

DRAFT for Public and Peer Review

**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
September 2017

Foreword

The Oregon Department of Fish and Wildlife is investigating the status of the Marbled Murrelet (*Brachyramphus marmoratus*) in Oregon in response to a petition from several conservation groups. The petition requests that the seabird be reclassified from threatened to endangered (uplisted) under the Oregon Endangered Species Act.

This draft report has been prepared by the Department for the Oregon Fish and Wildlife Commission, as a guide to the requirements of the Oregon Endangered Species Act, as a draft assessment of the biological status of the species, and as a document for public and peer review. Prior Marbled Murrelet status reviews by the Department (ODFW 1995, 2013) served as the starting point for this report, and new or updated information was incorporated wherever possible. A final report will be produced following completion of the public comment and peer review processes. The Department expects to present the final status review and reclassification analysis to the Commission in February 2018.

Cover Photo: Martin Raphael, U.S. Forest Service. Available from [Flickr](#).

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Executive Summary

The Marbled Murrelet (*Brachyramphus marmoratus*) is a small seabird that breeds along the Pacific Coast from Alaska to central California. Marbled Murrelets spend most of their lives at sea and forage on small fish and invertebrates in nearshore marine waters. Throughout much of their range, they fly inland for nesting in old-growth and late-successional forests. Marbled Murrelets do not construct nests, *per se*, but instead lay their single egg in a depression in moss or other substrate on a large or deformed tree branch, generally high in the live canopy.

Marbled Murrelets in Washington, Oregon, and California were listed as threatened under the federal Endangered Species Act in 1992, and were subsequently listed as state-threatened in Oregon under the Oregon Endangered Species Act in 1995. The species is listed as state-endangered in both Washington and California.

This status review and reclassification analysis is part of a rulemaking process undertaken by the Oregon Fish and Wildlife Commission. In response to a petition to uplist the Marbled Murrelet from threatened to endangered under the Oregon Endangered Species Act, the Commission must determine whether circumstances meet specific legal criteria to warrant reclassification. This review focuses on information relevant to the species' biological and legal status in Oregon, and will help to inform the Commission's decision. In order to uplist the Marbled Murrelet, the Commission must determine that the likelihood of survival of the species has diminished such that the species is in danger of extinction throughout any significant portion of its range within Oregon. It must also find that one or more of the following three factors exist: 1) that most populations of the species are undergoing imminent or active deterioration of their range or primary habitat; 2) that overutilization of the species or its habitat for commercial, recreational, scientific, or educational purposes is occurring or is likely to occur; or 3) that existing state or federal programs or regulations are inadequate to protect the species and its habitat.

In developing this review, we considered documented and verifiable scientific information and other best available data on the Marbled Murrelet. We reviewed many aspects of the species' biology, life history, population trends and demographics, marine and terrestrial habitat conditions, threats, and the adequacy of state and federal programs and regulations. Our evaluation resulted in the following considerations:

1. Marbled Murrelets have narrow habitat requirements and limited geographic distribution. Occupied landscapes tend to have large amounts of cohesive (unfragmented) older forest nesting habitat. Once nesting habitat is lost, high breeding site fidelity and energetic and flight constraints may further restrict distribution. Contemporary events that remove old-growth or mature forests may be difficult or impossible for the species to compensate for in the short-term since suitable habitat takes many decades or centuries to develop.
2. Changes in late-successional forests in Oregon since European settlement, due to timber harvest, fire, wind, and other factors, have significantly reduced Marbled Murrelet nesting habitat from historical levels. Loss and degradation of older forest nesting habitat were the primary reasons for initial state and federal listings. Since the 1990s, further habitat losses

have occurred, mainly due to timber harvest on nonfederal lands and wildfire on federal lands. Based on Northwest Forest Plan estimates, higher-suitability nesting habitat¹ declined in Oregon from approximately 853,400 acres in 1993 to 774,800 acres in 2012, a net loss of 78,600 acres (-9.2% change). Losses were greatest on nonfederal lands during this period; 59,200 acres (21.1%) of higher-suitability habitat were lost on nonfederal lands compared to 19,400 acres (3.4%) on federal lands.

3. Remaining nesting habitat persists mostly on public lands, including the Siuslaw and Rogue River-Siskiyou National Forests, forests owned by the Bureau of Land Management, and the state-owned and managed Tillamook, Clatsop, and Elliott State Forests. Older forest remnants are highly fragmented and contain a high proportion (>70-90%) of edge. Forest fragmentation and “edge effects” can increase predation rates and may result in other adverse effects to remaining patches (e.g., greater windthrow damage, microclimates less suitable to epiphyte² growth).
4. While natural disturbances have always shaped Oregon forests, climate change is expected to increase potential for habitat loss from catastrophic wildfires, insect infestations, disease outbreaks, and severe storms, and to exacerbate conditions unfavorable to murrelets in the marine environment.
5. There are no available surveys that provide a continuous assessment of Marbled Murrelet population trends in Oregon from 1995 to the present. A significant decline (>50%) on Oregon’s central coast was first detected in 1996 through at-sea surveys conducted from 1992-1999. However, surveys conducted for the Northwest Forest Plan’s Effectiveness Monitoring Program from 2000-2015 had an inconclusive trend for Oregon. It appears that the Oregon population may now be fluctuating around a new, lower baseline. Based on densities of Marbled Murrelets at sea, the Oregon population was estimated at 10,975 birds in 2015 and was likely somewhere between a wide range of 2,276 and 19,674 birds. Uncertainty in these estimates reflects considerable variability, due to the level of survey effort and the challenges of monitoring a highly mobile seabird that is sparsely and patchily distributed.
6. Marbled Murrelets have low fecundity. Low nest success has been reported wherever data are available across the federally-listed range, and in Oregon, nest success has been estimated at roughly 36%. Ratios of juveniles to adult birds counted at sea provide recent productivity indices of 0.0254-0.0598 for Oregon; while these juvenile:adult ratios have known limitations, they are an order of magnitude lower than what population models indicate is necessary to maintain stable populations (0.18-0.28).

¹ Higher-suitability habitat was defined and quantified by Raphael et al. (2016a). It represents those habitat classes (Classes 3 and 4) most likely to support Marbled Murrelet nesting, as determined by the authors’ maximum entropy (Maxent) models. Habitat change estimates considered both habitat losses and gains from 1993-2012.

² An epiphyte is an organism sustained entirely by nutrients and water received non-parasitically from within the canopy in which it resides (Moffett 2000). Moss is an example of a common Pacific Northwest epiphyte.

7. The Marbled Murrelet's life history strategy (e.g., long-lived, low annual reproductive potential, delayed reproductive maturity) requires high survivorship of young in order for breeding birds to successfully "replace" themselves over the course of their lifetimes to yield a stable or increasing population. Marbled Murrelet generation time has been estimated at about 10 years, and this life history strategy allows some flexibility for poor or no breeding success during adverse conditions, but only for relatively short periods of time. Adult or subadult mortality due to anthropogenic factors or catastrophic events, or cumulative or synergistic impacts that affect recruitment over long periods, could also lead to severe population declines or even extirpations. Based on predictions of demographic models by McShane et al. (2004), using what may be optimistic population parameters (e.g., survival = 83-92%, breeding propensity = 90% in most years, nest success = 23-46%), extinction probability is high in Oregon (over 80% by 2060 for Conservation Zone 4: Siskiyou Coast Range, over 80% by 2100 for Conservation Zone 3: Oregon Coast Range).
8. Predation, particularly by corvids (jays, crows, ravens), is a leading cause of Marbled Murrelet nest failure. Higher predator numbers and predation rates are generally associated with human activities and anthropogenic food sources. Predation pressure is expected to remain high or increase in the future and is of particular concern where parks, trails, or campgrounds overlap with murrelet habitat.
9. Marbled Murrelets require sufficient prey resources in the marine environment for survival and successful reproduction. Oceanic conditions influence the abundance, distribution, and timing of prey available to murrelets, and prey quality and availability in turn affect breeding propensity and success. A centennial shift in murrelet diet to lower (poorer quality) trophic levels has been documented in parts of the murrelet range. As with many other seabirds, low recruitment has also been linked, in part, to El Niño years and other warm water events.
10. A large oil spill remains a serious threat and could kill hundreds or thousands of Marbled Murrelets in Oregon. For example, the New Carissa oil spill in 1999 released over 70,000 gallons of fuel into the marine environment near Coos Bay, Oregon, killing an estimated 262 Marbled Murrelets.
11. Other emerging natural or anthropogenic threats to the species include, but are not limited to, energy development projects; harmful algal blooms that produce biotoxins, feather-fouling surfactants, or low-oxygen "dead zones" in the ocean; and contaminants in prey that can biomagnify through the food chain.
12. The threat posed by inadequate state and federal programs and regulations has decreased since state listing of the Marbled Murrelet in 1995. For example, implementation of the Northwest Forest Plan greatly reduced the rate of habitat loss due to timber harvest on federal lands. Nonetheless, existing state and federal programs and regulations have failed to prevent continued high rates of habitat loss on nonfederal lands in Oregon. Fisheries management is another example of state and federal programs and regulations that have been strengthened

since the listing of the Marbled Murrelet, with greater protections for its prey resources in Oregon.

Acknowledgments

Many organizations, agencies, and individuals contributed information and data for this review. We especially thank S. Kim Nelson of Oregon State University, Matt Gostin and Nick Palazzotto of the Oregon Department of Forestry, and Chelsea Waddell of the Bureau of Land Management for providing access to unpublished datasets. We also appreciate helpful insights and information from Robin Bown, Deanna Lynch, and Bridgette Tuerler, and permit data from Jennifer Miller, Colleen Henson, and Leslie Henry, all of the U.S. Fish and Wildlife Service.

Standard and Metric Equivalents

Standard Unit	Metric Unit
1 inch (in)	2.54 centimeters (cm) or 25.4 millimeters (mm)
1 foot (ft)	0.31 meters (m)
1 mile (mi)	1.61 kilometers (km)
1 acre (ac)	0.41 hectares (ha)
1 square mile (mi ²)	2.59 square kilometers (km ²)
1 ounce (oz)	28 grams (g)
Interval of 1 degree Fahrenheit (°F)	0.56 degrees Celsius (°C)

Key Acronyms

BLM	Bureau of Land Management
CCR	California Code of Regulations
CCS	California Current System
CFR	Code of Federal Regulations
CI	confidence intervals
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DBH	diameter at breast height
EEZ	Exclusive Economic Zone
ENSO	El Niño Southern Oscillation
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission

FPA	Oregon Forest Practices Act
FR	Federal Register
GIS	geographic information system
HCP	Habitat Conservation Plan
MMMA	Marbled Murrelet Management Area
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NWFP	Northwest Forest Plan
OAR	Oregon Administrative Rule
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
OESA	Oregon Endangered Species Act
ORS	Oregon Revised Statute
PCB	polychlorinated biphenyl
RIT	Recovery Implementation Team
RMP	Resource Management Plan
SD	standard deviation
USC	United States Code
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
WAC	Washington Administrative Code

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Chapter 1: Introduction

Why a Decision is Required

The Oregon Fish and Wildlife Commission (Commission) was petitioned by Cascadia Wildlands, the Center for Biological Diversity, Coast Range Forest Watch, Oregon Wild, the Audubon Society of Portland, and the Oregon Chapter of the Sierra Club in June 2016 to reclassify, or “uplist”, the Marbled Murrelet (*Brachyramphus marmoratus*) from threatened to endangered under the Oregon Endangered Species Act (OESA). In September 2016, the Commission found that the petition contained sufficient scientific information to justify proceeding with the requested action and accepted the petition for further evaluation. This decision initiated the rulemaking process, which includes: 1) consultation with affected agencies, tribes, local governments, other states, various organizations, and the public; 2) a review of the biological status of the Marbled Murrelet in Oregon to determine if circumstances meet legal criteria for reclassification; and 3) peer review of the Oregon Department of Fish and Wildlife’s (ODFW) biological status report. Pursuant to OAR 635-100-0111(1) and OAR 635-100-0110(8), the Commission is required to make a final determination on whether to uplist the Marbled Murrelet by June 21, 2018.

This chapter outlines the legal criteria for a reclassification determination and the potential effects of an uplisting decision. It also summarizes the species' current legal status.

Criteria for Reclassifying Species and Procedural Requirements of the Oregon Endangered Species Act

The OESA (ORS 496.171-496.192) and its implementing rules (OAR Chapter 635 Division 100) set out criteria and procedural requirements which must be met if the Commission is to reclassify a species from threatened to endangered. Specifically, the Commission must determine, based on documented and verifiable scientific information, that the likelihood of survival of the species has diminished such that the species is in danger of extinction throughout any significant portion of its range within Oregon (ORS 496.176(3), OAR 635-100-0105(1) and 635-100-0111(1)). In addition, the Commission must determine that at least one of the following factors exists: 1) that most populations are undergoing imminent or active deterioration of their range or primary habitat; 2) that overutilization of the species or its habitat for commercial, recreational, scientific, or educational purposes is occurring or is likely to occur; or 3) that existing state or federal programs or regulations are inadequate to protect the species or its habitat (ORS 496.176(3), OAR 635-100-0105(6)).

In making a reclassification determination, the Commission is required to consult with affected state and federal agencies, affected cities and counties, affected federally-recognized Indian tribes, the Oregon Natural Heritage Advisory Council, other states having a common interest in the species, and the interested public (ORS 496.176(4), OAR 635-100-0105(10)).

Effects of the Oregon Endangered Species Act

The most direct effect of listing a species as threatened or endangered under the OESA is through management decisions on state-owned or leased lands. Private lands are not directly affected by the OESA (ORS 496.192) except that no person is allowed to “take” a listed species anywhere in the state, and through the Oregon Forest Practices Act (FPA) (ORS 527.610-.992, OAR Chapter 629 Divisions 600-680), which requires special protection for both federal and state-listed species. Under the OESA, “take” is defined as “to kill or obtain possession or control of any wildlife” (ORS 496.004(16)).

