also summarized observations of nesting murrelets in areas with prolonged, loud noises caused by logging operations including heavy equipment, chainsaws, and log truck traffic and no reactions were observed. The authors concluded that nesting murrelets (adults and nestlings) were not easily disturbed except when confronted at or very near the nest itself, and nesting murrelets generally appeared habituated to noises in settings where anthropogenic disturbance was common. Current noise disturbance take avoidance practices for nesting murrelets in northern California are based on observations of other avian species including ground nesting birds (Greater sage-grouse and white-crowned sparrows) and species nesting in shrub and open woodland areas with nests less than 10 feet (3.05 meters) from the ground (various flycatcher species) (see USFWS 2020, Table 1, page 12) that are likely not comparable to a cryptic species nesting high in the canopy that has been documented to display little to no visible reaction in response to potential noise disturbance.

Delayed or aborted feeding attempts could also result in increased predation risk to adult murrelets or increased energetic costs through increased time the adult is commuting. However, Hull et al. (2001) compared energetic costs of murrelets nesting closer to foraging areas versus murrelets nesting further inland, and the murrelets nesting further inland offset the increase in energetic costs by making fewer feeding trips, delivering larger prey items, and having the ability to rebuild body mass between breeding seasons. Additionally, nest success and predation risk did not differ between murrelets nesting closer to foraging areas and murrelets nesting further inland. Given the

decades of baseline noise generated from the Covered Activities and ability of murrelets to become habituated to anthropogenic noise, it is unlikely that the Covered Activities will result in disturbance to murrelets nesting in the Plan Area. Furthermore, in the unlikely event that murrelets delay or abort feeding attempts in response to noise disturbance, it is unlikely that these behaviors will result in take. However, the indirect take estimates for this MMHCP were developed to be conservative to account for take that may occur as a result of auditory or visual disturbance.

5.2 ESTIMATING TAKE AND IMPACTS OF TAKE

Using the incidental take scenarios for Covered Activities implemented in accordance with this Plan, as described above, Green Diamond developed estimates of: (1) the quantity of take directly caused by the removal and alteration of timber stands that are Marginal Habitat in the Plan Area; (2) the quantity of take indirectly caused by edge effects and disturbance effects of Covered Activities occurring outside and proximal to potential nests in stands of Marginal Habitat and Suitable Habitat Reserves in the Plan Area; and (3) the murrelet population impacts of combined direct and indirect take by habitat modification and disturbance and loss in productivity (recruitment) over time due to removal of habitat. In addition, Green Diamond estimates the conservation benefits of murrelet population enhancement through the protection and recruitment of suitable murrelet habitat stands in the Plan Area so that the Service may compare the mitigation benefits of the MMHCP to the estimates of take and impacts of take.

5.2.1 Estimating Take from Forecasts of Timber Harvest

Green Diamond has maintained timber inventory records for its timber lands for over three decades. A range of strategies are used to collect timber inventory data and the methods for storing and utilizing the data have changed over time as technology has advanced. The current inventory in general is not stratified. Instead, each stand has an individual estimate of age, site quality, stocking and volume by tree species. Individual forested stand polygons range in size from less than 1 acre (0.4 hectares) to slightly over 1,000 acres (405 hectares), with an average size of 16.5 acres (6.3 hectares). Individual stand polygons are delineated to define areas of vegetation that are relatively homogeneous with respect to species composition, stocking, and age.

Prior harvesting has generally been used to delineate stand polygons in younger age classes (< 40 years). Stand ages for these polygons assume that regeneration was achieved in the year following harvest. Older stands have been delineated primarily by aerial photographic cover typing and LiDAR data models. In some cases, stand delineations were obtained from prior owners at the time of acquisition of the land by Green Diamond.

Inventory estimates typically come either from timber cruising conducted by Green Diamond, or from inventory values obtained from prior owners at the time of land acquisition. Approximately 109,445 acres (44,291 hectares) (48% of the net productive acres) have a recent inventory cruise, within the last 10 years. The stand cruises are validated by Green Diamond's inventory cruising administrator and imported into the Forest Projection and Planning System (Planning System) growth and yield simulator. For stands greater than or equal to 30 years old, 78% of those net productive acres have a recent inventory cruise. The remaining uncruised stands are, predominantly, either within 5 years of harvesting or exist as small, isolated patches scattered across the property.

For uncruised stands, or where no suitable inventory was available from a prior owner, there are two primary sources of inventory information: (1) photo-estimates, supported by field verification; or (2) stratification based on age and site, with expansion of cruise averages to uncruised stands within these strata. The latter case was used only for stands for which no information was available other than an estimate of stand age, primary site-species class (redwood or whitewood), and general site-class – 'good' (Site Classes I or II), 'medium' (III), or 'poor' site, (IV or V).

Green Diamond currently uses the Planning System, developed by the Forest Biometrics Research Institute, for inventory tracking and growth modeling. Prior to 2006, Green Diamond used a proprietary growth and yield model to manage legacy cruise data. All stand inventory information was converted to the Planning System format in 2006. All stand inventory data is updated annually for growth using Planning System.

All stands ≥ five years old are surveyed for stocking by species and height class. These are plot-based surveys that can be directly incorporated into Planning System. These data constitute the only empirical survey of regeneration on Green Diamond land. Because they effectively integrate the combined effects of planting, natural regeneration, and vegetation management through the first five years after stand establishment, these data are used as the basis for determining the initial species composition and stocking levels for all regenerated stands in the 100-year simulation.

Green Diamond manages its California timberlands for Long Term Sustained Yield under a Maximum Sustained Production plan prepared and approved in accordance with the California Forest Practice Rules under Title 14 CCR 913.11(a). Informally referred to as an "Option (a)" plan, Green Diamond's most recent Option (a) plan was completed in 2009. The Option (a) contains confidential proprietary information that is protected from public disclosure under California law. The Option (a) modeling used spatially explicit simulation of harvesting and growth of individual stand components over more than one rotation for 100 years, based on the GIS mapping of the standing inventory for Green Diamond's California timberlands as of January 1, 2008. The Option (a) modeling used even-aged silvicultural practices (clear-cutting) as the harvest/regeneration method. The projected harvest of forested areas (timber harvest units of similar age and constrained by acreage limits under the California Forest Practice Rules) is termed a California Comprehensive Harvest Forecast (Harvest Forecast).

Under the Green Diamond Option (a) plan, annual harvest levels are scheduled to balance forest growth and timber harvest over a 100-year period. The Option (a) rule (CCR 913.11 (a)) requires the landowner to demonstrate achievement of Maximum Sustained Production by satisfying the following five requirements, paraphrased below from the California Forest Practice Rules:

- Producing the yield of timber products … while accounting for limits on productivity due to constraints imposed from consideration of other forest values, including but not limited to, recreation, watershed, wildlife, range and forage, fisheries, regional economic vitality, employment and aesthetic enjoyment;
- Balancing growth and harvest over time;
- Realizing growth potential as measured by adequate site occupancy adequate site occupancy by species to be managed by the landowner;
- Maintaining good stand vigor;
- Making provisions for adequate regeneration.

Timber stands 45 years and older are available for regeneration harvest. However, implementation of intermediate treatments such as commercial thinning, as well as state laws that constrain both the size of even-aged management units and the timing of adjacent even-age harvesting operations, can delay the harvest of many stands until they reach the 70-year age class. The anticipated average age of harvest stands as currently modeled is about 50 years as the property approaches full regulation. A fully regulated condition means that future harvest is constrained over space and time by the size and spacing of harvest units dictated under the current regulations and chosen forest management strategy.

Because essentially all of Green Diamond's property has been harvested at some time in the past, the progress of timber harvesting across the ownership will reflect the pattern of age classes developed as a result of prior logging activity. Where large areas were initially harvested as continuous logging operations resulting in large tracts of even-aged young forest, present day harvesting operations are localized in these areas and occur over reduced acreages due to current regulations. California Forest Practice Rule constraints will cause the dispersal of activities over time and space within these blocks during current and future rotation periods. This is a product of the California Forest Practice Rules adjacency harvesting constraints that are applied to even-aged harvesting units resulting in retention of many stands far past planned rotation age and much smaller even-age harvest units. The current opening size for even age units is approximately 15 acres (6.07 hectares). If harvesting of a tract of mature timber is initiated around age 45, the harvesting of much of that tract will be constrained into the following decades, and the harvest of a few stands will be constrained past 70 years of age. This effect has been demonstrated in Green Diamond's growth and yield planning.

5.2.2 Estimating Direct and Indirect Take from Covered Activities

The effects of Covered Activities on habitat and potential impacts to murrelets and mitigation to offset those impacts required us to evaluate effects through a series of sequential steps in a process. That process included a variety of inputs including habitat delineation based on the habitat model (Appendix A), habitat assessments and available surveys for murrelet occupancy in forest stands (Appendix C), and model predicted habitat suitability and literature-based information on nesting parameters for marbled murrelets. The process was founded upon empirical and science-based estimates of impacts and the required conservation of available suitable habitat to fully offset potential impacts to murrelets as a result of plan implementation. A basic outline of this process is depicted in Figure 5-4, and it is described in further detail within this Section where we estimate the amount of potential take from Covered Activities along with mitigation under the Conservation Program. A more detailed accounting of the process along with calculations of take, murrelet productivity, and mitigation acres is found in Appendix B.

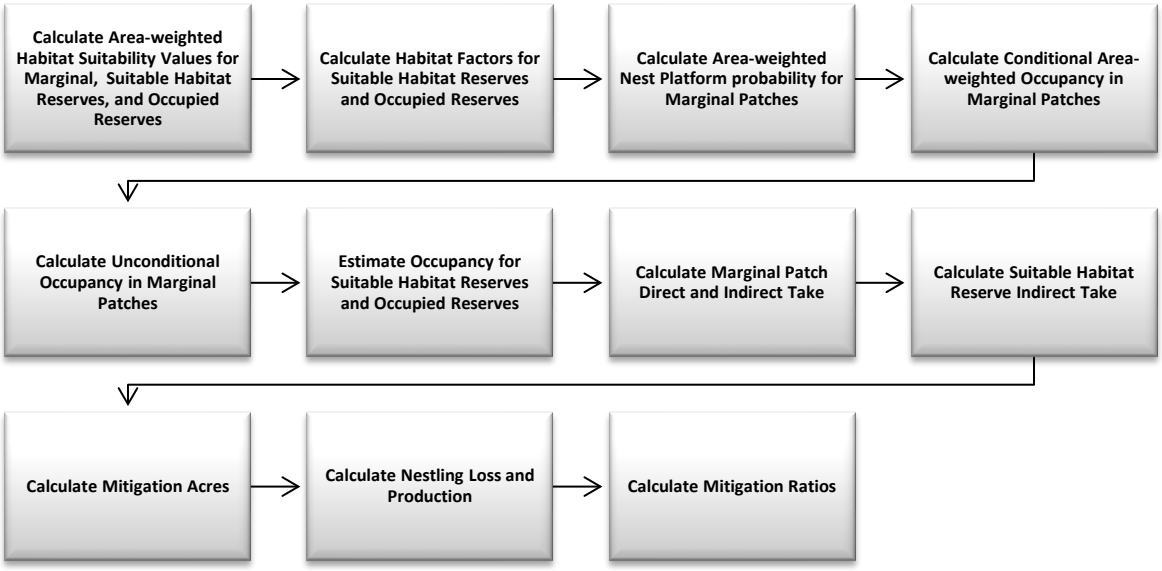


Figure 5-4. Flow chart of basic process used to calculate habitat suitability factors for habitat patches, relative occupancy of habitat patches, estimated direct and indirect take, estimated recruitment and loss of production of murrelets, and mitigation ratios. A more detailed flow chart of the process with estimates of take and mitigation is available in Appendix B.

5.2.2.1 Assessing Direct Take

Direct take was assessed by calculating the intersection of all model-classified patches of Marginal Habitat within the Plan Area and the Harvest Forecast with a starting year of 2023 over a 100-year period. The delineation of model classified Marginal Habitat is described in detail in Appendix A, and the process is briefly described here. We evaluated the final HSI model output based on 5-meter raster cells (i.e., pixels) covering Green Diamond timberlands and identified those in the Marginal Habitat and Suitable Habitat Reserve classes. We buffered the model classified patches of Marginal Habitat and Suitable Habitat Reserves outward by 80.25 meters (263.1 feet) to account for the radius of the 5-acre (2.02 hectare) moving window used in the model. All trees ≥ 50 meters within the 80.25 meter radius buffer contributed to the predicted HSI value for the central pixel in the buffer. A boundary was constructed around a habitat patch by connecting contributing trees ≥ 50 meters. This process resulted in an objective and repeatable process to identify potential habitat patches based on the model output. These patches of Marginal Habitat and Suitable Habitat Reserves were then intersected with future timber harvesting polygons from the Harvest Forecast to estimate potential incidental take for the permit term.

We used the first 50 years of the Harvest Forecast to estimate take based on projected timber harvest locations. We assumed that direct take of eggs, nestlings, and adult murrelets was only possible within Marginal Habitat because those areas could be subject to direct timber harvest (i.e.,

removal of habitat). The Suitable Habitat Reserves and the Occupied Reserves are unavailable for timber harvest, and therefore no direct take would occur in these areas. We estimated indirect take for timber harvest and Covered Activities adjacent to Suitable Habitat Reserves and within or adjacent to Marginal Habitat (Section 5.1.2.2). To calculate the estimated proportion of occupied Marginal Habitat from model-classified patches required two factors which when multiplied together become the desired product. These two factors are: 1) the proportion of Marginal Habitat patches with platforms capable of supporting nesting by marbled murrelets (hereafter platform capable) and 2) the proportion of Marginal Habitat patches (given platform potential) where occupied behaviors were observed during audio-visual surveys (see Appendix C). Briefly, a determination for a platform capable patch of Marginal Habitat was made based on field-based ground assessments involving a qualified wildlife biologist traversing areas of potential habitat in search of platform trees while using binoculars and the unaided eye. A platform tree is defined as a coniferous tree (Hamer and Nelson 1995a, Baker et al. 2006) with potential platforms. A potential platform is defined as a relatively flat surface at least 6-inches in diameter with nesting substrate on the platform, horizontal or vertical coverage to prevent exposure, and flight accessible to marbled murrelets (Baker et al. 2006, Burger 2002, Hamer and Nelson 1995a, McShane et al. 2004, Nelson and Wilson 2002). Additionally, the potential platform is part of the live crown of the tree. If substrate can't be confirmed from the ground, then it is presumed to exist. The substrate on a potential platform includes moss and other epiphytic growth along with accumulation of duff and debris. There needs to be minimum potential for a platform to support a marbled murrelet egg, cover and concealment for the nest and accessibility by the adults and for the nestling at time of fledging. If a platform tree is not within 100 meters (328 feet) of another platform tree, then the one tree does not constitute a Marginal Habitat patch. Generally, 3-4 trees having multiple platforms within 100 meters are required to be considered a platform capable patch. A determination of occupancy from the Pacific Seabird Group audio-visual survey protocol (Evans-Mack 2003; see Section 3.4) is based on the observation of occupied behaviors (typically sub-canopy flights) within potential habitat.

A non-random sample of Marginal Habitat patches that were defined by Timber Harvest Plan (Harvest Plan) driven areas, acquired between 2018 and 2020, resulted in 26 Marginal Habitat patches ground-assessed for platform potential and four of those 26 patches had platform capable trees meeting the criteria. This survey resulted in an area weighted rate of 0.2051 for platform capable Marginal Habitat patches. A similar but smaller sample of platform capable Marginal Habitat patches surveyed according to Pacific Seabird Group inland survey protocol for murrelet occupancy resulted in two of six areas occupied and an area weighted rate of 0.2649. Thus, the estimated proportion of platform capable and occupied Marginal Habitat from model-classified Marginal Habitat patches is the product of the two factors or 0.2051 * 0.2649 = 0.0543. Based on this non-random sample of Marginal Habitat patches from 2018-2020, we predict that approximately 21% of Marginal Habitat patches support trees with suitable platforms based on our definition of platform capable, approximately 26% of platform capable areas would result in detection of occupied behaviors if surveyed according to Pacific Seabird Group protocol, and a combined effort would result in approximately 5.4% of all Marginal Habitat patches being platform capable and supporting occupied behaviors.

To calculate the direct take of Marginal Habitat patches and convert those acres to potential impacts to nesting murrelets, we performed the following analyses. We sampled hypothetical nest trees within Marginal Habitat as defined by modeled tree approximate objects (TAOs ≥ 50 meters)

within a patch. These tree approximate objects are referred to as hypothetical nest TAOs in this analysis. We used a balanced acceptance sample (BAS) of hypothetical nest TAOs at a rate of 0.05 per acre (0.02 per hectare) iterated 100 times for each of the 50 harvest years and then intersected with year-specific harvested portions of a Marginal Habitat patch. Of the 7,130 acres of model predicted Marginal Habitat within the pre-expansion Plan Area (the approximately 358,626 acres of Green Diamond ownership constituting the Plan Area before its expansion; see Section 5.2.3), 5,116 acres were scheduled for harvest within the first 50 years of the harvest forecast. Of the 5,116 acres scheduled for harvest, 2,199 acres were scheduled for clearcut harvest and 2,917 acres were scheduled for selection harvest within riparian management zones. Given the product of estimated proportion of nest platform capable and potentially occupied Marginal Habitat at 0.0543, we predict that 119.5 acres of the 2,199 acres scheduled for clearcut harvest could be occupied by murrelets during the permit term (2,199 acres of clearcut harvest times 0.0543 proportion occupied equals approximately 119.5 acres of occupied habitat scheduled for harvest during the 50-year permit term). Note that this harvest of predicted occupied habitat is considered direct take because the hypothetical nest TAO could be removed during the clearcut harvest or even if the tree was retained due to requirements in other permits (e.g., the Forest HCP), effects to nesting murrelets would be similar and were assumed to cause direct take. The spatial location and exact configuration of potential timber harvest units in the harvest forecast will change during implementation of this HCP over the permit term, but Green Diamond will annually track harvest and report amounts of harvest and resulting incidental take within the annual reporting process (Section 6.3.1, Appendix E). Green Diamond has accounted for harvest that includes adjustments through land acquisitions and additional harvest within existing Marginal Habitat during the permit term. These adjustments in harvest are reflected in the requested authorized take of marbled murrelets (Section 5.2.9). The outcome is that Green Diamond will estimate incidental take on an annual basis as quantified by amounts of timber harvest that potentially impacts nesting marbled murrelets, and amount of incidental take, annual and cumulative, will be tracked and reported relative to authorized take (Section 5.2.11, Appendix E).

To estimate the number of eggs/nestlings potentially taken through direct harvest of Marginal Habitat over the plan term, we used a series of nesting parameters (factors) to calculate the number of eggs/nestlings per acre of Marginal Habitat (product). We used values for the nesting parameters taken from the literature primarily from habitat deemed higher quality than the most suitable within the Plan Area (i.e., the Occupied Reserves). We believe that using these values for nesting for all habitat in the Plan Area provides estimates of potential impacts to marbled murrelets that are on the upper end of the range. The biological factors affecting results that provide a more biologically realistic estimate of impacts in Marginal Habitat patches include estimates of nests per acre (0.05; see Conroy 2002), yearly nesting probability (0.7; Hébert and Golightly, 2006, Peery et al. 2004), and a professional biological opinion-based estimate of the proportion of adults to nestlings lost to direct harvest (0.1). Green Diamond's biological staff after consulting other murrelet scientists concluded that it is unlikely that adults would remain on a nesting platform while a tree was actively being felled during timber harvest and risk of killing or injuring an adult murrelet during this activity is very low.

Applying a yearly nesting probability of 0.70 yields a potential take of 0.052 eggs/nestlings per year (0.075 nest trees per year * 0.7 probability of nesting = 0.052 eggs/nestlings per year) and 2.62 eggs or nestlings (0.052 eggs/nestlings per year * 50 years) over the 50-year Plan term. To estimate direct take of adult murrelets, we used the same metrics for nestlings discounted to a rate

of 0.1 adult for every nestling taken (0.052 eggs/nestlings * 0.1 adults affected = 0.005 adults per year) results in 0.005 adults taken per year or 0.26 adults directly taken over the 50-year Plan term. The estimated amount of incidental take resulting from removal of 2,199 acres of Marginal Habitat through timber harvest is approximately 2.88 marbled murrelets over 50 years. Note that only 119 acres of the 2,199 harvested acres are predicted to be occupied by marbled murrelets, so incidental take only occurs in the occupied acres of Marginal Habitat. We assumed that one out of ten adults would be taken through direct harvest since it is unlikely that an adult murrelet incubating an egg would stay in a nest tree during harvest of that tree. An example of direct take from a modeled timber harvest area within a Marginal Habitat patch is shown in Figure 5-5. In this example, a harvest unit “B” in year 2064 from the Harvest Forecast intersects the Marginal Habitat patch and affects the hypothetical nest TAO in unit “B”. This is assumed to be a direct take of the nest, egg, nestling and potentially an adult based on the platform capable parameter, occupancy parameter, and nesting metrics used in the analyses.

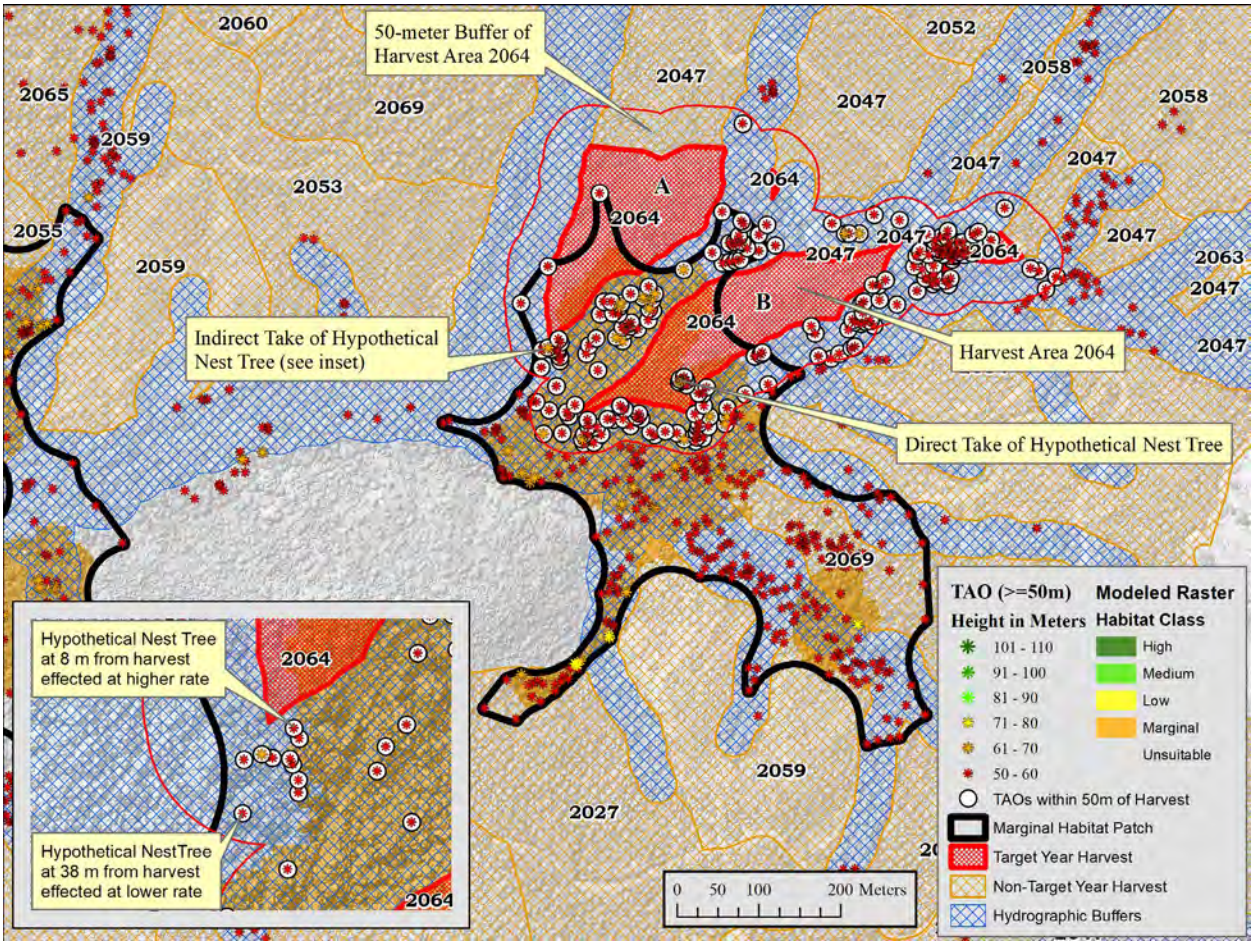


Figure 5-5. Illustration of modeled future timber harvest areas within and adjacent to a patch of Marginal Habitat. The year of modeled timber harvest is shown within non-target and target years (i.e., year of interest) for this example of potential direct and indirect take of hypothetical nest trees defined by tree approximate objects (TAO ≥ 50 meters) within the Marginal Habitat patch based on Green Diamond's marbled murrelet habitat suitability model. Using GIS, we intersected a 50-year harvest forecast and Marginal Habitat patches within the Plan Area. To estimate direct take for each year of harvest (2064 "B"), a balanced acceptance sample (BAS) of TAOs, iterated 100 times for each of 50 target harvest years, was intersected with year specific harvested portions of the patch at one TAO per 20.0 acres. To estimate indirect take, a BAS sample of TAOs, iterated 100 times for each of 50 target harvest years, was assessed for each samples distance to an adjacent harvest (2064 "A"). For samples within 50 meters of a harvest, a distance based decaying linear rate of 0.25 was applied at zero meters and declined to zero at 50 meters resulting in an estimated level of indirect take for the specific harvest year (see inset). If a BAS sample TAO was not located within a harvest area or within 50 meters in the harvest year of interest, that harvest did not constitute a direct or indirect take. This analysis was conducted for all 50 years of plan implementation to estimate direct and indirect take of hypothetical nest trees.

5.2.2.2 Assessing Indirect Take

To estimate indirect take of eggs and nestling murrelets, we used a similar approach to that described for direct take using the Harvest Forecast and identical nesting parameters. For estimating indirect take, we included harvest adjacent to Marginal Habitat and Suitable Habitat Reserves but not the Occupied Reserves since those areas are protected with a 300 foot (91.4 meter) vegetative buffer to avoid take. Indirect take was assessed by calculating the intersection of all model-classified patches of Marginal Habitat and Suitable Habitat Reserves within the Plan Area with a Harvest Forecast with a starting year of 2023 over a 100-year period. We used the first 50 years of the forecast to estimate indirect take based on projected timber harvest locations within 50 meters of the habitat patches (Figure 5-5, Marginal Habitat Direct and Indirect Take, Appendix B). We sampled hypothetical nest trees within Marginal Habitat and Suitable Habitat Reserves by sampling modeled TAOs ≥ 50 meters within a patch. We used a BAS of hypothetical nest TAOs at a rate of 0.05 nests per acre iterated 100 times and then intersected with year-specific harvest within 50 meters of habitat patches. The biological factors affecting results that provide a more realistic estimate of impacts in Marginal Habitat patches include estimates of nests per acre (0.05; see Conroy 2002) and yearly nesting probability (0.7; Hébert and Golightly 2006, Peery et al. 2004). We elected to use a nest density of 0.05 nests per acre (one nest every 20 acres) in the nesting parameter values for both Marginal Habitat and Suitable Habitat Reserves. Information on nest density is sparse, but published information suggests nest densities range from 0.05 to 0.38 nests per acre (0.02 to 0.15 per hectare) (Conroy 2002, Manley 1999, Hamer et al. 2021). Except for Conroy 2002, studies quantified both active and inactive nests (mainly inactive), so these estimates are probably greater than expected because inactive nests in the same tree or in proximity are unlikely to be active in the same year. Therefore, we believe our use of 0.05 nests per acre is a more biologically realistic estimate and may still be high given the probable low quality of the previously harvested patches of Marginal Habitat and Suitable Habitat Reserves within the managed forest landscape of the Plan Area. In addition, we maintained this same nesting parameter value for both Marginal Habitat and Suitable Habitat Reserves given the lack of information to suggest nest densities would be greater in the Suitable Habitat Reserves relative to Marginal Habitat. While the Suitable Habitat Reserves have greater predicted suitability (relative probability of observing occupied behaviors), the quantity of trees with potential nest platforms may still be limiting in these patches and would not necessarily result in a greater density of active nest sites if the stand was occupied. In contrast, an unharvested stand of old growth (> 200 years) is more likely to have an abundance of trees with potential nest platforms and could support a greater density of active nest sites.

For samples within 50 meters of a harvest, a distance based decaying linear rate was applied resulting in an estimated level of take for the specific harvest year of 0.25 at zero meters and declining at a linear rate to zero at 50 meters (Figure 5-6). The timber harvest units from the 50-year Harvest Forecast were buffered by 50 meters and this buffer was intersected with Marginal Habitat within the Plan Area. The intersection of the projected timber harvest units and 50 meter buffer with Marginal Habitat encompassed approximately 8,160 acres and resulted in an estimated indirect take of 1.86 eggs/nestlings over the 50-year Plan term. An example of indirect take from a modeled timber harvest unit buffered by 50 meters with the buffer intersecting a Marginal Habitat patch is shown in Figure 5-5. In this example, a harvest unit “A” in year 2064 from the Harvest Forecast is adjacent to the Marginal Habitat patch and affects the hypothetical nest TAO within 50 meters of unit “A” (see also inset in Figure 5-5 for application of decay rate for hypothetical nest

tree TAOs within the 50 meter buffer). This adjacent harvest is assumed to be an indirect take of the egg or nestling based on the platform capable parameter (0.2051), occupancy parameter (0.2649), and nesting metrics used in the analyses. The acres of harvest under this scenario are not located within suitable habitat but occur within a 50 meter disturbance buffer of the projected harvest unit (see 5.1.2.2 and Figure 5-6).

The timber harvest units from the 50-year Harvest Forecast buffered by 50 meters and the buffers intersected with Suitable Habitat Reserves within the Plan Area encompassed approximately 574 acres and resulted in an estimated indirect take of 0.78 eggs/nestlings over the 50-year Plan term. The acres of harvest under this scenario are not located within suitable habitat but occur within a 50 meter disturbance buffer of the projected harvest unit (see 5.1.2.2 and Figure 5-6). Similar to our method for estimating indirect take from adjacent harvest, we also estimated potential indirect take from single tree selection harvest within riparian management zones of Marginal Habitat by applying an estimated level of take at 0.25 for a specific harvest year where the unit was located within a riparian management zone that contained a hypothetical nest TAO. This approach assumes that a single tree could be selectively harvested adjacent to a hypothetical nest TAO and would likely be an overestimate of effects from single tree selection harvest within riparian management zones since very few trees are harvested from within riparian management zones, and the probability that a harvested tree is directly adjacent to a nest TAO is low. The projected timber harvest units that included riparian management zones encompassed approximately 2,917 acres and resulted in an estimated indirect take of 1.7 eggs/nestlings from selection harvest within these areas over the 50-year Plan term. We considered direct take within riparian management zones as improbable given tree retention requirements within riparian management zones and those prescribed under Terrestrial Retention of Ecosystem Elements (TREE) under the Forest Habitat Conservation Plan (Green Diamond 2019). We also considered but viewed as improbable and negligible any potential direct and indirect take from harvest within commercial thinning units for similar reasons. Combined indirect take due to harvest within 50 meters of Marginal Habitat and Suitable Habitat Reserves and within single tree selection riparian management zones is approximately 4.34 eggs/nestlings over the Permit term. An example of indirect take from a modeled timber harvest area within 50 meters of a Suitable Habitat Reserve is shown in Figure 5-7. In this example, a harvest unit in year 2048 from the Harvest Forecast is adjacent to the Suitable Habitat Reserve and affects the hypothetical nest TAO within 50 meters of the harvest unit.

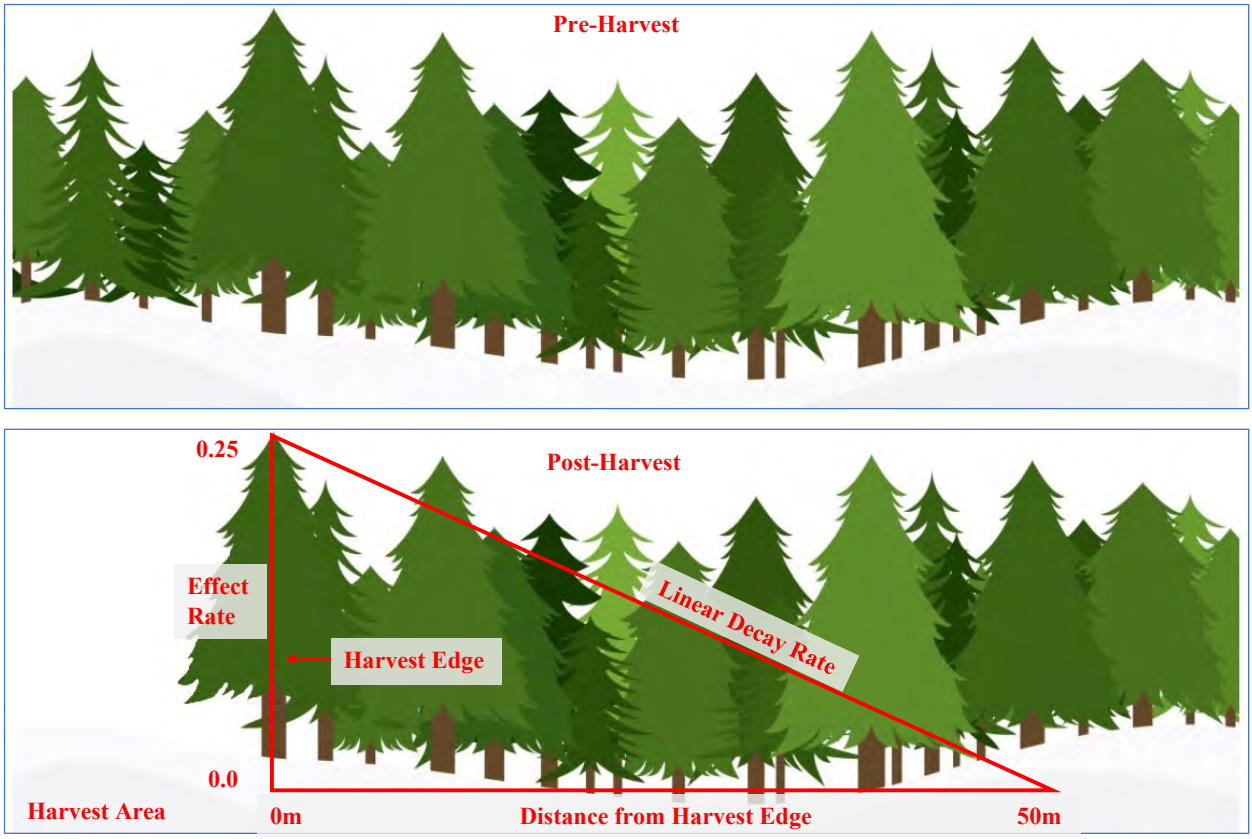


Figure 5-6. Illustration of a pre-harvest (top panel) and post-harvest (lower panel) forest stand within the Plan Area and an adjacent modeled timber harvest where a linear decay rate was applied to hypothetical marbled murrelet nest trees to estimate effects of indirect take attributed to reduced nest success from disturbance, exposure, or increased predation. The maximum effect was set at 0.25 for hypothetical nests on the edge (zero meters) of the harvest area (lower panel) and declined to zero at 50 meters from the edge of the harvest area. This analysis was conducted for all 50 years of plan implementation to estimate indirect take of hypothetical nest trees.

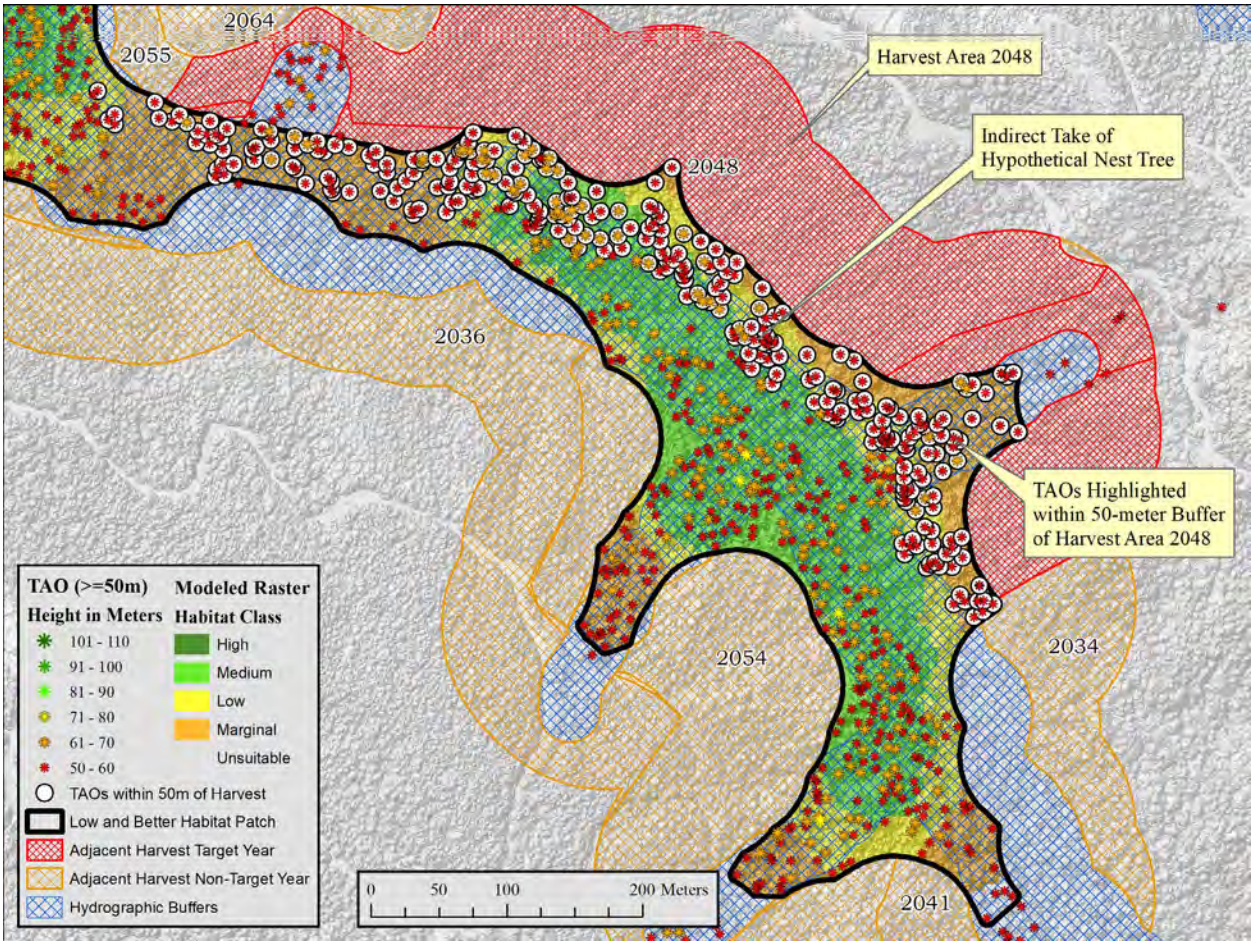


Figure 5-7. Illustration of modeled future timber harvest areas adjacent to a patch of Suitable Habitat Reserves habitat. The year of modeled timber harvest is shown within non-target and target years (i.e., year of interest) of timber harvest for this example of potential indirect take of hypothetical nest trees defined by tree approximate objects (TAO ≥ 50 meters) within the Suitable Habitat Reserve based on Green Diamond's marbled murrelet habitat suitability model. Using GIS, we intersected a 50-year harvest stand availability forecast and Suitable Habitat Reserves within the Plan Area. To estimate indirect take, a balanced acceptance sample (BAS) of TAOs, iterated 100 times, was assessed for each samples distance to an adjacent harvest (year 2048). For samples within 50 meters of a harvest, a distance based decaying linear rate was applied resulting in an estimated level of indirect take for the specific harvest year. If a BAS sample TAO was not located within 50 meters in the harvest year of interest, that harvest did not constitute indirect take. This analysis was conducted for all 50 years of plan implementation to estimate indirect take of hypothetical nest trees in Suitable Habitat Reserves (excluding Occupied Reserves).

5.2.2.3 Interaction of Climate Change and Variability with Incidental Take

This subsection describes how the HCP's estimates of incidental take account for natural climate variability and long-term anthropogenic climate change's possible influence on murrelet nesting dynamics, reproductive output, and spatial distribution (see Sections 3.5 and 4.2.2). The best and most suitable nesting habitats within the Plan Area are protected under this HCP (Sections 5.1.1.1, 6.2.2, 6.2.5) along with measures to minimize incidental take and best management practices

(Section 6.2.4) designed to reduce impacts, including those related to climate variation. Therefore, any climate-related changes, both natural and anthropogenic, may affect occupancy and nesting attempts in marginal habitat where the greatest potential exposure to covered forest management activities occurs (Appendix B.2). We evaluate whether episodic "good" and "bad" marine years for murrelet abundance and reproductive attempts in the Plan Area, as well as possible terrestrial impacts, could meaningfully change the exposure component of incidental take, and conclude that effects are minor, accounted for in estimates, and bounded over the 50-year permit term.

Climate-related phenomena such as marine upwelling, El Niño Southern Oscillation and Pacific decadal oscillation, and marine heatwaves may affect distribution and abundance of forage fish that marbled murrelets depend on for survival (Section 4.2.2.1). In "good" years where forage fish are abundant in the marine environment and proximal to terrestrial nesting habitat, marbled murrelet nesting attempts increase, and nest success may increase as adults are better able to provision adequate food resources to nestlings (Peery et al. 2004, Becker et al. 2007). In "bad" years, forage fish may be less abundant or less available because they are pushed into deeper, colder waters, or areas distant from terrestrial nesting habitat, because of episodic changes in ocean currents and temperatures. When forage fish are less abundant, reduced body condition and reduced breeding propensity by murrelets may occur (Peery et al. 2004, Becker et al. 2007). The changes in ocean conditions may also affect breeding phenology by causing slight shifts in timing of nesting and breeding distribution if murrelets spatially relocate in the marine environment in response to distribution of food resources (Becker and Beissinger 2003). The breeding period for murrelets accounts for variation in breeding phenology (Figure 5-3), and Green Diamond has conservatively estimated incidental take for Covered Activities throughout the calendar year rather than constrain estimates to activities that occur solely during the breeding season (Section 5.1.2.1).

Collectively, the good and bad condition of the marine environment related to food resources, slight shifts in timing of nesting (earlier or later), and location of breeding attempts may cause fractional changes in exposure of marbled murrelets to Covered Activities. In "good" years, higher breeding propensity may lead more murrelets to attempt nesting in the Plan Area, which results in a potential increase in exposure or risk of incidental take. In "bad" years, fewer murrelets attempt nesting, and the reverse is true; there is less exposure and risk of incidental take. Natural climate variability is already at play with respect to these factors affecting survival and reproduction in marbled murrelets. Climate change from anthropogenic factors may result in increased amplitude and/or frequency of normal process variation. And while climate change-caused variations are impossible to predict, they are likely to manifest as gradual shifts in baseline marine and terrestrial conditions over the permit term, with fluctuations (good years/bad years) around a stable mean.

While climate variability may influence the total number of nesting attempts in a given year and how many nests could be present where Covered Activities occur, it has little effect on the spatial extent of incidental take or the estimated amount of take. The gradual shifts in climate variability over the long-term comprise an even smaller fractional component of exposure and risk of incidental take. These effects are further constrained by habitat quality limits, seasonal and operational restrictions, and the small footprint of operations in Marginal habitat during the nesting period. In addition, anthropogenic climate change cannot be confidently isolated because it is not feasible to precisely predict climate change impacts over a particular period of time within the Eligible Plan Area. However, possible climate variation is already accounted for through

incorporation of best available information and the cautious approach and values incorporated into the estimates of incidental take described in this section and Appendix B.

Conditions in the marine environment influence prey availability, adult body condition, and whether murrelets enter the breeding population in a given year, while conditions in the terrestrial environment influence nest availability, nestling survival, and whether breeding attempts are ultimately successful and result in fledged young. These distinct domains operate largely independently but converge through murrelet life history to determine overall reproductive output and population trajectory. Similar to the marine environment, terrestrial nesting habitat is also influenced by natural climate variability and longer-term gradual shifts from anthropogenic factors. The climate induced stressors in the terrestrial environment such as drought and wildfire (see Section 6.5.2) act after marine influences set the stage for breeding and may amplify or compound effects on murrelet. For example, drought reduces canopy moisture and epiphyte abundance, potentially resulting in degraded nesting structures.

However, in northern California with the Eligible Plan Area in the heart of the range for redwood trees, a high proportion of known marbled murrelet nests occur in redwood trees where extraordinarily large branches and other tree deformities are used for nesting, and where accumulated canopy duff forms the nesting substrate (Hamer and Nelson 1995b, Baker et al. 2006, Golightly et al. 2009). This is different from areas where other conifers such as western hemlock, Sitka spruce, and Douglas-fir are more common and where murrelet more often rely on epiphyte cover to form the nest substrate (Hamer and Nelson 1995b, Burger 2002). The persistence of large branch platforms and duff accumulations in redwoods provides relatively stable nesting structures that may be less sensitive to climate-driven changes in canopy moisture and epiphyte development (Sillett and Van Pelt 2000, Sillett et al. 2022). Wildfire can remove or fragment habitat by reducing older forest structure and increasing edge and exposure to predation risk. Redwood trees are resistant to wildfire (Fritz 1932, Stephens and Fry 2005, Lorimer et al. 2009,) and Green Diamond's managed forest and transportation infrastructure further limit vulnerability of murrelet habitat to catastrophic wildfire effects within the Plan Area. In good years when marine conditions increase breeding propensity, terrestrial stressors can still constrain reproduction by limiting the quality and availability of nesting habitat resulting in failed nesting attempts or increased exposure and risk of incidental take. In bad years, when breeding propensity is reduced from poor marine conditions, degraded or diminished terrestrial habitat may have little influence on reproductive success because fewer murrelets are attempting to nest which also results in reduced exposure and incidental take. The conservation measures in this HCP protect high, medium and low suitability habitat (Sections 6.2.2, 6.2.5) through the proposed reserve system for these habitat categories, thereby minimizing exposure of breeding murrelets to climate-driven change in terrestrial habitat and limiting any amplification of take (Gaines et al. 2022). By protecting the best, most suitable habitat, the exposure and risk of take is limited to Marginal habitat where probability of nesting is low and accounted for within the conservative estimates of incidental take (Sections 5.1.1, 5.1.2, 6.2.2 and 6.2.5).

Green Diamond's estimates of incidental take under this proposed HCP incorporate effects from climate variability and longer-term shifts in the climate that may affect the two environmental domains occupied by marbled murrelets as discussed in this section. Our analyses and estimates of incidental take account for the best available information that incorporates values from scientific research that inherently include natural climate variability or process variation and any minor

fractional shifts resulting from the longer-term influences of anthropogenic forces that may combine with normal climate variation. This HCP limits exposure and risk of incidental take of marbled murrelets through protection of the most suitable habitat in the Occupied Reserves and Suitable Habitat Reserves (Sections 6.2.2, 6.2.5) thereby confining exposure and risk of incidental take to Marginal Habitat where likelihood of nesting is already low and spatially limited. In addition, this HCP includes Adaptive Management measures (Section 6.3.2), an Assurance Reserve (Section 6.3.2.4), and Measures for Changed Circumstances (Section 6.5.1) that are well suited to address shifts or changes in marine and terrestrial conditions that could be attributed to climate change.

5.2.3 Summary of Direct and Indirect Take and Adjustment to Estimates of Take Based on Changes to the Plan Area during MMHCP Development

Green Diamond has estimated the amount of incidental take that is likely to occur from Covered Activities within and adjacent to potential habitat for the marbled murrelet in the Plan Area over the Permit Term (5.2.2.1, 5.2.2.2, Appendix B) and a process to estimate the amount of incidental take that may occur through future land adjustments given certain assumptions about the acquired lands when added to the Plan Area and anticipated timber harvesting on those lands (5.2.8). The amount of incidental take occurring from Covered Activities over the Permit Term was estimated based on modeled habitat and 50 years of modeled timber harvest from Green Diamond's California Continuous Harvest Forecast (Harvest Forecast, 5.2.1). This analysis resulted in harvest of approximately 5,116 acres of Marginal Habitat from a total of 7,130 acres of Marginal Habitat and estimated take or harm to 6.44 murrelets. The Conservation Strategy prohibits harvest within Suitable Habitat Reserves (6.2.5), but Covered Activities adjacent to these areas could result in the disruption of essential behaviors affecting 0.78 murrelets over 50 years. In total, the harvest of 5,116 acres of Marginal Habitat through clearcut harvest (2,199 acres) and single tree selection (2,917 acres), and disturbance from adjacent timber harvest and Covered Activities buffered by 50 meters and intersecting with Marginal Habitat and Suitable Habitat Reserves (8,733 acres[3]) may cause incidental take of 7.22 murrelets over 50 years.

During the initial development of the MMHCP, we estimated incidental take based on the Green Diamond ownership that existed within the land adjustment area for the Green Diamond Aquatic HCP and the Forest HCP. The ownership within this area was approximately 358,626 acres (145,131 hectares) (Section 1.1), and this is referred to as the pre-expansion Plan Area. This initial concept excluded other Green Diamond ownership within Del Norte and Humboldt Counties. During the development of this MMHCP, we decided to expand the Plan Area to include all Green Diamond ownership within the two counties and to expand the Adjustment Area to eligible lands within this area. The inclusion of all ownership within the counties increased the Plan Area (expanded Plan Area) acreage to 380,554 acres (154,005 hectares), an increase of 21,928 acres (8,874 hectares). As a result of this decision, we needed to account for potential incidental take that could occur within these additional acres over the Permit Term. The additional 21,928 acres included 31 acres of Suitable Habitat Reserve and 50 acres of Marginal Habitat. The 31 acres of

[3] The acres within a 50 meter buffer of projected timber harvest units were used to estimate incidental take from disturbance due to Covered Activities (see Section 5.1.2.2 and Figure 5-6 for an explanation and example). These acres do not represent areas of timber harvest but rather an area of potential influence from Covered Activities that could cause disruption to essential behaviors and potential incidental take.

Suitable Habitat Reserve is 0.14% of the additional area (31 acres/21,928 acres), which is less than the ratio of Suitable Habitat Reserve to the original Plan Area at 0.23% (823.7 acres/358,626 acres). Therefore, potential indirect take from harvest adjacent to the added 31 acres is 0.0294 murrelets over 50 years (0.7808 original SHR take/823.7 acres SHR*31 acres of new SHR). The 50 acres of Marginal Habitat is 0.23% of the additional area (50 acres/21,928 acres), which is less than the ratio of Marginal Habitat to the original Plan Area at 1.99% (7130 acres/358,626 acres). Therefore, potential direct and indirect take from harvest adjacent to or within the added 50 acres of Marginal Habitat is 0.045 murrelets over 50 years (2.88 original Marginal Habitat direct take/7,130 acres Marginal Habitat*50 acres of new SHR + 3.55 original Marginal Habitat indirect take/7,130 acres Marginal Habitat*50). The sum of the direct and indirect take for the additional 31 and 50 acres of habitat combined with the original modeled estimates results in total estimated take of 7.29 murrelets over 50 years (Table 5-2).

Table 5-2. Estimated amount of incidental take to marbled murrelets from implementation of projected timber harvest and Covered Activities on modeled habitat during the 50-year permit term.

Estimates of Incidental Take on Expanded Plan Area[4]		
Estimated Direct Take[5] from Covered Activities	*Estimated Indirect Take[6] from Covered Activities*	*Total Estimated Take from Covered Activities*
2.90	4.39	7.29
Timber harvest acres causing Direct Take	*Timber harvest acres causing Indirect Take*	*Total timber harvest acres*
2,230	2,967	5,197[7]

[4]Green Diamond developed estimates of: (1) the quantity of take directly caused by the removal and alteration of timber stands that are Marginal Habitat in the Plan Area and (2) the quantity of take indirectly caused by edge effects and disturbance effects of Covered Activities occurring proximal to potential nest trees in stands of marginal and Suitable Habitat Reserves in the Plan Area. Calculations were modeled based on a 50-year California Continuous Harvest Forecast model and random selection of hypothetical nest trees from tree approximate objects used to model marbled murrelet habitat on 358,626 acres of ownership. This process resulted in an estimated take of 2.88 murrelet eggs, nestlings, and adults from direct removal of Marginal Habitat over the 50-year permit term. A similar process resulted in an estimated indirect take of 4.39 murrelet eggs or nestlings from adjacent harvest and other Covered Activities that could result in disturbance harm to marbled murrelets. During development of the MMHCP, we included an additional 21,928 acres of ownership in the Plan Area that were not used in the initial modeling process. This increase in size of the Plan Area to 380,554 acres increased direct take to 3.06 eggs, nestlings or adults and indirect take to 4.59 eggs or nestlings over the 50-year permit term.

[5] When the entire cycle of Covered Activities for sustainable timber harvesting results in significant alteration or removal of a stand of timber that is suitable habitat for nesting, take is estimated based on harvest as the culmination of all Covered Activities in the likelihood of an event that directly injures or kills adult murrelets and nests with eggs or nestlings. When an area of suitable habitat is removed by timber harvesting, it becomes a younger forest that is no longer habitat that is suitable for nesting nor is it susceptible to further take from Covered Activities that occur in or near the suitable habitat that has been removed.

[6]Indirect take may result from habitat modification or above-baseline noise disturbance caused by timber harvest outside of suitable nesting habitat, but near nest trees. Timber harvest outside of suitable habitat may create a hard edge of young forest on a suitable habitat stand that makes it more susceptible to predation on nesting murrelets. Indirect take may also occur when Covered Activities occur within suitable habitat and partial harvest of habitat (i.e., single tree selection silviculture) is near a nest tree causing harm to nestlings from disturbance.

[7] Acres include the original projected harvest at 5,116 acres plus the 81 acres added as described in 5.2.3. These acres were used to estimate incidental take over the Permit Term and are not a threshold for regulating authorized incidental take. The amount of authorized incidental take is tracked and reported as described in 5.2.8, 5.2.10 and Appendix E.

5.2.4 Sensitivity of the Take Estimate

The take estimate of 7.29 murrelets over the Permit term (Table 5-2) depends on two proportions estimated from small field samples: the proportion of Marginal Habitat patches with platform-capable trees (from 26 assessed patches) and the proportion of those patches that are occupied (from 6 surveyed patches). To characterize the resulting uncertainty, Green Diamond propagated the uncertainty in the model inputs through the take calculation (Appendix B). The analysis is a sensitivity and propagated-assumption analysis, not a statistical confidence bound, and is conditional on the structure of the calculation.

The expected modeled take equals the calculator estimate of 7.22 murrelets on the pre-expansion Plan Area by construction (the 0.074-murrelet increase from the Plan Area expansion brings the operative estimate to the 7.29 reported in Table 5-2; Section 5.4); across the propagated uncertainty the median is 5.54 and the 90 percent simulation interval is approximately 0.85 to 19.4 murrelets over the term.

The estimate of take reported in this plan is the expected number of murrelets taken over the Permit term, which corresponds to the calculator point estimate and to the mean of the propagated distribution. The upper bound of the 90 percent interval characterizes the uncertainty in that estimate; it is the value that would be exceeded in only about 5 percent of iterations under the modeled assumptions, and it is therefore a description of uncertainty rather than an alternative estimate of take. Because the propagated distribution is right-skewed, the expected value already lies above the median modeled outcome, so the estimate is not a low characterization of central tendency. The estimate of take is accordingly based on the expected value, and the upper bound of the interval is retained as a measure of uncertainty rather than adopted as the predicted level of take.

The uncertainty is dominated by the occupancy proportion, which was estimated from six patches. Varying occupancy alone across its range moves total take more than any other input, and substantially more than the platform proportion, nest density, or nesting probability.

Because the nestling production credited as mitigation in the reserved stands is calculated from the same occupancy, nest-density, and nesting-probability inputs that drive take (Section 5.2.5, 5.2.6), increases in take produced by these shared inputs are accompanied by corresponding increases in modeled reserve production, and the mitigation ratio remains well above 1 to 1 throughout the analyzed range. This robustness applies to the shared rate parameters and does not extend automatically to acreage or structural assumptions. The uncertainty explored above reflects how far the estimate could reasonably shift given limited field data. It does not suggest the underlying calculation itself underestimates take. To the contrary, several of the modeling assumptions were deliberately chosen to be conservative, meaning they tend to overestimate rather than underestimate potential take. These assumptions are listed in Section 5.4. The full sensitivity analysis, including the alternative representations of the proportions and the supporting methodology, is provided in Appendix B.

5.2.5 Assessing Productivity Loss from Timber Harvest

Productivity loss is not take. It is not authorized by the Permit, is not counted against the authorized take limit, and does not require mitigation under ESA Section 10. Green Diamond estimates and reports it so that the Service can evaluate potential population-level effects of the incidental taking over the permit term. Green Diamond has estimated the potential loss in productivity in support of 50 CFR 17.32(b)(1)(iv), which identifies that the conservation plan submitted to support a permit application should include the "likely impact of take on the species."

The potential loss of murrelets over the Permit term includes direct and indirect take (as described in Section 5.2.2.1 and 5.2.2.2) and loss of future recruitment due to removal of habitat that precludes murrelets from nesting in an area that is no longer suitable. The latter is not reasonably certain to result in death or injury to murrelets in future years, but a reduction in amount or quality of habitat could result in independent or combined effects, both environmental (i.e., physical suitability of the structure due to altered conditions such as greater exposure to rain and wind) and biological (i.e., greater risk of predation), reducing probability of nesting or nest success in future years. Habitat that is removed from timber harvest will not be replaced within the Permit term, and edge that is created from harvested areas adjacent to retained habitat may have reduced suitability over the short term, but adjacent stands will regenerate, and edge effects are ameliorated within the Permit term. In our assessment of productivity loss, we assumed an edge effect to retained habitat (Marginal Habitat or Suitable Habitat Reserves) until the regenerating stands were 37 years old or 80 feet (24.38 meters) tall (Malt and Lank 2009, Van Rooyen et al. 2011, WA DNR). Once regenerating forest stands achieved 80 feet in height, edge effects were no longer considered to influence productivity in the retained habitat. Murrelets that nest in areas altered by timber harvest may select alternate nest sites, choose the same nest site, or forego nesting in certain years.

We accounted for loss of murrelet productivity by evaluating areas harvested coincident with Marginal Habitat and areas harvested adjacent to Marginal Habitat and Suitable Habitat Reserves. This future loss of productivity is not considered ESA or CESA take, but it is reasonable to conclude that changes in habitat suitability or loss of habitat may contribute to changes in demographics of murrelets. These changes in demographics are not certain given the relatively minor losses of potential habitat and potential plasticity of murrelet nesting within the Plan Area and surrounding habitat. The estimates of productivity loss are provided for the Service to evaluate impacts to the murrelet population over time and within the range of the species.

To estimate productivity loss, we included harvest coincident with Marginal Habitat and adjacent to Marginal Habitat and Suitable Habitat Reserves. The Occupied Reserves were not included since those areas are protected with a 91.4 meter (300 foot) vegetative buffer to avoid take. Productivity loss was assessed by calculating the intersection and/or adjacency of all model-classified patches of Marginal Habitat and Suitable Habitat Reserves within the Plan Area with the Harvest Forecast using a starting year of 2023 over a 100-year period. We used the first 50 years of the forecast to estimate productivity loss based on projected timber harvest locations coincident to Marginal Habitat patches and within 50 meters of Marginal Habitat and Suitable Habitat Reserves. We used a BAS of hypothetical nest tree TAOs $\geq$ 50 meters at a rate of 0.05 per acre iterated 100 times per plan year and then intersected with year-specific harvest within or adjacent to habitat patches. We sampled hypothetical nest tree TAOs within Marginal Habitat patches based on the initial acreage of patches in year one and reduced each year based on the amount of habitat

harvested. For example, the initial number of nests available in Marginal Habitat patches was 6, but this number diminished over time to 2 as the area of Marginal Habitat was depleted due to harvest. For assessing productivity loss due to adjacent harvest, the BAS of hypothetical nest tree TAOs were intersected with year-specific harvest within 50 meters of Marginal Habitat and Suitable Habitat Reserves. For samples within 50 meters of a harvest, a distance based decaying linear rate was applied resulting in an estimated level of productivity loss for the specific harvest year of 0.25 at zero meters and declining at a linear rate to zero at 50 meters. The productivity loss for coincident and adjacent harvest was averaged and summed by year based on the timing of the harvest. If a hypothetical nest tree was removed in Marginal Habitat, there was productivity loss for the entire Permit term. For adjacent harvest, the productivity loss was accrued until the adjacent regenerating stand was 80 feet (24.4 meters) tall (or 37 years old) and was no longer considered as adversely affecting productivity. For example, a harvest in year 5 resulted in productivity loss for 37 years until the adjacent regenerating forest had reached a height of 80 feet. So, effects were considered ameliorated at this site (no productivity loss) in the remaining 8 years of the Plan. The biological factors affecting results that provide a more realistic estimate of impacts in Marginal Habitat patches include estimates of nests per acre (0.05; see Conroy 2002) and yearly nesting probability (0.7; Hébert and Golightly, 2006, Peery et al. 2004).

We estimated a cumulative annual average productivity loss of 1.54 eggs/nestlings due to harvest within Marginal Habitat, or 77 eggs/nestlings over the 50-year Permit term. Similar to calculations for take, this estimate was not projected to account for nest success or survival of fledglings to adult age. The estimate of cumulative annual average productivity loss for harvest adjacent to Marginal Habitat was 0.57 eggs/nestlings or approximately 28.6 for the Permit term. The estimate of cumulative annual average productivity loss for harvest adjacent to Suitable Habitat Reserves was 0.39 eggs/nestlings and approximately 19.5 for the Permit term. In total, we estimated a future loss of production of 125 eggs/nestlings over 50 years. The addition of the 31 acres of Suitable Habitat Reserve and 50 acres of Marginal Habitat from the 21,928 acres of ownership added during plan development contributes to additional productivity loss over time. Harvest adjacent to or within these 81 acres results in the potential loss of approximately 1.5 murrelets over 50 years. In total, we estimated a future loss of production of 126.6 eggs/nestlings over 50 years. This estimated productivity loss is separate from the 7.29 murrelets of direct and indirect take estimated in Sections 5.2.2.1 and 5.2.2.2. It is not take, is not authorized by the Permit, and is not counted against the take limit. The potential loss assumes that murrelets do not move nest locations and therefore is a conservative estimate of potential impacts.

During the public comment period for this MMHCP, Green Diamond provided the Service updated acreages for the Plan Area and the components of the Conservation Program, reflecting the Plan Area as of July 1, 2026, rather than the earlier datasets on which the take and mitigation estimates in this Section and Appendix B were calculated. As of July 1, 2026, the Plan Area decreased to 380,457 acres, Suitable Habitat Reserves increased to 946.4 acres and 96 patches, and Marginal Habitat decreased to 6,867 acres. The changes fall in the conservative direction relative to the original estimates: the reduction in Marginal Habitat reduces the acreage subject to harvest and therefore the anticipated direct and indirect take, while the increase in Suitable Habitat Reserves increases the productivity available as mitigation. Any potential timber harvest adjacent to these additional acres of Suitable Habitat Reserve that could result in indirect take and a very minor increase in estimated take is offset by the potential productivity from these same acres over the entire 50-year permit term (Section 5.2.6).

Because the updated acreages reduce anticipated take and increase mitigation, the quantitative take estimates (7.29 murrelets over the Permit Term; Table 5-2) and the mitigation ratios reported in Section 5.2.7 were not recalculated. Those estimates remain a conservative characterization of the impacts of the taking: actual take is expected to be at or below the modeled values, and the mitigation delivered by the Conservation Program equals or exceeds the values on which the ratios were based. Retaining the original estimates also preserves a conservative ceiling on the take authorized under the Permit, a maximum of approximately 15 murrelets, which already incorporates a substantial margin for future timberland acquisitions far exceeding the July 1, 2026, change. Green Diamond therefore presents these updated acreages here for the Service's information and has retained the original take and mitigation-ratio calculations in this Section and Appendix B without re-analysis.

5.2.6 Assessing Productivity Mitigation from Reserved Stands

Assessing the amount of mitigation put forth under the Conservation Program required determining the applicable Suitable Habitat Reserves from the total of these habitat patches within the Plan Area. The inapplicable Suitable Habitat Reserves (as described below) were removed from consideration as mitigation for estimated take. From the total 1802.8 acres (729.6 hectares) of patch delineated Suitable Habitat Reserves within the Plan Area we removed patches that were otherwise constrained, encumbered, or non-habitat (e.g., easement stands, off property habitat; see Table 5-3). These patches included Occupied Reserves both outside (411.7 acres (166.6 hectares), n = 24) and inside easements (201.4 acres (81.5 hectares), n = 7) for a 613.1-acre (248.1-hectare) total, confirmed non-habitat (non-platform capable, 85.7 acres (34.7 hectares), n = 19), habitat within 300-foot off property buffers (115.2 acres (46.6 hectares), n = 14), below 5-acre minimum habitat patch threshold (96.7 acres (39.1 hectares), n = 29), and non-habitat areas harvested post-acquisition of LiDAR (68.4 acres (27.7 hectares), n = 2). Removal from consideration based on these criteria resulted in 83 patches and 823.7 acres (333.3 hectares) of Suitable Habitat Reserves. These are the acres evaluated for mitigation of anticipated take. We also considered the additional benefits of recruitment from the Occupied Reserves.

Table 5-3. The reduction (-) in acres of the modeled classified Suitable Habitat Reserves due to constraints, encumbrances, and non-habitat valuations. The model classified Suitable Habitat Reserves have a starting acreage of 1,802.8. The final acres used to mitigate and offset take and production loss is 823.7.

Habitat Area and Constraints	Acres	Remaining Acres
Suitable Habitat Reserves starting acres	1,802.8	
Occupied Reserves (Conservation Easement)	(201.4)	1,601.4
Occupied Reserves (non-Conservation Easement)	(411.7)	1,189.7
Non-platform capable patches	(85.7)	1,104.0
Off-property patches	(115.2)	988.8
Less than 5-acre minimum	(96.7)	892.1
Harvested post-acquisition of LiDAR	(68.4)	823.7

The process used to estimate the proportion of occupied Suitable Habitat Reserves required a similar correction factor to that used for Marginal Habitat. However, we did not have an adequate sample (n=1) of field surveyed or Pacific Seabird Group surveyed Suitable Habitat Reserves to

calculate the area-weighted proportion of platform capable habitat or area weighted proportion of platform capable occupied habitat. In place of these two factors, we used the modeled relative probability of occupancy (RPO) projected to the study area to calculate the mean RPO within both the Marginal Habitat (Mean RPO = 0.0357) and Suitable Habitat Reserves (Mean RPO = 0.2163). As these are relative probabilities the difference in relative probability of occupancy between mean Suitable Habitat Reserves and mean Marginal Habitat is equal to 0.2163 / 0.0357 = 6.0588. The average Suitable Habitat Reserve is 6.06 times more likely to be occupied than the average Marginal Habitat patch. Then, multiplying the proportion of occupied potential Marginal Habitat patches (0.05432) by the model difference in relative probability of occupancy ratio (6.0588), yields the estimate of 0.32907 for the proportion of HSI model predicted occupied Suitable Habitat Reserves. Applying this correction factor (0.32907) to the remaining 823.7 acres of Suitable Habitat Reserves results in an estimate of 271.1 acres (109.7 hectares) of HSI model predicted occupied Suitable Habitat Reserves.

The next step is to convert the acres of HSI model predicted occupied Suitable Habitat Reserve into numbers of nestling marbled murrelets produced in these stands. For this calculation, we used the same nesting parameters used to calculate direct and indirect take from modeled timber harvest in Marginal Habitat patches. We used a nest density of 0.05/acre and an annual nesting probability of 0.7 (Peery et al. 2004, Hébert and Golightly 2006). Multiplying these factors by the acres results in production of 9.49 eggs/nestlings per year (271.1 acres * 0.05 nests/acre * 0.7 annual nesting probability = 9.5). The number of potential eggs/nestlings produced over the permit term is 474.3. These estimates do not include probability of success of the nest or the probability that a fledgling murrelet will survive to adulthood. Both factors would reduce the estimate by 82% based on the literature, or an estimated 2 eggs/nestlings surviving to adulthood annually. To make relative comparisons of take and mitigation, we used the number of eggs/nestlings lost (through take) or produced (through protection and mitigation) rather than place additional assumptions on the estimation process. The production potential for the Suitable Habitat Reserves is in place for the duration of the Permit term because these areas are not proposed for harvest resulting in mitigation that is concurrent with and in advance of impacts from Covered Activities. Because the harvest of 2,199.3 total acres of Marginal Habitat (or 119.5 acres of occupied Marginal Habitat) is dispersed over the permit term (approximately 2.4 occupied acres harvested on average per year) and the 823.7 total acres of Suitable Habitat Reserves (or 271.1 acres of occupied Suitable Habitat Reserve) are established and protected at the commencement of permit implementation, the marbled murrelet benefits from these protected acres for the entire permit term.

We also estimated the production of eggs/nestlings from the Occupied Reserves (excluding easement areas). The process used to estimate the proportion of Occupied Reserves required a similar correction factor to that used for Marginal Habitat. Similar to the Suitable Habitat Reserves, we did not have a sample of surveyed patches to calculate the area-weighted proportion of platform capable habitat in Occupied Reserves. For the Occupied Reserves, all areas were previously surveyed according to Pacific Seabird Group protocols (Section 3.4) and are considered occupied based on results of those surveys. For a relative comparison and to assess contribution of productivity in these areas, we used the HSI model predicted occupancy.

In place of these two factors, we used the modeled relative probability of occupancy (RPO) projected to the study area to calculate the mean RPO within both the Marginal Habitat (Mean RPO = 0.0357) and Occupied Reserves (Mean RPO = 0.3039). As these are relative probabilities

the difference in relative probability of occupancy between mean Marginal Habitat and mean Occupied Reserves is equal to the 0.3039 / 0.0357 = 8.513. Stands with characteristics of the Occupied Reserves would be 8.513 times more likely to be classified as occupied than stands with characteristics of modeled Marginal Habitat patches. Then, multiplying the proportion of occupied potential Marginal Habitat patches (0.0543) by the model difference in relative probability of occupancy (8.513), yields the estimate of 0.4623 for the proportion of HSI model predicted occupied murrelet stands. Applying this correction factor (0.4623) to the 492.5 acres of modeled murrelet stands results in an estimate of 227.7 acres (92.1 hectares) of HSI model predicted occupied murrelet stands. We estimated productivity from the murrelet stands using the same nesting parameters used to calculate direct and indirect take from modeled timber harvest. We used a nest density of 0.1/acre and an annual nesting probability of 0.7 (Peery et al. 2004, Hébert and Golightly 2006). Multiplying these factors by the acres results in production of 15.9 eggs/nestlings per year (227.7 acres * 0.1 nests/acre * 0.7 annual nesting probability = 15.9). The number of potential eggs/nestlings produced over the permit term is 797 (Appendix B). The production potential for the murrelet stands is in place for the duration of the Permit term because these areas are not proposed for harvest, and these areas are considered no take due to the 91.4 meter (300-foot) vegetative buffer.

Finally, because a high percentage of area for the Marginal Habitat patches will remain in place for the permit term, we estimated the potential productivity for the Marginal Habitat patches. Based on acres of remaining non-harvested Marginal Habitat over the 50-year plan term 4,984 (2,017 hectares), diminishing acres of harvested Marginal Habitat (2,199 acres (890 hectares) reduced to 0 over the plan term), Marginal Reduction Factor (0.9975), occupancy rate (0.0543), nests per acre (0.05), yearly nesting probability (0.70), an estimated 472.6 (9.4520/yr.) eggs/nestlings are produced from Marginal Habitat patches (Appendix B). However, the potential future recruitment of murrelets out of remaining Marginal Habitat is not used as mitigation for take or for evaluating recruitment or losses in productivity over the permit term.

5.2.7 Mitigation Ratios for Take and Productivity Loss

We used values of continued production (recruitment) and production loss to estimate mitigation ratios for the MMHCP and assess whether estimates of take were mitigated by the proposed Conservation Program. Mitigation ratios indicate that the 854.7 acres of Suitable Habitat Reserves offsets any loss from direct and indirect take at a rate of 67.5:1 (491.9 eggs/nestlings / 7.29 takes; Appendix B). When estimates of future production loss are included in this calculation, the mitigation ratio is 3.67:1 (491.9 / 133.9; Appendix B). When production from the fully protected Occupied Reserves is included, the ratio of mitigation to take is 176.8:1 (491.9 eggs/nestlings + 797.0 eggs/nestlings / 7.29 takes; Appendix B). When estimates of future production loss are included in this calculation, the mitigation ratio is 9.6:1 (491.9 eggs/nestlings + 797.0 eggs/nestlings / 7.29 takes + 77.1 eggs/nestlings + 28.6 eggs/nestlings + 19.5 eggs/nestlings + 1.5 eggs/nestlings; Appendix B, 5.2.5). These estimates account for the productivity loss and mitigation from the original 358,626-acre Plan Area and the 21,928 acres added during development of the MMHCP. The 3.67:1 and 9.6:1 figures include estimated productivity loss in the denominator, and the 176.8:1 and 9.6:1 figures include estimated production from the Occupied Reserves in the numerator. Productivity loss is not take (Section 5.2.5), and the Occupied Reserves are conserved baseline habitat rather than mitigation for authorized take (Section 7.2.1.2). Accordingly, the mitigation ratio for authorized incidental take is 67.5:1. The remaining

figures are reported for the Service's information as comparisons of conserved production to total estimated effect, and are not offered in satisfaction of the mitigation obligation.

It should be noted that because the harvest of Marginal Habitat stands occurs over the 50-year duration of the permit, it is a reasonable prediction that some production that would continue to occur until there is harvest that potentially causes take and future loss of production. An estimated 472.6 eggs/nestlings are produced in Marginal Habitat over the permit term (5.2.2.1, Appendix B) in areas that have not been harvested or have recovered due to regrowth of adjacent habitat. We did not account for this continued production from Marginal Habitat in the estimates of mitigation ratios, but any production from Marginal Habitat over the permit term would provide a potential benefit to the murrelet population. A second factor that was not included in the mitigation ratios is that some fraction of potential nest sites in both Marginal Habitat and Suitable Habitat Reserves impacted by coincident or adjacent harvest could result in adult murrelets relocating to an alternate nest location in areas not impacted by Covered Activities.

5.2.8 Estimates of Take from Land Adjustments During the Permit Term

This MMHCP allows for Plan Area land adjustments, and adding or removing lands from the Plan Area could result in a greater number of murrelet sites or fewer murrelet sites within the Plan Area over time and changes in estimates of potential direct and indirect take to murrelet sites as described above. The Adjustment Area (AA) within the EPA (1.4.6.1) has similar habitat conditions for the Covered Species and densities of murrelets are assumed to be like those reported in this MMHCP. Green Diamond's Covered Activities will be directly comparable on lands added to the Plan Area during the permit term. Therefore, we made the assumption that the same process described above to estimate potential direct and indirect take to murrelets on the Plan Area would also apply to lands added under this MMHCP. The estimate of habitat take on acquired lands is similar to the Plan Area and the Harvest Forecast. The potential direct and indirect take of marbled murrelets was estimated from ground assessments, surveys, and modeled future timber harvest on a land base of approximately 358,626 acres during the time period from 2023-2072. The land adjustment process in this MMHCP allows for lands in the Plan Area to be added to or removed without amendment.

The estimate of anticipated take for future land adjustments authorized under this MMHCP are similar to calculations of take for the Plan Area. Given that the Adjustment Area contains lands similar to those currently owned by Green Diamond, it is anticipated that future land acquisitions would have a similar harvest history and would be similar to the current ownership in terms of tree species and composition of forest age classes. Using this assumption, future land acquisitions are likely to have a similar percentage of habitat classified as Marginal Habitat, which is estimated at approximately 1.9% of the Plan Area. For example, if Green Diamond acquired 50,000 acres of land, we predict the amount of Marginal Habitat to be approximately 1.9% or 950 acres. Assuming a similar age class distribution and proposed harvest strategy for these newly acquired acres would result in a predicted harvest of approximately 71.4% (678 acres of the 950 acres of Marginal Habitat in the hypothetical acquisition) over 50 years. However, we do not know the timing of future land acquisitions, so applying the harvest acres over 50 years results in a conservative estimate of habitat take. Green Diamond has estimated that approximately 7.29 marbled murrelets would be taken through direct harvest and indirect disturbance over 50 years across the 380,554 acre Plan Area. This estimate converts to approximately one marbled murrelet per 52,200 acres

over the 50-year Permit Term, or approximately $1.92X10^{-5}$ murrelets per Plan Area acre. These factors can be applied to any size land acquisition following the aforementioned assumptions for habitat and rate of harvest. (The adjustment area take can be estimated by multiplying the percent increase or decrease (area of land adjustment) by the total estimated direct and indirect take on the PA of 7.29 murrelets by the proportional change in land area.

Based on estimates of direct and indirect take shown in Table 5-2, we can calculate the average change in estimates of take from reductions or increases in Covered Lands from removals and acquisitions during the permit term. The removal is the sale or transfer of land, and an acquisition is the purchase of land and timber or perpetual harvesting rights of the timber resource on a parcel of land. On average, Covered Activities could directly take 0.058 murrelet egg/nesting and adults each year or one in approximately 17 years. On average, Covered Activities could indirectly take 0.088 murrelet egg or nestling every 11 years. These estimates apply to the Plan Area and can be used to predict changes in take from land removals and acquisitions. For removals, the change is predicted by simply multiplying the annual rate times the number of acres. However, the values shown in Table 5-4 apply to the permit term and assume the reduction in acres occurs in year one of plan implementation. The removal of land will occur at undetermined intervals over the permit term, so a reduction in take will need to account for the timing of the land removal. For example, if 25,000 acres were removed at the midpoint of the permit term, or year 25, the overall effect in take reduction of 0.50 murrelets would be reduced on average by 50% (from 0.5 to 0.25) because some harvest is likely to have occurred in the first 25 years of plan implementation. The effect of land acquisitions and increases to estimated take is similarly calculated and based on several assumptions including the forest age composition of the acquired land and how the acquisition is integrated with the Harvest Forecast. We assumed that future land acquisitions would be similar to the Plan Area and that those lands would be integrated into the Harvest Forecast accordingly. We therefore assume that initial predictions apply to acquired lands and a similar rate could be applied to arrive at average increases in direct and indirect take based on acreage of lands acquired. Again, these values assume land acquisitions occur in year one of plan implementation and would need to be adjusted accordingly as actual acquisitions would be dispersed over the 50-year permit term. Similar to the effect described above for land removals that occur periodically during the permit term (Table 5-4), if Green Diamond acquired 100,000 acres in year 25 and added it to the Plan Area, the effect of harvesting these lands and changes to estimated take of marbled murrelets would be on average reduced by 50% (1.92 reduced to 0.96) because timber harvest and Covered Activities would only apply to the remaining 25 years of the permit term. In addition, we have allowed for an increase in land acquisitions that would double the Plan Area acreage, but this is an unlikely occurrence especially in year one of plan implementation.

Table 5-4. Effect of various changes in Plan Area acreage from land removals and acquisitions and the resulting changes in estimated take of marbled murrelets if the land adjustments occurred in the first year of plan implementation. The average decreases or increases in estimated take are based on results from habitat modeling and timber harvest forecasting on the expanded Plan Area of 380,554 acres. The estimated average rates of take from the habitat modeling and harvest forecasts are then applied to various examples of land base changes that may occur during permit implementation to arrive at average reductions or increases in take of marbled murrelets.

Effect of Plan Area Land Removals on Estimated Take			
Plan Acres Removed	*Average Direct Take Reduction*	*Average Indirect Take Reduction*	*Total Combined Average Take Reduction*
25,000	0.19	0.29	0.48
50,000	0.38	0.58	0.96
100,000	0.76	1.15	1.92
200,000	1.52	2.31	3.83
Effect of Plan Area Land Acquisitions on Estimated Take			
Plan Acres Acquired	*Average Direct Take Increase*	*Average Indirect Take Increase*	*Total Combined Average Take Increase*
25,000	0.19	0.29	0.48
50,000	0.38	0.58	0.96
100,000	0.76	1.15	1.92
200,000	1.52	2.31	3.83
380,554[8]	2.90	4.39	7.29

5.2.9 Amount of Authorized Incidental Take

Green Diamond is requesting authorized incidental take for timber harvest of model-based Marginal murrelet habitat of 10,232 acres and timber harvest and other Covered Activities adjacent to Suitable Habitat Reserves for 50 years. The doubling of Marginal Habitat acres that may be harvested under the requested take authorization includes harvest that may occur within the 2,014 acres of the 7,130-acre Marginal Habitat total that were not projected for harvest in the 50-year Harvest Forecast and future acquisitions of timberland consisting of Marginal Habitat (Table 5-4). The requested amount of authorized take also assumes a similar amount of incidental take from harvest adjacent to existing Suitable Habitat Reserves or habitat that may be designated as Suitable Habitat Reserves after acquisition (6.2.6). These activities are estimated to result in the taking or harming of a maximum of approximately 15 marbled murrelets over the Permit Term. If the acquisition of lands from the Adjustment Area doubled the amount of Marginal Habitat on day one of implementing this MMHCP, the total amount of authorized take (15) could occur over the permit term if forest age classes, harvest, and other assumptions are held constant. Green Diamond believes this is an overestimate of potential take and the more likely scenario would be harvest of

[8] This example of an increase in acreage represents a doubling of the Plan Area and estimates of take shown in Table 5-2.

Marginal Habitat within the range of approximately 5,116 – 10,232 acres or potential impacts to approximately 8 – 15 murrelets over 50 years.

5.2.10 Analysis of CESA Take and Mitigation under the MMHCP

The purpose of this analysis was to evaluate the conservation benefit of protecting 88 stands of Suitable Habitat Reserves, totaling 854.3 acres, for the 50-year permit term of the MMHCP. The analysis stated in the form of a question is: Does the 50-year protection of 854 acres of habitat fully mitigate for anticipated CESA take under the proposed MMHCP? This question was evaluated using 1) estimated CESA take; 2) estimated production from protection of 854 acres of habitat; 3) site specific data on murrelet occupancy of other reserved stands within the Plan Area; and 4) predicted incremental and lawful loss of habitat and murrelet productivity under a reference condition of take avoidance. The results of the analysis compare the MMHCP conservation benefit to the take avoidance scenario.