State agencies work together to implement conservation measures adopted by the Oregon Fish and Wildlife Commission, and ODFW biologists act as scientific consultants to other land and water managers to advise whether a management action can affect survival or recovery of a listed species.

The OESA requires particular state agencies to develop plans for the management and protection of endangered species (ORS 496.182(8), OAR 635-100-0140(6)), and to comply with survival guidelines adopted by the Oregon Fish and Wildlife Commission for threatened species (ORS 496.182(2), OAR 635-100-0130). Survival guidelines are quantifiable and measurable guidelines necessary to ensure the survival of individual members of the species (OAR 635-100-0100(13)). They may include take avoidance and protecting resource sites such as nest sites or other sites critical to the survival of individual members of the species.

Implications of Uplisting

If the Marbled Murrelet were to be uplisted, the Oregon Fish and Wildlife Commission would be required to establish survival guidelines for the species at the time of reclassification and to work with state land-owning and managing agencies to determine if state lands can play a role in the conservation of the species³ (ORS 496.182(2)(a), (8)(a)). Survival guidelines would serve as interim protection until endangered species management plans were developed and approved by applicable state agencies (required within 18 months of uplisting) and reviewed and approved by the Commission (required within 24 months of uplisting) (ORS 496.182(8)(a)(C), (D)). Further details on the timelines and requirements for the adoption of endangered species management plans are provided by ORS 496.182.

Marbled Murrelet Legal Status

United States

The Washington, Oregon, and California distinct population segment of the Marbled Murrelet was listed as threatened under the federal Endangered Species Act (ESA) in September 1992 (57 FR 45328). The U.S. Fish and Wildlife Service (USFWS) determined that the species was threatened by loss and modification of older forest nesting habitat, mainly due to timber harvest, as well as

³ Survival guidelines are not already in place for the Marbled Murrelet since it was first state-listed in May 1995, and the survival guidelines requirement became effective in July 1995.

mortality from gillnet fishing operations in Washington State and the effects of oil spills (57 FR 45328).

The Marbled Murrelet was listed as threatened under the OESA in 1995 (OAR 635-100-0125), also owing mainly to habitat loss (ODFW 1995). The species is currently considered state-endangered in both Washington (WAC 232-12-014) and California (14 CCR 670.5). The Marbled Murrelet has no special status with the State of Alaska at this time but is protected under the federal Migratory Bird Treaty Act.

Canada

In British Columbia, the Marbled Murrelet is listed as threatened under Canada's Species at Risk Act (Schedule 1).

Summary

The Oregon Fish and Wildlife Commission must determine whether the Marbled Murrelet qualifies for reclassification from threatened to endangered under the OESA. In making this determination, the Commission must consider the strength of evidence in support of the reclassification criteria outlined in the Oregon Revised Statutes and administrative rules, and must consult with interested and affected parties. If the Commission decides to uplist the species, the most direct effects would be on state land-owning and managing agencies. State land-owning and managing agencies would be required to comply with survival guidelines that ensure protection of individual members of the species. These survival guidelines would serve as interim protection measures until endangered species management plans were developed by applicable state agencies and approved by the Commission.

Chapter 2: General Biology and Ecology

Description

The Marbled Murrelet is a small Pacific seabird (24-25 cm [9.4-9.8 in] long, wing length 122-149 mm [4.8-5.9 in], adult mass 188-269 g [6.6-9.5 oz]) (Nelson 1997). It spends the greater part of its life in the marine environment but flies inland for nesting, mainly in mature and old-growth coniferous trees. Adults are similar in both size and appearance (sexually monomorphic) but have distinct breeding and winter plumages (Nelson 1997). In breeding plumage, the Marbled Murrelet has sooty-brown upperparts with rusty-brown margins (Carter and Stein 1995). The underparts are light mottled brown, often with rufous-brown flecking. The head and front part of the body have white feathers edged with black. The flanks are almost entirely dark brown. This cryptic plumage is believed to be an adaptation to nesting in forests and avoiding predation (Binford et al. 1975, Piatt et al. 2007). In winter plumage, the bird is "dark above" and "light below" (i.e., dark brownish-gray on the back with white on the sides of the head, nape, and flanks) (Carter and Stein 1995). The underparts are white with some brown feathering on the side. Fledglings appear similar to adults in winter plumage, with subtle differences (Nelson 1997, Piatt et al. 2007). Newly-hatched chicks are covered with yellowish, speckled down (Binford et al. 1975).

Taxonomy

The Marbled Murrelet belongs to the Alcidae, or auk, family. The species was first described by Gmelin in 1789 as *Colymbus marmoratus*, but was reclassified by Brandt in 1837 as *Brachyramphus marmoratus* (American Ornithologists' Union 1998). Currently, there are three recognized species within the *Brachyramphus* genus: 1) the Marbled Murrelet, which breeds in western North America; 2) the Long-billed Murrelet (*B. perdix*), which breeds in eastern Asia; and 3) the Kittlitz's Murrelet (*B. brevirostris*), which breeds in Russia and Alaska (American Ornithologists' Union 1998).

For much of the 20th century, the Long-billed Murrelet was considered a subspecies of the Marbled Murrelet. However, molecular research in the mid-1990s provided evidence that Marbled Murrelets and Long-billed Murrelets are genetically distinct (Zink et al. 1995, Friesen et al. 1996a,b), leading to recognition as separate species in 1997 (American Ornithologists' Union 1997).

Geographic Range and Distribution

Marbled Murrelets breed along the Pacific Coast of North America from the Bering Sea (Attu Island in the Aleutian Archipelago) south to the Santa Cruz Mountains of California (Ralph et al. 1995a, Nelson 1997, Burger 2002, Piatt et al. 2007; see Fig. 1). The geographic center of the global population occurs in the northern part of southeast Alaska (Ralph et al. 1995a). Large numbers of murrelets are found in the Kodiak Archipelago, Prince William Sound, and the Alexander Archipelago, and to the south along the coast to British Columbia (Piatt et al. 2007). In both directions from there, populations become more disjunct, with only sparse or small numbers of murrelets at the extreme ends of the range (Ralph et al.

1995a, McShane et al. 2004). Past habitat removal has also created large gaps that fragment population distribution within the core of the range (Ralph et al. 1995a, USFWS 1997, RIT 2012); in Oregon, large habitat gaps occur in the northwest portion of the state as well as the coastal strip between Reedsport and the Siskiyou Mountains (RIT 2012; Fig. 2). Birds winter throughout the breeding range, but the southern extent of occurrence is in southern California or northern Baja California, Mexico (Nelson 1997, McShane et al. 2004, Piatt et al. 2007; Fig. 1).



Figure 1. Marbled Murrelet range in North America. Approximate breeding (dark gray) and at-sea (blue) distributions are indicated. Figure modeled after Piatt et al. (2007), Fig. 1, p. 5. Base map adapted from [BlankMap-North America-Subdivisions/Wikimedia Commons/NuclearVacuum/CC-BY-SA-3.0](#).

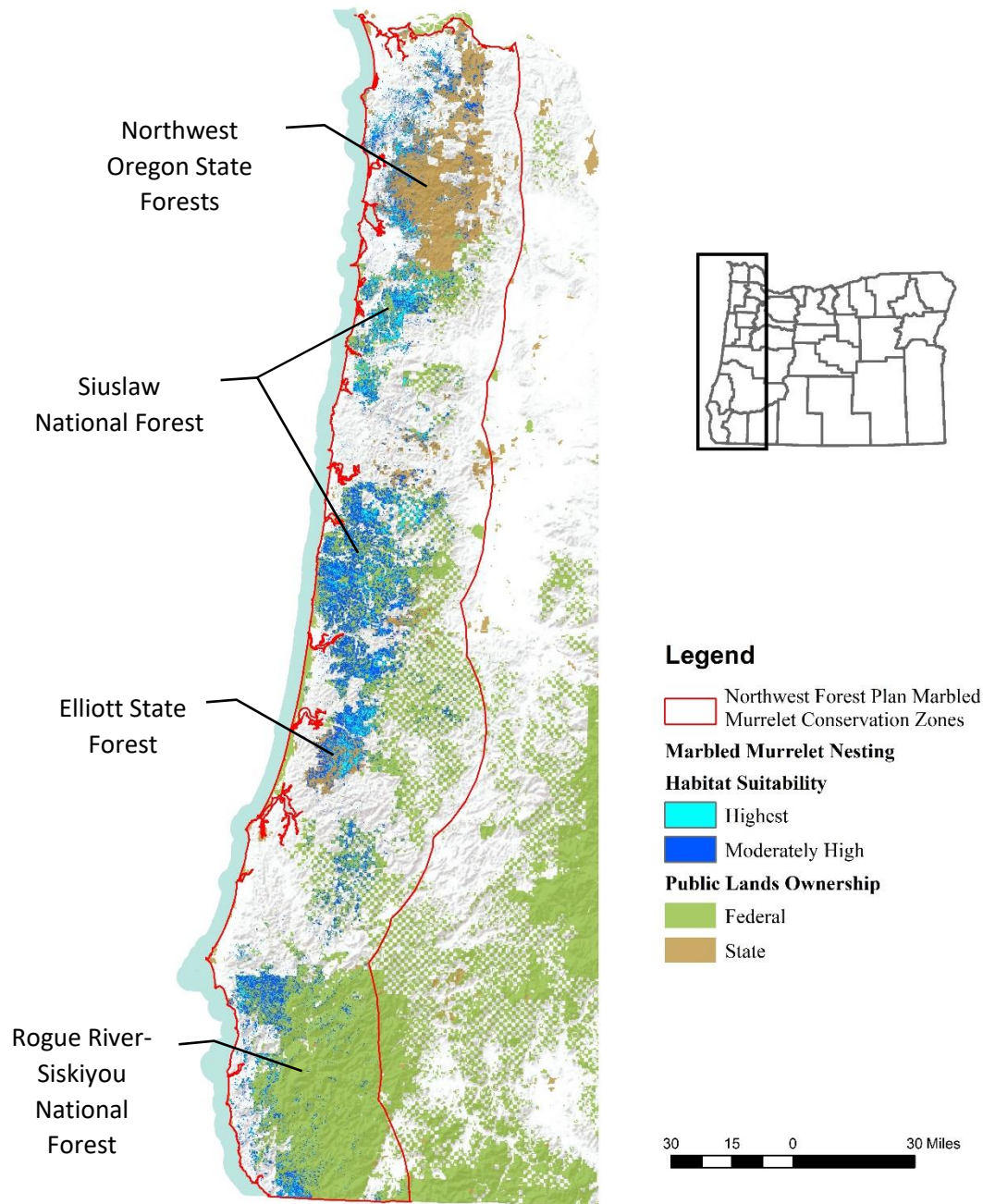


Figure 2. Federal (green shading) and state (brown shading) land ownership in western Oregon in relation to “higher-suitability” Marbled Murrelet nesting habitat in 2012 (habitat defined and modeled by Raphael et al. (2016a)). Moderately high suitability habitat (Class 3, deep blue) and highest suitability habitat (Class 4, sky blue) are shown and represent areas most likely to support Marbled Murrelet nesting. The approximate Marbled Murrelet breeding range is delineated in red (derived from the Northwest Forest Plan’s coastal Marbled Murrelet Conservation Zones). Habitat suitability and Conservation Zone boundary GIS data were provided by the [Northwest Forest Plan’s Interagency Regional Monitoring Program](#). Public land ownership and management boundaries were provided by the [U.S. Geological Survey’s Protected Areas Database](#). Base map provided by Esri, the U.S. Geological Survey, and the National Oceanic and Atmospheric Administration.

The Marbled Murrelet is a native species in Oregon (American Ornithologists' Union 1998, Marshall et al. 2003, Oregon Biodiversity Information Center 2016). It is found mainly in the Coast Range and Klamath physiographic provinces. Marbled Murrelets have been detected up to 129 km [80 mi] inland in Oregon (Nelson 1997), but most breeding behaviors indicative of occupancy/nesting have been recorded within 65 km [40 mi] of salt water (Evans Mack et al. 2003, p. 4; Fig. 3). During the breeding season in Oregon (April through September), murrelets are generally concentrated within 2 km [1.2 mi] of the shore when at sea (Strong et al. 1995, Falxa et al. 2016).