Estimated CESA Take: In section 5.1.1, we define take and pathways for take anticipated under the MMHCP. We also provide a brief description of take under the California Endangered Species Act as follows. Under California Fish & Game Code Section 2080.1(b), CDFW may find the MMHCP and Green Diamond's activities covered by the MMHCP to be consistent with the requirements of the CESA, which prohibits the "take" of listed species such as the marbled murrelet. Under the CESA, "take" means hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill. Fish & Game Code Section 86. It is noteworthy that the CESA definition of "take" is narrower than the ESA definition of take and does not include broader prohibition against harm and harassment as forms of take. In the examples of take provided, only one – the direct killing of murrelets during a timber harvest – falls firmly within the scope of take that is prohibited under the CESA. We describe two scenarios for take under this MMHCP. In the first scenario, we are focused on direct take, which is within the scope of take prohibited by CESA and that is direct harm and take from modification or removal of Marginal Habitat when it is occupied. Timber harvest is a form of habitat modification that could directly harm and therefore take a marbled murrelet when the timber harvest occurs in a timber stand that is occupied by marbled murrelets during the nesting season and a nest tree is disturbed to the extent that a nestling in a nest or an adult that will not leave the nest is directly injured or killed by timber falling. We estimated direct take (CESA take) at 2.9 marbled murrelet nestlings or adults over the 50-year permit term. The amount of authorized take requested under this MMHCP for harvest in Marginal Habitat in the Plan Area was adjusted to 5.8 murrelet nestlings or adults during the permit term to account for a high level of future timberland acquisitions that are added to the MMHCP, which is not necessarily likely to be achieved in the 50-year term.

Estimated production from suitable habitat reserves: A comprehensive analysis of the conservation benefits of the suitable habitat reserves resulted in an estimated production of 492 marbled murrelet eggs or nestlings from these stands over 50 years. While not all acres are expected to be occupied by marbled murrelets, on average, approximately 282 acres of the reserves are predicted to be occupied during the permit term. We used a mean nest density of 0.05 nests per acre (1 nest every 20 acres of reserve), and a mean annual nesting probability of 0.7 based upon information from scientific literature. From this information, we predicted that nests in suitable habitat reserves could produce 9.8450 eggs/nestlings annually and approximately 492 eggs/nestlings during the 50-year term.

Site specific data on murrelet site occupancy: Within the Plan Area, there are a suite of forest stands that are the highest quality habitat for marbled murrelets. These forest stands are known to be occupied by marbled murrelets based on prior survey efforts using audio visual detection surveys (6.2.2, Appendix C) and are referred to as the Occupied Reserves. We used annual detection data from inland surveys on 20 of the Occupied Reserves. Surveys were conducted from 1991 through 2001. For each year of survey in a reserve, we made a determination of occupancy, presence, or no detection under two scenarios. Our metric of interest in this evaluation was on a determination of "not occupied", which we coded as one. For scenario one, we coded occupied behavior detections as zero, and presence detections or no detection as one. If there were two consecutive years of one, the determination was not occupied. For scenario two, we coded occupied behavior detections and presence detections as zero, and no detection as one. If a stand was not surveyed in a given year, we coded it as zero. The 20 stands were surveyed for 11 years, but the final year was thrown out because it did not allow for a two-year evaluation window. The resulting data had 200 two-year periods. After eliminating years not surveyed, we had 139 valid two-year periods. For scenario one, there were 54 two-year periods with a determination of not occupied. This equates to 38.8% of the surveys with a not occupied determination (54/139). For scenario two, there were 15 2-year periods with a determination of not occupied. This equates to 10.8% of the surveys with a "not occupied" determination (15/139). The resulting analysis indicates that even the highest quality stands within the Plan Area are not occupied by murrelets every year, and a not occupied determination ranged from 10.8 – 38.8% for a two-year period. Given the lower relative habitat suitability of Suitable Habitat Reserves, annual occupancy is likely lower, and hence no detection or non-occupancy is likely greater than Occupied Reserves (i.e., >10.8 – 38.8%)

Loss of habitat and murrelet productivity from take avoidance: The CESA reference condition is take avoidance where landowners have the option to conduct habitat surveys and audio-visual surveys to avoid impacts to marbled murrelets resulting from timber harvest under the California Forest Practice Rules. Under CCR 919.11, Marbled Murrelet Protective Measures, the regulation states "Where there is evidence of an "active murrelet site" in or adjacent to the Harvest Plan area, or where there is evidence of a potential impact to a murrelet, the Director shall consult with CDFW as to whether the proposed Harvest Plan will result in a "take" or "jeopardy" (pursuant to the California Endangered Species Act) of the murrelet before the Director may approve or disapprove a Harvest Plan. Biological Assessments submitted with the Harvest Plan that are prepared according to the CDFW Guidelines for Consultation (F&GC § 2090) shall be provided to the CDFW during consultation. If CDFW determines jeopardy or a take will occur as a result of operations proposed in the Harvest Plan, the Director shall disapprove the Harvest Plan unless the Harvest Plan is accompanied by authorization by a wildlife agency acting within its authority under state or federal Endangered Species Acts." The take avoidance approach allows a landowner to survey for murrelets, and intermittent occupancy of forest patches results in timber harvest, permanent loss of intermittently occupied habitat and potential loss of 53 – 192 murrelet eggs/nestlings rather than protection of these areas for 50 years and continued benefits of murrelet productivity from these forest stands. In addition, any of the 854 acres that are unoccupied are the most suitable and are more likely to become occupied over the permit term. The mitigation benefit of this MMHCP protecting all 854 acres of Suitable Habitat Reserves exceeds the authorized CESA take of 5.8 murrelets and fully mitigates the impact under the CESA.

5.2.11 Annual Accounting of Take

In each annual report, Green Diamond will report the actual acres of Marginal Habitat harvested and the amount of harvest adjacent to (within 50 meters) Marginal Habitat and Suitable Habitat Reserves. Green Diamond will also report to the Service and CDFW any harvests within the buffers of the Occupied Reserves that are conducted according to MMHCP (Section 6.2.2 - Objective 2.2, 6.3.1.2, and Appendix D) for forest stand restoration purposes. Green Diamond will also report on an annual basis timberland acquisitions and removals resulting in changes to the amount of Marginal Habitat, Suitable Habitat Reserves and Occupied Reserves. As described in Section 5.2.2, Green Diamond will estimate incidental take on an annual basis as quantified by amounts of timber harvest operations (Covered Activities) that potentially impacts nesting marbled murrelets. The amount of incidental take, annual and cumulative, will be tracked and reported relative to authorized take (5.2.9 and Appendix E).

5.3 INFLUENCE OF TAKE ON MARBLED MURRELETS WITHIN CONSERVATION ZONE 4

Under the Northwest Forest Plan (Madsen et al. 1999) and the recovery plan for the marbled murrelet (USFWS 1997), programs and goals were established to monitor at-sea populations of marbled murrelets and terrestrial habitat. The purpose of the monitoring program is to assess status and trends of at-sea abundance of murrelets during the nesting season in coastal waters adjacent to the Northwest Forest Plan area in Conservation Zones 1 through 5 and monitor status and trend of murrelet nesting habitat throughout the listed range of the species (McIver et al. 2022). Conservation Zone 6 is not within the area of the Northwest Forest Plan. Conservation Zone 4, termed the Siskiyou Coast, extends from Coos Bay, Oregon south to the southern border of Humboldt County, California. This Section focuses on at-sea estimates of murrelet populations within Conservation Zone 4 which is the area of coastal waters adjacent to the Plan Area. However, population estimates for Zone 4 and the entire range are provided for assessing impacts to the marbled murrelet population. The population estimates for the entire range may be most relevant for ESA purposes since the murrelet was listed throughout its range in the lower 48 states and does not carry a Distinct Population Segment designation under ESA. The population in Zone 4 is relevant for assessing impacts under the CESA (Figure 5-8).

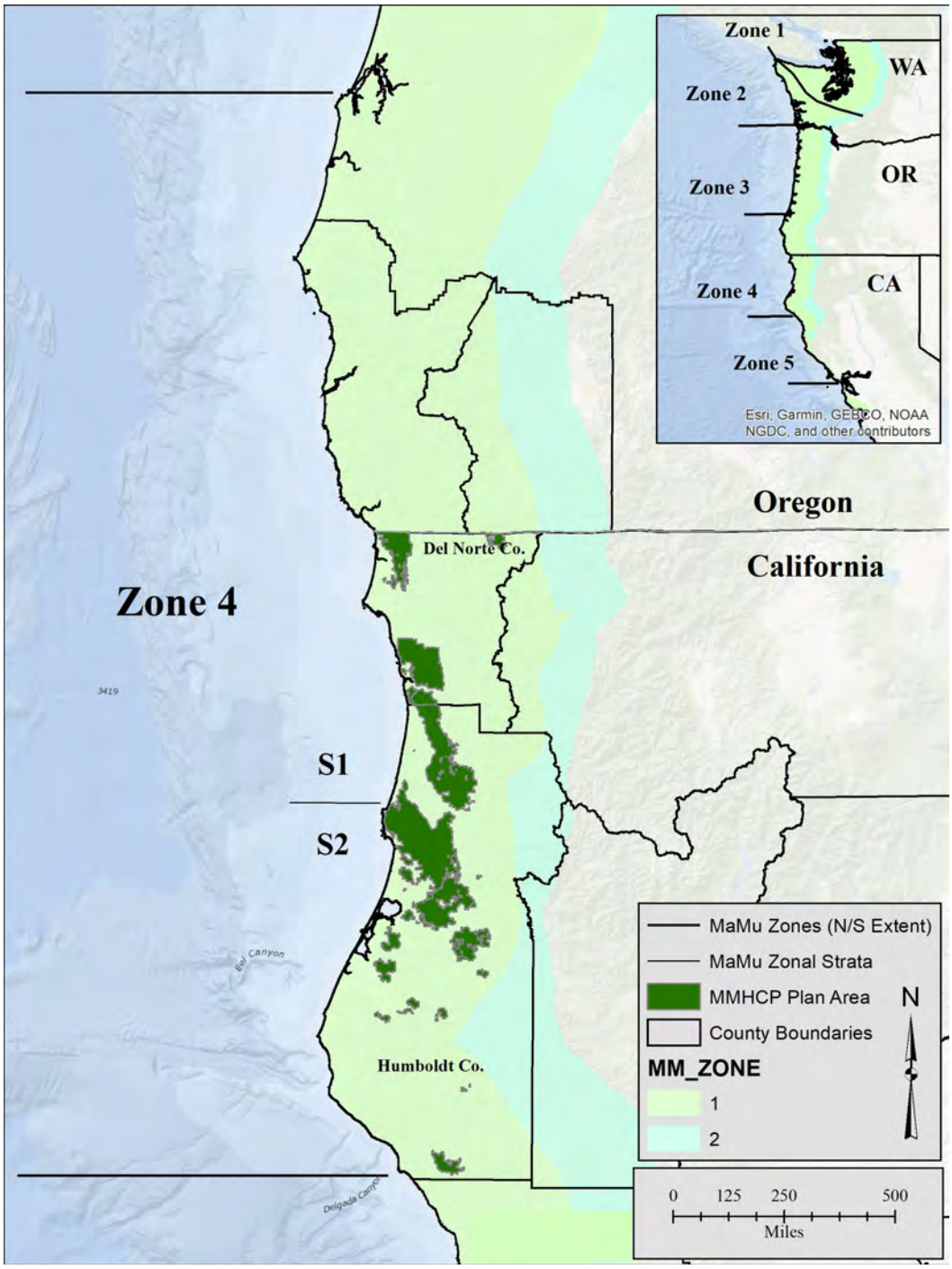


Figure 5-8. Marbled Murrelet Conservation Zones for at sea monitoring and terrestrial habitat monitoring under the Northwest Forest Plan (Madsen et al. 1999) and Marbled Murrelet Recovery Plan (USFWS 1997). The MMHCP Plan Area is shown in relationship to offshore and inland extent of Zone 4 encompassing northern California and Southern Oregon and strata (S1, S2) within the zone.

At sea monitoring was initiated in 2000 and continued annually through 2013. In 2014, the monitoring transitioned to an every-other-year approach due to funding constraints, and Conservation Zone 4 was placed on an odd-year schedule with surveys conducted in 2015, 2017, 2019, and 2021. As such, the most recent population and trend estimates are available through 2021 (McIver et al. 2022). The results from the at-sea monitoring indicate a positive slope for all Zones combined, although it was slight (0.3%) and confidence intervals overlapped zero. The range wide conclusion was no trend (Figure 5-9) with a 2020 population estimate of 19,685 murrelets (95% CI = 15,493 – 23,877). In Zone 4 and California, there was a positive trend that did not overlap zero, indicating an increase for the monitoring period of 2.8% annually in Zone 4 and 3.8% in California. The population estimate in 2021 for all of Zone 4 was 5,132 (95% CI = 3,739 – 8,243). In Zone 4 stratum 1 (Coos Bay to Trinidad), the population estimate was 4,476 (95% CI = 3,147 – 7,267) and in stratum 2 (Trinidad to Shelter Cove) the population estimate was 657 (95% CI = 90 – 1,521). The 2021 population estimate for California was 3,870 murrelets (95% CI = 2,727 – 5,014).

Based on our estimates of direct and indirect take (7.29) on the Plan Area, approximately 0.1458 murrelets could be taken annually, or 1 murrelet egg/nestling could be taken approximately every 7 years. This represents approximately 0.0007% of the 2020 range wide population, 0.0028% of the 2021 Conservation Zone 4 population, and 0.0038% of the 2021 California population. If the acquisition of lands from the EPA doubled the amount of Marginal Habitat on day one of implementing this MMHCP, the total amount of authorized take (15) could occur over the permit term if forest age classes, harvest, and other assumptions are held constant. This scenario could result in approximately 1 murrelet egg/nestling taken every 3.3 years and very minor increases in the effects to populations at scales of the range, Zone 4, and California. This is an overestimate of potential take and impacts to the regional murrelet population because land acquisitions and potential take would be dispersed over the 50-year permit term. These calculations are based on cautious and conservative estimates of nesting parameters and do not incorporate estimates of nesting success and juvenile survival. The incorporation of these additional factors would result in less impact to the murrelet population range wide and in California. The conservation of the Occupied Reserves, and Suitable Habitat Reserves habitat is a net positive conservation benefit for murrelets within the Plan Area, California, and within the listed range of the species.

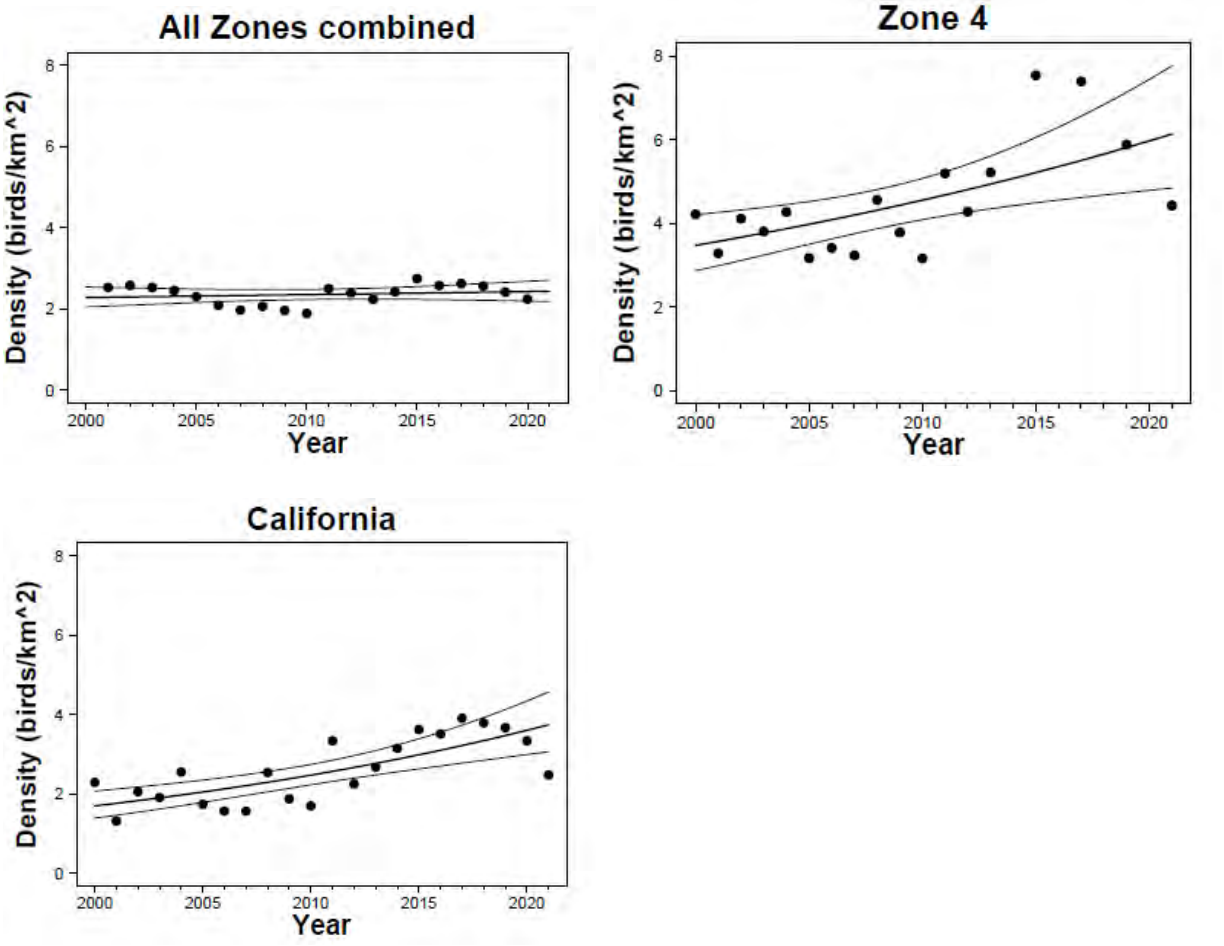


Figure 5-9. Density estimates for marbled murrelets for the years 2000 through 2021 for all Conservation Zones, Conservation Zone 4, and California.

5.4 SUMMARY OF KEY TAKE ASSESSMENTS

The following summarizes the conclusions of the take assessment analyses which are detailed earlier in this Section in Sections 5.2.2.1 and 5.2.2.2. The 50-year Harvest Forecast intersected with Marginal Habitat patches within the Plan Area results in 119.5 acres (48.36 hectares) of potentially occupied Marginal Habitat subject to modeled timber harvest (7,130 acres (2,885.4 hectares) total Marginal Habitat, with 5,116 acres (2,070.4 hectares) intersected, of which 2,917 acres (1,180.5 hectares) in Riparian Management Zone, leaving 2,199 acres (889.9 hectares) harvested * 0.0543 Marginal probability of occupancy = 119.5 acres of harvested occupied habitat over 50-year plan term). The average yearly rate of harvested nest trees within the 119.5 acres of Marginal Habitat harvested was 0.075. Applying a yearly nesting probability of 0.70 yields a potential direct take of 0.052 eggs/nestlings per year (0.075 nest trees per year * 0.7 probability of nesting = 0.052 eggs/nestlings per year) and 2.62 nestlings (0.052 eggs/nestlings per year * 50 years) over the 50-year Plan term. To estimate direct take of adult murrelets, we used the same metrics for nestlings discounted to a rate of 0.1 adult for every nestling taken (0.052 eggs/nestlings * 0.1 adults affected = 0.005 adults per year) results in 0.005 adults taken per year or 0.26 adults directly taken over the 50-year Plan term. The 50-year Harvest Forecast intersected within 50 meters of Marginal Habitat patches within the Plan Area results in the potential indirect take of

1.86 eggs/nestlings over the 50-year Plan term. The 50-year Harvest Forecast intersected within 50 meters of Suitable Habitat Reserves within the Plan Area results in the potential indirect take of 0.78 eggs/nestlings over the 50-year Plan term. We also estimated potential indirect take from single tree selection harvest within riparian management zones of Marginal Habitat by applying an estimated level of take at 0.25 for a specific harvest year where the unit was located within an riparian management zone that contained a hypothetical nest tree TAO. This process resulted in an estimated indirect take of 1.7 eggs/nestlings from selection harvest within riparian management zones over the 50-year Plan term. During development of this MMHCP, we expanded the Plan Area to include all Green Diamond ownership within the two counties and expanded the Adjustment Area to eligible lands within this area. The inclusion of all ownership within the counties increased the Plan Area acreage to 380,554 acres (154,005 hectares), an increase of 21,928 acres (8,874 hectares). These additional acres increased incidental take estimates by 0.074 murrelets over 50 years. These comprehensive analyses of Covered Activities associated with potentially occupied habitat results in a total estimated direct and indirect take of 7.29 nestling and adult murrelets over the 50-year Plan term.

In our estimates of incidental take, we made key assumptions that result in conservative estimates over the Permit Term. Those assumptions include:

1. Assumed take through increased predation risk due to edge effects.
    - Murrelets have been observed to select for nests closer to edges likely due to increased access (Burger 2002), and various studies have reported conflicting results on nest success related to proximity of nest to manmade hard edges and differences between manmade and natural edges (Nelson and Hamer 1995, Burger et al. 2009, McShane et al. 2004, and others).
    - Edges and other disturbance activities are common within the Plan Area creating a ubiquitous and evenly distributed berry crop which likely reduces the impacts of hard edges that will be created during the permit term as opposed to recreational areas (campgrounds, hiking trails, picnic areas, etc.) with concentrated and long-term anthropogenic influences (trash and crumbs or other activity that attracts Corvids) that contribute to increased predation.
2. Assumed take through noise disturbance.
    - Take through noise disturbance included in calculations even though this species has been documented to become habituated to noises in settings where anthropogenic disturbance is common.
3. Assumed take through microclimate effects and that those effects are consistent across nest types.
    - Increased wind or solar exposure could alter nests within close proximity to hard or soft edges, but site-specific conditions that may prevent or lessen the degree to which nests are impacted were not factored into the take calculations.
    - Nests within redwood trees include a duff substrate and not epiphytes susceptible to solar exposure.
    - It is unknown if a nesting pair of murrelets would find an alternative nest tree within the same patch but further away from the hard edge which would not result in take/reduced production.
4. Inclusion of two Marginal Habitat stands with recent occupied behaviors.

- Of the two Marginal Habitat stands with occupied behaviors that were included in the HSM and included in calculations for take, only one stand had below canopy occupied behaviors. The second stand had a single bird observed flying even with the top of a tall residual tree on the edge of a road bordering the stand; however, no other occupied behaviors were observed within this stand during five years of survey effort including surveys with multiple observers. Although this single observation of a bird flying over the stand was included as an occupied behavior, it's unlikely this stand is or was occupied. Inclusion of this stand represents a conservative estimate of nesting within areas predicted to have marginal suitability.

5. Reproductive parameters were held constant across habitat suitability categories
    - Marginal Habitat areas were assumed to have the same nest densities and nest success as low, medium and high suitability areas for calculating take and production (mitigation).
6. Habitat suitability modeling was based on stands within or directly adjacent to the Plan Area where occupied behaviors were observed
    - Nesting is assumed to occur within stands where occupied behaviors are observed but not all stands with occupied behaviors will contain murrelet nests. Therefore, the HSM predictions for potential habitat are conservative/more inclusive.
7. Take was assumed to occur for harvest occurring within or adjacent to suitable habitat at any point during the calendar year.
    - Actual take can only occur during the breeding season and coincident with the 30-day incubation or 30-day nestling development period.
    - Approximately 34% of annual harvest occurs outside of the breeding season
8. Take through edge effects included even though the overall amount of edge within the Plan Area will remain constant during the permit term and mimics conditions experienced within the Plan Area prior to HCP approval under take avoidance standards.
    - For take avoidance, platform trees are considered potential habitat regardless of proximity to hard edges (i.e., platform trees are considered potential habitat even when a vegetative buffer is absent).
9. When a large portion of a Marginal Habitat patch remains post-harvest, the remaining area is still considered Marginal Habitat and will continue to be assessed for additional take that occurs through harvest within or adjacent to the remaining patch.
    - Not accounting for additional harvest within or adjacent to the remaining Marginal Habitat patch would underestimate total take.
10. Assumed that some adult mortality would occur through direct effects of timber harvest (an adult incubating an egg that fails to flush when the nest tree is harvested or trees directly adjacent to the nest tree are harvested)
    - Extremely unlikely that an adult murrelet would continue to remain with the nest as the tree is harvested thus resulting in injury or death.
11. When modeled harvest occurred adjacent to Marginal Habitat and Suitable Reserves, we assumed that the harvest would occur up to the edge of the habitat patch. Given the shape and location of the habitat patches, the Forestry department will have to consider topographic and operational constraints when designing actual harvest units adjacent to the habitat patches. Therefore, this is a conservative estimate of impacts because designed harvest units will result in greater avoidance of these areas due to on-the-ground

considerations and constraints. So, there will be areas of Marginal Habitat and Suitable Reserves that are buffered due to these considerations which will also reduce indirect take effects.

Conceptual example for situations in the Plan Area that would potentially result in take:

Before actual take could occur within the Plan Area, several conditions must be met. For direct take to occur, a tree has to be located within potentially suitable habitat (less than 2% of the Plan Area), a tree has to have platform capability to support a nest, and the platform tree then has to be occupied by nesting murrelets (a given pair may not attempt nesting every year). Removal of the nest tree must occur during the breeding season (in a year when the nest is occupied by murrelets) within the 60-day period when incubation is occurring or when the nest is occupied by a nestling. This 60-day period may occur anytime during the breeding season (defined as March 24 through September 15), and approximately 34% of annual harvesting occurs outside of the breeding season. Additionally, approximately 2,199 acres of suitable (Marginal) habitat are projected for harvest during the 50-year permit term or approximately 44 acres annually.

Likewise, for indirect take to occur, harvest must be located adjacent to suitable habitat and adjacent to an occupied nest tree following the same conditions for breeding propensity and timing as described above for direct take. If harvest meets these criteria, then it is assumed that a nest site or nesting murrelet would be impacted by edge effects (noise disturbance, increased predation risk, and/or changes in microclimate). However, this species has not been observed to be sensitive to noise disturbance, especially in settings where elevated base-line noise conditions are common such as managed forest lands. Presence of ‘hard’ and ‘soft’ edges are common and historically present throughout the Plan Area creating more ubiquitous food sources for murrelet nest predators (i.e., Corvids), which contrasts with settings associated with hiking trails, campgrounds, or other recreational areas where increased anthropogenic food sources are more heavily concentrated resulting in increased concentrations of Corvids. With respect to changes in microclimate, the duff nest substrate associated with redwood trees is not as susceptible to changes in microclimate when compared to nests relying on epiphytic growth. Additionally, some studies have observed murrelets to select nest sites closer to edges where access may be easier (Burger 2002).

Section 6. Conservation Program

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Map 6-1-3. Marbled Murrelet Reserves 6-6

6.1 INTRODUCTION

Section 6 identifies the biological goals and objectives of this MMHCP and describes Green Diamond's Conservation Program for the Plan Area. The Conservation Program is designed to minimize and fully mitigate the effects of potential take described in Section 5 resulting from implementation of Covered Activities described in Section 2. Section 6.2 establishes the conservation strategy with a framework of biological goals and objectives supported by detailed descriptions of the conservation measures that will minimize and mitigate take and promote the recovery of the marbled murrelet. Section 6.3 describes the monitoring commitments and adaptive management measures Green Diamond will implement to ensure compliance, measure performance, and respond to uncertainty and new information. The adaptive management provisions included in section 6.3 identify options for responding to significant changes in the population or distribution of Covered Species and its habitat, should such changes be detected during prescribed monitoring. Section 6.4 further describes plan implementation and enforcement commitments, and Section 6.5 describes changed circumstances and unforeseen circumstances.

6.2 BIOLOGICAL GOALS AND OBJECTIVES AND CONSERVATION MEASURES

6.2.1 Introduction

To meet the statutory criteria for MMHCP approval, Green Diamond's conservation program must:

- Minimize and mitigate the impacts of authorized incidental take of marbled murrelets that may result from Covered Activities to the maximum extent practicable, and
- Ensure that any such take will not appreciably reduce the likelihood of the survival and recovery of such species in the wild.

In addition to these statutory criteria, the Service issued an Addendum to the 1996 HCP Handbook (also known as the Five Points Policy) stating an HCP must identify specific biological goals and objectives based on the conservation needs of the Covered Species and the potential impacts of the proposed action that warrant incidental take permit issuance (Final Addendum; 65 FR 35251).

The Handbook Addendum explains:

> *Explicit biological goals and objectives clarify the purpose and direction of an HCP's operating conservation program. They create parameters and benchmarks for developing conservation measures, provide the rationale behind the HCP's terms and conditions, promote an effective monitoring program, and, where appropriate, help determine the focus of an adaptive management strategy. . . .Biological goals provide broad, guiding principles for an HCP's operating conservation program and the biological goals are "the rationale behind the minimization and mitigation strategies" (Final Addendum; 65 FR 35251).*

Biological goals can be either habitat-based or species-based. Habitat-based goals are expressed in terms of the amount and or the quality of habitat. Species-based goals are expressed in terms

specific to individuals or populations of that species. This MMHCP's biological goals and objectives are primarily habitat-based. The goals and objectives guide the development of the operating conservation program.

As permit holder, Green Diamond's obligation for meeting the biological goals and objectives is proper implementation of the operating conservation program of this MMHCP. To qualify for No Surprises assurances, Green Diamond must implement the operating conservation program of this MMHCP and the terms and conditions of the Permit. Implementation may include provisions for ongoing changes in actions in order to achieve results or due to results from an adaptive management strategy (65 FR 35251).

Accordingly, to minimize and mitigate the impacts of incidental take within the Plan Area as described in this MMHCP and to ensure that such take does not jeopardize the marbled murrelet population. Green Diamond will implement measures that will, during the term of the Permit, protect and where needed allow development of the functional habitat conditions that are required for long-term survival to support well-distributed, viable populations of marbled murrelets. The conservation measures are based on the biological goals and objectives described below.

6.2.2 Goal One: Conserve Known Occupied Marbled Murrelet Habitat within the Plan Area – the Occupied Reserves

As stated in the Service's Recovery Plan for the marbled murrelet, the primary reason for listing the species as threatened was the loss of mature and old growth forests that function as nesting habitat (USFWS 1997). The objective of stabilizing the murrelet population was to protect occupied habitat, minimize the loss of unoccupied but suitable habitat, designate critical habitat, implement the Northwest Forest Plan, and develop HCPs that contribute to the conservation of the murrelet. The occurrence of suitable habitat on private lands within Conservation Zone 4 where this MMHCP is located is rare, and suitable nesting substrate (large limbs and platforms) and multi-layered canopies of forest stands and trees requires centuries to develop through the slow, continual process of forest succession. The Recovery Plan goes on to state that private lands covered by adequately designed and implemented HCPs would be an acceptable and effective means to protect occupied sites and for potentially providing replacement habitat in the future (USFWS 1997). The principle of Goal One is met through implementation of this MMHCP for a period of 50 years by protecting the most suitable and highest quality habitat that is currently or previously known occupied on the Plan Area.

Objective 1.1: Identify, Conserve, and Enhance the Occupied Reserves During the Permit Term

The main objective of Goal One is to retain the highest quality habitat within the Plan Area classified as occupied by marbled murrelets. To meet Objective 1.1, Green Diamond will identify, retain, protect, and enhance (see Objectives 2.1 and 2.2) 30 discrete patches of habitat that are considered occupied by marbled murrelets within the past 30 years based on observations during audio-visual surveys (Evans Mack 2003). The 30 Occupied Reserves includes an occupied stand ('Oil Creek') that was located on lands acquired by Green Diamond during the development of this MMHCP. These areas are identified in Green Diamond's Geographic Information System (GIS) and are hereafter referred to as Occupied Reserves in the context of the Conservation Program in this MMHCP (Maps 6-1-1, 6-1-2, 6-1-3). A few areas are comprised of smaller patches

(<2 acres) that are adjacent to and functionally associated with a larger contiguous patch of occupied habitat. Several of the 30 patches are associated with occupied habitat on adjacent state and federal land. A detailed description of these 30 patches along with a summary of results from audio-visual surveys is provided in Appendix C. A summary description of these areas is provided here in the context of Biological Objective 1.1. The known or presumed occupied habitat on adjacent state, federal, and other ownerships are hereafter referred to Adjacent Habitat Reserves and Adjacent Habitat Buffers. The Adjacent Habitat Reserves are not located on the Plan Area, but 300-foot (91.4-meter) vegetation buffers (Adjacent Habitat Buffers) for the protection of these areas are addressed by harvest restrictions in portions of the Plan Area.

Map 6-1-1. Marbled Murrelet Reserves

Map 6-1-2. Marbled Murrelet Reserves

Map 6-1-3. Marbled Murrelet Reserves

At the time of ESA listing of the marbled murrelet in 1990, Green Diamond was conducting timber harvest operations in small remnant patches of late seral forest characterized as potential habitat for marbled murrelets. An extensive effort was conducted to identify and survey potential habitat in the Klamath operating area of the ownership from 1990 through 1998 (Appendix C) to avoid take of the recently listed species within the requirements of the California Forest Practice Rules. The effort conducted with review by the Service and the California Department of Fish and Wildlife (CDFW) resulted in the identification of 25 late seral forest patches occupied by marbled murrelets totaling approximately 624.7 acres (Maps 6-1-1, 6-1-2, 6-1-3). A subset of six discrete patches of Occupied Reserves totaling approximately 230.6 acres is protected in two Deeds of Conservation Easement (CE) granted to Save the Redwoods League (Recovery Action 2.1.B.5, USFWS 1997). The total area of Conservation Easement encompassing Occupied Reserves is approximately 972 acres including the 230.6 acres of Occupied Reserves containing old growth redwood and other old growth conifer trees, and the balance of over 741 acres in regenerating forest stands within the CE boundaries surrounding the reserves. The CE areas are not included as mitigation commitments in the Conservation Program for this MMHCP, but these areas remain Green Diamond property in the Plan Area, and they are contributing to the murrelet population and future habitat. Some portions of the 300 foot (91.4 meter) buffers for the Occupied Reserves extend beyond the CE boundaries and are included in the Conservation Program (Goal Two) for this MMHCP. Results of recent surveys and reports provided to CDFW on CE areas are provided in Appendix C.

In 1998, Green Diamond acquired approximately 74,000 acres of land from Louisiana-Pacific Corporation (Louisiana -Pacific) in Humboldt County. Prior to the acquisition, Louisiana-Pacific had conducted audio-visual surveys in areas of potential habitat and confirmed occupancy by marbled murrelets in a patch of residual old-growth and mature second growth forest in the Maple Creek drainage. The area known as Clear Creek is approximately 29.6 acres. Green Diamond has conducted audio-visual surveys in this Occupied Reserve area as recently as 2022 (Appendix C). This area is included as an Occupied Reserve under Objective 1.1 (Maps 6-1-1, 6-1-2, 6-1-3).

Green Diamond has periodically conducted audio-visual surveys in potential murrelet habitat identified during the state timber harvest plan review process. In some instances, Green Diamond

has elected to protect and avoid potential habitat areas rather than conduct the minimum two-year audio-visual survey effort. As a result of recent survey efforts (Appendix C), four areas were recently classified as occupied by marbled murrelets and added to the suite of Occupied Reserves. These areas are Clear Creek East, Maple Creek, Bald Mountain Creek, and Oil Creek (Table 6-1, Maps 6-1-1, 6-1-2, 6-1-3).

To meet Objective 1.1, Green Diamond will identify, retain, protect, and enhance 24 Occupied Reserves encompassing 541.3 acres listed in Table 6-1 and depicted in Maps 6-1-1, 6-1-2, 6-1-3. These areas are catalogued in the Geographic Information System (GIS), operated using ESRI software, and available to resource managers conducting Covered Activities under the Permit. Resource managers use a variety of tools and techniques to identify the boundary of the Occupied Reserves in relation to Covered Activities including LiDAR, other remotely sensed data, and handheld global positioning system devices. Resource managers will employ a conservative approach for delineating and marking these boundaries in the field to ensure that on-the-ground boundaries and habitat retention post-harvest align with or extend beyond (outside) planimetric mapping of these protected areas. These areas will be retained during the Permit Term and protected from timber harvest and other Covered Activities under Biological Objective 4.1. The Occupied Reserves will be enhanced through either passive or active forest management within vegetation buffers further defined in Biological Objectives 2.1 and 2.2.

Table 6-1. Green Diamond inventory of Marbled Murrelet Occupied Reserves and 300-foot (91.4-meter) vegetation buffers in the Conservation Program meeting Biological Objective 1.1 to identify, retain, protect, and enhance known occupied marbled murrelet habitat during the Permit Term. The two Conservation Easement areas comprised of six Occupied Reserves are included for reference, but the areas currently under Conservation Easement are not eligible components of the Conservation Program.

Occupied Reserve Name	Maps 6-1-1 to 6-1-3	Stand Acres	Buffer Acres[1]	Total Acres	Conservation Easement
W530	1	52.8	76.5	129.3	No
W202	2	5.4	20.2	25.6	No
W302[2]	3	0.7	8.2	8.9	No
W302	4	58.7	83.8	142.6	No
K9	5	35.4	63.9	99.3	No
K7	6	13.7	30.1	43.8	No
T630	7	33.6	44.4	78.0	No
K8	8	15.6	31.7	47.3	No
U1500	9	21.3	37.1	58.4	No
EF Hunter	10	40.6	0.4, 62.2	103.2	Yes
T300 North	11	5.7	1.2, 21.7	28.5	Yes
Big Mynot	12	47.8	20.0, 57.8	125.6	Yes
Small Mynot	13	13.0	30.2	43.2	No
T300 South	14	7.3	0.4, 22.9	30.6	Yes
Pisgah View	15	1.5	12.9	14.4	No

[1] Acres within a 300 foot (91.4-meter) vegetation buffer surrounding the Occupied Reserve with buffers of some adjacent stands overlapping. When vegetation buffers for adjacent Occupied Reserves are overlapping, the area of overlap is assigned to one Occupied Reserve. Some portions of buffers for five Occupied Reserves occur outside of Conservation Easement boundaries. The first number in the column for these five reserves represents buffer acres outside of easement boundaries and therefore included in the Plan Area and Conservation Program.

[2] Adjacent to main stand

Occupied Reserve Name	Maps 6-1-1 to 6-1-3	Stand Acres	Buffer Acres[1]	Total Acres	Conservation Easement
U600	16	10.5	27.8	38.3	Yes
Miracle Mile	17	118.7	12.5, 91.2	222.5	Yes
T10 Shop	18	6.9	20.9	27.7	No
T10 Shop[2]	19	6.4	30.2	36.6	No
Arrow Mills	20	53.8	50.6	104.5	No
Klamath View Ridge North	21	11.5	11.3	22.8	No
Klamath View Ridge West	22	9.3	15.5	24.8	No
Klamath View Ridge South	23	9.9	18.8	28.7	No
D100	24	18.6	22.4	41.0	No
D10	25	26.2	40.1	66.3	No
Clear Creek East	26	20.7	40.2	60.9	No
Clear Creek	27	29.6	43.1	72.7	No
Maple Creek	28	11.0	27.1	38.1	No
Bald Mountain Creek	29	69.4	60.3	129.7	No
Oil Creek	30	16.5	15.2	31.7	No
Totals[3]		**771.9**	**1153.1**	**1925.0**	

6.2.3 Goal Two: Retain and Recruit Habitat for Marbled Murrelets within Vegetation Buffers for Occupied Reserves and Adjacent Habitat Reserves

The guiding principle for Goal Two is to provide additional protection to forest stands occupied by marbled murrelets by aiding the recovery of the occupied habitat and maintaining the microclimate of the stand. The occupied forest stands are the anchor habitat, and the young regenerating stands in buffers begin the process of expanding the remnant stands through initiation of forest management practices that accelerate the development of older forest structure. In addition, a vegetation buffer was believed to reduce noise into the stand to minimize potential disturbance to the species during the breeding season. In many cases, the adjacent forest was young regenerating stands that offered little protection to or amelioration of climatic effects due to disparate heights of the young forest buffer and the mature or old growth occupied habitat. While there is no specific written regulatory requirement for a vegetation management zone adjacent to forest habitat occupied by marbled murrelets within California, since the early 1990s, agencies have recommended vegetation buffers as beneficial to nesting murrelets and maintaining and enhancing habitat (USFWS 1997, Long and Ralph 1998). The unmanaged buffer zones around occupied sites have remained in place over the past three decades, but the growth of the regenerating forest has stagnated in the absence of stand management that would normally be initiated at 10-15 years of age with precommercial thinning followed by commercial thinning around 30 years. Green Diamond intends to meet Goal Two by maintaining the 300-foot (91.4-meter) vegetation buffers on Occupied Reserves and vegetation buffers on Adjacent Habitat Reserves and, where a harvest is already scheduled in the adjoining stand, accelerating the development of later seral habitat by reducing stem density and promoting tree growth with specific silvicultural treatments in the buffers (USFWS 1997, Soland et al. 2021). As described in this section (6.2.3), the vegetation buffers enhance the Occupied Reserves and Adjacent Habitat Reserves by retaining adjacent forest that will continue to develop toward suitable habitat

[3] Acres are calculated at full precision using GIS and individual numbers in each row are rounded to the nearest 0.1 acre. Any difference between the reported total and the sum of the individual values is due to rounding and not a discrepancy in underlying data.

conditions over time increasing amount of interior forest and mediating potential negative effects of edge on the Reserves (USFWS 1997). Green Diamond expects and predicts that vegetation buffer areas will improve the habitat suitability of Occupied Reserve areas and Adjacent Habitat Reserves over time and eventually will become suitable adding over 1,574 acres of habitat.

Objective 2.1: Establish Vegetation Buffers for Occupied Reserves and Adjacent Habitat Reserves.

To meet Objective 2.1, Green Diamond will establish a 300-foot (91.4-meter) vegetation buffer surrounding the Occupied Reserves and Adjacent Habitat Reserves on neighboring lands (e.g., Federal and state parks) listed in Table 6-2. The buffers are located within the Plan Area and, for the Conservation Easements, the 300-foot (91.4-meter) buffers that extend beyond the Conservation Easement boundaries are included in the Conservation Program. These vegetation buffers are identified in Green Diamond's GIS and are hereafter referred to as Occupied Reserve Buffers and Adjacent Habitat Buffers in the context of the Conservation Program in this MMHCP under Biological Objective 2.1. The total area contained within the buffers under Biological Objective 2.1 is 869.5 acres within the Occupied Reserve Buffers and 704.9 acres within the Adjacent Habitat Reserve Buffers with current forest ages ranging from <10 to >90 years (Table 6-2). Buffers are eligible for limited forest management according to Objective 2.2. Resource managers will use a variety of tools and techniques to conservatively delineate the buffers in relation to Covered Activities.

Table 6-2. Acres of forest age classes (years) in 300-foot (91.4-meter) vegetation buffers surrounding Occupied Reserves and off-property occupied or presumed occupied Adjacent Habitat Reserves.

	Occupied Reserve Buffers[4]		Adjacent Habitat Reserve Buffers	
Forest Age Class	**Acres**	**Percent**	**Acres**	**Percent**
0-9	11.0	1.3	6.8	1.0
10-19	39.9	4.6	16.7	2.4
20-29	8.8	1.0	8.6	1.2
30-39	88.2	10.1	85.0	12.1
40-49	416.5	47.9	264.3	37.5
50-59	34.3	3.9	133.9	19.0
60-69	82.1	9.4	121.2	17.2
70-79	106.3	12.2	13.7	1.9
80-89	30.0	3.4	18.4	2.6
> 90	52.6	6.0	36.3	5.1
Total[5]	869.5	100	704.9	100

Objective 2.2: Recruit Marbled Murrelet Habitat Within Vegetation Buffers for Occupied Reserves and Adjacent Habitat Reserves Where Adjacent Harvest Provides the Opportunity

To meet Objective 2.2, Green Diamond will implement silviculture treatments within the Plan-Area buffers for Occupied Reserves and Adjacent Habitat Reserves to promote and accelerate

[4] Acres within Conservation Easements are excluded from calculations.

[5] Acres are calculated at full precision using GIS and individual numbers in each row are rounded to the nearest 0.1 acre. Any difference between the reported total and the sum of the individual values is due to rounding and not a discrepancy in underlying data.

development of late seral habitat conditions or "old-growthness" (Bauhus et al. 2009) within the vegetation buffers. The treatments within the vegetation buffers will occur coincident with other planned commercial harvests adjacent to the buffers according to Green Diamond's near and long-term harvest scheduling in a manner that results in a logical harvest unit according to the California Forest Practice Rules (Forest Practice Rules) and in compliance with other Green Diamond HCPs and agreements. Any commercial harvest within the buffer will be opportunistic and no buffer will be entered as a stand-alone operation; thus, buffers with no adjacent scheduled harvest will receive no treatment during the Permit Term.

Where Green Diamond elects to treat a buffer, the following elements are fixed by this Plan and are described in the paragraphs that follow: buffer entry will occur only in conjunction with an adjacent scheduled harvest; treatment will be limited to light, individual tree harvest at basal area retention levels above those associated with a typical selection or commercial thin under the Forest Practice Rules; all trees to be harvested will be marked by or under the supervision of a Registered Professional Forester (RPF); treatment will occur outside of the marbled murrelet breeding season as specified in Appendix D; operations will not commence until the Service and CDFW have concurred; and no more than two entries are anticipated during the Permit Term. Within these constraints, stand-specific implementation detail is not fixed at this time, because treatments need to be tailored to the stands in which they will be implemented to achieve the desired conditions. Fixing stand-level prescriptions at this time would limit future options to address conditions as they exist on the landscape at the time of entry.

A light harvest within the 300-foot buffer is expected to reduce competition among retained trees and thereby maintain or improve their growth and vigor relative to no-entry conditions. Growth responses of retained trees following partial harvest, including commercial thinning and variable-density thinning, in the redwood region and in Pacific Northwest Douglas-fir forests are consistently positive in direction across independent studies, with greater increases for trees released from direct crown competition (Roberts and Harrington 2008, Dodson et al. 2012, Teraoka et al. 2017, Dagley et al. 2018, O'Hara et al. 2020). Reported effect sizes vary with retention level, initial competitive status, and time since treatment, and individual studies differ in statistical power; the consistency of the direction of response across sites, rather than the magnitude reported in any single study, is the basis for this expectation. Absent treatment, dense second-growth stands in the stem exclusion stage of development are subject to continued crown recession and elevated suppression mortality (Dodson et al. 2012, Soland et al. 2021).

Although harvested trees will be sold commercially, the treatment is a light-intensity restoration prescription designed to remove only a limited proportion of stand basal area while retaining canopy closure of 70% averaged across the treated area, structural complexity, and the interior forest conditions that are protective of nesting marbled murrelets. Prescriptions will establish or maintain a multi-aged stand structure, promote growth of leave trees across a range of diameter classes, and encourage natural reproduction.

Forest management within the vegetation buffers will accelerate the development of old-forest characteristics in these secondary forests. Treatments will develop forest attributes including vertical canopy stratification and diversity and horizontal variation in tree stem density (tree-to-tree gaps), and will retain large trees and trees most likely to respond to release treatments (Bauhus et al. 2009). Marking by the RPF will target variable spacing of residual conifers to create this

horizontal variation. Any harvested tree will be felled in a direction away from the adjacent Occupied Stand. The goal within the buffer will be to promote growth in tree height, diameter, and limb size. Harvesting will be conducted to create or retain structural diversity within the buffer area and to retain individual trees with key habitat elements such as complex crowns, large limbs, limb deformities, platforms, and other structural features that currently provide nesting substrate for marbled murrelets or are more likely to develop into suitable nesting substrate over time. Other existing key habitat elements such as snags, live legacy residual trees, and down old residual logs with rot and defect will also be retained.

Reduced stand density and the creation of small gaps will promote development of a post-harvest stand more complex in vertical structure and canopy gaps than the pre-harvest stand, and this complexity will continue to develop as the stand grows older. Buffer treatment may occur more than once during the Permit Term, but given the timing and frequency of Green Diamond's harvest cycle described in this HCP, two entries are the maximum anticipated. These treatments would be coincident with other adjacent harvest such as commercial thinning around 30–40 years of age and clearcut harvest at a minimum of 45 years of age. The restoration harvest conducted within the vegetation buffers themselves is distinct from, and substantially less intensive than, the adjacent commercial thinning and clearcut harvests. Due to constraints on adjacent harvests under the Forest Practice Rules, some final even-aged harvests in adjacent stands will occur beyond 70 years of age.

Prior to harvest operations, Green Diamond will notify the Service and CDFW and provide both agencies with the opportunity to conduct a field review of the RPF-marked buffer, including the specific trees marked for removal. Operations within the buffer will not commence until both the Service and CDFW have concurred on the level of harvest and the specific trees marked for removal, to ensure the proposed harvest meets the objectives for recruiting habitat for marbled murrelets and avoiding the potential for increased predation risk or other edge effects to occupied marbled murrelet habitat adjacent to the vegetation buffer.

Where stands within vegetation buffers are less than 20 years of age, a single precommercial thinning entry may be conducted to manage the density of planted trees and stems of sprout regenerated redwoods (O'Hara et al. 2015). Precommercial thinning involves thinning dense, young forest trees by mechanical means, including cutting individual trees or mechanically sawing or chipping rows or groups of trees. It also initiates appropriate stem spacing within the regenerating forest. Precommercial thinning may occur in redwood sprout dominated units or naturally regenerated conifer stands starting at age 9 or 10; by age 15 to 20, the optimum time for precommercial thinning has passed. Precommercial thinning is undertaken to remedy overstocked conditions in regenerated stands so that the remaining crop trees will achieve optimum diameter growth, and is performed once in the life of a stand and only in those stands with an excess number of trees per acre. As with the commercial harvest described above, precommercial thinning within a buffer will occur only in conjunction with the same activity scheduled in the adjoining stand; no buffer will be entered for precommercial thinning as a stand-alone operation.

6.2.4 Goal Three: Minimize Direct Take and Potential Disturbance Take to Marbled Murrelets and Establish Best Management Practices to Minimize Predatory Risk to Nesting Marbled Murrelets

Covered Activities occurring outside stands of Occupied Reserves and Adjacent Habitat Reserves may cause take if above-baseline noise disturbance causes significant impairment of essential behavior that leads to actual death or injury to murrelets. In close proximity, extraordinary loud noises may cause adults or nestlings to flush from the nest or cause adult murrelets to abandon or neglect an active nest. Nest abandonment or long-term neglect may result in take due to death of eggs or nestlings. Additionally, murrelets may experience reduced nesting success within close proximity to human-induced forest edges due to increased nest predation risk or changes in microclimate. The scientific literature on harm to nesting murrelets through audio-visual disturbance by forest management activities indicates a weak and uncertain relationship between ambient disturbance and nesting murrelets on a managed forest landscape (see Section 5.1.2.2). Likewise, the relative percentages of edge across the Plan Area will remain generally constant throughout the Permit Term because Green Diamond will continue to manage its forests for sustainable harvest through existing regulations, permits, and policies. Further, cryptic coloration of the egg/nestling/adult, crepuscular activity patterns, selection of hidden nest sites with high vertical and horizonal cover, retention of down by the nestlings, fledging after dusk, minimal or muted vocalizations from nests, remaining still or flattening against tree branches in response to predators, and other behavioral and breeding habitats of murrelets likely indicate that the species evolved under immense predation and nest site competition pressure. However, indirect harm from disturbance, increased predation risk, and habitat modification through changes in microclimate as well as forms of direct harm can be practically avoided by temporal and spatial buffers for specific types of activities proximate to protected murrelet nesting habitat.

If an active marbled murrelet nest is discovered during operations, operations within 0.25 mile of the nest will be suspended until after the breeding season (September 15) or until a qualified wildlife biologist has determined that the nest has failed or the young have fledged. Exceptions include road use and maintenance activities (D.2.1.1) and administrative land use activities (D.2.1.5) provided take minimization measures are implemented as described in D.2.6.

Objective 3.1: Establish Take Avoidance and Minimization Measures for Occupied Reserves and Adjacent Habitat Reserves

To meet Objective 3.1, Green Diamond has developed and will implement a comprehensive list of take avoidance and minimization measures for Covered Activities during the marbled murrelet breeding season within prescribed distances of the Occupied Reserves and Adjacent Habitat Reserves. These measures are described in detail in Appendix D and address vegetation buffers, seasonal disturbance buffers, road construction, road use, and road maintenance activities, rock pit development and use, timber harvest, forest regeneration, and administrative use of the Plan Area.

6.2.5 Goal Four: Conserve Suitable Habitat Reserves within the Plan Area

Similar to Goal One, the guiding principle of Goal Four is to protect other suitable habitats that are rare on the Plan Area, as identified by the Habitat Suitability Model (HSM, Appendix A). The growth and development of forest habitat and trees for murrelets is a process that occurs over a

period of 200 years or more and is rare on the managed forest landscape of the Plan Area where >99% of the area is composed of young or immature second and third growth forests less than 100 years of age. Because old forests and trees are rare, the retention and protection of the older and most structurally suitable habitat provides assurance that forest areas potentially occupied by marbled murrelets will be maintained, and habitat will continue to develop in these areas. Not all areas of potential habitat are predicted to be currently occupied by murrelets, but the areas with key habitat features identified by the HSM are the best option for recruiting suitable nesting habitat during the Permit Term within the Plan Area. Green Diamond will meet the guiding principle of Goal Four by using the HSM to identify a suite of forest stands within the Plan Area that are next best on the suitability scale relative to the Occupied Reserves under Goal One. This initial suite of Suitable Habitat Reserves will be conserved during the Permit Term and are identified as the primary form of mitigation for anticipated incidental take under this MMHCP.

Objective 4.1: Using the Habitat Suitability Model and Habitat Suitability Curve, Identify Low Suitable and Better Habitat, Establish Boundaries Using a Concave Hull Process, and Designate these Areas as No Harvest Suitable Habitat Reserves for the Permit Term

To meet Objective 4.1, Green Diamond will identify, retain, and protect 96 discrete patches of habitat totaling 946.4 acres (Section 5) that are considered low suitability and better habitat for marbled murrelets based on the marbled murrelet HSM developed by Green Diamond (Appendix A). These areas are identified in Green Diamond's GIS and are hereafter identified as Suitable Habitat Reserves in the context of the Conservation Program in this MMHCP (Maps 6-1-1, 6-1-2, 6-1-3). As described in Section 5.2.2.1 and Appendix A, a concave hull process was used to delineate a boundary around the model classified areas. The boundary encompassed all TAOs that contributed to the model classified patch plus a 5-meter buffer. Similar to other management boundaries, Resource Managers will use a variety of tools and techniques to conservatively delineate and mark these boundaries in relation to Covered Activities.

The Suitable Habitat Reserves are forest stands with a modeled habitat suitability value of at least 0.19 (Figure 5-1, Appendix A) and fall into a habitat classification rating of low, medium or high based on the modeled habitat suitability value. From the perspective of conservation value to murrelets, these stands are considered the second most important habitats in the Plan Area relative to the Occupied Reserves because they are more likely to provide important nesting structure and nesting habitat. The Suitable Habitat Reserves are primarily second growth forest (70-110 years old) with scattered remnant old trees or slightly aggregated old growth trees (> 200 years old) retained from the prior timber harvest. As the density of the scattered old growth trees increases within an area as measured by the HSM, the habitat suitability increases because these areas begin to acquire attributes of the Occupied Reserves (Figure 5-2). The true old growth trees (> 200 years old and generally > 60 meters in height) within these areas represent the potential nesting trees due to the time (age) required for large limbs, deformities, and other attributes of nesting platforms to develop. The patches or clumps of older trees also provide the increased vertical and horizontal heterogeneity and canopy gaps necessary for murrelets to aerially negotiate these areas for flight, landing, and nesting. During development of this MMHCP, Green Diamond, the Service, and CDFW reviewed Suitable Habitat Reserves during numerous field visits of the Permit Area to validate HSM predictions, and each group participated in a comprehensive GIS review of the spatial distribution, HSM predictions, and other biological and ecological factors for every Suitable Habitat Reserve designated under this MMHCP. All aspects of the comprehensive review

of the Suitable Habitat Reserves established this conservation goal as a key component for protecting and recruiting potential nesting habitat for marbled murrelets within the Plan Area.

Objective 4.2: Protect 36.3 acres of Suitable Habitat Reserve through Recorded Deed Restrictions

Of the 96 Suitable Habitat Reserves identified, retained, and protected under Objective 4.1, Green Diamond will establish deed restrictions over two patches totaling 36.3 acres. Green Diamond selected these Suitable Habitat Reserves based on patch size, modeled habitat suitability value (habitat suitability index, HSI; Appendix A), proximity to Occupied Reserves, and modeled murrelet productivity associated with the patch.

Section 5.2.2 analyzes take and the mitigation provided by the Suitable Habitat Reserves. Green Diamond estimates direct take of 2.88 murrelets, reported as 2.9 murrelets (Section 5.2.3 and 5.2.10), over the 50-year Permit Term, with authorized direct take of up to 5.8 murrelets to account for a high level of future timberland acquisitions added to the Plan Area under Section 6.4.7, which may not be achieved during the Permit Term (Sections 5.2.2.1, 5.2.8, 5.2.10).

The Suitable Habitat Reserves are expected to produce 0.5759 murrelet eggs or nestlings per gross acre over the 50-year Permit Term, based on an HSI-derived occupied proportion of 32.91 percent, a mean nest density of 0.05 nests per acre, and a mean annual nesting probability of 0.7 (Sections 5.2.6, 5.2.10; Appendix B). On the basis used to calculate mitigation ratios in Section 5.2.7, 10.1 gross acres of Suitable Habitat Reserve are expected to produce eggs or nestlings equal in number to the maximum authorized direct take of 5.8 murrelets, and 5.0 gross acres are expected to produce eggs or nestlings equal in number to the estimated direct take of 2.88 murrelets. The two Suitable Habitat Reserves subject to deed restriction under this Objective 4.2 total 36.3 acres, or 3.6 times the acreage corresponding to the maximum authorized direct take and 7.3 times the acreage corresponding to the estimated direct take. These figures relate only to the acres subject to deed restriction; the mitigation ratio for authorized incidental take under this MMHCP is stated in Section 5.2.7.

The deed restrictions provide a recorded, enforceable encumbrance running with the land for 50 years. This incremental legal durability is not otherwise afforded to the Suitable Habitat Reserves, which are protected during the Permit Term by the conservation commitments of this MMHCP. As set forth in Sections 5.2.7 and 5.2.10, protection of the Suitable Habitat Reserves under Objective 4.1 fully mitigates the impacts of the incidental take authorized under this MMHCP. The deed restrictions established under this Objective 4.2 do not substitute for that mitigation; they render a portion of it enforceable of record and thereby provide additional assurance that the protection of these Suitable Habitat Reserves will be maintained for the full 50-year term, with respect to incidental take authorized under both the federal Endangered Species Act and the California Endangered Species Act.

The deed-restricted Suitable Habitat Reserves are identified as follows. One Suitable Habitat Reserve (ID 'V06_PKey 1902', as identified in the Suitable Habitat Reserve attribute dataset provided to the Service and CDFW during reserve selection) is 25.8 acres located in the McDonald Creek watershed approximately 4.5 miles south of the town of Orick, in Humboldt County. A

second Suitable Habitat Reserve (ID 'V06_PKey 695') is 10.5 acres located in the Wilson Creek drainage approximately 8.0 miles north of the town of Klamath, in Del Norte County.

Green Diamond will record the deed restrictions, naming the Service and CDFW as beneficiaries, in the official records of Humboldt County and Del Norte County, California, within 60 days of issuance of a CDFW Consistency Determination under Fish and Game Code Section 2080.1. Within 60 days following recordation, Green Diamond will provide the Service and CDFW with copies of the recorded instruments and a map depicting their location and will include the recorded instruments and map in the next Annual Report (Section 6.4.3). Green Diamond will maintain the deed-restricted Suitable Habitat Reserves in its GIS.

If a deed-restricted Suitable Habitat Reserve is severely damaged or destroyed by a natural event and is released from the harvest and entry commitments of this MMHCP under Section 6.5.2, Green Diamond, the Service, and CDFW will confer on execution and recordation of an amendment to or release of the applicable deed restriction. If a deed restriction is released, Green Diamond will establish deed restrictions over replacement Suitable Habitat Reserves selected from among the Suitable Habitat Reserves protected under this MMHCP, in an amount sufficient to maintain not less than the acreage of Suitable Habitat Reserve identified in this Objective 4.2, and will record the replacement deed restrictions within 60 days of their identification. A deed-restricted Suitable Habitat Reserve removed from the Plan Area under Section 6.4.7.2 remains subject to its deed restriction, and no replacement deed restriction is required.

6.2.6 Goal Five: Ensure Compliance, Effectiveness, and Implementation of the Conservation Plan

Regulations implementing section 10(a)(1)(B) of the ESA require each HCP to implement the provisions stated therein, monitor the outcomes of the identified conservation measures, validation of the assumptions necessitated by the incomplete information upon which this Plan must rely, and identify adaptive management measures necessary to ensure that the overall conservation approach of this MMHCP functions as intended. Goal Five and the objectives identified within this section provide a framework within which these requirements are met. Specific monitoring and adaptive management commitments are described in detail in Section 6.3 below and detailed implementation commitments are described in Section 6.4 below.

The effectiveness monitoring is designed to confirm the expected benefits of the conservation program for habitat and to adjust the conservation strategy when monitoring indicates that adaptation is appropriate. Adaptive management is also a recognized requirement of habitat conservation plans under the Service's Five Points Policy, requiring an HCP to use monitoring and adaptive management to address scientific uncertainty concerning the conservation needs of Covered Species throughout the life of the Permit (Final Addendum; 65 FR 35251).

6.3 MONITORING AND ADAPTIVE MANAGEMENT

6.3.1 Compliance and Effectiveness Monitoring

Monitoring will occur to determine whether the MMHCP conservation program is implemented as written and to determine whether implementation results in anticipated habitat conditions.

Monitoring will document the types, amounts, and locations of Covered Activities addressed in the conservation program, and document changes in habitat conditions in HCP-managed areas. Green Diamond will track compliance monitoring internally and provide the results to the Service and CDFW annually. An initial monitoring plan describing how and when monitoring will be implemented to meet the objectives of this Plan is included as Appendix E. Changes may be made throughout the Permit Term as new technologies and strategies become available (see Section 6.3.1.9) if developed with and approved by the Service and CDFW. The following section describes the specific monitoring objectives established to meet the goals of the conservation program.

6.3.1.1 Monitor Covered Activities Around Occupied Reserves and Buffers (Goal One and Goal Three)

Green Diamond will monitor Covered Activities around Occupied Reserves and vegetation buffers to ensure that vegetation modification does not occur within the boundaries of the Occupied Reserves and vegetation modification within the buffers (for Occupied Reserves and Adjacent Habitat Reserves) complies with the provisions for habitat recruitment as described in Section 6.2.3 or as described in Appendix D including location and timing of Covered Activities. Green Diamond will also monitor Covered Activities that result in noise disturbance to ensure compliance with the provisions described in Appendix D.

6.3.1.2 Conduct Sampling within Buffer Areas to Assess Development of Murrelet Habitat (Goal Two)

Pre- and post-harvest sampling will be conducted in years when unevenaged management silviculture occurs within the buffer of an Occupied Reserve or Adjacent Habitat Reserve for the purpose of recruiting marbled murrelet habitat as described in Section 6.2.3 and Appendix D. Pre-harvest individual tree and stand characteristics for treated areas and untreated areas within the same buffer will be compared with post-harvest values and evaluated for favorable changes. Examples of potential variables include individual tree height and height distribution and densities or other surrogates for tree diameter or crown development. Additional post-harvest sampling will be conducted at an interval of 15 to 25 years through year 45 of the MMHCP permit. A minimum sample interval of 15 years allows for meaningful/measurable tree growth, and the sampling range of 15 – 25 years provides flexibility for post-harvest sampling to coincide with the periodic collection of LiDAR-derived or PhoDAR (Photography based LiDAR-like)-derived data. Survey results will be reported in annual reports for years with samples, and a comparison of the results will be reported in the 49th annual report along with recommendations for future recruitment opportunities that can be used for evaluation of whether the term of the Assurance Reserve should be extended (Section 6.3.2.4) and for development and adjustment of Permit Terms if Green Diamond seeks to renew and extend the HCP Section 6.4.8).

6.3.1.3 Monitor Covered Activities Around Suitable Habitat Reserves (Goals Three and Four)

Green Diamond will monitor Covered Activities around Suitable Habitat Reserves to ensure that vegetation modification does not occur within the boundaries of the Reserves except as described in Appendix D for road use (access, maintenance, upgrading, decommissioning, etc.) activities. Road use activities may result in incidental take through noise disturbance, and this form of incidental take is accounted for in the take calculations and take mitigation described in Sections

5.1 and 5.2. Vegetation modification as a result of road use activities are not expected to result in incidental take through habitat modification given the take avoidance measures described in Appendix D. Covered Activities that involve commercial timber harvest (i.e., units planned for timber harvest) within 50 meters of Suitable Habitat Reserves will be monitored and the annual and cumulative Suitable Habitat Reserve acres within 50 meters of an adjacent harvest will be presented in each annual report.

6.3.1.4 Monitor Marbled Murrelet Presence Associated with Suitable Habitat Reserves (Goal Four)

The growth and development of forest habitat and trees for murrelets is a process that occurs over a period of approximately 200 years or more and is rare on the managed forest landscape of the Plan Area where most forests are less than 100 years of age. Not all Suitable Habitat Reserves are predicted to be currently occupied by murrelets but these areas with key habitat features identified by the Habitat Suitability Model (Appendix A) are the best option for maintaining and recruiting suitable nesting habitat during the Permit Term. To evaluate and monitor marbled murrelet presence associated with a sample of Suitable Habitat Reserves, Green Diamond will deploy autonomous recording units (ARUs) or other approved detection techniques within a sample of Suitable Habitat Reserves once every ten years to collect acoustical data on presence of marbled murrelets (Appendix E). The acoustic data collected on murrelet presence will be used to: (i) evaluate murrelet use of habitat areas set aside for them (6.2.2, 6.2.5); (ii) refine the Habitat Suitability Model during re-assessment of habitat within the Plan Area (6.3.2.2); (iii) evaluate potential new suitable habitat (6.3.1.6); (iv) evaluate whether the term of the Assurance Reserve should be extended (6.3.2.4); and (v) for development and adjustment of conservation measures if Green Diamond seeks to renew and extend the term of the HCP (Section 6.4.8).

6.3.1.5 Estimate Age Classes and Mitigation Credit for Buffer Zones for Adaptive Management and Renewal (Goal Two)

As described in Section 6.2.3 (Objective 2.1), Green Diamond will establish 300-foot (91.4-meter) vegetation buffers around Occupied Reserves and occupied or presumed occupied habitat adjacent to the Plan Area (Adjacent Habitat Reserves). During the start of MMHCP implementation, the buffers contain stands in varying age classes (Table 6-2) and thus vary in habitat suitability. Although suitable nesting habitat for marbled murrelets may take more than 100 years to develop (USFWS, 1996), older stands within the Plan Area (i.e., current marginal stands or older riparian areas) or stands with a high residual tree component may approach suitable habitat or develop nesting platforms towards the end of the Permit Term. Additionally, Objective 2.2 (Section 6.2.3) describes MMHCP commitments designed to recruit marbled murrelet habitat within the buffers. Suitable habitat currently within the buffers or stands that develop into suitable habitat towards the end of the Permit Term will be available if needed for adaptive management or as mitigation upon MMHCP renewal (See 6.4.8). As described in Section 6.3.2.2, Green Diamond may elect to refine the habitat suitability model through adaptive management. The refined model will be used to reassess habitat suitability within the buffers at the end of the Permit Term to evaluate whether the term of the Assurance Reserve should be extended (Section 6.3.2.4) and to support and inform the renewal process (6.4.8).

6.3.1.6 Tracking Potential New Suitable Habitat

Green Diamond may voluntarily identify forested areas that may be managed for long-term recruitment of suitable marbled murrelet nesting habitat as long as they do not result in additional harvest restrictions on adjacent forest habitat within the Plan Area or added buffers. The forested areas managed for long-term recruitment of suitable habitat areas may include current Marginal Habitat, unsuitable areas (based on predictions from the HSM at the onset of Plan approval) adjacent to Suitable Habitat Reserves or buffers for Occupied Reserves and Adjacent Habitat Reserves, and other forested areas where Green Diamond voluntarily elects to recruit older forest habitat beneficial to marbled murrelets. Although vegetation buffers are not established around Suitable Habitat Reserves, operational constraints will result in additional acres of forested areas adjacent to Suitable Habitat Reserves that may be voluntarily retained (not an MMHCP commitment) and considered in the evaluation whether the term of the Assurance Reserve should be extended (6.3.2.4). These voluntarily retained and recruited stands may also be assessed as suitable habitat that could be useful in the development and adjustment of conservation measures if Green Diamond seeks to renew and extend the term of the MMHCP (Section 6.4.8). For example, a forested area situated between the boundary of a reserve and a riparian management zone may be inaccessible to equipment or infeasible to harvest due to operating costs and other logistical constraints. Likewise, the shapes of the reserves are dictated by existing habitat that may not result in a logical or practical management boundary, and Green Diamond may elect to avoid harvesting some areas adjacent to the reserve to create a boundary more conducive to timber harvest operations. Post-harvest retention of acres adjacent to Suitable Habitat Reserves may result in areas that could be added to Suitable Habitat Reserves at Plan renewal. The same factors and operational constraints described above could result in opportunities to modify 300-foot (91.4-meter) vegetation buffers around Occupied Reserves and Adjacent Habitat Reserves at Plan renewal. Green Diamond will monitor the post-harvest retention adjacent to the Suitable Habitat Reserves and habitat retained adjacent to the vegetation buffers of Occupied Reserves and Adjacent Habitat Reserves. New suitable habitat areas may develop for technical and economic reasons regardless of proximity to existing Suitable Habitat Reserves or Buffers. Such stands may include retention for riparian protection, unstable geology, or retention areas resulting from other species conservation plans. Within such areas, Green Diamond may elect to include Marginal Habitat acres as additional mitigation credit for use during the initial Permit Term (Section 6.3.2.3 -- the adaptive management reserve account) or as new or expanded Suitable Habitat Reserves if needed at the time of permit renewal (6.4.8).

6.3.1.7 Monitor Covered Activities When Timber Harvest Plan Units Overlap with Marginal Habitat Areas (Goal Five)

Green Diamond will monitor the location, extent, and timing of harvest in Marginal Habitat acres to ensure the proposed/predicted maximum extent of take is not exceeded and to ensure that retention of Suitable Habitat Reserves mitigates harvest of Marginal Habitat. Green Diamond will report the acres of Marginal Habitat harvested annually, and annual reports will include acres harvested during and outside of the breeding season. Prior to the end of the 49th Plan year, Green Diamond will complete a cumulative analysis of actual harvest of Marginal Habitat, and modeled take of individuals relative to predicted Marginal Habitat harvest and corresponding take over the term of the Plan that was estimated at Plan initiation. The Service and CDFW will use this cumulative retrospective analysis to determine whether the term of the Assurance Reserve (6.3.2.4)

must be extended. The Service and CDFW may also consider recruitment of new Marginal Habitat and Suitable Habitat during the Permit Term in evaluating whether the term of the Assurance Reserve must be extended (6.3.2.4).

6.3.1.8 Estimating Take from Cumulative Harvest Adjacent to Suitable Habitat and Harvest Adjacent to or within Marginal Areas

Green Diamond will monitor the location, extent, and timing of harvest adjacent to Suitable Habitat Reserves and harvest adjacent to or within Marginal Habitat Areas to ensure that the maximum extent of authorized incidental take is not exceeded. This evaluation is cumulative harvest across the Plan Area during the Permit Term, which includes the Plan Area and acquired lands from the Adjustment Area. To calculate the estimated indirect take based on harvest adjacent to Marginal Habitat or Suitable Habitat Reserves, the timber harvest units will be buffered by 50 meters (the distance based decaying linear rate for estimating indirect take described in Figure 5-6), and the 50-meter buffer will be intersected with the Marginal Habitat patches and Suitable Habitat Reserves (5.2.2.2). Annual reports will include the total annual and cumulative Suitable Habitat Reserve acres within 50 meters of adjacent harvest areas and total annual and cumulative Marginal Habitat acres within 50 meters of adjacent harvest areas. The total amount of annual and cumulative estimated take will also be presented in each annual report (Appendix E).

6.3.1.9 Monitoring Program Flexibility

The monitoring program is based on current monitoring technology and methodologies and on current understanding of the habitat conditions required by the Covered Species (i.e., large old trees with suitable nesting platforms within 50 miles of the Pacific Ocean). It is reasonable to expect that monitoring techniques and related technology will change through the fifty-year life of this Plan, and that understanding of suitable habitat, habitat structure, data collection methods, and analytical techniques will also change. Therefore, it is essential to build flexibility into the monitoring program to respond to these changes. Some monitoring approaches may be retired or replaced by more efficient and/or accurate techniques to address the same issues, and entirely new approaches may be implemented to address currently unforeseen issues. Changes to the monitoring program will be evaluated to ensure that they do not reduce the ability of the program to achieve its objectives: to evaluate the effectiveness of the conservation measures and provide feedback for adaptive management. Annual reporting and periodic reviews will provide the assessment needed to justify changes. Changes to the monitoring program will be subject to review and concurrence by the Service and the CDFW.

6.3.1.10 Non-Compliance Reporting Process (Goal Five)

When implementing take avoidance, Covered Activities allowed within the buffers and timing of activities are described in Section II, Item 32 of the submitted timber harvest plan along with take avoidance measures. Green Diamond personnel responsible for harvest plan layout and harvest operations coordinate with members of the Green Diamond Wildlife Department to ensure units are properly marked and those conducting the activities are aware and familiar with all measures. In addition to Green Diamond personnel monitoring implementation of Covered Activities, oversight is also provided by regulatory personnel with CalFire and CDFW through standard harvest plan review and implementation.

Similar to the process for take avoidance, the MMHCP coordinator will work with Green Diamond personnel responsible for harvest plan layout and harvest operations to ensure appropriate take avoidance and minimization measures (Appendix D) are applied in the written harvest plan and properly implemented. Additional oversight will also be provided by CalFire and CDFW personnel through standard harvest plan review and implementation. If a noncompliance event occurs within an Occupied Reserve, a Suitable Habitat Reserve, or within the 300-foot (91.4-meter) spatial or temporal buffers of an Occupied Reserve or Adjacent Habitat Reserve, the MMHCP coordinator will notify the Service and CDFW of the noncompliance in writing within two business days of becoming aware of the incident. Additional documentation will also be provided in the annual reports.

6.3.2 Adaptive Management

6.3.2.1 Adaptive Management Triggers

The adaptive management process addresses scientific uncertainties through monitoring of Biological Objectives to determine whether MMHCP conservation measures have intended effects. Different habitat conditions could trigger corrective action under adaptive management. If this occurs, Green Diamond will initiate an adaptive management process identifying appropriate changes in the conservation measures if they are warranted. The adaptive management process will include an assessment identifying the potential cause behind any negative monitoring result, its potential management activity relationship, and any appropriate management changes. Green Diamond will notify the Service and CDFW within 30 days after an analysis indicates a problem exists, requesting technical assistance from the Service and CDFW in determining the cause of the negative result(s). All available information will be used to make this determination, including results from other monitoring or research projects throughout the region where applicable.

A basic premise of adaptive management is that detection of unanticipated and undesirable outcomes of MMHCP implementation, such as changes in habitat conditions or status of Reserves within the Plan Area, provides better opportunity to address and consider ways to resolve these issues that are more biologically sound and cost effective. Green Diamond's findings will be reported to the Service and CDFW together with proposed actions if the conditions are found to be caused by and redressable through Green Diamond's management of the Plan Area. If the Service and CDFW agree or find that an adverse outcome of MMHCP implementation may be redressed in whole or in part by adaptive management, then the recommended adaptive management measures will be implemented by Green Diamond and debited from the adaptive management reserve account (Section 6.3.2.3) and/or the term of the Assurance Reserve is extended beyond the term of the MMHCP (6.3.2.4). The actions that will be taken are described below.

6.3.2.1.1 *Accidental Harvest within Occupied Reserves*

Green Diamond will monitor Covered Activities to ensure that harvest does not occur within the boundaries of the Occupied Reserves. Accidental harvest within an Occupied Reserve is not likely or anticipated. The Occupied Reserves are surrounded by a 300-foot vegetation buffer, and the only harvest occurring within the vegetation buffer would be associated with unevenaged management silviculture intended to recruit marbled murrelet habitat. As described in Section

6.2.3 Objective 2.2, harvest within the buffers will focus on trees lacking in structure or limb characteristics suitable for nesting by marbled murrelets, and harvest within the buffers would only occur coincident with a scheduled harvest unit adjacent to a buffer. Trees selected for harvest within these buffered areas would be marked individually by the registered professional forester or designee. Given the 300-foot vegetation buffer around Occupied Reserves and the fact that old-growth and late seral structures are not selected for harvest, accidental harvest within an Occupied Reserve is not likely or anticipated.

However, if accidental harvest occurs within an Occupied Reserve, Green Diamond will investigate the cause and propose preventative measures and consult with the Service and CDFW to determine the appropriate mitigation up to and including extending the term of the Assurance Reserve (6.3.2.4) or establishing an additional Assurance Reserve in the form of a deed covenant on a portion of the occupied stand. Other mitigation options include the retention of an equivalent or near equivalent tree within the 300-foot vegetation buffer, which would result in a new delineation of the Occupied Reserve and associated vegetation buffer. Alternatively, replacement acres could include marginal acres (as defined by the HSM developed at the start of permit implementation) at an offset of 8:1. For example, if one potential platform tree was unintentionally harvested within an Occupied Reserve, then eight trees within Marginal Habitat would be retained (reserved), and Marginal Habitat retention will be prioritized by proximity to the affected reserve. To determine the appropriate mitigation, Green Diamond and agency representatives will consider the following:

- Extent of the encroachment into the Occupied Reserve
- Biological value of harvested habitat with the following ranked highest to lowest value:
    - Potential platform tree
    - Modeled TAO (50 m or greater)
    - Security habitat (trees > 24 but < 50 m in height)
    - A tree not meeting the characteristics listed above

6.3.2.1.2 *Accidental Harvest within Buffers of Occupied Reserves or Adjacent Habitat Reserves*

Green Diamond will monitor Covered Activities to ensure that harvest within the Occupied Reserve Buffers or Adjacent Habitat Reserve Buffers complies with the provisions for habitat recruitment (Section 6.2.3) or as described in Appendix D. Accidental harvest or harvest that does not comply with the provisions of this MMHCP within the buffers is not likely or anticipated, but human error is possible over the Permit Term. Green Diamond conducts training to prevent these occurrences and implements measures throughout its processes to avoid violations of statutory rules and permit conditions. However, in the unlikely event of accidental harvest that does not comply with the provisions in this MMHCP, it will be offset by a 1:1 ratio of Marginal Habitat as defined by the HSM developed at the start of permit implementation, or other measures as agreed to between Green Diamond, the Service, and CDFW in the event that the scale/extent of the accidental harvest is significant. For example, if harvest unintentionally occurs within a buffer of an Occupied Reserve resulting in the removal of two trees (marginal or unsuitable), then two equivalent Marginal Habitat trees will be retained (reserved). Marginal Habitat retention or other unsuitable compensatory buffer habitat (other measures) will be prioritized by proximity to the reserve associated with the affected buffer.

6.3.2.1.3 *Accidental Harvest within Suitable Habitat Reserves*

Green Diamond will monitor Covered Activities to ensure that harvest does not occur within the boundaries of the Suitable Habitat Reserves. Unintentional harvest within a Suitable Habitat Reserve is not likely or anticipated. However, in the unlikely event of harvest within the boundary of a Suitable Habitat Reserve, it will be offset by a 6:1 ratio of Marginal Habitat as defined by the HSM developed at the start of permit implementation, or other measures as agreed to between Green Diamond, the Service, and CDFW if the extent of the accidental harvest is significant. For example, if harvest occurs within the boundary of a Suitable Habitat Reserve resulting in the removal of one tree, then six Marginal Habitat trees will be retained (reserved). Marginal Habitat retention or other Suitable habitat (other measures) will be prioritized by proximity to the affected reserve.

6.3.2.1.4 *Changes to Silviculture within Buffers for Occupied Reserves and Adjacent Habitat Reserves*

Green Diamond will implement silviculture treatments within the Occupied Reserve vegetation buffers and the Adjacent Habitat Reserve vegetation buffers to develop and promote late seral habitat conditions (Section 6.2.3, Objective 2.2). As described in that Objective, such treatments occur only coincident with a scheduled harvest adjacent to the buffer and are not scheduled as stand-alone operations. Changes to the silviculture treatment may be identified through MMHCP monitoring (Section 6.3.1.2) or other research conducted on or adjacent to the Plan Area such as ongoing studies by Redwood National Park. Any modification to the silviculture prescriptions within the buffers will require approval from the Service and CDFW.

6.3.2.2 Refinement of the Habitat Suitability Model

Green Diamond has designated 96 patches of Suitable Habitat Reserves encompassing approximately 946.4 acres within the Plan Area. These areas are designated as the primary form of mitigation for anticipated incidental take and will be protected and conserved for the Permit Term. These areas were identified and delineated based on the HSM and habitat patch delineation process described in Section 5 and Appendix A. A key component of suitable murrelet habitat is the presence of nesting platforms on large limbs, debris accumulations and epiphyte cover. The presence of nesting platforms is positively associated with tree and stand age because these structures often require centuries to develop along with the forest stand characteristics such as open and multi-layered forest canopies promoting use by murrelets. The current HSM uses various measures of tree heights and densities as surrogates for forest age and canopy structure that indirectly incorporates a measure of nesting platforms based on the assumption that suitable nesting platforms increase with tree and forest age and tree height, particularly in the coastal redwood zone of northern California. As remote sensing data collection technologies and data processing improves, our ability to develop habitat covariates associated with individual trees and forest canopy will also improve. It is likely that incorporation of other individual tree level habitat covariates that provide a more direct measure of platform suitability and abundance may lead to improved predictive ability from refined habitat suitability models. The goal of the refinement process is a model with improved predictive ability to reduce take and improve our ability to identify habitat with the greatest positive effects to conservation of murrelets in a working forest landscape.

Under Adaptive Management, Green Diamond will pursue refinement of a HSM for the Plan Area and Adjustment Area through acquisition of new LiDAR data and available information on habitat occupancy by marbled murrelets. If available, habitat modeling may also include nesting locations used by marbled murrelets in addition to occupied locations. The Service and CDFW will have input on the modeling process along with selection of covariates. Green Diamond will voluntarily select at least three subject matter experts to conduct a peer review of the model. Results of the peer review will be provided to the Service and CDFW. Green Diamond will implement the model reviewed by the Service and CDFW.

As timberland is acquired within the Adjustment Area, Green Diamond may elect to add these lands to the Plan Area through notice to the Service and CDFW as described in Section 6.4.7. Unless (or until) Green Diamond develops or refines the HSM, a prediction of Marginal Habitat and Suitable Reserves will be made using the HSM described in Appendix A. This information will be provided to the Service and CDFW via a notice of land transaction and in the subsequent annual report. Green Diamond will have the option of refining the HSM, and the Service and CDFW will have input on the modeling and review opportunity of the refined HSM prior to application on newly acquired lands or at permit renewal (6.4.7 and 6.4.8). After review by the Service and CDFW, Green Diamond will use the refined HSM to predict and identify Marginal Habitat and Suitable Habitat Reserves for inclusion in the Plan Area and as part of the Conservation Program for the Suitable Reserves. The use of a refined HSM will only apply to lands added to the Plan Area during the Permit Term and does not affect the initial suite of 96 areas and 946.4 acres of Suitable Habitat Reserves. The refined HSM is not intended to delineate Occupied Reserves since those areas were originally identified based on results of Pacific Seabird Group surveys and interpretation of color aerial photographs. However, the Service, CDFW and Green Diamond may agree upon use of the HSM as a tool to identify or refine boundaries of Occupied Reserves and associated buffers. Green Diamond may also use the refined HSM to identify boundaries of Adjacent Habitat Reserves and associated buffers. Green Diamond will not be required to refine the habitat model and may use the existing habitat model to identify potential habitat on or adjacent to acquired lands. In addition, if LiDAR data for habitat covariates required to implement the existing HSM (Appendix A) or to develop habitat covariates for the refined habitat model are unavailable, Green Diamond may elect to exclude these lands from the Plan Area until the data are available and habitat can be predicted from the existing or refined habitat models. Lands that are not added to the Plan Area would be treated under existing CA Forest Practice Rules for marbled murrelets with respect to timber harvest.