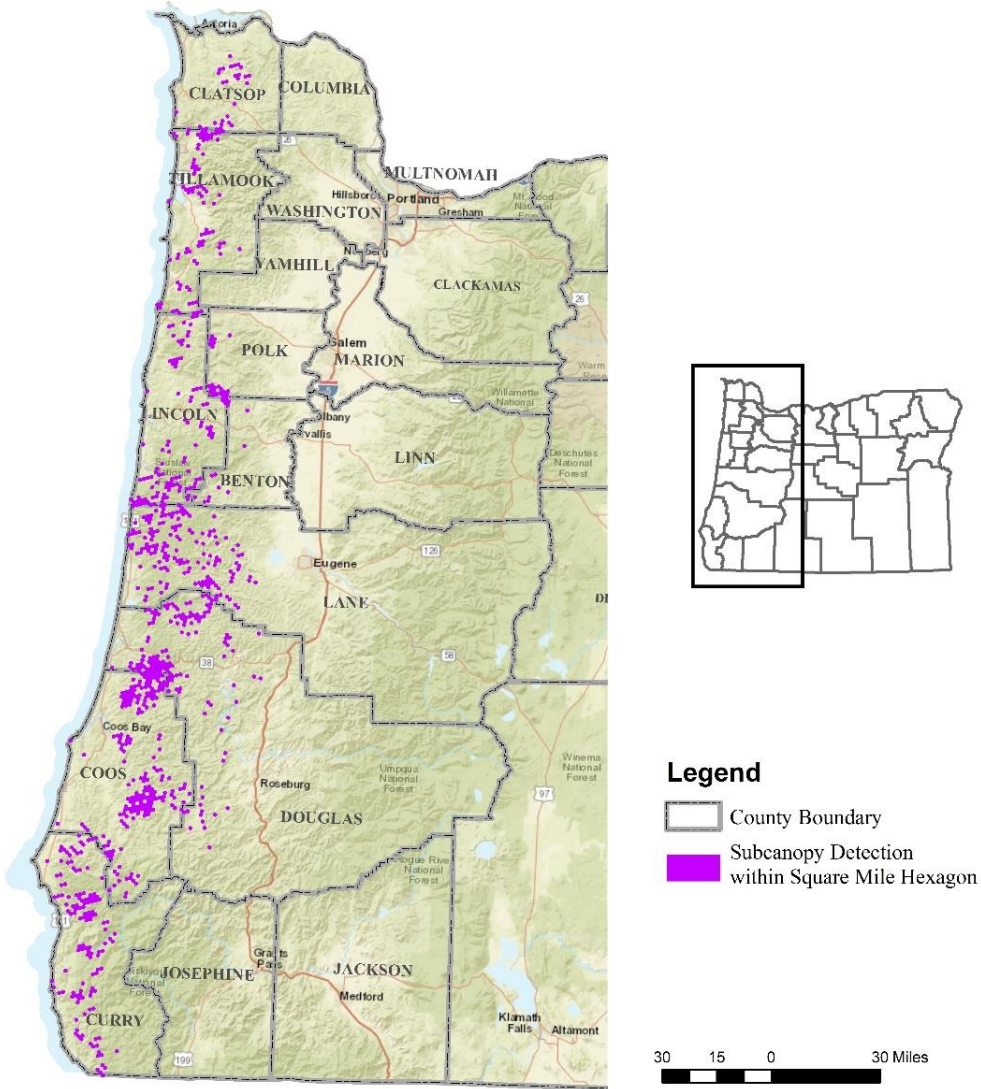


Figure 3. Approximate distribution of the Marbled Murrelet in Oregon based on available inland survey data gathered from 1988-2016. Inland survey data were provided by the Bureau of Land Management, Oregon Department of Forestry, and Oregon State University (note that surveys were not systematic across the state and covered various areas and time periods - see Inland Surveys in text for details). Subcanopy detections were selected from the survey results, and then summarized to indicate presence within a seamless 1 mi² hexagon dataset covering Oregon. County boundaries provided by Oregon Department of Administrative Services Geospatial Enterprise Office. Base map provided by Esri.

Types of Habitat Used

Marbled Murrelets spend a significant amount of time in the marine environment – in nearshore waters along exposed coastlines throughout the range, and in sheltered sounds and estuaries in Alaska, British Columbia, and Washington. Foraging, courtship, loafing, molting, and preening occur at sea. Marbled Murrelets have also been recorded feeding in freshwater lakes (Carter and Sealy 1986).

Inland, Marbled Murrelets use late-successional and old-growth forests almost exclusively for nesting. In Oregon, some nests have also been found in mature and young trees (66-150 years) containing older forest characteristics, such as platforms created by mistletoe infections or other deformities (Nelson et al. 2006). Since murrelets do not construct a nest, per se, the presence of potential nest platforms provided by large or deformed tree branches with moss or other substrate suitable for a nest “cup” is a particularly important habitat feature (Nelson 1997, Burger 2002, McShane et al. 2004, Nelson et al. 2006). These tree-nesting habits are unique among North American alcids; most alcids nest colonially on islands or cliffs at the marine-terrestrial interface. Nesting on open ground (especially in western Alaska where trees are absent), on cliffs, in rock crevices, or rarely in deciduous trees has been documented in parts of the northern Marbled Murrelet range, but not in Washington, Oregon, or California (Nelson 1997, McShane et al. 2004, Piatt et al. 2007).

Migration and Movements

Marbled Murrelets in Oregon (and elsewhere in the southern portion of the range) are not known to undertake large migratory movements (McShane et al. 2004). However, there may be some seasonal shifts in murrelet distribution. Studies from other areas have reported seasonal movements of birds south from breeding areas in fall and winter, from coastal waters to more sheltered inshore waters, or from breeding areas to waters further offshore (e.g., Rodway et al. 1992, Speich and Wahl 1995, Beauchamp et al. 1999).

Marbled Murrelets have been heard and observed over nesting areas throughout the year (Carter and Erickson 1992, Naslund 1993, O'Donnell et al. 1995). Detections are greatest during spring and summer, when activity is greatest and when attendance at inland sites is more consistent, and longer in duration. In most years, Marbled Murrelet detections reach a peak in the summer (Paton et al. 1990, O'Donnell et al. 1995, Nelson et al. 2006). In southeast Alaska, periods of no or reduced visitation to inland sites coincided with timing of murrelets' complete Pre-Basic molt in the fall (in which birds are flightless for 1-2 months at sea) and the Pre-Alternate (partial) molt in the spring (reviewed in Piatt et al. 2007). Reasons for visitation to inland sites during the non-breeding season are poorly understood, but birds may be maintaining pair bonds, examining future nesting areas, or engaging in other social activities (Carter and Sealy 1986, Naslund 1993).

Telemetry studies across the range have found high variability in home range sizes and nest-sea commuting distances for Marbled Murrelets (Whitworth and Nelson 2000, Hull et al. 2001, Kuletz 2005, Hébert and Golightly 2008, Barbaree et al. 2015, Lorenz et al. 2017). Differences probably reflect the distribution of suitable marine forage and terrestrial nesting habitat (Barbaree et al. 2015, Lorenz et al.

2017). In general, larger marine home ranges and commuting distances have been reported in the federally-listed range compared to Alaska (Lorenz et al. 2017).

In Washington, Lorenz et al. (2017) documented the greatest nest-sea commuting distances reported to date for breeding Marbled Murrelets (mean distance: 53.5 ± 28.4 km [33.2 ± 17.6 mi], range: 16.8-145.3 km [10.4-90.3 mi]). They found lengthy travel distances over land and over water. They suggested that nesting habitat declines, combined with poor marine conditions in the Salish Sea, may be forcing murrelets to travel further in this region. One failed breeder in their study nested within 4.7 km [2.9 mi] of sea on Vancouver Island but often foraged in the San Juan Islands (1-way commute of 138.3 km [85.9 mi]).

Foraging Behavior and Diet

Like other alcids, Marbled Murrelets are wing-propelled pursuit divers. They capture small schooling fish and marine invertebrates beneath the surface by “flying” underwater (Nelson 1997, Burger 2002). Foraging depths are largely unknown, though an alcid the size of a murrelet is likely to have a maximum diving depth of 47 m [154 ft] (Mathews and Burger 1998). Murrelets forage during the day and at night, solitarily or in groups (Carter and Sealy 1990, Strachan et al. 1995, Speckman et al. 2003). Off the coast of Oregon, groups of 2-3 murrelets are typically seen at sea (Strong et al. 1995), though foraging flocks comprised of thousands of murrelets have been observed in northern parts of the range where populations are much larger (Burkett 1995, Strachan et al. 1995). Marbled Murrelets prefer shallow, nearshore (within 5 km [3.1 mi] of shore) marine waters less than 30 m [98 ft] deep but may be found farther offshore during the non-breeding season and in Alaska (Nelson et al. 2006).

Marbled Murrelets are thought to be “flexible” foragers, feeding on the most abundant, suitable prey items (Burkett 1995, Nelson 1997). Prey quality and availability are affected by a combination of local and large-scale oceanographic processes (see Marine Habitat below). While little information is available on murrelet diet in coastal Washington and Oregon, several reviews have broadly characterized seasonal and geographic variation in diet across the murrelet range, and differences between adult and chick diet.

During the breeding season, fish prey dominate the diet (Sealy 1975, Carter 1984, Burkett 1995, Nelson 1997, Piatt et al. 2007). In contrast, during winter and spring, invertebrate species (e.g., euphausiids and mysids – shrimp-like crustaceans) may be taken in greater numbers (Burkett 1995, Piatt et al. 2007). Freshwater prey may also be important in some areas, particularly where large lakes with abundant salmonids occur near inland nesting habitat (Carter and Sealy 1986, Hobson 1990, McShane et al. 2004).

Pacific sand lance (*Ammodytes hexapterus*), Pacific herring (*Clupea pallasii*), and capelin (*Mallotus villosus*) are thought to be the main prey items north of Washington, whereas diet south of Canada is likely dominated by northern anchovy (*Engraulis mordax*), smelt (Osmeridae), and herring, with mysids and euphausiids also important in both regions (Burkett 1995, McShane et al. 2004). Most fish taken by murrelet adults and subadults are small larval or juvenile fish classes (30.1-60.0 mm [1.19-2.36 in] in size), whereas those fed to nestlings are much larger subadult or adult fish (Burkett 1995, Piatt et al. 2007). Chicks may be fed single large fish due to their higher energy values needed for growth and

development and/or the lessened transport costs or predation risks associated with fewer provisioning trips by parents to the nest site (see Piatt et al. 2007).

Several recent studies in the Salish Sea and in California indicate that the diet quality of Marbled Murrelets has declined over the last century due to regional changes in climate, overfishing, or both (Becker and Beissinger 2006, Norris et al. 2007, Gutowsky et al. 2009). Becker and Beissinger (2006) compared stable-carbon and -nitrogen isotope signatures in feathers from museum specimens (collected from 1895-1911) and birds caught at sea (collected 1998-2002) in central California. They found evidence of a 38% trophic level decline in pre-breeding diet over the last 100 years. They suggested that many murrelets forego breeding in years with insufficient food resources, particularly since egg formation is such an energetically expensive function. Using similar methods, Norris et al. (2007) and Gutowsky et al. (2009) reported drops in murrelet trophic feeding levels in their Salish Sea study areas over the last 150 years, and concluded that murrelets have been limited, in part, by food resources there. Since prey types vary in caloric content, reliance on less nutritious, energetically-poor prey items (e.g., krill) may be a major factor in reduced breeding propensity and low reproductive output also reported in these areas (Peery et al. 2004, Becker and Beissinger 2006, Becker et al. 2007, Lorenz et al. 2017).

Issues of prey distribution, abundance, timing, and quality are discussed further in Chapter 3.

Reproduction and Nesting Biology

For many years, the Marbled Murrelet represented what was perhaps the greatest ornithological mystery in the Pacific Northwest (Binford et al. 1975). Although it had long been suspected that murrelets nested in inland forest areas (Gabrielson and Jewett 1940), the first well-described Marbled Murrelet tree nest was not found until 1974 (in California) (Carter and Sealy 2005).

Intensive search efforts and improved survey techniques have led to the discovery of 75 Marbled Murrelet nests in Oregon since 1990 (S. K. Nelson, pers. comm.). Marbled Murrelet nests are extremely difficult to locate and monitor due to the fact that they are hidden high in the forest canopy. In addition, murrelets exhibit secretive behavior and rapid flight, further challenging observers. In Oregon, the search effort for nests has been mostly limited to research study sites and those found coincidentally with timber sale inventories. The 75 nests found do not represent the number of nesting murrelets in Oregon, but rather underscore the extreme difficulty in finding nests.

Timing, Clutch Size, and Renesting

Compared to other alcids, Marbled Murrelets have a long and asynchronous breeding season (Hamer and Nelson 1995a). Hamer and Nelson (1995a) found that the breeding period in Oregon lasts up to 149 days, beginning in April and ending in September. Across the range, timing of breeding varies with latitude and may be affected by food availability, weather, and ocean conditions. There are also indications that birds breed later or forego breeding altogether when food availability is poor (Peery et al. 2004; see also Foraging Behavior and Diet above).

Marbled Murrelets start to lay eggs as early as March in parts of the range, and lay only one, large (16-19% of body weight) egg per clutch (Nelson 1997). Renesting after early nest failure has been documented (McFarlane Tranquilla et al. 2003a, Barbaree et al. 2014); however, there is no evidence of second brooding (laying a second egg after successfully fledging a first chick) (McShane et al. 2004). Some eggs are laid as late as July (McFarlane Tranquilla et al. 2003b).

Nests

As described previously, Marbled Murrelets nest primarily in old-growth coniferous forest stands but may also use mature or younger stands with characteristics typically found in older forest types. Nests are normally well-hidden beneath overhanging branches, and are usually close to the tree trunk (Hamer and Nelson 1995b, Nelson and Wilson 2002). Nests are not constructed; instead, the egg is laid in a depression (nest cup) in moss, forest duff, or other suitable substrate on a natural platform on a large branch or on a deformity (e.g., mistletoe or “witches broom”) high in the canopy. Predator avoidance and the energetic and flight capabilities of murrelets are believed to have influenced many aspects of Marbled Murrelet breeding ecology, including nest-site selection (see Burger 2002, Nelson et al. 2006). See Nesting Habitat Associations below for more information.

Courtship

Courtship behavior has been frequently observed on the sea during early spring, throughout the summer, and in winter, but little is known about how and when Marbled Murrelets actually form pair bonds (Sealy 1975, Carter 1984, Carter and Stein 1995, Nelson 1997). Marbled Murrelets are commonly seen as pairs at sea throughout the year, but it is unclear whether they are necessarily breeding mates or perhaps temporarily foraging cooperatively (Sealy 1975, Strachan et al. 1995, McShane et al. 2004). In Oregon, pairs have been observed “prospecting” or visiting nest trees prior to egg laying (Nelson and Hamer 1995a, Nelson and Wilson 2002). Copulation has been observed in trees and on the water (Nelson 1997).

Incubation

After the female lays the single egg, the pair begins shared incubation in 24 hour shifts; exchanges of incubation duties generally occur before dawn, with one parent taking over incubation and the other leaving to forage at sea (Nelson 1997). Incubation lasts 28-30 days (Nelson 1997).