6.3.2.3 Adaptive Management Reserve Account and Range of Adaptive Management Change

Green Diamond will establish an Adaptive Management Reserve Account (AMRA) to cover offsets needed for noncompliance harvest (accidental harvest or harvest that is inconsistent with MMHCP provisions) within Occupied Reserves, Suitable Habitat Reserves, or vegetation buffers, and to respond to loss or substantial modification and function of Suitable Habitat Reserves due to Changed Circumstances, including circumstances changed due to climate change. As described in Section 6.3.2.1, Green Diamond will reserve acres of Marginal Habitat at specified ratios in the event that noncompliance occurs. To ensure that adequate acres of Marginal Habitat are available within the Plan Area to be used for adaptive management, Green Diamond will track on an annual basis, unharvested acres of Marginal Habitat. Based on predictions used to calculate take (5.1.2.1), approximately 2,014 acres of Marginal Habitat in the current ownership will remain unharvested

throughout the Permit Term. Although Green Diamond does not anticipate a change in the predicted amount of Marginal Habitat (other than new areas added to the Plan through acquisitions, Section 6.4.7), annual tracking and reporting will include the total amount of unharvested Marginal Habitat acres (areas unharvested and not predicted to be harvested during the Permit Term) and ensure that a minimum of 473 acres (one-half of the 946.4 acres of Suitable Habitat Reserves) are available for Adaptive Management and Changed Circumstances. The AMRA consists of Marginal Habitat stands that may be required as replacement reserves to compensate for damage to other reserves caused by Covered Activities and Changed Circumstances. The AMRA also consists of up to 20 acres of Occupied Reserves that may be used for remediation purposes through conveyance of a perpetual conservation easement at the sole discretion of Green Diamond. The use of habitat for remedial purposes from noncompliance or Changed Circumstances will be applied at the HSI ratios for the affected and replacement habitat. If a noncompliance or Changed Circumstance requires Green Diamond to replace acres, a withdrawal from the AMRA may originate from the unharvested balance of Marginal Habitat or 20 acres of Occupied Reserve within the Plan Area. Green Diamond will report a noncompliance or Changed Circumstance event to the Service and CDFW along with recommendations to remedy the situation. Upon agreement on a solution with the Service and CDFW, which may include no action, Green Diamond will document and report any changes to habitat classifications within the Plan Area or status of Reserves within the Plan Area used as remediation. For example, if 10 acres of Marginal Habitat are identified to remedy a noncompliance or a Changed Circumstance for loss or damage to an existing Suitable Habitat Reserve, Green Diamond will identify and reclassify these acres as newly designated Suitable Habitat Reserve (6.2.5, 6.4.1).

6.3.2.4 Performance Review and Mitigation Assurance Reserve

The monitoring and adaptive management commitments provided above serve Goal Five of the MMHCP (Section 6.2.6) by ensuring that Green Diamond: (i) manages its timberlands in compliance with the MMHCP; (ii) adjusts its management for accidental harvest or changed circumstance, (iii) provides the mitigation for impacts of incidental take authorized by the Permit; and (iv) refines understanding of how management of its timberlands impacts and benefits marbled murrelet habitat and marbled murrelets. To accomplish this, Green Diamond will establish an Assurance Reserve through a deed restriction for a period of 50 years, and extendable up to an additional 50 years if needed due to the condition of Green Diamond's landscape at permit expiration.

The Covered Activities include timber harvest that result in the long-term habitat reductions because of the time needed for trees to regrow and develop into suitable nesting habitat. Research shows that the old-growth characteristics needed for suitable nesting habitat can take 100 to 250 years to develop. The 50-year protection of Occupied Reserves and buffers that begins at permit issuance will offset the temporal loss of habitat that results from the time needed between timber harvest and the development of suitable murrelet nesting habitat. Green Diamond expects that unharvested forest will continue to develop, and some may become suitable murrelet nesting habitat during the Permit Term. However, if expectations are not met or other situations arise during the Permit Term, Green Diamond proposes a performance review of the ownership to evaluate the condition of the entire landscape and propose extending the deed restriction by up to another 50 years if needed to offset the temporal loss of Marginal Habitat.

Prior to the 49th anniversary of the approval of the MMHCP and issuance of the Permit, Green Diamond will also conduct a "Performance Review" of the MMHCP with the Service and CDFW to assess the cumulative impact of harvest of Marginal Habitat areas relative to the predicted extent of harvest and related incidental take authorized over the life of the Plan. This performance review will be linked to a mitigation "Assurance Reserve" established at the initiation of Plan implementation as an added assurance that the impacts of incidental take resulting from harvest of Marginal Habitat remain within the range of impact predicted by the MMHCP and whether the management of the MMHCP Plan Area is providing a net conservation benefit of suitable habitat protection, improvement, and recruitment of new marginal and suitable habitat above the baseline at Plan inception. The Assurance Reserve provides a recorded, enforceable encumbrance running with the land for the Permit Term, extendable for up to a further 50 years following the Performance Review. This incremental legal durability is not otherwise afforded to the Occupied Reserves, and it is the assurance the Reserve is intended to supply, that is, that the conservation program will continue to deliver the predicted benefit over the long period during which harvested Marginal Habitat regrows toward suitable condition. This long-term loss of marginal nesting habitat will be offset by the long-term protection of the Assurance Reserve, which is occupied, high-quality nesting habitat and a buffer that will continue to develop into habitat over the Permit Term. Timber harvest does not preclude the future development of the forest into habitat for marbled murrelets, and Green Diamond will manage the forest for regeneration after harvest (see Section 2 for a description of the Covered Activities).

6.3.2.4.1 *The Assurance Reserve*

Within sixty (60) days of Plan approval and Permit issuance, Green Diamond will establish an Assurance Reserve in the form of a deed covenant over an Occupied Reserve and its buffer that is enforceable for the term of the Permit. The Assurance Reserve deed covenant will be recorded in the real property records of Del Norte County, California. The Assurance Reserve will include the three Klamath View Ridge Occupied Reserve stands at 30.7 acres and the associated 300-foot buffer at 45.6 acres for a total area of 76.3 acres (See Appendix F, Figure F-2). The Klamath View Ridge Occupied Reserve is adjacent to occupied habitat on Redwood National Park land, Yurok Tribe land, and the Klamath River. This area is composed of three patches of habitat that are contiguous with habitat on Yurok land and Redwood National Park. The stand is 2.7 drainage miles and 1.6 air miles from the Pacific Ocean. The three patches of habitat exhibit northern and eastern exposure. The westernmost patch faces north into a side stream and appears to have the best topographic sheltering. The eastern areas face the Klamath River. The buffer area of these stands is early seral stage from prior forest management and is approximately 46 years old. The reserve is composed primarily of coast redwood and Douglas-fir along with minor components of Sitka spruce, western hemlock, and hardwoods such as red alder, big leaf maple, and tanoak. The three stands had median habitat suitability index values in the medium range (HSI = 0.34-0.57) for Occupied Reserves (Appendix A; Figure A-8) and consistent detections of occupied behavior during prior audio-visual surveys (Appendix C). Additional description of habitat in the Assurance reserve is found in Appendix F.

The Assurance Reserve will serve as a mitigation buffer for the Permit Term that may be extended for up to 50 years depending on the results of the Performance Review completed before the end of the 49th year of Permit implementation. If the Performance Review confirms that the performance of the MMHCP has: (1) fully mitigated the impacts of Marginal Habitat removal as

expected; and (2) the management of the MMHCP Plan Area is providing a net conservation benefit of suitable habitat protection and improvement and recruitment of new marginal and suitable habitat above the baseline at Plan inception, the Assurance Reserve will expire with the term of the Permit, may be extended for an additional 50 years as determined by the Service and CDFW as necessary or appropriate for purposes of the plan, or it may be extended in connection with Green Diamond's decision to seek Permit renewal (Section 6.4.8). If the Performance Review does not confirm that the Marginal Habitat removal has been fully mitigated as predicted or there are unanticipated impacts of Marginal Habitat harvest that preclude a finding of net conservation benefit from suitable habitat protection and improvement, and recruitment of new marginal and suitable habitat above the Plan baseline condition, the Service and CDFW may require that the Assurance Reserve be extended for up to 50 additional years to further mitigate the impacts of take and the slow temporal recovery of forest habitat during the initial 50-year term of the MMHCP.

6.3.2.4.2 *The Performance Review*

A Performance Review must be completed by Green Diamond before the 49th anniversary of Plan approval and Permit issuance for consideration by the Service and CDFW. This review will assess monitoring data from the MMHCP to answer three key questions that determine whether the Assurance Reserve should expire with the Permit Term or be extended for an additional 50 years as a durable and enforceable deed covenant commitment for further mitigation.

1. **Marginal Habitat Removal Compliance:**
    - Does the actual, cumulative quantity of Marginal Habitat removal through timber harvest over the MMHCP's entire term remain within the limits predicted at Plan inception, which determined the amount of incidental take authorized under the Permit?
    - **If yes:** No extension is required.
    - **If no:** The term of the Assurance Reserve should be extended for additional mitigation.
2. **Unanticipated Long-Term Impacts:**
    - Has monitoring revealed substantial, long-term impacts of Marginal Habitat removal that were not anticipated at Plan inception, and do those impacts exceed the mitigated take authorized by the Permit?
    - **If no:** No extension is required.
    - **If yes:** The term of the Assurance Reserve should be extended for additional mitigation.
3. **Net Conservation Benefit:**
    - Has management of the MMHCP Plan Area resulted in a net conservation benefit—through protection, improvement, and recruitment of suitable and Marginal Habitat—above the baseline at Plan inception, mitigating and offsetting unanticipated long-term impacts of Marginal Habitat removal?
    - **If yes:** No extension is required.
    - **If no:** The term of the Assurance Reserve should be extended for additional mitigation.

Under conservation commitments supporting Goals 1 through 5 of the MMHCP, Green Diamond is required to minimize and fully mitigate the impacts of take that are expected to occur incidental

to forest management operations (Sections 5.2.5 and 5.2.6). This is accomplished through retention and protection of occupied and suitable habitat that is relatively scarce in a managed landscape. Over the term of the MMHCP, Green Diamond predicts that the quality of Occupied Reserves and Suitable Habitat Reserves will improve and other forested habitat in vegetation buffers, such as those surrounding Occupied Reserves, will trend toward suitable habitat conditions over time throughout the Permit Area. In addition, other areas such as Riparian Management Zones and retention for Geological protections such as steep streamside slopes, will also trend toward suitable habitat conditions during the Permit Term and supplement existing suitable habitat through increasing habitat suitability index values for retained timber stands in reserved areas and adjacent buffers that improve in habitat quality over time. The improvement in quality is achieved through increases in tree height, diversity of tree heights, increases in limb size and development of nesting platforms, and increased variation of tree canopies and gaps as the forest ages. The development and improvement in quality of habitat is a slow progression that occurs over decades or centuries.

While habitat continues to develop and improve in reserve areas, buffer areas, and other retention areas, the harvest of Marginal Habitat resets forest development in the harvested areas, resulting in predicted incidental take and potential effects on marbled murrelet populations. These impacts occur within the broader context of long-term effects on murrelet nesting in protected and developing habitat across the entire Plan Area, where harvest events are dispersed across both time and space.

Meanwhile, areas of unsuitable and Marginal Habitat will progress toward suitability as the forest regenerates. Because timber is a continuously renewing resource, this process remains dynamic over time and subject to regulated forest practices and long-term commitments (Green Diamond 2007, 2018, 2019) designed to retain and recruit habitat within the working forest landscape.

The monitoring program of the MMHCP provides information on both the adverse impacts and the benefits of forest management under the MMHCP for marbled murrelets and their habitat in the Plan Area. Questions 1 and 2 ask and answer whether the adverse impacts of forest management were consistent with expectations and whether there were unexpected impacts identified through the monitoring program. Question 3 asks whether there were cumulative gains in habitat suitability through management under the MMHCP that provided net conservation benefits in excess of the predicted and any unanticipated impacts.

Question 1 is answered by Compliance Monitoring. Using a cautious approach to evaluating impacts on marbled murrelets, Green Diamond estimated that take could occur within occupied acres where timber harvest modifies habitat through the removal of 50 m and taller trees to an extent that marbled murrelets would no longer nest within the harvested area. On an annual basis, Green Diamond will monitor and record the acres of Marginal Habitat harvested such that an annual estimate of incidental take can be calculated based on predictions found in Appendix B. Green Diamond will also monitor and record the acres of Marginal Habitat and Suitable Habitat Reserves occurring within 50 m of adjacent harvest areas. This harvest results in estimates of authorized incidental take from disturbance created by Covered Activities. Green Diamond will also monitor, record, and report the acres of Marginal Habitat that are acquired and added to the Permit Area and where harvest occurs within and adjacent to these areas. Green Diamond will also monitor, record, and report the acres of Suitable Habitat Reserves that are acquired, added to the

Permit Area and where harvest occurs adjacent to these areas. As described above, this annual monitoring, tracking, and recording allows Green Diamond to report acres of timber harvest and estimates of potential incidental take according to predictions found in Appendix B. These processes and procedures allow Green Diamond to quantify, on an annual basis, acres harvested and amount of incidental take. At the end of the Permit Term, Green Diamond will have quantified the harvest of Marginal Habitat (acres existing upon Permit issuance and acres added through land transactions during the Permit Term), and the amount of harvest adjacent to Marginal Habitat and Suitable Habitat Reserves. In compliance with the permit, the acres harvested will be within the limits of authorized incidental take (Section 5.2.8).

Questions 2 and 3 are answered by Effectiveness Monitoring. Unanticipated impacts of forest management on marbled murrelets may be identified through monitoring and adaptive management commitments such as occupancy monitoring around suitable habitat reserves and refinement of the habitat suitability model. What if murrelet occupancy is not positively correlated with the protection and availability of suitable habitat reserves after considering and controlling for other factors such as ocean conditions and long-term population cycles? What if refinement of the habitat suitability model reveals that our understanding of murrelet habitat selection requires a shift in emphasis on the characteristics of stands targeted for retention and recruitment of suitable habitat? Monitoring and adaptive management may lead to insights on unanticipated impacts of forest management that come into focus after decades of Plan implementation.

Similarly, monitoring and adaptive management over decades may provide better insights and proof on the cumulative benefits of management under the MMHCP. Monitoring may confirm and provide a better understanding of the management conditions that cause development and improvement in quantity and quality of suitable habitat through protection of Occupied Reserves and Suitable Habitat Reserves, limited management of buffers on reserves, retention of selected Marginal Habitat areas, and recruitment of new Marginal Habitat that will provide a foundation for more suitable habitat recruitment in the long-term. Refinement of the habitat suitability model may also provide insights on managing for habitat characteristics that provide the greatest benefit for marbled murrelet nesting. Such refinements will allow Green Diamond to be more efficient in targeting habitat retention and development in locations that provide the most marbled murrelet productivity over the long-term.

Prior to expiration of the Permit, Green Diamond will conduct a comprehensive Performance Review of habitat conditions in the Permit Area and a review of the ratio of mitigation to incidental take and productivity loss based on actual harvest of Marginal Habitat and acres of Suitable Habitat Reserve in the Permit Area. This reassessment of habitat conditions will be based on the original HSM (Appendix A) so that comparable estimates of habitat acres and habitat suitability can be compared to adjustments from land transactions in the Permit Area rather than a refinement of the HSM. The results of the Performance Review will be presented to the Service and CDFW prior to the 49th anniversary of the Permit Term and reviewed with the agencies prior to expiration of the Permit. Green Diamond will provide an estimate of the mitigation ratio based on actual harvest and any changes to compensatory mitigation resulting from land transactions. For example, Green Diamond will calculate estimates of take and productivity loss based on timing of timber harvest, acquisition and harvest of acquired Marginal Habitat, and any additional compensatory mitigation from acquisition and protection of Suitable Habitat Reserves. These estimates will be compared to estimates in Section 5.2.8 and Appendix B. Green Diamond will also provide an estimate of

habitat development and succession based on the original HSM in areas of Marginal Habitat harvested during the Permit Term.

Within 90 days of receiving the comprehensive Performance Review prepared by Green Diamond, the Service and CDFW will meet with Green Diamond to review the results and discuss the answers to the questions provided by monitoring results, adaptive management, and Green Diamond's synthesis in the Performance Review. If the agencies are satisfied that implementation of the MMHCP has provided expected conservation benefits and fully mitigated the impacts of take during the term, the Assurance Reserve will be allowed to expire or be retained as part of an extension of the MMHCP term if sought by Green Diamond and approved by the Service and CDFW. If, after consultation with Green Diamond and CDFW, the Service determines that there were unanticipated impacts of take that were not fully mitigated, even after considering any monitoring data documenting cumulative improvement and recruitment of suitable habitat and new Marginal Habitat, then the Service may require Green Diamond to extend the term of the Assurance Reserve by execution and recordation of an amendment to the Assurance Reserve deed covenant extending its term for up to fifty (50) additional years as determined by the Service.

6.3.2.5 Conditions for Protecting Modeled Unsuitable Habitat with Confirmed Nesting

Green Diamond has estimated potential incidental take of marbled murrelets from Covered Activities in and adjacent to Marginal Habitat and Suitable Habitat Reserves (Sections 5.1 and 5.2), and mitigation to offset the potential incidental take has also been described and calculated (Section 5.2). Therefore, adaptive management measures or changes to take avoidance and minimization measures (Appendix D) are not proposed in the event nesting is confirmed in areas predicted as suitable habitat.

The probability of a pair of murrelets successfully nesting in modeled unsuitable habitat is unanticipated and would not alter the estimates of incidental take and productivity described in Section 5. Additionally, there is no direct evidence from this Plan Area region that murrelets successfully nest in a second and third growth managed forest. If Green Diamond discovers or is made aware of conclusive evidence of murrelet nesting in an area of modeled unsuitable habitat, Green Diamond in collaboration with the Service and CDFW will use available information, including LiDAR and field reviews to identify the area proximal to the evidence of nesting. The delineated nesting area would receive the same take avoidance and minimization measures applied to Suitable Habitat Reserves. Therefore, no harvest would occur within the area delineated as the nesting stand. No buffers (except as described below for temporary protection of an active nest) would be required since nesting occurred in the absence of seasonal or vegetation buffers. The conclusive evidence of nesting must be based on observation of an adult incubating an egg, a nestling, or a grounded nestling incapable of flight and not predated. If an active marbled murrelet nest is discovered during operations, operations within 0.25 mile of the nest will be suspended until after the breeding season (September 15) or until a qualified wildlife biologist has determined that the nest has failed or the young have fledged. Exceptions include road use and maintenance activities (D.2.1.1) and administrative land use activities (D.2.1.5) provided take minimization measures are implemented as described in D.2.6.

6.4 IMPLEMENTATION COMMITMENTS

This section identifies management commitments Green Diamond will adhere to, to ensure that the provisions of this MMHCP are implemented as intended. These commitments include the structure and function of an Internal Plan Compliance Team, the process by which Green Diamond will notify the Service and CDFW of its intent to implement Covered Activities that may affect Covered Species, the information to be provided to the Service and CDFW as outlined in MMHCP Sections, and the timing and purpose of scheduled field reviews of MMHCP implementation.

6.4.1 Internal Compliance Team

1. Green Diamond will designate an internal compliance team including a Plan Coordinator working in conjunction with Green Diamond's internal forestry, operations, and wildlife staff.
2. Green Diamond will staff this MMHCP Coordinator position with an academically trained and experienced wildlife biologist.
3. The MMHCP Coordinator or designee will ensure that the Occupied Reserves, Occupied Reserve Buffers, Adjacent Habitat Buffers, and Suitable Habitat Reserves are accurately mapped in Green Diamond's GIS database.
4. Green Diamond will ensure this MMHCP Coordinator or designee reviews each proposed harvest plan during its development, informs the registered professional forester preparing the harvest plan when any special restrictions and/or mitigations occur in the area (e.g., take minimization measures within buffer areas), and ensures compliance during implementation including ensuring that the reserve boundaries and buffered areas are appropriately flagged/marked on the ground and/or in the instructions to Operations (i.e., the harvest plan engineering report and other materials provided to the Contract Administrator or Licensed Timber Operator). Green Diamond will ensure the registered professional forester completes a pre-harvest checklist during harvest plan development covering all necessary compliance elements. Green Diamond will ensure that all Covered Activities, Section 2, (e.g., continuous operations, salvage logging, burning, blasting, roadside clearing, watercourse crossing replacement, road widening activities) are reviewed by the internal compliance team prior to initiating those activities.
5. The Plan Coordinator or compliance team members will prepare and maintain documentation indicating Plan compliance for internal use for every harvest plan within the Plan Area. Green Diamond maintains and updates an integrated Timberland Management Information System (TMIS) serving as an inventory tool for MMHCP implementation and compliance. The Service and CDFW may request to review internal compliance documents with notification and justification to the Plan Coordinator. The Plan Coordinator will provide access to the requested documents within 5 days or as agreed to with the Service and CDFW. This commitment is not intended to require Green Diamond to assemble and send information to the Service and CDFW or provide an additional standard of required information for regular or typical harvest plan review.
6. Following state harvest plan review and approval, Green Diamond's registered professional forester will implement the harvest plan as written, prepare a harvest plan post-harvest completion form documenting harvest plan compliance with MMHCP

provisions and submit this form to this MMHCP Coordinator. Green Diamond's MMHCP Coordinator will review the form to ensure compliance.

7. Green Diamond shall budget and expend such funds necessary to fulfill its obligations under this MMHCP's Operating Conservation Program. Green Diamond shall promptly notify the Service and CDFW of any material change in their financial ability to fulfill its obligations.

The following is an example of the procedures Green Diamond and the Internal Compliance Team will follow to ensure harvest plan compliance with the measures described in this MMHCP. During initial layout, the registered professional forester or designee reviews Green Diamond's existing databases and spatial information to determine potential restrictions. The registered professional forester or designee submits a formal Request for Resource Information to the Plan Coordinator or designee who then reviews the proposed harvest plan and associated Covered Activities to identify any special restrictions and/or mitigations that occur in the area (e.g., take minimization measures within buffer areas). The Plan Coordinator or designee ensures that the registered professional forester accurately incorporates any restrictions/mitigations in the written harvest plan and associated documents/materials that are provided to Operations. Prior to initiation of harvesting and associated operations, the Contract Administrator or designee confirms with the Plan Coordinator or designee that the timber harvest unit(s) and associated area are cleared for operations (i.e., any required surveys have been completed, any required restrictions/mitigations have been identified in the harvest plan and associated materials, and restrictions such as buffer or reserve boundaries have been accurately marked by the registered professional forester or designee). In collaboration with the registered professional forester, the Contract Administrator overseeing operations ensures compliance with the instructions in the harvest plan and associated materials. Following harvest completion, the registered professional forester or designee prepares a post-harvest completion form documenting MMHCP compliance that is reviewed by the Plan Coordinator or designee. Additional review is conducted annually by the Plan Coordinator or designee once harvest unit depletion information (aerial photos or other remote sensing data) are available to ensure operations were in compliance with the restrictions/mitigations required in the MMHCP. Additional review is also conducted by CalFire and CDFW throughout the harvest plan review and implementation process.

6.4.2 Harvest Plan Notice of Filing

When submitting any proposed harvest plans within the Plan Area to CalFire, Green Diamond will provide an informational copy of the harvest plan filing notice and a harvest plan area map to the Service and CDFW. The harvest plan filing notice and its cover letter will be modified from those currently provided to the Service to include specific information relevant to Covered Species under this MMHCP, similar to the information already provided for species covered under the FHCP (Green Diamond, 2019). The harvest plan filing notice will function as the notification to the Service and CDFW regarding anticipated or potential take of marbled murrelets, and implementation of MMHCP conservation measures intended to reduce the level and effects of anticipated take. This same notification process will be implemented for Covered Activities that have the potential for take of marbled murrelets but that do not require a timber harvest plan permit such as exemptions. During the first year of implementation, Green Diamond will coordinate with the Service and CDFW regarding specific changes to Green Diamond's harvest plan filing notice

format. Green Diamond will provide the following information to the Service and CDFW for THPs as those projects relate to the MMHCP:

1. A copy of the harvest plan Official Notice of Filing
2. A copy of the harvest plan map(s)
3. Presence/absence of Occupied Reserves or Adjacent Habitat Reserves within 300 feet (91.4m) of the harvest plan and a map depicting these areas when present. If treatment within the vegetation buffer is planned as described in Section 6.2.3 Objective 2.2, then the filing notice will include additional information including buffer age class, acres proposed for treatment, and final disposition of trees removed (commercial/onsite). As described in Section 6.2.3 Objective 2.2, field review will be conducted by the Service and CDFW prior to treatment (and likely prior to plan submittal to Calfire) to evaluate the proposed treatment.
4. Presence/absence of Suitable Habitat Reserves within 164 feet (50 m) of the harvest plan and a map depicting these areas when present
5. Presence/absence of Marginal Habitat within 164 feet (50 m) of the harvest plan and a map depicting these areas when present

Maps will not be provided with the Notice of Filing when any of items 3 through 5 do not occur within specified distances of the harvest plan.

6.4.3 Annual Reports

Green Diamond will prepare and submit an annual report to the Service and CDFW by March 31 following the first full year after this MMHCP's effective date and every year thereafter during this MMHCP term. These reports will summarize Operating Conservation Program compliance, results of the Effectiveness Monitoring Measures (Section 6.3.1) and any scheduled field reviews (Section 6.4.4) conducted in the prior year. Each annual report shall also disclose necessary Green Diamond expenditures for implementing this MMHCP's Operating Conservation Program during the prior calendar year and Green Diamond's current-year budget for implementing the Operating Conservation Program.

The annual report will provide a summary discussion of progress of implementation of management commitments. The summary discussion may be organized by general commitment group, as follows:

The following is an example of anticipated annual report content:

- Introduction
- Habitat Commitments
    - Marginal Habitat Areas
        - Summary of marginal acres harvested and cumulative running total for harvest within and outside of the breeding season.
    - Suitable Habitat Reserves
        - Summary of acres harvested within 50 m of Suitable Habitat Reserves and cumulative running total for harvest within and outside of the breeding season.
    - Buffers for Occupied Reserves and Adjacent Habitat Reserves

        - Estimate of age class and mitigation credit
        - Summary of Occupied Reserve buffer and Adjacent Habitat Reserve buffer acres harvested (as a result of adjacent commercial harvest) annually and cumulative total.
        - Summary of Precommercial Thinning within Occupied Reserve buffer and Adjacent Habitat Reserve buffer including acres treated annually.
        - Habitat recruitment sampling summary and comparison
    - Potential New Suitable Habitat Reserves
        - Summary of marginal or unsuitable forest areas adjacent to Suitable Habitat Reserves or Buffers (Occupied Reserves and Adjacent Habitat Reserves) voluntarily retained and with the potential to expand the Suitable Habitat Reserves or Buffers (Occupied Reserves and Adjacent Habitat Reserves) at renewal.
        - Summary of areas proposed for future mitigation credit (marginal acres voluntarily retained adjacent to Suitable Habitat Reserves or Buffers (Occupied Reserves and Adjacent Habitat Reserves)
- Estimates of take from cumulative harvest adjacent to Suitable Habitat Reserves and harvest adjacent to or within marginal acres.
- Land transactions and Plan Area adjustments
    - Tabular and spatial data including acreage and location of Suitable Habitat Reserves, Occupied Reserves and Buffers, and presence of Adjacent Habitat Reserve Buffers if present.
- Expenditures and Budget
- Literature Cited
- Adaptive Management Commitments
    - Non-compliance reporting
    - Reserve Account (monitor unharvested Marginal Habitat acres)
    - Habitat Suitability Model refinement
    - Silviculture changes within buffers for Occupied Reserves or Adjacent Habitat Reserves
- Changed Circumstances

The annual report will include a summary of any adaptive management measures in development or being implemented during the prior year. The annual report will include an evaluation of the effectiveness of each implemented adaptive management measure, to ensure that its implementation effectively addresses the biological purposes for its adoption.

6.4.4 Scheduled Reviews

For the first 5 years of this MMHCP, Green Diamond will schedule annual meetings with the Service and CDFW. In the second and fourth years, annual meetings may precede a field review of implemented conservation measures allowing their technical evaluation. In the event Service and CDFW determines from a field review that conservation measure implementation is not in accordance with this Operating Conservation Program, Green Diamond will develop recommendations with the Service and CDFW regarding implementation and may schedule

additional field reviews or annual meetings. Green Diamond will schedule additional meetings and field reviews upon notification and request from the Service and CDFW.

6.4.5 Assurance of Funding

Green Diamond warrants that it has, and shall expend, such funds as may be necessary to fulfill its obligations under the Operating Conservation Program. In each Annual Report to the Service and CDFW, Green Diamond will provide a summary of expenditures for implementing this MMHCP's Operating Conservation Program during the prior calendar year and Green Diamond's current-year budget for implementing the Operating Conservation Program. Green Diamond shall promptly notify the Service and CDFW, in writing, of any material change in Green Diamond's financial ability to fulfill its obligations. Upon notification of material changes that restrict Green Diamond's ability to fulfill its obligations, the Service may suspend the Permit until such obligations can be met. The Service shall respond to Green Diamond within 90 days of receipt of the Green Diamond notification. Green Diamond also warrants that it has and shall provide for acres and habitat to fulfill its obligations under Adaptive Management section 6.3.2.3 to cover offsets needed for noncompliance harvest (unintentional harvest or harvest that is inconsistent with MMHCP provisions) within Occupied Reserves, Suitable Habitat Reserves, or vegetation buffers, and to respond to loss or substantial modification and function of Suitable Habitat Reserves due to Changed Circumstances. To meet this commitment, Green Diamond has set aside 20 acres of Occupied Reserves and 473 acres of Marginal Habitat to address changed circumstances (Section 6.3.2.3).

In the event that CDFW grants to Green Diamond a consistency determination under California law for this MMHCP and requires financial assurances under California law, Green Diamond may provide additional security for the performance of this MMHCP in the form of a letter of credit or bond benefitting CDFW. During the first five years of the Term of the MMHCP, the principal sum of the letter of credit or bond shall be equivalent to the estimated budget for implementation of the MMHCP. At the end of the first five years of the Term of the MMHCP and for each five-year interval of the term thereafter, Green Diamond shall adjust the principal sum of the letter of credit or bond to be equivalent to the average of the MMHCP implementation budget reported to the Service and CDFW in the preceding annual reports.

The staffing requirements and responsibilities for implementation of this MMHCP are outlined in section 6.4.1 through 6.4.4. The costs of implementation, monitoring, and reporting are primarily associated with staffing of the Plan Coordinator position and designee (Senior Wildlife Biologist and Wildlife Biologist level II or III), Geospatial Analyst for analysis of timber harvest and timberland exchanges, and episodic requirements of the Forestry Department carrying out MMHCP implementation requirements for harvest adjacent to Reserve Areas. Green Diamond has identified the following approximate annualized expenditures for implementing the MMHCP. The annualized expenditures were estimated over a ten-year period accounting for inflation at 3% and peaks in expenditures that occur during monitoring years from increased Payroll, Supplies, and Consulting Services.

Annualized Expenditures

Item	Dollar amount
Payroll (wages and benefits)	$20,000.00
Supplies, Fuel, Repairs, Parts, Maintenance, Equipment	$5,700.00
Consulting services (statistician)	$1,200.00
Total Annualized Cost	$26,900.00

6.4.6 Permit Amendments

Green Diamond or the Service may propose administrative changes to this MMHCP and Permit ("Minor Modifications") by providing written notice to the other Party. Such notice shall include a statement of the reason for the proposed modification and an analysis of its environmental effects, including its effects on operations under this MMHCP and on the Covered Species. The Parties shall use reasonable efforts to respond to proposed modifications within 60 days of receipt of such notice. Proposed Minor Modifications shall become effective, and this MMHCP shall be deemed modified accordingly, immediately upon the other Party's written approval. Among other reasons, a receiving Party may object to a proposed Minor Modification based on a reasonable belief that such modification would result in operations, burdens or obligations under this MMHCP that are significantly different from those analyzed in connection with the original MMHCP; adverse effects on the environment that are new or significantly different from those analyzed in connection with the original MMHCP; or additional take not analyzed in connection with the original MMHCP approval. An objecting Party shall provide the other Party with written notice of the objection that includes a statement of the reason for the objection. If a Party objects, the proposal is not approved as a Minor Modification but may be processed as a Major Amendment of this MMHCP and Permit.

Examples of Minor Modifications to this MMHCP and Permit processed pursuant to this subparagraph may include, but are not limited to, the following:

- Corrections of typographic, grammatical, and similar editing errors that do not change the intended meaning
- Correction of any maps or exhibits to correct errors in mapping or to reflect previously approved changes in the MMHCP
- Minor changes to survey, monitoring or reporting protocols
- Clarifications to vague or undefined language or phrases
- Changes to operational prescriptions pursuant to, and within the foreseen range of changes resulting from adaptive management
- Extension of the duration of the term of the Assurance Reserve and/or additions of timberlands within the Plan Area to the Assurance Reserve
- Provision of additional financial assurances in connection with a consistency determination by the State of California
- Establishment, amendment, release, or substitution of deed restrictions over Suitable Habitat Reserves under Objective 4.2, including in connection with a consistency determination by the State of California
- Any other modifications to this MMHCP that are consistent with the biological goals and objectives described in this MMHCP that will not result in operations under this MMHCP

that are significantly different from those analyzed in connection with this MMHCP as approved, adverse impacts on the environment that are new or significantly different from those analyzed in connection with this MMHCP as approved, or Take of Covered Species not analyzed in connection with this MMHCP as approved, including but not limited to the approval or execution of agreements to facilitate execution and implement of this MMHCP, or actions by Green Diamond to delegate (while retaining full responsibility for compliance with) any of its duties under this MMHCP to a third party under its direct control.

- Green Diamond and the Service each shall maintain a file of Minor Modifications to this MMHCP that have been approved by all Parties and Green Diamond shall attach such Minor Modifications to each annual report covering the calendar year in which it is approved.

Additions to and removals from the Plan Area through land ownership adjustments are also minor modifications to the MMHCP when completed in compliance with the requirements of Section 6.4.7 of the MMHCP, which provides specific procedures and conditions for acquisitions and removal of timberlands from the Plan Area. Adjustments may be made in response to sales or acquisitions of timber lands within the identified Adjustment Area. Lands will be evaluated for Marginal Habitat, Suitable Habitat Reserves, and Occupied Reserves to determine whether changes fit within the scope of analysis of this HCP and permitting documents.

Any modifications to this MMHCP and Permit other than approved Minor Modifications shall be processed as an Amendment of the Permit and this MMHCP. Amendments must be approved in accordance with all applicable requirements of federal law, including but not limited to, the ESA, NEPA, and applicable implementing regulations in force at the time of the proposed Amendment. The Party proposing the amendment shall provide a statement of the reasons for the amendment and an analysis of its environmental effects, including its effects on operations under this MMHCP and on the Covered Species.

6.4.7 Land and Permit Area Adjustments

Green Diamond may acquire or sell lands throughout the Permit Term subject to the requirements of this section. This section describes the process of adding or removing lands from the Plan Area and Permit Area. The Plan Area is Green Diamond's ownership at the time of MMHCP development in Del Norte and Humboldt Counties, as well as the Adjustment Area where Green Diamond may purchase lands during the Permit Term. The Permit Area are those lands designated in the Permit where Green Diamond will have incidental take authorization for Covered Activities and will implement the conservation strategy. Green Diamond may acquire any lands and choose not to add them to the Plan and Permit Area; however, in this case, Green Diamond would be required to operate in a no take strategy for those new lands.

Nothing in this MMHCP limits Green Diamond's ability to purchase or sell property. This section describes the process to add new lands to or remove lands from the MMHCP, Plan Area, and Permit Area. Green Diamond may purchase new lands throughout the Permit Term and the MMHCP and associated permitting documents (i.e., NEPA and BO) include the Adjustment Area and Plan Area within the scope of analysis in anticipation of future acquisitions. Green Diamond anticipates that Covered Activities would not be implemented immediately on newly purchased lands and anticipates there will be sufficient time to add these lands to the Plan and Permit Area.

The Service cannot issue incidental take for lands that Green Diamond does not own or manage at the time of permit issuance according to the requirements of Section 10(a)(2)(B)(v). To address this concern, Green Diamond has established the Adjustment Area to analyze the area in which acquisitions are likely to occur.

Green Diamond has identified lands within the Adjustment Area that are like the Plan Area and may be added under the minor modification (administrative change) process. As demonstrated in sections 3, 4 and 5 of the MMHCP, the commercial timberlands in the Adjustment Area are similar to Green Diamond's current ownership. The impacts of incidental take and the benefits of the conservation strategy in the Adjustment Area are also expected to be the same as for the Plan Area.

6.4.7.1 Land Additions

The first step required of Green Diamond in adding timberland to the Plan Area is to provide a summary and habitat analysis of a land transaction to the Service and CDFW. If Green Diamond elects to add lands or perpetual harvest rights from the Adjustment Area to the Plan and Permit Area, it must provide written notice and the summary habitat analysis to the Service and CDFW prior to enrolling the land in the Plan Area. Green Diamond will use existing LiDAR data to conduct a habitat analysis on acquired lands using the HSM (Appendix A) to identify and delineate areas of potential habitat. When adding lands to the Plan Area, Green Diamond will provide a written description and mapped location of Occupied Reserves and Buffers, Adjacent Habitat Buffers and Suitable Habitat Reserves and only a written description of Marginal Habitat and Unsuitable areas. The written description will include information such as major vegetation types, acreage, approximate stand age, and any information available regarding the known status of murrelet occupancy and survey history for the area. If appropriate, Green Diamond will also include information on other species or resources present in the new lands. The purpose of a written description and map location for Occupied Reserves and Buffers and Suitable Habitat Reserves is that once included in the Plan Area, these areas are protected from timber harvest according to the objectives supporting Biological Goals One and Four. Marginal and unsuitable areas are unrestricted from timber harvest, and a written description and disclosure of acreage provides the Service and CDFW an accounting of harvestable acres within the Plan Area.

Green Diamond will apply the following process when acquiring timberlands with potential habitat. Prior to refinement of the HSM (Section 6.3.2.2), Green Diamond will apply the existing HSM and patch delineation process as described in Appendix A using available LiDAR data. This process will result in an accounting of Marginal and Suitable Habitat patches and these areas will be added to Green Diamond's GIS. The delineated Marginal Habitat patches will be available for timber harvest, and the Suitable Habitat patches will become interim Suitable Habitat Reserves. An interim Suitable Habitat Reserve will function as a Suitable Habitat Reserve unless (or until) Green Diamond elects to evaluate the status of the area under Adaptive Management and a refined HSM (Section 6.3.2.2). The original 96 areas of Suitable Habitat Reserve totaling 946.4 acres will not be available for harvest based on a refined HSM under Adaptive Management and are protected during the Permit Term. Green Diamond will provide a reporting of potential habitat in new acquisitions through the notification process (Section 6.4.2) and the results of the modeling in an annual report for the calendar year following the closing date for the acquisition. Through this process, Green Diamond will evaluate consistency of Plan Area adjustments over time with potential changes in anticipated incidental take analyzed and authorized under the Take Permit.

When Green Diamond acquires lands with forested habitat occupied by murrelets based on evidence from audio-visual surveys (Evans Mack 2003, Pacific Seabird Group 2024) or other confirmed evidence of nesting such as presence of nest cups from tree climbing, confirmed egg shell fragments followed by tree climbing, or observation of a "grounded nestling", the area will be adopted as an Occupied Reserve under Biological Objective 1.1 based on previously defined boundaries or an agreed upon boundary after consultation with the Service and CDFW. Given past land management activities within the EPA, many occupied habitat areas are known given the process of timber harvest plan review by CalFire and the responsibility of registered professional foresters to analyze impacts to biological resources. When these areas are added to the Plan Area through a land acquisition, the boundary and buffer for the occupied habitat will be added to Green Diamond's GIS database as described in Objectives 1.1 and Objective 2.1.

When Green Diamond acquires lands and designates an Occupied Reserve, a 300-foot (91.4-meter) vegetation buffer will be established around the newly designated Occupied Reserve. The vegetation buffer area for the newly designated Occupied Reserve will be added to the Occupied Reserve buffers layer maintained in Green Diamond's GIS. When Green Diamond acquires lands with adjacent occupied or presumed occupied habitat, a 300-foot (91.4-meter) vegetation buffer will be established around the Adjacent Habitat Reserve. The buffer area(s) for the newly designated Reserves will be added to Green Diamond's GIS. Buffers for Reserves are eligible for forest management according to Objective 2.2.

The Service and CDFW will respond to the requested addition within sixty days of receipt of the submission described herein either adding the new lands to the Permit, requesting additional information, or objecting to the addition. The Service or CDFW may object to a Green Diamond election by providing a written statement with specific reasons why the Service or CDFW believes the habitat analysis and identification of reserves and vegetation buffers is incorrect. In that case, the Service, CDFW and Green Diamond shall confer in good faith and pursue the dispute resolution mechanisms set forth in the MMHCP in an effort to reach an agreement. Until concurrence is reached, such lands will not become part of the Plan Area except pursuant to the Major Amendment process set forth in Section 6.4.6. The Take Permit and MMHCP shall be effective for Covered Activities on all lands that meet the definition of Plan Area upon their inclusion as a minor amendment pursuant to this section or a Major Amendment under Section 6.4.6.

6.4.7.2 Land Removals

Green Diamond may also remove property from the Plan Area under the minor amendment process with notification to the Service and CDFW. If the property to be removed from the Plan Area includes any Occupied Reserves and Buffers, Adjacent Habitat Buffers, or Suitable Habitat Reserves, the notice of removal must be supported by documentation that the property will be either: (i) managed by the new owner subject to assumption of the MMHCP obligations in a new incidental take permit held by the transferee (which is subject to the discretion and approval of the Service under regulations and criteria for assignment of a habitat conservation plan); or (ii) granted to the new owner subject to enforceable written covenants of record that apply the MMHCP restrictions to Occupied Reserves and Buffers, Adjacent Habitat Buffers, and Suitable Habitat Reserves on lands that are sold. Upon such notification with documentation in compliance with

the MMHCP, the Plan Area will automatically be reduced by sales, transfers, and conveyances of timberland to a third party.

If the lands being sold include only unsuitable habitat, Green Diamond shall notify the Service and CDFW of any transfer to a third party of ownership of real property or harvesting rights located within the Plan Area within sixty (60) days following such transfer. Such notice shall describe the affected real property with particularity, identify the name and address of the transferee, and include a detailed map showing the location of the transferred real property or harvesting rights. If the disposed land includes Marginal Habitat with or without unsuitable habitat, then Green Diamond will also report the number of acres of Marginal Habitat removed from ownership. The number of marginal acres in the Permit Area in the notification will not include an accounting of ongoing timber harvest concurrent with the active reporting period. A revised shapefile of the Plan and Permit Area will be provided in the next annual report. The removal of unsuitable and Marginal Habitat from the Plan Area through a sale or transfer is accomplished by notification to the Service or CDFW within sixty (60) days following such transfer because these areas do not carry any mitigation requirements or measures for no net loss of nesting habitat under this MMHCP.

When removing Reserves or buffers from the Plan Area, Green Diamond will also provide a notification and summary analysis to the Service and CDFW at least 60 days prior to a potential sale or conveyance of Reserves and buffers to a third party. Within sixty (60) days following the sale and conveyance of the property to a third party, Green Diamond will provide a written description and mapped location of the property removed from the Plan Area and any Occupied Reserves and vegetation buffers, Adjacent Habitat Reserve vegetation buffers, and Suitable Habitat Reserves. The written description will include information such as major vegetation types, acreage, approximate stand age, and any information available regarding the known status of murrelet occupancy and survey history for the area.

The MMHCP includes measures to ensure that there is no net loss in suitable habitat for murrelet nesting. To this end, the MMHCP protects and preserves Occupied Reserves and vegetation buffers, then it protects the Suitable Habitat Reserves as the best areas for development and maturation of suitable murrelet nesting habitat during the MMCHP term. The Occupied Reserves and vegetation buffers, the Adjacent Habitat Reserve vegetation buffers, and the Suitable Habitat Reserves established on day one of the MMHCP provide the baseline for no net loss of marbled murrelet nesting habitat and conservation additionality in the Plan Area. To maintain the baseline with no net loss of marbled murrelet habitat, Green Diamond may freely sell and convey portions of the Plan Area to third parties provided that: (i) any Occupied Reserves and vegetation buffers, Adjacent Habitat Reserve vegetation buffers, or Suitable Habitat Reserves removed from the Plan Area will remain subject to deed covenants (enforceable by Green Diamond or the Service and CDFW) that prevent the harvest or disturbance of Occupied Reserves and vegetation buffers, Adjacent Habitat Reserve vegetation buffers, or Suitable Habitat Reserves during the term of the MMHCP; or (ii) portions of the Plan Area are transferred to a nonfederal entity that, prior to completion of the land transaction, has agreed to be bound by the MMHCP as it applies to the transferred land and the transferee has obtained an Take Permit for the Covered Species subject to the regulations and discretion of the Service for permit assignment and assumption.

6.4.8 Permit Renewal

Green Diamond may renew and extend the term of the MMHCP if, 30 days prior to permit expiration, it provides the Service with a re-assessment of suitable habitat in the Plan Area and revised estimates of the mitigation ratio including incidental take, comparative population benefits, and the impacts of taking on the population demonstrating that management under the MMHCP under an extended term continues to minimize and mitigate take to the maximum extent practicable. In addition, to renew and extend, Green Diamond must implement the MMHCP in compliance with federal law and remain eligible to hold permits issued by the Service.

6.4.9 Enforcement and Dispute Resolution

Except as set forth below, Green Diamond and the Service each shall have all remedies otherwise available to enforce the terms of this MMHCP, Take Permit, and the Operating Conservation Program.

The Parties acknowledge that the Covered Species is unique and that its loss as a species would result in irreparable damage to the environment, and that therefore injunctive and temporary relief may be appropriate to ensure compliance with the terms of this MMHCP.

No Party shall be liable in compensable damages to any other Party for any breach of this MMHCP or Take Permit, any performance or failure to perform a mandatory or discretionary obligation imposed by this MMHCP or any other cause of action arising from this MMHCP and Take Permit.

Without limiting the applicability of rights granted to the public pursuant to the ESA or other federal law, this MMHCP shall not create any right or interest in the public, or any member thereof, as a third-party beneficiary hereof, nor shall it authorize anyone to maintain a suit for personal injuries or damages pursuant to the provisions of this MMHCP. The duties, obligations, and responsibilities of Green Diamond and the Service with respect to third parties shall remain as imposed under existing law.

Nothing contained in this MMHCP is intended to limit the authority of the United States government to seek civil or criminal penalties or otherwise fulfill its enforcement responsibilities under the ESA or other applicable law.

The Parties recognize that good faith disputes concerning implementation of, or compliance with, or suspension, revocation or termination of this MMHCP or the Take Permit may arise from time to time. The Parties agree to work together in good faith to resolve such disputes, using the dispute resolution procedures set forth herein below or such other procedures upon which the Parties may later agree. However, if at any time any Party determines that circumstances so warrant, it may seek any available remedy without waiting to complete dispute resolution. Unless the Parties agree upon another dispute resolution process, or unless an aggrieved Party has initiated administrative proceedings or suit in federal court as provided herein, the Parties may use the following process to attempt to resolve disputes:

- Where the dispute is regarding a Party's compliance with the Permit or the Operating Conservation Program, the aggrieved Party shall notify the other Party of the provision that may have been violated, the basis for contending that a violation has occurred, and the

remedies it proposes to correct the alleged violation. Where the dispute is over the proper implementation of the Permit or the Operating Conservation Program, the aggrieved Party shall notify the other Party of the provision over which the issue arises, the basis for contending that implementation is not proper and the changes it proposes to resolve the dispute.

- The Party receiving the notice provided in (a) shall have 30 days, or such other time as may be agreed, to respond. During this time it may seek clarification of the information provided in the initial notice. The aggrieved Party shall use its best efforts to provide any information then available to it that may be responsive to such inquiries.
- Within 30 days after such response was provided or was due, representatives of the Parties having authority to resolve the dispute shall meet and negotiate in good faith toward a solution satisfactory to all Parties, or shall establish a specific process and timetable to seek such a solution.
- If any issues are not resolved through such a process, the Parties shall consider non-binding mediation and other alternative dispute resolution processes and, if a dispute resolution process is agreed upon, shall make good faith efforts to resolve all remaining issues through that process.

6.4.9.1 Conditions for Take Permit Suspension or Relinquishment

The Service may suspend or revoke the Take Permit for cause in accordance with the laws and regulations in force at the time of such suspension or revocation. Such suspension or revocation may apply to the Take Permit in whole or in part, and may apply only to specified Covered Species, portions of the Plan Area, or certain Covered Activities.

Green Diamond may relinquish the Take Permit before expiration of the full term of the Take Permit in accordance with the regulations in force on the date of such relinquishment and this implementation commitment. The applicable regulations are currently codified at 50 CFR §§ 13.26 and 17.32(b)(8). Unless later modification of these regulations dictates otherwise, to relinquish the Take Permit, Green Diamond shall, within 30 calendar days of discontinuing incidental take and the exercise of other rights granted by the Take Permit, return the Take Permit to the issuing office together with a written statement surrendering the Take Permit for cancellation. Relinquishment of the Take Permit will result in termination of this MMHCP except that Green Diamond shall carry out the following measures for the duration of the original Take Permit Term:

- When conducting timber operations and related land management activities within the Plan Area (as it exists as of the relinquishment date), prevent and avoid take of animals that are of a species listed as threatened or endangered under the ESA.
- Using this MMHCP approved by the Service, implement the timing and/or buffer restrictions set forth in this MMHCP protocol to ensure that potential nesting murrelets in Occupied Reserves are not displaced or otherwise subject to take through those activities.
- Maintain in effect, in accordance with their recorded terms, any deed restrictions established over Suitable Habitat Reserves under Objective 4.2, which shall not be released, amended, or terminated by reason of the relinquishment.

As designed and as analyzed in this MMHCP, the measures provided in MMHCP Section 5, Section 6, and Appendix D are intended to result in Green Diamond having fully and continuously

fulfilled its obligations under the Take Permit such that no additional post-relinquishment mitigation is required. Upon any relinquishment of the Take Permit, Green Diamond will be deemed to have fully and completely satisfied its obligations under the Take Permit, including those to minimize and mitigate the impacts of take that may occur incidental to the Covered Activities on the Covered Species within the Plan Area before or as those impacts arise. The foregoing does not release, amend, or terminate any deed restriction recorded under Objective 4.2, which remains enforceable in accordance with its recorded terms notwithstanding relinquishment of the Take Permit and termination of this MMHCP. After Green Diamond relinquishes the Take Permit, it shall be deemed cancelled. Upon surrender of the Take Permit, no further take shall be authorized under the terms of the Take Permit.

6.4.10 Wildlife Agencies Review for Approval and Plan Implementation

As provided throughout the Conservation Program described in this Section 6, there are commitments with provisions where Green Diamond is required to respond to information requests, provide reports, review analysis, collaborate, and seek concurrence in cooperation with the Service and CDFW. In all such instances where Green Diamond is required to provide information and reports, engage in analysis and review, or seek concurrence or technical assistance, Green Diamond shall respond to requests from, direct reports to, engage in review with, and seek concurrence from the Field Supervisor or Deputy Field Supervisor of the Arcata Fish and Wildlife Office and, for measures or impacts concerning Covered Species subject to a CDFW consistency determination, the Regional Manager for the CDFW Northern Region. As described in this MMHCP, required communications may be included in required annual reports or in separate reports submitted by Green Diamond.

6.5 MEASURES FOR CHANGED AND UNFORESEEN CIRCUMSTANCES IN THE PLAN AREA

6.5.1 "Changed Circumstances"

"Changed Circumstances" means "changes in circumstances affecting a species or geographic area covered by a conservation plan or agreement that can reasonably be anticipated by plan or agreement developers and the Service and that can be planned for (e.g., the listing of new species, or a fire or other natural catastrophic event in areas prone to such events)." 50 CFR § 17.3. Changed circumstances are not unforeseen circumstances.

Changes that will constitute changed circumstances under this Plan are described in this Section 6.5 together with the specific conservation and mitigation measures that Green Diamond agrees to implement in response to such changed circumstances. Green Diamond shall give notice to the Service and CDFW within 7 days after learning that any of the changed circumstances has occurred. As soon as practicable thereafter, but no later than 30 days after learning of the changed circumstances, Green Diamond shall modify its activities in the manner described herein to the extent necessary to mitigate the effects of the changed circumstances on Covered Species and shall report its actions to the Service and CDFW within 15 days after initiating such modifications. Green Diamond shall make such modifications without awaiting notice from the Service and CDFW. If the Service determines that changed circumstances have occurred and that Green Diamond has not responded in accordance with this MMHCP, the Service shall so notify Green

Diamond and shall direct Green Diamond to make the required changes. Within 30 days after receiving such notice, Green Diamond shall make the required changes and report to the Service and CDFW on its actions. Such changes are provided for in this MMHCP, and hence do not require amendment of this MMHCP and Take Permit. If additional conservation and mitigation measures beyond those provided for in this MMHCP are deemed necessary by the Service to respond to changed circumstances, the Service may not require any such additional conservation and mitigation measures without Green Diamond's consent, provided that Green Diamond is implementing this MMHCP.

This MMHCP includes the following seven potential changed circumstances as defined in applicable federal regulations and policies:

- A fire severely damages or destroys a protected Occupied Reserve and its buffer or a Suitable Habitat Reserve.
- A windstorm severely damages or destroys a protected Occupied Reserve and its buffer or a Suitable Habitat Reserve.
- A geological event such as an earthquake or deep-seated landslide severely damages or destroys a protected Occupied Reserve and its buffer or a Suitable Habitat Reserve.
- A forest pathogen severely damages or destroys a protected Occupied Reserve and its buffer or a Suitable Habitat Reserve.
- Disease afflicting the Covered Species
- Climate change/ocean conditions affecting the Covered Species
- Lapse of state or federal permits (e.g., AHCP, Forest HCP, Marten SHA) that establish and perpetuate mature forest stand retention on a trajectory to develop and recruit suitable marbled murrelet nesting habitat beyond the term of the HCP.

6.5.2 Severe Damage to or Destruction of Occupied Reserves or Suitable Habitat Reserves

There are four categories of natural events that could cause severe damage to or destruction of the Occupied Reserves and vegetation buffers or Suitable Habitat Reserves that are protected under the MMHCP: wildfire, windstorm, catastrophic geological events, or forest pathogen events.

Wildfire: Most wildfires in the Plan Area are small and low-intensity events that may burn into or through an old growth stand with little or no damage. Catastrophic wildfire is uncommon within the range of the marbled murrelet. However, natural or anthropogenic climate variation may increase the frequency or severity of such fires (*see* Sections 3.5, 4.2.2). If a wildfire occurs in the Plan Area during the term of this MMHCP, Green Diamond may take all measures reasonably necessary to extinguish such a fire. The strategy for responding to and suppressing forest fires is generally established by CalFire, and Green Diamond may have little ability to influence such strategy. However, where reasonably possible and consistent with the primary goal of containing and extinguishing the fire, Green Diamond will encourage development and implementation of a fire-response strategy that protects Occupied Reserves and vegetation buffers and Suitable Habitat Reserves from damage or destruction. During and immediately following a wildfire, Green Diamond may take action to clear roads of fallen trees even where roads are located within or in close proximity to protected Occupied Reserves and vegetation buffers and Suitable Habitat Reserves.

Wind: If a windstorm event occurs in the Plan Area, there is no management response that Green Diamond can implement to mitigate damage to protected Occupied Reserves and vegetation buffers and Suitable Habitat Reserves. Immediately following a windstorm event, Green Diamond may take action to clear roads of fallen trees even where roads are located within or in close proximity to protected Occupied Reserves and vegetation buffers and Suitable Habitat Reserves.

Geologic Event: The Plan Area is in an area well known for frequent but generally small earthquakes. Earthquakes are quite common and generally are of a relatively insignificant magnitude, typically magnitude 2 to 3 on the Richter scale. Occasionally, greater magnitude events occur, but they are impossible to predict. In the forest environment, earthquakes of magnitude 6 or less on the Richter scale produce little, if any, visible change, and no significant impact to wildlife habitat. It is possible that some trees may fall from earthquakes or landslide effects. Regardless of cause, fallen trees are not so significant in number as to require additional mitigations and/or changes in this MMHCP's management scenario or restrictions. However, if a catastrophic geologic event such as an earthquake or substantial landslide occurs and it severely damages or destroys an Occupied Reserve and buffers or Suitable Habitat Reserve, there is no management response that Green Diamond can implement to mitigate damage to protected murrelet stands. During and immediately following a geologic event, Green Diamond may take action to clear roads of fallen trees, soil, rock, and debris even where roads are located within or in close proximity to protected Occupied Reserves and vegetation buffers and Suitable Habitat Reserves.

Forest Pathogens: Careful and thoughtful forest management and proper treatments can usually keep forest insects and diseases under control. Site quality and nutrient availability play a key role in forest health and vigor. Because much of the Plan Area is of high site quality, infestations are less likely to occur within the healthy forests occupying these sites. It is possible that changes in climate conditions—whether natural or anthropogenic—could make forests more susceptible to Forest Pathogens (Agne et al. 2018, Dudney et al. 2021, USFWS 2024). Infestations by generally recognized types of forest pests or pathogens are not expected to have significant adverse effects on the Covered Species within the Plan Area.

If Green Diamond becomes aware of a forest pathogen that presents an active threat to protected Occupied Reserves and vegetation buffers and Suitable Habitat Reserves, Green Diamond shall promptly notify the Service and CDFW and seek to meet and confer with the Service and CDFW on potential actions that Green Diamond could take to mitigate damage to protected Occupied Reserves and vegetation buffers and Suitable Habitat Reserves. If the Service and CDFW consents to any prophylactic or mitigating action proposed by Green Diamond, Green Diamond may implement the approved action even if it impacts protected Occupied Reserves and vegetation buffers and Suitable Habitat Reserves.

In all events of damage or destruction to protected Occupied Reserves and vegetation buffers and Suitable Habitat Reserves due to natural events, Green Diamond will notify the Service and CDFW within 10 days of discovery of an event that damaged or destroyed a protected Occupied Reserve and buffer or Suitable Habitat Reserve. Within 30 days of discovery, Green Diamond will provide the Service and CDFW with an assessment of the extent of the damage (in acres) and whether the damage to the stand will cause it to be marginal or unsuitable habitat under the HSM. If Green Diamond finds that the damaged stand has become marginal or unsuitable habitat, the Service, CDFW, and Green Diamond will confer on whether the no entry and harvest commitments under

the MMHCP should be released from the MMHCP commitments applicable to that Occupied Reserve and buffer or Suitable Habitat Reserve so that Green Diamond may conduct salvage and/or reforestation activities within the formerly protected stand. If a reserve or buffer is released for management in this manner, any acres removed from MMHCP reserve or buffer commitments would be accounted for (removed from calculations of take mitigation).

If an entire protected Occupied Reserve and buffers or Suitable Habitat Reserve is removed from protection under the MMHCP because it is no longer suitable habitat, Green Diamond, the Service, and CDFW will confer to determine whether the removal will cause a deficit in Green Diamond's positive ratio mitigation to expected take of the Covered Species and if mitigation must be replaced with the AMRA lands to ameliorate the effects of the Changed Circumstance. The impact on mitigation will consider:

What percentage of the protected Occupied Reserves and vegetation buffers and Suitable Habitat Reserves were rendered marginal or unsuitable by natural events? Because the protected stands are not concentrated geographically in the Plan Area, it is unlikely a natural event will have a catastrophic impact that will reverse the positive ratio of mitigation to incidental take.

Does the natural event also cause a reduction in incidental take due to natural removal of Marginal Habitat? An extensive natural event can be expected to degrade and destroy marginal suitable habitat as well as Occupied Reserves and vegetation buffers and Suitable Habitat Reserves.

If the Occupied Reserve and buffer or Suitable Habitat Reserve remains functional, Green Diamond will apply the following supplemental prescriptions within the Plan Area:

- Other than trees that are downed or dead due to the wildfire, wind, geologic event, or forest pathogen, Green Diamond will not remove more timber than it would have been allowed to remove had no forest altering occurred in the stand, unless the Service and CDFW determines removal of such additional timber would not materially reduce the habitat's functional benefit for the Covered Species.
- Conduct salvage of trees downed or dead by wildfire, wind, geologic event, or forest pathogen in compliance with state law. In addition, conducting any salvage operations within a reserve will be done to retain structural features that contribute to future habitat for the Covered Species.
- Reforestation of any reserve affected by wildfire, wind, geologic event, or forest pathogen will be implemented as soon as reasonably possible.

6.5.3 Disease Afflicting Marbled Murrelets

All species of wildlife including the Covered Species have the potential to be adversely affected by various diseases. Avian influenza is a disease in birds caused by an infection of bird flu type A viruses. Avian influenza type A viruses are classified as low pathogenicity and high pathogenicity based on the virus' ability to cause disease and mortality in chickens in a laboratory setting (https://www.cdc.gov/flu/avianflu/avian-in-birds.htm).

The highly pathogenic virus was first detected in wild birds in the United States in 2021 (https://www.usgs.gov/centers/nwhc/science/avian-influenza-surveillance). The virus has not

been detected in marbled murrelet populations. Green Diamond can take no management action that will influence disease transmission among wild birds. Green Diamond can only seek to ensure that murrelet nesting habitat is protected and recruited over a very long timeframe so that nesting habitat is not a limiting factor for murrelet populations in Conservation Zone 4. If disease is found to be a primary influence on murrelet populations within Conservation Zone 4 and occupancy of terrestrial habitat including Green Diamond lands, Green Diamond, the Service, and CDFW will confer to assess potential effects and status of AMRA lands relative to the Changed Circumstance.

6.5.4 Climate Change/ Marine Conditions

The conservation strategy for the proposed MMHCP will protect old growth forest stands and develop mature forest stands with high murrelet nesting habitat suitability characterized by large trees and an emerging multi-layered canopy. This is consistent with recommendations for "intentional forestry" to mitigate the effects of climate change by enhancing carbon sequestration, biodiversity, and forest resilience through the protection of "Elder Trees" or ETs and the recruitment of "Potential Elder Trees" or PETs (Antione and Sillett 2021, Sillett et al. 2022, Sillett et al. 2025). The proposed MMHCP will protect all old growth ET forest stands in the Plan Area as Occupied Reserves with buffers (see Sections 6.2.2 and 6.2.3 above) and the MMHCP will designate and protect Suitable Habitat Reserves consisting of PETs that are expected to develop improved nesting habitat over time (see Section 6.2.5 above). By protecting all of the occupied old growth nesting habitat in the Plan Area and setting aside Suitable Habitat Reserves of mature forest stands with the highest likelihood of developing into nesting habitat, the MMHCP will enhance the reproductive potential of the marbled murrelet population in the Plan Area. Although it is impossible to predict future changes in local and regional climatic conditions from climate change, the best available science shows that protecting these reserves will bolster the conservation and recovery of marbled murrelets in the face of climate change (Gaines et. al 2022, USFWS 1997).

The protected Occupied Reserves and vegetation buffers and Suitable Habitat Reserves are among the most durable forest habitat components known to exist, because these forest stands have evolved and persisted through hundreds of years of climate variations and can be expected to persist well beyond the term of the MMHCP (see Section 4.2.2). In addition to providing habitat resilience as a buffer against climate change, the carbon sequestered in these protected reserves will provide a small, incremental climate change mitigation benefit by reducing GHGs in the Earth's atmosphere.

Even so, changed circumstances could entail a loss of forest stands in Occupied Reserves or Suitable Habitat Reserves due to the potential effects of climate change, such as increased frequency or severity of wildfire or forest pathogens. These changed circumstances are anticipated and treated by Section 6.5.2 and the Adaptive Management Reserve Account provided for in Section 6.3.2.3 of this MMHCP.

A more dynamic change in circumstances that may be attributed to climate is ocean conditions, which Green Diamond can do little to influence or mitigate. The temperature and current tidal and upwelling regimes of the North Pacific may be more dynamic due to climate change, with dramatic impacts on the abundance and distribution of fish and smaller biota in the food chain. As a result, the feeding and migration habitats of the marbled murrelet may result in years without nesting or shifting of marbled murrelet populations among the Pacific Coast Conservation Zones to take

advantage of better ocean and food conditions. Green Diamond can take no management action that will materially influence ocean conditions and can only seek to ensure that murrelet nesting habitat is protected and recruited over a very long timeframe so that nesting habitat is not a limiting factor when murrelet populations are concentrated or increasing in Conservation Zone 4. If a change in marine conditions is found to be a primary influence on murrelet populations within Conservation Zone 4 and occupancy of terrestrial habitat including Green Diamond lands, Green Diamond, the Service, and CDFW will confer to assess potential effects and status of AMRA lands relative to the Changed Circumstance.

6.5.5 Development of New Suitable Marbled Murrelet Habitat in the Plan Area Under Management Prescriptions Contained in Conservation Plans and Agreements for Other Covered Species in the Plan Area

Green Diamond manages the Plan Area under long term conservation plans for other species such as anadromous fish and amphibians that are covered species under the Aquatic HCP approved by the Service in 2007, or the northern spotted owl, fisher, and tree voles that are covered species under the Forest HCP approved by the Service in 2019, or the Humboldt marten that is a covered species under a Safe Harbor Agreement with the California Department of Fish and Wildlife approved in 2018. These conservation plans and agreements include forest stand and tree retention measures that cumulatively result in the establishment of maturing forest stands across more than 25 percent of the Plan Area. As these stands mature, with larger tree size, potential nesting platforms, multi-layered canopies, and sheltered interior spaces, they can reasonably be expected to become suitable habitat for the marbled murrelet in the longer term beyond the term of the MMHCP, and to a lesser degree and in some circumstances, during the term of the MMHCP.

Should Green Diamond's management under various conservation plans and agreements result in the recruitment of more marbled murrelet suitable habitat, Green Diamond will produce net conservation benefits that are not needed as mitigation for the incidental take expected under this MMHCP. Under the guidance for MMHCP Renewal in Section 6.4.8, a reassessment of suitable habitat in the Plan Area and revised estimates of incidental would be conducted in support of renewal and new or expanded Suitable Habitat Reserves would be confirmed and credited for their conservation and mitigation benefits at that time. The Performance Review (6.3.2.4) and evaluation of the Assurance Reserve will also provide information on whether there were cumulative gains in habitat suitability through management under the MMHCP.

6.5.6 Unforeseen Circumstances

"Unforeseen Circumstances" means changes in circumstances affecting a Covered Species or geographic area covered by this MMHCP that could not reasonably have been anticipated by Green Diamond and the Service at the time of this MMHCP's negotiation and development, and that result in a substantial and adverse change in the status of the Covered Species. (50 CFR § 17.3)

All changes in circumstances affecting a Covered Species or its habitat in the Plan Area that are not described previously as Changed Circumstances are considered not reasonably foreseeable in the context of this MMHCP. For the purposes of this Plan, such changes are Unforeseen Circumstances. In the event that Unforeseen Circumstances occur, Green Diamond will make Plan

modifications through discussions with the Service and CDFW according to the No Surprises Assurances and procedures set forth in the Service's No Surprises rule.

6.5.7 "No Surprises Assurances"

Provided that Green Diamond has complied with its obligations under the Take Permit and this MMHCP, the Service can require Green Diamond to provide mitigation beyond that provided for in this MMHCP only in accordance with the ESA "No Surprises" regulations in 50 C.F.R. §§ 17.22(b)(5) and 17.32(b)(5) as they exist as of the Effective Date. If such No Surprises regulations are modified or amended after the Effective Date, such modifications or amendments shall not apply to this MMHCP and Take Permit unless reliance on the regulations in effect as of the Effective Date is prohibited by statute or court order.

If the Service makes a finding of Unforeseen Circumstances, it shall have up to 120 days, or a longer period with Green Diamond's consent, to determine the nature and location of additional or modified mitigation required to address the Unforeseen Circumstances. During such period, Green Diamond agrees to avoid undertaking any activity that would appreciably reduce the likelihood of the survival and recovery of the affected Covered Species.

In the event that Green Diamond is wholly or partially prevented from performing the obligations of this MMHCP because of unforeseeable causes beyond the reasonable control of and without the fault or negligence of Green Diamond, including but not limited to third party actions, sudden actions of the elements not identified as Changed Circumstances, or actions of a non-participating federal agency, state agencies or local jurisdictions, Green Diamond shall be excused from whatever performance is affected by such unforeseeable cause to the extent so affected, provided that nothing in this section shall be deemed to authorize any Party to violate the ESA, and provided further that:

- The suspension of performance is of no greater scope and no longer duration than is required by the unforeseeable cause.
- Within 15 days after the occurrence of the unforeseeable cause Green Diamond shall give the Service and CDFW written notice describing the condition, an estimate of how long Green Diamond expects it to persist, and how Green Diamond plans to remedy the effects of the temporary suspension of performance.
- Green Diamond shall use its best efforts to remedy its inability to perform.
- When Green Diamond is able to resume performance of its obligations, Green Diamond shall give the Service and CDFW written notice to that effect.

Section 7. Assessment of the Conservation Strategy's Effectiveness

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7.1 INTRODUCTION

This section discusses how this MMHCP's operating conservation program described in Section 6 fulfills ESA requirements and provides the Service with the basis for authorizing take of the Covered Species pursuant to an incidental take permit.

For an HCP to be approved under ESA Section 10, the Service must find the applicant will "to the maximum extent practicable, minimize and mitigate the impacts of such taking [incidental to otherwise lawful actions], and the taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild." In addition, the Service must receive assurances the applicant will implement the plan and "will ensure that adequate funding for the plan will be provided" 16 U.S.C. 1539(a)(2)(A) and (B).

The Service prepared an HCP Handbook (2016) explaining these approval criteria. The Handbook also describes the process an applicant should follow with the Service to develop an HCP fulfilling ESA requirements.[1] In addition to addressing the essential statutory criteria, the HCP Handbook requires an HCP to:

- Include and expressly state the biological goals and objectives of the plan for the Covered Species
- Incorporate an adaptive management program addressing conservation program uncertainties and potential adjustments to the conservation program over the life of the plan

This Section 7 describes how the operating conservation program described in Section 6 addresses the impacts of Plan Area Covered Activities on the Covered Species, which are described in Section 5. This section describes how individual MMHCP measures will:

- Avoid or minimize potential Covered Species take caused by Plan Area Covered Activities
- Mitigate potential effects of Covered Species take caused by Plan Area Covered Activities
- Ensure Covered Activities do not cause any appreciable reduction in Covered Species survival and recovery likelihood in the wild
- Examine all potential individual and cumulative take effects and all conservation benefits, together with their relative significance, for the Covered Species.

Generally, the MMHCP achieves these requirements by one or more of the following:

- Avoiding or minimizing an environmental *effect* that could cause incidental take and its associated impacts
- Identifying specific measures designed to mitigate incidental take effects (both in the nature and extent of impact)
- Providing other conservation benefits that contribute to recovery of the Covered Species.

[1] The MMHCP was developed using the guidance provided by the Service's HCP Handbook released in 2016 and the Service's Policy on Mitigation released in 2023. *U.S. Fish & Wildlife Service Mitigation Policy* Appendix 1, 501 FW 2, May 2023. Both documents provide non-binding guidance on the ESA's statutory and regulatory provisions applicable to the development and approval of the MMHCP.

In addition to measures designed to avoid or address specific effects, the Plan includes actions to improve conditions for the Covered Species. These additional measures provide a mitigation level that fully offsets and exceeds anticipated take effects.

The 1996 HCP Handbook requires that an HCP "*will not appreciably reduce the likelihood of the survival and recovery of Covered Species and does not explicitly require an HCP to recover listed species, or contribute to their recovery objectives outlined in a recovery plan"* (USFWS, 1996:3-20). It further states *"however, recovery is nevertheless an important consideration in any HCP effort"* (USFWS, 1996:3-20). Accordingly, the 1996 HCP Handbook advises "*[t]o put this in practical terms, applicants should be encouraged to develop HCPs that produce a net positive effect for the species or contribute to recovery plan objectives"* (USFWS, 1996: 3-20). The 2016 HCP Handbook provides similar guidance distinguishing between recovery as a desired goal, but not a legal requirement for approval of an HCP; "*we encourage applicants to develop conservation plans that are consistent with the recovery plans and contribute to the recovery of the covered species*" USFWS, 2016:2-5.

The marbled murrelet is a Covered Species that is listed and addressed by a Service recovery plan. This section describes this MMHCP conservation program's consistency with the Marbled Murrelet Recovery Plan. This consistency provides added confidence this MMHCP meets and in some cases exceeds the ESA Section 10 standards applicable to each identified impact on murrelets. Stated another way, the extra measures supply added assurance that a sufficient level of conservation is being provided to address any concern about the sufficiency of any particular measure to address the extent of a particular type of impact. Furthermore, these measures improve conditions beyond the ESA Section 10 minimize and mitigate standard. This MMHCP fully mitigates the impacts of potential incidental take caused by the Covered Activities in the Plan Area and it contributes to the long-term recovery of the marbled murrelet.

Finally, this section:

- Provides assurances that Green Diamond will provide adequate resources for this MMHCP implementation
- Justifies Green Diamond's reasonable conclusion that this MMHCP conservation measures minimize and mitigate take to the maximum extent practicable
- Provides the Service with evidence that implementation of the MMHCP is not likely to jeopardize the continued existence of marbled murrelets.
- Verifies that this MMHCP includes an adaptive management program meeting the intent of the HCP Handbook.

Table 7-1. Summary of plan elements and ESA approval criteria.

Biological Goals & Objectives & Implementation Commitments	Measures to Avoid & Minimize Take Effects	Measures to Mitigate Take Effects Through Conservation & Recovery	Adaptive Management Measures
Goal 1: Conserve known occupied marbled murrelet habitat. (6.2.2) - Identify, protect, retain known and presumed occupied marbled murrelet nesting stands (Occupied Reserves). (6.2.2) - Apply same protection to any acquired Occupied Reserves. (6.4.7)	No timber harvest in Occupied Reserves (take avoidance and minimization for vegetation modification resulting from Covered Activities related to road use and maintenance is described in Appendix D). (6.2.2)	No possibility of survey and release of Occupied Reserves found to be unoccupied. (6.2.2) Any Occupied Reserves that are acquired will be protected from timber harvest. (6.4.7)	Monitor Covered Activities around Occupied Reserves and buffers for compliance. (6.3.1.1) Remedial requirements for accidental harvest in Occupied Reserves. (6.3.2.1.1, 6.3.2.3)
Goal 2: Retain and recruit habitat within managed vegetation buffers for Occupied Reserves or Adjacent Habitat Reserves. (6.2.3) - Allow limited management in Occupied Reserve Buffers and Adjacent Habitat Buffers to enhance recruitment of murrelet habitat. (6.2.3) - Apply vegetation buffer requirements to any acquired Occupied Reserves. (6.4.7)	Establish 300-foot vegetation buffer on Occupied Reserves and on occupied murrelet stands adjacent to Plan Area (Adjacent Habitat Buffers). (6.2.3) No timber harvest operations in Occupied Reserve Buffers and Adjacent Habitat Buffers during marbled murrelet nesting season (6.2.3). Take avoidance and minimization measures for Covered Activities related to road use and maintenance are addressed in Appendix D.	Any harvest in Occupied Reserve Buffers or Adjacent Habitat Reserve Buffers outside nesting season shall be limited to uneven-aged selection harvest for long-term development and recruitment of marbled murrelet habitat added to Occupied Reserves. (6.2.3)	Sampling of buffer areas that receive habitat enhancement treatment to measure habitat response. (6.3.1.2) Remedial requirements for non-compliant harvest in buffers. (6.3.2.1.2., 6.3.2.3) Evaluate the development of new suitable habitat in buffer zones and other retention/no harvest areas in the Plan Area. (6.3.1.6)

Biological Goals & Objectives & Implementation Commitments	Measures to Avoid & Minimize Take Effects	Measures to Mitigate Take Effects Through Conservation & Recovery	Adaptive Management Measures
Goal 3: Conduct Covered Activities within the Plan Area with Spatial and Temporal Buffers to Avoid or Minimize Direct Take and Potential Disturbance Take to Marbled Murrelets and Establish Best Management Practices to Minimize Predatory Risk to Nesting Marbled Murrelets. (6.2.4) - Exclude or condition operations in buffers with the potential to disturb nesting murrelets or induce predator effects. (6.2.4) - Apply buffer requirements to any Occupied Reserves acquired. (6.2.3, 6.4.7)	Establish nesting season and areal operational buffers around Occupied Reserve and Adjacent Habitat. (6.2.4, Appendix D)	Apply nesting season and areal operational buffers on Occupied Reserves acquired and added to the Plan Area. (6.2.3, 6.4.7, Appendix D)	Conduct Sampling within Buffer Areas to Assess Development of Murrelet Habitat. (6.3.1.2) Estimate Age Classes and Mitigation Credit for Buffer Zones for Adaptive Management and Renewal. (6.3.1.5) Non-Compliance Reporting Process. (6.3.1.10)

Biological Goals & Objectives & Implementation Commitments	Measures to Avoid & Minimize Take Effects	Measures to Mitigate Take Effects Through Conservation & Recovery	Adaptive Management Measures
Goal 4: Conserve Suitable Habitat Reserves within the Plan Area (6.2.5) - Exclude operations from Suitable Habitat Reserves that provide the best opportunity to retain, develop and recruit murrelet habitat in the Plan Area and may be used for nesting. (6.2.5) -Establish restricted deed on 2 Suitable Habitat Reserves. (6.2.5) - Apply same protection to any Suitable Habitat Reserves acquired. (6.4.7)	No timber harvest in 96 Suitable Habitat Reserves identified by habitat suitability model. (6.2.5)	No timber harvest in 96 Suitable Habitat Reserves identified as best candidates for murrelet habitat recruitment by habitat suitability model. (6.2.5) No possibility of survey and release of 96 Suitable Habitat Reserves found to be unoccupied. (6.2.5) Any Suitable Habitat Reserves that are acquired will be protected from timber harvest unless a refined HSM is approved by the Service. (6.4.7)	Monitor Covered Activities around Suitable Habitat Reserves for compliance. (6.3.1.3 and 6.3.2.1.3) Remedial requirements for unintended harvest in Suitable Habitat Reserves. (6.3.2.1, 6.3.2.3)
Goal 5: Ensure compliance, effectiveness, implementation and durability of the MMHCP (6.2.6, 6.3, 6.4) - Provide financial assurances. - Designate responsible staff - Training for staff and contractors - Compliance monitoring - Effectiveness monitoring	Ensure compliance with take avoidance and minimization measures. (6.2.6) Protect unsuitable habitat with confirmed nesting. (6.3.2.5)	Ensure compliance with mitigation and recovery measures. (6.2.6) Establish Assurance Reserve as compensatory mitigation for the temporal loss of Marginal Habitat. (6.3.2.4)	Compliance monitoring and reporting. (6.3.1, 6.4.3) Performance Review before year 49 determines whether the Assurance Reserve term is extended. (6.3.2.4.2)

Biological Goals & Objectives & Implementation Commitments	Measures to Avoid & Minimize Take Effects	Measures to Mitigate Take Effects Through Conservation & Recovery	Adaptive Management Measures
Implementation Commitment: Land and Plan Area Adjustments - for acquisitions, conserve Occupied Reserves and associated buffers and Suitable Habitat Reserves identified on added lands. (6.4.7.1) - for removals, convey subject to covenants that preserve Occupied Reserves and Suitable Habitat Reserves for the term of the MMHCP. (6.4.7.2)	The permit holder may adjust the Plan Area through sales of property from the Plan Area provided that any Occupied Reserves, associated buffer areas, and Suitable Habitat Reserves are conveyed to third parties subject to covenants requiring management of such areas consistent with the requirements of the MMHCP for the term of the MMHCP and such covenants may be enforced by Green Diamond or the Service. (6.4.7)	The permit holder may adjust the Plan Area through acquisitions of comparable lands in the Adjustment Area that may be added to the Plan Area provided that the acquired lands are assessed by the permit holder for known and presumed occupied habitat areas (Occupied Reserves) and low suitable and better habitat areas (Suitable Habitat Reserves), which are then identified, delineated, and protected in the same manner as the original Plan Area. (6.4.7)	N/A

7.2 THE RELATIONSHIP BETWEEN THE MARBLED MURRELET CONSERVATION PROGRAM AND HCP APPROVAL CRITERIA

7.2.1 Measures to Avoid, Minimize and Mitigate the Impacts of Take on the Marbled Murrelet

Using guidance and terminology of the Service's Mitigation Policy (USFWS 2023), this section 7.2.1 will describe the key conservation measures of the MMHCP and the conservation benefits associated with those measures. Consistent with the Service's Mitigation Policy, the MMHCP conservation strategy uses the hierarchy of mitigation that begins with avoidance of take, then uses measures to minimize take, and then completes mitigation of residual take through compensatory measures.

Consistent with the Mitigation Policy, the MMHCP uses a landscape-ecosystem approach to conservation, recognizing that the Plan Area and Adjustment Area should be managed wholistically with a long-term, durable, pro-active strategy for murrelet conservation and recovery. This MMHCP tiers off of and builds upon Green Diamond's federally approved conservation plans used to manage most of the Plan Area for ecosystem elements that conserve aquatic species and key terrestrial species such as the northern spotted owl, fisher, marten, and tree voles. To be effective, the mitigation strategy in this MMHCP is implemented within the Plan Area and under

the control of Green Diamond. The mitigation strategy found in the conservation program (Section 6) addresses (i.e. nexus) and is proportionate to the impacts of the Covered Activities (Section 5). The mitigation strategy is also science-driven and based in large part on the landscape specific murrelet habitat model developed by Green Diamond and described in Section 5 and Appendix A.

For the marbled murrelet, the baseline condition of the Plan Area and the similar Adjustment Area is a managed forest landscape with relatively few remnant stands of old growth forest that provide large nesting platforms and a multi-layered canopy conducive to murrelet flight and cover. These stands provide the highest quality suitable habitat for marbled murrelet nesting and, in accordance with the Mitigation Policy, these areas receive priority protection under the MMHCP as the habitat anchors in the Plan Area and Adjustment Area landscape. Using the murrelet suitable habitat model, the remainder of the Plan Area is evaluated to identify forest stands that have the most potential to be recruited and developed as murrelet nesting habitat. The development of high quality murrelet nesting habitat takes a very long time – centuries. The tree stands with the highest potential for development as habitat have groups of very old and large trees with emerging nesting platforms and canopy diversity. In the Green Diamond suitable habitat model, these "low suitable and better" stands are also protected as priority habitat that is now or may develop to be marbled murrelet nesting habitat during the term of the MMHCP. Under the MMHCP, protection for established and emerging murrelet nesting stands is the core of the mitigation strategy found in the conservation program. Any further development of murrelet nesting habitat requires a time frame that extends beyond the term of the MMHCP. Therefore, the term and the renewal of the MMHCP are particularly important for murrelet conservation. Under the MMHCP, there are areas of younger forests that are not suitable habitat, but they are targeted for long-term development as habitat through prescriptions and incentives. Management buffers on known and presumed occupied old growth stands are prescribed for protection and limited management that avoids take and accelerates development of more complex, older forest characteristics. In addition, the MMHCP provides assurances for Green Diamond to develop older and more complex forest stands adjacent to protected low suitable and better stands without adding harvest restrictions and operational buffers around new suitable habitat. The MMHCP includes prescriptions and incentives that will begin the process of management of younger forests into older forests during the term of the MMHCP so that there are more options for further development of suitable habitat through future extension and renewal of the MMHCP.

Table 7-1 provides a summary of the biological goals and objectives of the MMHCP, the conservation measures that support those goals and objectives, and their role in avoiding or minimizing take or in mitigating and compensating for residual impacts of take that do occur due to Covered Activities. A more detailed description of the key conservation measures and their role in mitigation follows.

7.2.1.1 Protection for Occupied Reserves

Portions of the Plan Area that are known or presumed occupied marbled murrelet nesting habitat are identified and defined as Occupied Reserves. Consistent with the Service's Recovery Plan for the Marbled Murrelet (USFWS 1997) and the Service's Mitigation Policy (USFWS 2023), Occupied Reserves are protected as the highest quality marbled murrelet nesting habitat in the Plan Area. No timber harvest is allowed in the Occupied Reserves and Green Diamond will make no attempt to survey such areas for non-occupancy and release for timber harvest. This eliminates

any risk of direct take of nesting murrelets. Avoiding risk to the highest quality habitat for an "Evaluation" or Covered Species is the first step in the Service's Mitigation Policy.

The avoidance and minimization of murrelet take by activities proximate to Occupied Reserves is also addressed by vegetation and activity limitation buffers around Occupied Reserves and occupied murrelet stands in existing conservation easements in the Plan Area or located on third-party ownership adjacent to the Plan Area (see 7.2.1.2 and 7.2.1.3 below).

Protection for Occupied Reserves also contributes to recovery of the species. On a managed forest landscape where most old growth forest stands have been removed, the restoration of extensive old growth stands would require centuries. The Occupied Reserves are the remnants of old growth forest that must be retained as anchors for long-term development of more forest stands and larger forest stands with mature and old growth forest characteristics conducive to marbled murrelet nesting. Green Diamond recognizes the need for a legally enforceable commitment to retain and protect the Occupied Reserves. Any murrelet occupied old growth forests that Green Diamond might acquire in the Adjustment Area would be added to the Occupied Reserves under the MMHCP if the acquired timberlands are added to the Plan Area. Green Diamond has estimated the murrelet conservation contribution of the Occupied Reserves (Section 5.2.6). That contribution will grow as additional occupied stands are acquired and added to the Plan Area.

7.2.1.2 Vegetation Management in Occupied Reserve Buffers and Adjacent Habitat Buffers

The conservation and recovery benefits of Occupied Reserves will be further enhanced under the MMHCP by the designation of 300-foot vegetation buffers around Occupied Reserves (Occupied Reserve Buffers) and around occupied murrelet stands in existing conservation easements in the Plan Area or located on third-party ownership adjacent to the Plan Area (Adjacent Habitat Buffers). Forest stands in these buffers will be managed to accelerate the development of mature and old growth forest characteristics through limited selection harvest outside the nesting season. Any harvest management in these areas will occur outside the breeding season and it will be only for the purpose of developing groups of larger, complex trees with nesting platforms and a multi-layered forest canopy. Any commercial harvest within the vegetation buffer will occur only where a harvest is already scheduled in the adjoining stand, so that no buffer is entered as a stand-alone operation. Development of these stands likely will require more than the first term of the MMHCP, but the development of such habitat must begin somewhere in the Plan Area and Occupied Reserve Buffers and Adjacent Habitat Buffers represent the most strategic locations for such development because they will build on and expand the extent of existing occupied nesting stands while also protecting murrelets in occupied nesting habitat from edge-effect take. In the long run, the forest stand characteristics of Occupied Reserve Buffers and Adjacent Habitat Buffers will become more like the Occupied Reserves and adjacent occupied stands they are designed to protect. Occupied Reserve Buffers will also be established and managed for habitat recruitment around any Occupied Reserves acquired by Green Diamond and added to the Plan Area in the future. Green Diamond has not estimated a murrelet conservation contribution of Occupied Reserve Buffers and Adjacent Habitat Buffers for compensatory mitigation purposes, but the establishment and development of these buffers in the current and future Plan Area owned and managed by Green Diamond is a contribution to marbled murrelet recovery.

Green Diamond has protected the Occupied Reserves from harvest under a no-take policy since the marbled murrelet was listed in 1992, and the 300-foot vegetation buffers have been in place since each stand was documented as occupied. The Occupied Reserves are therefore treated in this Plan as baseline conserved habitat rather than as compensatory mitigation for authorized take. Green Diamond also estimates and reports the murrelet production associated with the Occupied Reserves, approximately 797 eggs or nestlings over the permit term, as a contribution to the conservation and recovery of the species. That estimate is reported for the Service's information and is not offered as, or counted toward, mitigation for authorized take.

7.2.1.3 Prescribed High Disturbance Activity Limitations in and Around Occupied Reserve Buffers and Adjacent Habitat Buffers

Take of murrelets nesting in Occupied Reserves or occupied stands on adjacent ownerships or in existing Conservation Easements will be avoided and mitigated through: (i) enforcement of seasonal operating restrictions in Occupied Reserve Buffers and Adjacent Habitat Buffers, and (ii) enforcement of additional buffer requirements for activities that pose a substantial risk of direct interference with essential breeding and rearing behavior or indirect inducement of adverse impacts such as increased predation. Although documented take through disturbance by proximate management activities or induced predator behavior is rare, the scientific literature and Service guidelines promote the avoidance of seasonal and other activity restrictions on timberlands proximate to occupied marbled murrelet nesting stands. The MMHCP prescribes seasonal and other activity restrictions for Occupied Reserve Buffers, Adjacent Habitat Buffers, and certain high-disturbance risk activity buffers around occupied murrelet nesting areas. These prescriptions would also apply to any timberlands acquired by Green Diamond from the Adjustment Area and added to the Plan Area.

7.2.1.4 Protection for Suitable Habitat Reserves

The scarce, high-value resource marbled murrelet nesting stands in a managed landscape is first protected and enhanced through Occupied Reserves, Occupied Reserve Buffers, and Adjacent Habitat Buffers, but the MMHCP also uses Green Diamond's Habitat Suitability Model described in Section 5 and Appendix A to identify those portions of the Plan Area that exhibit mature forest habitat characteristics that are most advanced toward development old growth forest stands like the Occupied Reserves. Under the MMHCP, all forest stands identified as low suitable or better are set aside for management as Suitable Habitat Reserves where no timber harvest will occur. In the Suitable Habitat Reserves, Green Diamond will cease any efforts to survey for absence of murrelet occupancy and consequent release for timber harvest. Instead, Green Diamond will dedicate these areas for long-term retention and development as the best candidates for current and emerging marbled murrelet nesting habitat during the term of the MMHCP. Because Suitable Habitat Reserves are protected and developed as increasingly productive murrelet habitat during the term of the MMHCP, the Suitable Habitat Reserves may be considered as compensatory mitigation.

Of course, the commitment to eliminate timber harvest in these areas will avoid and minimize take that might otherwise occur over the term of the MMHCP as these areas mature and become more likely to be used for marbled murrelet nesting and in greater density. Even more significant, however, is the contribution to recovery of the murrelet. Green Diamond has estimated the

potential contribution of these protected Suitable Habitat Reserves to marbled murrelet population recovery so that the Service can compare this compensatory mitigation to the predicted amount of incidental take that may occur due to Green Diamond's timber harvest in portions of the Plan Area that are not suitable habitat or are only Marginal Habitat. As might be expected, the risk of take in areas of unsuitable or Marginal Habitat is very low because the presence of murrelets and likely utilization of those areas as habitat is also very low. In Section 5 of the MMHCP, the methods for estimating murrelet take and the comparative compensatory benefits of the Suitable Habitat Reserves are described in detail. The compensatory mitigation provided by Suitable Habitat Reserves in combination with the additional contributions to recovery through other MMHCP measures such as the Occupied Reserves and Buffers are fundamental to demonstrating that the MMHCP minimizes and mitigates murrelet take to the maximum extent practicable.

7.2.1.5 Conservation of Occupied and Suitable Habitat in Plan Area Additions and Removals

The Service's Mitigation Policy (USFWS 2023) suggests that "no net loss" is an important criterion by which to design and measure a mitigation strategy. The MMHCP includes measures to ensure that there is no net loss in suitable habitat for murrelet nesting. To this end, the MMHCP protects and preserves Occupied Reserves (7.2.1.1 – 7.2.1.3), then it protects the Suitable Habitat Reserves as the best areas for current habitat and development and maturation of suitable murrelet nesting habitat during the MMHCP term (7.2.1.4). The Occupied Reserves, their associated buffers, and the Suitable Habitat Reserves established on day one of the MMHCP provide the baseline for no net loss of marbled murrelet nesting habitat and conservation additionality in the Plan Area.

To maintain the baseline with no net loss of marbled murrelet habitat, Green Diamond may freely sell and convey portions of the Plan Area to third parties provided that any Occupied Reserves or Suitable Habitat Reserves that are removed from the Plan Area will nonetheless be subject to either assumption of the MMHCP obligations in a new incidental take permit held by the transferee or enforceable covenants (enforceable by Green Diamond or the Service) that prevent the harvest of Occupied Reserves or Suitable Habitat Reserves during the term of the MMHCP.

To further the goals of no net loss and additionality for murrelet recovery, Green Diamond will also use a process for timberland acquisitions and additions to the Plan Area that secures newly added Occupied Reserves, Occupied Reserve Buffers, Adjacent Habitat Buffers, and Suitable Habitat Reserves. When property is acquired from the Adjustment Area that has been analyzed by Green Diamond and accepted by the Service as similar to the initial Plan Area, Green Diamond may add the acquired property to the Plan Area provided that it: (i) identifies and protects occupied marbled murrelet nesting stands as Occupied Reserves with associated MMHCP buffer prescriptions; and (ii) Green Diamond applies the murrelet Habitat Suitability Model (Section 5, Appendix A) to the acquired property to identify low suitable and better forest stands that qualify as Suitable Habitat Reserves that are protected from harvest.

For acquired lands only, Suitable Habitat Reserves will be subject to the no harvest prescription unless (or until) Green Diamond refines the Habitat Suitability Model to address the availability of nesting platforms within a forest stand. Refinement of the Suitable Habitat Model is an objective of the MMHCP Adaptive Management Program (6.3.2.3).

7.2.1.6 The Assurance Reserve and Performance Review

The Covered Activities include timber harvest of Marginal Habitat that produces a long-term, temporal loss of potential nesting habitat, because the old-growth characteristics required for suitable murrelet nesting can take 100 to 250 years to develop. To provide added assurance that this temporal loss is fully offset and that the impacts of incidental take remain within the range predicted by the MMHCP, Green Diamond will establish an Assurance Reserve at the initiation of Plan implementation (Section 6.3.2.4). Within sixty days of Plan approval and Permit issuance, Green Diamond will record a deed covenant in the real property records of Del Norte County over the three Klamath View Ridge Occupied Reserve stands and their 300-foot buffer, 76.3 acres of occupied, high-quality nesting habitat contiguous with occupied habitat on Redwood National Park and Yurok Tribe land, enforceable for the term of the Permit (Section 6.3.2.4.1).

The Assurance Reserve contributes to the ESA Section 10 approval criteria in three respects. First, it strengthens the demonstration that the MMHCP mitigates the impacts of take to the maximum extent practicable by directly addressing the temporal dimension of habitat loss: the durable protection of occupied habitat that will continue to develop over the Permit term offsets the lag between harvest of Marginal Habitat and the recruitment of replacement nesting habitat elsewhere in the Plan Area. Second, because the restrictive covenant is recorded and legally enforceable by Green Diamond or the Service, and is extendable for up to 50 additional years, it supplies the durability that the Service's Mitigation Policy (USFWS 2023) identifies as essential to effective compensatory mitigation. Third, it provides the Service with an assurance mechanism, the Performance Review, that reinforces the finding that Covered Activities will not appreciably reduce the likelihood of marbled murrelet survival and recovery.

The Performance Review operationalizes this assurance. Before the 49th anniversary of Plan approval, Green Diamond will complete a Performance Review for the Service and CDFW evaluating whether (1) cumulative Marginal Habitat removal remained within the limits predicted at Plan inception, (2) monitoring revealed any substantial, unanticipated long-term impacts of that removal, and (3) management of the Plan Area achieved a net conservation benefit above the Plan-inception baseline (Section 6.3.2.4.2). If the review confirms that Marginal Habitat removal was fully mitigated as predicted and a net conservation benefit was achieved, the Assurance Reserve may expire with the Permit term; if it does not, the Service and CDFW may require that the Reserve be extended by up to 50 additional years. This performance-linked, extendable commitment ensures that the mitigation provided by the MMHCP remains commensurate with the actual, observed impacts of take over the full life of the Plan.

7.2.1.7 Mitigation Effectiveness and Durability

Consistent with ESA requirements, Green Diamond assures the Service it will provide the resources necessary for MMHCP implementation. Section 6.3.1 describes Green Diamond’s commitment to compliance monitoring under the MMHCP and Section 6.4 describes the reporting commitments and staffing and other resources Green Diamond will provide for Plan implementation. To ensure this MMHCP integrates harvest planning with conservation measures designed to benefit the marbled murrelet, a Plan Coordinator will work with Green Diamond’s wildlife, forestry and operations staff. The Plan Coordinator will ensure that timber harvest plan development and implementation is consistent with this MMHCP. Green Diamond’s significant

investment in reliable timber inventory data and a state-of-the-art Timberland Management Information System provides a substantial and reliable resource for planning and implementing timber harvesting and regular reporting to the Service that complies with all MMHCP conservation measures. In addition to staffing and management information systems, Green Diamond has a 25-year record of reliable implementation and compliance with seven Service-approved habitat conservation plans and CCAAs. Additional details on Internal Compliance Team procedures are provided in Section 6.4.1.

7.2.2 No Appreciable Reduction in Likelihood of Marbled Murrelet Survival and Recovery

Under the Northwest Forest Plan (Madsen et al. 1999) and the recovery plan for the marbled murrelet (USFWS 1997), programs and goals were established to monitor at-sea populations of marbled murrelets and terrestrial habitat. The purpose of the monitoring program is to assess status and trends of at-sea abundance of murrelets during the nesting season in coastal waters adjacent to the Northwest Forest Plan area in Conservation Zones 1 through 5 and monitor status and trend of murrelet nesting habitat throughout the listed range of the species (McIver et al. 2022). Conservation Zone 6 is not within the area of the Northwest Forest Plan. Conservation Zone 4, termed the Siskiyou Coast, extends from Coos Bay, Oregon south to the southern border of Humboldt County, California. This Section focuses on at-sea estimates of murrelet populations within Conservation Zone 4 which is the area of coastal waters adjacent to the Plan Area. However, population estimates for Zone 4 and the entire range are provided for assessing impacts to the marbled murrelet population. The population estimates for the entire range may be most relevant for ESA purposes since the murrelet was listed throughout its range in the lower 48 states and does not carry a Distinct Population Segment designation under ESA. The population in Zone 4 is also relevant for assessing impacts under the CESA. The most recent population and trend estimates are available through 2021 (McIver et al. 2022). The results from the at-sea monitoring indicate a positive slope for all Zones combined, although it was slight (0.3%) and confidence intervals overlapped zero. The range wide conclusion was no trend (Figure 5-8) with a 2020 population estimate of 19,685 murrelets (95% CI = 15,493 – 23,877). In Zone 4 and California, there was a positive trend that did not overlap zero indicating an increase for the monitoring period of 2.8% annually in Zone 4 and 3.8% in California. The population estimate in 2021 for all of Zone 4 was 5,132 (95% CI = 3,739 – 8,243). In Zone 4 stratum 1 (Coos Bay to Trinidad), the population estimate was 4,476 (95% CI = 3,147 – 7,267) and in stratum 2 (Trinidad to Shelter Cove) the population estimate was 657 (95% CI = 90 – 1,521). The 2021 population estimate for California was 3,870 murrelets (95% CI = 2,727 – 5,014).

Based on our estimates of direct and indirect take, approximately 0.15 murrelets would be taken annually, or one murrelet egg/nestling would be taken every seven years. The total estimated take of murrelets over the permit term (~8) represents approximately 0.0004% of the 2020 range wide population, 0.002% of the 2021 Conservation Zone 4 population, and 0.002% of the 2021 California population. The potential take of one marbled murrelet over a six-to-seven-year period as a result of Covered Activities results in lower estimated impacts to the murrelet population. These calculations are based on cautious and conservative estimates of nesting parameters and do not incorporate estimates of nesting success and juvenile survival. The conservation of the Occupied Reserves, and Suitable Habitat Reserves habitat is a net positive conservation benefit for murrelets within the Plan Area, California, and within the listed range of the species.

7.2.3 Contributions to Marbled Murrelet Recovery

- The Service's marbled murrelet conservation strategy specifically includes the development of HCPs. In particular, the important role of HCPs on nonfederal land like Green Diamond is addressed by the Service in its Recovery Plan for the Marbled Murrelet (USFWS 1997), which recommends HCPs on nonfederal lands to complement federal conservation strategy and describes them in Section 2.3.2 of the Recovery Actions. The Recovery Plan states, "Adequately designed and implemented HCPs will be very important in the conservation of marbled murrelets on . . . private lands and are likely to be the most effective and acceptable means of protecting most occupied sites on nonfederal lands in the near future and potentially providing replacement habitat in the long term" (USFWS, 1997). HCPs on nonfederal land "with appropriate measures to minimize and mitigate incidental take in the short term while providing for maintenance or creation of habitat for the long term probably offer the best means for conservation of the species" (USFWS, 1997).

The MMHCP minimizes and mitigates incidental take through several commitments discussed above. The MMHCP also contributes to marbled murrelet recovery in several ways. Occupied Reserves and Suitable Habitat Reserves provide the anchor of productive nesting habitat in the Plan Area that will be protected and is expected to improve in quality over time. Buffers on Occupied Reserves and Adjacent Habitat Reserves are managed for accelerated development of suitable habitat conditions that will be added to reserves. Initially, these buffers will protect the murrelet productivity of occupied stands and over time, they will also contribute to available suitable nesting habitat and productivity.

More suitable habitat may also be voluntarily developed by Green Diamond in response to assurances in the MMHCP that allow Green Diamond to develop additional portions of the Plan Area into new suitable habitat stands without adding harvest restrictions or operating buffers on adjacent timberlands (6.3.1.6). An additional, durable contribution to recovery is provided by the Assurance Reserve, which places occupied, high-quality nesting habitat under a recorded deed covenant that is extendable beyond the initial Permit term (7.2.1.6, 6.3.2.4).

7.3 TAKE IS MINIMIZED AND MITIGATED TO THE MAXIMUM EXTENT PRACTICABLE

ESA Section 10 requires that each habitat conservation plan address the conservation needs of the Covered Species by minimizing and mitigating the impacts of take to the maximum extent practicable. Under the HCP Handbook, this requirement is satisfied if the combination of HCP measures to minimize and mitigate the impacts of take "fully offset" such take. (USFWS and NMFS 2016: 9-29). As demonstrated in subsection 7.2, this MMHCP contributes substantial positive benefits for survival and recovery of the Covered Species that outweigh the impacts of take. The MMHCP not only avoids and minimizes take of marbled murrelets, but it mitigates take by managing for the protection and development of emerging suitable habitat that will contribute more productive murrelet habitat and murrelet population benefits than the adverse population effects of harvest of timberlands that are either not suitable habitat or, at best, Marginal Habitat. The MMHCP not only provides a surplus of quantified compensatory mitigation for the estimated impacts of take by Covered Activities, it incorporates additional measures and strategies with

conservation benefits that contribute to recovery of the murrelet. Because these mitigation measures fully offset the impacts of incidental take that may occur under the MMHCP. (USFWS and NMFS 2016: 9-29 to 9-32), the Service need not place a heavy emphasis on the "*maximum extent practicable* criterion because the adequacy of the mitigation provided in this MMHCP is not "*a close call*." (USFWS, 1996:7-3).

When an HCP does not fully offset the impacts of take, the ESA also recognizes a practical, technical or economic limit to the conservation measures a permit-holder can provide and the Service can require for approval, called "*the maximum extent practicable".* According to the HCP Handbook and Mitigation Policy, the "*maximum extent practicable"* is a marginal feasibility or economic cost-benefit analysis or cost-effectiveness analysis asking whether more mitigation is reasonably possible or required because additional conservation benefits justify the cost (USFWS and NMFS 2016:9-33). The Service is not required to apply this test in an instance where the proposed HCP, such as the MMHCP, fully offsets the impacts of take. (USFWS and NMFS, 2016:9-28). Even so, the operating conservation program proposed in Section 6 of the MMHCP also reflects conservation of Covered Species to the maximum extent practicable, after a process of considering alternatives that would require fewer or more conservation measures with varying biological benefits and economic costs.

In Sections 1 and 8, Green Diamond describes the alternatives to the proposed taking and conservation program that were considered during development of this MMHCP. Green Diamond considered a passive approach to ESA compliance (No New Permit and Plan) with no intentional and coordinated conservation program. The "no take" alternative posed greater adverse economic impact on Green Diamond, employment, and the regional economy with reduced biological benefit. Management alternatives that affect less habitat but do not provide better biological outcomes are evidence of the technical or practical limits of minimizing and mitigating take.

The No New Plan and Permit alternative would require a conservative 'no take' compliance strategy with added costs and significant timber harvest delays for implementation of marbled murrelet survey protocols to verify the absence of murrelet occupancy before harvest or, in the case of detected occupancy, reduced timber harvest, reduced timberland productivity, and reduced employment and production in forestry, logging and sawmills. This alone was economically unreasonable, but it also provided less biological benefits than the proposed operating conservation program in Section 6.2.

7.4 ACCOUNTABILITY AND UNCERTAINTY ADDRESSED THROUGH MONITORING, EXPERIMENTATION, AND ADAPTIVE MANAGEMENT

Consistent with the requirements for approval of an HCP, the MMHCP incorporates commitments for compliance and effectiveness monitoring (6.3.1) and adaptive management (6.3.2). Compliance monitoring will ensure that reserve areas are protected as promised and vegetation and operating buffers are maintained. Adaptive management ensures that compensatory mitigation is required for any noncompliance. Effectiveness monitoring will track and assess the effectiveness of management measures in buffer areas that are designed to protect and accelerate the development of suitable habitat. Management measures that prove effective may then be used more broadly for suitable habitat development. Finally, Green Diamond will attempt to refine the

Habitat Suitability Model using experience with management to determine if there are more manageable variables that produce suitable habitat.

The MMHCP manages uncertainty and risk by identifying foreseeable Changed Circumstances and appropriate responses to Changed Circumstances events (Section 6.5). The MMHCP also provides for the possibility of Permit suspension or termination when there is an unforeseen circumstance leading to the death or injury of protected bird species. If the circumstances will jeopardize the species, the Service and/or CDFW may ask more of Green Diamond.

7.5 CONCLUSIONS REGARDING MITIGATION OF IMPACTS AND PROVISION OF CONSERVATION BENEFITS

To avoid, minimize or mitigate significant cumulative environmental effects, Green Diamond considered the magnitude and significance of potential cumulative effects, considered alternatives and included specific conservation measures in the Operating Conservation Program to address cumulative effects. Where substantial uncertainties remain, adaptive management provisions accommodate flexible MMHCP implementation.

Green Diamond evaluated cause-and-effect relationships among the Covered Activities, potential for take of the marbled murrelet and the potential impact of such take, including cumulative effects. Specifically, in Section 5, Green Diamond analyzed the potential for cumulative effects likely causing take or resulting from incidental take. Green Diamond also evaluated the potential for incremental effects from Covered Activities combining in space and time with existing conditions or adverse and positive effects of third-party actions in and around the Eligible Plan Area.

The Plan design focuses on addressing factors with the greatest probability for limiting Covered Species. Green Diamond believes the Plan as designed significantly improves Covered Species habitat at the landscape scale, with the added benefit that specific measures retain and recruit particular habitat elements beneficial to the Covered Species.

As described above and summarized in Section 6, Green Diamond will minimize and mitigate each of the potential impacts to the maximum extent practicable, including cumulative impacts. Although particular impact types or potential limiting factors may not be significant alone, this MMHCP addresses each potential impact type or potential limiting factor as individually significant and the bottleneck for each Covered Species' local population. In addition, the operating conservation program as a whole addresses potential effects and limiting factors collectively. This ensures Green Diamond's Covered Activities pursuant to the operating conservation program minimize and mitigate all individual and cumulative impacts to the maximum extent practicable and contribute to conservation efforts benefiting the Covered Species.

Furthermore, the Plan includes a monitoring and adaptive management program providing mechanisms to adjust the conservation measures as appropriate. This provides further assurances that this MMHCP meets the statutory and regulatory criteria described above. Under these circumstances, incidental take of Covered Species is not expected to appreciably reduce the likelihood of survival and recovery of the Covered Species in the wild.

Finally, Green Diamond expects individual conservation measures and the operating conservation program as a whole to provide significant net benefits to the Covered Species and its habitat over the permit term. The conservation program will contribute to the recovery of the marbled murrelet.

Section 8. Alternatives Considered

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8.1 INTRODUCTION

This section describes, in accordance with the requirements of ESA Section 10 and the Service's Habitat Conservation Planning and Incidental Take Processing Handbook (HCP Handbook; USFWS and NMFS 2016), the alternatives to the proposed taking of the Covered Species that Green Diamond considered during preparation of this Marbled Murrelet Habitat Conservation Plan (MMHCP) and explains why those alternatives were not selected. Green Diamond identified these alternatives through its MMHCP preparation process and through the Service's NEPA document scoping process. The primary alternatives for the Service's action on the Take Permit are analyzed in detail in the NEPA document, which may address any of the following alternatives.

Section 5.6 of the HCP Handbook explains that an applicant for an HCP should address the alternatives to taking that were considered in developing the HCP. In accordance with that guidance, Green Diamond considered two alternatives to the proposed MMHCP conservation program: (1) No New Permit and Plan (No Action), and (2) Landscape Habitat Conservation with No Harvest in Murrelet Habitat Reserves, which is the Proposed Action and Green Diamond's preferred alternative. These two alternatives are described below.

8.2 NO NEW PERMIT AND PLAN

Under this alternative, the no action alternative for purposes of the NEPA document, Green Diamond would manage its California Timberlands without a new incidental take permit or MMHCP for the marbled murrelet. Green Diamond has managed its timberlands under a no-take policy for the marbled murrelet since the species was listed under the federal ESA as threatened in 1992. Under the No New Permit and Plan alternative, Green Diamond would continue to rely on its existing no-take compliance strategy for the marbled murrelet—a form of case-by-case take avoidance that is both Intensive and Passive in its application—without the benefit of a coordinated, landscape-level conservation program.

The No New Permit and Plan alternative encompasses two take avoidance approaches that Green Diamond has employed since listing, and which it would continue to apply in the absence of the MMHCP.

8.2.1 Intensive Take Avoidance

Intensive Take Avoidance is the approach Green Diamond has applied to active forest management since the marbled murrelet's ESA listing. This approach seeks to comply with the ESA take prohibition by avoiding harvest operations in known occupied marbled murrelet nesting habitat and in close proximity to such habitat during the nesting season when essential murrelet behavior might be seriously disrupted. Under Intensive Take Avoidance, forest stands with uncertain habitat suitability and occupancy must be evaluated on a case-by-case basis before harvest can proceed. This process involves a multi-year investment in protocol surveys conducted by trained biologists to determine with confidence whether an area is occupied, and therefore unavailable for harvest, or unoccupied and available.

Under this approach, Green Diamond foresters or biologists and regulatory agency representatives must first conduct a Survey Area Assessment, through desk review and field observation, to

determine whether one or more platform trees are present within a proposed harvest area or within 402 meters of its boundary – the threshold that triggers the requirement for protocol audio-visual surveys under the Pacific Seabird Group (PSG) protocol. If protocol surveys are required, Green Diamond must propose and implement a nesting-season survey of the stand using an approved number and distribution of survey locations and schedule of sufficient duration to monitor for murrelet behavior. The PSG protocol requires surveys to be conducted across at least two consecutive breeding seasons before a determination of non-occupancy can be made. This process is expensive, time-consuming, and uncertain in its results.

Green Diamond does not support the Intensive Take Avoidance alternative because it:

- Is expensive and time-consuming due to the requirement for a case-by-case Survey Area Assessment of each proposed timber harvest unit to determine whether platform trees are present within or within 402 meters of the harvest area, warranting protocol audio-visual surveys over at least two nesting seasons.
- Is inefficient because it does not use scientific modeling methods—such as the habitat suitability model (HSM) developed by Green Diamond for the MMHCP—to identify timber stands with higher suitability and likelihood of murrelet presence and risk of take, and does not allow rigorous advance identification of stands where harvest may proceed because habitat suitability is marginal and the risk of take is low.
- Does not reliably protect suitable habitat, because protection under take avoidance follows a positive occupancy determination and harvest follows a negative one. Green Diamond applied this approach on the Plan Area from 1991 through 2001: stands determined to be potentially occupied were protected, and all other stands were harvested (Appendix C, Section C.2). Habitat that supports murrelets but does not produce detectable occupied behavior during the survey window is therefore harvested under take avoidance, whereas under the MMHCP it is identified by the habitat suitability model and protected as a Suitable Habitat Reserve for the full permit term without survey.
- Because occupancy of murrelet stands is intermittent, take avoidance permits harvest of stands during intervals in which occupancy is not detected, resulting in the permanent loss of intermittently occupied habitat and an estimated foregone production of 53 to 192 marbled murrelet eggs or nestlings (Section 5.2.8). Under the MMHCP, those same stands are protected for the full 50-year permit term without survey, and the Suitable Habitat Reserves alone are estimated to produce approximately 492 eggs or nestlings over the term. Take avoidance therefore trades a small, quantified, authorized and mitigated amount of take for a substantially larger unquantified and unmitigated loss of habitat and future production. Take avoidance avoids the legal category of take; it does not avoid the biological consequence.
- Does not necessarily produce a better conservation outcome. Under this approach, stands are protected only while occupancy is detected, and stands for which occupancy is not detected, including stands that support murrelets, remain available for harvest. The MMHCP accepts a quantified and mitigated amount of incidental take in exchange for the identification and protection of the Plan Area's highest-value nesting habitat for the full permit term, without reliance on survey detection. Green Diamond's assessment is that this exchange produces a materially better conservation outcome, and Sections 3.4, 5.2.8; Appendices C and E provide the basis for that conclusion.

- Does not provide regulatory certainty to Green Diamond with respect to future timber harvest operations in areas where maturing forest stands under other conservation plans—including the AHCP/CCAA, Forest HCP, and Marten SHA—may develop into murrelet suitable habitat over time, thereby triggering additional take avoidance requirements and operational constraints.
- Does not provide conservation measures that invest in the protection and long-term development of murrelet nesting habitat at the landscape scale, and therefore does not contribute meaningfully to murrelet recovery.
- Does not offer a durable, long-term solution for reconciling Green Diamond's timber operations with ESA requirements in a manner that provides the No Surprises regulatory assurances available under an approved HCP and Take Permit.
- Reduces Green Diamond's annual harvest, long-term forest productivity, and regional employment and economic production, without providing commensurate biological benefits relative to the MMHCP.

8.2.2 Passive Take Avoidance

Passive Take Avoidance is similar to Intensive Take Avoidance in that it sets a very high standard for compliance by requiring confidence that no activities will take marbled murrelets. However, Passive Take Avoidance does not invest additional resources in field assessments to reduce uncertainty and rule out murrelet occupancy, and therefore does not allow timber harvest to proceed in areas where occupancy is uncertain. Instead, Passive Take Avoidance simply avoids timber harvest in any area where there is a perceived risk of murrelet take due to some degree of suitable habitat potential, even if that risk is low and unconfirmed by survey.

Green Diamond does not support the Passive Take Avoidance alternative because it:

- Places Green Diamond's timberland investment on a trajectory of progressive, cumulative set-asides of forest stands for conservation without timber harvest, as additional maturing stands across the Plan Area develop potential habitat characteristics under the existing AHCP/CCAA, Forest HCP, and Marten SHA.
- Would render Green Diamond's forest management business financially unviable and cause severe economic disadvantage in its communities through the loss of jobs and income at Green Diamond and at its customers and suppliers.
- Does not provide greater biological benefit than the proposed MMHCP because, while it avoids harvest in all areas of perceived habitat risk, it does not invest in a landscape-level habitat assessment, a coordinated habitat conservation program, or monitoring and adaptive management measures designed to ensure long-term conservation outcomes for the murrelet, and imposes substantially greater economic burden on Green Diamond's timber operations than the preferred alternative without commensurate conservation gain.
- Does not provide regulatory certainty to Green Diamond and does not offer the No Surprises assurances available under an approved HCP and Take Permit.

In summary, the No New Permit and Plan alternative—whether implemented through Intensive or Passive Take Avoidance—fails to use scientific methods to efficiently and proactively identify and protect the most valuable murrelet habitat, does not provide a landscape-level conservation program that benefits murrelet recovery, does not provide economic certainty for Green

Diamond's continued investment in sustainable forestry and community employment, and does not offer the regulatory assurances available under an approved HCP. For these reasons, Green Diamond does not support this alternative.

8.3 LANDSCAPE HABITAT CONSERVATION WITH NO HARVEST IN MURRELET HABITAT RESERVES (PREFERRED ALTERNATIVE)

This alternative is the Proposed Action and provides the basis for Green Diamond's application for a 50-year Take Permit under ESA Section 10(a)(1)(B). It is Green Diamond's preferred alternative because it addresses marbled murrelet conservation through a science-based, landscape-level conservation program that minimizes and mitigates to the maximum extent practicable the impacts of incidental take while preserving the financial viability of Green Diamond's California timber operations and their long-term benefit to regional employment and the regional economy.

Under this alternative, the MMHCP establishes a coordinated conservation program using a peer-reviewed habitat suitability model (HSM) developed from LiDAR data to identify, classify, and protect the marbled murrelet habitat most important to conservation and recovery, while allowing continued sustainable timber harvest in areas of unsuitable or marginal habitat quality. Green Diamond developed and will implement the following conservation measures under the preferred alternative:

- Identifies and protects 24 Occupied Reserves totaling approximately 541.3 acres—patches of old-growth or late-seral forest stands that are known or presumed to be occupied by marbled murrelets based on audio-visual surveys—from all timber harvest during the permit term.
- Establishes 300-foot (91.4-meter) vegetation buffers around Occupied Reserves and around occupied or presumed occupied murrelet stands on adjacent state, federal, or other private ownerships (Adjacent Habitat Reserves), restricting commercial timber harvest within approximately 1,574.4 acres of buffer habitat and managing those buffers through limited single-tree selection harvest outside the breeding season to accelerate development of older-forest characteristics conducive to murrelet nesting. The buffer entry is opportunistic rather than scheduled, no buffer is entered as a stand-alone operation, and buffers with no adjacent scheduled harvest receive no treatment during the permit term.
- Identifies and protects 96 Suitable Habitat Reserves totaling approximately 946.4 acres—forest stands classified as low suitable or better habitat by the HSM (habitat suitability index ≥0.19)—from all timber harvest during the permit term, providing the primary compensatory mitigation for incidental take authorized under the MMHCP.
- Implements seasonal and areal disturbance buffers for timber harvest and other high-disturbance Covered Activities proximate to Occupied Reserves and Adjacent Habitat Reserves during the marbled murrelet breeding season (March 24 through September 15) to minimize the risk of noise disturbance and edge-effect take of nesting adults and nestlings.
- Allows sustainable timber harvest to proceed in areas of the Plan Area classified as Marginal Habitat (HSI 0.03–0.189) or unsuitable habitat, where the probability of murrelet

nesting and risk of incidental take is low, under strict harvest planning and compliance monitoring protocols.

- Quantifies and tracks direct and indirect incidental take annually, requesting authorization for a maximum of approximately 15 marbled murrelets of incidental take over the 50-year permit term, including provisions for additional take from future land acquisitions within the Adjustment Area.
- Implements a comprehensive compliance monitoring and effectiveness monitoring program, including annual reporting to the Service and CDFW, periodic field reviews, and tracking of harvest acres within and adjacent to Marginal Habitat and adjacent to Suitable Habitat Reserves.
- Establishes an Assurance Reserve through a recorded deed covenant over the Klamath View Ridge Occupied Reserve and its 300-foot buffer (76.2 acres total), providing an enforceable, long-term performance assurance linked to a Performance Review completed before the 49th year of the permit term.
- Maintains an Adaptive Management Reserve Account (AMRA) consisting of approximately 473 acres of Marginal Habitat and 20 acres of Occupied Reserve land, available to offset unanticipated take, accidental harvest in reserved areas, and Changed Circumstances such as natural disturbance events during the permit term.

Under this alternative, Green Diamond manages its timber operations to provide Plan Area habitat for the marbled murrelet through the protection and development of a reserve system anchored by the Occupied Reserves and expanded through the designation of Suitable Habitat Reserves. The conservation commitments of the AHCP/CCAA, Forest HCP, and Marten SHA are complementary conservation measures operating independently within the Plan Area that will contribute to the development of additional suitable murrelet habitat in riparian management zones, geological protection areas, and species-specific reserve areas across more than 25 percent of the Plan Area over the course of the permit term. Green Diamond has designed the MMHCP to contribute to the survival and recovery of the marbled murrelet in Conservation Zone 4 and across its range, consistent with the Service's Recovery Plan for the Marbled Murrelet (USFWS 1997).

Green Diamond prefers this alternative because it:

- Uses the landscape-specific, peer-reviewed HSM to proactively identify and protect the highest-quality murrelet nesting habitat in the Plan Area—both currently occupied and potentially occupiable—providing a more efficient and biologically defensible foundation for conservation than case-by-case, survey-driven take avoidance.
- Provides quantified, science-based estimates of incidental take and compensatory mitigation that are designed to satisfy ESA Section 10 approval criteria by demonstrating mitigation of the impacts of authorized take, with Suitable Habitat Reserve protection generating murrelet productivity benefits that are estimated to exceed predicted take by a ratio of 67.5:1. Ratio based on inputs and calculations shown in Appendix B.
- Provides appropriate balance between investment in conservation through foregone timber harvest and habitat modeling refinement, monitoring, and adaptive management, and preservation of Green Diamond's financial viability and contribution to the region's economic health.

- Positions Green Diamond to receive No Surprises regulatory assurances upon Service approval of the MMHCP and Take Permit, such that, provided obligations are performed, the Service will not require additional mitigation measures or land use restrictions beyond those provided for in the MMHCP with respect to the marbled murrelet, except as provided under applicable No Surprises regulations.
- Is designed to contribute to marbled murrelet recovery consistent with the Service's Recovery Plan by protecting and improving occupied nesting habitat on nonfederal lands, voluntarily protecting suitable habitat reserves, and developing new suitable habitat through managed buffers on recognized occupied habitat.
- Recognizes and supplements Green Diamond's existing conservation investments under the AHCP/CCAA, Forest HCP, and Marten SHA, whose independent conservation commitments are producing maturing forest stands across more than 25 percent of the Plan Area that contribute to the long-term development of suitable murrelet nesting habitat within a comprehensive conservation framework.

Section 6 of this MMHCP fully describes the Conservation Program implementing this preferred alternative.

Appendix A. Habitat Suitability Model

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A.1 INTRODUCTION

Key objectives for the MMHCP include identifying forested areas (patches) that correlate well with areas exhibiting marbled murrelet presence, delineating management boundaries for these patches, and classifying habitat suitability in order to make meaningful conservation commitments. Therefore, Green Diamond developed a marbled murrelet habitat suitability model (HSM) based on environmental covariates derived from high resolution light imaging detection and ranging (LiDAR) data. The HSM was developed concurrent with the development of the MMHCP and underwent initial review by the Service, CDFW, and third party subject matter experts in habitat modeling and marbled murrelet ecology. In February 2025, the resulting HSM research paper was officially published through an open access journal, PLOS ONE (Lamphear et al. 2025). The full publication and supplemental material are included in this appendix.

From a management standpoint, this HSM offers a repeatable and spatially explicit framework for identifying forest patches that may contain suitable marbled murrelet nesting habitat. The delineation of patches using the concave hull process allows integration with silvicultural planning, regulatory compliance, and habitat monitoring. The classification into “marginal”, “low”, “medium”, and “high” suitability supports decision-making thresholds and conservation commitments. This appendix describes the methods used to develop the HSM and delineate management-friendly patches and provides additional context for understanding the assumptions when applying the model in a management framework.

PLOS ONE

RESEARCH ARTICLE

Marbled murrelet habitat suitability in redwood timberlands of Northern Coastal California utilizing LiDAR-derived individual tree metrics

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Abstract

The marbled murrelet (*Brachyramphus marmoratus*) is a threatened seabird found from Southern California to Alaska that forages at sea but nests in near coastal forests. Marbled murrelet nesting habitat is generally comprised of old-growth or mature forests with large trees having platforms suitable for nesting. Here, we estimate a habitat suitability model (HSM) that relates evidence of nesting to characteristics of putative trees derived from high resolution light imaging detection and ranging (LiDAR) data. Our study area in Northern California contained stands of old-growth forests on state, federal, and private lands but was predominated by private second-growth redwood and Douglas-fir timberlands. We estimated a two-sample HSM using Maxent software and implemented objective and repeatable covariate selection, model evaluation, and classification methods. Our HSM predicts relative likelihood of occupancy using predicted Habitat Suitability Index (HSI) values that we then classify into five habitat classes based on a novel use of the predicted to expected (P/E) ratio curve. From HSI predictions, we identified patches of murrelet habitat and estimated concave polygons surrounding individual trees within and proximately close to each patch. These methods provide repeatable boundaries for identification of patches and important individual trees based on HSI. Patches with greater relative probability of occupancy were characterized by high densities of 60-meter and taller trees, a large sum of heights for 50-meter and taller trees, and high values of standard deviation of 50-meter and taller trees. During hold-out model evaluations, our HSM showed extremely high fidelity for known patches with indirect evidence of nesting based on occupancy.

Introduction

The United States Fish and Wildlife Service listed the marbled murrelet (*Brachyramphus marmoratus*) as threatened under the federal Endangered Species Act in 1992. That same year, the state of California listed the bird as endangered under the California Endangered Species Act.

At the time, scientists knew that this seabird foraged offshore and nested in nearshore older forests along the Pacific Coast of the United States and Canada. Since then, several studies have investigated landscape and stand-level characteristics that comprise suitable marbled murrelet nesting habitat. Several studies of landscape scale habitat use found associations between marbled murrelet nesting and large amounts of unfragmented old-growth or mature forests [1–3]. Other studies characterized marbled murrelet nesting habitat as un-fragmented old-growth low elevation sites within the fog zone near other marbled murrelet nesting sites [4–7]. Still other studies found a negative association between marbled murrelet nest sites and increasing amounts of forest fragmentation, edge, and areas of logged and immature forests [1, 6, 8–12].

At a smaller scale, individual forest stands containing marbled murrelet nests tend to have high densities of large trees (minimum diameter at breast height of 120 centimeter (4 feet)) with multiple platforms, multiple canopy layers, canopy gaps, high epiphyte thickness, high epiphyte percentages, and greater tree heights [5, 12–17]. In one Oregon study, observed nest trees contained 8-92 platforms [3]. Other Oregon studies documented few nests in non-old growth trees (60-80 years) with dwarf mistletoe, deformations, or structural elements that support a nest [17, 18]. In addition, canopy complexity is an important component of nesting stands because openings are required for landing and takeoff [9, 11, 19]. In California, marbled murrelets nest primarily in old growth redwood and Douglas-fir forests [4, 12, 16, 20–22]. Carter and Erickson [23] documented marbled murrelets nesting up to 40 kilometers inland from the northern California coast. This literature provides a basis for identifying potential marbled murrelet habitat using stand-level criteria, but we wanted to develop a reliable tool for identifying a continuum of probable marbled murrelet habitat across a landscape at scales smaller than the typical stand.

In our study, we had three objectives. First, as part of a federal habitat conservation plan (HCP), we developed a correlative habitat suitability model (HSM) for marbled murrelets to identify, at the patch and study area scale, forested areas that correlate well with areas where marbled murrelets have exhibited indirect evidence of nesting ("occupied behaviors"; [24]) or where other observations provided direct evidence of nesting (e.g., radio telemetry or tree climbing). Second, we developed habitat classes based on the predicted to expected (P/E) ratio curve of HSI values [25, 26]. Third, we estimated concave polygons surrounding the patch and individual trees that influence nesting potential of an area and used these polygons to delineate management-friendly patch boundaries and associated habitat quality predictions. These patch boundaries would include trees in the core area of nesting patches but also included peripheral large trees that contributed to nesting suitability. To our knowledge, this would be the first successful use of LiDAR derived height and density of individual trees to model marbled murrelet nesting habitat.

Study area

Our study area, comprised of Green Diamond Resource Company lands plus a ½ mile buffer, was located on a mix of commercial timberlands, state, federal, and Tribal lands, with a negligible proportion of public or private non-timberlands, in Humboldt and Del Norte Counties, California (Fig 1). The study area was limited to the extent of our high-resolution LiDAR data collected in 2017/2018. Timberland ownership within the 238,355-hectare (588,987-acre) study area was composed of Green Diamond Resource Company (63.8%), other Private (25.0%), State or Federal including Redwood National and State Park, U. S. Forest Service and Bureau of Land Management (8.6%), and Tribal including Yurok and Hoopa lands (1.8%). The remainder (< 1%) were public or private non-timberlands. Hereafter, we will use the term

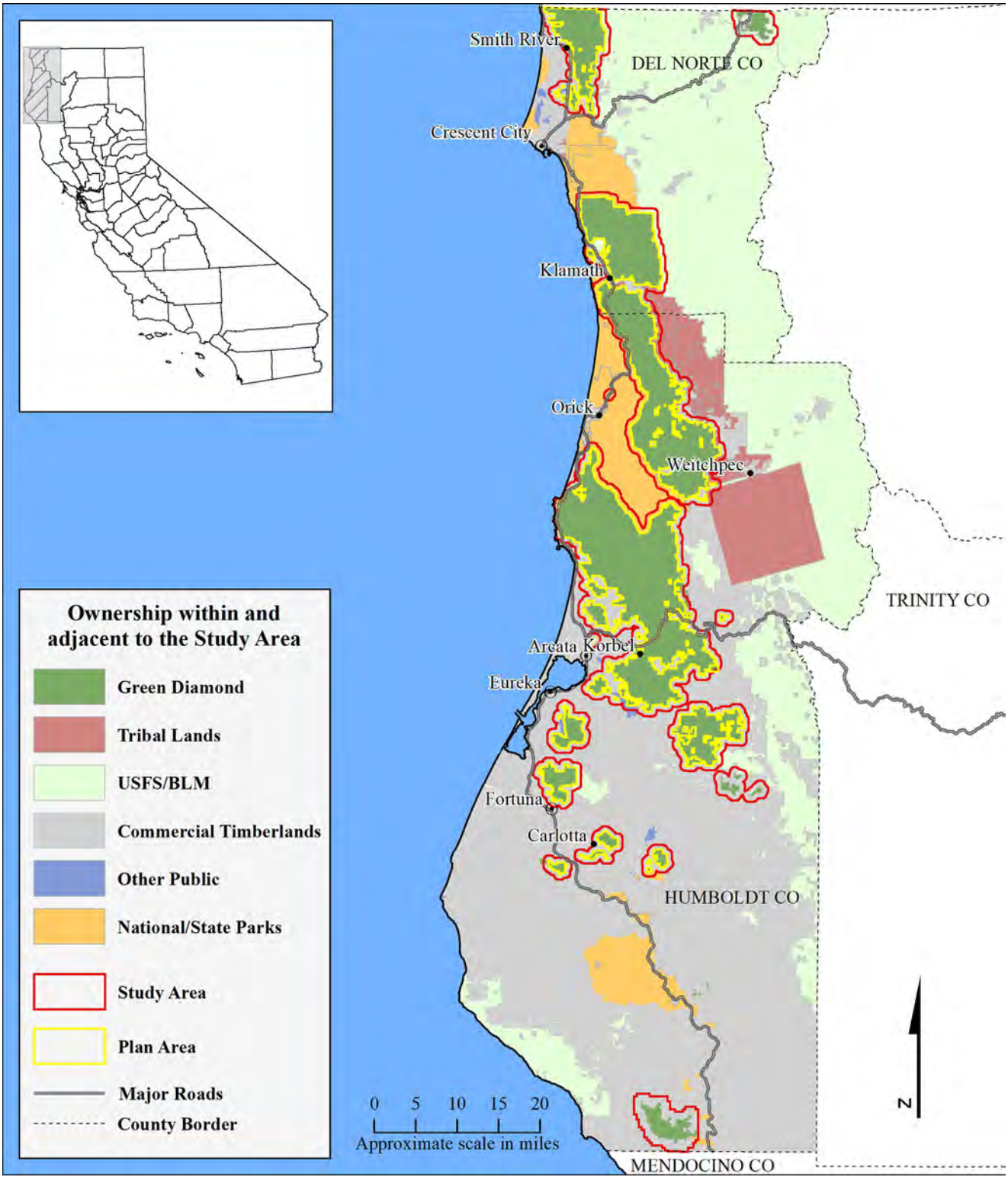

Fig 1. Ownership within the study area. The study area, composed of Green Diamond timberlands in Humboldt and Del Norte Counties, and a surrounding 0.5-mile buffer that contained State, Federal, Tribal, other Private Commercial timberlands, and Private non-timberlands. The Plan Area comprised a subset of Green Diamond Timberlands.

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"private timberlands" for both Green Diamond and non-Green Diamond timberlands within the study area. The portion of our study area included in Green Diamond's HCP application is 145,100 hectares (358,549 acres). Hereafter, we refer to this portion of the study area as the "Plan Area".

The entire study area was within 50 kilometers (31.1 miles) of the Pacific Ocean, and elevation ranged from five to 1550 meters (5,085 ft). The present-day climate on the North Coast of California is characterized as temperate Mediterranean. Along the Pacific Ocean, winters are generally mild and rainy, and summers are mild, cool, and dry. Further inland, the weather varies from the oceanic climate and temperatures increase throughout the year into a hot summer. Variation in air temperature is generally low along the coast as maritime influence dominates, with decreasing affect inland. Yearly minimum air temperature varies spatially across the study area from -1.6˚Celsius (29.5˚Fahrenheit) to 5.3˚ Celsius (41.6˚ Fahrenheit) with cooler minimum temperatures concentrated inland and in the north. Yearly maximum air temperature varies similarly from 17.5˚ Celsius (63.6˚ Fahrenheit) to 35˚ Celsius (95.0˚ Fahrenheit) with warmer temperatures concentrated inland and in the broad river valleys nearer the coastline. Annual precipitation occurs mostly as rain from November through April averaging 198 centimeters (78 inches) and varies from 106 centimeters (42 inches) near the coast to 320 centimeters (155 inches) in the coastal mountains [27]. Substantial and persistent snow occurs at elevations above 1000 meters (3,280 feet).

In our study area, coast redwood (*Sequoia sempervirens*) forest dominated in the coastal areas and at lower elevations. Douglas-fir (*Pseudotsuga menziesii*) replaced redwood as elevation and distance from the coast increased. Hardwoods exist as pure stands or common forest components. Red alder (*Alnus rubra*) and maple (*Acer macrophyllum*) dominated in coastal mesic sites, while tanoak, madrone (*Arbutus menziesii*) and giant chinquapin (*Chrysolepis chrysophylla*) occurred at higher, more xeric sites.

Private timberlands in the study area have been subjected to timber harvest for more than a century. Forests on private timberlands consist primarily of second and third-growth trees ranging in age from recently harvested to approximately 120 years. Private timberlands contain small and scattered patches of unharvested or partially harvested old growth forest ($< 0.2\%$ of private timberlands). Larger intact old growth forests occur on state and federal lands. State and federal lands in the study area consist of some of the largest old growth coastal redwood forests remaining within the California range of the marbled murrelet [28].

Methods

We estimated the two-sample HSM [29, 30] for murrelet nesting habitat using Maxent software [31]. Our two-sample HSM compared environmental conditions (i.e., habitat characteristics) at a sample of "used" locations to those at a sample of "available" locations. We estimated our HSM using the two-sample used-available methodology [29], also referred to as presence-background [31, 32], because we had extensive GIS coverage of known occupied patches but no widespread objective surveys of putative nest trees to establish use and non-use. We selected covariates to include in the HSM using an objective and repeatable four-step procedure. We validated the model by inspecting the magnitude and variation of performance measures over bootstrap replicates drawn from the raw data. We derived habitat classes by objectively identifying changes ("kinks") in the predicted-expected ratios [26] over an increasing range of suitability. We estimated concave polygons surrounding the patch and individual trees that influence nesting potential of an area and used these polygons to delineate practical and identifiable stand boundaries and associated habitat quality predictions. These practical

and identifiable patch boundaries included trees in the core area of nesting stands but also included peripheral large trees that contributed to nesting suitability.

Used habitat polygons

We constructed polygons of "use" as forest areas with indirect evidence of nesting and labeled them "occupied habitat polygons". We constructed "used" polygons, rather than used trees or points, due to the paucity of data on known nest locations within our study area. Prior studies faced a similar paucity of nest locations and, like us, defined "occupied behaviors" in a stand as an indication of potential nesting in the stand [24, 33, 34]. We reviewed available survey data collected from Federal and State parks, Bureau of Land Management reserves, private unharvested old growth forests, private partially harvested old growth, and private young (< 70 years old) forests with residual old growth trees containing "occupied behaviors" within the study area [16, 35, 36]. Surveys were conducted by various certified observers across multiple years over the past three decades for different purposes including monitoring efforts on public lands under the Northwest Forest Plan, Habitat Conservation Plans on private lands, and pre-project surveys on private timberlands. We included as "used" polygons all confirmed occupied patches. In total, forty-eight habitat patches, ranging from 0.1 to 463.4 hectares with a mean of 51.2 hectares were included and sampled as use areas.

Murrelet occupied behaviors in forest stands and contiguous habitat were established by three methods. Occupancy was established using audio-visual surveys conducted according to inland survey protocols for marbled murrelets that account for imperfect detection [24, 37], using radar surveys [38], and using direct evidence of murrelet nesting reported by other studies [21, 22]. The audio-visual inland survey protocol dictated multiple site visits (≥ 5) over a minimum of two years. During these surveys, occupied behaviors were noted such as stationary vocalizations from a tree, landing in a tree, flights below and through the forest canopy, and circling flights below or above the forest canopy. If murrelet occupied behaviors were observed, we assigned "used" status to the area. If surveys on private timberlands failed to observe occupied behaviors, the forested areas were cleared for harvest under California timber harvest plan permits [39]. The audio-visual surveys provided evidence of non-use when surveys failed to observe occupied behavior. Many of these non-use areas were subject to timber harvest prior to acquisition of the LiDAR data, and we could not derive accurate LiDAR covariates in these areas. We included these cleared for harvest areas among the "available" habitat.

When occupied behaviors were observed, the boundaries of the patch associated with the occupied behavior were established based on notable differences in forest age (or structure) such as between unharvested or lightly harvested old growth habitat (> 200 years old) and adjacent young managed forests generally less than 70 years old. We also considered the concept of contiguous habitat from surveyed areas [24]. On Green Diamond timberland, we included 24 patches that contained historic indirect evidence of nesting, and three patches with recent indirect evidence of nesting. We established the boundaries of the three recent patches using spatial kernel density estimation (95% KDE) of audio/visual detections. Forty-eight total used habitat patches, ranging from 0.1 to 463.4 hectares with a mean of 51.2 hectares were included and sampled from.

We utilized pre-existing data for these analyses such that field site access was not required. Data utilized was either publicly available (i.e., data from federal and state entities) or permission was obtained for use of data collected from private lands (i.e., Green Diamond Resource Company and Humboldt Redwood Company). Since we utilized pre-existing data, no permits were required for field site access or survey work.

Balanced sampling – "Used" and "Available" points

After establishing "used" polygons, we drew a single balanced acceptance sample (BAS) [40, 41] containing 117,804 locations across the entire 238,310-hectare (588,838-acre) study area. Our BAS had an average density of one sample point per 2.02 hectares (5-acres). We extracted all BAS points falling inside "used" polygons, but then excluded those within 20 meters of their patch boundary. We removed points inside but near the patch boundary to reduce edge effects (bias) in LiDAR-derived moving window covariates. We chose the inner exclusion zone distance of 20 meters, which is less than the 35.89-meter radius of our smallest 1-acre moving window, to maximize the number of "used" locations while balancing our concern over edge effect bias. We identified a total of 1,080 BAS points falling inside the "used" polygons after excluding those within 20 meters of patch boundaries (Fig 2). We considered these 1,080 points as "used", while we considered the totality of BAS points (117,804 points) as "available".

LiDAR data

LiDAR data was collected over the 238,355-hectare study area (Fig 1) from December 2017 through February 2018 using a Cessna Caravan aircraft carrying a Riegl VQ-1560i LiDAR sensor. Wave form data was collected and discretized in real-time on board the aircraft yielding up to 14 returns per pulse. Survey altitude above ground (AGL), speed, swath overlap, and central wavelength of the laser were 1,306 meters, 120 knots, 55%, and 1064 nanometers, respectively. Specifications called for a minimum density of 30 pulses/m^2. Our realized pulse density averaged greater than 40 pulse/m^2, with a maximum of 560 returns per m^2. Ninety-five percent of returns had horizontal and vertical accuracy of $\leq$ 20 centimeters. We have found that pulse densities greater than the typical United States Geological Survey standard (>=8/m^2) are necessary to resolve individual trees using local maxima methods. This is especially true where redwood stump sprouts produce tree leaders within 1 meter of each other. Raw LiDAR data consisted of the rectified and classified 3-dimensional location of every return collected by the sensor.

We processed the raw LiDAR data in LAStools [42] which among other things allowed us to discretize the (x, y, z) point cloud into "voxels" (a 3-dimensional pixel extending from ground to AGL), measure the distribution of points inside voxels (5-meter by 5-meter footprint), and develop a 0.25-meter resolution Digital Surface Model (DSM) for the canopy surface. Voxel metrics were calculated using LAStools and described below. We derived tree approximate objects (TAOs) by applying a local maxima process to the canopy DSM that ultimately extracted the (x, y) location and height (z) of the TAO [43–46].

Covariates

We compiled eighty HSM covariates on a 5-meter grid covering the entire study area. We grouped these eighty covariates into six general themes [47] based on their hypothesized importance as predictors of murrelet nesting habitat (S1 Table in S1 File). The "Biographic/Geographic" group included 14 covariates such as elevation, distance to coast, aspect, and solar radiation. The "Climate" group included 6 covariates such as annual precipitation, air temperature, growing degree days, and whether a location was in the zone of coastal influence. The "LiDAR Canopy Metrics" group included 10 canopy metrics including the number of returns in each 5-meter by 5-meter voxel footprint, average return height above ground (a measure of central canopy height), and variation in returns within a given voxel. The "LiDAR Percentile" group included 19 variables measuring the height inside each voxel from which a certain percentage of the returns were received. We derived 16 TAO based statistics in the "TAO Point Statistics" group such as the minimum, mean, maximum, sum and standard

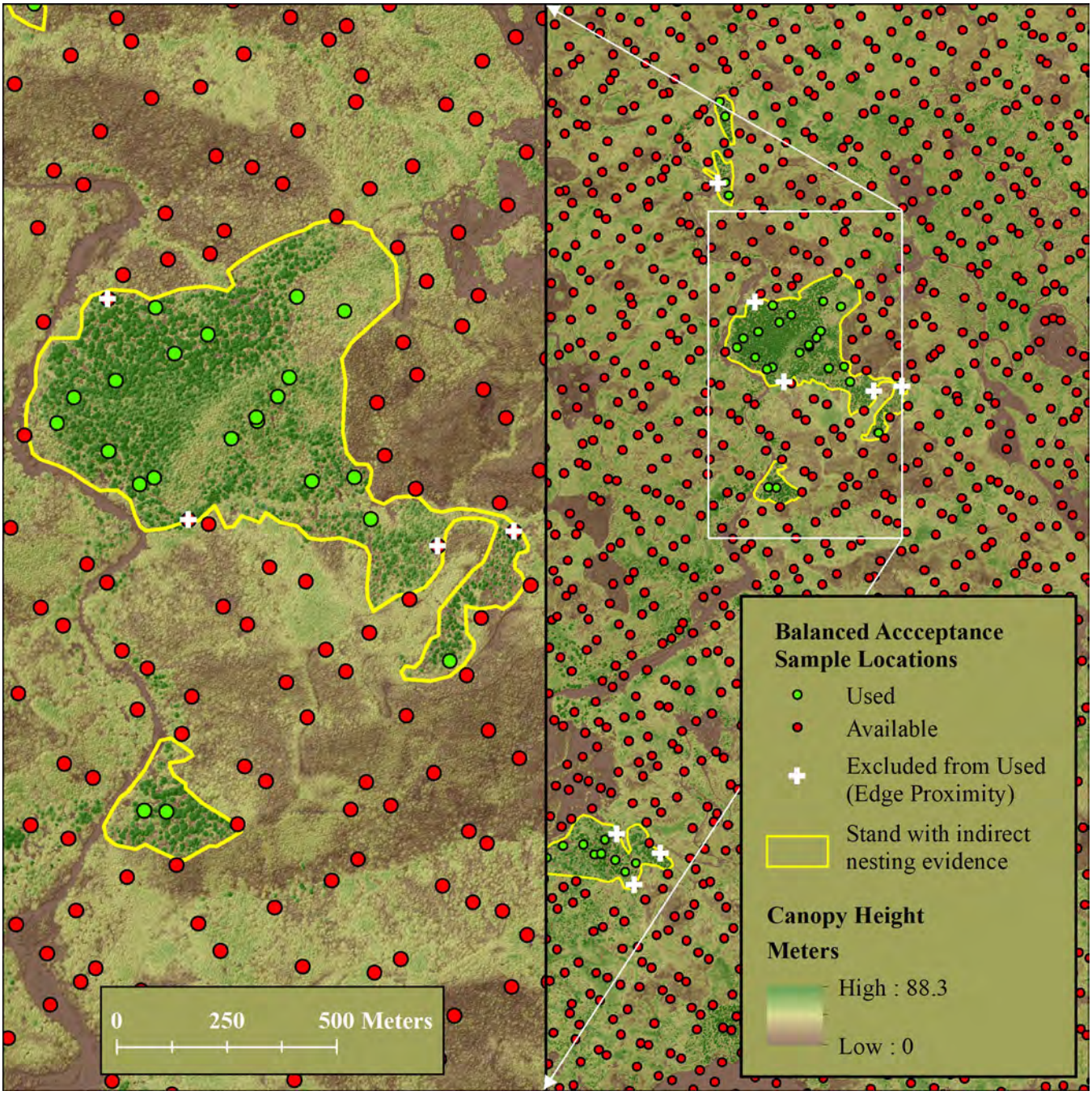

Fig 2. Balanced acceptance sampling (BAS). Illustration of Balanced Acceptance Sample (BAS) within the study area. We sampled "used" points (green dots) and "available" locations (both green and red dots) at an average density of one point per 5 acres. We excluded from the sample of "used" points any location within 20 meters inside the boundary of a patch with indirect evidence of nesting to reduce moving window edge effects (white crosses). We classified all BAS points (inside, outside, and near boundary) as "available". Dark brown areas with low canopy height are prior clear cuts of varying age.

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deviation of TAOs $\geq$ 50 meters in height within 1- and 5-acre circular plots surrounding the (x, y) location of a voxel [48]. The "TAO Point Density" group included 15 covariates such as number of TAOs $\geq$ 50 meters within a 1- and 5-acre circular plot centered on the voxel's (x, y) location. Only covariates in the "TAO Point Statistics" and "TAO Point Density" groups were averaged over spatial areas and subject to bias near patch edges, which we mitigated by

eliminating used points within 20 meters of patch boundaries. Spatial reference for our 5-meter resolution covariate grids was NAD83, UTM Zone 10.

Model selection

We investigated pairwise correlations among covariates by computing Pearson's R^2, Cramer's V, and box plots. From these, we identified pairs and groups of correlated variables that could cause model instability if included in the same model. We identified correlated covariates despite the known robustness of two-sample HSMs to covariate collinearity [49, 50]. We considered these sets of correlated covariates during all phases of model selection, except the first.

We performed HSM model selection in 4 phases. Phase 1 screened covariates in each of our six covariate themes by fitting all theme covariates to the "used" and "available" points at once in Maxent. Strongly correlated covariates in the same group were allowed in the Phase 1 model because Phase 1 simply screened variables based on predictive strength. We assessed the predictive strength of individual covariates using a combination of measures reported by Maxent. We evaluated marginal plots, percent contribution, permutation importance, regularized training gain, and testing gain to assess predictive strength [51]. High strength covariates exhibited a biologically reasonable marginal response, fitting the known and accepted knowledge base, and possessed high relative influence (typically values $\geq$ 20), as measured by percent contribution and permutation importance. Maxent's jackknife test measured the goodness of fit of the model. We advanced covariates with jackknife values of approximately 2.5 or better during both regularized training and testing gain. A jackknife value of 2.5 translates to a likelihood improvement of 12.2 (= exp (2.5)) times relative to the null model [52].

During phase 2, we combined the top Phase 1 covariates across groups into a single model but prohibited correlated covariates from appearing in the same model. We defined covariates to be correlated when their pairwise Pearson and Cramer V statistics exceeded 0.65. Due to these correlation prohibitions, we ultimately obtained two HSM models each containing nine pairwise uncorrelated covariates. At the end of Phase 2, we advanced the covariates from each model that exhibited high predictive strength based on percent contribution, permutation importance, regularized training gain, and testing gain.

During Phase 3, we divided the five unique covariates that advanced from Phase 2 into four groups of three uncorrelated covariate groups (Pearson's R^2 less than 0.65). We fitted each of the four models and assessed relative quality using the Akaike information criterion (AIC) [53] over 10 bootstrap resamples of the data. We inspected boxplots of AIC over bootstrap iterations and advanced to Phase 4 the model with the lowest median AIC.

During phase 4, we optimized Maxent's regularization multiplier using the best Phase 3 model. Prior phases had Maxent's regularization multiplier set at a value of 2. Phase 4 was designed to investigate the predictive strength of multipliers around 2. We tried nine regularization multipliers from 1.0 to 5.0 in steps of 0.5 and chose the value with lowest median AIC over 10 bootstrap resamples.

During all model selection phases, we set Maxent to perform 10 bootstrap replicates each with 5000 fitting iterations. We used scaled logistic output and model form combinations of Linear, Quadratic, Product, and Hinge shapes. During each bootstrap replicate, Maxent fitted the HSM model to a random subset of 80 percent of the selected "used" locations and computed model fit statistics on the remaining 20 percent.

Habitat classification

To classify habitat across the study area, we estimated break points in a smoothed continuous P/E ratio curve [25, 26]. P/E curves provide insight into an organism's use of the available

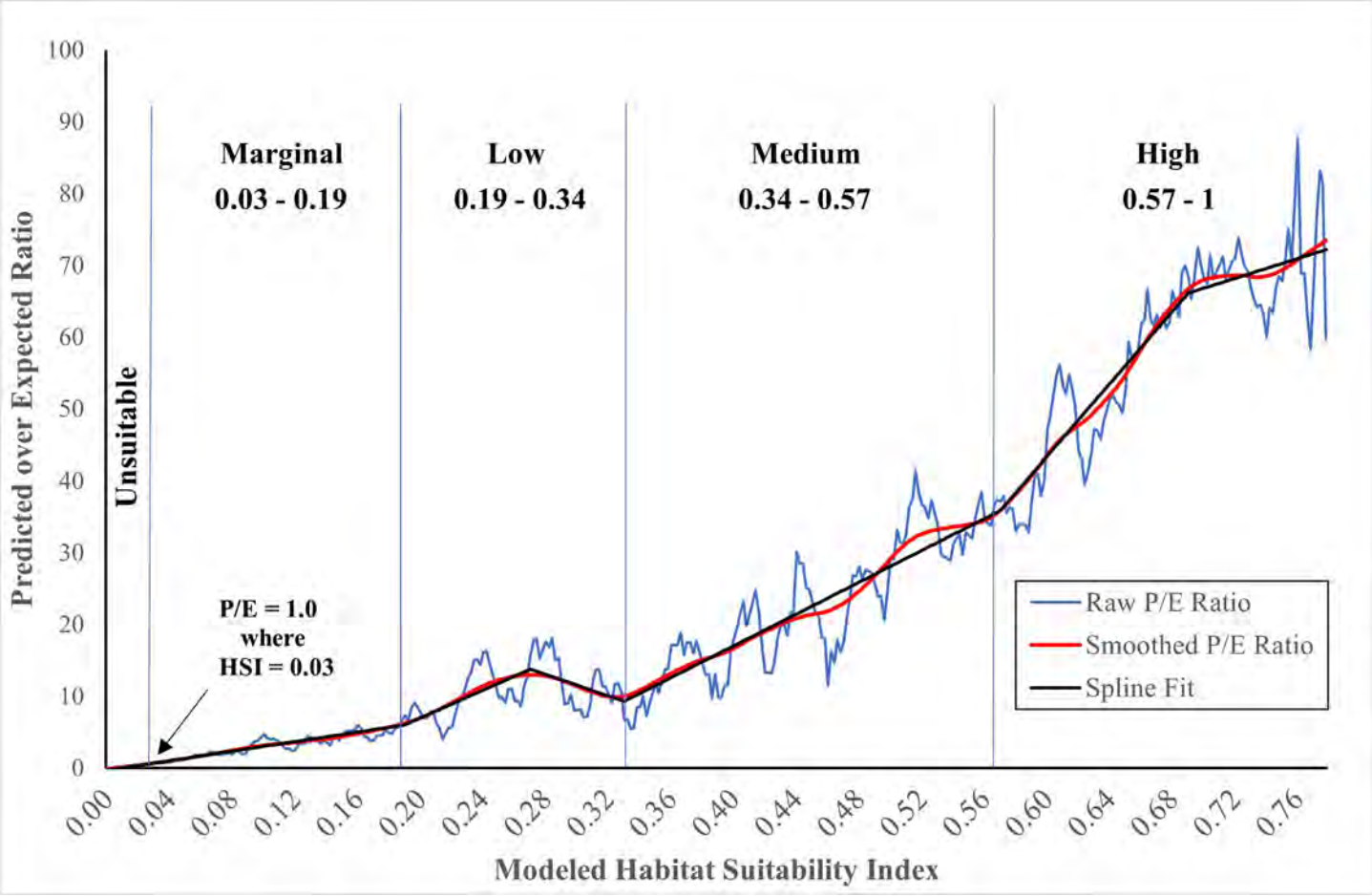

Fig 3. Predicted-to-Expected (P/E) ratio curve. P/E curve from the final HSM model showing the continuous Boyce (raw P/E ratio) curve, smoothed curve [54]; function supsmu in R) and fitted lines from a spline model with kinks at habitat classification breaks.

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habitat as predicted by model HSI values. The expectation from a sound result is that as model predicted habitat quality increases use will increase as well. We constructed the P/E curve from our final HSM predictions using overlapping bins (discrete ranges) of predicted HSI values with widths equal to 0.02 centered on values from 0.02 to the maximum prediction, in steps of 0.002. Segments of the P/E curve with different slopes indicate changes in the accumulation of "used" points relative to "available" and represent a change in selection habits relative to the other segments (Fig 3). To identify specific breakpoints, we fitted a piece-wise linear curve via ordinary least-squares to the smoothed P/E curve and searched for the best fitting habitat breakpoints via direct search across all possible breakpoint combinations. We computed breakpoints on a smoothed version of the raw P/E ratios that we smoothed using function "supsmu" in R [54] to aid visual interpretation and speed the search for breakpoints; but the identified breakpoints varied little when we segmented the un-smoothed P/E curve.

We forced the first habitat breakpoint at the maximum HSI value with P/E < 1.0 because those areas contained fewer "used" points than expected by chance [26]. We regarded locations with P/E < 1.0 to be "unsuitable". For P/E values > 1.0, we combined areas with predicted values between each of the best-fitting breakpoints and attached a descriptive label to the class. Ultimately, we identified four habitat classes for areas with P/E values > 1.0 that we

labeled "marginal", "low", "medium", and "high" (see Results). We used these categories to delineate murrelet habitat patches.

Patch delineation

We identified marbled murrelet habitat patches by first mapping habitat classes onto 5-meter raster cells (i.e., pixels) covering the entire study area. We then buffered patches of "low" or better habitat outward by 80.25 meters (263 feet) to encompass areas adjacent to the patch that could have contributed to habitat quality inside the "low" and better patch (Fig 4). Our buffer distance (i.e., 80.25 meters) was the radius of the 2-hectare (5-acre) circular moving windows that were a part of the best model's TAO-based covariates and hence TAOs within this distance contributed to predictions inside the patch. Within this buffered region, we identified all TAOs $\geq$ 50 meters. We then placed a concave hull [55] around all TAOs $\geq$ 50 meters and smoothed its perimeter to construct boundaries around patches of habitat with better-than-random selection characteristics. We computed concave hulls using the concaveman R package [56] with concavity parameter set to 0.8 and default length threshold set to 0.0. We smoothed the perimeter of our concave hulls by computing a 60-meter outward buffer followed by a 55-meter inward buffer. This outward and inward buffering process removed many internal intrusions (bays between peninsulas) when they occurred and thereby made the perimeter both more conservative (larger), realistic, and easier to follow in the field.

Model evaluation

We used the receiver operating characteristic curve (ROC) and area under curve (AUC) output from Maxent to evaluate overall model prediction ability. AUC ranges from 0 to 1, with a value of 0.5 indicating predictions no different than random chance and with AUC = 1 indicating perfect discrimination. In addition to AUC, we computed the sensitivity of our model to correctly predict "used" locations given a specific threshold above which locations were considered "habitat", and below which locations were considered "not habitat". Using that same threshold, we computed the Positive Predictive Value [57] and Cohen's Kappa [58, 59] to assess the predictive value of our HSM. We evaluated marginal plots of relative probability of selection (i.e., HSI value) by each covariate in the final model to gain insight into model predictions and to assess the biological reasonableness of predictions in each dimension.

Results

HSM model selection

The six Maxent runs completed during Phase 1 (covariate screening) yielded eleven covariates (S2 Table in S1 File). We advanced three covariates from the TAO Point Density and TAO Point Statistics themed groups, two from the Biogeographic/Geographic group, and one each from the TAO Percentiles, Canopy metrics, and Climate groups. At the end of Phase 1, we discounted two covariates (Coast_Dist and PPT) with high influence because they exhibited implausible bimodal marginal plots at the extremes of their ranges. We ultimately discounted another variable (ZCI) that was initially elevated to Phase 2 but exhibited very low Permutation Importance and regularized training/testing gain. The categorical nature of the ZCI variable, essentially defining the coastally influenced fog zone, provided little spatial discrimination in our study area.

After separating correlated covariates, we fitted two Maxent models during Phase 2 of model selection (S2 Table in S1 File). Both models contained nine uncorrelated variables. We identified top variables in both models, removed duplicates among the top models, and

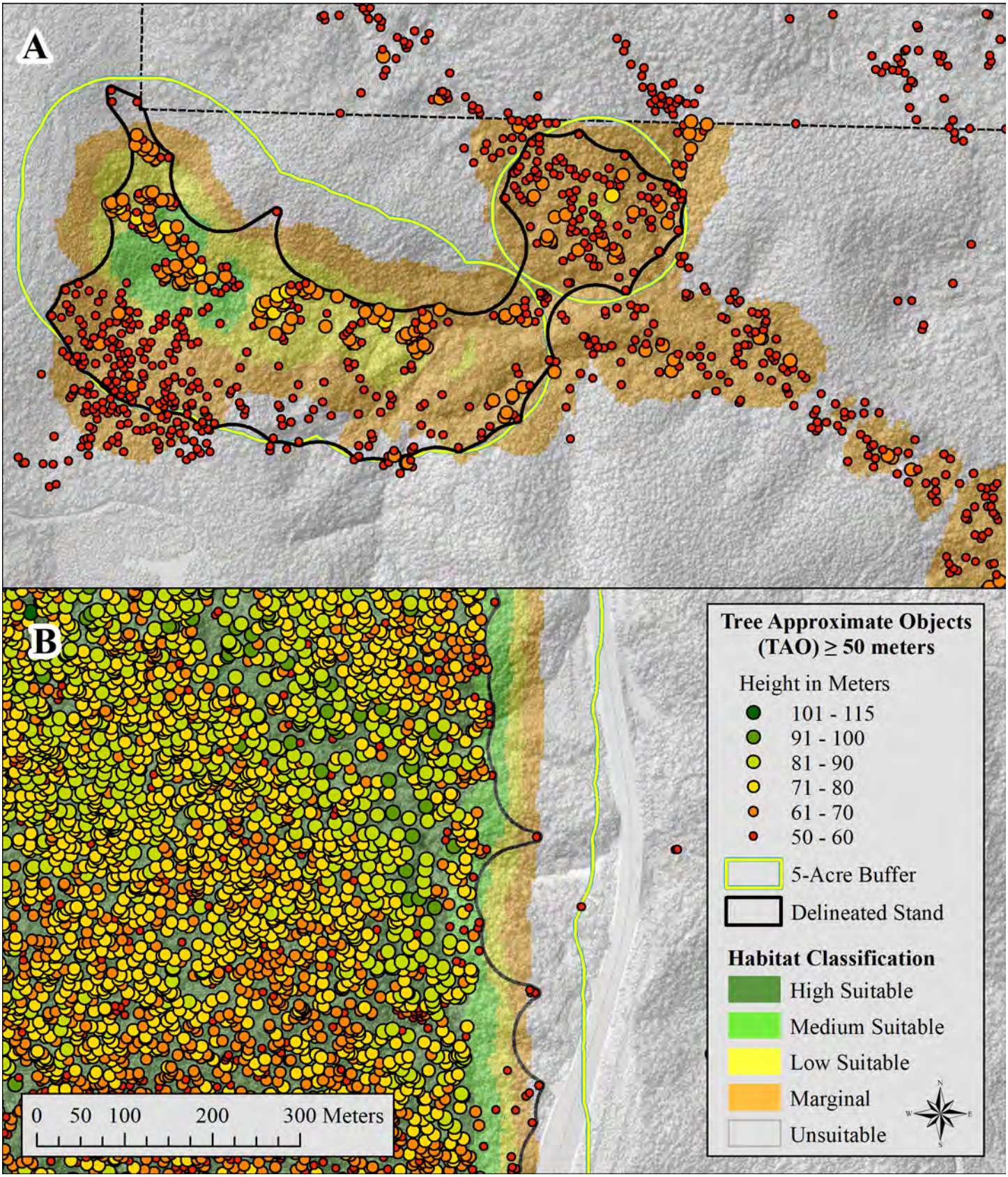
A
B
Tree Approximate Objects (TAO) ≥ 50 meters
Height in Meters
101 - 115
91 - 100
81 - 90
71 - 80
61 - 70
50 - 60
5-Acre Buffer
Delineated Stand
Habitat Classification
High Suitable
Medium Suitable
Low Suitable
Marginal
Unsuitable
0 50 100 200 300 Meters

Fig 4. Habitat delineation and TAOs. Map panels show examples of delineated marbled murrelet habitat patches. Patch boundaries (black) were derived by constructing a five-acre (2-hectare, 80.25 meter) buffer around Low or better suitability pixels (HSI values ≥ 0.19, Fig 3), selecting all tree approximate objects (TAO) ≥ 50 meters in height inside the buffer, and computing a concave hull around these trees. TAOs ≥ 50 meters within 80.25 meters of a pixel contributed to predictions of Low and better habitat areas. Panel (A) illustrates a higher quality patch delineated on Green Diamond property within the Plan Area and panel (B) illustrates an area of old-growth forest in Redwood National and State Park between the Plan Area boundary and the ½ mile outer buffer delineating the boundary of the Study Area.

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advanced five covariates from Phase 2 to 3. All five advancing covariates came from the TAO-based density and height themed groups. Covariates in the percentile and canopy metric groups, as well as those in the biogeographic, and climate groups displayed little predictive value compared to the TAO-based density and height covariates. In this stage, the Simpson Diversity Index for TAO height classes (SDI_3cl_5ac) appeared to perform well exhibiting a high Percent Contribution but yielded a very low Permutation Importance. During ancillary Phase 2 investigations, we discovered computational inconsistencies in the Simpson Diversity Index results and dropped this covariate.

During Phase 3, we fitted four models that represented all possible models of uncorrelated covariates (S2 Table in S1 File). Among these four, the model containing density of TAOs ≥ 60 meters, total height of TAOs ≥ 50 meters, and the standard deviation of TAO heights ≥ 50 meters produced the lowest median AIC (ΔAIC to next best model = 39.3). This model also produced the least variability in AIC among the four models tested (Fig 5), suggesting stability and consistency among random replicates. Among covariates in this model, tree density (TAOs ≥ 60 meters) and total height (of TAOs ≥ 50 meters) contributed more to predictions than the standard deviation of tree height (of TAOs ≥ 50 meters).

We ran Maxent nine times during Phase 4 to identify the best regularization multiplier (RM) between 1.0 and 5.0. The Maxent run with RM equal to 2.0 produced the lowest AIC among those tested and the least amount of variation over bootstrap replicates (Table 1, Fig 6). We set RM to 2.0 during covariate selection (Phases 1 through 3) and we were not surprised that RM = 2.0 produced the lowest AIC because we found in prior Maxent modeling efforts that an RM = 2.0 is a good compromise between model complexity (lower RM values) and simplicity (higher RM values). We acknowledge that using a different RM during Phases 1 through 3 could conceivably have resulted in a different best-fitting model. Regardless, the minimum AIC with RM = 2.0 supports the idea that no other combination of RM and covariates in our final model performed better, and subsequent model evaluation indicated that our final model adequately fitted the "used" and "available" data.

Marginal plots for the three TAO-based density and height covariates in our final model (Fig 7) revealed positive correlations between relative probability of selection and all three measures. HSI values associated with TAO density increased linearly from 0 (no trees ≥ 60 meters) to 25 tall trees per hectare (10 trees per acre) in a surrounding 2-hectare (5-acre) circle. HSI values associated with standard deviation of TAO height increased linearly from 0 to 6 meters (19.7 feet) in a 2-hectare (5-acre) circle, respectively. Beyond those levels, relative probability of selection reached a maximum at 10 meters, then decreased. For the sum of individual TAO heights within the surrounding 2-hectare (5-acre) area, HSI values increased curvilinearly, plateauing around a sum of 13,000 meters, without appreciable change to 15,000 meters.