Chick-rearing

The chick is semiprecocial at hatching and is covered in cryptic down (Nelson 1997). It is brooded for 1 or 2 days by the adults, and then left alone at the nest for most of the chick-rearing period while both parents forage at sea (McShane et al. 2004). Murrelet chicks grow rapidly compared to other alcids (De Santo and Nelson 1995, Nelson 1997).

Adults make up to 8 visits a day to the nest, typically bringing just one large fish to the chick each trip (Nelson 1997). Adults approach the nest below tree canopy height and usually ascend steeply to the nest in “stall out” fashion (Nelson and Peck 1995, Nelson and Hamer 1995a), landing on a moss-covered “pad” near the nest. Most feedings are at dawn or dusk, though some occur mid-day (Nelson 1997).

Fledging

Just prior to fledging, the murrelet chick plucks off remaining down, revealing the juvenile plumage (Nelson 1997). Chicks fledge between 27 and 40 days, or 58-71% of adult mass (Nelson 1997). This variation is likely due to provisioning rates, which in turn may depend on prey availability. At fledging, young are thought to fly alone directly from the nest to the ocean (Nelson 1997, Nelson et al. 2006). After departing the nest, there is no evidence of further parental care (Nelson 1997, Nelson et al. 2006).

Many recently-fledged Marbled Murrelets do not make it to the ocean, as evidenced by the fact that numerous fledglings have been found grounded on the forest floor at varying distances from the ocean (Nelson and Hamer 1995a). Because the grounded young still had their egg tooth and down feathers on the neck and back, they were known to have recently fledged. Young birds may experience difficulties in navigating through the forest to the ocean since they have no prior flight experience, muscle development may be inadequate, and they are not accompanied or guided by adults. Once grounded, murrelets may not be able to take flight again or get to the ocean by other means.

Breeding Site Fidelity

Marbled Murrelets are thought to have high fidelity to nesting sites (Divoky and Horton 1995), though there are few data from individually-marked birds (Nelson et al. 2006, Plissner et al. 2015). Findings of multiple nests of different ages within the same tree and reuse of the same nest platform in different years (e.g., Nelson and Peck 1995, Nelson and Wilson 2002, Burger et al. 2009) provide some of the best support for fidelity at the smallest (tree or nest platform) spatial scales (Plissner et al. 2015).

In their recent review, Plissner et al. (2015) examined evidence of breeding site fidelity in Marbled Murrelets at watershed-, stand-, tree-, and nest platform- levels. They concluded that areas (at various scales) used for nesting in one year are often occupied in subsequent years, but it is unknown whether these are the same birds or different individuals. They also found some indications that fidelity at the tree or nest platform scale may be lower where habitat is more continuous and where suitable sites are less limited (see Burger et al. 2009). They underscored the need for additional studies using marked birds to further investigate these relationships. In general, adult alcids exhibit high philopatry (they typically return to breed where they hatched) and high site fidelity (they typically breed at the same location year after year if they are successful), and Marbled Murrelets are likely similar (McShane et al. 2004).

Social Behavior

Unlike many other seabirds, Marbled Murrelets do not form dense colonies. They have been described as solitary or semi-colonial breeders (Simons 1980, Divoky and Horton 1995, Nelson 1997). In Oregon, two active nests were only 30 m [98 ft] apart at one site in the Coast Range (Nelson and Wilson 2002), but in general, there is little information on densities of concurrently active nests (reviewed in Plissner et al. 2015). Solitary nests may be grouped within suitable habitat, and birds are commonly seen interacting socially in flight over nesting areas (Nelson and Hamer 1995a). At sea, Marbled Murrelets are highly social and often occur in groups, presumably because secrecy to avoid predation is not as important as in forests (Nelson 1997, Speckman et al. 2003).

Terrestrial Habitat

Nesting Habitat Associations

Marbled Murrelet habitat associations have been examined at various scales. We briefly summarize nest, tree, stand, and landscape characteristics below, relying heavily on reviews by Burger (2002), McShane et al. (2004), and Nelson et al. (2006), and emphasizing findings from Oregon. We include selected variables for all nests found to date in Oregon in Table 1 from S. K. Nelson.

Nest Characteristics

At the nest and tree scales, the presence of large platforms with adequate nesting substrate (e.g., moss) is particularly important (Nelson 1997, Burger 2002, McShane et al. 2004, Nelson et al. 2006). Foliage cover above and around the nest, tree size, nest height, and proximity to openings in the canopy are among other factors positively associated with nest sites (McShane et al. 2004, Nelson et al. 2006). There is also evidence to suggest that murrelets select distinctive trees for nesting from among trees available within a stand (Silvergieter and Lank 2011).

Tree Species

All known nests in Washington, Oregon, and California have been in conifers (Burger 2002, Nelson et al. 2006), but nesting has been documented in a deciduous tree (red alder, *Alnus rubra*) in British Columbia (Bradley and Cooke 2001). In Oregon, all nests have been located in western hemlock (*Tsuga heterophylla*), Douglas-fir (*Pseudotsuga menziesii*), Sitka spruce (*Picea sitchensis*), and western red cedar (*Thuja plicata*) (Hamer and Nelson 1995b; Nelson and Wilson 2002; S. K. Nelson, unpubl. data). However, Marbled Murrelets do not seem to select particular tree species. Rather, nest tree species are usually the dominant or abundant species found within the range that provide suitable nest platforms and other preferred characteristics (Burger 2002, Nelson et al. 2006, Silvergieter and Lank 2011).

Tree Size and Age

Nest trees used by Marbled Murrelets are primarily large, tall old-growth or mature trees (>49 cm [19 in] dbh, >33 m [108 ft] tall, Table 1a; Nelson 1997, Burger 2002, McShane et al. 2004, Nelson et al. 2006). In a sample of 10 nests from Oregon, Hamer and Nelson (1995b) found that the mean nest tree age was 209 years, and the youngest tree was 180 years old. Nelson and Wilson (2002) subsequently found 37 nests on state lands in Oregon, 25 of which were in mature (80-165 years old) trees; a single nest was also located in a young (66 years old) western hemlock on the Tillamook State Forest. The younger and mature trees had structural elements (deformities or dwarf mistletoe infestations) characteristic of older trees.

Platforms and Nesting Substrate

Nests are typically on large limbs (mean limb diameter at the trunk: 22 cm [8.7 in], mean limb diameter at the nest: 23 cm [9.1 in], Table 1b; Nelson 1997, Burger 2002, McShane et al. 2004, Nelson et al. 2006) and high in the live canopy (>10 m [33 ft] above ground, Table 1b; Nelson 1997). Measured platform widths were all >7 cm [2.8 in] (Table 1b). In most areas, these platforms supported thick mats of moss, other epiphytes, or forest duff/litter; mean moss and duff/litter depth were 4.3 cm [1.7 in] and 2.3 cm [0.91 in], respectively (Table 1b). Since the nest cup is merely a depression, this substrate on the nest limb helps to hold the egg in place and keep it from falling (Nelson et al. 2006).

Cover

Most nests have high amounts of protective foliage above or to the side (mean vertical cover: 83%, mean horizontal cover: 53%, Table 1b; Nelson et al. 2006). Nest cover may help to reduce detection by predators and/or provide protection from inclement weather (Hamer and Nelson 1995b, Burger 2002, Nelson et al. 2006).

Stand Characteristics

Occupied stands in Oregon are mostly fire-regenerated stands dominated by Douglas-fir, western hemlock, or Sitka spruce (Grenier and Nelson 1995, Nelson and Wilson 2002). High densities of large trees with platforms, multiple canopy layers, and canopy gaps that provide murrelets flight access to nest sites appear important (Nelson et al. 2006). Such structure and complexity are most often found in old-growth forests and some mature or younger forest types.

Platform Density

Nelson and Wilson (2002) found that nest plots tended to have more platforms (and more platform trees) than non-nest plots in western Oregon. Nest trees found in Oregon have contained from 8-92 platforms (Table 1a). Based on an analysis of platform use as a function of number of platforms per tree in British Columbia, Silvergieter and Lank (2011) suggested that murrelets do not select trees with more platforms, per se, but rather select individual platforms. In other words, platforms in trees with varying numbers of platforms seem to be used in proportion to their availability.

Stand Age and Tree Density

Grenier and Nelson (1995) compared habitat characteristics of sites occupied by murrelets in Oregon to random sites. They found that occupied sites tended to be in older stands, with larger midstory trees, larger dominant or remnant trees, and higher densities of dominant or remnant trees. As noted above, Nelson and Wilson (2002) reported nesting in some younger forest stands in Oregon where platforms had been created by deformities and mistletoe. These and other studies support the idea that stand structure is more important in determining use by murrelets than stand age or size.

Access

Marbled Murrelets have high wing loading (ratio of body mass to wing area). This helps to reduce drag underwater but requires that they fly at high speeds (often >70 kph [44 mph]) and altitudes (>1,000 m [3,281 ft]) to remain airborne (Nelson 1997, Burger 2002). Consequently, murrelets have low maneuverability relative to many other birds, making take-offs and landings more difficult. This constraint has likely influenced nest-site choice; gaps in the canopy that provide unobstructed flight access to nests, and nest platforms that are high enough to allow for stalled landings and jump-off departures, are important habitat features (Burger 2002, Nelson et al. 2006). Sites with multiple canopy layers or with openings near the nest site may provide such access, though there may be a tradeoff between selecting easily accessible sites and those that might be too open, attracting predators (Hamer and Nelson 1995b, Nelson and Wilson 2002, Nelson et al. 2006).

Landscape Characteristics

Throughout their range, Marbled Murrelets nest primarily in low-elevation coniferous forests within 52 mi of the coast (McShane et al. 2004, Nelson et al. 2006). At a landscape scale, murrelet use (based on various survey methods and definitions) is generally associated with large amounts of unfragmented old-growth or mature forests (Burger 2002, Raphael et al. 2002, Meyer and Miller 2002, McShane et al. 2004, Nelson et al. 2006, Burger and Waterhouse 2009, Raphael et al. 2015, Raphael et al. 2016b). The importance of slope, aspect, or other topographical features is more equivocal.

Elevation

Marbled Murrelet nests have been found at elevations from sea level up to 1,500 m [4,921 ft] throughout the range (Burger 2002). However, all nests in Oregon have been located at 617 m [2,024 ft] or less (Table 1a). This may be because high elevations are not present throughout much of the southern range, and where they occur, suitable habitat is lacking (Hamer and Nelson 1995b, McShane et al. 2004, Nelson et al. 2006).

Distance to Coast

Proximity to the coast was an important predictor of murrelet occupancy in some studies (e.g., Meyer and Miller 2002, Meyer et al. 2002) but not others (reviewed in Burger 2002). All nests found in Oregon

have been located within 49 km [30 mi] of the coast (Table 1a), and most audio-visual detections indicative of nesting have been recorded within 65 km [40 mi] (Evans Mack et al. 2003, p. 4; Fig. 3).

Murrelets seem to avoid nesting directly adjacent to the ocean in the southern portion of the range, perhaps because wind affects suitable tree or platform development or nests are more exposed to adverse weather conditions (Nelson et al. 2006), or because human development or predators in coastal areas affect use (Hamer and Nelson 1995b, Nelson et al. 2006). Nelson et al. (2006) concluded that distance inland may be determined by a combination of energetic constraints, habitat availability, site fidelity, predation pressure, or other factors.

Slope, Aspect, and Moisture

There is no evidence that murrelets prefer a particular aspect for nesting, though aspect or other topographical features could affect moisture levels or other conditions conducive to platform creation or epiphyte growth (McShane et al. 2004, Nelson et al. 2006).

There is some evidence that slope is important in nest-site selection, and that steep slopes are usually avoided within Washington, Oregon, and California. Use of slopes may be tied to factors other than the slope itself, such as local predation pressure or timber harvest patterns (see discussion in Nelson et al. 2006).

Fragmentation Level

In general, Marbled Murrelet nest sites are negatively associated with increasing amounts of forest fragmentation (reviewed in Burger 2002, McShane et al. 2004, Nelson et al. 2006). Aspects of landscape pattern and configuration (e.g., adjacent habitat, proximity to human activities, type of edge) are also important due to their influence on edge effects and predator-prey dynamics (see Fragmentation of Habitat below). In southern Oregon, Meyer et al. (2002) found that murrelets were most abundant in unfragmented old-growth forest patches located within a matrix of mature second-growth forest, and Meyer and Miller (2002) found that occupied areas had less fragmented and isolated old-growth forest compared to unoccupied areas. Similarly, in western Oregon, Ripple et al. (2003) found that the proportion of old-growth forest was a key predictor of murrelet nest sites, and that edge-related habitat variables (i.e., edge-perimeter density, nest-patch perimeter, high-contrast edge at nest patches) were lower at murrelet nest sites than random sites.

Amount and Distribution of Terrestrial Habitat

Loss of older forests was cited as the main factor in multi-state and federal Marbled Murrelet listings in the 1990s (CDFG 1994, ODFW 1995, Desimone 2016, USFWS 1997, 57 FR 45328). There have been many efforts to quantify the extent of this loss across different time periods. Such estimates can vary depending upon the definitions used for suitable habitat, reliability of mapping and GIS data, assumptions, and algorithms used (Piatt et al. 2007, COSEWIC 2012, Raphael et al. 2016a). We review historical and current habitat conditions below.

Table 1. Selected Marbled Murrelet nest tree (Table 1a) and nest (Table 1b) characteristics. Data were provided by S. K. Nelson for all 75 nests found in Oregon since 1990. Mean values are shown for variables measured, along with standard deviation (SD) and range.