Habitat classification

The continuous P/E curve for our study showed a generally increasing trend from 0.0 up to the maximum HSI value of 0.78 (Fig 3). Our P/E ratio exceeded 1.0 for HSI values greater than 0.03; hence we considered areas with HSI <= 0.3 as "unsuitable" The best fitting break point

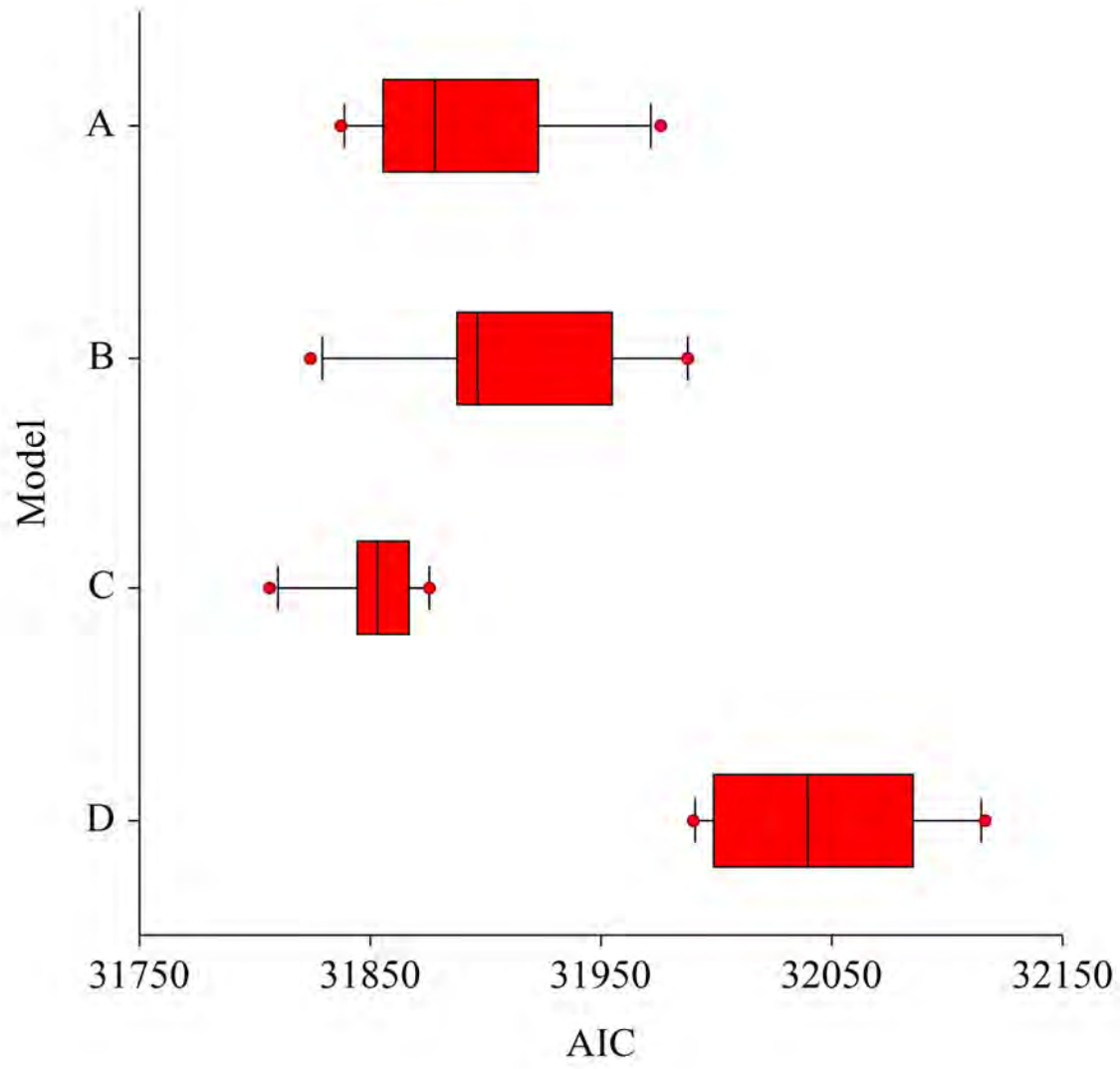

Fig 5. AIC plot - Final model selection. Box and whisker plots of Akaike Information Criteria (AIC) values for the four models with three-variable combinations. The best three-variable model (C) consisted of the point density of tree approximate objects (TAO) ≥ 60m within a 5ac buffer, the sum of heights of TAO ≥ 50m within a 5ac buffer, and the standard deviation of TAO ≥ 50m within a 5ac buffer. Median and dispersion for model C are the lowest suggesting both parsimony and consistency between replicates. Box boundaries are at the 25th and 75th percentiles, the whiskers extend from the 10th to the 25th and the 75th to the 90th percentiles, and the outliers (red dots) are represented beyond the whiskers.

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model for HSI values above 0.03 included five break points at 0.19, 0.27, 0.34, 0.57, and 0.69. The P/E segment between 0.27 and 0.34 identified P/E ratios with negative slope in HSI value. Decreasing P/E on this segment may be due to removal of "used" locations within 20 meters of "used" patch edges that we implemented to reduce edge effects. We consider the brief and small decrease in P/E in this segment an anomaly in an otherwise monotonically increasing curve and immaterial to management implications; consequently, we removed the 0.27 break-point thereby combining the adjacent categories. In addition, we discarded the breakpoint at 0.69 because it fell at the highest end of the suitability curve where the slope of the line flattens and hence imparted little management concern. The final set of breakpoints delineated the

Table 1. AIC based regularization multiplier assessment. The results of nine iterative replicated model runs of the best candidate (3var_C) resulting from varying the Regularization Multiplier (RM) in Maxent from 1 to 5 by steps of 0.5 and listed by Akaike Information Criteria (AIC) values. The RM value of 2.0 exhibited both the lowest AIC value and least AIC dispersion between replicates followed by a non-competitive RM of 1.0 (ΔAIC of 6.8).

Regularization Multiplier	Average Number of Model Parameters	Average of log Likelihood	Average AIC	Delta AIC
2.0	36.7	-15889.3	31852.0	
1.0	42.7	-15886.7	31858.7	6.8
2.5	34.7	-15900.5	31870.5	18.5
1.5	38.7	-15902.9	31883.3	31.3
3.5	30.0	-15916.7	31893.4	41.4
3.0	33.5	-15913.8	31894.7	42.7
4.0	34.3	-15918.1	31904.7	52.7
5.0	30.2	-15932.0	31924.5	72.5
4.5	33.6	-15931.6	31930.4	78.5

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five habitat classes which we labeled unsuitable (0 – 0.03), marginal (0.03 – 0.19), low (0.19 – 0.34), medium (0.34 – 0.57), and high (0.57 – 0.78). We note that a large proportion of the "marginal" areas were adjacent to and dependent upon areas of "low" or better habitat. That is, without the supporting TAOs in nearby "low" or better habitat, a large proportion of our "marginal" habitat would have been deemed "unsuitable" (Fig 4).

Under our classification scheme, the study area, and smaller Plan Area were heavily dominated by unsuitable habitat (96.01% and 98.08% respectively) due to the scarcity of TAOs $\geq$ 50 meters (Table 2). The remainder of the Study and Plan Areas are mostly marginal (2.36% and 1.63%), with less than 0.7% in the low, medium, or high classifications. We found that 20 of the 24 historic known used patches in the Plan Area contained at least one HSI value in the medium or high habitat suitability index range, while 17 of the 24 contained average HSI values in the low or better classes (Fig 8).

Patch delineation

In the Study Area, we identified 312 patches encompassing 5,421 hectares (13,395 acres; Fig 9). Similarly, within the smaller Plan Area, we identified 171 patches, encompassing 729 hectares (1,802 acres), that received classifications of low suitability or better (Table 3). Within the Plan Area, twenty-four of the 171 patches occurred in or adjacent to known "used" patches. An additional 34 patches in the Plan Area were near boundaries where most of the contributing TAOs were located just outside of the Plan Area but still in the Study Area (e.g., Prairie Creek Redwoods State Park).

In the Plan and Study Areas, polygon patches we considered occupied comprised 89.9% and 99.5%, respectively, of the raster-based high habitat classification, 54.2% and 66.8% of the medium classification, and 30.7% and 28.9% of the low classification. Not surprisingly, these figures indicate that most of the better murrelet habitat occurred in the patches we considered occupied, and hence few high-quality patches exist outside our already identified "used" patches. Small areas of low, medium, or high suitability were occasionally left outside of concave hull delineated patches because they lacked 50-meter and taller trees (Fig 4).

Model evaluation

Our final HSM model attained an AUC value of 0.99 (Table 4, Fig 10). Furthermore, AUC varied little over the ten bootstrap replicates evaluated by Maxent. AUC = 0.99 indicates a model with very high predictive ability and low probability of false negatives. We adopted the lower

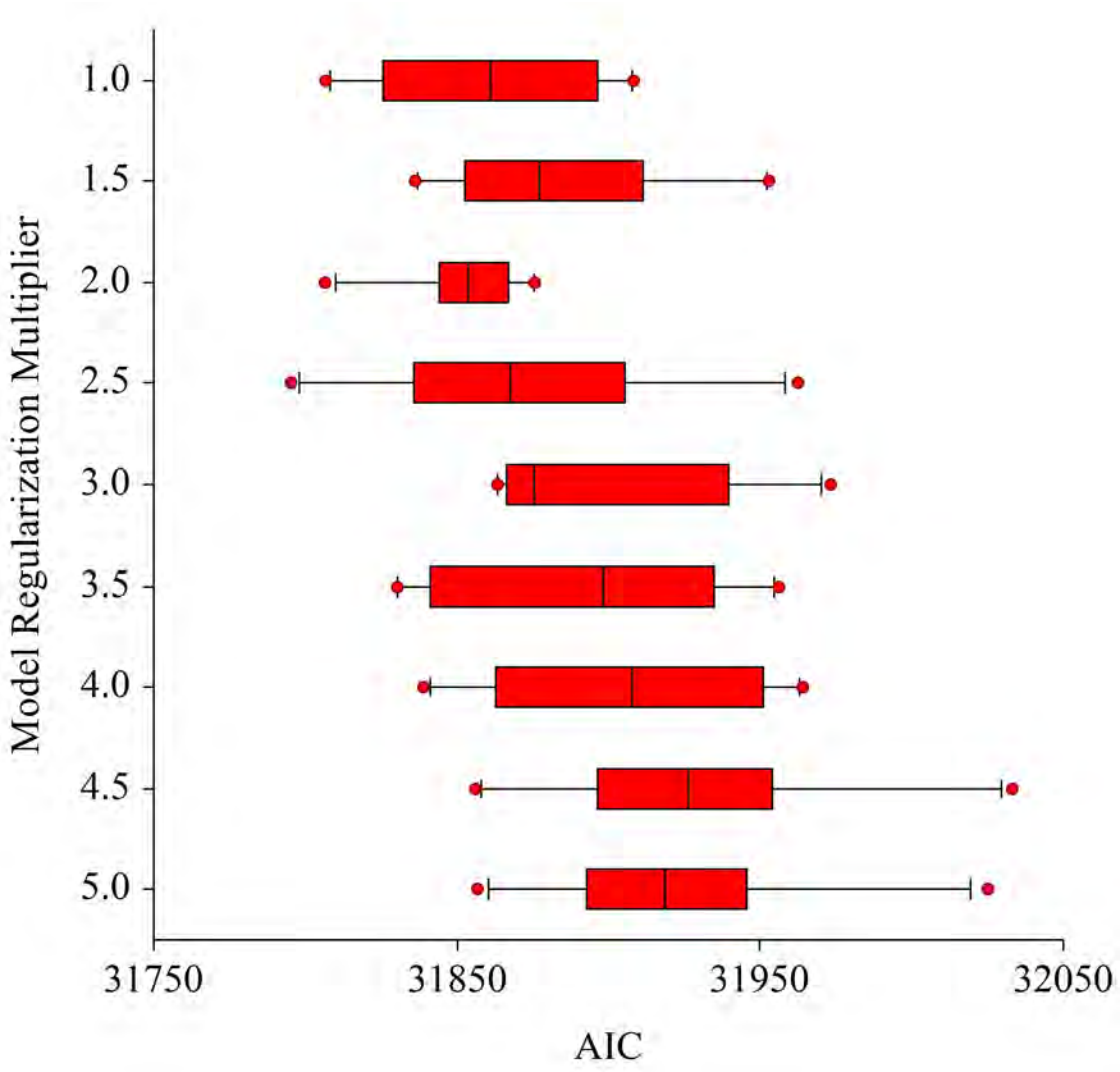

Fig 6. AIC plot - Regularization multiplier assessment. Box and whisker plots of Akaike Information Criteria (AIC) values for the best three-variable model (C) with regularization multiplier varied from 1.0 to 5.0 in 0.5 increments. Median and dispersion for the model with RM = 2.0 are the lowest suggesting both parsimony and consistency between replicates. Box boundaries are at the 25th and 75th percentiles, the whiskers extend from the 10th to the 25th and the 75th to the 90th percentiles, and the outliers (red dots) are represented beyond the whiskers.

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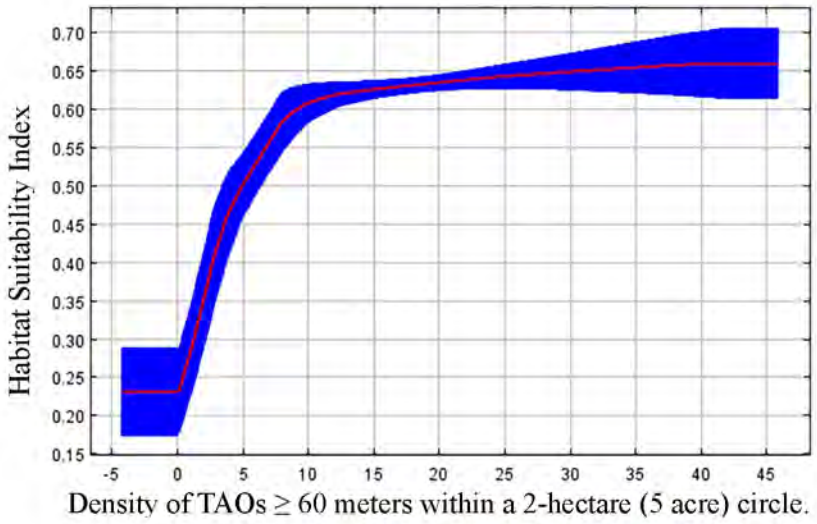
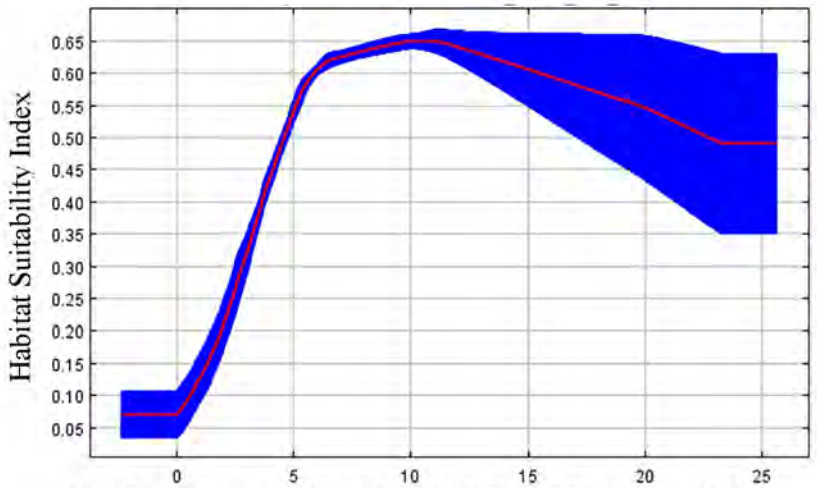
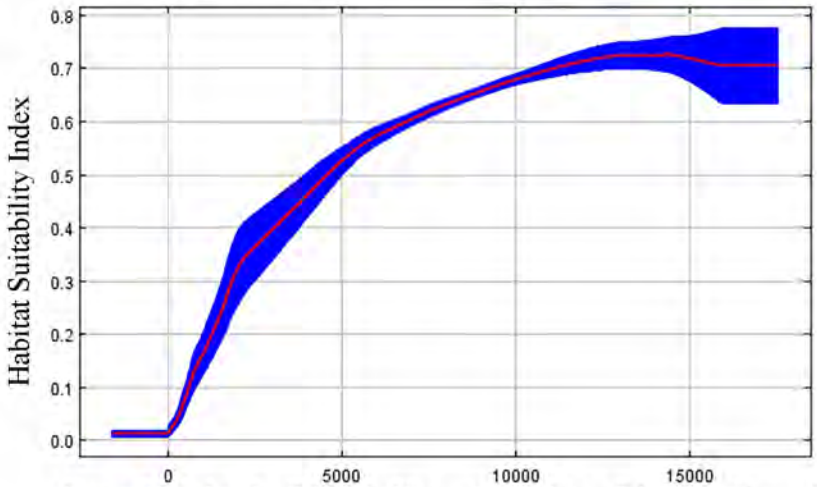
limit of the Low habitat class (i.e., HSI = 0.19) as the threshold above which we classified an area as murrelet habitat. With this threshold, our model achieved a sensitivity value of 0.89 indicating that nearly all "used" locations had HSI values above the threshold and were predicted to be habitat by the model. Our model attained a Positive Predictive Value (PPV) of 0.49, indicating a significant number of "available" locations (987) with HSI values above the threshold (0.19). Our model achieved a Cohen's Kappa value of 0.63 and indicated "substantial" agreement between the predicted habitat areas and known "used" locations if we adopt the guidelines of Landis and Koch [60]. Other authors consider Cohen's Kappa = 0.63 to be "good" agreement [61, 62].Table 5 presents these results in a confusion matrix format, reinforcing the metrics from Table 4.



Density of TAOs ≥ 60 meters within a 2-hectare (5 acre) circle.



Standard deviation of height for TAOs ≥ 50 meters within a 2-hectare (5 acre) circle.



Sum of heights for TAOs ≥ 50 meters within a 2-hectare (5 acre) circle.

Fig 7. (Top, Middle, and Bottom) Final model covariate response plots. Marginal plots showing response of relative habitat suitability to final model covariates: (Top) Density per acre of TAOs ≥ 60 meters tall within a 5-acre circle, (Middle) Standard deviation in height for TAOs ≥ 50 meters tall within a 5-acre circle, and (Bottom) Sum of heights for TAOs ≥ 50 meters tall within a 5-acre circle. The red line represents the mean value for 10 replicate runs and the blue shade is ± one standard deviation.

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Discussion

Our "used" habitat records on private timberland were derived from focused surveys conducted by trained individuals after input and guidance from regulatory agencies. We surveyed a wide and representative range of environmental conditions within the study area to establish used patches because these surveys were necessary to obtain timber harvest permits. Our BAS sample minimized sampling bias of background values because points came from a spatially balanced sample of environmental conditions within and outside of known occupied habitats.

Within the California range of marbled murrelets, only 26 nest trees have been reported and only 1 fell on private timberland in our study area. These 26 nest trees were used in analyses conducted for the Northwest Forest Plan [28], and these authors supplemented their small sample size by including additional information from eggshell fragments (n=56), downed young (n=11), and an equivalent total number of occupied sites (n=93). Like Hamer and Nelson [14] and Lorenz et al. [28], we used several sources of information to determine habitat use. We sourced most information from inland audio-visual surveys conducted on private timberland prior to timber harvest plan approvals from 1992 to 2021. During this period, we conducted audio-visual surveys in all areas that the landowner, state, and federal agencies agreed could potentially be murrelet habitat. Hence, the surveyed areas covered all potential murrelet habitat based on the prevailing knowledge of habitat during the study period. In total, we surveyed 26 such areas and our model ended up classifying these areas as ranging from unsuitable to medium, with most classified as unsuitable or marginal.

We do not know the degree to which detection probability varies with the covariates influencing the relative probability of occupancy [63]. However, on private timberlands we used data from surveys designed to clear areas for timber harvest and that were designed to detect murrelet presence with 95% or greater accuracy. Because of this, we discount the possibility that a large number of murrelets were not detected on private timberlands and that the rare non-detection depended on covariates affecting selection. We also discount the possibility that high densities of large trees reduce detection probability because the audio-visual surveys were specifically designed to detect murrelets in these situations.

We used a very large "available" sample which has been noted to artificially improve AUC simply because it is partially dependent on the ratio of "used" to "available" points [63]. Our large "available" sample was necessary to adequately quantify the distribution of extremely

Table 2. Summary of habitat classes by plan and study area. Areal extant and percentage within each marbled murrelet habitat class (HSM raster), along with relative habitat suitability index (HSI) range, on the Plan and Study area.

		Plan Area		Study Area	
Habitat Class	HSI Range	Hectares (Acres)	Percent	Hectares (Acres)	Percent
Unsuitable	0.0 – 0.03	142,319 (351,678)	98.08%	228,847 (565,491)	96.01%
Marginal	0.03 – 0.19	2,370 (5,856)	1.63%	5,617 (13,880))	2.36%
Low	0.19 – 0.34	243 (601)	0.17%	1,106 (2,732)	0.46%
Medium	0.34 – 0.57	143 (354)	0.10%	1,155 (2,855)	0.48%
High	0.57 – 0.78	24 (60)	0.02%	1,630 (4,028)	0.68%
Total		145,100 (358,549)	100.00%	238,355 (588,987)	100%

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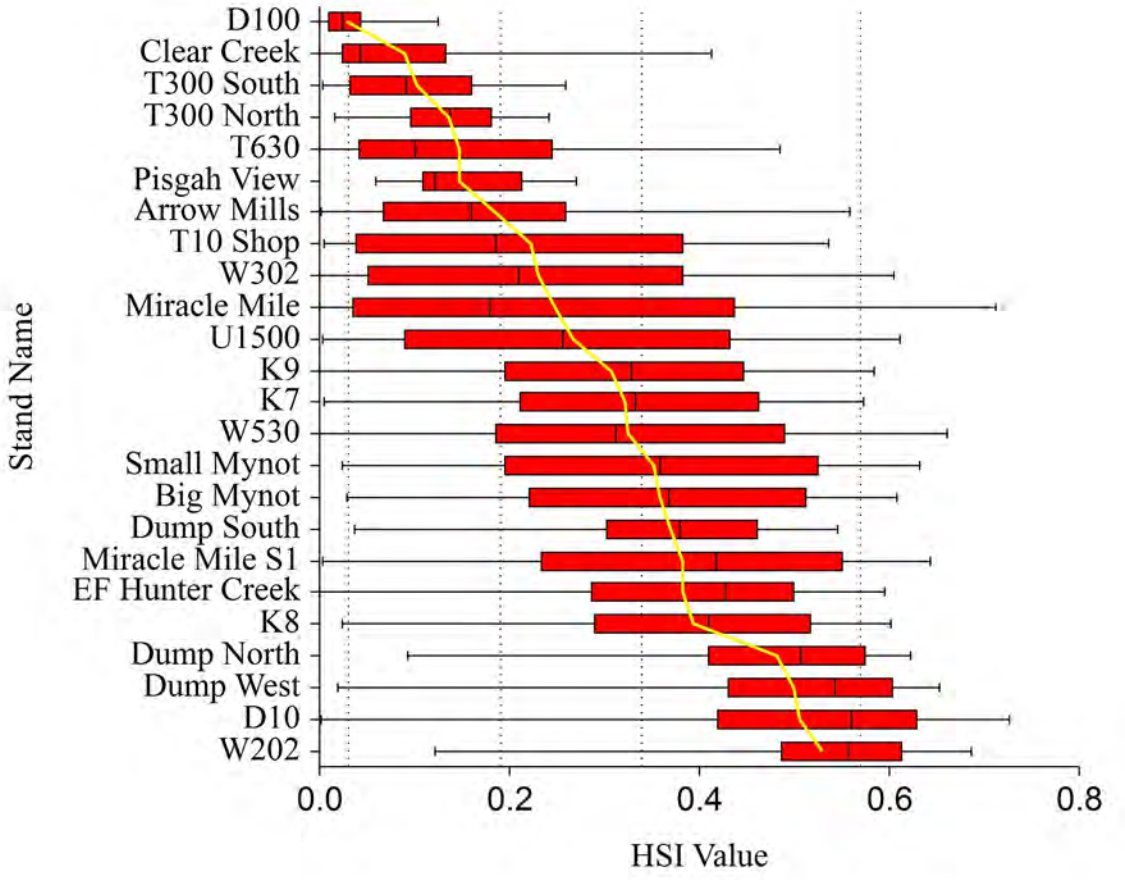

Fig 8. Mean and median HSI values for historic murrelet stands. Box and whisker plots showing mean and median Habitat Suitability Model (HSM) values of 24 historic forest stands containing observed marbled murrelet nesting behavior. Box boundaries are at the 25th and 75th HSM percentiles, the whiskers extend to the extents of the range, and the yellow line represents the mean HSM value. Vertical dashed lines represent the boundaries of the derived habitat classification; unsuitable (0 - 0.03), marginal (0.03 - 0.19), low (0.19 - 0.34), medium (0.34 - 0.57), and high ($\geq$ 0.57).

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patchy and sometimes rare environmental conditions relevant to marbled murrelets. To assess whether our large "available" sample artificially inflated AUC, we refitted the final model after randomly reducing the "available" sample from 117,804 to 11,828 records (10.04% of the original). The refitted final model yielded an AUC of 0.987 compared to the original model's AUC = 0.989. Likewise, we simulated the effects of smaller "available" samples on Cohen's Kappa by successively halving the "available" sample. Contrary to expectations, Kappa increased from 0.63 (117,804 "available" points) to a maximum of 0.90 (7,295 "available" points – close to the Maxent default of 10,000) then decreased to 0.72 (228 "available" points). While variable, all simulated Kappa values suggest substantially better prediction than random classification. Generally, Kappa (κ) values less than 0.4 are considered poor, $0.4 < \kappa < 0.75$ are considered good, and κ greater than or equal to 0.75 excellent [58, 60–62]. Our reported value of 0.63 falls in the "good" range.

Our HSM scored very high to reasonably well on the predictive accuracy measures we computed. The principal issue impeding higher sensitivity scores is the existence of used locations with HSI values below the threshold of 0.19 (i.e., false negatives) affecting approximately 11% of our "used" sample. Two conditions resulted in false negatives. The foremost was due to

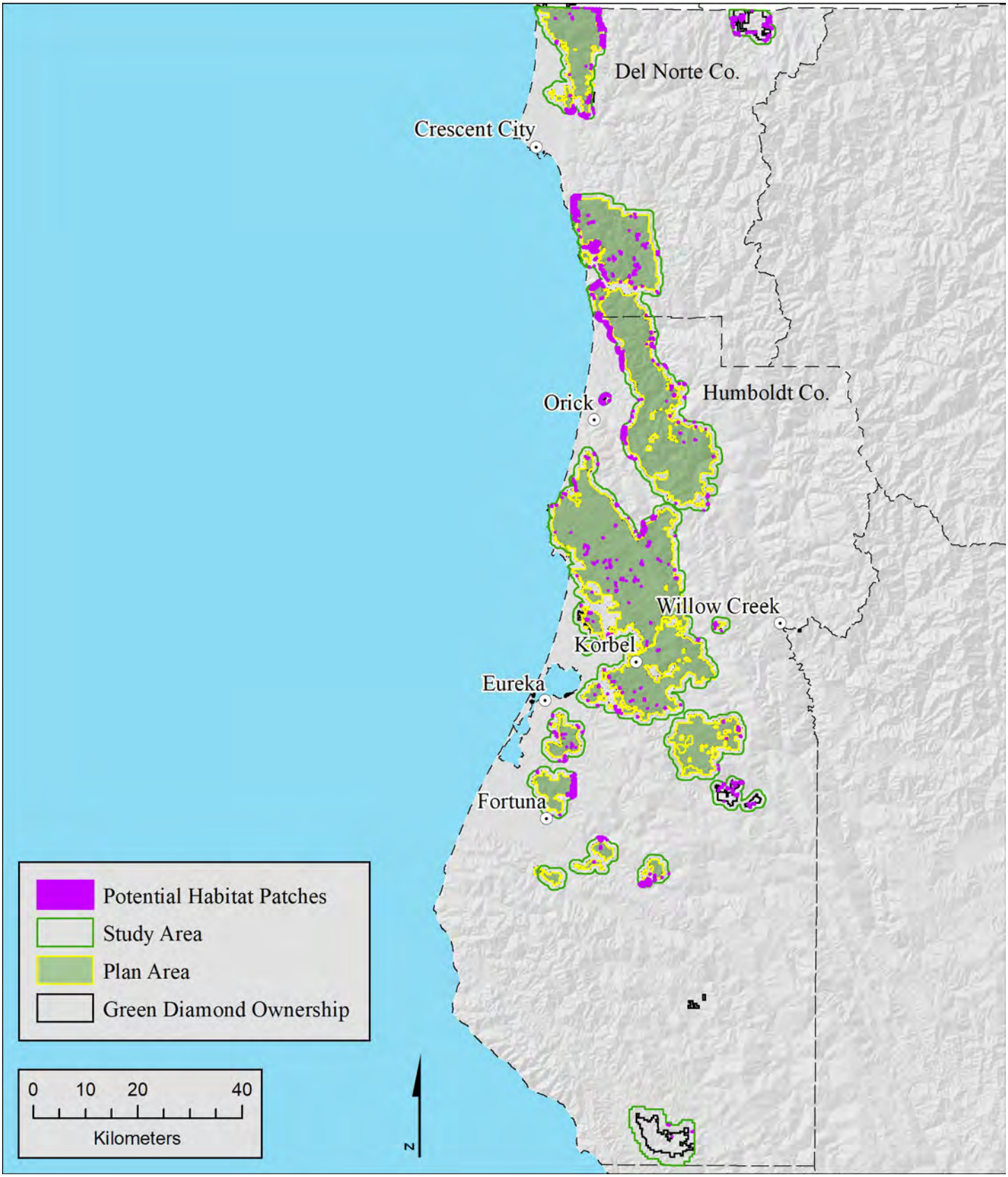
Del Norte Co.
Crescent City
Humboldt Co.
Orick
Willow Creek
Korbel
Eureka
Fortuna
Potential Habitat Patches
Study Area
Plan Area
Green Diamond Ownership
0 10 20 40
Kilometers
N

Fig 9. Potential habitat across the study area. Distribution of potential habitat patches within the Study Area. Patches were identified via a concave hull process applied to all TAO's within a five-acre buffer (80.25m radius) of areas identified as low suitable or better (HSI $\geq$ 0.19) by the Maxent model.

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forest heterogeneity within the occupied patches falling mostly on managed timberlands. Within the "used" patches, internal and edge inclusions of low-quality habitat (sparse large trees) with HSI values below the threshold were present in approximately 8% of the used sample. A less important effect occurred near the abrupt edge between old trees and surrounding young forest. Model selection supported a 2-hectare (5-acre, 80.25-meter radius) moving window to calculate predictor variables resulting in gradual decreases in HSI values as the circular window moved out of presumed nesting patches and into adjacent younger forest (Fig 11). This decline near patch edges results in approximately 3% of our used locations near patch edges being associated with HSI values below the threshold.

PPV is directly affected by the presence of predicted habitat outside of the "used" or known occupied patches. Our relatively low PPV value is typical in "used" - "available" HSM predictive efforts where the extent of true occupancy is likely greater than known prior to modeling and when the sample of used locations is small relative to the study area.

Our correlative HSM model indicated that fine-scale, LiDAR-based, individual tree covariates were the best predictors of habitat suitability for marbled murrelets. We summarized the height and density of our derived individual trees (TAOs) at two different scales, 1-acre, and 5-acre, using moving window methods that best represent existing known and potential habitat patches within the study area. Synthesizing individual tree metrics using moving window methods is a compromise between selecting too small an area, and detail is lost, too large an area and resolution is lost. Exploratory assessment of known murrelet stands suggested areas less than 1-acre increased noise due to small sample size (no TAOs within the circle) and areas greater than 5 acres failed to resolve the clear boundaries between previously mapped habitat and the surrounding young managed timberlands. During model selection, the 5-acre scale outperformed covariates compiled at the 1-acre scale and no climatic or biographic/geographic themed variable performed well enough to be included in the final phase. We conclude that the 5-acre scale is a better predictor of marbled murrelet habitat within managed landscapes where environmental covariates are patchily distributed and more dispersed than in large homogeneous old growth stands. We hypothesize that low variation in the climatic, biographic, and geographic variables at a study area scale rendered these covariates ineffective as

Table 3. Summary of model delineated habitat. The values represent the model predicted area by suitability classes and occupancy status, rounded to the nearest whole hectare, based on the raw HSM raster. "Used" patches are those with documented occupied behaviors, and within the Study Area include patches on Federal and State parks, Bureau of Land Management reserves, unharvested old growth private managed forests, partially harvested old growth forests, and younger (< 70 years old) second and third growth forests with residual old growth trees. "Available" patches are areas with non-confirmed Occupancy (Occupied behaviors) status. Both "Used" and "Available" are delineated by methods described in the text.

	Plan Area (Green Diamond only)					
	Unsuitable	**Marginal**	**Low**	**Medium**	**High**	**Plan Total**
Used	16	86	70	96	24	292
Available	21	270	118	29	0	437
Total	37	356	188	125	24	729
	Study Area (Green Diamond plus ½-mile off-property buffer)					
	Unsuitable	**Marginal**	**Low**	**Medium**	**High**	**Study Total**
Used	109	377	339	627	1,465	2917
Available	172	1,083	620	466	163	2504
Total	281	1,460	960	1092	1628	5,421

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Table 4. Model performance measures. Predictive performance measures for the final model of marbled murrelet habitat using training data and HSI threshold of 0.19. Sensitivity is the number of correctly predicted used locations divided by the total number of locations predicted to be "habitat" (i.e., TP / (TP + FN) = 956 / 1,080). Positive predictive value is number of correctly predicted used locations divided by total number of used locations (i.e., TP / (TP + FP) = 956 / (956 + 987). Cohen's Kappa measures the agreement between known and predicted values and is defined as 2(TP * TN – FN * FP) / (TP + FP) * (FP + TN) + (TP + FN) * (FN + TN)) (i.e., 221,044,368 / 351,924,612).

Performance Metric	Metric Value
Area under the curve (AUC)	0.99
Sensitivity - True Positive Rate (TPR)	0.89
Positive Predictive Value (PPV)	0.49
Cohen's Kappa (k)	0.63

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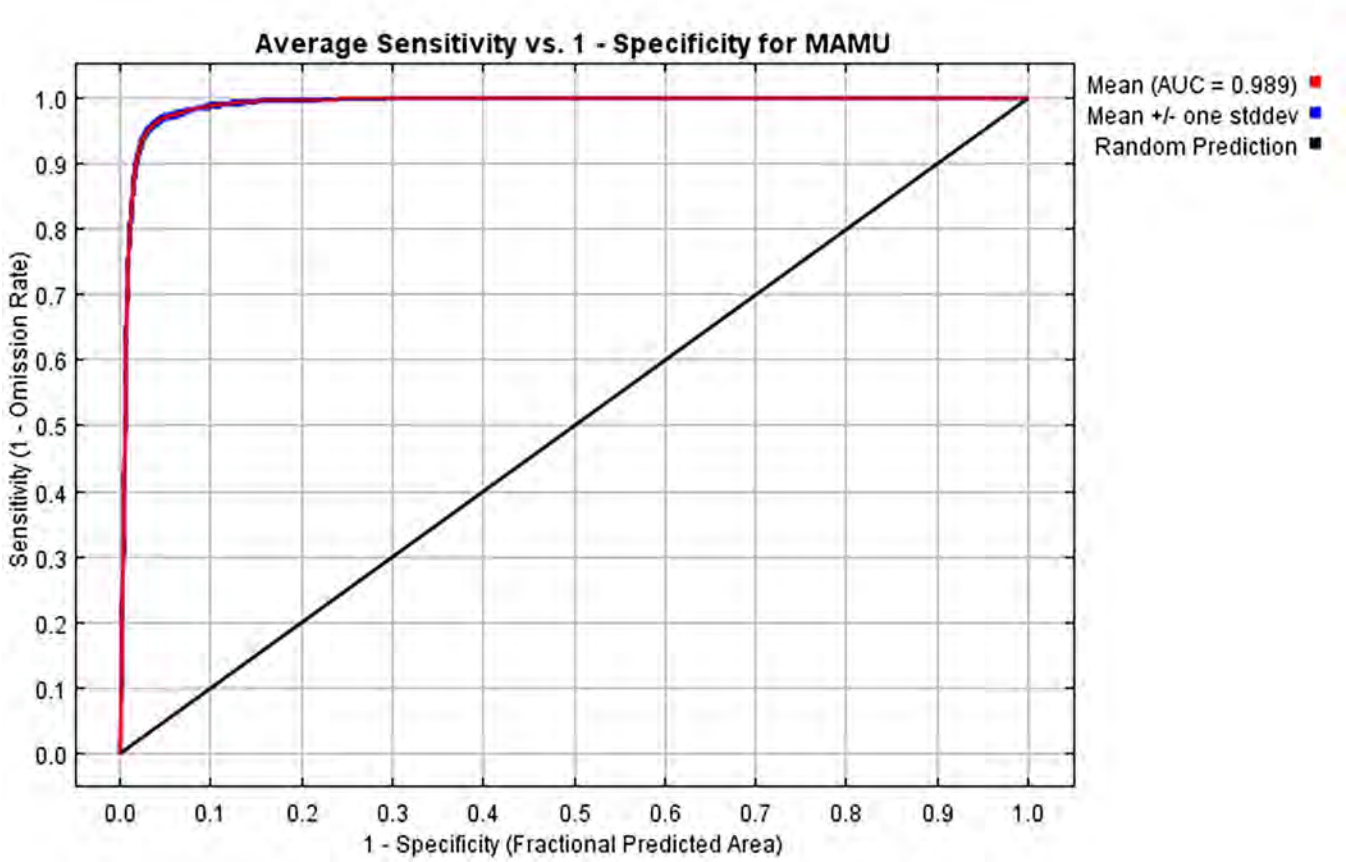

Fig 10. Receiver Operating Characteristic (ROC) curve. This ROC curve is an average of 10 replicate runs. The average training Area Under the ROC Curve (AUC) for replicate runs is 0.989, and the average standard deviation is 0.001. The best model in our analysis predicting the environmental niche of marbled murrelets for the study area had an AUC value of 0.989 and exhibited very low deviation from the mean of the ten replicates over the full ROC curve. This value indicates a model with high predictive ability and low probability of false negatives.

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Table 5. Confusion matrix. Contingency table showing the true positives, false positives, false negatives, and true negatives based on the "used" and "available" model input and the predicted model output.

	True Positive (Used)	True Negative (Available)	Total
Predicted Positive (Used)	TP = 956	FP = 987	1,943
Predicted Negative (Available)	FN = 124	TN = 115,737	115,861
Total	1,080	116,724	117,804

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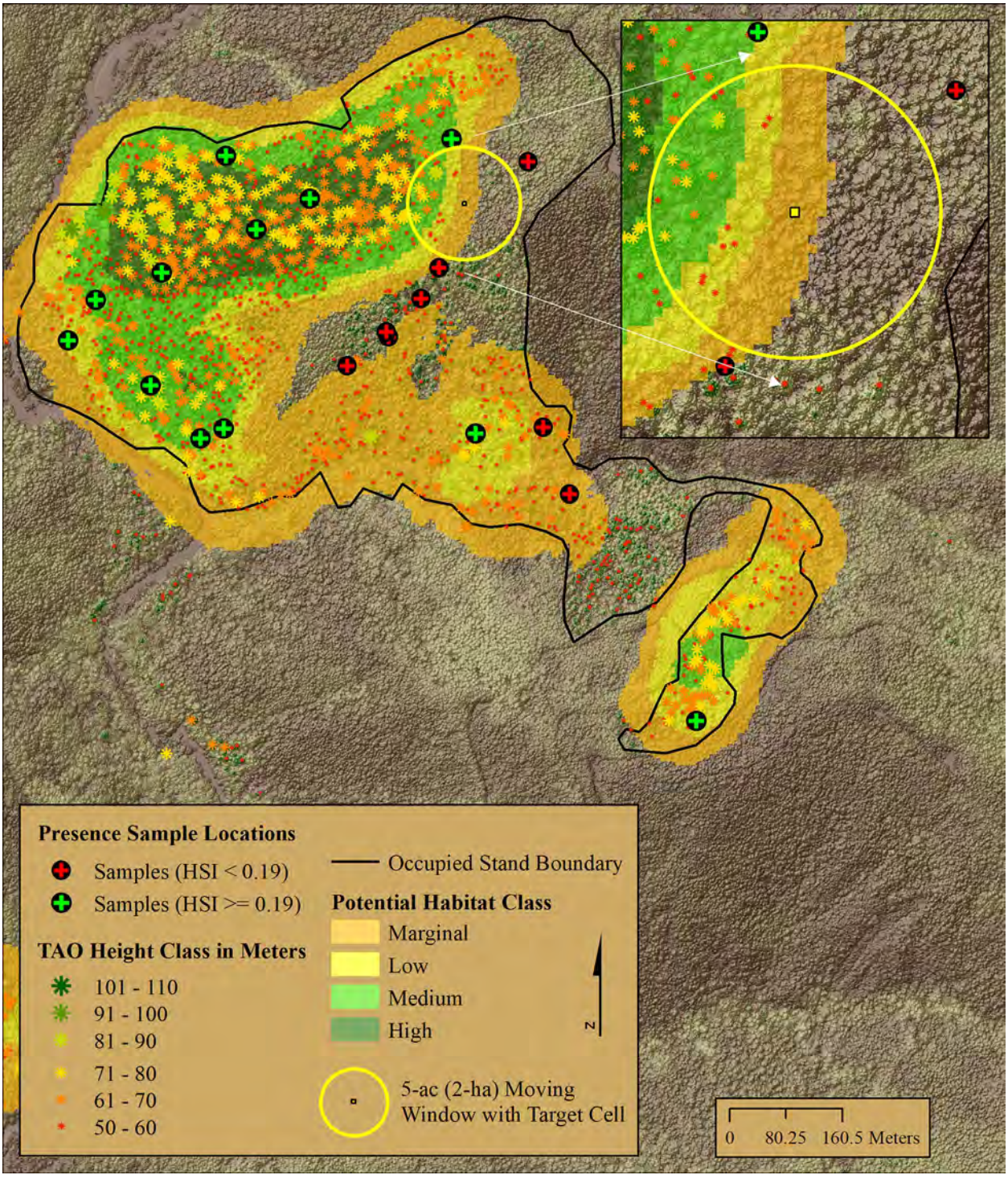

Fig 11. BAS training samples. An example of BAS sample locations used to train the Maxent model, TAOs ≥ 50 meters tall, potential habitat classifications, and 5-acre circular moving window with central target cell. As the 5-acre circular window moves from a core area containing higher densities of TAOs ≥ 50 meters to non-habitat area with low densities or no TAOs ≥ 50 meters outside the occupied stand, the modeled HSI values calculated for the target cell decrease as a result. This heterogenous distribution of TAOs ≥ 50 within occupied stands results in internal pockets and areas adjacent to the occupied stand edges with HSI values below the threshold value of 0.19 leading to perceived errors of omission (black circle/red +).

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predictors. We suspect habitat selection could be associated with natural geographic factors such as topographic position and distance to coast (which is positively correlated with elevation) as found in other studies [64, 65]; however, the entire relevant range of geographic and topographic conditions was not well represented in our study and hence the variable selection procedure did not include these factors in the model.

In Oregon, Hagar et al. [64] used a suite of Gradient Nearest Neighbor (GNN) covariates and LiDAR derived covariates to develop a logistic regression model predicting relative probability of marbled murrelet occupancy in similar aged forest stands that were all considered potential habitat based on age ($>$ 80 years) and structural characteristics. They found that the model with five LiDAR derived variables along with distance to the coast performed better than the model with GNN derived variables. The LiDAR variables they used were better predictors of habitat for marbled murrelets at stand and watershed scales when applied to independent data sets, although overall performance was low on the independent data set. They interpreted the LiDAR-derived variables in their model as cover in the upper portion of the canopy, maximum tree height, maximum height of the bottom of the canopy, variation in vertical stratification of the canopy, and distribution of variation across canopy height intervals. These findings are consistent with studies that found multi-layered old forests provide the components necessary to support nesting by marbled murrelets [14, 17, 66]. Clyde [65] assessed the use of individual tree objects, modeled from LiDAR to calculate the local Moran's I spatial statistic (LMI), to identify the presence of vertically isolated trees and or clusters of tall trees. While the LMI metric yielded low predictive power, canopy height was shown to be important for the highest ranked areas.

Finally, our study advances understanding of marbled murrelet habitat use by incorporating fine scale LiDAR derived individual tree metrics (height, height diversity and density) directly into predictive covariates. All three LiDAR variables included in our HSM are more direct measures of small-scale marbled murrelet habitat requirements than indirect area-based point cloud metrics derived at various raster scales and resolutions. However, because our data contains information on tall trees $\geq$ 50 meters, field assessments of the presence, quantity, and quality of platforms may facilitate identification of habitat because young tall trees might not provide suitable platforms for nesting [67]. In the future, LiDAR point cloud data may provide platform information on individual trees that will inform future marbled murrelet HSMs.

Supporting information

S1 File.
(ZIP)

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References

1. McShane C, Hamer T, Carter H, Swartzman G, Friesen V, Ainley D, et al. Evaluation report for the 5-year status review of the marbled murrelet in Washington, Oregon, and California. Report to the U.S. Fish and Wildlife Service. 2004.
2. Raphael MG, Falxa GA, Lynch D, Nelson SK, Pearson SF, Shirk AJ, et al. Status and trend of nesting habitat for the marbled murrelet under the Northwest Forest Plan. In: Northwest Forest Plan — the first 20 years (1994-2013): status and trend of marbled murrelet populations and nesting habitat. Pacific Northwest Research Station General Technical Report PNW-GTR-933. 2016. https://doi.org/10.2737/PNW-GTR-933
3. Oregon Department of Fish and Wildlife. Status Review of the Marbled Murrelet (Brachyramphus marmoratus) in Oregon and evaluation of criteria to reclassify the species from threatened to endangered under the Oregon endangered species act. Oregon Department of Fish and Wildlife. 2018.
4. Meyer CB, Miller SL, Ralph CJ. Multi-scale landscape and seascape patterns associated with marbled murrelet nesting areas on the U.S. west coast. Landscape Ecology. 2002; 17: 95–115.
5. Meyer CB, Miller SL, Ralph CJ. Logistic regression accuracy across different spatial and temporal scales for a wide-ranging species, the marbled murrelet. In: Resource Selection Methods and Applications. Omnipress. 2003. pp. 94–106.
6. Raphael MG, Shirk AJ, Falxa GA, Lynch D, Nelson SK, Pearson SF, et al. Factors influencing status and trend of marbled murrelet populations: an integrated perspective. In: Northwest Forest Plan — the first 20 years (1994-2013): status and trend of Marbled Murrelet populations and nesting habitat. Pacific Northwest Research Station General Technical Report PNW-GTR-933. 2016. https://doi.org/10.2737/PNW-GTR-933
7. Valente JJ, Nelson SK, Rivers JW, Roby DD, Betts MG. Experimental evidence that social information affects habitat selection in marbled murrelets. Ornithology 2021; 138: 1–13. https://doi.org/10.1093/ornithology/ukaa086
8. Burger AE. Using radar to estimate populations and assess habitat associations of Marbled Murrelets. Journal of Wildlife Management. 2001; 65: 696–715.
9. Burger AE. Conservation assessment of marbled murrelets in British Columbia: review of the biology, populations, habitat associations and conservation. 2002. Technical Report Series. No. 387. Canadian Wildlife Service. www.sfu.ca/biology/wildberg/bertram/mamurt/links.htm.
10. Cullen SA. Using radar to monitor populations and assess habitat associations of marbled murrelets within the Sunshine Coast forest district. 2002. Surrey, British Columbia: Ministry of Water, Land and Air Protection.
11. Nelson SK, Huff MH, Miller SL, Raphael MG. Marbled murrelet biology: habitat relations and populations. In: Northwest Forest Plan—The first 10 years (1994-2003): Status and trends of populations and nesting habitat for the marbled murrelet. Pacific Northwest Research Station General Technical Report PNW-GTR-650. 2006. https://doi.org/10.2737/PNW-GTR-650
12. Baker LM, Peery MZ, Burkett E, Singer SW, Suddjian DL, Beissinger SR. Nesting habitat characteristics of the marbled murrelet in central California redwood forests. Journal of Wildlife Management 2006; 70: 939–946.

13. Hamer TE. Inland habitat associations of marbled murrelets in western Washington. In: Ecology and conservation of the marbled murrelet. Pacific Southwest Research Station General Technical Report PNW-GTR-152. 1995. https://doi.org/10.2737/PSW-GTR-152

14. Hamer TE, Nelson SK. Characteristics of marbled murrelet nest trees and nesting stands. In: Ecology and conservation of the marbled murrelet. Pacific Southwest Research Station General Technical Report PNW-GTR-152. 1995. https://doi.org/10.2737/PSW-GTR-152

15. Grenier JJ, Nelson SK. Marbled Murrelet habitat associations in Oregon. In: Ecology and conservation of the marbled murrelet. Pacific Southwest Research Station General Technical Report PNW-GTR-152. 1995. https://doi.org/10.2737/PSW-GTR-152

16. Miller SL, Ralph CJ. Relationship of marbled murrelets with habitat characteristics at inland sites in California. In: Ecology and conservation of the marbled murrelet. Pacific Southwest Research Station General Technical Report PNW-GTR-152. 1995. https://doi.org/10.2737/PSW-GTR-152

17. Nelson SK, Wilson AK. Marbled Murrelet habitat characteristics on state lands in western Oregon. OR Cooperative. Fish and Wildlife Research Unit, Oregon State University, Department of Fisheries and Wildlife, Corvallis. 2002.

18. Oregon Department of Fish and Wildlife. Biological assessment of the marbled murrelet (Brachyramphus marmoratus) in Oregon and evaluation of criteria to reclassify the species from threatened to endangered under the Oregon endangered species act. Oregon Department of Fish and Wildlife, Salem, Oregon. 2021.

19. Hamer TE, Nelson SK, Jones J, Verschuyl J. Marbled murrelet nest site selection at three fine spatial scales. Avian Conservation and Ecology 2021; 16: 4. https://doi.org/10.5751/ACE-01883-160204

20. Meyer CB, Miller SL, Ralph CJ. Stand-scale habitat associations across a large geographic region of an old-growth specialist, the marbled murrelet. Wilson Bulletin. 2004; 116: 197–210.

21. Hébert PN, Golightly RT. Movements, nesting, and response to anthropogenic disturbance of marbled murrelets (Brachyramphus marmoratus) in Redwood National and State Parks, California. 2006. Report FHWA/CA/IR-2006/04. Sacramento, CA: California Department of Transportation.

22. Golightly RT, Hamilton CD, Hebert PN. Characteristics of marbled murrelet (*Brachyramphus marmoratus*) habitat in northern California. 2009. Report to the California Department of Fish and Game, Sacramento, CA.

23. Carter HR, Erickson RA. Status and conservation of the marbled murrelet in California, 1892-1987. 1988. California Department of Fish and Game, Sacramento, CA. 68pp.

24. Evans Mack D, Ritchie WP, Nelson SK, Kuo-Harrison E, Harrison P, Hamer TE. Methods for surveying Marbled Murrelets in forests: a revised protocol for land management and research. 2003. Pacific Seabird Group Technical Publication Number 2. Available from: https://pacificseabirdgroup.org/psg-publications/technical-publications/

25. Boyce MS, Vernier PR, Nielsen SE, Schmiegelow F. Evaluating resource selection functions. Ecol Modell. 2002; 157: 281–300. https://doi.org/10.1016/S0304-3800(02)00200-4

26. Hirzel AH, Le Lay G, Helfer V, Randin C, Guisan A. Evaluating the ability of habitat suitability models to predict species presences. Ecological Modelling. 2006; 199: 142–152. https://doi.org/10.1016/j.ecolmodel.2006.05.017

27. PRISM Climate Group, Oregon State University, http://prism.oregonstate.edu, acquired Feb. 2023.

28. Lorenz TJ, Raphael MG, Young RD, Lynch D, Nelson SK, McIver B. Status and trend of nesting habitat for the marbled murrelet under the Northwest Forest Plan, 1993 to 2017. Pacific Northwest Research Station General Technical Report PNW-GTR-998. 2021.

29. Manly BF, McDonald LL, Thomas DL, McDonald TL, Erickson WP. Resource selection by animals: statistical design and analysis for field studies. 2nd ed. Kluwer Academic Publishers. 2002.

30. Warton D, Aarts G. Advancing our thinking in presence-only and used-available analysis. The Journal of Animal Ecology. 2013; 82: 1125–1134. https://doi.org/10.1111/1365-2656.12071 PMID: 23488567

31. Phillips SJ, Dudík M, Schapire RE. A maximum entropy approach to species distribution modeling. Proceedings of the twenty-first international conference on machine learning. 2004; 655–662.

32. Guillera-Arroita G, Lahoz-Monfort JJ, Elith J, Gordon A, Kujala H, Lentini PE, et al. Is my species distribution model fit for purpose? matching data and models to applications. Global Ecology and Biogeography. 2015; 24: 276–292. https://doi.org/10.1111/geb.12268

33. Plissner JH, Cooper B, Day RH, Sanzenbacher PM, Burger AE, Raphael MG. A review of marbled murrelet research related to nesting habitat use and nest success. Final Report Prepared for Oregon Department of Forestry, Salem, Oregon. 2015; 424 pp.

34. Washington Department of Natural Resources. Appendix D. Occupied Sites Focus Paper. In: Long-term conservation strategy for the marbled murrelet. Final Environmental Impact Statement. Washington Department of Natural Resources, Olympia, WA. 2019. https://www.dnr.wa.gov/mmltcs.

35. Chinnici SJ. Marbled murrelet inland monitoring annual report. 2020. https://www.hrcllc.com/sites/default/files/inline-files/2020%20Marbled%20Murrelet%20Annual%20Report.pdf.

36. Humboldt Redwood Company. Habitat conservation plan for the properties of The Pacific Lumber Company, Scotia Pacific Company LLC, and Salmon Creek Corporation. The Pacific Lumber Company, Scotia, California, USA. 1999. https://www.hrcllc.com/sites/default/files/inline-files/HCP%20updated%20to%2003-2019.pdf

37. Ralph CJ, Nelson SK, Shaughnessy MM, Miller SL, Hamer TE. 1994. Methods for surveying marbled murrelets in forests: a protocol for land management and research. Pacific Seabird Group.

38. Bigger D, Peery MZ, Chinnici S, Courtney S. Efficacy of audio-visual and radar surveys for studying marbled murrelets in inland habitats. Journal of Wildlife Management. 2006; 70: 505–516.

39. California Department of Forestry and Fire Protection. California Forest Practice Rules. 2024. https://bof.fire.ca.gov/media/qs5p1yk4/2024-forest-practice-rules-and-act-final.pdf.

40. Robertson BL, Brown JA, McDonald TL, Jaksons P. BAS: Balanced acceptance sampling of natural resources. Biometrics. 2013; 69: 776–784. https://doi.org/10.1111/biom.12059 PMID: 23844595

41. Brown JA, Robertson BL, McDonald TL. Spatially balanced sampling: application to environmental surveys. Procedia Environmental Sciencies. 2015; 27: 6–9.

42. LAStools. 2019. Efficient LiDAR Processing Software (version 190507, academic), obtained from http://rapidlasso.com/LAStools

43. Popescu SC, Wynne RH. Seeing the trees in the forest: Using lidar and multispectral data fusion with local filtering and variable window size for estimating tree height. Photogrammetric Engineering and Remote Sensing. 2004; 70: 589–604. https://doi.org/10.14358/PERS.70.5.589

44. Tiede D, Hochleitner G, Blaschke T. A full GIS based workflow for tree identification and delineation using laser scanning. The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences. 2005; XXXV1: 9–14.

45. Chen Q, Baldocchi D, Gong P, Kelly M. Isolating individual trees in a savanna woodland using small footprint lidar data. Photogrammetric Engineering and Remote Sensing. 2006; 72: 923–932.

46. Jeronimo SMA, Kane VR, Churchill DJ, McGaughey RJ, Franklin JF. Applying LiDAR individual tree detection to management of structurally diverse forest landscapes. Journal of Forestry. 2018; 116: 336–346. https://doi.org/10.1093/jofore/fvy023

47. Hirzel AH, Le Lay G. Habitat suitability modeling and niche theory. Journal of Applied Ecology. 2008; 45: 1372–1381. https://doi.org/10.1111/j.1365-2664.2008.01524.x

48. North MP, Kane JT, Kane VR, Asner GP, Berigan W, Churchill DJ, et al. Cover of tall trees best predicts California spotted owl habitat. Forest Ecology and Management. 2017; 405: 166–178. https://doi.org/10.1016/j.foreco.2017.09.019

49. Elith J, Phillips SJ, Hastie T, Dudik M, Chee YE, Yates CJ. A statistical explanation of Maxent for ecologists. Diversity and Distributions. 2011; 17: 43–57. https://doi.org/10.1111/j.1472-4642.2010.00725.x

50. Feng X, Park DS, Liang Y, Pandey R, Papes M. Collinearity in ecological niche modeling: confusions and challenges. Ecology and Evolution. 2019; 9: 10365–10376. https://doi.org/10.1002/ece3.5555 PMID: 31624555

51. Phillips SJ. 2017. A Brief Tutorial on Maxent. Available from url: http://biodiversityinformatics.amnh.org/open_source/maxent/. Accessed on 07/11/2019.

52. Young N, Carter L, Evangelista P. A MaxEnt Model v3.3.3e Tutorial (ArcGIS v10), Natural Resource Ecology Laboratory at Colorado State University. 2011. http://ibis.colostat.e.edu/webcontent/ws/coloradoview/tutorialsdownloads/a_maxent_model_v7.pdf.

53. Akaike H. A new look at the statistical model identification, IEEE Transactions on Automatic Control. 1974; 19: 716–723. https://doi.org/10.1109/TAC.1974.1100705

54. Friedman JH. 1984. SuperSmoother: A variable span scatterplot smoother. Laboratory for Computational Statistics, Stanford University Technical Report No.5. R-Package supsmu.

55. Park JS, Oh SJ. A new concave hull algorithm and concaveness measure for n-dimensional datasets. Journal of Information Science and Engineering. 2012; 29; 379–392.

56. Gombin J, Vaidyanathan R, Agafonkin V. A very fast 2D concave hull algorithm in JavaScript, wrapped in R. 2020. http://www.github.com/joelgombin/concaveman/

57. Parikh R, Mathai A, Parikh S, Chandra Sekhar G, Thomas R. Understanding and using sensitivity, specificity and predictive values. Indian Journal of Ophthalmology. 2008; 56: 45–50. https://doi.org/10.4103/0301-4738.37595 PMID: 18158403

58. Cohen J. A coefficient of agreement for nominal scales. Educ Psychol Meas. 1960; 20: 37–46. https://doi.org/10.1177/001316446002000104 hdl:1942/28116. S2CID 15926286.

59. Smeeton NC. Early history of the kappa statistic. Biometrics. 1985; 41: 795. JSTOR 2531300.

60. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics. 1977; 33: 159–174. https://doi.org/10.2307/2529310 PMID: 843571

61. Fleiss JL. Statistical methods for rates and proportions. 2nd ed. New York: John Wiley; 1981.

62. Luck GW. 2002. The habitat requirements of the rufous treecreeper (Climacteris rufa). 2. validating predictive habitat models. Biological Conservation. 2002; 105; 395–403. https://doi.org/10.1016/S0006-3207(01)00223-3

63. Yackulic C, Chandler R, Zipkin E, Royle J, Nichols J, Grant E, et al. Presence-only modelling using MAXENT: When can we trust the inferences? Methods in Ecology and Evolution. 2013; 4: 236–243. https://doi.org/10.1111/2041-210x.12004

64. Hagar J, Eskelson B, Haggerty P, Nelson S, Vesely D. Modeling marbled murrelet (Brachyramphus marmoratus) habitat using LiDAR-derived canopy data. Wildlife Society Bulletin. 2014; 38: 237–249. https://doi.org/10.1002/wsb.407

65. Clyde GE. A fine-scale lidar-based habitat suitability mapping methodology for the marbled murrelet (*Brachyramphus marmoratus*) on Vancouver Island, British Columbia. 2017. M.Sc. Thesis, The University of Victoria. 2017. Available from: https://dspace.library.uvic.ca/handle/1828/7923.

66. Raphael MG, Falxa GA, Dugger KM, Galleher BM, Lynch D, Miller SL, et al. Status and trend of nesting habitat for the marbled murrelet. Pacific Northwest Research Station General Technical Report. PNW-GTR-848. 2011. https://doi.org/10.2737/PNW-GTR-848

67. Sillett S, Antoine M, Campbell-Spickler J, Carroll A, Coonen E, Kramer R, et al. Manipulating tree crown structure to promote old-growth characteristics in second-growth redwood forest canopies. Forest Ecology and Management. 2018; 417: 77–89. https://doi.org/10.1016/j.foreco.2018.02.036

Table S1. Assessed Variable List. Variables grouped by theme, used to develop a habitat suitability model for marbled murrelets on the study area in Northern California. All variables were developed at a 5-meter raster cell scale. We based climate covariates on Parameter-elevation Regressions on Independent Slopes Model (PRISM 2004) 30-yr normal data (1981 - 2010), except for Growing Degree Days data which was extracted from normal for 1951 - 1980. [1] Tree Approximate Object (TAO) – the detection of individual trees is quantified as tree approximate objects (TAO) where points are described as the crown of a predominant tree and possibly several subordinate trees resulting in a more consistent unit of analysis (North et al. 2017, Jeronimo et al. 2019).

Variable Theme	Variable Name	Variable Description	Source Data
Geographic/Landform	Elev	Elevation in meters above mean sea level (NAVD88)	LiDAR
	Slope_p	slope in percent (first derivative of elevation (Elev)	LiDAR
	Coast_Dist	Distance inland from the Pacific Ocean in meters	1:24,000 scale coastline
	Sp2000	Relative, elevation-based, position in percent between the ridge top directly upslope and the valley bottom directly downslope of the target location	USGS DTM
	Aspect_4d	Categorical value representing North (315-45), South (135-225), East (225-315), and West (45-135)	LiDAR
	TPI_2000	Topographic Position Index run with a circular radius of 2,000 meters	LiDAR
	TPI_1000	Topographic Position Index run with a circular radius of 1,000 meters	LiDAR
	TPI_300	Topographic Position Index run with a circular radius of 300 meters	LiDAR
	TPI_150	Topographic Position Index run with a circular radius of 150 meters	LiDAR
	EucDist_PerStrms	Euclidian distance from the nearest perennial (Class I and Class II) stream	LiDAR Hydrography
	AreaSol	Diffuse and direct incoming solar radiation in watthours per square meter (WH/m2)	LiDAR
	AreaSolDir	Direct incoming solar radiation in watthours per square meter (WH/m2)	LiDAR
	AreaSolDif	Diffuse incoming solar radiation in watthours per square meter (WH/m2)	LiDAR
	AreaSolDirDur	Duration of direct incoming solar radiation in hours	LiDAR
Climate	PPT_30yr_Normal	Annual precipitation (mm) from PRISM 30-yr normal (1981-2010)	PRISM Climate Data
	TMAX_30yr_Normal	Annual average maximum temperature (Celsius) from PRISM 30-yr normal (1981-2010)	PRISM Climate Data
	TMEAN_30yr_Normal	Annual average mean temperature (Celsius) from PRISM 30-yr normal (1981-2010)	PRISM Climate Data
	TMIN_30yr_Normal	Annual average minimum temperature (Celsius) from PRISM 30-yr normal (1981-2010)	PRISM Climate Data
	GDD_30yr_Normal	Growing degree days above 50°F from PRISM 30-yr normal (1951-1980)	PRISM Climate Data
	ZCI	Modeled inland extent of coastal fog and the inland extent of the Pacific Ocean moderating effect on higher inland air temperatures	PRISM based model
LiDAR Canopy Metrics	ABV	Number of LiDAR returns within the prescribed cell above the cutoff of 1.37 meters (height of DBH measurement)	LiDAR
	ALL	Total number of LiDAR returns within the prescribed cell	LiDAR
	AVG	Average height (above ground) of LiDAR returns within the prescribed cell above the cutoff of 1.37 meters (height of DBH measurement)	LiDAR
	COV	Number of first returns above the cover cutoff divided by the Number of all first returns and output as a percentage for all LiDAR returns within the prescribed cell above the cutoff of 1.37 meters (height of DBH measurement)	LiDAR
	DNS	Number of all LiDAR returns above the cover cutoff divided by the Number of all returns and output as a percentage for all LiDAR returns within the prescribed cell above the cutoff of 1.37 meters (height of DBH measurement)	LiDAR
	KUR	Kurtosis value of all LiDAR returns within the prescribed cell above the cutoff1.37 meters (height of DBH measurement)	LiDAR
	MAX	Maximum value of all LiDAR returns within the prescribed cell above the cutoff of 1.37 meters (height of DBH measurement)	LiDAR
	MIN	Minimum value of all LiDAR returns within the prescribed cell above the cutoff of 1.37 meters (height of DBH measurement)	LiDAR
	SKE	Skewness value of all LiDAR returns within the prescribed cell above the cutoff of 1.37 meters (height of DBH measurement)	LiDAR
	STD	Standard deviation from the mean of all LiDAR returns within the prescribed cell above the cutoff of 1.37 meters (height of DBH measurement)	LiDAR
Percentiles	P05	Height value at which 5 percent of the LiDAR returns are below, or 95 percent of the LiDAR returns are above.	LiDAR
	P10	Height value at which 10 percent of the LiDAR returns are below and 90 percent of the LiDAR returns are above	LiDAR
	P15	Height value at which 15 percent of the LiDAR returns are below and 85 percent of the LiDAR returns are above	LiDAR
	P20	Height value at which 20 percent of the LiDAR returns are below and 80 percent of the LiDAR returns are above	LiDAR
	P25	Height value at which 25 percent of the LiDAR returns are below and 75 percent of the LiDAR returns are above	LiDAR
	P30	Height value at which 30 percent of the LiDAR returns are below and 70 percent of the LiDAR returns are above	LiDAR
	P35	Height value at which 35 percent of the LiDAR returns are below and 65 percent of the LiDAR returns are above	LiDAR
	P40	Height value at which 40 percent of the LiDAR returns are below and 60 percent of the LiDAR returns are above	LiDAR
	P45	Height value at which 45 percent of the LiDAR returns are below and 55 percent of the LiDAR returns are above	LiDAR
	P50	Height value at which 50 percent of the LiDAR returns are below and 50 percent of the LiDAR returns are above	LiDAR

Variable Theme	Variable Name	Variable Description	Source Data
LiDAR	P55	Height value at which 55 percent of the LiDAR returns are below and 45 percent of the LiDAR returns are above	LiDAR
	P60	Height value at which 60 percent of the LiDAR returns are below and 40 percent of the LiDAR returns are above	LiDAR
	P65	Height value at which 65 percent of the LiDAR returns are below and 35 percent of the LiDAR returns are above	LiDAR
	P70	Height value at which 70 percent of the LiDAR returns are below and 30 percent of the LiDAR returns are above	LiDAR
	P75	Height value at which 75 percent of the LiDAR returns are below and 25 percent of the LiDAR returns are above	LiDAR
	P80	Height value at which 80 percent of the LiDAR returns are below and 20 percent of the LiDAR returns are above	LiDAR
	P85	Height value at which 85 percent of the LiDAR returns are below and 15 percent of the LiDAR returns are above	LiDAR
	P90	Height value at which 90 percent of the LiDAR returns are below and 10 percent of the LiDAR returns are above	LiDAR
	P95	Height value at which 95 percent of the LiDAR returns are below and 5 percent of the LiDAR returns are above	LiDAR
TAO Point Statistics	TAO_All_Max_1ac	Maximum of individual TAO[1] heights (m) within 1-acre circular moving window based on all TAOs.	LiDAR TAO Model
	TAO_All_Mean_1ac	Mean of individual TAO heights (m) within 1-acre circular moving window.	LiDAR TAO Model
	TAO_All_Min_1ac	Minimum of individual TAO heights (m) within 1-acre circular moving window	LiDAR TAO Model
	TAO_All_Range_1ac	Range in individual TAO heights (m) within 1-acre circular moving window	LiDAR TAO Model
	TAO_All_Std_1ac	Standard deviation of individual TAO heights (m) within 1-acre circular moving window	LiDAR TAO Model
	TAO_All_Sum_1ac	Sum of individual TAO heights (m) within 1-acre circular moving window	LiDAR TAO Model
	TAO_All_Max_5ac	Maximum of individual TAO heights (m) within 5-acre circular moving window	LiDAR TAO Model
	TAO_All_Mean_5ac	Mean of individual TAO heights (m) within 5-acre circular moving window	LiDAR TAO Model
	TAO_All_Min_5ac	Minimum of individual TAO heights (m) within 5-acre circular moving window	LiDAR TAO Model
	TAO_All_Range_5ac	Range in height (m) of all individual TAOs within 5-acre circular moving window	LiDAR TAO Model
	TAO_All_Std_5ac	Standard deviation of height (m) of all individual TAOs within 5-acre circular moving window	LiDAR TAO Model
	TAO_All_Sum_5ac	Sum of individual TAO heights (m) within 5-acre circular moving window	LiDAR TAO Model
	TAO_GE50_Std_1ac	Standard deviation of height (m) of all TAO where height in year 2018 is ≥ 50 meters within 1-acre circular moving window	LiDAR TAO Model
	TAO_GE50_Std_5ac	Standard deviation of height (m) of all TAO where height in year 2018 is ≥ 50 meters within 5-acre circular moving window	LiDAR TAO Model
	TAO_GE50_Sum_1ac	Sum of heights (m) of all TAO where height in year 2018 is ≥ 50 meters within 1-acre circular moving window	LiDAR TAO Model
	TAO_GE50_Sum_5ac	Sum of heights (m) of all TAO where height in year 2018 is ≥ 50 meters within 5-acre circular moving window	LiDAR TAO Model
TAO Point Density	TAO_GE40_PD_1ac	Count of TAOs within a 1-acre moving window where height in 2018 is ≥ 40m	LiDAR TAO Model
	TAO_GE40_PD_5ac	Count of TAOs within a 5-acre moving window where height in year 2018 is ≥ 40m	LiDAR TAO Model
	TAO_GE50_PD_1ac	Count of TAOs within a 1-acre moving window where height in year 2018 is ≥ 50m	LiDAR TAO Model
	TAO_GE50_PD_5ac	Count of TAOs within a 5-acre moving window where height in year 2018 is ≥ 50 meters	LiDAR TAO Model
	TAO_GE60_PD_1ac	Count of TAOs within a 1-acre moving window where height in year 2018 is ≥ 60 meters	LiDAR TAO Model
	TAO_GE60_PD_5ac	Count of TAOs within a 1-acre moving window where height in year 2018 is ≥ 70 meters	LiDAR TAO Model
	TAO_GE70_PD_1ac	Count of TAOs within a 1-acre moving window where height in year 2018 is ≥ 70 meters	LiDAR TAO Model
	TAO_GE70_PD_5a	Count of TAOs within a 1-acre moving window where height in year 2018 is ≥ 40 meters and is < 50 meters	LiDAR TAO Model
	TAO_40_50_PD_1ac	Count of TAOs within a 1-acre moving window where height in year 2018 is ≥ 40 meters and is < 50 meters	LiDAR TAO Model
	TAO_40_50_PD_5ac	Count of TAOs within a 5-acre moving window where height in year 2018 is ≥ 40 meters and is < 50 meters	LiDAR TAO Model
	TAO_50_60_PD_1ac	Count of TAOs within a 1-acre moving window where height in year 2018 is ≥ 50 meters and is < 60 meters	LiDAR TAO Model
	TAO_50_60_PD_5ac	Count of TAOs within a 5-acre moving window where height in year 2018 is ≥ 50 meters and is < 60 meters	LiDAR TAO Model
	TAO_60_70_PD_1ac	Count of TAOs within a 1-acre moving window where height in year 2018 is ≥ 60 meters and is < 70 meters	LiDAR TAO Model
	TAO_60_70_PD_5ac	Count of TAOs within a 5-acre moving window where height in year 2018 is ≥ 60 meters and is < 70 meters	LiDAR TAO Model
	SDI_3cl_5ac	Simpson's Diversity Index run on 3 classes TAO_40_50_PD_5ac, TAO_60_70_PD_5ac, and TAO_GE70_PD_5ac) represents the diversity in height class of these three groups within a 5-acre moving window	TAO classified in 3 strata

[1] Tree Approximate Object (TAO) – the detection of individual trees is quantified as tree approximate objects (TAO) where points are described as the crown of a predominant tree and possibly several subordinate trees resulting in a more consistent unit of analysis (North et al. 2017, Jeronimo et al. 2018).

Table S2. Modeling Phases and Variable Groupings. Tabular diagram of variable groupings within Phases 1, 2, and 3 including percent contribution (PC) and permutation importance (PI) from Maxent output. Variables with green shading moved to the next phase of modeling. See Table S1 for complete list of variables with descriptions.

Phase 1

LASTools Percentiles		
Variable	PC	PI
p95	90.6	96.8
p90	2.7	0.3
p85	2.1	0.3
p80	0.6	0.0
p05	0.6	0.7
p70	0.5	0.2
p75	0.4	0.0
p60	0.4	0.1
p50	0.3	0.0
p10	0.3	0.4
p40	0.2	0.0
p65	0.2	0.5
p45	0.2	0.0
p20	0.2	0.3
p25	0.2	0.2
p55	0.1	0.0
p30	0.1	0.1
p35	0.1	0.0
p15	0.1	0.0

Metrics		
Variable	PC	PI
max	71.1	85.7
avg	16.7	2.3
std	7.5	1.5
all	3.4	5.9
dns	0.8	0.7
cov	0.4	3.4
abv	0.1	0.3
kur	0.1	0.1
min	0.0	0.1
ske	0.0	0.0

TAO Point Density		
Variable	PC	PI
TAO_GE60_PD_5ac	47.7	19.9
SDI_3cl_5ac	14.1	1.7
TAO_GE50_PD_5ac	10.6	13.2
TAO_GE60_PD_1ac	9.9	0.1
TAO_GE50_PD_1ac	7.1	1.4
TAO_GE70_PD_5ac	3.7	5.6
TAO_60_70_PD_5ac	2.1	1.6
TAO_GE40_PD_5ac	2.0	35.7
TAO_GE40_PD_1ac	0.9	7.2
TAO_60_70_PD_1ac	0.6	0.3
TAO_GE70_PD_1ac	0.5	0.6
TAO_50_60_PD_5ac	0.4	5.7
TAO_40_50_PD_5ac	0.4	3.9
TAO_40_50_PD_1ac	0.1	2.2
TAO_50_60_PD_1ac	0.1	0.9

TAO Point Statistics		
Variable	PC	PI
TAO_GE50_Sum_5ac	50.4	24.7
TAO_GE50_Std_1ac	31.3	2.0
TAO_GE50_Std_5ac	5.1	35.9
TAO_GE50_Sum_1ac	3.2	0.9
TAO_All_Max_1ac	2.2	6.6
TAO_All_Max_5ac	1.8	7.8
TAO_All_Mean_1ac	1.5	1.0
TAO_All_Mean_5ac	1.2	15.0
TAO_All_Range_5ac	0.8	0.4
TAO_All_Sum_5ac	0.8	1.7
TAO_All_Std_1ac	0.7	1.0
TAO_All_Sum_1ac	0.3	1.1
TAO_All_Min_5ac	0.3	0.8
TAO_All_Min_1ac	0.1	0.1
TAO_All_Range_1ac	0.1	0.7
TAO_All_Std_5ac	0.1	0.4

Geographic/Landform		
Variable	PC	PI
Coast_Dist	46.8	29.4
Elev	21.8	28.0
EucDist_PerStrms	16.2	11.7
AreaSolDirDur	3.8	1.7
TPI_2000	3.1	12.3
Slope_p	2.5	0.7
TPI_1000	2.1	4.5
sp2000	1.1	0.7
AreaSolDif	1.1	10.7
TPI_300	0.6	0.1
TPI_150	0.3	0.1
Aspect_4d	0.2	0.1
AreaSolDir	0.2	0.1
AreaSol	0.0	0.0

Climate		
Variable	PC	PI
PPT	37.2	26.9
ZCI	26.0	1.8
TMAX	14.8	30.4
TMEAN	9.8	20.1
GDD	6.8	10.8
TMIN	5.4	10.0

Phase 2

Best Subset A		
Variable	PC	PI
TAO_GE60_PD_5ac	56.2	4.1
TAO_GE50_Sum_5ac	15.1	80.4
SDI_3cl_5ac	11.6	0.2
TAO_GE50_Std_1ac	10.7	0.7
max	1.9	1.1
p95	1.3	0.1
Elev	1.2	7.1
TMAX	1.1	4.5
EucDist_PerStrms	0.9	1.7

Best Subset B		
Variable	PC	PI
TAO_GE50_Sum_5ac	41.8	8.2
SDI_3cl_5ac	34.3	0.4
TAO_GE50_Std_5ac	8.2	56.2
TAO_GE50_PD_5ac	6.3	8.4
max	2.9	1.4
Elev	2.4	13.4
TMAX	2.2	8.6
p95	1.3	0.5
EucDist_PerStrms	0.6	2.9

Phase 3

3var_a (AIC = 31891.3)		
Variable	PC	PI
TAO_GE60_PD_5ac	61.8	5.3
TAO_GE50_Sum_5ac	20.7	93.7
TAO_GE50_Std_1ac	17.5	1.1

3var_b (AIC = 31910.1)		
Variable	PC	PI
TAO_GE50_Sum_5ac	64.9	33.6
TAO_GE50_Std_5ac	28.1	55.2
TAO_GE50_PD_5ac	7.0	11.2

3var_c (AIC = 31852.0)		
Variable	PC	PI
TAO_GE60_PD_5ac	67.1	1.5
TAO_GE50_Sum_5ac	24.5	75.8
TAO_GE50_Std_5ac	8.4	22.7

3var_d (AIC = 32043.2)		
Variable	PC	PI
TAO_GE50_Sum_5ac	58.5	88.6
TAO_GE50_Std_1ac	34.5	5.1
TAO_GE50_PD_5ac	7.0	6.3

Table S-3. Ranking of top four models based on Akaike Information Criteria, the best 3 variable model (C) consisted of the point density of tree approximate objects (TAO) ≥60m within a 5ac buffer, the sum heights of TAO ≥50m within a 5ac buffer, and the standard deviation of TAO ≥50m within a 5ac buffer. Averages reported in columns were calculated from 10 bootstrap replicates of the raw data wherein the model in question was refitted to each replicate.

Model	Average Number of Model Parameters	Average of logLikelihood	Average AIC	Delta AIC
C	36.7	-15889.3	31852.0	
A	35.0	-15910.7	31891.3	39.3
B	37.4	-15917.6	31910.1	58.1
D	38.9	-15982.7	32043.2	191.2

Appendix B. Flow Chart and Calculator

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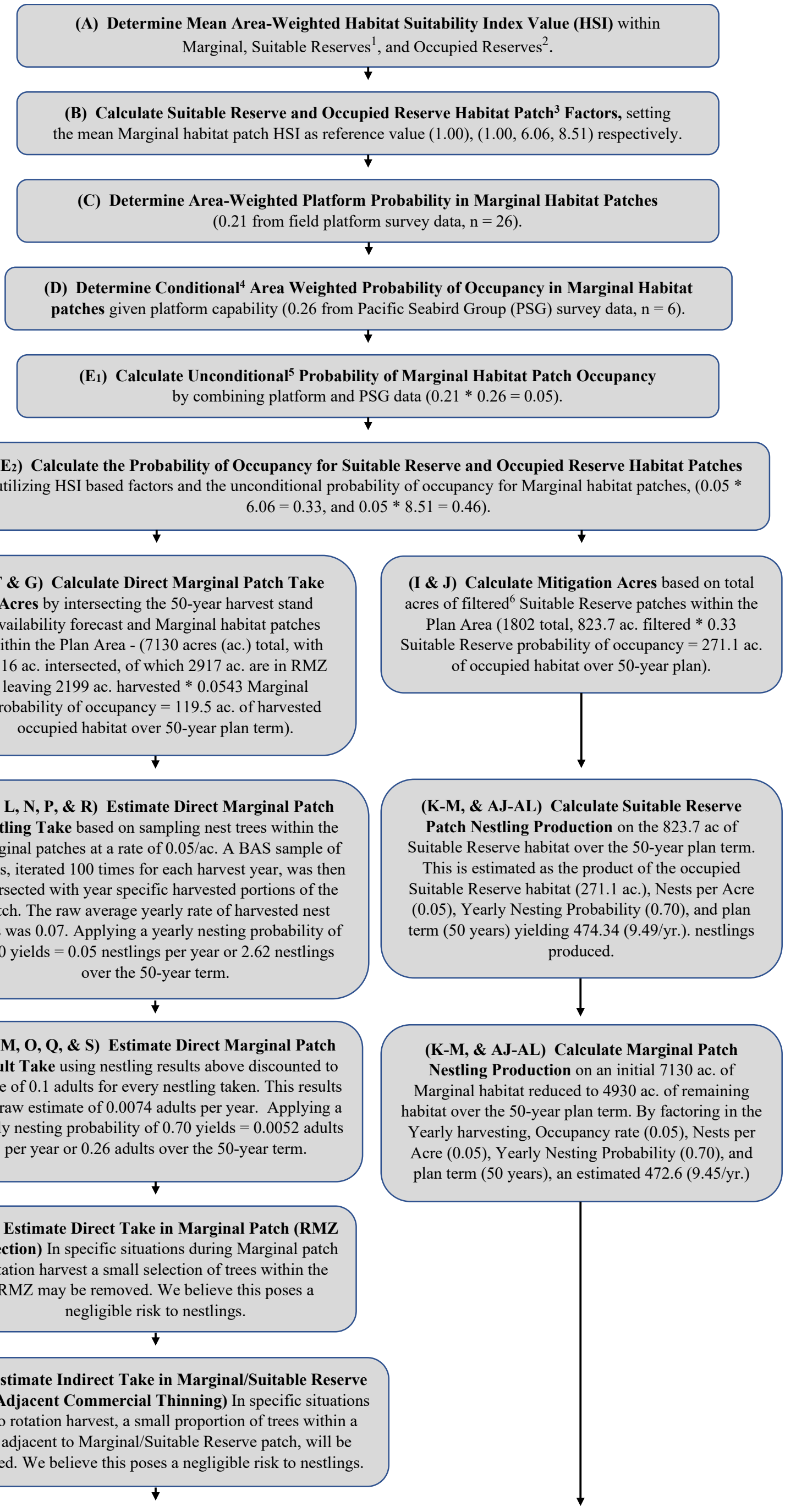
B.1 FLOW CHART



(K, L, Y-AA) Estimate Indirect Take in Marginal Patch RMZ from Selection Harvest In specific situations a small proportion of trees within a Marginal patch RMZ may be harvested. Based on a sample of 0.05 TAOs/acre, an indirect effect at the maximum rate of 0.25 nestlings/sample nest was estimated at 1.70 nestlings over the 50-year term.

(U) Estimate Direct Take in Marginal Patch (Commercial Thinning) In specific situations prior to rotation harvest, a small proportion of trees within a Marginal patch may be harvested. We believe this poses a negligible risk to nestlings.

(V-X) Estimate Indirect Marginal Patch Nestling Take based on sampling nest trees within the Marginal patches at a rate of 0.05/ac. A BAS sample of TAOs, iterated 100 times for each harvest year, was assessed for each samples distance to an adjacent harvest. For samples within 50 meters of a harvest a distance based decaying linear rate was applied resulting in an estimated level of take for the specific harvest year. Summed by year, averaged over the 100 iterations, and yearly nesting probability applied yields 1.86 nestlings over the 50-year term.