Table 1a. Nest tree characteristics

	Tree DBH (cm)	Tree Height (m)	No. Platforms in Nest Tree	Distance from Ocean (km)	Distance to Edge (m)	Elevation (m)
Mean	141	56	26	22	51	330
SD	48	14	19	10	45	150
Range	49-279	33-85	8-92	1-49	0-185	53-617

Table 1b. Nest characteristics

	Nest Limb Height Above Ground (m)	Nest Limb Diameter at Trunk (cm)	Limb Diameter at Nest (cm)	Distance from Trunk (cm)	Nest Platform Width (cm)	Moss Depth Adjacent to Nest (cm)	Duff & Litter Depth in Nest Cup (cm)	% Horizontal Cover (Side)	% Vertical Cover (Overhead)
Mean	36	22	23	110	25	4.3	2.3	53	83
SD	14	10	9	116	10	2.4	1.9	19	21
Range	10-75	7-56	10-47	0-762	7-51	0.0-11.0	0.0-8.4	13-85	25-100

Habitat in Oregon

Historical Summary

Historically, Marbled Murrelets are believed to have inhabited coastal old-growth forests throughout the Pacific Northwest and northwestern California (USFWS 1997, McShane et al. 2004). Field-survey data are lacking for historical conditions, but estimates derived from early mapping and vegetation reconstruction efforts and simulations indicate that declines in old-growth in recent history (last 100-200 years) are unprecedented (Booth 1991, Teensma et al. 1991, Bolsinger and Waddell 1993, Ripple 1994, Perry 1995, Wimberly et al. 2000, Strittholt et al. 2006). According to Strittholt et al. (2006), old-growth forests across the Pacific Northwest once covered about two-thirds of the land base; today, only about 28% of old-growth remains due mainly to timber harvest and other land use changes. Strittholt et al. (2006) estimated that 95% of old conifer Puget Lowland Forests (in Washington) and 82% of old conifer Central Pacific Coastal Forests (in Washington and Oregon) have been lost since the time of European settlement, much of which was likely murrelet habitat. Similar estimates of remaining old-growth (5-20%), depending on the region, have been reported by others within the federally-listed range of the Marbled Murrelet (see Falxa et al. 2016).

In the Oregon Coast Range, most forest lands have been intensively managed for timber since the early 1900s and have had a complex fire history as well. Thus, the landscape today consists of a mosaic of young and older forests. Many older forests have been reduced to small, isolated patches (Spies and Franklin 1988), and the historical fire regime has been largely replaced by short-rotation (30-60 year) timber harvest on private lands (Wimberly et al. 2000).

In the mid-1800s and early 1900s, large wildfires burned extensive areas of Oregon Coast Range forests (Teensma et al. 1991, Ripple 1994, Perry 1995). Teensma et al. (1991), as cited by Perry (1995), estimated that stands 200 years of age and older represented 40-50% of Coast Range forests between 1850 and 1920, and declined to 20% by 1940 following large fires in the Tillamook area. If trees between 100 and 200 years old were considered in these estimates, potential Marbled Murrelet habitat might have comprised 70% of the Coast Range forests in 1920 and 50% in 1940 (Perry 1995). Perry (1995) also reported that considerable old-growth acreage (228,600-364,000 ha or 565,000-900,000 ac) had already been logged in the Oregon Coast Range by the 1930s.

In another analysis, Ripple (1994) traced the history and extent of old-growth forests in western Oregon in the context of fire cycles, size class distribution, the amount of pre-logging old-growth, and spatial forest patterns of western Oregon. He showed that by the early 1900s, 71% of all conifer forests were in the large forest class (large old-growth, small old-growth, and large second-growth), of which 89% was spatially connected as one patch. Similar to Teensma et al. (1991), Ripple (1994) found that the amount of old-growth in the Coast Range was approximately 43% in the 1930s, and 61% before the large fires of the late 1840s.

Current Habitat

In Oregon, there are an estimated 6,610,400 ac of “habitat-capable” forest lands within the Marbled Murrelet range, including approximately 774,800 ac of “higher-suitability” (Classes 3 and 4) habitat most likely to support Marbled Murrelet nesting (see 2012 estimates in Raphael et al. 2016a; Fig. 2). This higher-suitability habitat is almost entirely in the Coast Range (635,300 ac) and Klamath (139,500 ac) physiographic provinces, along the central coast and southwestern portion of the state. Most of these lands are federally-owned (Coast Range: 69% federal, 31% nonfederal; Klamath: 84% federal, 16% nonfederal) (Raphael et al. 2016a).

Patterns of forest age and structure in western Oregon are strongly tied to type of land ownership due to varying policy, regulatory, and/or management regimes (Ohmann et al. 2007, Raphael et al. 2016a). State and federal land ownership within the Marbled Murrelet range in Oregon is shown in Fig. 2. Based on 2012 habitat data produced by Raphael et al. (2016a) (available from the [Northwest Forest Plan’s Interagency Regional Monitoring Program](#)), ODFW estimates that ownership of higher-suitability habitat in Oregon is roughly 16% Bureau of Land Management (BLM), 55% U.S. Forest Service (USFS), 15% Oregon Department of Forestry (ODF), 12% private, and 2% other.

Changes since the 1990s

Raphael et al. (2016a) conducted the most recent habitat change analysis within the Northwest Forest Plan (NWFP) area. They used maximum entropy (Maxent) models to compare gains and losses in the amount and distribution of nesting habitat between “bookend” years of 1993 and 2012, and to identify causes of observed loss. Overall, their analysis showed further fragmentation of the landscape and net declines in older forest habitat across the NWFP area since the 1990s. They found that Marbled Murrelet higher-suitability habitat declined from 2,535,000 ac in 1993 to 2,226,800 ac in 2012, a net loss of 308,200 ac (-12% change) within the plan area. In Oregon specifically, they found that higher-suitability habitat declined from 853,400 ac in 1993 to 774,800 ac in 2012, a net loss of 78,600 ac (-9.2% change) (Raphael et al. 2016a; Table 2, Fig. 4). Losses were greatest on nonfederal lands during this period; in Oregon, 59,200 ac (21.1%) of higher-suitability habitat were lost on nonfederal lands compared to 19,400 ac (3.4%) on federal lands (Raphael et al. 2016a; Table 2, Fig. 4). Within federal land ownership in Oregon, approximately 200 ac (0.3%) of higher-suitability habitat were lost on nonreserved lands (where commercial timber harvest may be permitted) compared to 19,200 ac (3.8%) on reserved lands (where commercial timber harvest is generally prohibited) (Raphael et al. 2016a; see Northwest Forest Plan in Chapter 4 for more information on federal land allocations and management).

Habitat losses were due to timber harvest, windthrow, wildfire, insects, disease, and natural disturbances (Table 3). Raphael et al. (2016a) found clear differences between land ownerships in the factors responsible for these changes. On federal lands in Oregon, they attributed 80% of losses to wildfire, namely the Biscuit Fire of 2002 in southern Oregon. On nonfederal lands in Oregon, they attributed 98% of losses to timber harvest, most of which occurred in the Coast Range, but acknowledged that other short-term disturbances from landslides, wind blowdown, and flooding could account for a small proportion of these harvest losses due to a lack of spatial data on those events (Table 3).

High levels of forest fragmentation were evident throughout Oregon. On nonfederal lands, nearly 90% of potential murrelet habitat occurred as “edge” in 2012 (as opposed to interior habitat, see Raphael et al. 2016a). Federal lands had lower proportions of edge habitat, but even these were high (>70% edge in reserved lands, >80% in nonreserved lands) (Raphael et al. 2016a).

In the absence of systematic inland surveys for the Marbled Murrelet (see Inland Surveys below), the analysis by Raphael et al. (2016a) serves as the best available statewide habitat assessment for the species. It may not be suitable for fine-scale assessments, however, and did not distinguish between different types of land ownership (e.g., private, state) in the “nonfederal” category. Below, we summarize limited audio-visual survey data, and discuss results of Raphael et al. (2016a) for nonfederal and federal lands in conjunction with forest inventory and other information sources.

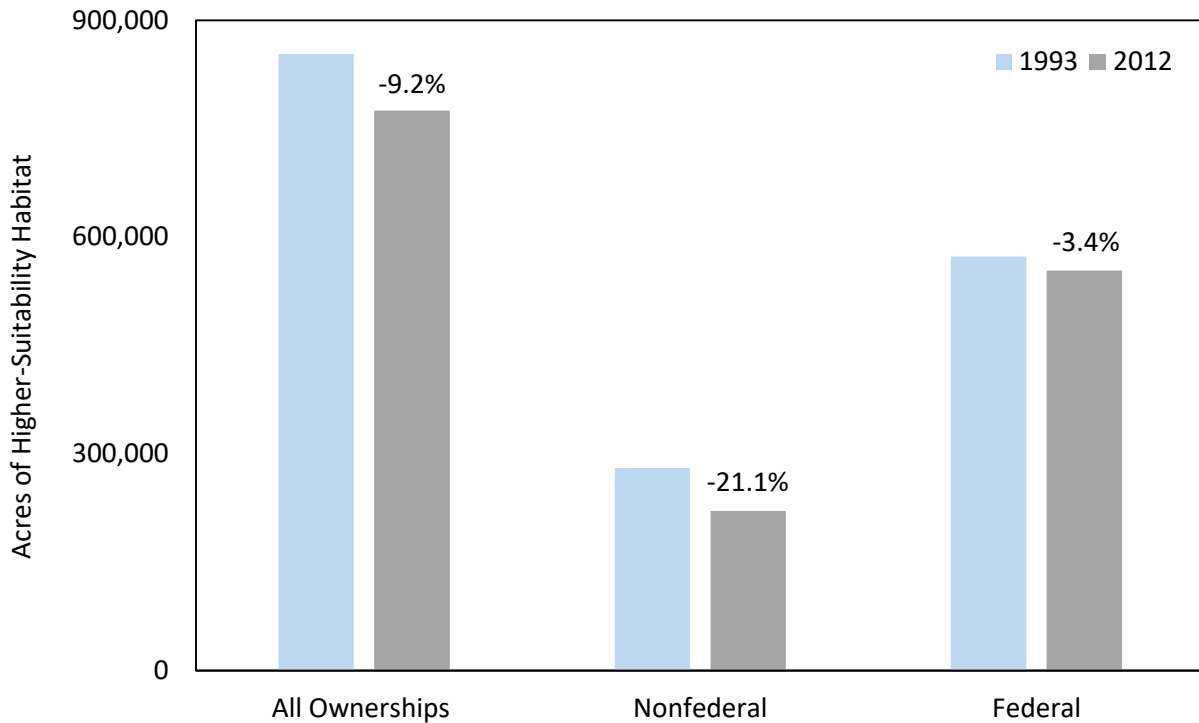


Figure 4. Net change in acreage of higher-suitability Marbled Murrelet nesting habitat from 1993 (blue bars) to 2012 (gray bars) in Oregon on 1) all land ownerships combined, 2) nonfederal (state, private, other) lands only, and 3) federal (reserved and nonreserved) lands only (data from Raphael et al. 2016a). Habitat change estimates considered both habitat gains and losses during this period.

Table 2. Acres of loss, gain, and net change in Marbled Murrelet higher-suitability (Classes 3 plus 4) nesting habitat in Oregon from 1993 to 2012 for 1) nonfederal lands only and 2) all land ownerships combined (data from Raphael et al. 2016a, Table 2-10, p. 79).

Province	Nonfederal Lands Only				All Land Ownerships			
	Losses	Gains	Net Change		Losses	Gains	Net Change	
			Acres	%			Acres	%
Coast Range	120,236	64,180	-56,056	-22.0	171,212	117,373	-53,839	-7.8
Willamette Valley	16	5	-11	-66.2	17	5	-12	-57.6
Western Cascades	2	0	-2	-83.3	6	3	-3	-18.1
Klamath	12,760	9,673	-3,087	-11.9	63,451	38,710	-24,741	-15.1
Total	133,014	73,858	-59,156	-21.1	234,686	156,091	-78,595	-9.2

Table 3. Attribution of loss (in acres) of Marbled Murrelet higher-suitability nesting habitat in Oregon from 1993 to 2012 on 1) nonfederal lands only and 2) all land ownerships (data from Raphael et al. 2016a, Table 2-13, p. 81).

Province	Nonfederal Lands Only				All Land Ownerships			
	Timber Harvest	Wildfire	Insects	Natural Disturbance	Timber Harvest	Wildfire	Insects	Natural Disturbance
Coast Range	80,049	197	1,456	0	83,086	253	1,580	18
Willamette Valley	10	0	0	0	10	0	0	0
Western Cascades	2	0	0	0	2	0	0	0
Klamath	8,004	14	128	0	9,650	20,235	231	46
Total	88,065	211	1,584	0	92,748	20,488	1,811	64

Inland Surveys and Habitat Occupancy

Systematic surveys of Marbled Murrelet nesting habitat are not available. To date, most inland surveys for the species have been concentrated in areas proposed for timber sales or for specific research projects. Tree climbing and audio-visual surveys have been used most extensively in Oregon.

A primary goal is often to determine whether a project site is “occupied” or not by Marbled Murrelets; evidence of occupancy generally confers some level of protection. Audio-visual surveys are widely used for this purpose, and in Washington, Oregon, and California, they typically follow a standardized protocol developed by the Pacific Seabird Group (current protocol is Evans Mack et al. 2003; a revised protocol is under development, S. K. Nelson, pers. comm.). These surveys rely on a sampling design and repeated site visits to determine murrelet presence, probable absence, and occupancy with a high

degree of confidence. Evans Mack et al. (2003, p. 3) defines an occupied site as one “where murrelets have been observed exhibiting subcanopy behaviors, which are behaviors that occur at or below the forest canopy and that strongly indicate that the site has some importance for breeding. Occupied sites include nest sites. A nest site is a site with an active nest or evidence of a nest, including eggs, eggshell fragments, or a downy chick.”