(V-X) Estimate Indirect Suitable Reserve Patch Nestling Take based on sampling nest trees within the Suitable Reserve patches at a rate of 0.05/ac. A BAS sample of TAOs, iterated 100 times for each harvest year, was assessed for each samples distance to an external adjacent harvest. For samples within 50 meters of a harvest a distance based decaying linear rate was applied resulting in an estimated level of take for the specific harvest year. Summed by year, averaged over the 100 iterations, and yearly nesting probability applied yields 0.78 nestlings over the 50-year term.

(AM) Calculate Mitigation Ratio #1a (Suitable Reserve production divided by all take, but without loss of Marginal production). Suitable Reserve (474.34) nestling production over the 50-year term divided by the sum of nestling and adult Direct and Indirect take over the 50-year term: (Direct Marginal – nestlings (2.62), adults (0.26), Indirect Marginal nestlings (1.86), Indirect Suitable Reserve nestlings (0.78), and Indirect RMZ selection 1.70 yielding a total take of 7.22 nestlings/adults over the term and a mitigation ratio of 65.71:1.

(AN) Calculate Mitigation Ratio #1b (Suitable Reserve production divided by all take, including loss of Marginal and Suitable Reserve production). Suitable Reserve (474.34) nestling production over the 50-year term divided by the sum of nestling and adult Direct and Indirect take over the 50-year term: (Direct Marginal - nestlings (2.62), adults (0.26), Indirect Marginal nestlings (1.86), Indirect Suitable Reserve nestlings (0.78), Indirect Marginal RMZ selection 1.70, Marginal production loss (77.08, Area) and (28.62, Adj. Harvest) and Suitable Reserve production loss (19.46), yielding a total take and loss of 132.37 nestlings/adults over the term and a mitigation ratio of 3.58:1.

(AO) Calculate Mitigation Ratio #2a (Suitable Reserve and Occupied Reserve production divided by all take, without loss of Marginal production). Suitable Reserve (474.34) and Occupied Reserve (796.99) nestling production over the 50-year term divided by the sum of nestling and adult Direct and Indirect take over the 50-year term: (Direct Marginal - nestlings (2.62), adults (0.26), Indirect Marginal nestlings (1.86), Indirect Suitable Reserve nestlings (0.78), and Indirect RMZ selection 1.70 yielding a total take of 7.22 nestlings/adults over the term and a mitigation ratio of 176.11:1.

(AP) Calculate Mitigation Ratio #2b (Suitable Reserve and Occupied Reserve production divided by all take, including loss of Marginal and Suitable Reserve production). Suitable Reserve (474.34) and Occupied Reserve (796.99) nestling production over the 50-year term divided by the sum of nestling and adult Direct and Indirect take over the 50-year term: (Direct Marginal - nestlings (2.62), adults (0.26), Indirect Marginal nestlings (1.86), Indirect Suitable Reserve nestlings (0.78), Indirect Marginal RMZ selection 1.70, Marginal production loss (77.08, Area) and (28.62, Adj. Harvest) and Suitable Reserve production loss (19.46), yielding a total take and loss of 132.37 nestlings/adults over the term and a mitigation ratio of 9.60:1.

1) Suitable Habitat Reserves refers to habitat patches with a Low suitable or better core (HSI ≥ 0.19). Also known as LS&B.
2) Occupied Reserves refers to the Known Occupied MaMu Stands in model derived form (patches).
3) Habitat patch refers to polygonal areas derived from the concave hull process which maintains both the area and all constituent elements (Tree Approximate Objects - TAOs) around the targeted habitat suitability classification.
4) Conditional probability requires that the platform condition be met before assessing occupancy and therefore is a portion of the combined probability of a patch prior to any survey.
5) Unconditional probability is the combined probabilities of platform capability and occupancy based on PSG surveys.
6) Low Suitable patch filtering included removing the recently discovered and Historic Known Occupied Marbled Murrelet stands, field surveyed non-platform patches, recently harvested non-habitat, patches less than 5 acres, and patches within 300 feet of the property boundary.

Low Suitable and better = Suitable Habitat Reserves or Suitable Reserves
Known Occupied MaMu Stands = Occupied Reserves

B.2 CALCULATOR

Parameter	Marginal Stands	Suitable Reserves	Occupied Reserves*	Cross Reference to Flow Chart
Habitat Inputs				
Area Weighted Mean HSI value of Marginal, Low Suitable and Better (LS&B), and Known Occupied MaMu Stands (patch) within the Plan Area	0.04	0.22	0.30	**A**
Habitat Quality Inflation Factor based on modeled Relative Probability of Occupancy (HSI)	**1.00**	**6.06**	**8.51**	**B**
Area weighted proportion of platform capable potential habitat (field surveyed sample, n = 26)	0.21	NA	NA	**C**
Area weighted proportion of platform capable occupied potential habitat (PSG survey, n = 6)	0.26	NA	NA	**D**
Area weighted proportion of occupied potential habitat (Marginal) and HSI model predicted occupancy (LS&B and Known Occupied MaMu Stands	0.05	0.33	0.46	**E_1 and E_2**
Harvested acres (over 50-year term, based on 100-yr HSAF, harvest outside RMZ in matrix only)	2199	NA		**F**
Habitat Input Synthesis				
Take Acres (Marginal, 50-year term)	119.5	NA	NA	**G**
Take Acres (Marginal, Annual)	2.4	NA	NA	**H**
Proposed Mitigation Acres (LS&B, criteria based subset, n = 91)	NA	823.7	492.5	**I**
Proposed Occupied Mitigation Acres (LS&B)	NA	271.1	227.7	**J**
Nesting Parameters				
Nests per Acre	0.05	0.05	0.10	**K**
Yearly Nesting Probability (given stand occupancy)	0.70	0.70	0.70	**L**
Mean Proportion of Adults Lost to Harvest	0.10	0.10	0.10	**M**
Direct Take				
Direct Take: Estimated raw take (nestlings, yearly, Harvest)	0.07	NA	NA	**N**
Direct Take: Estimated raw take (adults, yearly, Harvest)	0.01	NA	NA	**O**
Direct Take: Estimated take (nestlings, yearly, Harvest)	0.05	NA	NA	**P**
Direct Take: Estimated take (adults, yearly, Harvest)	0.01	NA	NA	**Q**
Direct Take: Estimated take (nestlings, 50-year term, Harvest)	2.62	NA	NA	**R**
Direct Take: Estimated take (adults, 50-year term, Harvest)	0.26	NA	NA	**S**
Direct Take (RMZ Selection Harvest)				
Direct Take: Estimated take (nestlings, yearly, Harvest)	0.00	NA	NA	**T**
Direct Take (Commercial Thinning Harvest)				
Direct Take: Estimated take (nestlings, yearly, Harvest)	0.00	NA	NA	**U**
Indirect Take (Adjacent Harvest)				
Indirect Take: Estimated raw take, harvest year effect at 0.25 (nestlings, Adj. Harvest - Single Yr.)	0.05	0.02	NA	**V**
Indirect Take: Estimated take, harvest year effect at 0.25 (nestlings, yearly, Adj. Harvest - Single Yr.)	0.04	0.02	NA	**W**
Indirect Take: Estimated take, harvest year effect at 0.25 (nestlings, 50-year term, Adj. Harvest - Single Yr.)	1.86	0.78	NA	**X**
Indirect Take (RMZ Selection Harvest)				
Indirect Take: Estimated raw take, selection harvest year effect at maximum 0.25 (nestlings, Selection Harvest - Single Yr.)	0.05	NA		**Y**
Indirect Take: Estimated take, selection harvest year effect at maximum 0.25 (nestlings, yearly Selection Harvest - Single Yr.)	0.03	NA		**Z**
Indirect Take: Estimated take, selection harvest year effect at maximum 0.25 (nestlings, 50-year term Selection Harvest - Single Yr.)	1.70	NA		**AA**
Indirect Take (Adjacent Commercial Thinning Harvest)				
Indirect Take: Estimated take, Comm. Thin. harvest year effect at maximum 0.25 (nestlings, 50-year term Selection Harvest - Single Yr.)	0.00	0.00	NA	**AB**
Combined Take				
Combined Take: Estimated 50-year total of Direct and Indirect take	6.44	0.78	0.00	**AC**
Production Loss or Gain				
Production Loss: Estimated raw loss, Cumulative (juveniles: eggs or nestlings, yearly average, Harvest, lost area/nest, cum)	2.20	NA	NA	**AD**
Production Loss: Estimated loss, Cumulative (juveniles: eggs or nestlings, yearly average, Harvest, lost area/nest, cum)	1.54	NA	NA	**AE**
Production Loss: Estimated loss, Cumulative (juveniles: eggs or nestlings, 50-year term, Harvest, lost area/nest, cum)	77.08	NA	NA	**AF**
Production Loss: Estimated raw loss, Cumulative (juveniles: eggs or nestlings, yearly average, Adj. Harvest, nest effect, cum)	0.82	0.56		**AG**
Production Loss: Estimated loss, Cumulative (juveniles: eggs or nestlings, yearly average, Adj. Harvest, nest effect, cum)	0.57	0.39		**AH**
Production Loss: Estimated loss, Cumulative (juveniles: eggs or nestlings, 50-year term, Adj. Harvest, nest effect, cum)	28.62	19.46		**AI**
Production Gain: Estimated raw gain, Cumulative (juveniles: eggs or nestlings, yearly average)	13.50	13.55	22.77	**AJ**
Production Gain: Estimated gain, Cumulative (juveniles: eggs or nestlings, yearly average)	9.45	9.49	15.94	**AK**
Production Gain: Estimated gain, Cumulative (juveniles: eggs or nestlings, 50-year term)	472.60	474.34	796.99	**AL**
Mitigation Ratios				
Mitigation Ratio (LS&B production / all take, not including lost Marginal and LS&B production)	NA	**65.71**	NA	**AM**
Mitigation Ratio (LS&B production / all take, including lost Marginal and LS&B production)	NA	**3.58**	NA	**AN**
Mitigation Ratio (LS&B, and Known Occupied MaMu Stands production / all take, not including lost Marginal and LS&B production)	NA	NA	**176.11**	**AO**
Mitigation Ratio (LS&B, and Known Occupied MaMu Stands production / all take, including lost Marginal and LS&B production)	NA	NA	**9.60**	**AP**

* Non-easement MaMu Stands (patches)

Low Suitable and Better = Suitable Habitat Reserves

Known Occupied MaMu Stands = Occupied Reserves

Appendix B. Flow chart of process to calculate potential incidental take and mitigation in the proposed HCP and accompanying take "calculator" that is referenced to steps in the flow chart.

B.2.1 Take calculation steps referenced in the Take Calculator and Flow Chart

B.2.1.1 Habitat Inputs

(A) Using the delineated and classified potential habitat patches, Area Weighted Average HSI values were calculated for each class (Marginal, Suitable Habitat Reserves, and Occupied Reserves).

(B) To calculate the Habitat Quality Inflations Factors the Marginal Area Weighted Average HSI value was set as the reference, the values for Suitable Habitat Reserve and Occupied Reserve Habitat Quality Inflations Factors were computed based on the ratios of the target class Area Weighted Average HSI value divided by the reference class Area Weighted Average HSI value.

(C) Based on a sample of 26 Marginal patches, an Area Weighted proportion of platform capability was calculated.

(D) Based on a sample of 6 platform capable Marginal patches, an Area Weighted proportion of occupancy probability was calculated.

(E1 and E2) The Area Weighted Proportion of occupied habitat representing the proportion of occupied area by class. For Marginal patches this is the product of platform capable and occupied estimates for Suitable Habitat Reserves and Occupied Reserves (C and D), the resulting Marginal value was multiplied by the Habitat Quality Inflation Factor (B) to estimate the value for Suitable Habitat Reserves and Occupied Reserves.

(F) The estimated Marginal harvest is generated from a total of 7130 ac. of delineated Marginal patches, intersected with planned/scheduled harvest units from the 50-year Harvest Stand Availability Forecast over the 50-year term. Of the total intersection, a proportion of the harvested area is in RMZ with the remainder in the clear-cut harvest matrix within the Marginal patches.

B.2.1.2 Habitat Input Synthesis

(G) Direct Marginal take acres are based on the harvested acres times the Marginal probability of occupancy which results in the estimated acres of occupied and harvested area over the 50-year term.

(H) Yearly Direct Marginal take acres are based on (G / 50-year term) yielding an average acres per year taken.

(I) Proposed mitigation acreages within delineated Suitable Habitat Reserve and conservation acreages within Occupied Reserve patches/stands post constraint, encumbrance, and non-habitat valuation reduction. (Table 5-2)

(J) The estimated occupied mitigation acres of delineated Suitable Habitat Reserve and conservation acreages within Occupied Reserve patches based on the Area Weighted proportion of occupied habitat by classification (E_1 and E_2).

B.2.1.3 Nesting Parameters

(K) Estimated number of nests per acre used in take and production calculations.

(L) Estimated yearly nesting probability of a pair given patch occupancy.

(M) Estimated proportion of adults lost due to direct take of nest tree, e.g., remaining in a felled nest tree to their demise.

B.2.1.4 Direct Take

(N) Model estimated raw yearly direct nestling take due to harvest within Marginal habitat patches. Based on 100 model iterations for each of the 50 harvest years and a BAS sample of TAOs representing nests (based on nest density K) distributed across the delineated Marginal habitat patches.

(O) Estimated raw yearly direct adult take due to harvest within delineated Marginal patches. Based on Model estimated raw yearly direct nestling take (N) with a factor of (M) adults lost for every nestling taken.

(P) Model estimated raw yearly direct nestling take (N) reduced by Yearly Nesting Probability (L).

(Q) Estimated raw yearly direct adult take (O) reduced by Yearly Nesting Probability (L).

(R) Estimated 50-year direct nestling take, (P) X 50-year term.

(S) Estimated 50-year direct adult take, (Q) X 50-year term.

B.2.1.4.1 Direct Take (RMZ Selection Harvest)

(T) Estimated direct take due to RMZ selection harvest within delineated Marginal patches. For take to occur, harvest of the Marginal RMZ, concurrent nesting in the harvested RMZ, and the selection of the nest tree within the RMZ selection would all need to occur. Probability is negligible.

B.2.1.4.2 Direct Take (Commercial Thinning Harvest)

(U) Estimated direct take from Commercial Thinning harvest within delineated Marginal patches. For take to occur, commercial thinning harvest within the Marginal patch, concurrent nesting in the harvested area, and the selection of the nest tree under commercial thinning selection would all need to occur. Probability is negligible.

B.2.1.5 Indirect Take (Adjacent Harvest)

(V) Model estimated raw yearly indirect nestling take due to adjacent harvest adjacent to delineated Marginal and Suitable Habitat Reserve patches. Based on 100 model iterations for each harvest year and a BAS sample representing nests at a nest density of (K), distance from the sample nest and harvest edge was computed using a decreasing with distance effect.

(W) Estimate from (V) reduced by Yearly Nesting Probability (L), (V X L).

(X) Estimated 50-year indirect nestling take from adjacent harvest, (W) X 50-year term.

B.2.1.5.1 Indirect Take (RMZ Selection Harvest)

(Y) Model estimated indirect raw yearly nestling take due to RMZ selection harvest of delineated Marginal patches. Based on 100 model iterations for each harvest year and a BAS sample of nest at a rate of 0.05 nests/acre,

(Z) Estimate from (Y) reduced by Yearly Nesting Probability (L), (Y X L).

(AA) Estimated 50-year indirect nestling take from RMZ selection harvest, (Z) X 50-year term.

B.2.1.5.2 Indirect Take (Adjacent Commercial Thinning Harvest)

(AB) Estimated indirect take from Commercial Thinning harvest adjacent to delineated Marginal and Suitable Habitat Reserve patches. For take to occur would require, commercial thinning harvest adjacent to the Marginal or Suitable Habitat Reserve patch, concurrent nesting within 50 meters of the harvested area, and the harvest of a tree in direct proximity of the nest tree. Probability is negligible.

B.2.1.6 Combined Take

(AC) All estimated take (direct and indirect) summed by habitat classification. Estimated take in this Appendix B reflects the Plan Area prior to the adjustment described in Section 5.2.3.

B.2.1.7 Production Loss or Gain

The quantities in this section are estimates of murrelet production and of reduction in future production. They are not take, are not authorized by the Permit, and are not included in the combined take estimate at (AC).

(AD) Model estimated yearly production loss due to harvest of Marginal patches. Based on 100 model iterations for each harvest year and BAS sample TAO and nest density (K). The cumulative loss of Marginal nesting habitat over the 50-year term was used to calculate the potential loss of nestlings. Areas harvested early in the term account for a higher loss than areas harvested near the end of the term.

(AE) Estimate from (AD) reduced by Yearly Nesting Probability (L), (AD X L).

(AF) Estimated 50-year production loss within Marginal Habitat, (AE) X 50-year term.

(AG) Model estimated yearly production loss due to harvest adjacent to Marginal and Suitable Habitat Reserve patches. Based on 100 model iterations for each harvest year and BAS sample TAO and nest density (K). The cumulative indirect effect over the 50-year term was used to calculate the potential loss of nestlings. Area harvested early in the term accounts for a higher loss than areas harvested near the end of the term. Once the adjacent harvested area canopy returned to security height cumulative effect ceased.

(AH) Estimate from (AG) reduced by Yearly Nesting Probability (L), (AG X L).

(AI) Estimated 50-year production loss from harvest adjacent to Marginal Habitat and Suitable Habitat Reserves, (AH) X 50-year term.

(AJ) Estimated raw yearly production gain from Marginal, Suitable Habitat Reserve, and Occupied Reserve habitat. This estimate is based on a cumulative sum using occupied acres (G and J) and nest density (K) divided by the 50-year term for each habitat classification. For Marginal patches the non-harvest matrix, Non-harvest RMZ, and the Selection RMZ areas were used for production acreage. All areas within the Suitable Habitat Reserves and Occupied Reserves were used for production acreage.

(AK) Estimate from (AJ) reduced by Yearly Nesting Probability (L), (AJ X L).

(AL) Estimated 50-year production, (AK) X 50-year term.

B.2.1.8 Mitigation Ratios

(AM) This Mitigation Ratio is based on estimated nestling production from Suitable Habitat Reserves only (AL) divided by all take occurring in Marginal and Suitable Habitat Reserves (AC) over the 50-year term. This estimate does not include the potential loss of Marginal and Suitable Habitat Reserve production from (AF or AH) in the denominator.

(AN) This Mitigation Ratio is based on estimated nestling production from Suitable Habitat Reserves only (AL) divided by all take occurring in Marginal and Suitable Habitat Reserves (AC) over the 50-year term. This estimate includes the potential loss of Marginal and Suitable Habitat Reserve production from (AF or AH) in the denominator.

(AO) This Mitigation Ratio is based on estimated nestling production from Suitable Habitat Reserves and Occupied Reserves (AL) divided by all take occurring in Marginal and Suitable Habitat Reserves (AC) over the 50-year term. This estimate does not include the potential loss of Marginal and Suitable Habitat Reserve production from (AF or AH) in the denominator.

(AP) This Mitigation Ratio is based on estimated nestling production from Suitable Habitat Reserves and Occupied Reserves (AL) divided by all take occurring in Marginal and Suitable Habitat Reserves (AC) over the 50-year term. This estimate includes the potential loss of Marginal and Suitable Habitat Reserve production from (AF or AH) in the denominator.

B.2.1.9 Sensitivity of the Take Estimate

The estimate of 7.29 murrelets (7.22 murrelets pre-expansion) taken over the 50-year Permit term (Table 5-2, Section 5.2.3) depends in part on two field-based proportions estimated from small samples: the area-weighted proportion of Marginal Habitat patches that contain platform-capable trees (0.2051, from 26 assessed patches) and the area-weighted proportion of platform-capable patches determined to be occupied (0.2649, from 6 surveyed patches). Because these proportions rest on limited sampling, Green Diamond conducted a sensitivity analysis to characterize the range of take that is consistent with the uncertainty in the model inputs. The analysis is a sensitivity and propagated-assumption analysis of the take calculation described in Section 5.2.2 and Appendix

B. It is not a statistical confidence bound on the actual number of murrelets taken, and it is conditional on the structure and assumptions of that calculation.

Method

The uncertainty in each input was propagated through the take calculation using a Monte Carlo simulation of 300,000 iterations. The two field proportions were each represented by a Beta distribution preserving the area-weighted mean at the size of its sample (26 and 6 patches). The number of nests per acre, the yearly nesting probability, and the adult-to-nestling ratio were represented by distributions centered on their operative values. Because the platform and occupancy proportions were held fixed in the underlying simulation of tree placement (Appendix B), take is proportional to their product, and the simulation rescales the estimate accordingly. A secondary layer represented the placement variability retained from the tree-approximate-object sampling, using a standard deviation of 30 percent of each component's value.

Result

The expected modeled take equals the calculator estimate of 7.22 murrelets on the pre-expansion Plan Area by construction; the simulated sample mean is 7.24, the difference being sampling variation. Across the propagated uncertainty the median is 5.54 and the 90 percent simulation interval is 0.85 to 19.41 murrelets over the term (Table B-1, Figure B-1). The distribution is right-skewed (low take estimates are more likely than high), and the estimate is weakly constrained by the available data.

Table B-1. Propagated distribution of total take (pre-expansion Plan Area, 50-year term).

Statistic	Value
Point estimate (calculator)	7.22
Propagated median	5.54
90% simulation interval	0.85 to 19.41
95% simulation interval	0.53 to 23.71
Probability take exceeds 7.22	0.38
Probability take exceeds 10	0.24
Probability take exceeds 15	0.10

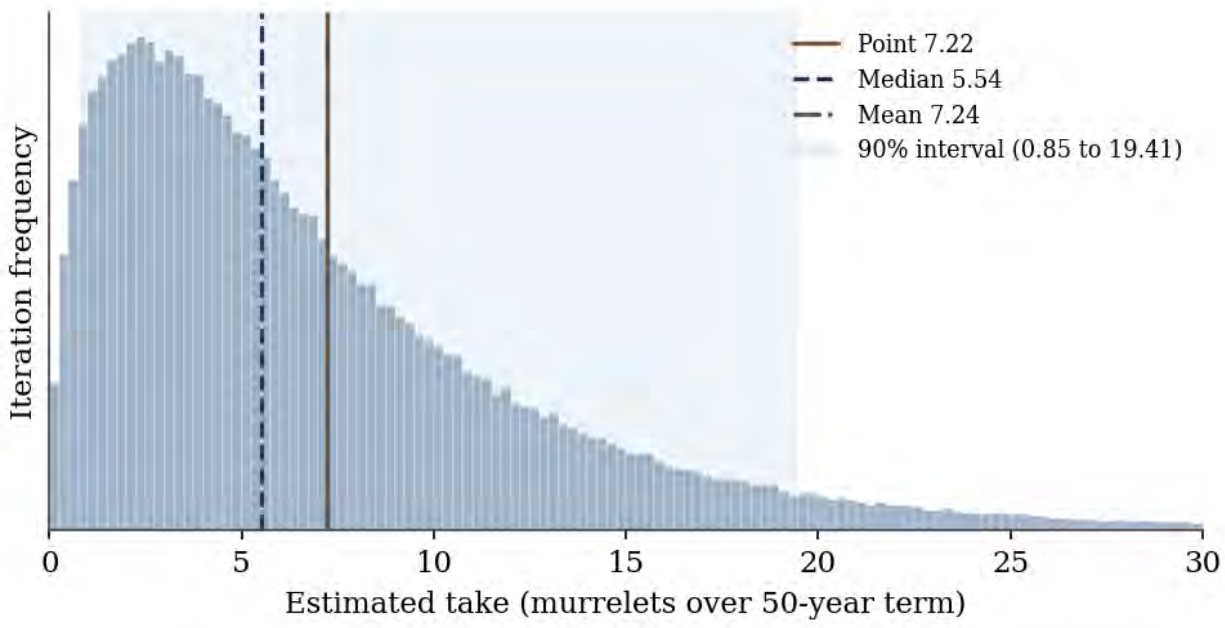


Figure B-1. Propagated distribution of total take. Vertical lines mark the calculator point (7.22), the median (5.54), and the mean (7.24); the shaded band is the 90 percent simulation interval.

The estimated take reported in this plan is the expected number of murrelets taken over the Permit term, which corresponds to the calculator point estimate and to the mean of the propagated distribution. The 90 percent interval presented above characterizes the uncertainty in that estimate; its upper bound is the value that would be exceeded in only about 5 percent of iterations under the modeled assumptions, and it is therefore a description of uncertainty rather than an alternative estimate of take. Because the propagated distribution is right-skewed, the expected value already lies above the median modeled outcome, so the estimate is not a low characterization of central tendency. For these reasons the estimate of take is properly based on the expected value, and the upper bound of the sensitivity interval is retained as a measure of uncertainty and not adopted as the predicted level of take.

Sensitivity to the representation of the proportions

Because the statistical representation of the two proportions is itself an assumption, the take interval was recomputed under four alternative proportion models (Table B-2). The interval remains wide and occupancy-dominated under all four. The operative model lies below the Jeffreys and uniform-prior posteriors and above a Haldane-type sensitivity case, so it is not the most take-inflating of the alternatives.

Table B-2. Total take under four representations of the two field proportions.

Proportion representation	Mean	Median	90% interval
Operative (area-weighted, at sample n)	7.22	5.51	0.85 to 19.36
Jeffreys posterior	7.91	6.36	1.45 to 19.61
Uniform-prior posterior	8.90	7.37	1.93 to 21.05
Haldane-type (improper prior)	6.83	5.29	0.98 to 17.90

Dominant source of uncertainty

The uncertainty is dominated by the occupancy proportion, which was estimated from six patches (Figure B-2). Varying occupancy alone across its range moves total take more than any other input, and substantially more than the platform proportion, nest density, or nesting probability.

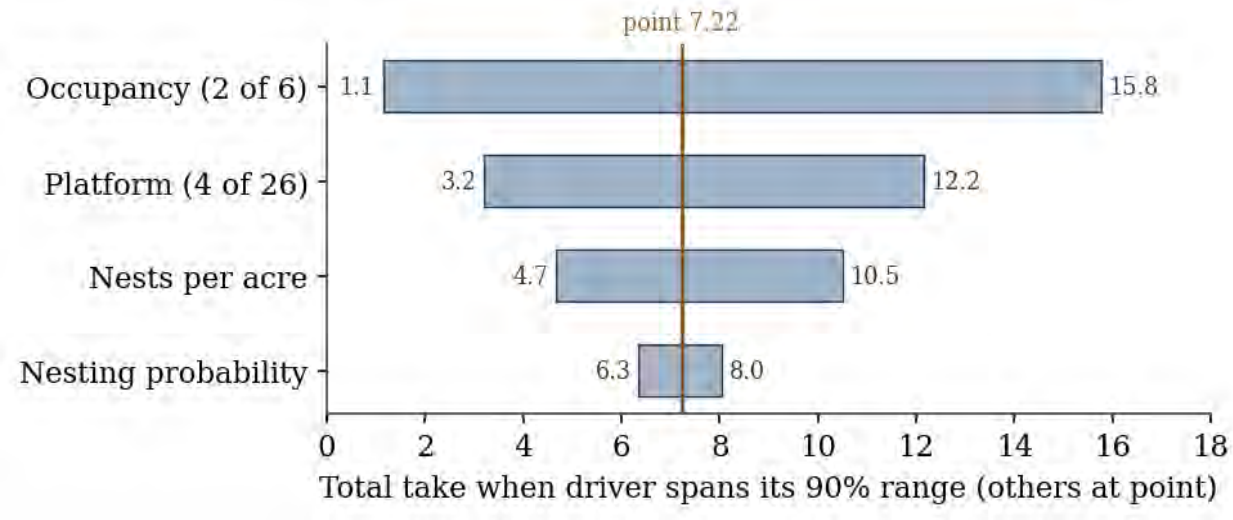


Figure B-2. Contribution of each input to the uncertainty in total take, shown as the total-take range when each input alone spans its 90 percent range and the others are held at their point values.

Robustness of the mitigation ratio

The nestling production credited as mitigation in the reserved stands (Section 5.2.5) is calculated from the same occupancy, nest-density, and nesting-probability inputs that drive take. Increases in take produced by these shared inputs are therefore accompanied by corresponding increases in modeled reserve production, and the mitigation ratio (Section 5.2.6) remains well above 1 to 1 throughout the propagated range. Under three treatments of the placement variability (production independent of take, production linked to the Suitable Habitat Reserve take component, and production and take fully common), the modeled ratio has a 90 percent lower bound of approximately 37 to 1 and does not fall below 1 to 1 in any iteration (Table B-3). This robustness applies to the shared rate parameters; it does not extend automatically to acreage or structural assumptions, and a high ratio indicates modeled robustness rather than biological equivalency.

Table B-3. Mitigation ratio (reserve production divided by total take) under three treatments of placement variability.

Treatment	Median ratio	90% interval
Independent	63.8	36.7 to 110.6
Reserve-linked	64.1	38.2 to 104.4
Fully common	65.8	64.4 to 66.7

Limitations

The interval reflects uncertainty in the quantified inputs together with the disclosed distributional assumptions. It does not encompass structural uncertainty in the take calculation itself, such as the linearity of the indirect-take relationship, the treatment of indirect effects against the single nearest harvest edge, or the habitat classification. The proportion intervals are conditional on the nominal sample sizes; a design-based effective sample size derived from patch areas would refine them. An extension of the indirect-effect distance from 50 to 100 meters, which would raise the estimate to approximately 11.6 murrelets, is a screening estimate only, pending confirmation from the spatial data.

Conclusion

The take estimate is weakly constrained by the available occupancy data, with essentially all of the uncertainty attributable to the small occupancy sample. The modeled mitigation remains adequate across the full range of the analysis. These findings support the survey and adaptive-management commitments described in Section 6 and Appendix E.

Appendix C. Marbled Murrelet Plan Area Survey History

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C.1 INTRODUCTION

This appendix summarizes the history of marbled murrelet surveys conducted within the Plan Area. Section C.2 describes the habitat assessment and audio/visual survey protocols implemented from 1991 through 2001 and the occupied stands identified during that period. Section C.3 describes the revised habitat criteria applied from 2015 through 2022, including the proprietary habitat suitability model developed in 2020, and the results of the audio-visual surveys conducted between 2017 and 2021. Section C.4 summarizes the surveys conducted within the two conservation easements located in the Plan Area from 2006 through 2022.

Survey history is presented chronologically because both the criteria used to identify potential nesting habitat and the protocols applied to it changed over the three periods described. All surveys summarized in this appendix followed the Pacific Seabird Group protocol and standards in effect at the time they were conducted.

C.2 SURVEY HISTORY 1991 – 2001

In the early- to late-1990s, Arcata Redwood Company (ARCo), a subsidiary owned by Green Diamond Resource Company (formerly Simpson Timber Company) conducted a comprehensive assessment of potential marbled murrelet habitat within an approximately 142,000-acre area considered for inclusion in a habitat conservation plan (HCP) for marbled murrelets. Green Diamond's GIS and forest inventory database were used to identify all areas with various densities of residual trees per acre. These areas were then inspected by representatives from ARCo, the Service, and CDFW. Areas identified as potential habitat and scheduled for timber harvest were surveyed. Stands determined to be potentially occupied habitat were protected, and all other stands were harvested. This section summarizes the assessment and survey protocol implemented 1991 – 2001 and the results.

C.2.1 Protocol Summary

Habitat assessments were conducted in collaboration with the Service, CDFW, and CalFire. Audio/visual surveys were conducted in stands determined to be potentially suitable for nesting murrelets. Audio/visual surveys conducted from 1991 through 2001 followed the Pacific Seabird Group protocol and standards in place at that time.

C.2.1.1 Identifying the Project Area, Survey Area and Habitat to Survey

A combination of GIS mapping (forest inventory), aerial photo examination, and field inspections were used to assess the occurrence of areas with residual trees that could be potentially suitable for nesting murrelets. First, areas with residual trees based on forest inventory were mapped. Residual trees were defined by size relative to the surrounding young growth stand. Therefore, residual trees were not purely old-growth trees and this was considered to be a conservative approach. Residual trees were mapped and color coded by three density levels: 5-15, 16-25, and >25 residual trees/acre. If several individual polygons occurred in close proximity, they were considered a single area of residuals. The lowest density level (i.e., 5 residual trees per acre) was selected after examining the average number of residuals present in areas identified as unsuitable but approaching the characteristics of potential suitable habitat and through discussions with

agency and species experts. Residual areas approximately 5 acres or less and isolated from other residual areas or occupied murrelet stands were not considered in the final habitat assessments.

After mapping the residual areas, representatives from ARCo, the Service, and CDFW jointly examined aerial photos to eliminate areas lacking the quality and density of residuals to be considered potential murrelet habitat. If residual areas were judged to be potential habitat or a determination could not be made from aerial photos, then field inspections were conducted.

C.2.2 Audio/Visual Survey Results

All surveys were conducted by trained/certified ARCo biologists following the Pacific Seabird Group-endorsed standard protocols current for that time.

In 1991, 243 surveys were conducted for approximately 1,068 acres resulting in eight occupied stands (Table C-1). In 1992, 482 surveys were conducted for approximately 2,205 acres resulting in eight occupied stands. In 1993, 184 surveys were conducted for approximately 1,144 acres resulting in two occupied stands. Starting in 1993, stands with occupied behaviors were searched for eggshell fragments, but no fragments were observed. In 1994, 165 surveys were conducted for approximately 788 acres resulting in two occupied stands. Seventeen occupied stands were searched for eggshell fragments, and fragments were found in the "Big Mynot" stand. The tree near the fragments was climbed outside of the breeding season, and one nest was confirmed. In 1995, 154 surveys were conducted for approximately 692 acres resulting in one occupied stand but no eggshell fragments. In 1996, 138 surveys were conducted for approximately 658 acres resulting in no additional occupied stands.

Thus, a total of 21 occupied stands were discovered between 1991 and 1996. Surveys continued through 2001 primarily focusing on stands with prior detections or previously documented occupied behaviors. One stand of potential habitat, the "Pisgah View" stand (formerly named "R-3") was not surveyed by ARCo biologists, but this 1.5-acre stand was contiguous with a stand owned by the U.S. Bureau of Outdoor Recreation (administered by the U.S. Forest Service) with occupied behaviors observed during surveys in 1993. Therefore, the "Pisgah View" stand was also considered occupied. Another stand ("T630") received 40 surveys between 1991 and 1996 resulting in 11 detections but no occupied behaviors. Additional surveys in this stand resulted in occupied behaviors in 1998 bringing the total number of occupied stands to 23. Survey summaries and descriptions of these 23 stands are presented in Table C-2.

Prior to Green Diamond's acquisition of the former Louisiana-Pacific ownership in 1998, Louisiana-Pacific conducted murrelet surveys in several watersheds in Humboldt County. The only area of the Louisiana-Pacific ownership where murrelets were detected was in the Maple Creek watershed adding one additional occupied stand to the previous total (n=24).

In 2006, the Miracle Mile Conservation Easement was established that included four of the occupied marbled murrelet stands: Miracle Mile, T300 South, T300 North, and U600. In 2013, a second conservation easement was established that included the occupied EF Hunter stand and the occupied Big Mynot stand. These conservation easement stands and associated surveys are summarized in Section C.4 below.

Table C-1. Summary of marbled murrelet surveys from 1991 through 1996.

Year	Acres surveyed	# of stands surveyed	# of surveys	# of surveys with detections	% of surveys with detections	Total # of detections	# of surveys with observations of occupied behaviors	% of surveys with observations of occupied behaviors	Total # of observations of occupied behaviors
1991	1068	29	243	40	16.5	432	20	8.2	162
1992	2205	63	482	106	22.0	1101	31	6.4	150
1993	1144	36	184	42	22.8	766	14	7.6	42
1994	788	27	165	57	34.5	996	30	18.2	190
1995	692	22	154	56	36.4	471	25	16.2	130
1996	658	20	138	36	26.1	310	18	13.0	109

Table C-2. Marbled murrelet survey information in occupied stands on Green Diamond Resource Company lands 1991 – 2001.

Stand Name	Acres	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Arrow Mills	53.8	NS	O	P	O	O	O	O	O	O	NS	P
K7	13.7	O	O	N	N	P	N	P	N	NS	P	NS
K8	15.6	O	O	N	P	O	N	O	P	P	NS	P
K9	35.4	P	P	N	O	N	N	N	N	NS	N	P
Miracle Mile*	118.7	O	O	O	O	O	O	O	O	O	NS	NS
T300 South and North*	13.0	O	O	O	O	O	O	O	O	NS	NS	NS
T630	33.6	P	P	N	N	N	N	N	O	P	NS	N
U600*	10.5	NS	O	P	O	O	O	O	O	NS	NS	NS
U1500	21.3	P	P	O	N	P	P	P	N	N	N	N
EF Hunter*	40.6	O	P	N	O	P	O	P	N	N	P	N
Big Mynot*	47.8	O	P	O	O	O	O	P	P	O	NS	P
R-3 (Pisgah View)	1.5	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Small Mynot	13.0	NS	P	O	O	P	P	P	O	NS	P	NS
T10 Shop**	13.3	O	O	N	P	P	N	P	N	NS	N	N
W202	5.4	NS	P	N	O	O	O	O	O	O	O	NS
W302**	59.4	NS	O	N	O	N	N	N	P	P	P	P
W530	52.8	NS	O	N	P	P	P	P	O	O	O	NS
Alder Camp (D100)	18.5	NS	NS	P	P	O	N	O	P	NS	NS	NS
Freeway (D10)	26.2	NS	O	O	O	P	O	O	P	P	O	P
Klamath View Ridge (South, West and North)	30.6	N	O	P	O	O	P	O	O	O	O	NS

O – "Occupied" Behaviors Detected, P – "Presence" Detected, N – No Detections, NS – No Survey Conducted
*Denotes a stand associated with a conservation easement established prior to Plan implementation
**Includes main stand and adjacent satellite stand

C.3 SURVEY HISTORY 2015 – 2022

From 2002 through 2014, Green Diamond and agency representatives continued to apply similar criteria for identifying areas of potential habitat as those procedures implemented 1991 through 2001. Agency field inspections and consultations were focused on larger (> 5 acres) areas of older forests or mature forests with a high residual component plus field inspections to confirm the presence of platform structures. Some new areas of potential habitat were identified in 2002 through 2014 primarily associated with adjacent federal and state lands, but no additional occupied areas were identified on the Green Diamond ownership. Starting in 2015, agency representatives began applying a different set of criteria to identify areas of potential habitat based on new interpretations of information presented in the revised Pacific Seabird Group protocol (Evans Mack 2003). From 2015 through 2020, identification of potential habitat relied heavily on determinations made by agency representatives during field inspections since the new criteria was not easily observed through traditional remote sensing techniques. This new definition of habitat resulted in a significant increase in areas on the Green Diamond ownership considered potentially suitable for nesting murrelets, and audio-visual surveys were conducted over large portions of the ownership between 2017 and 2021.

In 2020, Green Diamond developed a proprietary habitat suitability model to help identify areas of potential habitat based on objective criteria derived from known occupied areas on or directly adjacent to the Green Diamond ownership. Areas identified through the habitat model were inspected in the field for potential platform trees, and determinations on habitat potential were made in collaboration with agency representatives. The following section summarizes the assessment and audio-visual survey methods utilized in 2015 through 2022 and results from the audio-visual surveys.

C.3.1 Protocol Summary

C.3.1.1 Identifying the Project Area, Survey Area and Habitat to Survey 2015 – 2019

As described above, new interpretations of the information presented in the revised Pacific Seabird Group survey protocol (Evans Mack 2003) were implemented on the Green Diamond ownership starting in 2015. Potential habitat included stands with two or more potential platform trees spaced no more than 100 meters apart. A potential platform tree was defined as a tree with a limb 4-inches in diameter or greater with a relatively flat surface and no minimum standards for number of platforms per tree or per acre. Additionally, other criteria such as platform substrate, cover and access were not considered. As a result of these broad metrics, traditional remote sensing methods could not be utilized to refine which areas were in need of field inspections. Therefore, representatives from Green Diamond and CDFW relied heavily on collaborative field inspections during the timber harvest plan (harvest plan) review process. Areas identified as potential habitat regardless of size received a 300-foot no vegetation modification buffer and a 0.25-mile seasonal disturbance buffer, and Green Diamond had the option to conduct audio-visual surveys following the 2003 Pacific Seabird Group survey protocol.

Audio-visual surveys were conducted in select areas between 2017 and 2021. Typically, representatives from CDFW would identify all or a portion of potential platform trees during the

preharvest field inspections or make a recommendation for Green Diamond biologists or designated consulting biologists to complete the field inspections. Number of stations and station placement followed the guidelines in the 2003 Pacific Seabird Group survey protocol along with input and recommendations from CDFW, which typically increased the number of stations. Likewise, survey design followed the 2003 Pacific Seabird Group protocol with recommendations from CDFW on the timing of surveys and number of surveys per station. Similar to the recommendations for number of stations, CDFW input typically increased the overall number of surveys required compared to the Pacific Seabird Group guidelines, including the use of multiple observers conducting simultaneous surveys, and the majority of stands were surveyed longer than the two-year requirements.

C.3.1.2 Identifying the Project Area, Survey Area and Habitat to Survey 2020 – 2022

In 2020, Green Diamond developed a proprietary habitat suitability model (Appendix A) to help identify areas of potential habitat based on characteristics of known occupied stands on or adjacent to the Green Diamond ownership. Areas predicted by the model, regardless of suitability (i.e., marginal, low, medium, or high) or size were examined in the field by Green Diamond biologists certified to conduct marbled murrelet audio-visual surveys. In addition to use of the habitat model, Green Diamond biologists would also review the proposed harvest area for the presence of previously identified potential or occupied marbled murrelet habitat by reviewing Green Diamond's GIS database, past consultations with CDFW, and the California Natural Diversity Database. Field inspections involved a certified biologist traversing areas in search of platform trees. A platform tree was defined as a coniferous tree with one or more potential platforms. A potential platform was defined as a relatively flat surface at least 6-inches in diameter with nesting substrate, horizontal and vertical cover to prevent exposure, access for marbled murrelets, and contained within the live crown. If three or more platform trees spaced no more than 100 meters apart were observed, then Green Diamond consulted with representatives from CDFW, and at times, the Service. In addition to the definitions for a potential platform tree and spacing criteria, number of platforms per tree, type of platform, and proximity to other areas of potential or occupied habitat were also considered.

Areas identified as potential nesting habitat received a 300-foot no vegetation modification buffer and a 0.25-mile seasonal disturbance buffer. However, these buffers were often reduced based on site specific conditions. Although Green Diamond retained the option to conduct Pacific Seabird Group protocol audio-visual surveys in areas identified as potential habitat, no audio-visual surveys were conducted for newly assessed harvest plans in 2020 – 2022.

C.3.2 Survey Results

C.3.2.1 2015 – 2019

Between 2015 and 2019, approximately 1,578 acres associated with 43 harvest plan units were identified as potential habitat using the methods described above. Based on model predictions, approximately 1,123 acres were classified as unsuitable, 226 were classified as marginal suitability, and 151 acres were classified as low, medium or high suitability. Of the 1,578 acres of potential habitat, 628.57 acres received audio-visual surveys from 2017 through 2021 (Table C-3). A total of 432 surveys were conducted resulting in two stands (80.4 total acres) with occupied

behaviors (Table C-4). A third stand (Clear Creek East) also included one observation of a bird flying even with the top of a supra-canopy residual tree. This stand was surveyed for five years with no other observed behaviors, and all follow-up surveys indicated that the bird was likely travelling past the stand towards a nearby known occupied stand as no birds were observed using the Clear Creek East stand. Although survey results indicated that the stand was not occupied, this stand was conservatively included in all MMHCP analyses as an occupied area.

C.3.2.2 2020 – 2022

From 2020 through 2022, ground-based habitat assessments were conducted for approximately 1,414 acres including 321 acres of unsuitable habitat, 658 acres of marginal habitat, and 435 acres of low, medium and high suitability. Acreages and suitability categories were derived by summing the acres within the marginal and low suitable and better hulls as defined in Appendix A. Only hulls located on the Green Diamond ownership were included in the totals. Therefore, this is a conservative estimate of the overall acres assessed since additional areas were assessed outside of the hull boundaries and adjacent to the ownership.

Of the 1,414 acres assessed, 27.6 acres associated with 17 harvest plan units were identified as potential habitat. Of the 27.6 acres of potential habitat, approximately 0.4 acres were classified as unsuitable habitat, 20.8 acres were classified as marginal habitat, and 6.4 acres were classified as low suitable or better. No audio-visual surveys were conducted in areas identified as potential habitat 2020 – 2022.

In addition to the areas assessed above, an occupied marbled murrelet stand referred to as ‘Oil Creek’ (Section 6.2.2) was identified on lands acquired by Green Diamond in 2023. Audio-visual surveys demonstrating occupancy at Oil Creek were conducted by the previous landowner in 2021 and 2022 prior to Green Diamond’s acquisition of the property. Therefore, these surveys were not included in this Appendix C. The Oil Creek stand has nonetheless been incorporated into the Plan as an Occupied Reserve.

Table C-3. Summary of marbled murrelet surveys from 2017 through 2021.

Year	Acres surveyed	# of stands surveyed	# of surveys	# of surveys with detections	% of surveys with detections	Total # of detections	# of surveys with observations of occupied behaviors	% of surveys with observations of occupied behaviors	Total # of observations of occupied behaviors
2017	54.0	4	24	2	8.3	4	0	0.0	0
2018	258.6	8	52	1	1.9	1	0	0.0	0
2019	125.7	6	46	8	17.4	21	0	0.0	0
2020	643.5	23	171	16	9.4	71	4	2.3	16
2021	549.5	19	139	3	2.2	4	0	0.0	0

Table C-4. Marbled murrelet survey information in occupied stands on Green Diamond Resource Company lands 2017 – 2021.

Stand Name	Acres	2017	2018	2019	2020	2021
Clear Creek East	20.7	P	N	P*	P	P
Maple Creek	11.0	N	N	P	O	N
Bald Mtn Creek	69.4	N	N	NS	O	P

O – "Occupied" Behaviors Detected, P – "Presence" Detected, N – No Detections, NS – No Survey Conducted

*Visual observation of a single murrelet flying even with the top of a supra-canopy residual tree along the edge of a road bordering the stand. The bird then made a 'U-turn' in an adjacent clearcut stand before flying back over the Clear Creek East stand. Clear Creek East stand included in the MMHCP analyses and conservation measures as an occupied stand.

C.4 SURVEY HISTORY OF CONSERVATION EASEMENTS

Two conservation easements are located within the Plan Area: Miracle Mile and E F Hunter/Big Mynot. The Miracle Mile Conservation Easement is approximately 672 acres located in the Terwer Creek drainage of the Lower Klamath Basin. The EF Hunter/Big Mynot Conservation Easement is approximately 298 acres. The Big Mynot stand is located on a ridge between two forks of Mynot Creek, and the EF Hunter Creek stand is located in the headwaters of the East Fork of Hunter Creek. Approximately 142 acres of the Miracle Mile stand, 48 acres of the Big Mynot stand, and 40 acres of the E.F. Hunter stand are old-growth forest surrounded by younger stands less than 50 years-old. Both conservation easements are owned by Save the Redwoods League and managed for habitat, ecosystem, and other natural values including breeding habitat for marbled murrelets. Additionally, the conservation easements prohibit commercial timber harvest. Surveys for marbled murrelets in the Miracle Mile easement were conducted through Save the Redwoods League from 2006 through 2022, with two years of surveys taking place every five years. The following sections summarize surveys conducted through 2022.

C.4.1 Protocol Summary

C.4.1.1 Identifying the Project Area, Survey Area and Habitat to Survey

The marbled murrelet surveys were conducted following the established Pacific Seabird Group protocol (Evans Mack 2003). Survey areas were comprised of four old-growth redwood stands within the Miracle Mile Conservation Easement (Miracle Mile, T300 North, T300 South, U600). The T300 North and South stands were combined into a single survey site. Stations within each site were placed within or immediately adjacent to the old-growth stands and spread evenly throughout to provide complete coverage. Thirteen stations were established in 2006 but reduced to six stations to allow for more visits at stations with detections.

C.4.2 Survey Results

Thirteen stations were established within the easement 2006 through 2017 resulting in 54 surveys in each two-year period. Occupied behaviors were observed during four surveys 2006 – 2007, one survey 2011 – 2012, and three surveys 2016 – 2017. In 2021 and 2022, six of the 13 established stations were surveyed a total of 54 times, and occupied behaviors were observed during three surveys. Table C-5 summarizes the overall survey results for the three sites located within the Miracle Mile Conservation Easement.

Table C-5. Survey results 2006 through 2022 for the stands within the Miracle Mile Conservation Easement.

Stand Name	Acres	2006	2007	2011	2012	2016	2017	2021	2022
Miracle Mile	118.7	O	N	P	P	N	P	O	P
T300 North and South	13.0	N	O	P	P	P	O	P	O
U600	10.5	O	O	O	P	P	O	O	P

O – "Occupied" Behaviors Detected, P – "Presence" Detected, N – No Detections

Appendix D. Take Avoidance and Minimization Measures

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D.1 INTRODUCTION

As described in Section 5 of the MMHCP, the term "take" under the ESA means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct. Harm in the definition of take means an act which actually kills or injures wildlife or significantly disrupts essential behaviors to the extent that injury or death is likely to occur. The term "take" under the CESA means to hunt, pursue, catch, capture or kill or attempt to engage in such conduct.

MMHCP Covered Activities have the potential to cause incidental take individually or cumulatively in two scenarios: (1) direct take of murrelets that are killed or injured when occupied suitable nesting habitat is harvested (ESA and CESA "take"); and (2) indirect take when Covered Activities occurring outside the boundaries of suitable nesting habitat cause significant impairment of essential behavior leading to actual death of or injury to murrelets (harm under ESA "take"). Examples of indirect take may include edge-effects from habitat modification or edge-effects from noise or visual disturbance. A more detailed description of "take" is provided in Section 5.1.1.

For the purposes of this HCP, Green Diamond estimated take based on the removal or alteration of potentially occupied Marginal Habitat and potential indirect take (edge-effects) from Covered Activities occurring in close proximity to occupied stands. Section 5.2 further describes the assessment and estimates of take and mitigation for the level of take anticipated to occur during the MMHCP permit term. Even though Covered Activities have the potential to cause direct and indirect harm, all forms of take can be practically avoided by temporal and spatial buffers for specific activities. As such, this appendix provides a detailed description of the measures that will be implemented to avoid and minimize take of nesting marbled murrelets.

D.2 TAKE AVOIDANCE AND MINIMIZATION MEASURES

D.2.1 Vegetation and Disturbance Buffers for Occupied and Presumed Occupied Marbled Murrelet Stands (Occupied Reserves and Adjacent Habitat Reserves)

All occupied and presumed occupied marbled murrelet stands (Occupied Reserves and Adjacent Habitat Reserves) will receive a 300-foot (91.4-meter) vegetation and seasonal disturbance buffer. This protection applies to occupied stands on the Plan Area (Occupied Reserves), neighboring lands (Adjacent Habitat Reserves), and lands added to the Plan Area through acquisition.

Vegetation buffer

A 300-foot vegetation buffer will be placed around all known occupied and presumed occupied marbled murrelet stands (Occupied Reserves and Adjacent Habitat Reserves; Maps 6-1-1, 6-1-2, and 6-1-3). The vegetation buffer functions to protect the murrelet stands from edge effects such as increased predation and changes in microclimate. The forested areas within the buffers will continue to mature over time eventually developing the structure and conditions resulting in suitable habitat that supports murrelet nesting and contributing to increased suitability and "interior habitat" conditions within the original occupied habitat.

The distance of 300 feet was chosen based on current and historical take avoidance practices in California, recommendations in the *Recovery Plan for the Marbled Murrelet* (USFWS 1997) and

documentation in published literature demonstrating that the majority of edge effects are captured within 164-328 feet (50-100 meters) of hard edges such as recent clearcut harvest areas or young regenerating forests (Paton 1994, Chen et al. 1992, Raphael et al. 2002). Additionally, this 300-foot vegetation buffer has been in place around known or presumed occupied stands within the Plan Area since these stands were originally documented as occupied creating a baseline condition of protected stands.

Disturbance buffer

A 300-foot seasonal disturbance buffer will be placed around all known occupied and presumed occupied marbled murrelet stands (Occupied Reserves and Adjacent Habitat Reserves) from March 24 through September 15 except as described below where a shorter disturbance period is allowed for certain activities. The disturbance buffer functions to minimize potential take that may occur as a result of auditory or visual disturbance. As described in Section 5.1.2.2, take through auditory disturbance may occur if above-baseline noise interferes with essential behavior to the degree that it causes actual death or injury to murrelets such as flushing a murrelet nestling from its nest or egg/nestling neglect that results in death. Based on observations at known marbled murrelet nests (see Long and Ralph 1998), take through noise disturbance within the Plan Area is unlikely given the baseline conditions and the fact that marbled murrelets become habituated to noises in settings where anthropogenic disturbance is common.

The distance of 300 feet was chosen based on take avoidance measures that have been implemented in the Plan Area since these stands were originally documented. Although standard take avoidance measures in California begin with a 0.25-mile seasonal disturbance buffer, past consultations with CDFW and technical assistance requests through the Service result in smaller disturbance buffers based on guidance from the Arcata FWS office (USFWS 2020). Given baseline (ambient) noise conditions within the Plan Area, action generated noise levels tend to be ameliorated after a distance of 300 feet. Additionally, this 300-foot disturbance buffer is consistent with take avoidance measures being implemented in other areas of the marbled murrelet range based on guidance from the Service (USFWS 2015).

This section describes activities and timing of activities allowed within the 300-foot vegetation and seasonal disturbance buffers.

D.2.1.1 Road construction, use, and maintenance

D.2.1.1.1 Rocked roads

Use of rocked roads including equipment, rock, and log hauling and administrative traffic shall be allowed during the marbled murrelet breeding season within the 300-foot buffer so long as noise and the number of passes within the buffer are minimized (see take minimization measures summary in Section D.2.6 below).

Road maintenance activities required to maintain the running surface of the road such as dust abatement, surface grading, and mechanical control of roadside vegetation (brushing) shall be allowed within the buffer during the breeding season so long as noise and the number of passes within the buffer are minimized as described below in Section D.2.6. Additionally, road grading

and brushing within the buffer during the breeding season shall only be allowed between two hours after sunrise and two hours before sunset.

These types of road use and maintenance are mobile in nature and temporary/short-term potential disturbances. All other activities are permitted within the buffer but outside of the breeding season except as described in Section D.2.1.1.4 where specific activities associated with Green Diamond's approved Aquatic Habitat Conservation, California Forest Practice Rules (Forest Practice Rules), or other permits are required before the end of the breeding season.

Emergency road maintenance activities such as cleaning of culverts during storm events and the removal of fallen trees on the road shall be allowed within the buffer during the breeding season so long as noise emissions and the amount of activity within the buffer are minimized.

D.2.1.1.2 Dirt roads

Use of dirt roads (Covered Activities that do not involve vegetation disturbing activities) where less than 500 continuous feet of the road passes within 300 feet of an occupied or presumed occupied stand shall be allowed during the marbled murrelet breeding season so long as noise and the number of passes within the buffer are minimized, and activities only occur between two hours after sunrise and two hours before sunset (see take minimization summary Section D.2.6).

All other road maintenance activities (Section 2.2.5) are allowed within the buffer but outside of the breeding season unless listed below in Section D.2.1.1.4 for maintenance required under Green Diamond's approved Aquatic Habitat Conservation Plan, the Forest Practice Rules, or other permits.

D.2.1.1.3 Road construction or reconstruction

Road construction (Section 2.2.5) shall be allowed within the buffers outside of the breeding season so long as construction is restricted to the outer 200 feet (61 meters) and only occurs within stands 15 years or younger. Any site-specific modifications shall be approved through technical assistance with the Service.

Road reconstruction (Section 2.2.5) shall be allowed within the buffers outside of the breeding season in stands that are currently lacking in height to provide security habitat (i.e., stands generally less than 37 years or 80 feet tall, see Section 5.2.2.2) for the Occupied Reserve or Adjacent Habitat Reserve or in stands providing security habitat but where removal is limited to vegetation that does not meet the criteria for security habitat. Additionally, the footprint of the road prism shall be limited to the width necessary to facilitate safe passage and to comply with the requirements of Green Diamond's Aquatic Habitat Conservation Plan or other regulations.

D.2.1.1.4 Maintenance, road upgrading, road decommissioning, or access required under Green Diamond's Aquatic Habitat Conservation Plan (AHCP), the Forest Practice Rules, or other permits

Covered Activities related to road use (access, maintenance, upgrading, decommissioning, construction, etc.) required under Green Diamond's AHCP, the Forest Practice Rules, or other permits shall be allowed within the 300-foot buffers between August 1 and September 15 between

two hours after sunrise and two hours before sunset. Noise emissions and the duration of activity within the buffer shall be minimized. Examples of required activities include crossing replacement or removal, cross drain replacement, grading, and associated access. Measures included in the AHCP and other similar regulations are designed to benefit aquatic resources by reducing sediment inputs into watersheds.

D.2.1.1.5 Rock pit blasting

Rock pit blasting shall not occur within 0.25 mile of known or presumed occupied stands (Occupied Reserves and Adjacent Habitat Reserves) during the breeding season.

D.2.1.2 Commercial Timber Harvest-related Activities

Commercial timber harvest activities such as felling, bucking, yarding, and loading shall not be allowed within the buffer during or outside of the breeding season except as described above in Section D.2.1.1 or below in Sections D.2.1.3 and D.2.1.4. For helicopter operations (aerial yarding), the disturbance buffer is extended to 0.25 mile during the breeding season. Commercial timber harvest activities also include salvaging activities (Section 2.2.3) except salvage activities implemented in response to "Changed Circumstances" (Section 6.5).

D.2.1.2.1 Tailholds

Tailholds shall be allowed within the buffers during the breeding season but not within the Occupied Reserves or Suitable Habitat Reserves. Use of drones to aid in the establishment of tailholds shall be allowed within the buffer during the breeding season so long as flights over or within 50 meters of Occupied Reserves are avoided.

D.2.1.3 Forest Regeneration

Activities related to forest regeneration following a commercial harvest shall be allowed within the buffer; however, not all activities are allowed during the breeding season. These activities accelerate the growth and development of regenerating forests which benefit the marbled murrelet and its habitat.

D.2.1.3.1 Site Preparation, Prescribed Burning, Slash Treatment

Site preparation including prescribed burning (broadcast and pile), machine piling of slash, mechanical scarification, and bio-mass harvesting shall not occur within the buffer during or outside of the breeding season. Even-aged commercial harvest is not proposed within the buffers. Uneven-aged harvest proposed within the buffers as described below in section D.2.1.4 will restrict site preparation activities to outside of the buffers. Prescribed burning will not occur adjacent to the buffers unless the fire can be isolated to outside of the buffers with no obvious risk to the buffer or adjacent occupied marbled murrelet stand. On-site chipping shall not occur within the buffer during the breeding season.

D.2.1.3.2 Tree Planting and Control of Competing Vegetation

Tree planting and control of competing vegetation involve hand tools that do not result in noise disturbance, and duration of these activities is short (generally one day). Therefore, these activities shall be allowed within the buffer during the breeding season.

D.2.1.3.3 Precommercial Thinning and Pruning

A single precommercial thinning entry may be conducted within the buffers to manage the density of regenerating conifer and hardwood saplings. Precommercial thinning and pruning occurs in stands 10-20 years old primarily using chainsaws. Although studies have shown that chainsaw use does not result in noise disturbance for nesting murrelets unless the activity occurs directly under a nest tree (Hébert and Golightly 2006), chainsaw use has not typically been allowed within these known or presumed occupied stands historically, thus creating a baseline condition. Therefore, these activities are allowed within the buffer during the breeding season between August 1 and September 15 or outside of the breeding season. Precommercial thinning within a buffer will occur only in conjunction with the same activity scheduled in the adjoining stand; no buffer will be entered for precommercial thinning as a stand-alone operation.

D.2.1.4 Unevenaged Management Silviculture within Occupied Reserve Buffers or Adjacent Habitat Reserve Buffers to Recruit Marbled Murrelet Habitat

Silviculture treatments may be implemented within the Occupied Reserve buffers and Adjacent Habitat Reserve buffers to develop and promote late seral habitat conditions. The treatments within the buffers will occur coincident with other planned harvests adjacent to the buffers according to Green Diamond's near- and long-term harvest scheduling, the Forest Practice Rules, and other Green Diamond HCPs and agreements. Although trees removed under this prescription may be sold commercially, this treatment is a light-intensity restoration prescription designed to remove only a limited portion of the stand basal area while retaining canopy closure, structural complexity, and the interior forest conditions that are protective of nesting marbled murrelets. The term 'commercial silviculture treatment' is used in this appendix to distinguish between precommercial treatments (treatments occurring within young stands approximately 10 to 20 years old) and the restoration treatment occurring within rotation age stands 45 years and older where the harvested trees may be sold commercially. The treatments within the buffers may occur more than once within the Permit Term, and the silviculture prescription allowed within the buffers is further described in Section 6.2.3.

The commercial silviculture treatments within the buffers shall occur outside of the breeding season. Certain road use and maintenance activities (D.2.1.1.4) and certain forest regeneration activities (D.2.1.3.3) are allowed within the buffers during the breeding season.

D.2.1.5 Administrative Land Use Activities

Administrative land use activities shall be allowed within the buffers during the breeding season without restrictions so long as stopping within the buffer, passes through the buffer, and noise within the buffer during the breeding season are kept to a minimum when feasible. Administrative land use activities include but are not limited to water drafting, wildlife surveys, forest inventory, minor forest product harvesting, and equipment maintenance and associated administrative traffic.

Compliance with these measures will be overseen by Green Diamond for activities conducted by employees and non-employees. Company employees receive training on these restrictions, signage is posted along roads to identify restricted areas, and non-employees permitted to conduct activities are required (as a condition of their access permit) to adhere to all Green Diamond rules and regulations, including these buffer restrictions.

D.2.1.6 Existing Hard Edges within Vegetation Buffers

Hard edges created by major roads or watercourses

In situations where a major road (permanent rocked, paved, or public roadway) or watercourse (Class I watercourse) passes through the vegetation buffer and creates a 'hard edge', Green Diamond may seek technical assistance with the Service to request no vegetation modification restrictions for the portion of the buffer that occurs on the opposite side of the road or watercourse from the occupied or presumed occupied stand. In these situations where the roads and watercourses create a hard edge, the portion of the buffer that is separated from the occupied or presumed occupied stand fails to provide protection (security habitat) for the occupied/presumed occupied stand. Therefore, site-specific measures may be developed. All other noise disturbance minimization measures shall apply as described in this appendix.

Hard edges created by powerline right-of-way

Within the Plan Area, there are two instances where a powerline right-of-way occurring adjacent to occupied or presumed occupied habitat creates a hard edge. One powerline right-of-way travels through the vegetation buffer for habitat associated with the Del Norte Coast Redwoods State Park. The right-of-way is approximately 140 feet (43 meters) from the edge of the Del Norte Coast Redwoods State Park habitat and ranges approximately 50-80 feet (15-24 meters) wide creating a hard edge towards the outer portion of the vegetation buffer (Figure D-1). Therefore, no vegetation modification restrictions are proposed for the portions of the vegetation buffer located south and east of the right-of-way (i.e., situated on the opposite side of the right-of-way in relation to the murrelet habitat). All other noise disturbance minimization measures shall apply as described in this appendix.

The second right-of-way travels through the vegetation buffer for habitat associated with Harry A. Merlo State Recreation Area. The right-of-way is situated at varying distances from the murrelet habitat ranging from the edge of the habitat to greater than 100 feet (30 meters) from the habitat. The right-of-way width ranges from 25 feet (8.0 meters) to 70 feet (21 meters). No vegetation modification restrictions are proposed for the portions of the vegetation buffer located east of the right-of-way (i.e., situated on the opposite side of the right-of-way in relation to the murrelet habitat). All other noise disturbance minimization measures shall apply as described in this appendix.

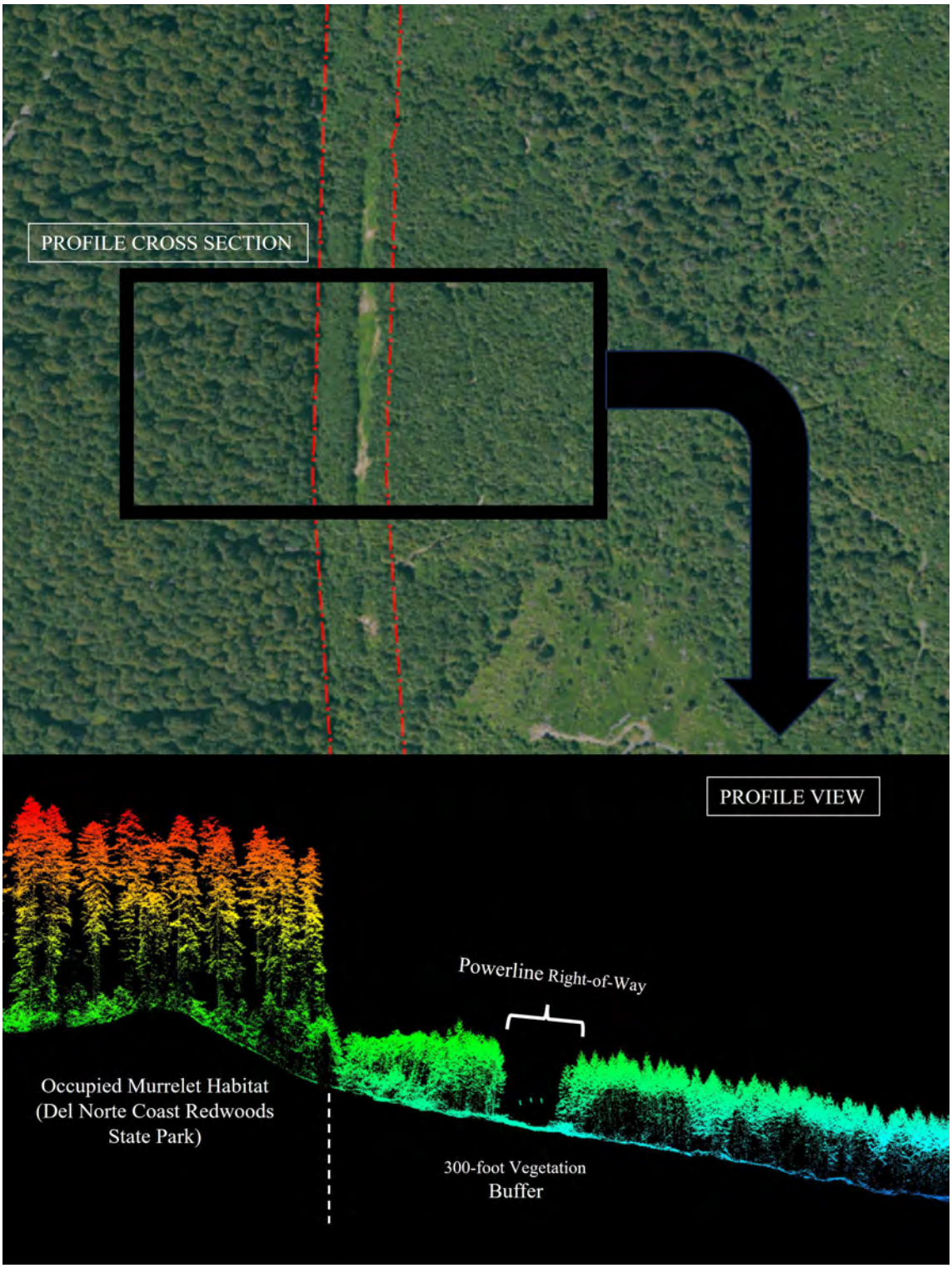

Figure D-1. LiDAR point cloud profile view of the Del Norte Coast Redwoods State Park Adjacent Habitat Reserve, 300-foot vegetation buffer, and hard edge created by a powerline right-of-way.

D.2.2 Low, Medium, and High Suitability Patches (Suitable Habitat Reserves)

No harvest operations or vegetation modification shall occur within Low, Medium, or High suitability patches (Suitable Habitat Reserves) except Covered Activities related to road use and maintenance for existing roads. Road reconstruction shall only be allowed through site-specific technical assistance with Service to confirm that the vegetation to be removed is of insufficient height and structure to provide security habitat (generally less than 80 feet and lacking complex crown or limb features) or that vegetation to be removed results in no substantive change to the overall function of the habitat reserve. Prescribed burning shall not occur adjacent to Suitable Habitat Reserves unless the fire can be isolated to outside of the Suitable Habitat Reserves with no obvious risk to the reserves.

D.2.3 Unsuitable and Marginal Habitat Patches

All Covered Activities are allowed within Unsuitable and Marginal Habitat patches without restrictions.

D.2.4 Best Management Practices

Litter such as food, food wrappers, or other forms of anthropogenic food waste may attract members of the family Corvidae (ravens, crows, jays) documented nest predators of the marbled murrelet. Increased accessibility of food in murrelet nesting habitat may cause jays or other corvids to reduce territory size and concentrate in these areas (Marzluff and Neatherlin 2006, West and Peery 2017). In order to minimize take, litter that may attract corvids shall not be deposited within the Occupied Reserves, disturbance buffers, or Suitable Habitat Reserves. Within the Plan Area, management actions such as training for contractors and employees and signage (denoting the locations of Occupied Reserves and associated buffers) will be undertaken to minimize the risk of attracting murrelet nest predators through unintentional feeding.

D.2.5 Active Nest Protection Measures

If an active marbled murrelet nest is discovered during operations, operations within 0.25 mile of the nest will be suspended until after the breeding season (September 15) or until a qualified wildlife biologist has determined that the nest has failed or the young have fledged. Exceptions include road use and maintenance activities as described in D.2.1.1 and administrative land use activities (D.2.1.5) provided take minimization measures are implemented as described below in D.2.6.

D.2.6 Take Minimization Measures Summary

The following provides a high-level summary of the take minimization measures described in this appendix. This summary is not exhaustive. Please refer to the appendix text for the complete list of measures and detailed descriptions.

- The marbled murrelet breeding season shall be from March 24 through September 15 with an early end to the breeding season (August 1) for certain Covered Activities described below.

- No vegetation modification shall occur in stands identified as Occupied Reserves or Suitable Habitat Reserves except as described for road use (access, maintenance, construction, upgrading, decommissioning, etc.).
- A 300-foot vegetation buffer shall be established around Occupied Reserves and Adjacent Habitat Reserves except as described below:
    - Where a powerline right-of-way passes through the buffer for murrelet habitat associated with the Del Norte Coast Redwoods State Park and Harry A. Merlo State Recreation Area such that a portion of the buffer is isolated/separated from the murrelet habitat and fails to provide protection for the murrelet habitat (i.e., hard edge), vegetation modification restrictions shall only apply to the portion of the buffer providing protection/security habitat for the reserves.
- A 300-foot seasonal disturbance buffer shall be established around Occupied Reserves and Adjacent Habitat Reserves.
- Road Use and Maintenance
    - Use and Maintenance of rocked roads shall be allowed within the 300-foot buffers during the breeding season with the following provisions:
        - Hauling operations including log, rock, and equipment shall be permitted provided all other protection measures listed below are implemented.
        - The maximum speed limit shall be 15 miles per hour.
        - Tracked equipment shall be transported on a trailer unless safe passage by trailer is not possible or passage by trailer is not feasible. If passage by trailer is not possible due to safety or other operational constraints, then walked equipment will be allowed with the following provisions:
            - Activity within the buffer shall only occur between two hours after sunrise and two hours before sunset.
            - Noise emissions and the number of passes through the buffer shall be minimized.
            - Stopping or backing while in the buffer shall be minimized.
        - Slamming of dump truck gates, use of horns, use of “jake” brakes and other loud noises shall not occur within the 300-foot buffer during the breeding season except for safety or emergency purposes.
        - Stationary road activities (maintenance, use, upgrading, decommissioning, etc.) required to comply with Green Diamond’s Aquatic Habitat Conservation Plan, the Forest Practice Rules, and other permits such as culvert replacement or ditch clearing shall be allowed within the 300-foot buffer outside of the breeding season and during the breeding season between August 1 and September 15. For activities occurring during the breeding season between August 1 and September 15, the following provisions apply:
            - Work shall be scheduled as late in the breeding season as operationally feasible and encroach on the buffer gradually when possible.
            - Activities shall only occur between two hours after sunrise and two hours before sunset.
            - Noise emissions and the extent of activity within the buffer shall be minimized.

- Emergency road maintenance activities such as cleaning of culverts during storm events and the removal of fallen trees on the permanent roads shall be permitted so long as noise and amount of activity within the 300-foot buffer during the breeding season is minimized.
- Routine road maintenance activities to maintain the running surface of the rocked roads including dust abatement (water or lignin application), light surface grading, and mechanical control of roadside vegetation (brushing) shall be allowed within the buffer during the breeding season so long as the following conditions are applied:
  - Noise emissions and the number of passes through the buffer shall be minimized.
  - Stopping or backing when in the buffer shall be minimized.
  - Road grading and brushing shall only occur between two hours after sunrise and two hours before sunset.
- Administrative traffic shall be allowed within the buffer during the breeding season without restrictions so long as noise is kept to a minimum and stopping only occurs for safety or wildlife survey purposes.
- Signs indicating seasonal restrictions shall be placed along the roads at the perimeter of the buffer at the start of the breeding season.

o Use and Maintenance of dirt roads shall be allowed within the 300-foot buffers during the breeding season with the following provisions:

- Covered Activities described below shall be allowed on dirt roads within the 300-foot buffers during the breeding season where less than 500 continuous feet of the road passes within the buffer of a stand.
- Vegetation disturbing activities shall only occur outside of the breeding season.
- All activities described below shall be allowed within the buffer during the breeding season between two hours after sunrise and two hours before sunset provided all other listed protection measures are implemented.
- Hauling operations including log, rock, and equipment shall be permitted provided all other protection measures listed below are implemented:
- The maximum speed limit shall be 15 miles per hour.
- Tracked equipment shall be transported on a trailer unless safe passage by trailer is not possible or passage by trailer is not feasible. If passage by trailer is not possible due to safety or other operational constraints, then walked equipment will be allowed so long as all other provisions listed below are implemented.
  - Noise emissions and the number of passes through the buffer shall be minimized.
  - Stopping or backing while in the buffer shall be minimized.
- Slamming of dump truck gates, use of horns, use of "jake" brakes and other loud noises shall not occur within the 300-foot buffer during the breeding season except for safety or emergency purposes.
- Stationary road activities (maintenance, use, upgrading, decommissioning, etc.) required to comply with Green Diamond's Aquatic Habitat Conservation Plan, the Forest Practice Rules, or other permits such as

culvert replacement or ditch clearing shall be allowed within the 300-foot buffer outside of the breeding season and during the breeding season between August 1 and September 15. For activities occurring during the breeding season between August 1 and September 15, the following provisions apply:

- Vegetation disturbing activities shall only occur outside of the breeding season.
- Work shall be scheduled as late in the breeding season as operationally feasible and encroach on the buffer gradually when possible.
- Noise emissions and the extent of activity within the buffer shall be minimized.

- Emergency road maintenance activities such as cleaning of culverts during storm events and the removal of fallen trees on the roads shall be permitted so long as noise and amount of activity within the 300-foot buffer during the breeding season is minimized.
- Routine road maintenance activities to maintain the running surface of the roads including dust abatement (water or lignin application) and light surface grading shall be allowed within the buffer during the breeding season so long as the following conditions are applied:
  - Noise emissions and the number of passes through the buffer shall be minimized.
  - Stopping or backing when in the buffer shall be minimized.
- Administrative traffic shall be allowed within the buffer during the breeding season without restrictions so long as noise is kept to a minimum and stopping only occurs for safety or wildlife survey purposes.
- Signs indicating seasonal restrictions shall be placed along the roads at the perimeter of the buffer at the start of the breeding season.

- Road Construction
  - Road construction shall not be allowed within the buffers during the breeding season.
  - Road construction shall only be allowed within the buffer outside of the breeding season if construction is restricted to the outer 200-feet of the buffer and only occurs within stands 15 years or younger.
  - Road construction within the buffer shall be limited to the minimum road prism width necessary to facilitate safe passage and comply with Green Diamond's AHCP, the Forest Practice Rules, and other permits.
  - Any site-specific modifications shall be approved through the technical assistance process with Service.
- Road Reconstruction
  - Road reconstruction shall be allowed within the buffer outside of the breeding season so long as the following provisions are implemented:
    - Activities only occur within the buffer in stands lacking in height to provide security habitat (generally stands less than 37 years old or less than 80 feet tall) or in stands providing security habitat but

where removal is limited to vegetation not meeting the criteria for security habitat.
  - No modification of Occupied Reserves or Adjacent Habitat Reserves shall occur.
  - No modification of potential platform trees (as determined by a qualified wildlife biologist) within the buffer shall occur.
  - Reconstruction within the buffer shall be limited to the minimum road prism width necessary to facilitate safe passage and comply with Green Diamond's AHCP, the Forest Practice Rules, or other permits.
  - Any site-specific modifications shall be approved through the technical assistance process with Service.

- Commercial Harvest
  - Activities related to commercial timber harvest such as felling, bucking, yarding and loading shall not occur within the 300-foot buffer except as described for Road Use and Maintenance, Reforestation Activities, and Unevenaged Management to Recruit Marbled Murrelet Habitat.
  - For helicopter operations, the disturbance buffer is extended to 0.25 mile during the breeding season.
- Tailholds shall be allowed within the buffers during the breeding season but not within Occupied Reserves or Suitable Habitat Reserves. Use of drones to set tailholds within the buffers shall be allowed during the breeding season so long as flights over or within 50 meters of the Occupied Reserve are avoided.
- Forest Regeneration Activities
  - Site preparation including prescribed burning, machine piling of slash, mechanical scarification, bio-mass harvesting, and slash pile burning shall not occur within the buffer during or outside of the breeding season.
  - Prescribed burning shall not occur adjacent to the buffers or Suitable Habitat Reserves unless the fire can be isolated to outside of the buffers or outside of Suitable Habitat Reserves with no obvious risk to the buffer or reserves.
  - Tree planting and control of competing vegetation shall be allowed within the buffer during the breeding season without restrictions.
  - Precommercial thinning and pruning shall be allowed within the buffers during the breeding season between August 1 and September 15 or outside of the breeding season.
- Rock pit blasting shall not occur within 0.25 mile of Occupied Reserves or Adjacent Habitat Reserves during the breeding season.
- Covered Activities shall be allowed within areas identified as Unsuitable or Marginal Habitat during and outside of the breeding season without restrictions.

Appendix E. Effectiveness and Compliance Monitoring Program

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Figure E-2. Decadal monitoring sites (central Plan Area). Location of Suitable Habitat Reserves on Green Diamond ownership and Plan Area for the marbled murrelet Habitat Conservation Plan. The sampling frame for decadal monitoring of marbled murrelet presence associated with Suitable Habitat Reserves using a passive acoustic monitoring approach included Suitable Habitat Reserves comprised of habitat trees on the ownership (Sampling Frame In). Adjacent habitat was not included (Sampling Frame Out). A balanced acceptance sample of 20 stands from the "In" frame was selected and is shown as Selected Stands (BAS). Four additional stands were selected based on biological judgment (Selected Stands Supplemental). Three stands of Occupied Reserves were selected for reference purposes in the monitoring program (Selected Occupied Reserves). E-7

Figure E-3. Decadal monitoring sites (southern Plan Area). Location of Suitable Habitat Reserves (Suitable Habitat Reserve) on Green Diamond ownership and Plan Area for the marbled murrelet Habitat Conservation Plan. The sampling frame for decadal monitoring of marbled murrelet presence associated with Suitable Habitat Reserves using a passive acoustic monitoring approach included Suitable Habitat Reserves comprised of habitat trees on the ownership (Sampling Frame In). Adjacent habitat was not included (Sampling Frame Out). A balanced acceptance sample of 20 stands from the "In" frame was selected and is shown as Selected Stands (BAS). Four additional stands were selected based on biological judgment (Selected Stands Supplemental). Three stands of Occupied Reserves were selected for reference purposes in the monitoring program (Selected Occupied Reserves)..... E-8

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E.1 COMPLIANCE AND EFFECTIVENESS MONITORING

Monitoring will occur as described in Section 6.3 to determine whether the MMHCP conservation program is implemented as written and to determine whether implementation results in anticipated habitat conditions. This appendix describes the specific objectives for monitoring and tracking compliance and provides a summary of the overall compliance and effectiveness monitoring commitments included in this Marbled Murrelet HCP.

E.2 MONITORING PROGRAM FOR MARBLED MURRELET PRESENCE ASSOCIATED WITH SUITABLE HABITAT RESERVES

The growth and development of forest habitat and nest trees for murrelets occurs over about 200 years or more and is rare on the managed forest landscape of the Plan Area where most forests are less than 100 years old. Not all Suitable Habitat Reserves are predicted to be currently occupied by murrelets but these areas with key habitat features identified by the Habitat Suitability Model (HSM, Appendix A) are the best option for maintaining and recruiting suitable nesting habitat during the permit term. To evaluate and monitor marbled murrelet presence associated with a sample of Suitable Habitat Reserves, Green Diamond will deploy autonomous recording units (ARUs) within a sample of Suitable Habitat Reserves once every ten years (a minimum of five sample periods over 50 years) to collect acoustic data on presence and probable absence of marbled murrelets. The acoustic data collected on murrelet presence will be used to evaluate murrelet use of habitat areas set aside for them (6.2.2, 6.2.5), refinement of the HSM during the permit term and during re-assessment of habitat within the Plan Area when seeking renewal at the end of the term (6.2.7, 6.4.7) (6.3.2.3), and for evaluation of potential new suitable habitat (6.3.1.6).

The use of ARUs or passive acoustic monitoring (PAM) is becoming increasingly common in avian studies as an effective tool for monitoring (Lesmeister and Jenkins 2022) and research, and the devices have several benefits over observer-based methods such as point counts. Some benefits of ARUs include the ability of researchers to establish recording schedules on the devices for effective detection of the focal species, faunal community, or period of interest ("time of day"), devices can be deployed for months at a time for "repeat" visits to estimate detection probabilities and to minimize cost of field visits for deployment and retrieval, and they are well-suited to rare species, those that vocalize infrequently, or are sensitive to human presence. Another benefit is that a permanent, reviewable record is established via the recordings of vast amounts of environmental sounds that minimize variability such as levels of expertise of observers. The establishment of a permanent and reviewable record increases quality control and utility of the data for additional analyses over the long term (Turgeon et al. 2017). Recent developments in ARU technology allows for on-board processing of audio files and transmission of a synopsis of the processed data via satellite telemetry (https://instinctenvironmental.com/). For the marbled murrelet, the use of ARUs may have a substantial benefit over AV surveys with respect to observer safety and surveying remote habitat because the need for observers traversing to areas for pre-dawn surveys is eliminated. The use of ARUs in monitoring also has limitations, some of which can be overcome with study design and quality control measures. Some limitations with the technique include non-vocal or infrequent vocalizing individuals, determining the detection distance and effective area surveyed may be difficult to quantify, total area surveyed may be less than observer-based methods under certain field conditions due to background noise, and changes over time in manufacturers and equipment technology may introduce additional variability into monitoring programs that will need to be addressed as these factors potentially influence collected

data. Although, many of these limitations including microphone sensitivity, can be included as covariates in statistical analyses to adjust between sites and years (Turgeon et al. 2017), perhaps more effectively than observer-based methods.