The limitations of audio-visual surveys have been reviewed by various authors (e.g., Burger 2002, McShane et al. 2004). Burger (2002, p. 37) summarized the following key limitations:

- detections do not give reliable and accurate indicators of the actual numbers of murrelets present in a particular stand;
- detections show high diurnal and seasonal variability and are strongly affected by weather, especially cloud cover and rain;
- they do not show the actual sites used for nesting, although they are useful in locating nests;
- visibility (canopy opening) and to a lesser extent noise (streams, etc.) can affect detections;
- differences among observers adds variability to the data, despite efforts to standardize training and observation techniques;
- ground-based observers cannot access all the forests accessible to murrelets.

Nevertheless, in the absence of other information, audio-visual survey data from several key land-managing agencies provide some indication of inland distribution and areas that may be particularly important to murrelets in Oregon (Fig. 3). Most surveys have been limited to BLM, USFS, and ODF lands to date (Table 4).

Table 4. Summary of Marbled Murrelet survey stations and detections by ownership/management area. Data spanned various timeframes and were provided by the Bureau of Land Management (1997-2016), Oregon Department of Forestry (1989-2016), and Oregon State University (included U.S. Forest Service and all other ownerships; 1988-2016).

Ownership or Managing Entity	Total No. of Survey Stations	Total No. of Murrelet Detections (Subcanopy Detections)
Bureau of Land Management	10,737	1,160 (514)
U.S. Forest Service	7,556	1,886 (477)
Other Federal Agency	56	4 (2)
Oregon Dept. of Forestry	27,625	3,119 (827)
Oregon Dept. of Parks & Recreation	237	101 (42)
Other State Agency	246	1 (0)
Private	1,733	383 (116)
Other	11	0 (0)

Nonfederal Lands

Raphael et al. (2016a) estimated that 29% (about 221,100 ac) of higher-suitability habitat is found on nonfederal lands in Oregon. These nonfederal lands are mostly state- and privately-owned, though small amounts of county, tribal, and other public lands are also represented.

State Lands

The extent of suitable Marbled Murrelet habitat on state lands is mostly restricted to ODF-managed lands, including the Elliott State Forest (most of which is owned by the State Land Board) and lands in Tillamook, Clatsop, Lane, Polk, Benton, and Lincoln counties, and some state parks managed by the Oregon Parks and Recreation Department (Fig. 2).

ODF manages over 650,000 ac of state forest lands within the range of the Marbled Murrelet. ODF currently has 124 Marbled Murrelet Management Areas (MMMAs), or areas containing designated occupied habitat based on audio-visual surveys and nests found. These MMMAs (and associated buffers) encompass 19,934 ac of forest land, including 10,589 ac in the Elliott, 5,228 ac in the Tillamook, and 1,614 ac in the Clatsop State Forests (ODF, unpubl. data; Table 5).

Table 5. Number of Marbled Murrelet Management Areas (MMMAs) and associated acreage on the Clatsop, Tillamook, and Elliott State Forests (data provided by M. Gostin, ODF).

State Forest	Number of MMMAs	Total Acreage
Clatsop	10	1,614
Tillamook	32	5,228
Elliott	42	10,589

ODF-managed lands have been inventoried in terms of forest age class and stand type. A general analysis indicates that the majority of coniferous stands in northwest Oregon state forests (which include the Clatsop and Tillamook State Forests) are less than 85 years old (ODF 2010, p. S-8 and Table 2-9, p 2-82). About half of the conifer stands in the Elliott State Forest are more than 85 years old (ODSL and ODF 2011, p. 2-73 and Fig. 2-4, p. 2-74 and Table 2-8, p. 2-74).

Private Lands

Very little information is available on Marbled Murrelet use of private lands in Oregon. McShane et al. (2004) estimated that there were about 2,709,516 ac of commercial forest lands within 50 mi of the coast in Oregon, 87% of which was within 35 mi of the coast. Our examination of the 2012 habitat data from Raphael et al. (2016a) indicates that there are about 3.4 million ac of potential habitat (Classes 1, 2, 3, and 4 combined, where Class 1 is lowest-suitability and Class 4 is highest-suitability) on private forest lands in Oregon, both commercial and non-commercial, less than 3% of which is higher-suitability (Classes 3 and 4) habitat. While there are several known occupied sites on private lands (S. K. Nelson, pers. comm.), the full extent of occupied habitat on private lands in Oregon is unknown, and this is an important data gap for our review.

Forest inventory and harvest data tend to support the assumption that Marbled Murrelet habitat is not extensive on private lands. For example, an analysis by Greber et al. (1990, p. 39-40) focused on economic implications of the federal listing of the Northern Spotted Owl (*Strix occidentalis caurina*) noted that: 1) nonindustrial owners have a much higher proportion of their acres older than 60 years of age than does the forest industry; 2) little timber over 85 years of age exists on private land, and few of these acres would qualify as old-growth; and 3) forest industry lands are generally managed on a 50- to 60-year rotation. More recently, Ohmann et al. (2007) found that 1) sparse and open-canopy forests and 2) young- to middle-aged forests predominate on private lands in the Oregon Coast Range. These forest types accounted for 83% and 68%, respectively, of the private forest land base.

Federal Lands

Raphael et al. (2016a) estimated that 71% (about 553,700 ac) of higher-suitability habitat is found on federal lands in Oregon. These lands are administered primarily by the USFS and BLM. Most of this habitat is within designated reserved areas and is unlikely to be harvested under current federal regulations (Raphael et al. 2016a).

The two major areas of Marbled Murrelet habitat remaining in Oregon are the Siuslaw National Forest and the Rogue River-Siskiyou National Forest (Fig. 2). As depicted in Fig. 2, the Siuslaw National Forest is a particularly important area for murrelets along the central coast. In the 1930s, this forest had over 375,000 ac of older forests (USFS 2014). In 1993, there were about 337,000 ac with old-growth structure index threshold of ≥ 80 years average stand age (OGSI 80) and 211,000 ac with old-growth structure index threshold of ≥ 200 years average stand age (OGSI 200) (USFS 2014). In 2012, there were about 340,000 ac with OGSI 80 and 244,000 ac with OGSI 200, suggesting that older forests have largely been restored or maintained on the Siuslaw National Forest during this period (USFS 2014).

In the Rogue River-Siskiyou National Forest, the 2002 Biscuit Fire was responsible for considerable loss (>14,000 ac) of murrelet nesting habitat (McShane et al. 2004, Raphael et al. 2016a). In fact, this fire represents the largest single natural stochastic event resulting in murrelet habitat loss in recent history (McShane et al. 2004). In 2003, McShane et al. (2004) reported that there were about 95,165 ac of suitable Marbled Murrelet habitat remaining in the Rogue River-Siskiyou National Forest in Oregon.

Other States and Canada

Washington

In Washington, Raphael et al. (2016a) estimated that there were 1,549,000 ac of higher-suitability nesting habitat in 1993 compared to 1,343,200 ac in 2012, a net loss of about 205,800 ac (-13.3% change). Most losses during this period occurred on nonfederal lands and were attributed to timber harvest (Raphael et al. 2016a).

California

Carter and Erickson (1992) reviewed the loss of coastal old-growth forest in California since the early 1800s. By 1978, less than 15% of the original 1.9 million ac remained and about 30% of the remaining old-growth redwood acreage (or 4% of the original acreage) was preserved in parks. More recently, Raphael et al. (2016a) reported that there were 132,600 ac of higher-suitability nesting habitat in 1993 compared to 108,900 ac in 2012, a net loss of about 23,600 ac (-17.8% change). Nearly all losses occurred on nonfederal lands and were attributed to timber harvest.

Alaska

Information on the extent of suitable habitat in Alaska is limited. For southeast Alaska only, about 2.3 million ha [5.7 million ac] of productive old-growth forest remain, 413,900 ha [1,022,769 ac] of which have high potential for Marbled Murrelet nesting (Albert and Schoen 2006 in Piatt et al. 2007). Piatt et al. (2007) estimated that murrelets have probably lost <15% of suitable forest nesting habitat in Alaska since industrial logging began in the 1950s. Overall, habitat loss due to timber harvest is assumed to be a contributing factor, rather than a major driver, of murrelet declines in Alaska, and a multitude of human activities and natural factors likely account for declining trends observed in murrelet populations in many parts of the state (Piatt et al. 2007).

British Columbia

There are approximately 1.98 million ha [4.89 million ac] of suitable nesting habitat in British Columbia (COSEWIC 2012). Rough estimates of nesting habitat loss since European settlement range from 35-53% (summarized in COSEWIC 2012). Greatest losses have occurred on Vancouver Island and the southern mainland (Burger 2002). On a more recent timescale, Long et al. (2011) concluded that suitable nesting habitat declined by 20-22% between 1978 and 2008 in British Columbia.

Fragmentation of Habitat

Major changes have occurred in forested lands over the last 150-200 years, including considerable loss of late-successional forest and fragmentation of remaining forest into smaller or more isolated patches (Harris 1984). Fragmentation can result from timber harvest, fire, development, agriculture, or other natural or anthropogenic forms of habitat modification. Fragmentation not only reduces the quantity of habitat, but also may impact the quality of areas that remain. It can affect a multitude of ecological phenomena, including forest microclimates (e.g., temperature, light, wind, moisture), movement and dispersal of organisms, plant and animal community composition, and forest resiliency to future disturbances or stressors (Lehmkuhl and Ruggiero 1991, Halpern and Spies 1995, Chen et al. 1999). Fragmentation alters the pattern and configuration of the original forest, exposing remnant patches to increased "edge effects" (Lehmkuhl and Ruggiero 1991, Murcia 1995).

While habitat loss could be expected to result in the displacement of nesting birds, fragmentation could lead to both displacement and reduced breeding success (Divoky and Horton 1995). If all available nest sites in adjacent habitat are occupied, then displaced birds could attempt to breed in suboptimal sites

with reduced success, forego breeding altogether, or prospect for new nest sites elsewhere (Divoky and Horton 1995). However, few murrelets are thought to disperse to new areas for nesting or to “pack” into remaining habitat in higher densities (Burger 2001, Raphael et al. 2002, Burger and Waterhouse 2009), an idea that is further supported by central California genetics research. Peery et al. (2010) found evidence of recent genetic discreteness in the central California murrelet population that may be tied to increasing habitat fragmentation over the last century. Strong fidelity to nesting sites may hamper colonization of new areas, even where suitable habitat remains (Divoky and Horton 1995).

Disturbed areas and edges may convey poorer breeding success or survival for those murrelets that do nest. Adverse edge effects may be due, in part, to higher predator densities or predation rates along edges as opposed to interior habitat (Nelson and Hamer 1995b). One important nest predator of murrelets, the Steller’s Jay (*Cyanocitta stelleri*), is known to concentrate in “patchy” or “edgy” areas and near human activities (Raphael et al. 2002, Marzluff et al. 2004). Windthrow, exposure to the elements, or other disturbances may be more pronounced at forest edges (McShane et al. 2004). Differences in sunlight, temperature, or moisture at clearcut edges may also reduce epiphyte growth and survival important for murrelet nest platforms (van Rooyen et al. 2011).

Edge effects are not static and can change over time (Malt and Lank 2007, 2009; van Rooyen et al. 2011). The type of adjacent habitat can also influence edge effects and may explain why some studies have failed to detect such effects (e.g., Marzluff and Restani 1999, Bradley 2002). “Hard” edges (recent clearcuts) tend to produce detrimental effects whereas “soft” edges (regenerating forest) or natural (e.g., riparian) edges have lessened or no edge effects, respectively (Bradley 2002; Malt and Lank 2007, 2009; van Rooyen et al. 2011). As discussed earlier, proximity to human habitation or activities is also important for predator-prey dynamics. Campgrounds, picnic areas, and other sources of human-supplied food tend to support elevated levels of corvids (jays, crows, ravens), which can lead to higher nest depredation for nearby murrelets (Marzluff and Neatherlin 2006, Bensen 2017).

Marine Habitat

California Current System

The nearshore marine environment along the Oregon coast is strongly influenced by the California Current System (CCS). The CCS is an eastern boundary current known for its high productivity. As described in Pacific Fishery Management Council (2013), the CCS flows along the West Coast from southern British Columbia to Baja California and is composed of a complex system of currents and processes. The main CCS surface current is massive and flows southward 50 to 500 km [31 to 311 mi] offshore, moving cold water from the North Pacific toward the equator. The California Undercurrent flows northward, moving water toward the pole beneath the surface current in the summer, then surfaces near the shelf break where it is known as the Davidson Current in the winter. This is a much narrower band of water. The CCS is also characterized by strong, localized wind-driven coastal upwelling, particularly in spring-summer. Upwelling brings cold, nutrient-rich waters from depth to the surface along the coast, supporting primary productivity that serves as the base for the food chain. The locally-driven coastal upwelling processes vary on much smaller temporal and spatial scales than offshore processes. Underwater canyons, coastal headlands, and offshore banks as well as regional

differences in winds and freshwater input are all important factors affecting these coastal upwelling processes and resulting productivity. The northern portion of the CCS, including much of the coastal waters off Oregon, has a relatively wide continental shelf, several banks that facilitate retention processes, numerous underwater canyons that intensify upwelling, more freshwater input, and generally weaker and more intermittent upwelling-favorable winds during spring-summer and strong downwelling-favorable winds in winter. The shelf narrows near Cape Blanco, and some of the strongest upwelling-favorable coastal winds occur from here down to Cape Mendocino in California. This transition area also marks the southern boundary for the oil-rich subarctic zooplankton species.

Variability in winds, sea surface temperatures, and sea level pressures affect upwelling and marine productivity in the CCS. Year-to-year variability (e.g., El Niño) and longer-term regime shifts (e.g., Pacific Decadal Oscillation) can have consequences for seabird diet and foraging areas. During strong El Niño events, coastal upwelling winds are reduced, there is an intrusion of offshore subtropical water, surface waters are warmer and more nutrient-poor than usual, and there can be dramatic declines in primary and secondary production that can lead to poor recruitment, growth, and survival for many resident species. It is common to have northward range extensions of many tropical species during El Niño events. During La Niña events, the reverse is generally true, with colder, more nutrient-rich waters present. Many studies have shown that reliance on different suites of prey species due to environmental conditions can impact seabird productivity (e.g., Ainley et al. 1995, Sydeman et al. 2006, Wells et al. 2008, Wolf et al. 2009, Cury et al. 2011, Thompson et al. 2012). In general, cold water events or cold ocean phases have been linked to greater prey availability for breeding seabirds (Ainley et al. 1995, Veit et al. 1997, Hyrenbach and Veit 2003, Ainley and Hyrenbach 2010), though a combination of ocean processes operating at various temporal and spatial scales ultimately determine foraging opportunities.

Marine Habitat Associations

During the breeding season, most Marbled Murrelets in Oregon are found in nearshore marine waters along the central coast (Strong 1995, Strong et al. 1995, Strong 2003, Falxa et al. 2016). In recent years (2009-2014), highest densities were detected in inshore sampling units just south of Yaquina Bay to Winchester Bay (Marbled Murrelet Effectiveness Monitoring Module 2015). As noted previously, large gaps in at-sea distribution appear to reflect a lack of nearby suitable nesting habitat.

Recent studies indicate that at-sea murrelet distribution during the breeding season is positively associated with the amount of unfragmented nesting habitat directly inland. Raphael et al. (2015) and Raphael et al. (2016b) examined terrestrial and marine factors influencing murrelet densities at-sea throughout the NWFP area. They found that murrelet densities were best explained by terrestrial factors; murrelets were concentrated in areas with the most abundant and cohesive terrestrial habitat nearby. The authors cautioned that these results do not imply that ocean conditions are unimportant to murrelets and could reflect chosen variables or scaling issues (Raphael et al. 2016b) or the fact that small numbers of murrelets in the study area underutilize much of the available foraging habitat (Raphael et al. 2015). Similarly, Lorenz et al. (2016) examined marine resource selection of Marbled Murrelets in Washington. Locations with higher amounts of nesting habitat close to shore, in cool waters, and with low human footprint were used most. Prey availability undoubtedly plays a role in murrelet distribution at sea, but in the absence of widespread temporal and spatial prey occurrence

data, these studies relied heavily on indirect measures of marine productivity (e.g., sea surface temperature, chlorophyll-a, oceanic or upwelling indices) as proxies which the authors acknowledged may not fully capture complex relationships between murrelets and their prey.

Little is known about Marbled Murrelet habitat use during winter (Nelson 1997). Murrelets may be more dispersed and farther from shore outside the breeding season (Strachan et al. 1995). A pilot study using boat-based, shore-based, and aerial surveys was undertaken along the Oregon coast in winter 2015 for seabirds and marine mammals (Fox and D'Andrea 2016). Marbled Murrelets were among the species detected on nearshore boat transects (2.71-8.55 birds per km² [1.05-3.30 birds per mi²] and surveys from land (1.61-6.68 birds per km² [0.62-2.58 birds per mi²]) (Strong 2015). Future efforts may provide valuable information on these winter marine bird communities, but conclusions would be premature from the available data.

Population Status

Genetic Population Structure

Varying degrees of demographic isolation or genetic diversity can have implications for adaptability and extinction risk. Several recent studies have examined the genetic population structure of Marbled Murrelets. Early work by Friesen et al. (1996a, 1997) found low but significant population structuring in Marbled Murrelets; however, small sample sizes precluded determining how those populations differed. Subsequent studies by Friesen et al. (2005) and Congdon et al. (2000) found evidence for a genetic cline (gradual change in genetic makeup across the species' geographic range), but these studies lacked murrelets from Washington or Oregon. Piatt et al. (2007) completed the first analysis of population genetic structure based on neutral genetic markers that included murrelets sampled throughout the range, including Oregon and Washington. They confirmed that Marbled Murrelets in the western and central Aleutian Islands and central California differ significantly from those in central parts of the range, and that Marbled Murrelets comprise three genetically distinct units: 1) western and central Aleutian Islands, 2) eastern Aleutian Islands to northern California, and 3) central California.

The genetic differentiation of the central California population appears to be a recent phenomenon possibly due to habitat fragmentation over the last century. Peery et al. (2010) found that the murrelet population in central California lost alleles at 3 of 9 microsatellite loci over the last century, a 6.9% decline in allelic richness. They tied this loss in genetic resources to habitat loss and fragmentation that reduced the resident breeding population. While immigration does occur, dispersing birds breed so little and contribute so few offspring that they fail to produce a "rescue" effect. Peery et al. (2010) concluded that additional habitat fragmentation may further isolate populations both demographically and genetically.

While birds in Washington and Oregon are assumed to have less restricted gene flow than those on the periphery of the range, Piatt et al. (2007) concluded that loss of any one of the above three genetically distinct units could compromise the long-term viability of the global population if an essential portion of the species' genetic resources and/or local adaptations are lost. Recent work by Vásquez-Carrillo et al. (2014) indicates that there is at least some population-level genetic differentiation within the core of the

range. They detected differences in major histocompatibility complex (MHC)-derived peptide frequencies between southeast Alaska and Oregon murrelets as well as low allele and peptide richness at individual and population levels in Oregon. They suggested that Marbled Murrelets in Oregon may be especially vulnerable to novel diseases or pathogens (since MHC diversity has been linked to disease resistance and fitness in some other bird species) and could be considered of special conservation concern. Overall, the findings of Vásquez-Carrillo et al. (2014) support the idea that maintenance of conservation units across the Marbled Murrelet range is important for preserving this species' genetic diversity and future adaptive capacity.

Population Size and Trend

North American Population

There is limited information on the historical distribution and numbers of Marbled Murrelets. Historical information has been summarized by many authors, including Marshall (1988), Carter and Erickson (1992), Leschner and Cummins (1992), Mendenhall (1992), Nelson et al. (1992), Piatt and Ford (1993), Rodway et al. (1992), Speich et al. (1992), and Ralph (1994). Anecdotal evidence and available quantitative data all suggest major population declines over the last 150 years or so (Ralph 1994, McShane et al. 2004). Steepest declines are suspected during the period of industrial logging of most murrelet habitat from 1850-1980 (McShane et al. 2004).

Recent assessments suggest that the global Marbled Murrelet population is on the order of 300,000-400,000 individuals today, with roughly 70% in Alaska, 25% in British Columbia, and 5% in Washington, Oregon, and California combined (COSEWIC 2012, Environment Canada 2014). While murrelets in Washington, Oregon, and California together represent only a small proportion of the current global population, this area accounts for about 18% of the total linear range of the species and likely supported larger populations in the past (McShane et al. 2004).

Oregon Population

For monitoring and management purposes, the USFWS Recovery Plan (USFWS 1997) recognized six recovery units or "Conservation Zones" across the federally-listed range in Washington, Oregon, and California where Marbled Murrelets are found on land or at sea (Fig. 5). These include: 1) Puget Sound (Conservation Zone 1), 2) Western Washington Coast Range (Conservation Zone 2), 3) Oregon Coast Range (Conservation Zone 3), 4) Siskiyou Coast Range (Conservation Zone 4), 5) Mendocino (Conservation Zone 5), and 6) Santa Cruz Mountains (Conservation Zone 6).

Conservation Zones 3 and the northern portion of Conservation Zone 4 occur in Oregon. Conservation Zone 3 begins at the Columbia River and runs south to North Bend, Coos County, Oregon (USFWS 1997). Conservation Zone 4 spans North Bend, Coos County, Oregon, south to the southern end of Humboldt County, California (USFWS 1997). Both zones include marine waters within 1.2 mi of the ocean shoreline and lands up to 35 mi from the coast plus any designated critical habitat units beyond that point.



Figure 5. Map of Marbled Murrelet Conservation Zones in Washington, Oregon, and California (adapted from USFWS 1997, Fig. 8, p. 114 and Falxa et al. 2016, Fig. 1-1, p. 4). Conservation Zone shapefiles were provided by the [Northwest Forest Plan's Interagency Regional Monitoring Program](#). Base map provided by Esri.

Due to the difficulty of locating and monitoring Marbled Murrelets on land, population estimates for Washington, Oregon, and California are based entirely on at-sea surveys. Through the NWFP Effectiveness Monitoring Program, standardized boat surveys have been conducted since 2000 during the breeding season in Conservation Zones 1-5. Conservation Zone 6 in central California is sampled independently of the NWFP Program and has supported a small population in recent years (Henry 2017).

Population estimates from at-sea surveys are derived from murrelet densities and the area of coastal waters sampled (Raphael et al. 2007). For the most recent year of surveys with state-level estimates (2015), average densities were 1.46 murrelets per km² [0.56 murrelets per mi²] in Washington, 5.29 murrelets per km² [2.04 murrelets per mi²] in Oregon, and 3.62 murrelets per km² [1.40 murrelets per mi²] in California, or 2.75 murrelets per km² [1.06 murrelets per mi²] for the NWFP area combined (Lynch et al. 2017). Highest at-sea densities during the breeding season have been found in southeast Alaska (e.g., 111 murrelets per km² [42.9 murrelets per mi²], Haynes et al. 2011) and British Columbia (e.g., 45.16 murrelets per km² [17.44 murrelets per mi²], Burger et al. 2008).

Lynch et al. (2017) estimated that there were approximately 24,100 Marbled Murrelets (95% CI: 19,700, 28,600) within the entire NWFP area in 2015, with approximately 10,975 of those in Oregon (95% CI: 2,276, 19,674) (Table 6, Fig. 6). The extremely wide confidence intervals in these and many other NWFP population estimates convey considerable variability, due in part to the level of survey effort and challenges of sampling a highly mobile seabird that is sparsely and patchily distributed (Falxa et al. 2016, Lynch et al. 2017).

Table 6. Annual Marbled Murrelet population size estimates for Oregon based on at-sea surveys (data from Lynch et al. 2017, Table 4, p. 14). Population size is based on murrelet densities. Ninety-five percent confidence limits and area surveyed are also indicated.

Year	Density (Murrelets per km ²)	Total Murrelets	Total Murrelets 95% CL Lower	Total Murrelets 95% CL Upper	Area (km ²)
2000	3.85	7,983	4,095	11,870	2,071
2001	4.43	9,168	5,935	12,402	2,071
2002	3.64	7,530	4,473	10,586	2,071
2003	3.56	7,380	4,547	10,213	2,075
2004	4.40	9,112	5,532	12,692	2,071
2005	3.36	6,966	4,589	9,344	2,071
2006	3.68	7,617	5,779	9,455	2,071
2007	2.59	5,357	3,009	7,704	2,071
2008	3.64	7,541	4,893	10,189	2,071
2009	3.58	7,423	4,454	10,393	2,071
2010	3.95	8,182	4,678	11,686	2,071
2011	4.05	8,379	2,209	14,550	2,071
2012	3.76	7,780	4,183	11,377	2,071
2013	4.74	9,818	6,158	13,480	2,071
2014	5.50	11,384	5,104	17,664	2,071
2015	5.29	10,975	2,276	19,674	2,071

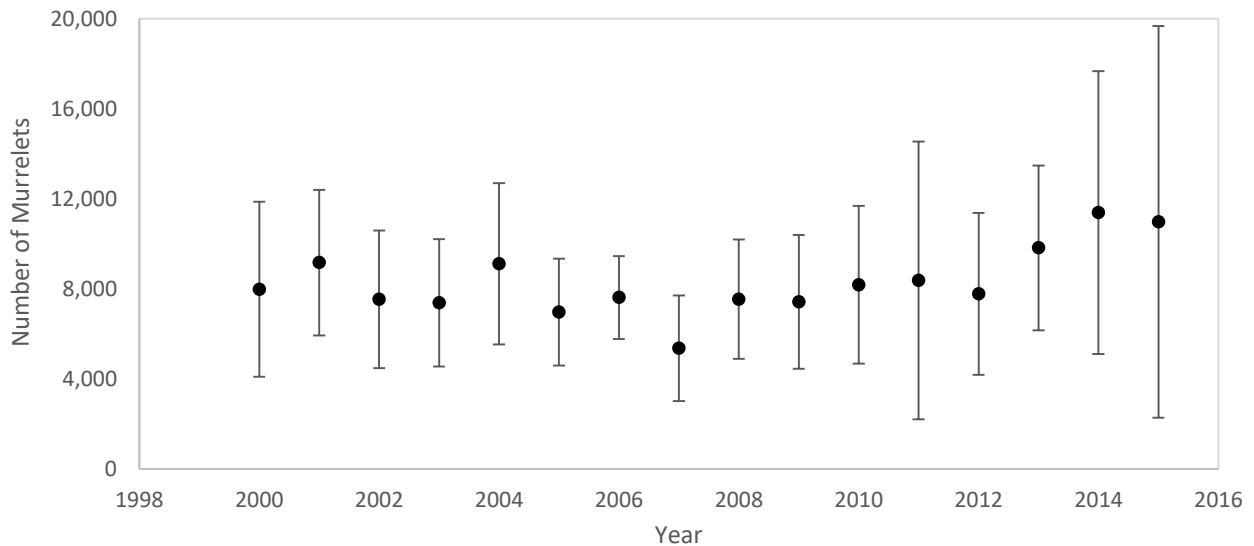


Figure 6. Annual Marbled Murrelet population estimates and 95% confidence intervals from Oregon at-sea surveys, 2000-2015 (data from Lynch et al. 2017, Table 4, p. 14). Lynch et al. (2017) also reported annual rates of change but found no evidence of a population trend in Oregon during this period (see text and Table 7).

Lynch et al. (2017) found no evidence of a trend from 2001-2015 for the entire NWFP area or for Oregon specifically (but see Washington and California trends below). They reported annual rates of change of -0.13% (95% CI: -1.7, 1.4) for the NWFP area and 1.7% (95% CI: -0.3, 3.7) for Oregon (Table 7). Since the confidence intervals overlapped zero in both instances, the evidence for a trend was inconclusive.