Autonomous acoustic recording units have been used in several field studies of marbled murrelets. In California, Borker et al. (2015) used ARUs and audio-visual (AV) surveys to compare detections at seven forested sites. They analyzed data from June 15 through August 5 for 3-hour periods from ARUs and visual and auditory detections from AV surveys following established protocols. The ARUs sampled greater than ten times more survey periods than the AV method and both methods detected marbled murrelets at all sites. The AV surveys detected a greater number of murrelets per survey, but fewer overall detections compared to ARUs. They found that ARUs achieved a 90% likelihood of detecting murrelets at all sites after ten survey periods. In Alaska, Cragg et al. (2016) compared detections of marbled murrelets using radar, AV surveys, and ARUs. At 12 sites with paired AV surveys and ARUs during 2011-2012, they found no difference in mean pre-sunrise counts of murrelets in forested habitat. Autonomous acoustic recorders detected four types of marbled murrelet vocalizations and two non-vocal sounds, wingbeats and jet sounds, and were able to record a greater amount of data on seasonal trends in detections from June to August due to the longer and continuous deployment period of the devices. In British Columbia from 2016-2018, Cragg et al. (2019) assessed the efficacy of ARUs to sample marbled murrelet vocal activity in potential nesting habitat across varying levels of forest fragmentation and 36 patch sizes ranging from approximately 10 acres to over 170 acres. Murrelet presence was detected at all AV and radar sites and two additional AV sites where murrelets were not detected due to low survey effort. Murrelets were detected all months of ARU deployment from May through August, and five of six sites with occupied behaviors from AV surveys corresponded with peak activity levels and researcher classified "abundant" ARU detections suggesting a potential relationship with breeding activity. A smaller sampling radius of ARUs suggests greater suitability of the technique for stand level surveys (Cragg et al. 2019, Burger et al. 2020). In Oregon and Washington, Duarte et al. 2024 used data from the passive acoustic monitoring program for northern spotted owl populations by expanding analysis to murrelet detections. For the marbled murrelet, published and unpublished information indicates that ARUs perform equally well as AV surveys for detection of the species in forested habitat.

Objectives:

- Use PAM with ARUs to assess and monitor murrelet use in a sample of Suitable Habitat Reserves (~24) over the 50-year permit term. A sample of three Occupied Reserves will be monitored at the same time/frequency as a reference for murrelet occupancy.
- Green Diamond will survey murrelet presence/absence at decadal intervals in the sample of 27 Suitable Habitat Reserves and Occupied Reserves. Presence data will include counts of murrelets based on calls and flight sounds and will be considered a measure of murrelet use of the Suitable Habitat Reserves and Occupied Reserves. The first survey will occur at approximately year five of HCP implementation and successive surveys will occur in all 27 stands (24 Suitable Habitat Reserves and 3 Occupied Reserves) every 10 years so that a total of five surveys are completed prior to the end of the 50-year permit term.
- Murrelet presence/absence data from PAM over the permit term will allow for integration of new data refining the HSM and improving our understanding of murrelet use in managed forests and effective conservation measures.

Green Diamond has designated 96 patches of Suitable Habitat Reserves encompassing approximately 946.4 acres within the Plan Area, although additional Suitable Habitat Reserves may be added pending the process described in Section 6.4. These areas will be protected and conserved for the permit term in a dynamic working forest environment, and as such, are appropriate areas for long-term monitoring of marbled murrelets via repeated surveys implemented through the MMHCP. A subset of the 96 Suitable Habitat Reserves are formed by Plan Area habitat and adjacent (off-ownership) habitat (number and area). Although only the acres within the Plan Area for these Suitable Habitat Reserves are attributed to the total acres in Suitable Habitat Reserve for this MMHCP, eight "edge affected" Suitable Habitat Reserves were included in the monitoring sampling frame based on the entire core of the Suitable Habitat Reserve and majority of the area being on Green Diamond ownership. Of the eight Suitable Habitat Reserves that are edge effected, two were selected in the balanced acceptance sample (BAS) and two were selected as supplemental sample stands for long-term monitoring in the Plan Area (Figures E-1 to E-3). A BAS of 20 Suitable Habitat Reserves was drawn for acoustic monitoring over five decadal intervals. In addition, four Suitable Habitat Reserves were selected based on biological and visual judgement (Selected Stands Supplemental, Figures E-1 to E-3) to complement the 20 BAS samples and reduce any apparent gaps in the selection. Three Occupied Reserves were selected as reference stands for PAM in each of the five decadal periods. The BAS sample of Suitable Habitat Reserves was drawn using a hierarchical approach based on criteria including latitude (Y coordinate), sum of TAOs ≥ 70 m, distance from coast (X coordinate), 95th percentile of HSI value for the patch, and stand size (ac) to ensure a well distributed and representative sample of reserved stands (Figures E-1 through E-3). These Suitable Habitat Reserves and Occupied Reserves will be surveyed for marbled murrelet presence at decadal intervals by placing one or more ARUs within the designated patches. The number of ARUs will be determined by overall patch area and configuration with a goal for one ARU covering approximately 15 acres (150 m radius). Linear stands that are long and narrow, but less than 20 acres may require two ARUs to effectively sample the area. A minimum of five surveys will occur over the permit term. The likely survey periods will be years 5, 15, 25, 35, and 45 of the permit term, with some flexibility (± 1 year). ARUs will be placed in the patch to maximize acoustic coverage while also minimizing ambient noise that may reduce effectiveness of the device (e.g., excessive stream noise). ARUs will be secured to a tree or metal t-post approximately 2 m (6 ft) above the ground. ARUs will be deployed between May 1 and July 30 to cover early and late breeding season for marbled murrelets. At minimum, ARUs will be programmed to record during the diel period from one hour before sunrise to one hour after sunrise, but other sampling periods (around sunset or during the day) can be added at the discretion of Green Diamond. Acoustic data will be processed using available software or packages to detect various calls and sounds of marbled murrelets and may be used to estimate detection probability and occupancy. Examples of available software include Kaleidoscope (https://www.wildlifeacoustics.com) and a convolutional neural network analysis package (e.g., PNW-Cnet v4; Ruff et al. 2020). Modifications to this monitoring approach may occur with approval by the Service and CDFW.

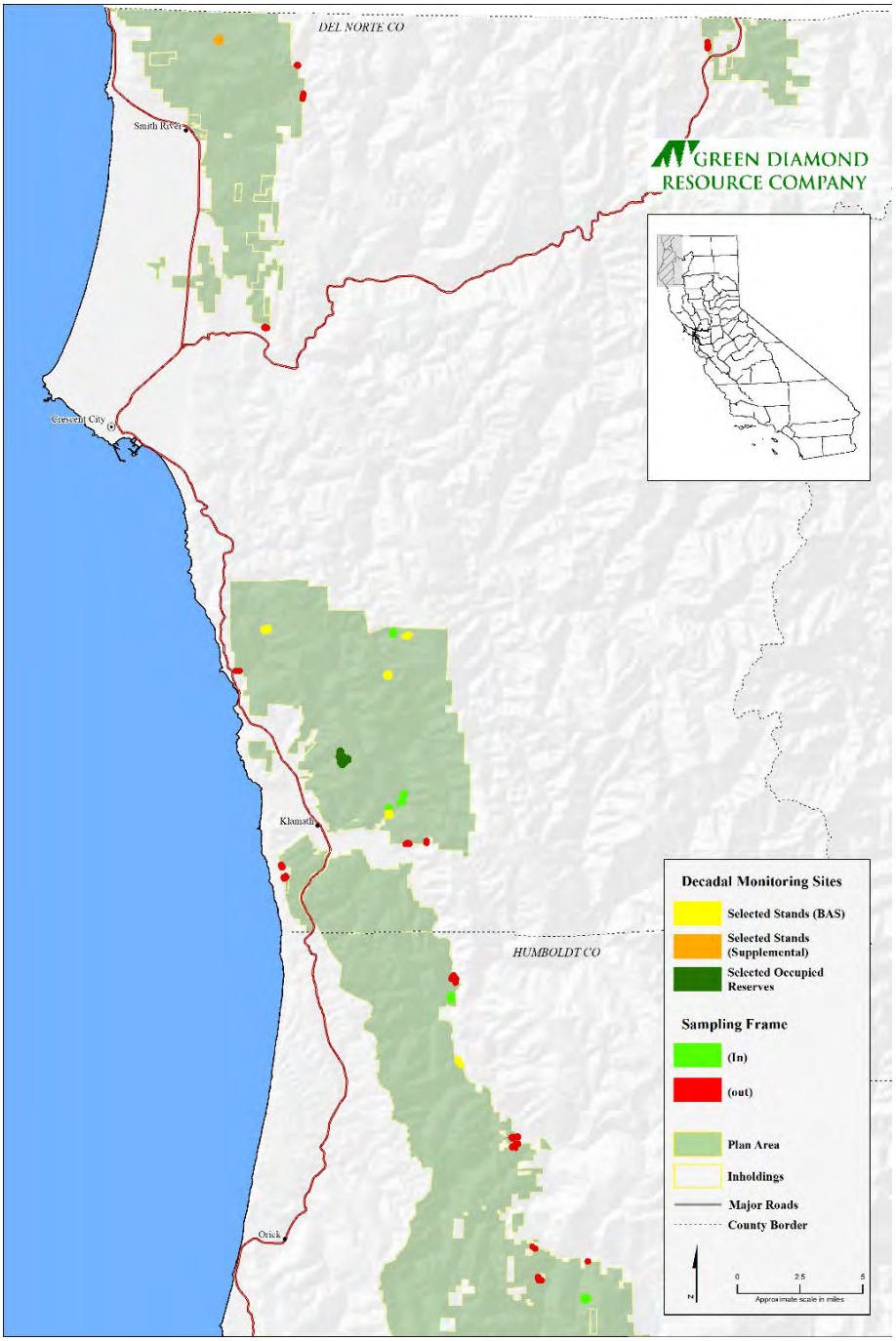

Figure E-1. Decadal monitoring sites (northern Plan Area). Location of Suitable Habitat Reserves on Green Diamond ownership and Plan Area for the marbled murrelet Habitat Conservation Plan. The sampling frame for decadal monitoring of marbled murrelet presence associated with Suitable Habitat Reserves using a passive acoustic monitoring approach included Suitable Habitat Reserves comprised of habitat trees on the ownership (Sampling Frame In). Adjacent habitat was not included (Sampling Frame Out). A balanced acceptance sample of 20 stands from the "In" frame was selected and is shown as Selected Stands (BAS). Four additional stands were selected based on biological judgment (Selected Stands Supplemental). Three stands of Occupied Reserves were selected for reference purposes in the monitoring program (Selected Occupied Reserves).

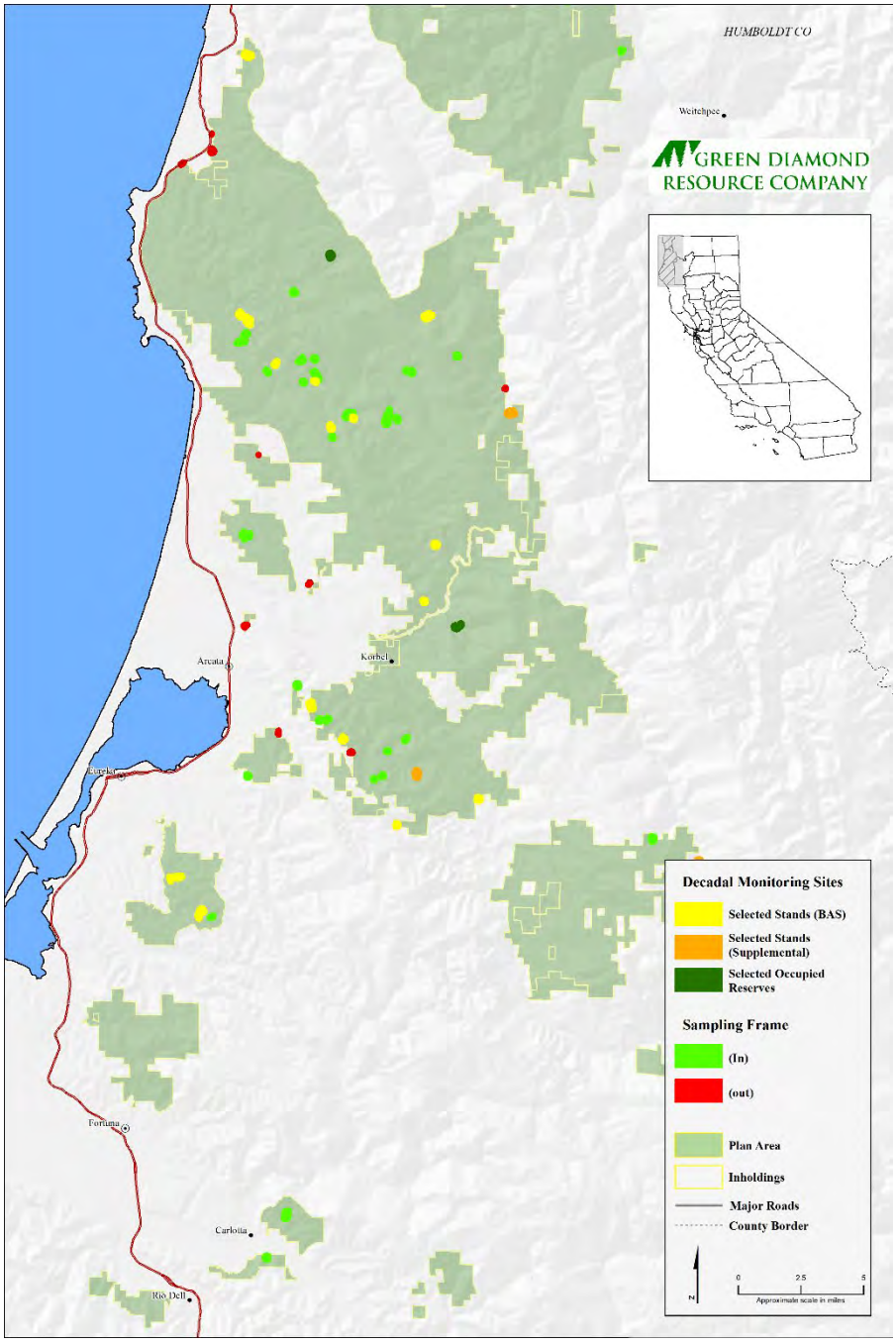

Figure E-2. Decadal monitoring sites (central Plan Area). Location of Suitable Habitat Reserves on Green Diamond ownership and Plan Area for the marbled murrelet Habitat Conservation Plan. The sampling frame for decadal monitoring of marbled murrelet presence associated with Suitable Habitat Reserves using a passive acoustic monitoring approach included Suitable Habitat Reserves comprised of habitat trees on the ownership (Sampling Frame In). Adjacent habitat was not included (Sampling Frame Out). A balanced acceptance sample of 20 stands from the "In" frame was selected and is shown as Selected Stands (BAS). Four additional stands were selected based on biological judgment (Selected Stands Supplemental). Three stands of Occupied Reserves were selected for reference purposes in the monitoring program (Selected Occupied Reserves).

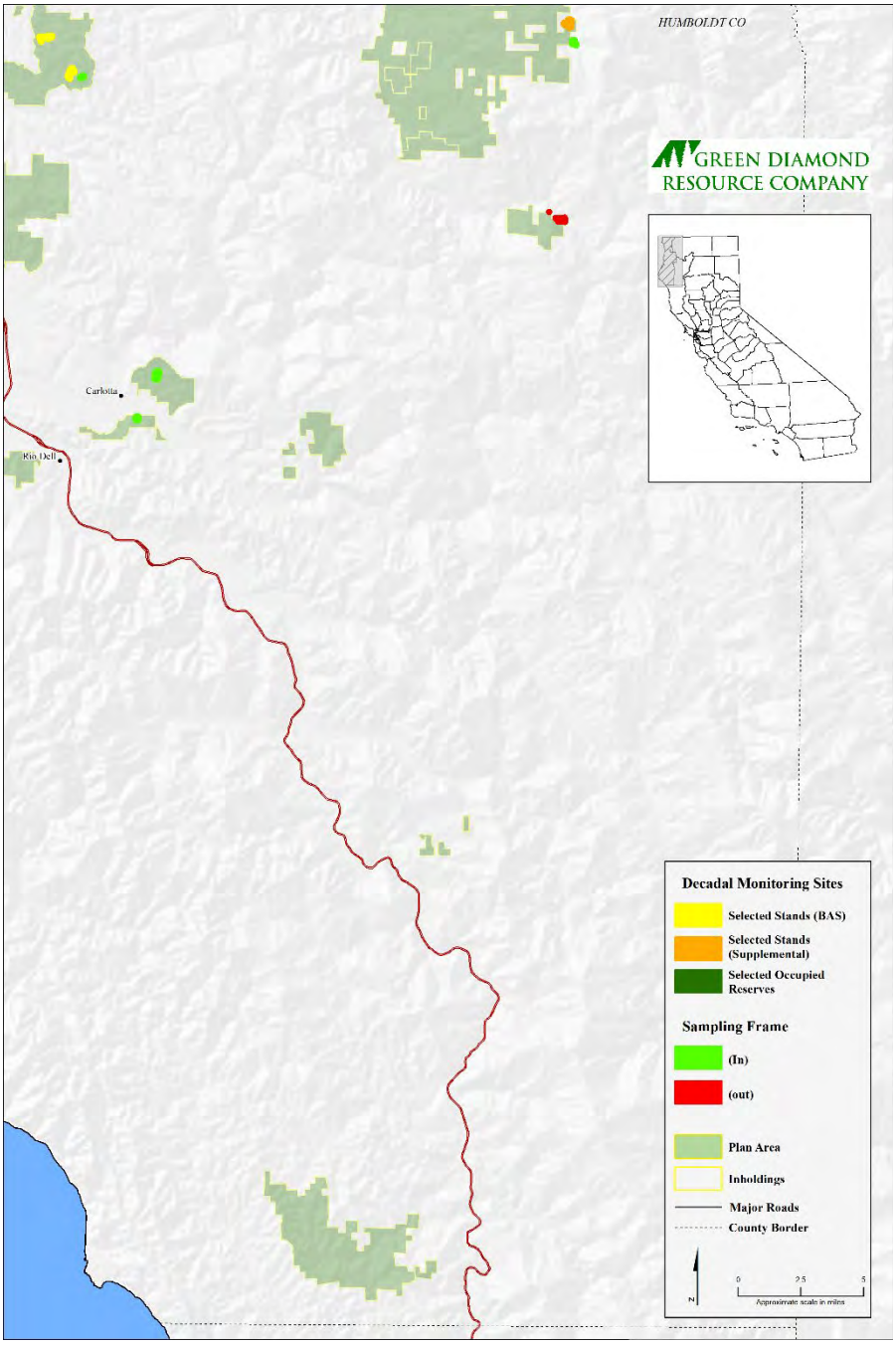

Figure E-3. Decadal monitoring sites (southern Plan Area). Location of Suitable Habitat Reserves (Suitable Habitat Reserve) on Green Diamond ownership and Plan Area for the marbled murrelet Habitat Conservation Plan. The sampling frame for decadal monitoring of marbled murrelet presence associated with Suitable Habitat Reserves using a passive acoustic monitoring approach included Suitable Habitat Reserves comprised of habitat trees on the ownership (Sampling Frame In). Adjacent habitat was not included (Sampling Frame Out). A balanced acceptance sample of 20 stands from the "In" frame was selected and is shown as Selected Stands (BAS). Four additional stands were selected based on biological judgment (Selected Stands Supplemental). Three stands of Occupied Reserves were selected for reference purposes in the monitoring program (Selected Occupied Reserves).

E.2.1 Literature cited

Borker, A.L., Halbert, P., McKown, M.W., Tershy, B.R., Croll, D.A.. 2015. A Comparison of Automated and Traditional Monitoring Techniques for Marbled Murrelets Using Passive Acoustic Sensors. Wildlife Society Bulletin 39:813-818. https://doi.org/10.1002/wsb.608

Burger, A.E., Waterhouse, F.L., Cragg, J.L. 2020. Research options to address knowledge gaps on Marbled Murrelet terrestrial habitat requirements. Prov. B.C., Victoria, B.C. Tech. Rep. 130.

Cragg, J.L., Burger, A.E., Piatt, J.F.. 2016. Techniques for monitoring Brachyramphus murrelets: A comparison of radar, autonomous acoustic recording and audio-visual surveys. Wildlife Society Bulletin 40:130-139. https:// doi.org/10.1002/wsb.623.

Cragg J.L., Waterhouse, F.L., Doyle F.I., Mather, M.H., Schroeder, B.K. 2019. Seasonal patterns and metrics of marbled murrelet (Brachyramphus marmoratus) vocal activity from autonomous recording units. 2019 Pacific Seabird Group 46th Annual Meeting Scientific Program Full Abstracts Page 13.

Duarte, A., Weldy, M. J., Lesmeister, D. B., Ruff, Z. J., Jenkins, M. A., Valente, J. J., Betts, M. G. 2024. Passive acoustic monitoring and convolutional neural networks facilitate high-resolution and broadscale monitoring of a threatened species. Journal of Ecological Indicators 162:1-10. https://doi.org/10.1016/j.ecolind.2024.112016.

Lesmeister, D.B., Jenkins, J.M.A. 2022. Integrating new technologies to broaden the scope of northern spotted owl monitoring and linkage with USDA forest inventory data. Frontiers in Forests and Global Change 5:966-978. https://doi.org/10.3389/ffgc.2022.966978

Ruff, Z.J., Lesmeister, D.B., Duchac L.S., Padmaraju, B.K. Sullivan, C.M. 2020. Automated identification of avian vocalizations with deep convolutional neural networks. Remote Sensing in Ecology and Conservation. 6:79-92. https://doi: 10.1002/rse2.125

Turgeon, P. J., Van Wilgenburg, S. L. Drake, K. L. 2017. Microphone variability and degradation: implications for monitoring programs employing autonomous recording units. Avian Conservation and Ecology 12(1):9. https://doi.org/10.5751/ACE-00958-120109

E.3 TRACKING AND REPORTING ANNUAL AND CUMULATIVE TAKE

As described in Section 5.1 and 5.2, the alteration or removal of Marginal Habitat may result in direct take, and harvest operations within 50 m of Marginal Habitat or Suitable Habitat Reserves may result in indirect take. These model-classified patches of Marginal Habitat and Suitable Habitat Reserves were intersected with future timber harvesting polygons from the Harvest Forecast to estimate potential incidental take (direct and indirect).

Based on the calculations described in Section 5.2.2.1, the 50-year Harvest Forecast intersected with Marginal Habitat patches within the Plan Area results in direct take of approximately 2.62 eggs/nestlings and 0.26 adults during the 50-year permit term. Harvest adjacent to Marginal Habitat, harvest adjacent to Suitable Habitat Reserves, and harvest within single tree selection

riparian management zones results in indirect take of approximately 4.34 eggs/nestlings during the 50-year permit term. The sum of direct and indirect take results in total estimated take of 7.22 murrelets over 50 years. As described in Section 5.2.3, adjustments were made to the take estimates based on changes that occurred to the Plan Area during development of this MMHCP. After accounting for the Plan Area changes, the sum of direct and indirect take results in total estimated take of 7.29 murrelets over 50 years. To account for additional harvest flexibility and future land acquisitions, Green Diamond is requesting authorized incidental take of approximately 15 marbled murrelets over the Permit Term (doubling of the projected estimates of take as described in Section 5.2.3).

As described in Section 6.3.1.7, Green Diamond will monitor the location, extent, and timing of harvest in Marginal Habitat to ensure the proposed/predicted maximum extent of take is not exceeded. The annual and cumulative acres of Marginal Habitat harvested will be presented in each annual report along with the estimates of direct take based on actual acres of Marginal Habitat harvested. As described in Section 6.3.1.8, Green Diamond will monitor the location, extent, and timing of harvest adjacent to Suitable Habitat Reserves and Marginal Habitat patches. To calculate the estimated indirect take based on harvest adjacent to Marginal Habitat or Suitable Habitat Reserves, the timber harvest units will be buffered by 50 m (the distance based decaying linear rate for estimating indirect take described in Figure 5-6), and the 50-m buffer will be intersected with the Marginal Habitat patches and Suitable Habitat Reserves (5.2.2.2, 6.3.1.8). Annual reports will include the total annual and cumulative Suitable Habitat Reserve acres within 50 m of adjacent harvest areas and total annual and cumulative Marginal Habitat acres within 50 m of adjacent harvest areas. The total amount of annual and cumulative estimated take will also be presented in each annual report. Table E-1 is an example of the incidental take tracking spreadsheet that will be included with each annual report. Through annual tracking and future harvest projections, Green Diamond will ensure incidental take is not exceeded (i.e., maximum of 15 marbled murrelets as estimated based on timing and location of actual harvest).

Table E-1. Take accounting spreadsheet example for estimating annual and cumulative incidental take (direct and indirect) based on hypothetical examples of timber harvest operations within Marginal Habitat and adjacent to Marginal Habitat or Suitable Habitat Reserves (SHR) over a ten-year period.

Harvest Year	Clearcut Harvest in Marginal	Selection Harvest in Marginal	Total Harvest in Marginal (Actual Clearcut and Selection)	Cumulative Total Harvest in Marginal	Marginal Acres within Adjacent Harvest's 50m Buffer	Cumulative Marginal Acres within Adjacent Harvest's 50m Buffer	Cumulative Estimated Take from Harvest in Marginal (Clearcut and Selection)	Cumulative Estimated Take from Marginal Acres within Adjacent Harvest's 50m Buffer	Cumulative Estimated Take from Marginal	SHR Acres within Adjacent Harvest's 50m Buffer	Cumulative SHR Acres within Adjacent Harvest's 50m Buffer	Cumulative Estimated Take from SHR Acres within Adjacent Harvest's 50m Buffer	Cumulative Estimated Total Take (Marginal + SHR)
2026	37.4	43.5	80.9	80.9	162.7	162.7	0.1	0.0	0.1	28.8	28.8	0.039	0.1
2027	13.6	32.6	46.2	127.1	113.3	276.0	0.1	0.1	0.2	6.6	35.4	0.048	0.2
2028	44.3	37.9	82.2	209.3	135.4	411.4	0.2	0.1	0.3	4.2	39.6	0.054	0.3
2029	20.3	56.1	76.4	285.7	201.6	613.0	0.3	0.1	0.4	3.8	43.4	0.059	0.5
2030	28.2	14.7	42.9	328.6	101.5	714.5	0.3	0.2	0.5	12.7	56.1	0.076	0.5
2031	49.2	21.9	71.1	399.7	81.4	795.9	0.4	0.2	0.539	4.8	60.9	0.083	0.6
2032	26.5	75.7	102.2	501.9	206.0	1001.9	0.4	0.2	0.677	17.3	78.2	0.106	0.8
2033	42.3	91.5	133.8	635.7	164.4	1166.3	0.6	0.3	0.835	19.4	97.6	0.133	1.0
2034	18.5	40.2	58.7	694.4	67.1	1233.4	0.6	0.3	0.903	11.8	109.4	0.149	1.1
2035	25.7	22.2	47.9	742.3	69.7	1303.1	0.7	0.3	0.961	0.9	110.3	0.150	1.1
2036	56.0	141.4	197.4	939.7	263.5	1566.6	0.8	0.4	1.198	15.0	125.3	0.171	1.4

E.4 COMPLIANCE AND EFFECTIVENESS MONITORING PROGRAM SUMMARY

The monitoring program is based on current monitoring technology and methodologies and on current understanding of the habitat conditions required by marbled murrelets. Some monitoring approaches may be retired or replaced by more efficient and/or accurate techniques to address the same issues, and entirely new approaches may be implemented to address currently unforeseen issues. Annual reporting and periodic reviews will provide the assessment needed to justify changes to the monitoring program, and changes will be subject to review and concurrence by the Service and CDFW to ensure continued effectiveness. The following section provides a list and summary of monitoring and reporting commitments included in this MMHCP.

Monitoring Commitment One (6.3.1.1) – Monitor covered activities around Occupied Reserves and Buffers: Green Diamond will monitor covered activities around Occupied Reserves and Buffers to ensure that vegetation modification does not occur within the boundaries of the Occupied Reserves and vegetation modification within the Buffers (of Occupied Reserves and Adjacent Habitat Reserves) complies with the provisions of habitat recruitment as described in Section 6.2.3 or Appendix D. If a noncompliance event occurs within an Occupied Reserve, Occupied Reserve Buffer, or Adjacent Habitat Reserve Buffer, the MMHCP coordinator will notify the Service and CDFW in writing within two business days of becoming aware of the incident (6.3.1.10). Additional documentation will also be provided in the annual reports.

Reporting Commitment One – Buffers for Occupied Reserves and Adjacent Habitat Reserves: Annual reports will include a summary of Occupied Reserve buffer and Adjacent Habitat Reserve buffer acres harvested (annual and cumulative as a result of adjacent commercial harvest, Section 6.2.3). Annual reports will also include documentation for any noncompliance events related to Covered Activities within Occupied Reserves, Occupied Reserve buffers or Adjacent Habitat Reserve buffers.

Monitoring Commitment Two (6.3.1.2) – Development of murrelet habitat within buffer areas: Pre- and post-harvest sampling will be conducted in years when unevenaged management silviculture occurs within the buffer of an Occupied Reserve or Adjacent Habitat Reserve for the purpose of recruiting murrelet habitat as described in Section 6.2.3. Pre-harvest individual tree and stand characteristics for treated areas and untreated areas within the same buffer will be compared with post-harvest values and evaluated for favorable changes. Additional post-harvest sampling will be conducted at an interval of 15 to 25 years through year 45 of the MMHCP permit.

Reporting Commitment Two – Pre- and post-harvest buffer sampling: Pre- and post-harvest sampling results will be reported in annual reports for years with samples, and a comparison of the results will be reported in the 49th annual report along with recommendations for future recruitment opportunities.

Monitoring Commitment Three (6.3.1.3 and 6.3.1.8) – Monitor covered activities around Suitable Habitat Reserves: Green Diamond will monitor Covered Activities around Suitable Habitat Reserves to ensure that vegetation modification does not occur within the boundaries of the Reserves except as described in Appendix D for road use (access, maintenance, upgrading,

decommissioning, etc.) activities. Green Diamond will monitor the location, extent, and timing of harvest adjacent to Suitable Habitat Reserves.

Reporting Commitment Three – Harvest adjacent to Suitable Habitat Reserves: Annual reports will include the total annual and cumulative Suitable Habitat Reserve acres within 50 m of adjacent harvest areas (within and outside of the breeding season). The total amount of annual and cumulative estimated take will also be presented in each annual report. For the calculation to estimate indirect take based on harvest adjacent to Suitable Habitat Reserves, the timber harvest units will be buffered by 50 m (the distance based decaying linear rate for estimating indirect take described in Figure 5-6), and the 50-m buffer will be intersected with Suitable Habitat Reserves (5.2.2.2). If a noncompliance event occurs within a Suitable Habitat Reserve, the MMHCP coordinator will notify the Service and CDFW in writing within 48 business hours two business days of becoming aware of the incident (6.3.1.10). Additional documentation will also be provided in the annual reports.

Monitoring Commitment Four – Monitor marbled murrelet presence associated with Suitable Habitat Reserves (Section 6.3.1.4, Appendix E.2): Marbled murrelet presence will be monitored within 24 Suitable Habitat Reserves and 3 Occupied Reserves using autonomous recording units or other techniques approved by the Service and CDFW to evaluate murrelet use (6.2.2, 6.2.5). Presence data will include counts of murrelets based on calls and flight sounds and will be considered a measure of murrelet use of the Suitable Habitat Reserves and Occupied Reserves. Sampling will occur every ten years (± one year).

Reporting Commitment Four – Murrelet presence associated with Suitable Habitat Reserves: ARU sampling will occur every 10 years (± one year) beginning in year five (± one year) in 24 predetermined Suitable Habitat Reserves and 3 predetermined Occupied Reserves. Green Diamond will provide an annual report to the Service and CDFW one to two years subsequent to each year in which sampling occurs. Annual reports will include a summary of data collected by the ARUs during that period including the following:

- Name and location of each sampled Suitable Habitat Reserve and Occupied Reserve
- Type of ARUs used and analytical methods/software used to process data and for detecting murrelet calls on ARUs
- Number and locations of ARUs deployed at each Suitable Habitat Reserve and Occupied Reserve
- Within-season range of dates of ARU deployment
- Specific dates and time of day each ARU was recording
- Sampling rates of deployed ARUs
- Specific dates and times of positive detections of murrelets by ARU including type of detection (e.g., ‘keer’ call, wing sounds).

Monitoring Commitment Five – Monitor covered activities when timber harvest occurs adjacent to or overlaps with Marginal Habitat areas (6.3.1.7, 6.3.1.8): Green Diamond will monitor the location, extent, and timing of harvest within Marginal Habitat areas and adjacent to Marginal Habitat areas to ensure the proposed/predicted maximum extent of take is not exceeded.

Reporting Commitment Five – Harvest within and adjacent to Marginal Habitat: Annual reports will include a summary of acres harvested within and adjacent to Marginal Habitat. Annual reports will include the total annual and cumulative Marginal Habitat acres within 50 m of adjacent harvest areas (including totals for harvest occurring within and outside the breeding season). The total amount of annual and cumulative estimated take (based on actual harvest) and the total amount of annual and cumulative projected (predicted estimates) will also be presented in each annual report. For the calculation to estimate indirect take based on harvest adjacent to Marginal Habitat, the timber harvest units will be buffered by 50 m (the distance based decaying linear rate for estimating indirect take described in Figure 5-6), and the 50-m buffer will be intersected with Marginal Habitat patches (5.2.2.2).

Monitoring Commitment Six – Tracking new and potential suitable habitat (6.3.1.6, 6.3.2.3, 6.3.2.4): Green Diamond may voluntarily identify forested areas that may be managed for long-term recruitment of suitable marbled murrelet nesting habitat including current Marginal or unsuitable habitat. Green Diamond will monitor the post-harvest retention (of Marginal and unsuitable habitat) adjacent to the Suitable Habitat Reserves and habitat retained adjacent to vegetation buffers of Occupied Reserves and Adjacent Habitat Reserves. Green Diamond will also monitor retention in riparian management zones, unstable geologic areas, and retention resulting from other species conservation plans. Such monitoring may include the use of the refined habitat suitability model if available/developed. Marginal Habitat included in these additional retention areas may be used during the current permit term to augment the Adaptive Management Reserve Account (6.3.2.3). New and potential suitable habitat may also be used for development and adjustment of conservation measures should Green Diamond seek to renew and extend the term of the MMHCP (6.4.8) or when evaluating the performance of the MMHCP and potential need to extend the term of the Mitigation Assurance Reserve (6.3.2.4).

Reporting Commitment Six – Tracking new and potential suitable habitat: Annual reports will include a summary of Marginal Habitat or unsuitable forest areas retained adjacent to Suitable Habitat Reserves or Buffers (Occupied Reserves and Adjacent Habitat Reserves). Annual reports will also include a summary of Marginal Habitat areas proposed for mitigation credit for use during the initial permit term (adaptive management reserve account, Section 6.3.2.3). As part of the Adaptive Management Performance Review, the 49th annual report will include a summary of new suitable habitat based on a reassessment of habitat using the model developed at the start of the permit term or based on a refined habitat suitability model if available.

Monitoring Commitment Seven – Adaptive Management Performance Review and Mitigation Assurance Reserve (6.3.2.4): A Performance Review must be completed by Green Diamond before the 49th anniversary of the Plan approval and Permit issuance for consideration by the Service and CDFW. The Performance Review will 1) evaluate whether or not the Marginal Habitat removed through timber harvest over the Permit term remained within the predicted limits; 2) if there were unanticipated long-term impacts that resulted from removal of Marginal Habitat; and 3) whether or not management of the MMHCP Plan resulted in a net conservation benefit (through protection, improvement, and recruitment of suitable and Marginal Habitat) above the baseline at Plan inception.

Reporting Commitment Seven – Adaptive Management Performance Review and Mitigation Assurance Reserve: The 49th annual report will include the results of the comprehensive performance review. The performance review will include estimates of take and productivity loss based on timing of timber harvest, acquisition and harvest of acquired Marginal Habitat, and any

additional compensatory mitigation from acquisition and protection of Suitable Habitat Reserves. The performance review will also include a reassessment of habitat conditions in the Permit Area based on the original HSM including estimates of habitat development and succession based on areas of Marginal Habitat harvested during the Permit Term.

Monitoring Commitment Eight – Land and Permit Area Adjustments (6.4.7): Green Diamond will monitor and track land transactions that result in addition to or removal of lands from the Permit Area. Green Diamond will use existing LiDAR data to conduct a habitat analysis on acquired lands using the HSM described in Appendix A to identify and delineate areas of Marginal Habitat and suitable habitat. When Green Diamond acquires lands with forested habitat occupied by murrelets based on evidence from audio-visual surveys (Evans Mack 2003, Pacific Seabird Group 2024) or other confirmed evidence of nesting such as presence of nest cups from tree climbing, confirmed egg shell fragments followed by tree climbing, or observation of a "grounded nestling", the area will be adopted as an Occupied Reserve under Biological Objective 1.1 based on previously defined boundaries or an agreed upon boundary after consultation with the Service and CDFW. Green Diamond will also monitor land transactions to determine if property to be removed from the Plan Area includes Occupied Reserves and Buffers, Adjacent Habitat Reserve Buffers, Suitable Habitat Reserves, or Marginal Habitat areas.

Reporting Commitment Eight – Land and Permit Area Adjustments: Annual reports will include a summary of land and Permit Area adjustments including total acres of Marginal Habitat, Suitable Habitat Reserves, Occupied Reserves, and Buffers for Occupied or Adjacent Habitat Reserves and a revised shapefile of the Plan and Permit Area. As described in Section 6.4.7, additional notifications are required for land adjustments that occur in addition to the annual reporting process.

Monitoring Commitment Nine – Changed Circumstances (6.5.1): Green Diamond does not implement a separate, formal monitoring program specifically for Changed Circumstances. Rather, potential Changed Circumstances are identified through routine forest management activities, implementation of the MMHCP, and ongoing awareness of conditions affecting species and protected habitat.

Reporting Commitment Nine – Changed Circumstances (6.5.1): Reporting for Changed Circumstances is event-driven rather than scheduled. If Green Diamond becomes aware that a Changed Circumstance has occurred, it will notify the Service and CDFW in accordance with the timelines specified in Section 6.5 and provide any required assessments or reports describing the event, implemented response measure, and subsequent actions as applicable. For example, Green Diamond will notify the Service and CDFW within seven days of learning that the Changed Circumstance has occurred. Green Diamond will implement the applicable response measure(s) as soon as practicable, but no later than 30 days after learning of the Changed Circumstance. Green Diamond will report to the Service and CDFW within 15 days after initiating the response measure. If there is damage to or destruction of an Occupied Reserve, Occupied Reserve Buffer, or Suitable Habitat Reserve (due to wildlife, wind, geologic event, or forest pathogen), Green Diamond will notify the Service and CDFW within 10 days of discovery of the damage, and Green Diamond will provide the Service CDFW with an assessment of the damage within 30 days of discovery.

Appendix F. Mitigation Assurance Reserve

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Figure F-2. Planimetric view of the three Occupied Reserves (Klamath View Ridge West, Klamath View Ridge North, and Klamath View Ridge South) comprising the Assurance Reserve and 300-foot vegetation buffer. Redwood and Douglas-fir trees greater than 50 meters were categorized into 10-meter height classes used to derive predictor variables for the marbled murrelet habitat suitability model. The raw model output, consisting of five habitat classes (unsuitable, marginal, low, medium and high) is overlaid on a LiDAR-based shaded relief image. The figure also includes the location of the profile transect used to develop Figure F-3. ..... F-4

Figure F-3. A profile view (vertical distribution or 'slice' of LiDAR returns along a west-to-east transect) beginning in the Klamath View Ridge West stand, crossing the 300-foot buffer, and ending in the Klamath View Ridge North stand (see 'profile transect' location in Figure F-2). (a) Vertical axis represents elevation as a height above mean sea level. (b) The vertical axis represents the normalized view as height above ground level allowing for direct comparison of tree heights. Tree heights range from 70-90 meters within the Klamath View Ridge stands and 25-30 meters within the buffer for the vertical distribution of LiDAR returns given the location of the profile transect in Figure F-2. (c) Modeled Habitat Suitability Index (HSI) values along the profile transect (west-to-east transect). The values are extracted from the raster output with dark green indicating the highest suitability, light green representing medium suitability, and yellow indicating low suitability. HSI decreases near and within the buffer (shorter trees) as a result of the HSI model variables and five-acre moving window (Appendix A). F-5

F.1 INTRODUCTION

As described in Section 6.3.2.4.1, Green Diamond will establish an Adaptive Management Assurance Reserve in the form of a deed covenant over three Occupied Reserve stands (Klamath View Ridge South, Klamath View Ridge West, and Klamath View Ridge North) and associated 300-foot vegetation buffers for a total area of 76.3 acres (Map 6-2). The Assurance Reserve will be protected for the 50-year permit term for the MMHCP. Based on the results of the performance review process (6.3.2.4.1), the deed covenant may be extended for up to an additional 50 years (for a maximum protection period of 100 years). This appendix describes the characteristics of the Assurance Reserve stand and associated vegetation buffer.

F.2 ASSURANCE RESERVE DESCRIPTION

The Klamath View Ridge stands total 30.6 acres adjacent to other occupied habitat on Redwood National Park and contiguous with other occupied habitat on Yurok Tribal Lands. The Assurance Reserve is located approximately 1.6 miles from the Pacific Ocean and approximately 0.12 miles (200 meters) from the Klamath River. The reserve is comprised of coast redwood and Douglas-fir with minor components of Sitka spruce, western hemlock, and hardwoods such as red alder, big leaf maple, and tanoak. The reserve stands range in age from 80 years to more than 150 years. The associated 300-foot vegetation buffer totals 45.6 acres and is approximately 46 years old.

Marbled murrelet audio-visual surveys were conducted for the Klamath View Ridge stands from 1991 through 2000 with consistent detections of murrelet presence and occupied behaviors (Appendix C). From 1991 through 1996, 63 surveys were conducted resulting in 570 detections. The most recent surveys occurred in 2000 resulting in additional observations of occupied behavior. Tree heights within the Assurance Reserve range from 10 meters to greater than 100 meters with the distribution of tree heights primarily exceeding 40-50 meters including a scattered component of trees greater than 75 meters (Figure F-1). The Assurance Reserve has median habitat suitability index (HSI) values in the medium range (0.34-0.57) for Occupied Reserves (Appendix A; Figure A-8).

In contrast, the 300-foot buffer has areas of marginal and low suitability with the majority of the buffer classified as unsuitable (Figure F-2). Additionally, the primary distribution of tree heights comprising the stands within the 300-foot buffer are less than 50 meters (Figure F-2). Figure F-3 is a LiDAR-derived profile view demonstrating the differences in tree heights and HSI values along a west-to-east transect crossing from the Klamath View Ridge West stand through the 300-foot buffer and ending in the Klamath View Ridge North stand. The location of the profile transect is depicted in the planimetric view of the Assurance Reserve and associated buffer in Figure F-2 and was selected to provide a representative view of tree heights within the reserve stands and buffer.

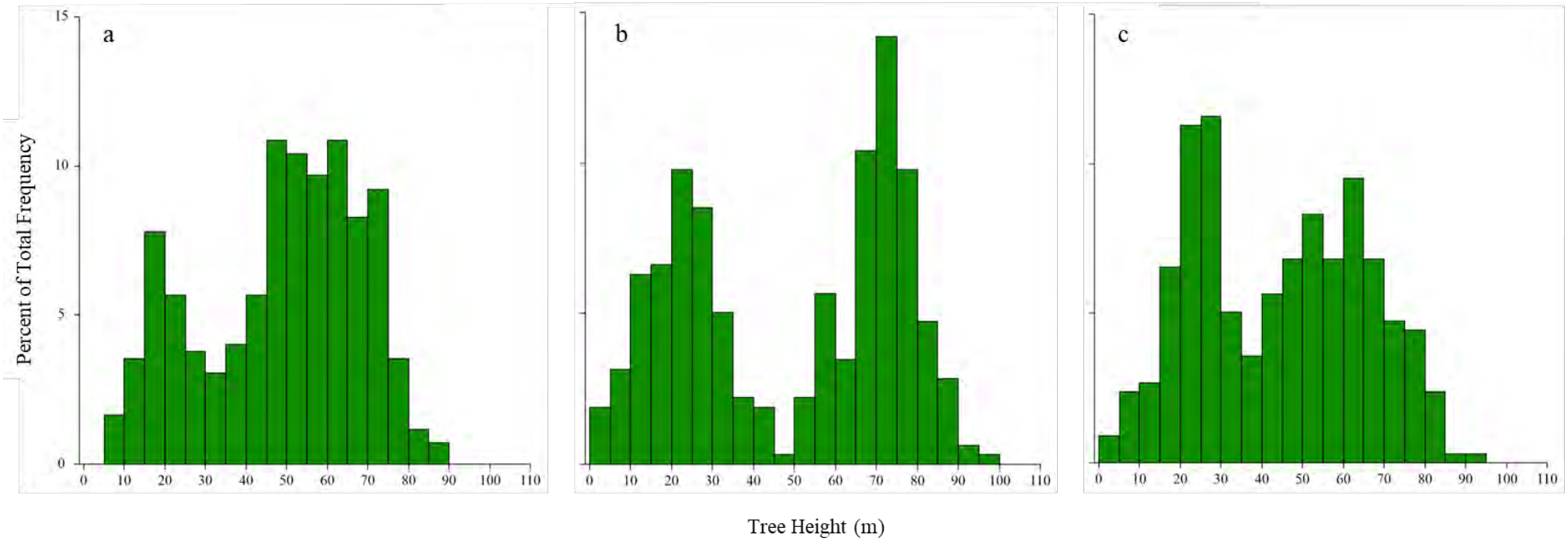

Figure F-1. Histogram of tree height distribution for the Klamath View Ridge Occupied Reserve Stands comprising the Assurance Reserve. (a) Klamath View Ridge North stand exhibits mild bimodality with most trees exceeding 50 meters and a peak around 60-65 meters. (b) Klamath View Ridge West stand exhibits bimodality with most trees exceeding 50 meters and a peak around 70-75 meters. (c) Klamath View Ridge South stand exhibits mild bimodality with most trees exceeding 40 meters, a primary peak 20-30 meters, and a secondary peak 50-70 meters.

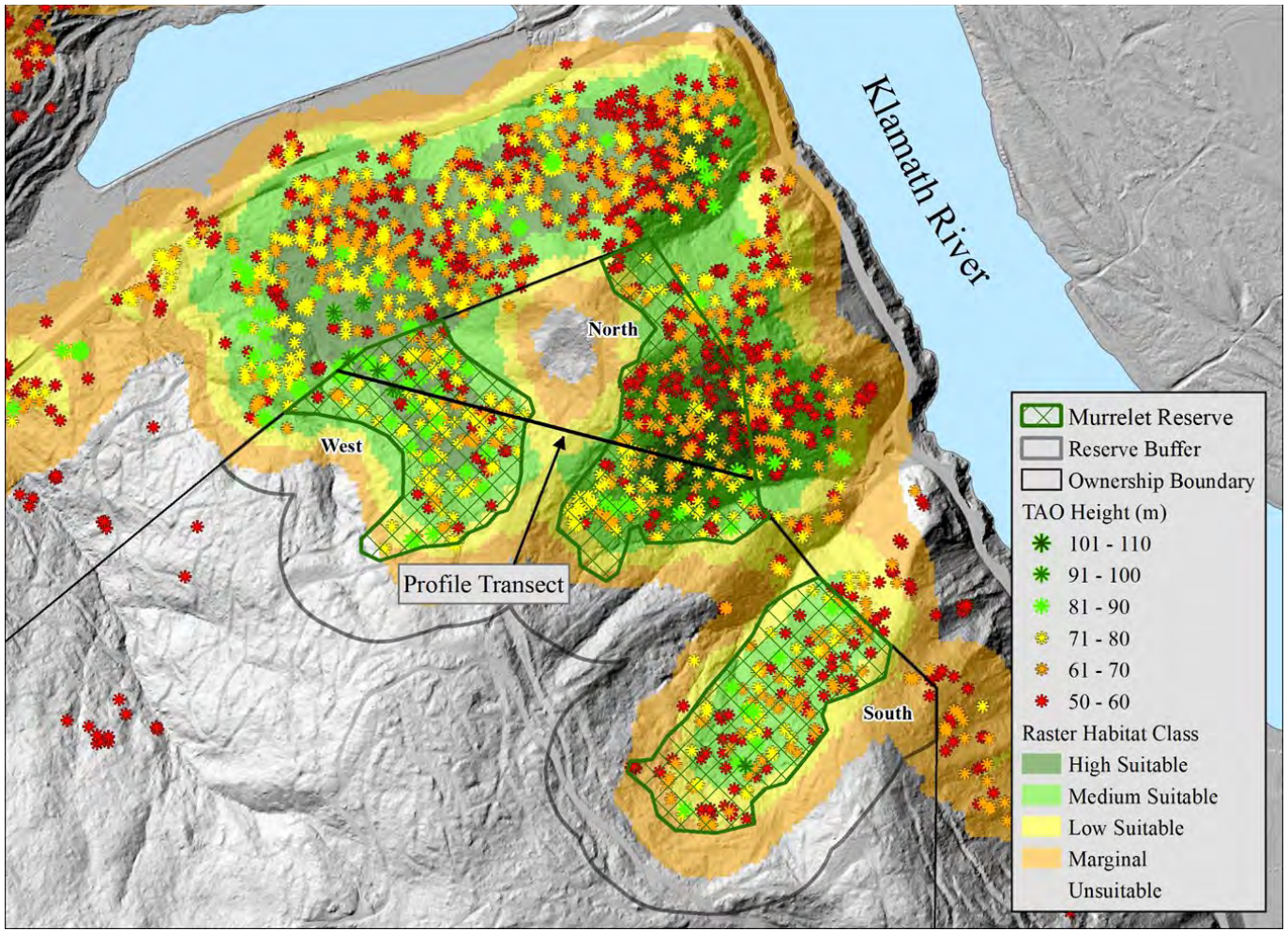

Figure F-2. Planimetric view of the three Occupied Reserves (Klamath View Ridge West, Klamath View Ridge North, and Klamath View Ridge South) comprising the Assurance Reserve and 300-foot vegetation buffer. Redwood and Douglas-fir trees greater than 50 meters were categorized into 10-meter height classes used to derive predictor variables for the marbled murrelet habitat suitability model. The raw model output, consisting of five habitat classes (unsuitable, marginal, low, medium and high) is overlaid on a LiDAR-based shaded relief image. The figure also includes the location of the profile transect used to develop Figure F-3.

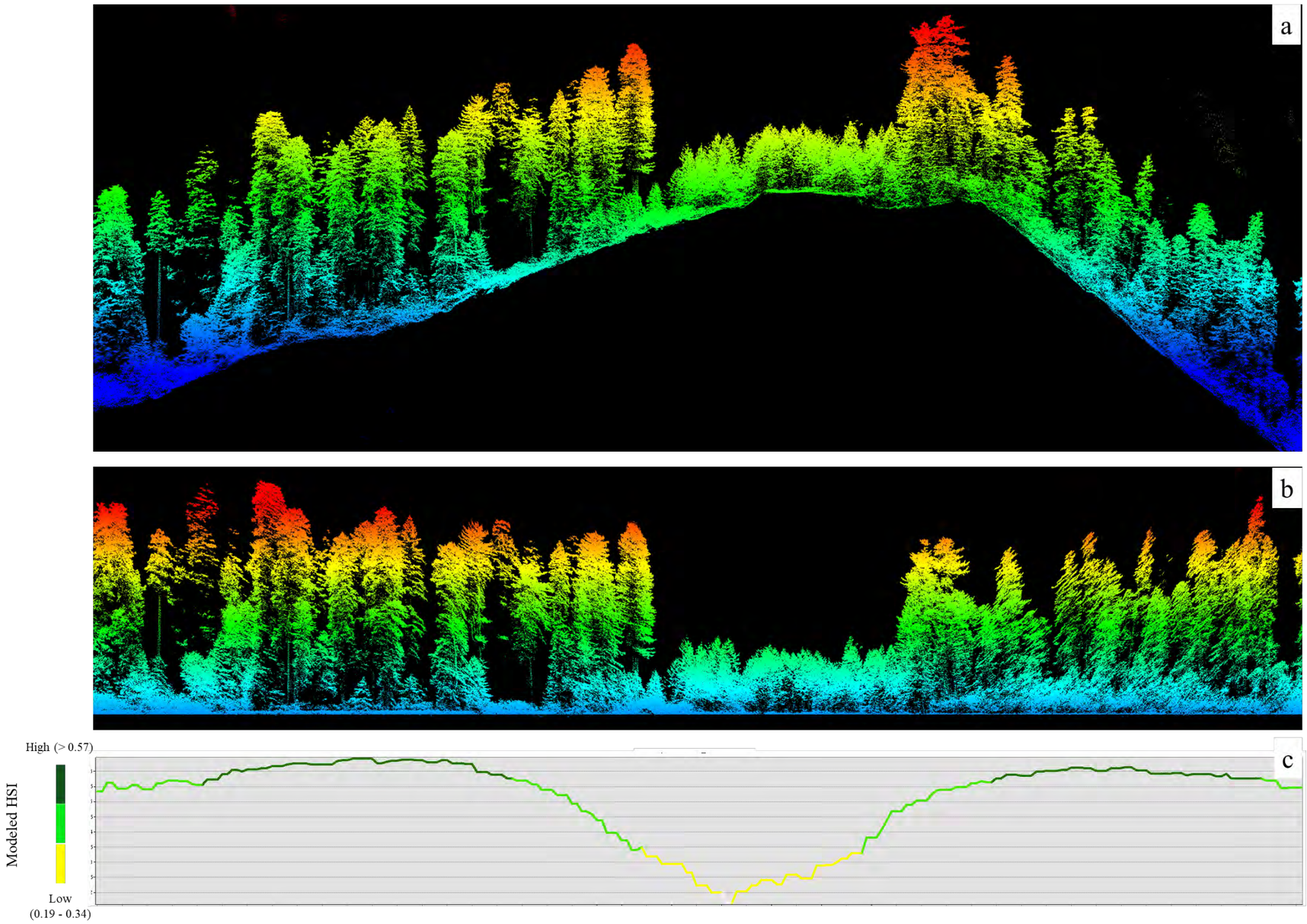

Figure F-3. A profile view (vertical distribution or 'slice' of LiDAR returns along a west-to-east transect) beginning in the Klamath View Ridge West stand, crossing the 300-foot buffer, and ending in the Klamath View Ridge North stand (see 'profile transect' location in Figure F-2). (a) Vertical axis represents elevation as a height above mean sea level. (b) The vertical axis represents the normalized view as height above ground level allowing for direct comparison of tree heights. Tree heights range from 70-90 meters within the Klamath View Ridge stands and 25-30 meters within the buffer for the vertical distribution of LiDAR returns given the location of the profile transect in Figure F-2. (c) Modeled Habitat Suitability Index (HSI) values along the profile transect (west-to-east transect). The values are extracted from the raster output with dark green indicating the highest suitability, light green representing medium suitability, and yellow indicating low suitability. HSI decreases near and within the buffer (shorter trees) as a result of the HSI model variables and five-acre moving window (Appendix A).

Appendix G. Glossary of Terms and Abbreviations

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G.1 ABBREVIATIONS

AA	Adjustment Area
AHCP	Aquatic Habitat Conservation Plan
AMRA	Adaptive Management Reserve Account
ARCo	Arcata Redwood Company
ARU	Autonomous recording units
AUC	Area Under the ROC Curve
BAS	Balanced Acceptance Sample
CCAA	Candidate Conservation Agreement with Assurances
CCR	California Code Regulations
CalFire	California Department of Forestry and Fire Protection
CDFW	California Department of Fish and Wildlife
CE	Conservation Easement
CESA	California Endangered Species Act
DBH	Diameter at Breast Height
EPA	Eligible Plan Area
ESA	Endangered Species Act
FHCP	Forest Habitat Conservation Plan
GIS	Geographic Information Systems
HAB	Harmful Algae Blooms
HCP	Habitat Conservation Plan
HSI	Habitat Suitability Index
HSM	Habitat Suitability Model
LiDAR	Light Detection and Ranging
MATO	Master Agreement for Timber Operations

MMHCP	Marbled Murrelet Habitat Conservation Plan, also abbreviated 'Marbled Murrelet HCP'
Marten SHA	Marten Safe Harbor Agreement, also abbreviated 'Marten SHA'
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NSO	Northern Spotted Owl
PA	Plan Area
P/E	Predicted-to-Expected Ratio
QSI	Quantum Spatial Inc.
RPO	Relative Probability of Occupancy
RSF	Resource Selection Function
SHR	Suitable Habitat Reserve
TAO	Tree Approximate Object
TREE	Terrestrial Retention of Ecosystem Elements
USFWS	United States Fish and Wildlife Service, also abbreviated 'the Service'

G.2 DEFINITIONS

Adaptive management: As defined by the Services for purposes of their HCP program, a method for examining alternative strategies for meeting measurable biological goals and objectives, and then, if necessary, adjusting future conservation management actions according to what is learned (65 Federal Register 106, 36245).

Adjacent Habitat Reserve: Occupied or presumed occupied areas not located within the Plan Area but located within 300 feet of the plan area. Examples include occupied areas on Redwood National and State Park lands, U.S. Forest Service lands, and Bureau of land Management.

Adjustment area: Commercial timberland acreage and associated roads within the EPA which, at any point in time while the MMHCP is in effect, are not within the Plan Area where the Service has authorized take and thus not covered by the ITP but are eligible for acquisition and inclusion in the Plan Area without amendment and are fully analyzed within the MMHCP.

Aerial yarding: Movement of logs to a landing by use of helicopters, or balloons, often used where roads cannot be constructed to provide access to a harvesting unit.

Age class: One of the intervals into which the age range of trees is divided for classification or use in management.

Broadcast burn: A prescribed fire allowed to burn over a designated area with well-defined boundaries to achieve some land management objective.

Bucking: Use of a saw to remove log lengths from a tree after it has been felled.

Buffer: A vegetation strip or management zone of varying size, shape, and character maintained along Occupied Reserves and Adjacent Habitat Reserves to minimize the impacts of actions on marbled murrelets.

Cable yarding: Taking logs from the stump area to a landing using an overhead system of winch-driven cables to which logs are attached with chokers.

California Forest Practice Rules (CFPRs): Rules promulgated by the California Board of Forestry and administered by the California Department of Forestry and Fire Protection governing the conduct of commercial timber operations on state and private land in California.

Candidate conservation agreement with assurances (CCAA): An agreement between a non-federal property owner and the Service(s), in which the property owner commits to implement conservation measures for a proposed or candidate species or a species likely to become a candidate or proposed in the near future. The property owner also receives assurances from the Service(s) that additional conservation measures will not be required and additional land, water, or resource use restrictions will not be imposed should the currently unlisted species become listed in the future (64 Federal Register 116, 32727). The agreement accompanying with an enhancement of survival permit issued under section 10(a)(1)(A) of the ESA.

Changed circumstances: Changes in circumstances affecting a species or geographic area covered by a conservation plan that can reasonably be anticipated by plan developers and the Services and that can be planned for (e.g. the listing of a new species, or a fire or other natural catastrophic event in areas prone to such events.). 50 CFR §§ 17.3, 222.102. Changes that will constitute Changed Circumstances, and the responses to those circumstances, are described in Plan Section 5. Changed Circumstances are not Unforeseen Circumstances.

Class I watercourses: All current or historical fish-bearing watercourses and/or domestic water supplies that are on site and/or within 100 feet downstream of the intake.

Class II watercourses: As used in the Plan, watercourses containing no fish, but support or provides habitat for aquatic vertebrates. Seeps and springs that support or provide habitat for aquatic vertebrates are also considered Class II watercourses with respect to the conservation measures.

Class III watercourses: Small seasonal channels which do not support aquatic species but have the potential to transport sediment to Class I or II watercourses.

Clearcutting: Even-aged regeneration method where all the merchantable trees in the stand are removed in one harvest. Regeneration is accomplished by natural or artificial means.

Commercial harvest: Removal of merchantable trees from a stand.

Commercial thinning: removing selected trees that may contain commercial value, to create additional growing space for crop trees.

Corvids: Birds in the family Corvidae especially common ravens (*Corvus corax*) and Steller's jays (*Cyanocitta stelleri*).

Conservation Zones: In the Recovery Plan for the Marbled Murrelet (1997), the USFWS identified six conservation zones within the continental United States that cover the marbled murrelet's range. These zones correspond with large tracts of older forests near the coast where marbled murrelets can be found in the breeding season and to some extent in the winter. The six zones from north to south include: Zone 1, Puget Sound; Zone 2, Western Washington Coast Range; Zone 3, Oregon Coast Range; Zone 4, Siskiyou Coast Range; Zone 5, Mendocino; and Zone 6, Santa Cruz Mountains. Green Diamond's MMHCP plan area falls within Zone 4.

Covered activities: Certain activities carried out by Green Diamond in the Plan Area that may result in incidental take of Covered Species and all those activities necessary to carry out the commitments reflected in the Plan's Operating Conservation Program.

Covered species: The species identified in this Plan (Marbled Murrelet), which the Plan addresses in a manner sufficient to meet all of the criteria for issuing an incidental take permit under ESA Section 10(a)(1)(B) and all of the criteria for issuing an enhancement of survival permit under ESA Section 10(a)(1)(A), as applicable.

Critical habitat: Specific areas, both occupied and unoccupied, that are essential to the conservation of a listed species and that may require special management considerations or protections.

Cumulative effect: As defined in the Services' HCP Handbook and Draft CCAA Handbook: Under NEPA regulations, the incremental environmental impact or effect of the action together with the impacts of past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes such other actions (40 CFR 1508.7). Under ESA section 7 regulations, the effects of future state or private activities not involving federal activities, that are reasonably certain to occur with the action area of the federal action subject to consultation (50 CFR 402.02).

Diameter at breast height (DBH): The diameter of a tree 4.5 feet above the ground on the uphill side of the tree.

Ecological Sections and Subsections: (Alternatively: Ecological Regions and subregions) Described in Miles and Goudy 1997 as a scientific basis for regionalization of ecosystems into successively smaller, more homogeneous units using associations of environmental factors (e.g., climate, physiography, water, soils, air, hydrology). A Sections and subsections are ecological units of a Subregion. A Section is thousands to tens of square miles and is the highest hierarchical level at the subregion scale, and a subsection is a smaller unit within the Section.

Effective date: The date(s) upon which the ITP and ESP are issued by the Services.

Eligible plan area (EPA): All privately owned commercial timberlands that, over the life of the Plan, are either included within the Plan Area or are eligible for inclusion in the Plan Area. This is the entire commercial timberland acreage analyzed in the Plan to support the Plan's provisions allowing for additions and deletions of lands from the Plan Area of the term of the Plan and Permits.

Endangered: The classification given to an animal or plant in danger of extinction within the foreseeable future throughout all or a significant portion of its range.

Even-aged stand: A stand of trees composed of a single age class in which the range of tree ages is usually +/- 20 percent of rotation.

Even-aged management: The application of a combination of actions that results in the creation of even-aged stands. Clearcut, shelterwood, or seed tree cutting methods produce even-aged stands.

Environmental impact statement (EIS): A document prepared to describe the effects for proposed activities on the environment.

Feasible: Capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, operational, and technological factors, and considering what is allowable under the law.

Forest management: The practical application of biological, physical, quantitative, managerial, economic, social, and policy principles to the regeneration, management, utilization, and conservation of forests to meet specified goals and objectives while maintaining the productivity of the forest.

Front-end loader: A machine with special forks, lifts, or grapples for loading logs onto trucks, pallets, or railcars.

Green Diamond's ownership: Commercial timberlands that Green Diamond owns in fee and lands owned by others subject to Green Diamond harvesting rights.

Ground-based yarding: Movement of logs to a landing by use of tractors, either tracked or rubber tired (rubber tired skidders) or shovels (hydraulic boom log loaders).

Habitat: The place, natural or otherwise, (including climate, food, cover, and water) where an animal, plant, or population naturally or normally lives and develops.

Habitat conservation plan (HCP): As defined in the Services' HCP Handbook, a planning document that is a mandatory component of an application for an incidental take permit under ESA Section 10(a)(1)(B); also known as a conservation plan. The document that, among other things, identifies the operating conservation program that will be implemented to minimize, mitigate, and monitor the effects of incidental take on the species covered by a Section 10(a)(1)(B) permit.

Habitat suitability model (HSM): A statistical method for predicting the suitability of a location for a species based on their observed relationship with environmental conditions.

Harass: A form of take under the ESA. Defined in ESA implementing regulations promulgated by the Department of Interior as an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.3).

Hard edge: A boundary line defined by a significant difference in vegetation height such as old-growth forest next to young regenerating forest.

Harm: A form of take under the ESA. Defined in federal regulations as an act which actually kills or injures fish and wildlife. Such an act may include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering (50 CFR part 222.102; also see 50 CFR part 17.3).

Harvesting: All activities necessary to cut, remove, and transport timber products from the Plan Area.

Harvesting rights: The rights to conduct timber operations on lands owned in fee by another. Short-term harvesting rights generally expire upon the conclusion of timber operations, upon a date certain, or a combination of the two. Perpetual harvesting rights pertain to existing and subsequent crops of timber and continue without expiration.

Helicopter yarding: (Alternatively: aerial yarding). Movement of logs to a landing by use of helicopters, or balloons, often used where roads cannot be constructed to provide access to a harvesting unit.

Incidental take: The taking of a federally listed species, if such taking is incidental to, and not the purpose of, carrying out otherwise lawful activities.

Incidental take permit (ITP): A permit issued by the Services pursuant to ESA Section 10(a)(1)(B) authorizing incidental take of federally listed species named on the permit.

ITP species: The Covered Species for which Green Diamond is seeking an ITP; the species named on the ITP.

Jeopardy: term under the Endangered Species Act that refers to an action that is reasonably expected to diminish a species' numbers, reproduction, or distribution so that the likelihood of survival and recovery in the wild is appreciably reduced.

Landings: The areas where harvested trees are gathered (through skidding or yarding) for subsequent transport out of the forest.

Large woody debris (LWD): Larger pieces of wood in stream channels or on the ground, including logs, root wads, and large chunks of wood that provide important biological and physical functions.

Listed species: A species, subspecies, or qualifying distinct population segment of a vertebrate species on the lists of threatened and endangered wildlife and plants in 50 CFR 17.11 and 17.12. Also, a species, subspecies, or variety of plant or animal on the lists of the endangered, threatened, and rare species maintained by the California Fish and Game Commission.

Marginal Habitat: The portions of the Plan Area that are suitable for occupancy by marbled murrelets (as predicted by the HSM) with the lowest predicted value on the suitability scale relative to the Suitable Habitat Reserves and Occupied Reserves.

Maximum extent practicable: Term used in the ESA and federal regulations to describe the level of impact minimization and mitigation required for incidental take of a listed species to be authorized under ESA Section 10(a)(1)(B).

Maximum sustained production: Harvest levels planned under CFPRs to balance forest growth and timber harvest over a 100-year period and to achieve maximum sustained production of high quality timber products while protecting resource values such as water quality and wildlife.

Merchantable: Trees or stands having the size, quality, and condition suitable for marketing under a give economic condition, even if not immediately accessible for logging.

Migratory Bird Treaty Act (MBTA): The Migratory Bird Treaty Act implements various treaties and conventions between the U.S. and Canada, Japan, Mexico and the former Soviet Union for the protection of migratory birds. Under the Act, taking, killing or possessing migratory birds is unlawful.

Minor forest products: Secondary forest materials including tree burls, stump products, boughs and greenery for wreaths and floral arrangements or similar purposes.

Mitigation ratio: The ratio of values gained per unit area to values lost per unit area. With respect to this MMHCP, the ratio of estimated marbled murrelet production to marbled murrelet loss from direct and indirect take.

National Environmental Policy Act (NEPA): The Act establishes national environmental policy and goals for the protection, maintenance, and enhancement of the environment and provides a process for implementing these goals within the federal agencies.

National Marine Fisheries Service (NMFS): A division of the U.S. Department of Commerce that is responsible for the stewardship of the nation's marine resources, the protection and recovery of listed marine species, and the authorization of incidental take of listed marine species.

Occupied Reserve: The portions of the PA that are considered to be baseline occupied or presumed occupied marbled murrelet habitat that are not subject to timber harvesting during the term of the MMHCP. The Occupied Reserves may not be sold, conveyed, or otherwise transferred to a third party unless conveyance is subject to a restrictive covenant or conservation easement that prohibits timber harvest for the Term of the MMHCP. Green Diamond may sell and convey a perpetual conservation easement interest in any portion of the Occupied Reserves to the federal government, State of California or a qualified land trust provided that the terms of the conservation easement prohibit harvest within the Occupied Reserves and are otherwise consistent with the

MMHCP. Occupied Reserves are conserved baseline habitat and are not offered as compensatory mitigation for authorized incidental take under this MMHCP.

Operating conservation program: As defined in 50 CFR §§ 17.3, 222.102, those conservation management activities which are expressly agreed upon and described in a conservation plan or its implementing agreement (IA), if any, and which are to be undertaken for the affected species when implementing an approved conservation plan, including measures to respond to changed circumstances. In this Plan, the conservation management activities and specific measures (including provisions for changed circumstances, funding, monitoring, reporting, adaptive management, and dispute resolution) as set forth in Section 6.2.

Pacific Seabird Group (PSG): a society of professional seabird researchers and managers with a focus on conservation and management of seabirds.

Plan: The Marbled Murrelet Habitat Conservation Plan prepared by Green Diamond.

Plan area (PA): All commercial timberland acreage where Green Diamond owns fee lands and Harvesting Rights (Green Diamond's ownership), during the period of such ownership within the term of the Permits, subject to the limitations described in the Operating Conservation Program, and roads on lands where Green Diamond owns and exercises Road Access Rights within its approved Timber Harvesting Plan (THP) areas in the Eligible Plan Area during the term of the Plan and Permits. This is the geographic area where incidental take will be authorized, the Covered Activities will occur, and the Operating Conservation Program will be implemented. Except where stated otherwise in the Plan, references to lands, commercial timberlands, and Green Diamond's ownership in the context of the Plan Area include lands owned in fee and lands subject to harvesting rights. (All commercial timberlands within the Eligible Plan Area during the term of this MMHCP)

Precommercial thinning: Thinning or pruning dense young forest trees to achieve optimum diameter growth and increase the eventual product value of the tree.

Prescribed burning: Introduction of fire under controlled conditions to remove unwanted brush, logging slash, and/or woody debris or specified forest elements.

Productivity loss (production loss): The estimated reduction in future marbled murrelet egg or nestling production attributable to the removal of, or edge effects adjacent to, potential nesting habitat over the permit term. Productivity loss is not reasonably certain to result in death or injury to individual murrelets and is not take under the ESA or CESA. It is estimated and reported for the Service's evaluation of population-level effects and is not counted against authorized take.

Regeneration: The renewal of tree cover by natural or artificial means. Also, the young tree crop (seedlings and saplings).

Registered professional forester (RPF): A person who holds a valid license as a professional forester pursuant to Article 3, Section 2, Division 1 of the California Public Resources Code (as in effect on the date of issuance of the Permits).

Residual: A tree that remains standing after some event such as selection harvest.

Riparian management zone: A riparian buffer zone on each side of a Class I or Class II watercourse that receives special treatments, to provide temperature control, nutrient inputs, channel stability, sediment control, and LWD recruitment.

Rotation: The planned number of years between the regeneration of an even-aged stands and its final cutting at a specified stage.

Rotation age: The age of a stand when it is harvested at the end of a rotation.

Salvage operations: The removal of dead trees or trees damaged or dying because of injurious agents other than competition, to recover economic value that would otherwise be lost.

Second growth: Timber stands established after natural or human-caused removal of the original stand or previous forest growth.

Selection harvest: The removal of trees, individually or in small groups, from the forest.

Shovel loader: (Alternatively: heel-boom loader). A stationary piece of log loading equipment located on roads and landings, similar to a construction crane, that uses a crane-like grapple to deck, move, and load logs onto log trucks from one central pivot point.

Silviculture: The specific methods by which a forest stand or area is harvested and regenerated over time to achieve the desired management objectives.

Skid trail: An access cut through the woods for skidding logs with ground-based equipment. Skid trails are not typically built to a high enough standard for use by highway vehicles, such as a log truck, and is therefore not a road.

Slash: Woody residue left on the ground after trees are felled, or accumulated there as a result of a storm, fire, or silvicultural treatment.

Snag: A standing dead tree.

Stand: A group of trees that possesses sufficient uniformity in composition, structure, age, spatial arrangement, or condition to distinguish it from adjacent groups.

Stand improvement: An intermediate treatment made to improve the composition, structure, condition, health, and growth of even- or uneven-aged stands.

Suitable Habitat Reserve: The portions of the PA that are suitable for occupancy by marbled murrelets (as predicted by the HSM) or areas possessing key habitat features that will continue to develop into suitable habitat during the permit term. The Suitable Habitat Reserves are next best on the suitability scale relative to the Occupied Reserves and are not subject to timber harvest during the term of the MMHCP. The Suitable Habitat Reserves may not be sold, conveyed, or otherwise transferred to a third party unless conveyance is subject to a restrictive covenant or conservation easement that prohibits timber harvest for the Term of the MMHCP. Green Diamond may sell and convey a perpetual conservation easement interest in any portion of the Suitable Habitat Reserves to the federal government, State of California or a qualified land trust provided

that the terms of the conservation easement prohibit harvest within the Suitable Habitat Reserves and are otherwise consistent with the MMHCP.

Sustained yield: The yield of commercial wood that an area can produce continuously at a given intensity of management consistent with required environmental protection and which is professionally planned to achieve over time a balance between growth and removal.

Take: To harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." 16 USCA § 1532(19); 50 CFR § 222.102. "Harm" means an act that actually kills or injures fish or wildlife, which act may include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including for the Service species breeding, feeding or sheltering and for NMFS species breeding, spawning, rearing, migrating, feeding or sheltering. 50 CFR §§ 17.3, 222.102.

Terrestrial retention of ecosystem elements (TREE): Habitat retention application guidelines for the Green Diamond ownership under this FHCP.

Tree-approximate Objects (TAOs): Term applied to individual tress modeled from LiDAR data which may under-represent smaller trees or co-dominant clusters of trees.

Thinning: A treatment made to reduce stand density of trees primarily to improve growth, enhance forest health, or recover potential mortality.

Threatened: The classification given to a plant or animal species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

Timber felling: Physically cutting a tree from its stump including cutting of the felled tree into predetermined log lengths.

Timber harvesting: All activities necessary to cut, remove, and transport timber products from an area.

Timber harvesting plan (THP): A plan describing a proposed timber harvesting operation pursuant to 14 CCR section 4582 (as in effect on the date of issuance of the Permits).

Tractor logging: Use of a tractor to carry logs from the harvest site to a landing.

Uneven-aged: A stand with trees of three or more distinct age classes, either intimately mixed or in small groups.

Unforeseen Circumstances: Changes in circumstances affecting a species or geographic area covered by the Plan that could not reasonably have been anticipated by Green Diamond and the Services at the time of the Plan's development, and that result in a substantial and adverse change in the status of the covered species." 50 CFR §§ 17.3, 222.102.

Unsuitable Habitat: The portions of the PA that are unsuitable for occupancy by marbled murrelets (as predicted by the HSM) and are the lowest on the suitability scale relative to the Marginal Habitat, Suitable Habitat Reserves, and Occupied Reserves.

Watercourse: Any well-defined channel with distinguishable bed and bank showing evidence of having contained flowing water indicated by deposit of rock, sand, gravel, or soil. Watercourse also includes manmade watercourses.

Yarding: (Alternatively: skidding). The movement of forest products from the stump to the landing.

Appendix H. Literature Cited

Agne, M.C., P.A. Beedlow, D.C. Shaw, D.R. Woodruff, E.H. Lee, S.P. Cline, and R.L. Comeleo. 2018. Interactions of predominant insects and diseases with climate change in Douglas-fir forests of western Oregon and Washington, U.S.A. Forest Ecology and Management 409:317-332.

Akaike, H. 1974. A new look at the statistical model identification, IEEE Transactions on Automatic Control, 19(6):716-723, doi:10.1109/TAC.1974.1100705.

American Wood Council. 2024. Environmental product declaration for U.S. Pacific Coast softwood lumber https://corrim.org/wp-content/uploads/2025/08/PC-EPD-08232025.pdf

Antoine, M.E., and S.C. Sillett. 2021. Intentional forests: growing hope for the future. International Dendrology Society Yearbook. https://www.humboldt.edu/redwoods/docs/Antoine&Sillett2022_IDS%202021.pdf

Bahn, V., and D. Newsom. 2002. Habitat suitability mapping for marbled murrelets in Clayoquot Sound. In: Multi-scale studies of populations, distribution and habitat associations of marbled murrelets in Clayoquot Sound, British Columbia. A.E. Burger and T.A. Chatwin (editors). B.C. ministry of Water, Land and Air Protection, Victoria, B.C. pp. 101-120.

Baker, J.S., G. Van Houtven, J. Phelan, G. Latta, C.M. Clark, K.G. Austin, O.E. Sodiya, S.B. Ohrel, J. Buckley, L.E. Gentile, J. Martinich. 2023. Projecting U.S. forest management, market, and carbon sequestration responses to a high-impact climate scenario. Forest Policy and Economics 147:1-17.

Baker, L.M., M.Z. Peery, E. Burkett, S.W. Singer, D.L. Suddjian, and S.R. Beissinger. 2006. Nesting habitat characteristics of the marbled murrelet in central California redwood forests. Journal of Wildlife Management 70:939-946.

Barbaree, B.A., S.K. Nelson, B.D. Dugger, D.D. Roby, H.R. Carter, D.L. Whitworth, and S.H. Newman. 2014. Nesting ecology of Marbled Murrelets at a remote mainland fjord in southeast Alaska. Condor 116:173–184.

Bauhaus, J., K. Puettmann, and C. Messier. 2009. Silviculture for old-growth attributes. Forest Ecology and Management 258:525-537.

Becker, B.H., and S.R. Beissinger. 2003. Scale-dependent habitat selection by a nearshore seabird, the marbled murrelet, in a highly dynamic upwelling system. Marine Ecology Progress Series 256:243-255.

Becker, B.H., M.Z. Peery, S.R. Beissinger. 2007. Ocean climate and prey availability affect the trophic level and reproductive success of the marbled murrelet, an endangered seabird. Marine Ecology Progress Series. 329:267-79.

Bergman, R.D., E. Oneil, I.L. Eastin, and H. Han. 2014. Life cycle impacts of manufacturing redwood decking in Northern California. Wood and Fiber Science 46:322-339. https://wfs.swst.org/index.php/wfs/article/view/1707

Bigger, D., M.Z. Peery, S. Chinnici, and S.P. Courtney. 2006. Efficacy of audio-visual and radar surveys for studying marbled murrelets in inland habitats. Journal of Wildlife Management. 70: 505–516.

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.

Boyce, M.S., P.R. Vernier, S.E. Nielsen, and F. Schmiegelow. 2002. Evaluating resource selection functions, Ecological Modelling, Volume 157, Issues 2–3, Pages 281-300, ISSN 0304-3800, https://doi.org/10.1016/S0304-3800(02)00200-4.

Brodrick, P.G., L.D.L. Anderegg, and G.P. Asner. 2019. Forest drought resistance at large geographic scales. Geophysical Research Letters 46:2752-2760. https://doi.org/10.1029/2018GL081108

Brown, J.A., B.L. Robertson, and T.L. McDonald. 2015. Spatially balanced sampling: application to environmental surveys. Procedia Environmental Sciences 27: 6–9.

Burger, A.E. 2001. Using radar to estimate populations and assess habitat associations of Marbled Murrelets. Journal of Wildlife Management. 65: 696–715.

Burger, A.E. 2002. Conservation assessment of marbled murrelets in British Columbia, a review of biology, population, habitat associations, and conservation. Pacific Yukon Region, Canadian Wildlife Service, 168 pp.

Burger, A.E., F.L. Waterhouse, and J.L. Cragg. 2020. Research options to address knowledge gaps on marbled murrelet terrestrial habitat requirements. Prov. B.C., Victoria, B.C. Technical Report 130.

Burger, A.E., I.A. Manley, M.P. Silvergieter, D.B. Lank, K.M. Jordan, T.D. Bloxton, and M.G. Raphael. 2009. Re-use of nest sites by Marbled Murrelets (*Brachyramphus marmoratus*) in British Columbia. Northwestern Naturalist 90:217–226.

Burger, A.E., R.A. Ranconi, M.P. Silvergieter, C. Conroy, V. Bahn, I.A. Manley, A. Cober, and D.B. Lank. 2010. Factors affecting the availability of thick epiphyte mats and other potential nest platforms for marbled murrelets in British Columbia. Canadian Journal of Forest Research. 40:727-746.

California Air Resource Board (CARB). 2017. Glossary of terms used in greenhouse gas inventories. https://www.arb.ca.gov/cc/inventory/faq/ghg_inventory_glossary.htm accessed on December 4, 2025.

California Department of Fish and Wildlife (CDFW). 2014. California Interagency Wildlife Task Group. User's manual for version 9.0 of the California Wildlife Habitat Relationships System and BioView. Sacramento, California.

California Department of Forestry and Fire Protection. 2024. California Forest Practice Rules. 431 pp.

California Forest Climate Action Team. 2018. California forest carbon plan: managing our forest landscapes in a changing climate. Sacramento, CA, 178 p.

California Forest Observatory. 2020. https://forestobservatory.com/

California Timberland Task Force (Timberland Task Force). 1993. The report of the California Timberlands Task Force 1993. California Agencies. Paper 175.

Carter, H.R., and R.A. Erickson. 1988. Status and conservation of the marbled murrelet in California, 1892-1987. California Department of Fish and Game, Sacramento, CA. 68 pp.

Cavole, L.M., A.M. Demko, R.E. Diner, A. Giddings, I. Koester, C.M.L.S. Pagniello, M.-L. Paulsen, A. Ramirez-Valdez, S.M. Schwenck, N.K. Yen, M.E. Zill, and P.J.S. Franks. 2016. Biological impacts of the 2013–2015 warm-water anomaly in the Northeast Pacific: Winners, losers, and the future. Oceanography 29(2):273–285, http://dx.doi.org/10.5670/oceanog.2016.32.

Chen, J., J.F. Franklin, and T.A. Spies. 1992. Vegetation responses to edge environments in old-growth Douglas-fir forests. Ecological Applications 2:387-396.

Chen, Q., D. Baldocchi, P. Gong, and M. Kelly. 2006. Isolating individual trees in a savanna woodland using small footprint lidar data. Photogrammetric Engineering and Remote Sensing 72: 923–932.

Chinnici, S.J. 2020. Marbled murrelet inland monitoring annual report.

Chmura, D.J., P.D. Anderson, G.T. Howe, C.A. Harrington, J.E. Halofsky, D.L. Peterson, D.C. Shaw, and J.B. St. Clair. 2011. Forest responses to climate change in the northwestern United States: ecophysiological foundations for adaptive management. Forest Ecology and Management 261:1121-1142.

Clyde, G.E. 2017. A fine-scale lidar-based habitat suitability mapping methodology for the marbled murrelet (*Brachyramphus marmoratus*) on Vancouver Island, British Columbia. M.Sc. Thesis, The University of Victoria.

Cohen, J. 1960. A coefficient of agreement for nominal scales. Educational and Psychological Measurement 20: 37–46.

Conroy, C.J., V. Bahn, M.S. Rodway, L. Ainsworth, and D. Newsom. 2002. Estimating nest densities for marbled murrelets in three habitat suitability categories in the Ursus Valley, Clayoquot Sound. In:

Multi-scale studies of populations, distribution and habitat associations of marbled murrelets in Clayoquot Sound, British Columbia. A.E. Burger and T.A. Chatwin (editors). B.C. ministry of Water, Land and Air Protection, Victoria, B.C. pp. 121-137.

Cragg, J.L., A.E. Burger, and J.F. Piatt. 2016. Techniques for monitoring *Brachyramphus* murrelets: a comparison of radar, autonomous acoustic recording, and audio-visual surveys. Wildlife Society Bulletin. 40:130-139.

Cragg, J.L., F.L. Waterhouse, F.I. Doyle, M.H. Mather, and B.K. Schroeder. 2019. Seasonal patterns and metrics of marbled murrelet vocal activity from autonomous recording units. Proceedings of the 46th annual meeting of the Pacific Seabird Group. Pp 13.

Cullen, S.A. 2002. Using radar to monitor populations and assess habitat associations of marbled murrelets within the Sunshine Coast forest district. Surrey, British Columbia: Ministry of Water, Land and Air Protection.

Cushing, L.J., Y. Ju, S. Kulp, N. Depsky, S. Karasaki, J. Jaeger, A. Raval, B. Strauss, and R. Morello-Frosch. 2023. Toxic tides and environmental injustice: social vulnerability to sea level rise and flooding of hazardous sites in Coastal California. Environmental Science and Technology. 57:7370-7381. https://doi.org/10.1021/acs.est.2c07481

Dagley, C.M., J.-P. Berrill, L.P. Leonard, and Y.G. Kim. 2018. Restoration thinning enhances growth and diversity in mixed redwood/Douglas-fir stands in northern California, U.S.A. Restoration Ecology. https://doi.org/10.1111/rec.12681

DellaSala, D.A., P. Brandt, M. Koopman, J. Leonard, C. Meisch, P. Herzog, P. Alaback, M.I. Goldstein, S. Jovan, A. MacKinnon, and H. von Wehrden. 2018. Climate change may trigger broad shifts in North America's Pacific coastal rainforests. Pages 233–244 in DellaSala DA, Goldstein MI, editors. Encyclopedia of the Anthropocene. Volume 2: Climate Change. Reference Module in Earth Systems and Environmental Sciences. Elsevier, Oxford, UK.

Divoky, G.J., and M. Horton. 1995. Breeding and natal dispersal, Nest Habitat Loss and Implications for Marbled Murrelet Populations. In: Ecology and Conservation of the Marbled Murrelet. Ralph, C.J., Hunt Jr., G.L., Raphael, M.G. & Piatt, J.F. (Eds.). USDA Forest Service General Technical Report PSW-GTR-152. pp. 83-88.

Djahangard, M., H. Zhang, and R. Yousefpour. 2024. Assessing the ecological complexity and uncertainty of predicting forest ecosystem services under climate change. Ecological Complexity. 60:1-15. https://doi.org/10.1016/j.ecocom.2024.101106

Dodson, E.K., A. Ares, and K.J. Puettmann. 2012. Early responses to thinning treatments designed to accelerate late successional forest structure in young coniferous stands of western Oregon, USA. Canadian Journal of Forest Research 42:345-355. doi:10.1139/X11-188

Duarte, A., M.J. Weldy, D.B. Lesmeister, Z.J. Ruff, J.M. Jenkins, J.J. Valente, and M.G. Betts. 2024. Passive acoustic monitoring and convolutional neural networks facilitate high-resolution and broadscale monitoring of a threatened species. Ecological Indicators, 162:112016. https://doi.org/10.1016/j.ecolind.2024.112016

Dudney, J., C.E. Willing, A.J. Das, A.M. Latimer, J.C.B. Nesmith, and J.J. Battles. 2021. Nonlinear shifts in infectious rust disease due to climate change. Nature Communications 12:5102. https://doi.org/10.1038/s41467-021-25182-6

EcoAdapt. 2021. Coastal redwood forests: climate change vulnerability assessment summary for the Santa Cruz Mountains Climate Adaptation Project. Version 1.0 EcoAdapt, Bainbridge Island, WA. https://ecoadapt.org/data/documents/EcoAdapt_SantaCruzMtnsVASummary_CoastalRedwoodForest_FINAL_Mar2021.pdf

EcoAdapt. 2024. Coastal redwood forests: climate change vulnerability assessment summary for the Golden Gate Biosphere Region. EcoAdapt, Bainbridge Island, WA. https://ecoadapt.org/data/documents/EcoAdapt_GGBN_VASummary_CoastalRedwoodForests_FINAL_Oct2024.pdf

Elith, J., S.J. Phillips, T. Hastie, M. Dudik, Y.E. Chee, and C.J. Yates. 2011. A statistical explanation of Maxent for ecologists. Diversity and Distributions 17: 43–57.

Environmental Protection Agency. 2024. Greenhouse gas mitigation potential in the U.S. forestry and agriculture sector. U.S. Environmental Protection Agency, Office of Atmospheric Protection. Washington, DC. EPA. https://www.epa.gov/system/files/documents/2024-03/epa-430-r-23-004-mitigationreport_full_report_v2.pdf

Evans Mack, D., W.P. Ritchie, S.K. Nelson, E. Kuo-Harrison, P. Harrison, and T.E. Hamer. 2003. Methods for surveying Marbled Murrelets in forests: a revised protocol for land management and research. Pacific Seabird Group Technical Publication Number 2. Available from http://www.pacificseabirdgroup.org.

Falxa, G.A., and M.G. Raphael, tech. coords. 2016. Northwest Forest Plan—the first 20 years (1994–2013): status and trend of marbled murrelet populations and nesting habitat. Gen. Tech. Rep. PNW-GTR-933. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 132 p.

Feng, X., D.S. Park, Y. Liang, R. Pandey, and M. Papes. 2019. Collinearity in ecological niche modeling: confusions and challenges. Ecology and Evolution. 9: 10365–10376.

Fleiss, J.L. 1981. Statistical methods for rates and proportions. 2nd ed. New York: John Wiley.

Friedman, J.H. 1984. SuperSmoother: a variable span scatterplot smoother. Laboratory for Computational Statistics, Stanford University Technical Report No. 5. R-Package supsmu. https://purl.stanford.edu/fy579rh2058

Fritz, E. 1932. The role of fire in the redwood region. Berkeley, CA: University of California press, 23 p.

Gaines, W.L., P.F. Hessburg, G.H. Aplet, P. Henson, S.J. Prichard, D.J. Churchill, G.M. Jones, D.J. Isaak, and C. Vynne. 2022. Climate change and forest management on federal lands in the Pacific Northwest, USA: managing for dynamic landscapes. Forest Ecology and Management 504:119794. https://doi.org/10.1016/j.foreco.2021.119794

Golightly, R.T., and S.R. Schneider. 2009. Observations of incubation in year 8 of a long-term monitoring effort at a marbled murrelet nest in northern California. Report to the California Department of Fish and Game, Sacramento, California.

Golightly, R.T., and S.R. Schneider. 2011. Years 9 and 10 of a long-term monitoring effort at a Marbled Murrelet nest in northern California. Report by Department of Wildlife, Humboldt State University, Arcata, CA. 22 pp.

Golightly, R.T., S.R. Schneider, and P.M. Hébert. 2009. Characteristics of marbled murrelet (*Brachyramphus marmoratus*) habitat in northern California. Report to the National Parks Service and California and California Department of Fish and Wildlife, Sacramento, CA, USA.

Gombin, J., R. Vaidyanathan, and V. Agafonkin. 2020. A very fast 2D concave hull algorithm in JavaScript, wrapped in R. http://www.github.com/joelgombin/concaveman/

Green Diamond. 1992. Habitat Conservation Plan for the Northern Spotted Owl on the California Timberlands of Green Diamond Resource Company (formerly Simpson Timber Company). 332 pp.

Green Diamond. 2007. Aquatic Habitat Conservation Plan (AHCP). 552 pp.

Green Diamond. 2010. Master Agreement for Timber Operations (MATO). 78 pp.

Green Diamond. 2012. Coastal Marten Conservation Memorandum of Understanding. 16 pp.

Green Diamond. 2016. California Condor Memorandum of Understanding. 25 pp.

Green Diamond. 2018. Humboldt Marten Safe Harbor Agreement. 71 pp.

Green Diamond. 2019. Forest Habitat Conservation Plan (FHCP). 828 pp.

Green Diamond. 2020. Coastal Marten Conservation Memorandum of Understanding between the Service and Green Diamond. 16 pp.

Gregor, K., A. Krause, C.P.O. Reyer, T. Knoke, B.F. Meyer, S. Suvanto, and A. Rammig. 2024. Quantifying the impact of key factors on the carbon mitigation potential of managed temperate forests. Carbon Balance and Management. https://doi.org/10.1186/s13021-023-00247-9

Grenier, J.J., and S.K. Nelson. 1995. Marbled Murrelet habitat associations in Oregon. Pp. 191–204 in C.J. Ralph, G.L. Hunt, Jr., M.G. Raphael, and J.F. Piatt, Technical Editors. Ecology and conservation of the Marbled Murrelet. USDA Forest Service, Pacific Southwest Research Station, Albany, CA. General Technical Report PSW-GTR-152.

Guillera-Arroita, G., J.J. Lahoz-Monfort, J. Elith, A. Gordon, H. Kujala, P.E. Lentini, M.A. McCarthy, R. Tingley, and B.A. Wintle. 2015. Is my species distribution model fit for purpose? Matching data and models to applications. Global Ecol. Biogeogr. 24:276-292.

Hagar, J.C., B.N. Eskelson, P.K. Haggerty, K.S. Nelson, D.G. Vesely. 2014. Modeling marbled murrelet (*Brachyramphus marmoratus*) habitat using LiDAR-derived canopy data. Wildlife Society Bulletin 38: 23-249.

Hamer, T.E. 1995. Inland habitat associations of marbled murrelets in western Washington. In: Ecology and conservation of the marbled murrelet. Pacific Southwest Research Station General Technical Report PNW-GTR-152.

Hamer, T.E., and S.K. Nelson. 1995a. Nesting chronology of the marbled murrelet. In: Ecology and conservation of the marbled murrelet. C.J. Ralph, G.L. Hunt, Jr., M.G. Raphael, and J.F. Piatt, technical editors. Gen. Tech. Rep. PSW-GTR-152. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture. pp 49-56.

Hamer, T.E., and S.K. Nelson. 1995b. Characteristics of Marbled Murrelet nest trees and nesting stand. Pages 69-82 in C.J. Ralph, G.L. Hunt, Jr., M.G. Raphael, and J.F. Piatt, eds. Ecology and conservation of the Marbled Murrelet. U.S. Department of Agriculture, Forest Service General Technical Report PSW-GTR-152, Albany, CA.

Hamer, T.E., K. Nelson, J. Jones, and J. Verschuyl. 2021. Marbled murrelet nest site selection at three fine spatial scales. Avian Conservation and Ecology 16(2): https://www.ace-eco.org/vol16/iss2/art4/

Han, H., E. Oneil, R.D. Bergman, I. Eastin, and L.R. Johnson. 2015. Cradle-to-gate life cycle impacts of redwood forest resource harvesting in northern California. Journal of Cleaner Production 99:217-229.

Hébert, P.N., and R.T. Golightly. 2006. Movements, nesting, and response to anthropogenic disturbance of marbled murrelets (*Brachyramphus marmoratus*) in Redwood National and State Parks, California. California Department of Fish and Game, Habitat Conservation Planning Branch Species Conservation and Recovery Program Report 2006-02 and California Department of Transportation Report Number F/CA/IR-2006/04, Sacramento, California, USA.

Hedd, A., D.F. Bertram, J.L. Ryder, and I.L. Jones. 2006. Effects of interdecadal climate variability on marine trophic interactions: rhinoceros auklets and their fish prey. Marine Ecology Progress Series. 309:263-278.

Hirzel, A.H., and G. Le Lay. 2008. Habitat suitability modeling and niche theory. Journal of Applied Ecology 45: 1372–1381.

Hirzel, A.H., G. Le Lay, V. Helfer, C. Randin, and A. Guisan. 2006. Evaluating the ability of habitat suitability models to predict species presences. Ecological Modeling. 199:142-152.

Hull, C.L., G.W. Kaiser, C. Lougheed, L. Lougheed, S. Boyd, and F. Cooke. 2001. Intraspecific variation in commuting distance of Marbled Murrelets (*Brachyramphus marmoratus*): Ecological and energetic consequences of nesting further inland. Auk 118(4):1036-1046.

Humboldt Redwood Company. 1999. Habitat conservation plan for the properties of The Pacific Lumber Company, Scotia Pacific Company LLC, and Salmon Creek Corporation. The Pacific Lumber Company, Scotia, California, USA.

Hyrenbach, K.D., and R.R. Veit. 2003. Ocean warming and seabird communities of the southern California current system (1987 – 1998): responses at multiple temporal scales. Deep-Sea Research II. 50:2537-2566.

Intergovernmental Panel on Climate Change (IPCC). 2007. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van

der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge. https://www.ipcc.ch/site/assets/uploads/2018/03/ar4_wg2_full_report.pdf

IPCC. 2013. Summary for Policymakers. In: T.F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.). Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, NY. Available at: https://www.ipcc.ch/report/ar5/wg1/full-report/

Jeronimo, S.M.A., V.R. Kane, D.J. Churchill, R.J. McGaughey, and J.F. Franklin. 2018. Applying LiDAR individual tree detection to management of structurally diverse forest landscapes. Journal of Forestry 116: 336–346.

Johnstone, J.A., and T.E., Dawson. 2010. Climate Context and ecological implications of summer fog decline in the coast redwood region. PNAS. 107:4533-4538. https://www.pnas.org/doi/10.1073/pnas.0915062107

Landis, J.R., and G.G. Koch. 1977. The measurement of observer agreement for categorical data. Biometrics 33: 159–174.

LAStools. 2019. Efficient LiDAR Processing Software (version 190507, academic), obtained from http://rapidlasso.com/LAStools.

Lesmeister, D.B., and J.M.A. Jenkins. 2022. Integrating new technologies to broaden the scope of northern spotted owl monitoring and linkage with USDA forest inventory data. Frontiers in Forests and Global Change. 5:966978. DOI:10.3389/ffgc.2022.966978

Leuschner, C., and F.C. Meinzer. 2024. Drought resistance and drought adaptation of Douglas-fir (*Pseudotsuga menziesii*) – A review. Perspectives in Plant Ecology, Evolution and Systematics. https://doi.org/10.1016/j.ppees.2024.125829

Long, L.L., and C.J. Ralph. 1998. Regulation and observations of human disturbance near nesting Marbled Murrelets. Arcata, CA: Pacific Southwest Research Station, Redwood Sciences Laboratory, Forest Service, U.S. Department of Agriculture.

Lorenz, T.J., M.G. Raphael, R.D. Young, D. Lynch, S.K. Nelson, and W.R. McIver. 2021. Status and trend of nesting habitat for the marbled murrelet under the Northwest Forest Plan, 1993 to 2017. U.S. Department of Agriculture, Forest Service General Technical Report PSW-GTR-998, Portland, OR. 64 pp.

Lorenz, T.J., M.G. Raphael, T.D. Bloxton, and P.G. Cunningham. 2017. Low breeding propensity and wide-ranging movements by Marbled Murrelets in Washington. Journal of Wildlife Management 81: 306-321.

Lorimer, C.G., D.J. Porter, M.A. Madej, J.D. Stuart, S.D. Veirs Jr., S.P. Norman, K.L. O'Hara, and W.L. Libby. 2009. Forest Ecology and Management 258:1038-1054.

Luck, G.W. 2002. The habitat requirements of the rufous treecreeper (*Climacteris rufa*). 2. validating predictive habitat models. Biological Conservation 105; 395–403.

Madsen, S., D. Evans, T. Hamer, P. Henson, S. Miller, S.K. Nelson, D. Roby, and M. Stapanian. 1999. Marbled Murrelet effectiveness monitoring plan for the Northwest Forest Plan. USDA, U.S. Forest Service. PNW General Technical Report 439. 51 pp.

Malt, J.M., and D.B. Lank. 2007. Temporal dynamics of edge effects on nest predation risk for the marbled murrelet. Biological Conservation 140:160-173.

Malt, J.M., and D.B. Lank. 2009. Marbled Murrelet nest predation risk in managed forest landscapes: dynamic fragmentation effects at multiple scales. Ecological Applications 19: 1274-1287.

Manley, I.A. 1999. Behavior and habitat selection of marbled murrelets nesting on the sunshine coast. M.S. Thesis, Simon Fraser University, Burnaby, BC. 163 p.

Manley, I.A., and S.K. Nelson. 1999. Habitat Characteristics associated with nest success and predation at marbled murrelet nest trees. Abstract. Pacific Seabirds 26:40.

Manly, B.F., L.L. McDonald, D.L. Thomas, T.L. McDonald, and W.P. Erickson. 2002. Resource selection by animals: statistical design and analysis for field studies, 2nd edition. Kluwer Academic Publishers: Dordrecht, Netherlands.

Marzluff, J.M., and E. Neatherlin. 2006. Corvid response to human settlements and campgrounds: causes, consequences, and challenges for conservation. Biological Conservation 130:301-314.

Marzluff, J.M., J.J. Millspaugh, P.Hurvitz, and M.S. Handcock. 2004. Relating resources to a probabilistic measure of space use: forest fragments and Steller's Jays. Ecology 85: 1411-1427.

Maxwell, C., R.M. Scheller, J.W. Long, and P. Manley. 2022. Forest management under uncertainty: the influence of management versus climate change and wildfire in the Lake Tahoe Basin, USA. Ecology and Society. 27(2):15. https://doi.org/10.5751/ES-13278-270215

McIver, W., J. Baldwin, M.M. Lance, S.F. Pearson, C. Strong, M.G. Raphael, A. Duarte, K. Fitzgerald, and K. Nelson. 2022. Marbled murrelet effectiveness monitoring, Northwest Forest Plan: 2021 summary report. 25 p.

McShane, C., T. Hamer., H. Carter, G. Swartzman, V. Friesen, D. Ainley, R. Tressler, K. Nelson, A. Burger, L. Spear, T. Mohagen, R. Martin, L. Henkel, K. Prindle, C. Strong, and J. Keany. 2004. Evaluation report for the 5-year status review of the Marbled Murrelet in Washington, Oregon, and California. Report prepared for the U.S. Fish and Wildlife Service, Region 1, Portland, Oregon. EDAW, Inc., Seattle, Washington.

Meyer, C.B., S.L. Miller, and C.J. Ralph. 2002. Multi-scale landscape and seascape patterns associated with marbled murrelet nesting areas on the U.S. west coast. Landscape Ecology 17: 95–115.

Meyer, C.B., S.L. Miller, and C.J. Ralph. 2003. Logistic regression accuracy across different spatial and temporal scales for a wide-ranging species, the marbled murrelet. In: Resource Selection Methods and Applications. Omnipress. pp. 94–106.

Meyer, C.B., S.L. Miller, and C.J. Ralph. 2004. Stand-scale habitat associations across a large geographic region of an old-growth specialist, the marbled murrelet. Wilson Bulletin 116:197-210.

Miles, S.R., and C.B. Goudey. 1997. Ecological subregions of California. USDA General Technical Report R5-EM-TP-005.

Miller, S.L., and C.J. Ralph. 1995. Relationship of marbled murrelets with habitat characteristics at inland sites in California. Pages 205-218 in Ralph, C.J., G.L. Hunt, M.G. Raphael, and J.F. Piatt (eds.). Ecology and conservation of the marbled murrelet. General Technical Report. PSW-GTW-152. Pacific Southwest Experimental Station, U.S. Forest Service, Albany, California. 420 pp.

Nelson, S.K. 1997. Marbled Murrelet (*Brachyramphus marmoratus*), version 2.0. In The Birds of North America (A.F. Poole and F.B. Gill, Editors). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bna.276.

Nelson, S.K., and A.K. Wilson. 2002. Marbled Murrelet Habitat Characteristics on State Lands in Western Oregon. Unpublished report to the Oregon Department of Forestry, Salem, OR. Final report, Oregon Cooperative Fish and Wildlife Research Unit, Oregon State University, Department of Fisheries and Wildlife, Corvallis, OR.

Nelson, S.K., and T.E. Hamer. 1995. Nest success and the effects of predation on marbled murrelets. Pp. 89-97. In: Ecology and conservation of the marbled murrelet (C.J. Ralph, G.L. Hunt, Jr., M.G. Raphael, and J.F. Piatt, eds). U.S. Forest Service, General Technical Report. PSW-GTR-152, Albany, California.

Nelson, S.K., M.H. Huff, S.L. Miller, and M.G. Raphael. 2006. Marbled murrelet biology: habitat relations and populations. In: Northwest Forest Plan—The first 10 years (1994-2003): Status and trends of populations and nesting habitat for the marbled murrelet. Pacific Northwest Research Station General Technical Report PNW-GTR-650.

North, M.P., J.T. Kane, V.R. Kane, G.P. Asner, W. Berigan, D.J. Churchill, S. Conway, R.J. Gutierrez, S. Jeronimo, J. Keane, A. Koltunov, T. Mark, M. Moskal, T. Munton, Z. Peery, C. Ramirez, R. Sollmann, A. White, and S. Whitmore. 2017. Cover of tall trees best predicts California spotted owl habitat. Forest Ecology and Management 405: 166–178.

O'Hara, K.L., L. Narayan, and K.G. Cahill. 2015. Twelve-year response of coast redwood to precommercial thinning treatments. Forest Science 61:780-789.

O'Hara, K.L., L. Narayan, and L.P. Leonard. 2020. Interactions between thinning and bear damage complicate restoration in coast redwood forests. iForest 13:1-8. https://doi.org/10.3832/ifor3135-012

O'Hara, K.L., L.E. Cox, S. Nikolaeva, J.J. Bauer, and R. Hedges. 2017. Regeneration dynamics of coast redwood, a sprouting conifer species: a review with implications for management and restoration. Forests 8:1-19. doi:10.3390/f8050144

Oregon Department of Fish and Wildlife. 2018. Status Review of the Marbled Murrelet (*Brachyramphus marmoratus*) in Oregon and evaluation of criteria to reclassify the species from threatened to endangered under the Oregon endangered species act. Report prepared for the Oregon Department of Fish and Wildlife Commission. Oregon Department of Fish and Wildlife, Salem, OR. 134 pp.

Oregon Forest Resource Institute (OFRI). 2007. Carbon in Oregon's managed forests. https://oregonforests.org/sites/default/files/2020-07/OFRI_CarbonSpecialReport_DIGITAL.pdf

Pacific Seabird Group. 2024. A revised protocol for surveying marbled murrelets in forests. Pacific Seabird Group Technical Publication Number 6. (https://pacificseabirdgroup.org/psg-publications/technical-publications/)

Parikh, R., A. Mathai, S. Parikh, G. Chandra Sekhar, and R. Thomas. 2008. Understanding and using sensitivity specificity and predictive values. Indian Journal of Ophthalmology 56: 45–50.

Park, J.S., and S.J. Oh. 2012. A new concave hull algorithm and concaveness measure for n-dimensional datasets. Journal of Information Science and Engineering 29; 379–392.

Paton, P.W.C. 1994. The effect of edge on avian nesting success: how strong is the evidence? Conservation Biology 8:17-26.

Peery, M.Z., S.R. Beissinger, S.H. Newman, E.B. Burkett, and T.D. Williams. 2004. Applying the declining population paradigm: diagnosing causes of poor reproduction in the Marbled Murrelet. Conservation Biology 18: 1088-1098.

Petr, M., G. Vacchiano, D. Thom, P. Mairota, M. Kautz, L.M.S. Goncalves, R. Yousefpour, S. Kaloudis, and C.P.O. Reyer. 2019. Inconsistent recognition of uncertainty in studies of climate change impacts on forests. Environmental Research Letters. https://doi.org/10.1088/1748-9326/ab4670

Phillips, S.J. 2017. A Brief Tutorial on Maxent. Available from url: http://biodiversityinformatics.amnh.org/open_source/maxent/. Accessed on 07/11/2019.

Phillips, S.J., M. Dudík, and R.E. Schapire. 2004. A maximum entropy approach to species distribution modeling. Page 83 of: Proceedings of the twenty-first international conference on Machine learning. ACM.

PhysOrg. 2023. Redwoods and climate change: vulnerability, resilience, and hopeful potential in world's tallest trees. https://phys.org/news/2023-01-redwoods-climate-vulnerability-resilience-potential.html

Piatt, J.F., J.K. Parrish, H.M. Renner, S.K. Schoen, T.T. Jones, M.L. Arimitsu, K.J. Kuletz, B. Bodenstein, M. Garcia-Reyes, R.S. Duerr, R.M. Corcoran, R.S.A. Kaler, and others. 2020. Extreme mortality and reproductive failure of common murres resulting from the northeast Pacific marine heatwave of 2014-2016. PLOS ONE. https://doi.org/10.1371/journal.pone.0226087.

Plissner, J. H, B.A. Cooper, R.H. Day, P.M. Sanzenbacher, A.E. Burger, and M.C. Raphael. 2015. A review of marbled murrelet research related to nesting habitat use and nest success: final report. Report to Oregon Department of Forestry, Salem, OR, USA.

Popescu, S.C., and R.H. Wynne. 2004. Seeing the trees in the forest: Using lidar and multispectral data fusion with local filtering and variable window size for estimating tree height. Photogrammetric Engineering and Remote Sensing. 70: 589–604.

PRISM Climate Group. 2023. Oregon State University. URL: http://prism.oregonstate.edu

Ralph, C.J., S.K. Nelson, M.M. Shaughnessy, S.L. Miller, and T.E. Hamer. 1994. Methods for surveying marbled murrelets in forests: a protocol for land management and research. Pacific Seabird Group.

Raphael, M.G., A.J. Shirk, G.A. Falxa, D. Lynch, S.K. Nelson, S.F. Pearson, C. Strong, and R.D. Young. 2016b. Factors influencing status and trend of Marbled Murrelet populations: an integrated perspective. pp. 95-124 In: Falxa, G.A. and M.G. Raphael, technical editors. 2016. Northwest Forest Plan—The first 20 years (1994-2013): status and trend of marbled murrelet populations and nesting habitat. General Technical Report PNW-GTR-933. Pacific Northwest Research Station, U.S. Forest Service, Portland, Oregon.

Raphael, M.G., D. Evans Mack, J.M. Marzluff, and J.M. Luginbuhl. 2002. Effects of forest fragmentation on populations of the marbled murrelet. Studies in Avian Biology, No. 25:221-235.

Raphael, M.G., G.A. Falxa, D. Lynch, S.K. Nelson, S.F. Pearson, A.J. Shirk, and R.D. Young. 2016a. Status and trend of nesting habitat for the marbled murrelet under the Northwest Forest Plan. pp. 37-94 In: Falxa, G.A. and M.G. Raphael, technical editors. 2016. Northwest Forest Plan— The first 20 years (1994-2013): status and trend of marbled murrelet populations and nesting habitat. General Technical Report PNW-GTR-933. Pacific Northwest Research Station, U.S. Forest Service, Portland, Oregon.

Raphael, M.G., G.A. Falxa, K.M. Dugger, B.M. Galleher, D. Lynch, S.L. Miller, S.K. Nelson, and R.D. Young. 2011. Status and trend of nesting habitat for the marbled murrelet. Pacific Northwest Research Station General Technical Report PNW-GTR-848.

Roberts, S.D., and C.A. Harrington. 2008. Individual tree growth response to variable-density thinning in coastal Pacific Northwest forests. Forest Ecology and Management 255:2771-2781.

Robertson, B.L., J.A. Brown, T.L. McDonald, and P. Jaksons. 2013. BAS: Balanced acceptance sampling of natural resources. Biometrics 69: 776–784.

Ruff, Z.J., D.B. Lesmeister, L.S. Duchac, B.K. Padmaraju, and C.M. Sullivan. 2020. Automated identification of avian vocalizations with deep convolutional neural networks. Remote Sensing in Ecology and Conservation. 6:79-92.

Sahoo, K., R. Bergman, and T. Runge. 2021. Life-cycle assessment of redwood lumber products in the US. International Journal of Life Cycle Assessment 26:1702-1720.

Save the Redwoods League. 2013. Save the Redwoods League climate change study finds recent unprecedented growth surge in redwoods plus other key findings. Press release, August 14, 2013. https://www.savetheredwoods.org/research/save-the-redwoods-league-climate-change-study-finds-recent-unprecedented-growth-surge-in-redwoods-plus-other-key-findings/

Sawyer, J.O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento, CA. 471 pp. (online manual https://vegetation.cnps.org/)

Sillett, S.C., and R. Van Pelt. 2000. A redwood tree whose crown is a forest canopy. Northwest Science 74:34-43.

Sillett, S.C., M.E. Antoine, A.L. Carroll, M.E. Graham, A.R.O. Chin, and R. Van Pelt. 2022. Rangewide climatic sensitivities and non-timber values of tall *Sequoia sempervirens* forests. Forest Ecology and Management 526:1-36.

Sillett, S.C., M.E. Antoine, J. Campbell-Spickler, A.L. Carroll, E.J. Coonen, R.D. Kramer, and K.H. Scarla. 2018. Manipulating tree crown structure to promote old-growth characteristics in second-growth redwood forest canopies. Forest Ecology and Management 417: 77–89.

Sillett, S.C., R. Van Pelt, A.L. Carroll, R.D. Kramer, A.R. Ambrose, and D. Trask. 2015. How do tree structure and old age affect growth potential of California redwoods? Ecological Monographs, 85(2):181–212.

Sillett, S.C., R.D. Kramer, B. Fuentes, A.L. Carroll, M.E. Antoine. 2025. Contributions of exceptional trees to improved management of coast redwood forests in California. Forest Ecology and Management. https://doi.org/10.1016/j.foreco.2025.122943

Smeeton, N.C. 1985. Early history of the kappa statistic. Biometrics 41: 795.

Soland, K.R., L.P. Kerhoulas, N.J. Kerhoulas, and J.R. Teraoka. 2021. Second-growth redwood forest responses to restoration treatments. Forest Ecology and Management. 496:119370 https://doi.org/10.1016/j.foreco.2021.119370.

Sonne, E. 2006. Greenhouse gas emissions from forestry operations: a life cycle assessment. Journal of Environmental Quality 35:1439-1450.

Stephens, S.L, and D.L. Fry. 2005. Fire history in coast redwood stands in the Northeastern Santa Cruz Mountains, California. Fire Ecology 1:2-19.

Teraoka, J.R., P.J. van Mantgem, and C.R. Keyes. 2017. Low thinning and crown thinning of two severities as restoration tools at Redwood National Park. pp. 259-266 In: Proceedings of the Coast Redwood Science Symposium—2016. General Technical Report PSW-GTR-258. Pacific Southwest Research Station, U.S. Forest Service, Albany, California.

Tiede, D., G. Hochleitner, and T. Blaschke. 2005. A full GIS based workflow for tree identification and delineation using laser scanning. The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences XXXV1: 9–14.

Turgeon, P.J., S.L. Van Wilgenburg, and K.L. Drake. 2017. Microphone variability and degradation: implications for monitoring programs employing autonomous recording units. Avian Conservation and Ecology. 12(1) https://doi.org/10.5751/ace-00958-120109.

U.S. Department of Agriculture (USDA) Forest Service. 1998. Ecological subregions of California: section and subsection descriptions. (online manual https://web.archive.org/web/20080304224853/http://www.fs.fed.us/r5/projects/ecoregions/).

U.S. Fish and Wildlife Service (USFWS). 1992. Endangered and threatened wildlife and plants; Determination of threatened status for the Washington, Oregon, and California population of the marbled murrelet; final rule. Federal Register 57: 45328-45337. October 1, 1992.

USDA and United States Department of Interior (USDI). 1994. Standards and Guidelines for management of habitat for late-successional and old-growth forest related species within the range of the Northern spotted owl: Attachment A to the Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents within the Range of the Northern spotted owl. https://www.fs.usda.gov/r6/reo/library/downloads/documents/NWFP-S&G-1994.pdf

USFWS. 1996. Endangered and threatened wildlife and plants; final designation of critical habitat for the marbled murrelet. 61 FR 26256-26320.

USFWS. 1997. Recovery plan for the Marbled Murrelet (*Brachyramphus marmoratus*) in Washington, Oregon, and California. USFWS Region 1, Portland, Oregon, USA.

USFWS. 2015. Revised in-air disturbance analysis for marbled murrelets. Unpublished agency document prepared by E. Teachout. U.S. Fish and Wildlife Service, Washington Fish and Wildlife Office, Lacy, Washington. 17 pp.

USFWS. 2016. Endangered and Threatened Wildlife and Plants; determination of critical habitat for the marbled murrelet. Federal Register Vol. 81, No. 150, 51248-51370. August 4, 2016.

USFWS. 2019a. Marbled murrelet (*Brachyramphus marmoratus*) 5-year review. Lacey, Wash.

USFWS. 2019b. Final Environmental Impact Statement for Green Diamond Resource Company Forest Habitat Conservation Plan. https://ecos.fws.gov/docs/plan_documents/neis/neis_3596.pdf

USFWS. 2020. Estimating the effects of auditory and visual disturbance to northern spotted owls and marbled murrelets in northwestern California. Unpublished agency document. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, California. October 1, 2020. 47 pp.

USFWS. 2023. U.S. Fish and Wildlife Service Mitigation Policy. Appendix 1, 501 FW2, May 2023. 26 pp.

USFWS. 2024. Species Biological Report for Marbled Murrelet CA, OR, WA DPS. https://ecos.fws.gov/docs/recovery_plan/MAMU%20SBR_Final%20WFWO_20240723.pdf

USFWS and National Marine Fisheries Service (NMFS). 2016. Habitat conservation planning and incidental take permit processing handbook. U.S. Department of Interior. U.S. Fish and Wildlife Service And U.S. Department of Commerce National Oceanic and Atmospheric Administration National Marine Fisheries Service, Washington D.C.

Valente, J.J., S.K. Nelson, J.W. Rivers, D.D. Roby, and M.G. Betts. 2021. Experimental evidence that social information affects habitat selection in marbled murrelets. Ornithology 138: 1–13.

van Rooyen, J.C., J.M. Malt, and D.B. Lank. 2011. Relating microclimate to epiphyte availability: edge effects on nesting habitat availability for the Marbled Murrelet. Northwest Science 85: 549-561.

Warton, D., and G. Aarts. 2013. Advancing our thinking in presence-only and used-available analysis. The Journal of animal ecology. 82. 10.1111/1365-2656.12071.

WDNR (Washington Department of Natural Resources). 2019. Appendix D. Occupied Sites Focus Paper. In: Longterm conservation strategy for the marbled murrelet. Final Environmental Impact Statement. Washington Department of Natural Resources, Olympia, WA.

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

World Resource Institute. 2021. Forests absorb twice as much carbon as they emit each year. https://www.wri.org/insights/forests-absorb-twice-much-carbon-they-emit-each-year#main-content

Yackulic, C.B., R. Chandler, E.F. Zipkin, J.A. Royle, J.D. Nichols, E.H. Campbell Grant, and S. Veran. 2013. Presence-only modelling using MAXENT: When can we trust the inferences? Methods in Ecology and Evolution 4: 23-243.

Young, N., L. Carter, and P. Evangelista. 2011. A MaxEnt Model v3.3.3e Tutorial (ArcGIS v10), Natural Resource Ecology Laboratory at Colorado State University.

MARBLED MURRELET HABITAT CONSERVATION PLAN

MAP ATLAS

Green Diamond Resource Company

Del Norte and Humboldt Counties, California

HOW TO USE THIS ATLAS

This Map Atlas is a companion volume to the Marbled Murrelet Habitat Conservation Plan (MMHCP). Maps are compiled here rather than embedded in the narrative sections because of their size and page format. Each map retains the number assigned to it in the MMHCP section that cites it, so Map 4-3-1 is the first map in the critical habitat series of Section 4 regardless of where it falls in this atlas. Maps are ordered by citing section. Where several maps share a title, they present the same data for different portions of the ownership; the map number distinguishes them.

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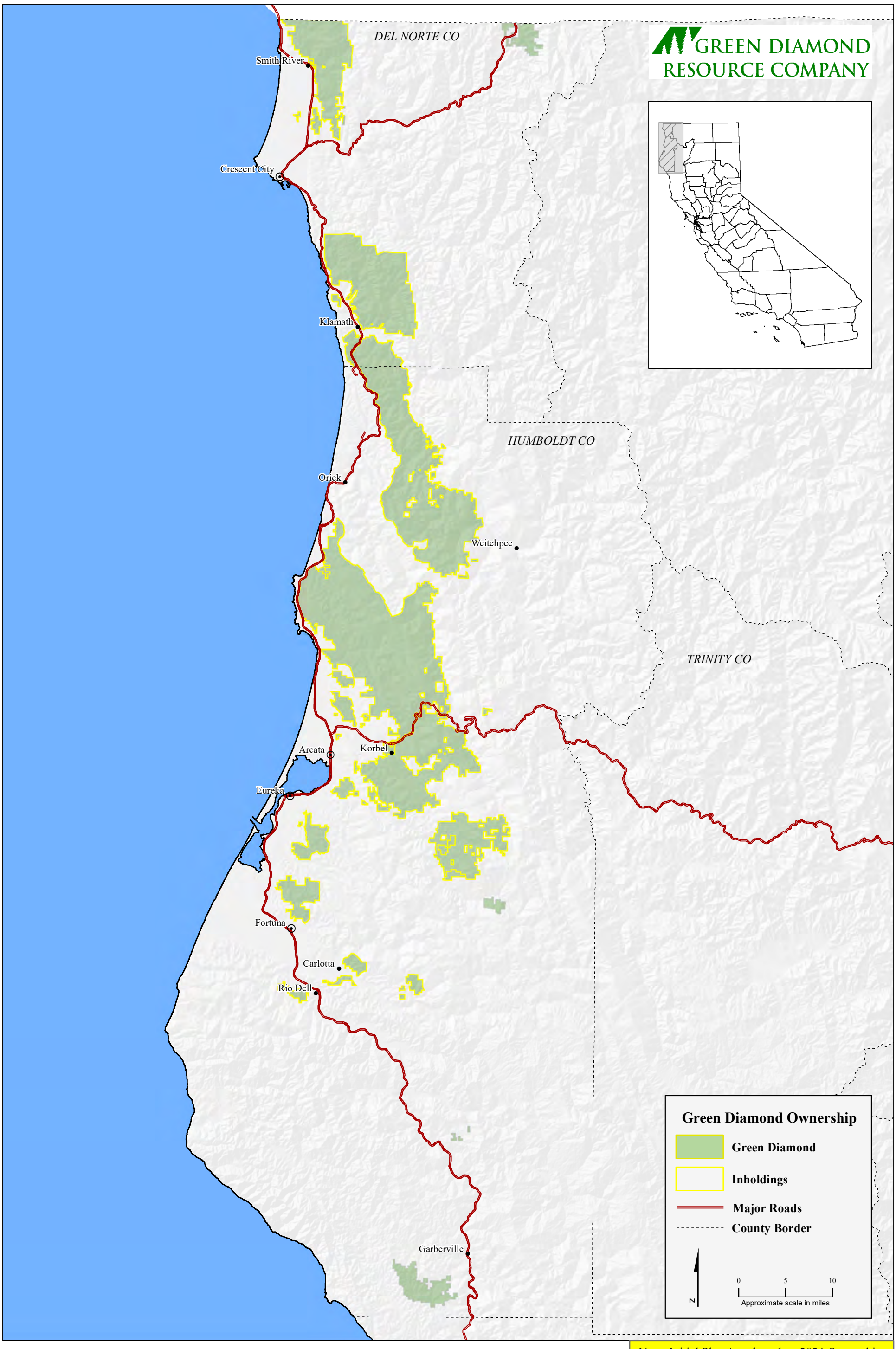
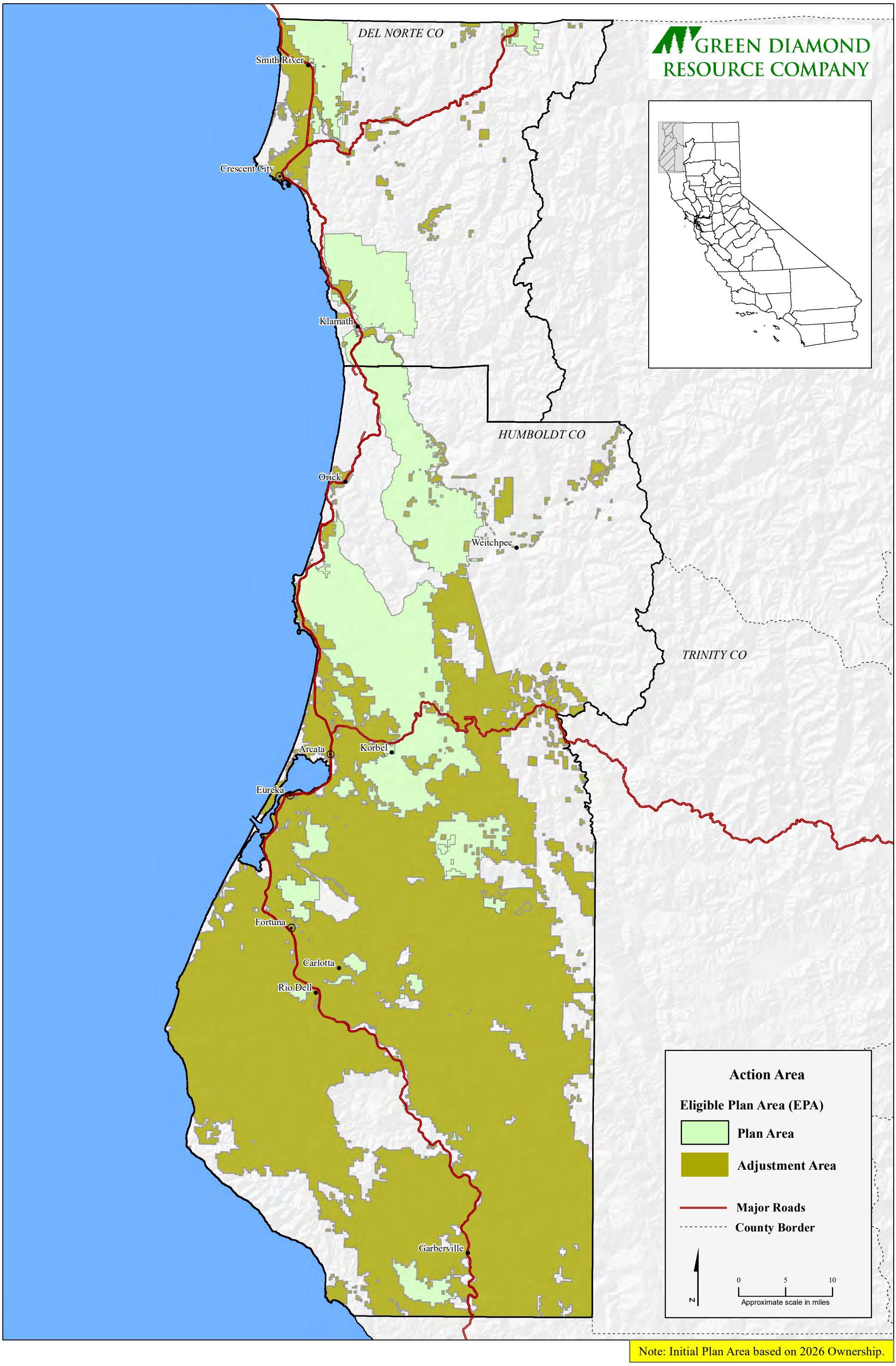
Map 6-1-1. Marbled Murrelet Reserves

Map 6-1-2. Marbled Murrelet Reserves

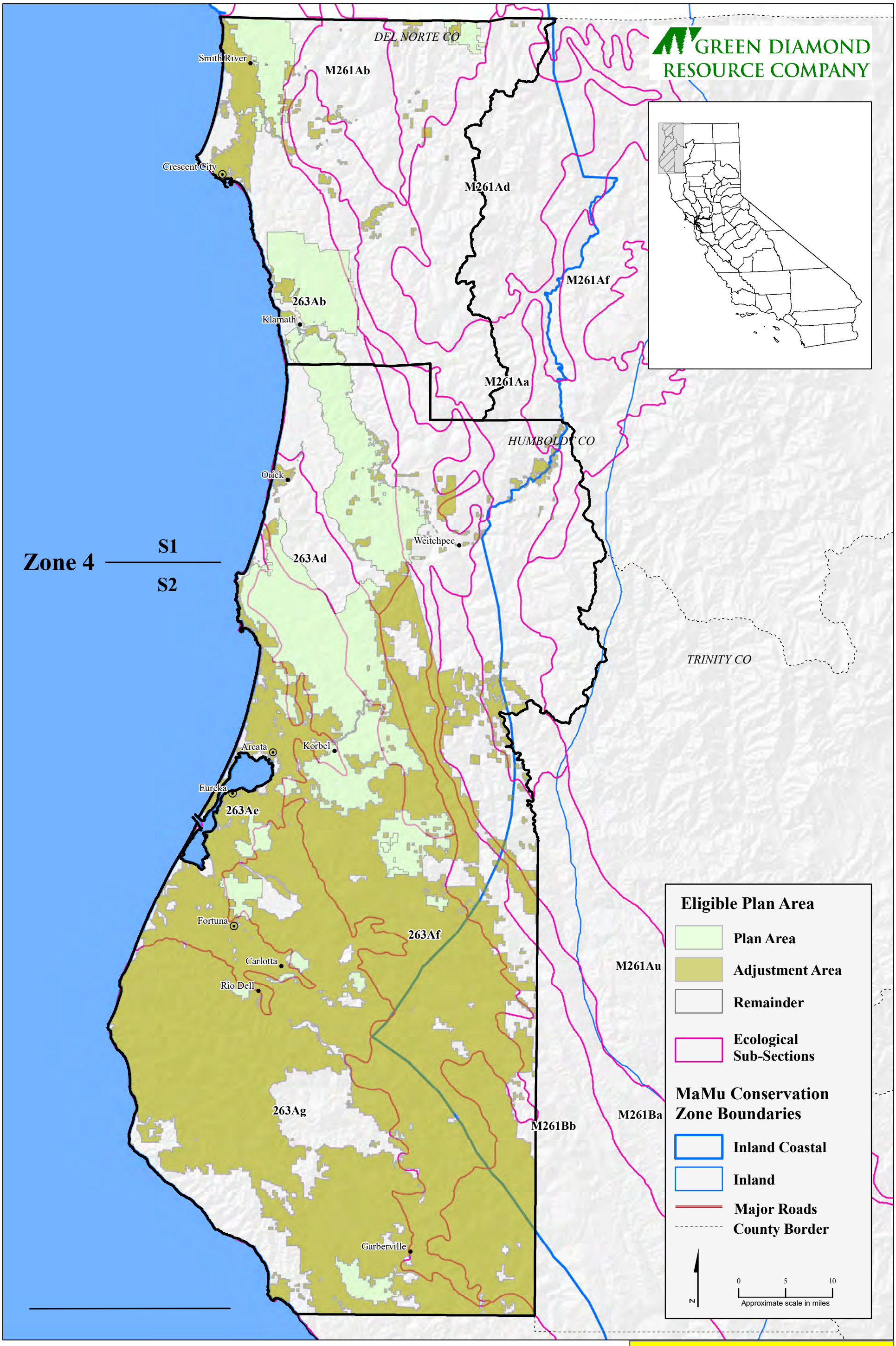
Map 6-1-3. Marbled Murrelet Reserves



Map 1-1. Green Diamond Ownership in Eligible Plan Area of California

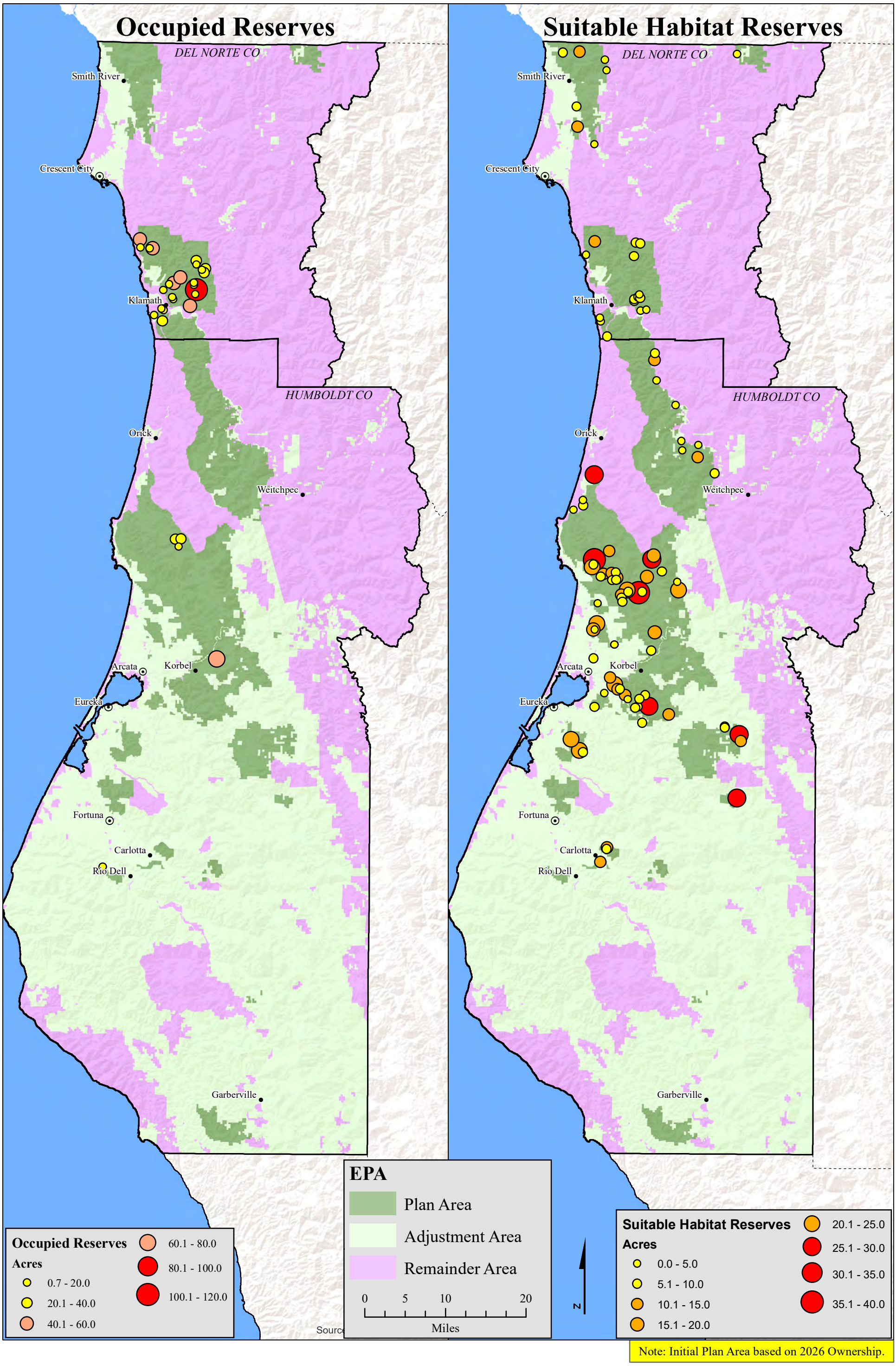


Map 1-2. Eligible Plan Area in California



Map 4-1. Green Diamond Ownership and Marbled Murrelet (MaMu) Conservation Boundaries in Eligible Plan Area of California 1

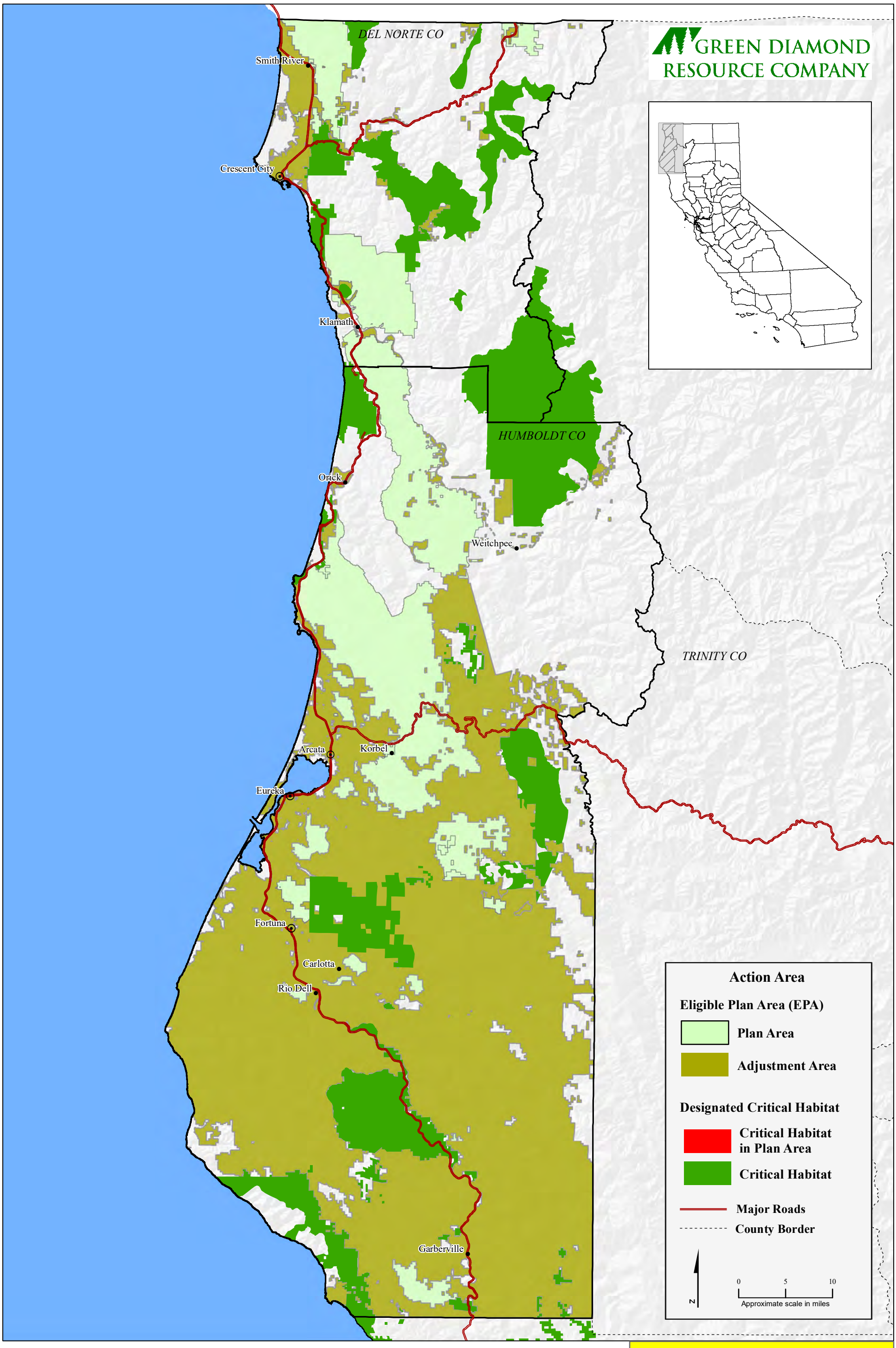
July 2026



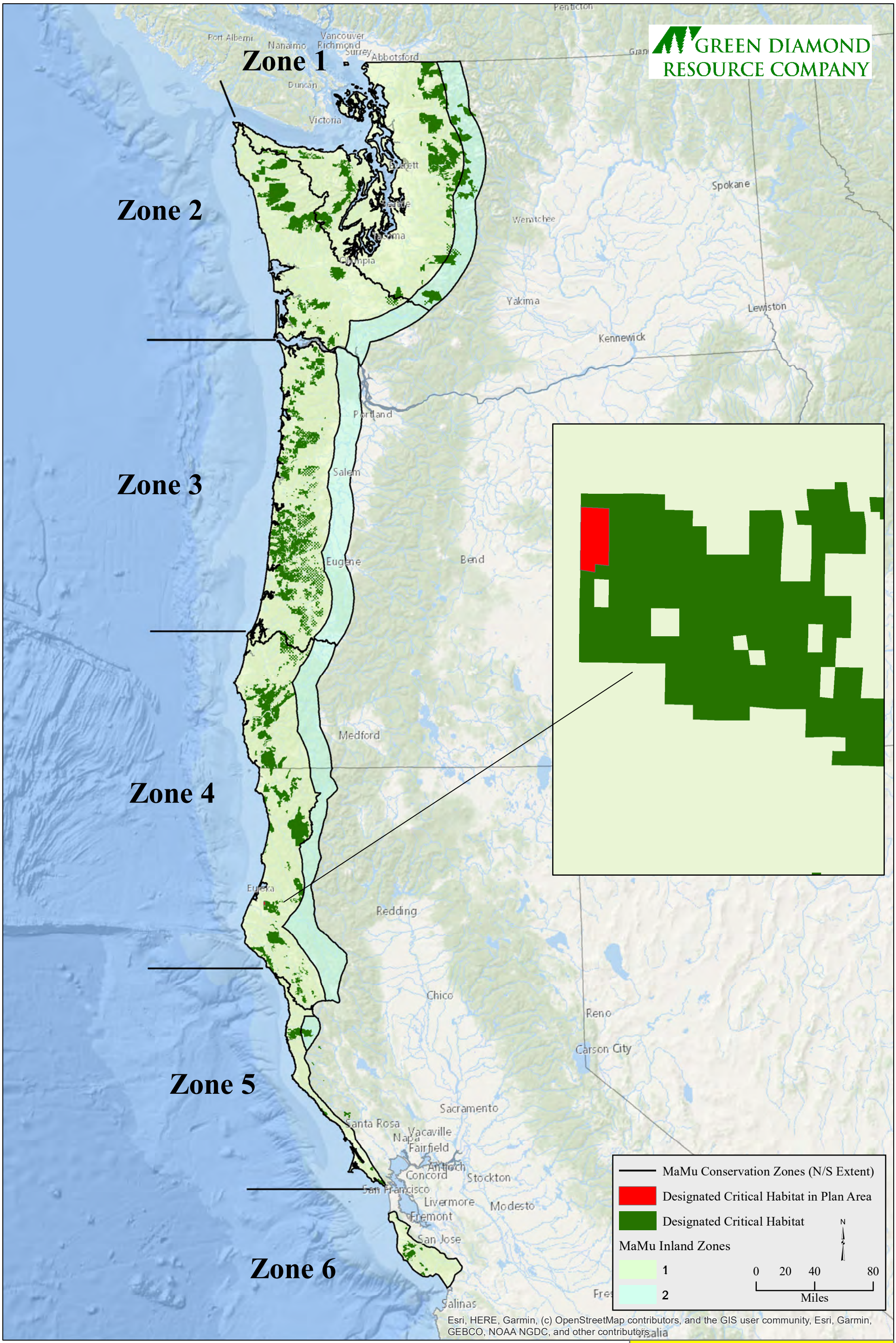
Map 4-2. Marbled Murrelet Habitat on the Plan

Area 1

July 2026

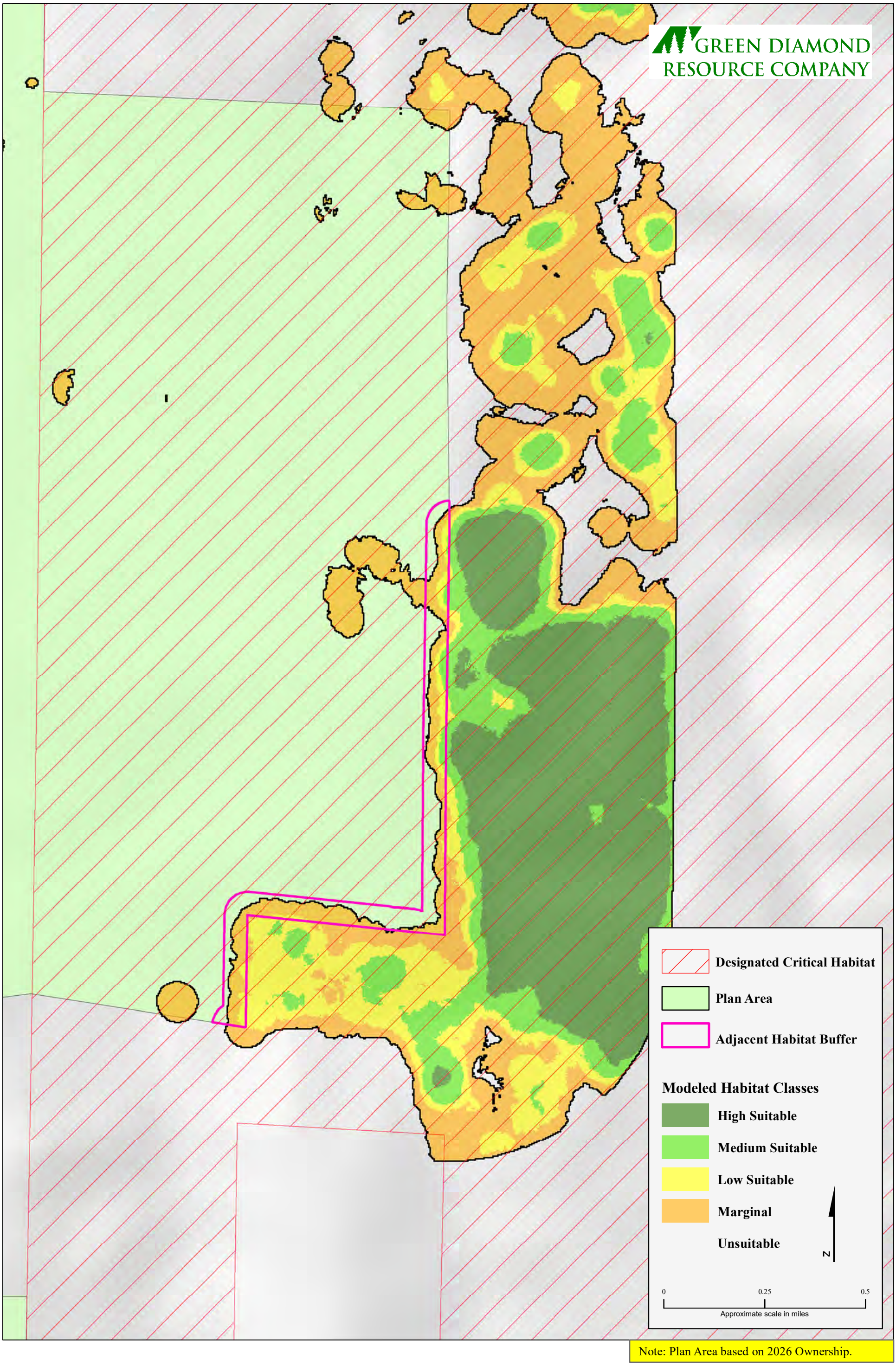


Map 4-3-1. Designated Critical Habitat in the Plan Area



Note: Plan Area based on 2026 Ownership.

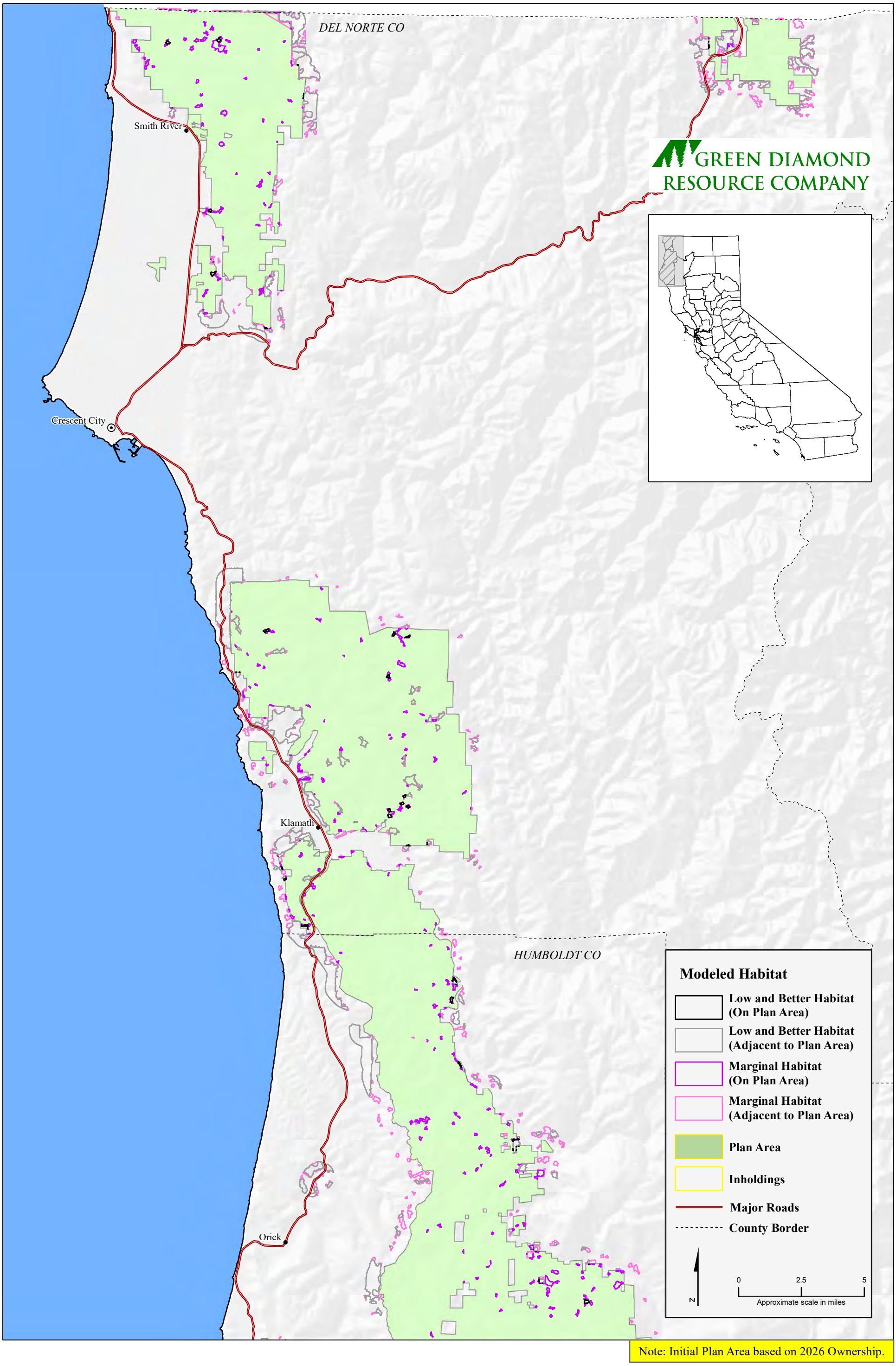
Map 4-3-2. Plan Area Critical Habitat Relative to Conservation Zone and Range-Wide Critical Habitat



Map 4-3-3. Habitat Suitability of Designated Critical Habitat

1

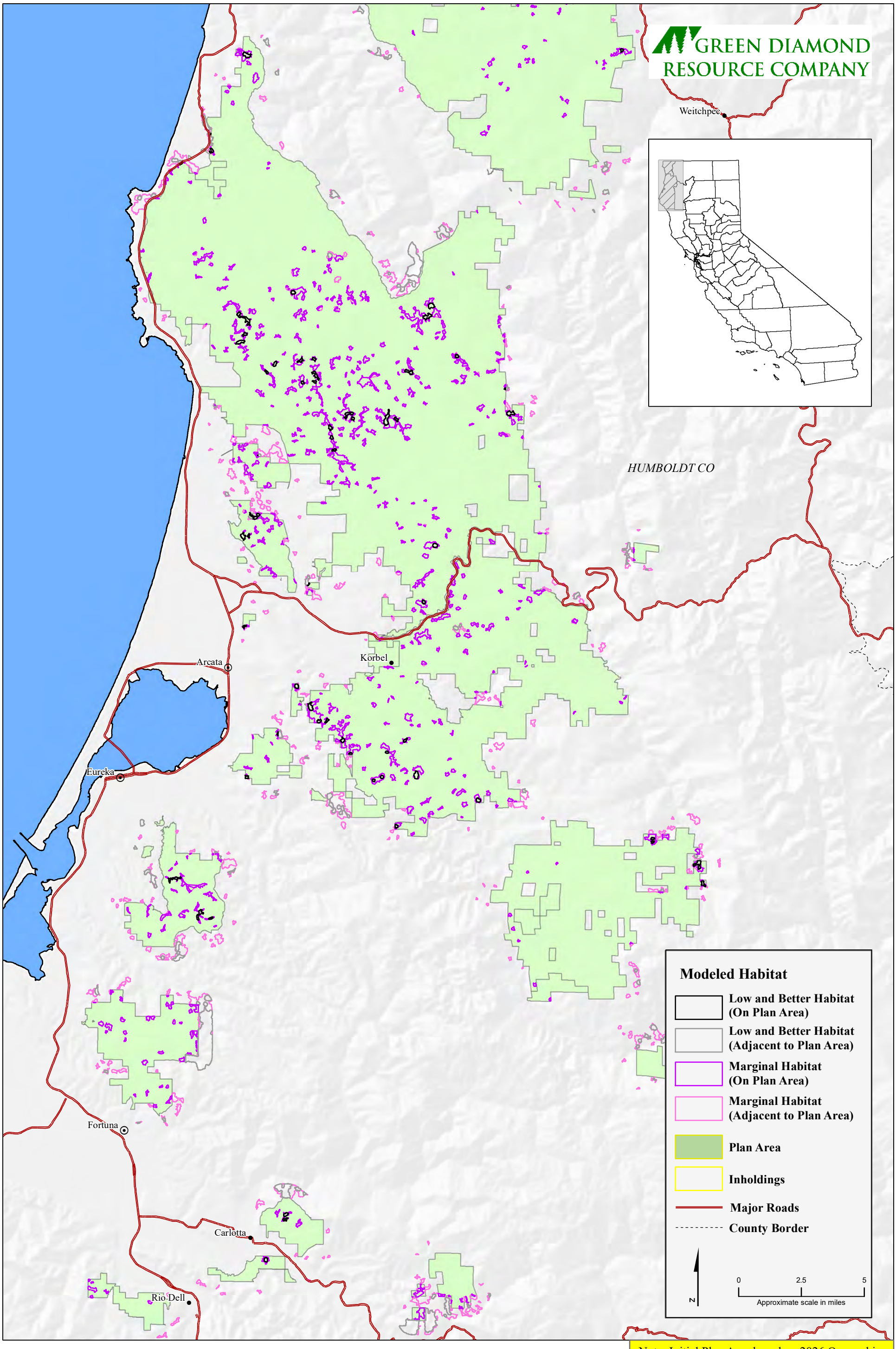
July 2026



Map 5-1-1. Modeled Habitat

1

July 2026



Map 5-1-2. Modeled Habitat

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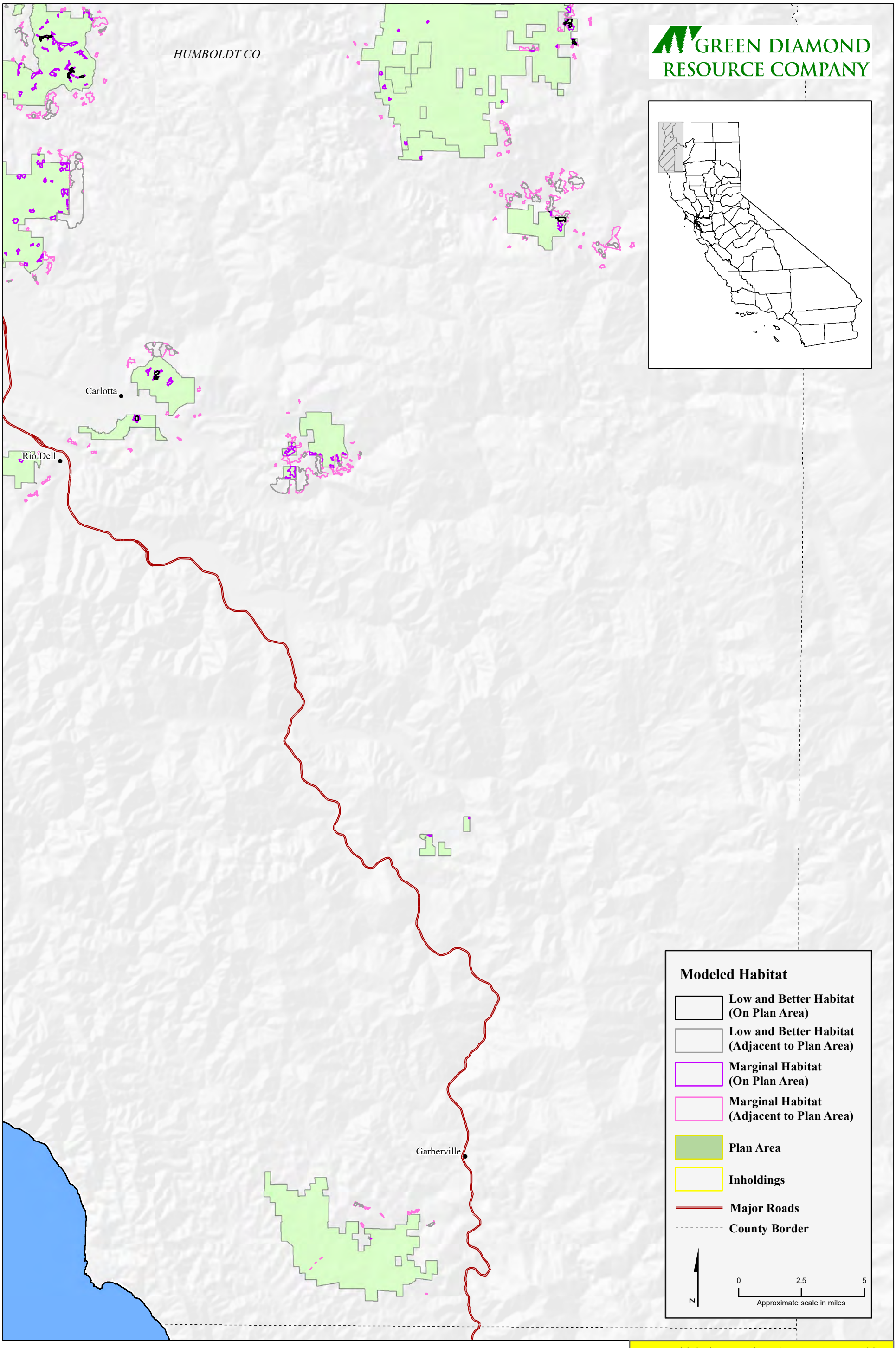
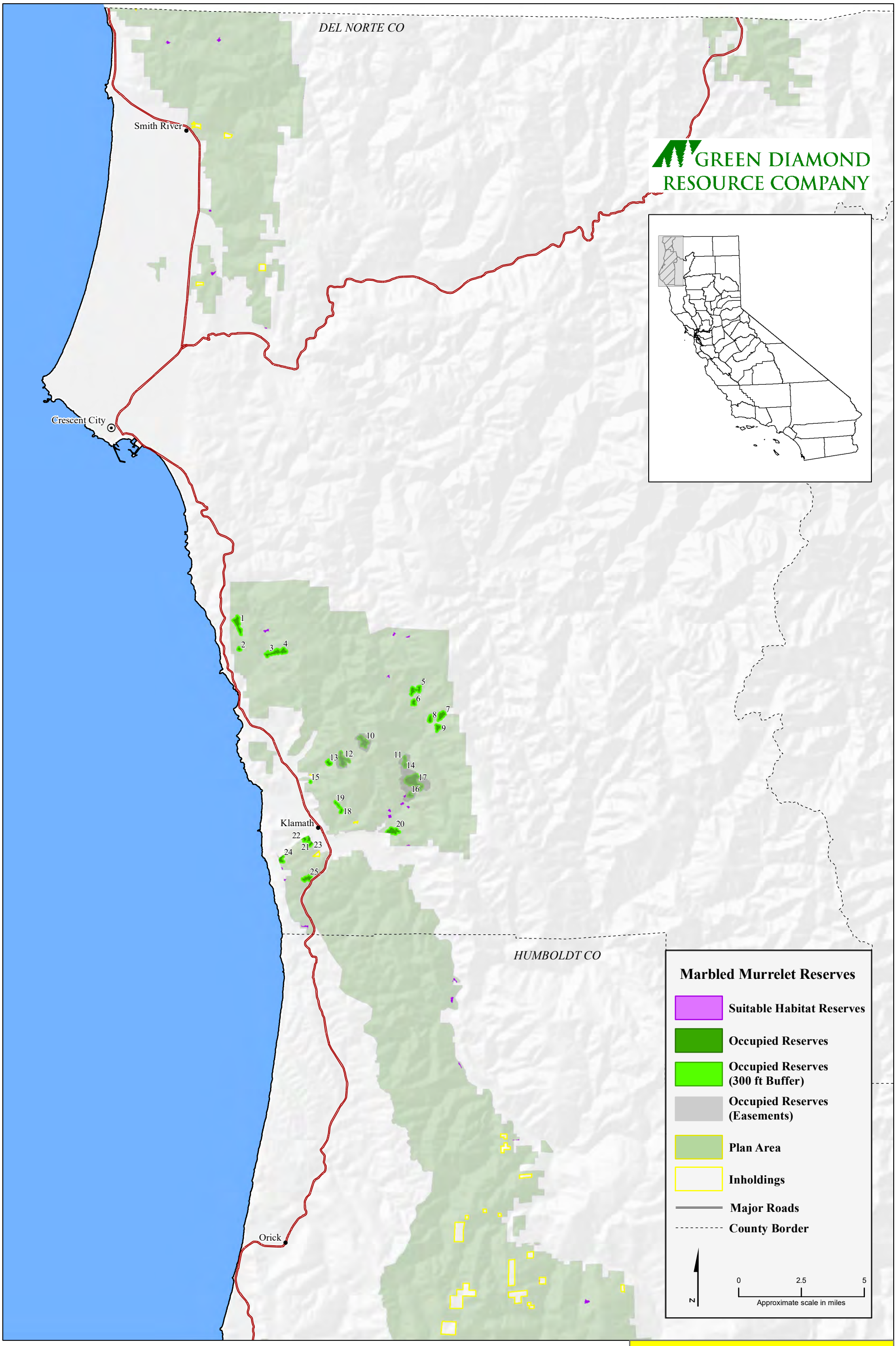


Map 5-1-3. Modeled Habitat

1

July 2026



Map 6-1-1. Marbled Murrelet Reserves

1

July 2026

GREEN DIAMOND RESOURCE COMPANY

Weitchpec

27 26

28

HUMBOLDT CO

29

Korbel

Arcata

Eureka

Fortuna

Carlotta

30

Rio Dell

Marbled Murrelet Reserves

- Suitable Habitat Reserves
- Occupied Reserves
- Occupied Reserves (300 ft Buffer)
- Occupied Reserves (Easements)
- Plan Area
- Inholdings
- Major Roads
- County Border

N

0 2.5 5

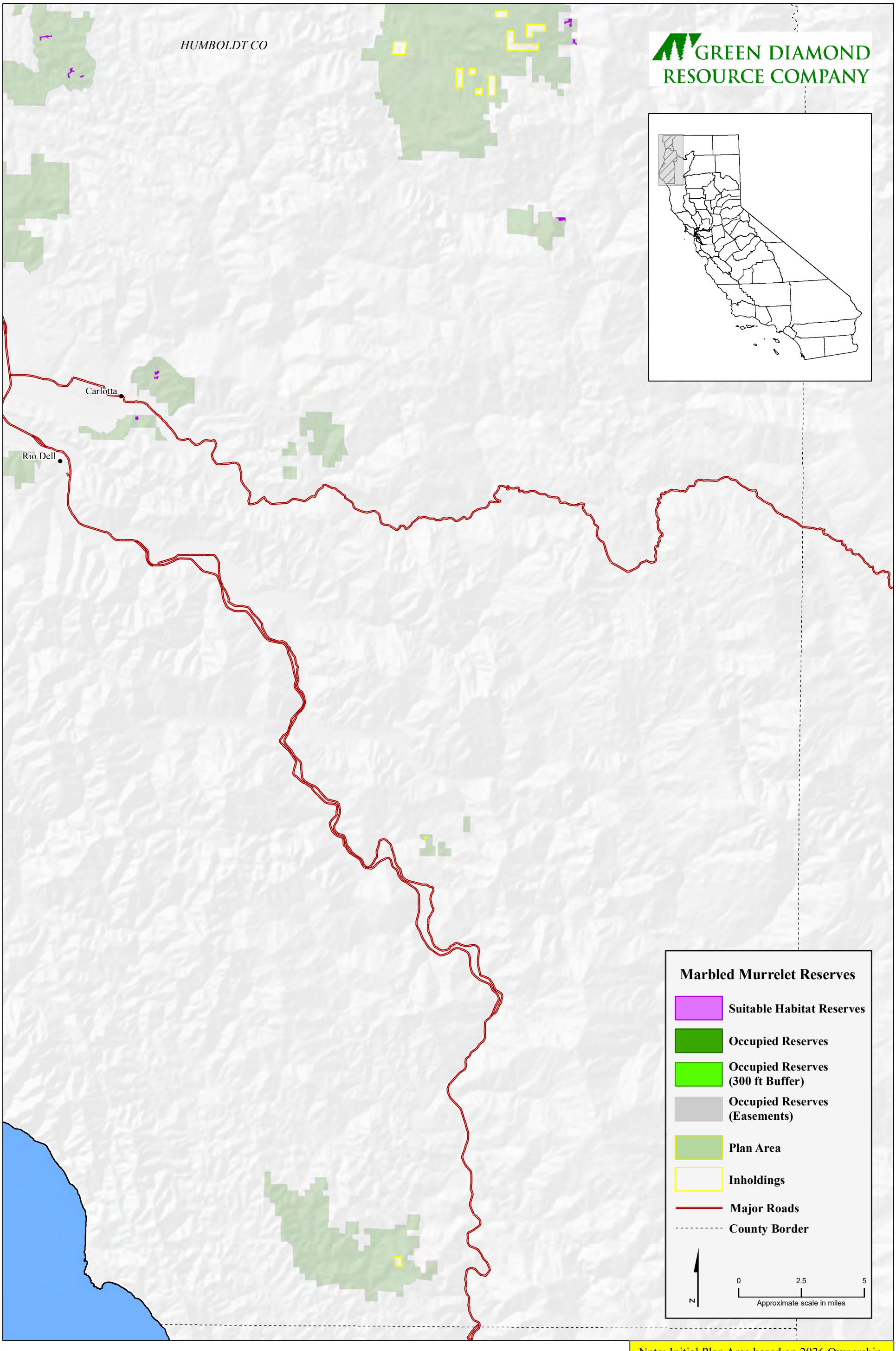
Approximate scale in miles

Note: Initial Plan Area based on 2026 Ownership.

Map 6-1-2. Marbled Murrelet Reserves

1

July 2026



Map 6-1-3. Marbled Murrelet Reserves

1

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