Table 7. Annual rates of population change based on Marbled Murrelet at-sea surveys. Ninety-five percent confidence limits are for the estimates of percent annual change. Adjusted R² values and P-values (for a 1-tailed test of whether the annual rate of change is less than zero) are also indicated (data from Lynch et al. 2017, Table 2, p. 8).

Zone or State	Period of Analysis	Annual rate of change (%)	95% CL Lower	95% CL Upper	Adjusted R²	P-value
Zone 3	2000-2016	1.1	-0.9	3.3	0.022	0.266
Zone 4	2000-2015	3.0	0.4	5.6	0.270	0.027
Oregon	2000-2015	1.7	-0.3	3.7	0.136	0.088
All Zones	2001-2015	-0.13	-1.7	1.4	0.000	0.863

The lack of a definitive trend in the NWFP area represents a departure from prior analyses. Miller et al. (2012) previously reported an annual decline of 3.7% across the NWFP area from 2000-2010 (an overall decline of 29%), but with the addition of several years of data, there is no longer evidence for a trend across the 2001-2015 time period. Mechanisms driving these recent patterns are unknown, but Falxa et al. (2016) acknowledge that aspects of sampling design and bird movement cannot be entirely ruled out. Habitat change does not likely explain at-sea density increases since 2011 because murrelet habitat takes many decades to centuries to develop (see Falxa et al. 2016). Interpretation of at-sea densities and trends is further complicated by the greater statistical power needed to detect small changes (see power analysis by Falxa and Raphael 2016); the fact that murrelets are long-lived, so there may be years of lag time before population responses to habitat changes are actually detected (Ralph et al. 1995a, Miller et al. 2012, Raphael et al. 2016b); highly variable marine conditions affecting foraging and breeding success (Burkett 1995) and potentially at-sea distribution and survey logistics (see Raphael et al. 2007); and poor understanding of bird movements and associated gene flow (Peery et al. 2010).

As with any sampling design, power to detect a change when one actually exists is an important consideration. A study with low statistical power has a reduced chance of detecting a true effect because of low sample size, small effects, or both. In their recent power analysis for the Marbled Murrelet at-sea surveys, Falxa and Raphael (2016) concluded that 95% or greater power to detect a 5% annual decline has been achieved for Zones 3 and 4. However, given highly variable estimates and current reduced sampling effort, they do not expect to achieve 80% or greater power to detect a 2% annual decline until 2020 and 2021 for Zones 3 and 4, respectively; 95% or greater power to detect a 2% annual decline will not be achieved until 2024 and 2023 for Zones 3 and 4, respectively. We understand this to mean that the ability to detect smaller annual declines in Oregon remains limited, and that statistical power should be kept in mind when interpreting at-sea survey results (most recently summarized by Lynch et al. 2017).

It is unclear to what degree dispersing birds may be affecting at-sea densities. Genetics research in central California has shown that murrelets moving from the north can mask declines in the resident population. Peery et al. (2010) found that dispersing birds in Conservation Zone 6 were not true immigrants but rather “visitors” as few nested or contributed offspring to the resident population. Birds may be moving following early nest failures elsewhere or to more productive winter foraging areas.

Population status and trend information prior to implementation of the NWFP Effectiveness Monitoring Program at-sea surveys in 2000 is very limited. Available population estimates generated for Oregon in the early-mid 1990s varied widely due to differences in survey techniques, timing, area covered, and assumptions (Table 8). The USFWS Recovery Plan (USFWS 1997, p. 17-18) underscored “the need for further development of consistent survey methods for the entire range, without which comparable estimates cannot be obtained”.

Table 8. Summary of studies estimating statewide Marbled Murrelet population size in Oregon in the 1990s (prior to implementation of standardized Northwest Forest Plan at-sea surveys in 2000). These figures do not reflect population trends, but rather various independent estimates. They should not be compared directly to current Northwest Forest Plan population estimates due to differences in methodology (see Raphael et al. 2007).

Study	Technique	Year	Estimate
Nelson et al. 1992	Shore-based	1988-1992	1,000 breeding pairs
Strong et al. 1995	Shore-based, aerial, and boat	1992, 1993	2,500 (shore-based)-22,250 (boat) individuals
Varoujean and Williams 1995	Aerial	1995	6,400-6,800 individuals

Boat-based surveys were ultimately found to be more reliable than aerial or shore-based counts due to more thorough coverage, proximity to birds, more observers, and longer scanning time (Strong et al. 1995). Strong (2003) conducted the first systematic at-sea surveys over many years (from 1992-1999) and reported a significant decline in murrelets along the central Oregon coast. He reported that murrelets declined in that region by >50%, from roughly 9,750 birds (95% CI: 4,030, 14,870) in 1992-93 to 4,100 birds (95% CI: 870, 6,440) in 1997-99. He suggested that one possibility for this steep decline was heavy logging in the Siuslaw National Forest in the 1980s, but that a population response was not detected until 1996 by at-sea surveys.

Other States and Canada

Washington

Lynch et al. (2017) estimated that there were approximately 7,494 Marbled Murrelets (95% CI: 3,667, 11,320) in Washington State in 2015. They found strong evidence for a recent downward trend in Washington. They estimated the annual rate of change at -4.4% (95% CI: -6.8, -1.9) (Lynch et al. 2017), which represents a 44% decline in murrelet abundance from 2001 to 2015 (Desimone 2016). Substantial, continued habitat loss, high rates of nest predation, and changes in the marine food web are among suspected causes of recent declines (Desimone 2016).

In the Salish Sea specifically, Lynch et al. (2017) reported a 4.9% average annual rate of decline (95% CI: 7.7, 2.1) for the 2001-2016 period. Historically, Marbled Murrelets in Puget Sound and the San Juan Islands were described as “common” or “numerous” by Rathbun (1915) and Miller (1935), as summarized by Speich et al. (1992). Puget Sound has experienced profound anthropogenic changes over the last 200 years, including widespread removal of lowland old-growth forests (Perry 1995) and high rates of land use conversion, urbanization, and nearshore habitat modification (Azous and Horner 1997, Fresh et al. 2011, Simenstad et al. 2011).

California

Lynch et al. (2017) estimated that there were approximately 5,666 Marbled Murrelets in California (excluding Conservation Zone 6) in 2015 (95% CI: 3,970, 7,362). From 2000 to 2015, there was some evidence of an increase; Lynch et al. (2017) reported an annual rate of change of +3.8% (95% CI: +0.9, +6.8). In Conservation Zone 6, estimates from 2001-2016 ranged from a low of 174 birds in 2008 (95% CI: 91, 256) to a high of 699 birds in 2003 (95% CI: 567, 860) (Henry 2017). Little nesting habitat remains in California, and contemporary rates of habitat loss are lower than in the past, so high nest predation, changes in ocean conditions that affect marine forage, and post-fledging mortality are thought to be the main mechanisms affecting murrelet recruitment in this part of the range (RIT 2012).

Alaska

Based on projections from available data, Piatt et al. (2007) estimated *Brachyramphus* murrelet populations in Alaska at approximately 415,700 birds in 1999 and 271,182⁴ birds in 2006. They reported significant annual declines of 5.4-12.7% at 5 of 8 sites since the early 1990s. Overall, their analysis indicates a rapid and widespread decline of murrelets in Alaska (about 70% from the 1980s to 2006), particularly in southeast Alaska and Prince William Sound. In Prince William Sound, declines of 2.3% per year since the 1970s have been attributed primarily to changes in the marine environment since habitat loss due to timber harvest has been relatively low there (Piatt et al. 2007).

British Columbia

The most recent population estimate for Marbled Murrelets in British Columbia, Canada, is 72,600-125,600, with a median of 99,100 birds (Bertram et al. 2007 in COSEWIC 2012). Using radar counts of Marbled Murrelets across six conservation zones, Bertram et al. (2015) reported an annual rate of change of -1.6% (95% CI: -3.2%, 0.01%) from 1996 to 2013, though the confidence intervals just overlapped zero at the 95% level. At the conservation region scale, they found strong evidence for declines in East Vancouver Island (-9% per year) and the South Mainland Coast (-3% per year). Piatt et al. (2007) also reported declines in at-sea densities of Marbled Murrelets using available data spanning 1979 to 2006 and concluded that there is “a consistent pattern of decline in numbers of Marbled Murrelets wherever there are reasonable data to test trends in British Columbia” (p. 54). Declines have

⁴ This estimate includes both Marbled Murrelets and Kittlitz’s Murrelets. After accounting for the estimated population of Kittlitz’s Murrelets (approximately 33,736 birds), Environment Canada (2014) reported that the Alaska Marbled Murrelet population was 237,500 birds in 2006.

been linked to extensive loss of forest nesting habitat and changes in marine conditions that affect prey availability (Burger 1995, Piatt et al. 2007, Bertram et al. 2015).

Demographics

Longevity, Age at First Breeding, Fecundity, and Sex Ratio

Compared with other alcids, Marbled Murrelets are long-lived and have delayed sexual maturity and low fecundity (Nelson 1997). Generation time (average age of parents in the population, as defined by COSEWIC 2012) has been estimated at about 10 years (Burger 2002, McShane et al. 2004, COSEWIC 2012), and lifespan is not believed to exceed 25 years (McShane et al. 2004). Marbled Murrelets presumably begin nesting at 2-5 years of age (Beissinger 1995, De Santo and Nelson 1995, McShane et al. 2004). They lay only one egg per clutch and re-nesting rates are low, so nest success (number of fledglings produced per pair of adults that attempt breeding in a given year) has substantial influence on overall fecundity (number of female offspring fledged per adult female per year) (Burger 2002, Peery and Henry 2010).

A sex ratio of 1:1 for adults and juveniles is likely (reviewed in Burger 2002, McShane et al. 2004).

Demographic Models

Models can be useful tools for understanding, explaining, and predicting the dynamics and persistence of populations. They can signal stable or unstable populations based on varying fecundity and survival inputs. Most demographic models published in the peer-reviewed literature for Marbled Murrelets have relied on relatively simple Leslie Matrix models. While these models have many assumptions and are limited by our understanding of vital rates and future conditions, they nonetheless provide insights into the demographic, environmental, and stochastic factors affecting population viability and extinction risk. In the most recent demographic modeling for the federally-listed range, McShane et al. (2004) used a series of female-only, multi-aged, discrete-time stochastic Leslie Matrix models to project population size by zone over 40 years. Among their assumptions were that annual adult survivorship was 83-92%, nest success was 0.324-0.460 for Zone 3 and 0.230-0.324 in Zone 4, juvenile:adult ratios (see below) were 0.080 for Zone 3 and 0.084 for Zone 4, and that 90% of adults breed in most years (the latter was reduced to 50% in “severe El Niños”, modeled to occur in 3 of every 25 years). They forecasted mean annual rates of decline of 2-6% across all zones initially. Earlier modeling efforts produced similar rates of decline of 4-7% per year for the federally-listed range (Beissinger 1995, Beissinger and Nur 1997).

McShane et al. (2004) also reported extinction probabilities by zone over 100 years. They projected probabilities of extinction of: 1) 100% within 40 years for Zones 5 and 6, 2) 0% within 40 years and 100% within 100 years for Zones 2, 3, and 4, and 3) 0% within 40 years and 25% within 100 years for Zone 1. For the entire federally-listed population, the probability of extinction within 100 years was 16%, with a mean 3-state population size of 45 birds (all within Zone 1). For Oregon specifically (Zones 3-4), the probability of extinction exceeded 80% by 2060 for Zone 4 and exceeded 80% by 2100 for Zone 3. Projections were especially sensitive to immigration rates and fecundity. Under the model inputs and

assumptions, these results signal high extinction risk for Marbled Murrelets in Oregon within the century.

Recent field studies (e.g., Peery et al. 2004; Beissinger and Peery 2007; CCR 2008, 2013; Lorenz et al. 2017) suggest that the above fecundity, breeding propensity, and nest success values used by McShane et al. (2004) may, in fact, be optimistic (see Reproductive Success below). Further studies to obtain vital rate data for Oregon and elsewhere in the range will help to refine models in the future.

Survival

Early Marbled Murrelet population models relied on an adult survival value of 0.85-0.90 derived from other alcids (Beissinger 1995, Beissinger and Nur 1997). Subsequent field studies have supported the assumption of high adult survival. Cam et al. (2003) provided the first direct survival estimates of 0.93 (95% CI: 0.63-0.99) and 0.83 (95% CI: 0.72, 0.90) from two samples in a Marbled Murrelet mark-recapture study in British Columbia. Peery et al. (2006) estimated annual survival rates for after-hatch-year Marbled Murrelets in central California and reported survival rates of 0.868 and 0.896 for untagged males and females, respectively, and 0.531 and 0.572 for radio-tagged males and females, respectively; mortality of radio-tagged birds was highest during a domoic acid algal bloom.

Reproductive Success

Marbled Murrelet reproductive success is determined by a combination of marine and terrestrial factors, such as nest predation, timing, foraging conditions, prey availability, and adult survival during the breeding season (McShane et al. 2004). While population growth may be most affected by adult survival, sustained low reproductive success can also limit populations (Burger 2002, McShane et al. 2004, COSEWIC 2012). Breeding parameter estimates are derived from direct monitoring of located nests, telemetry, counts of juvenile birds at-sea, and population modeling. All have certain biases and assumptions, though telemetry estimates are thought to be the most reliable (McShane et al. 2004, Piatt et al. 2007). Across the federally-listed range, nearly all available estimates point to poor breeding success (e.g., McShane et al. 2004; Peery et al. 2004; Beissinger and Peery 2007; CCR 2008, 2013; Lorenz et al. 2017).

Juvenile:Adult Ratios

Due to the difficulty of finding murrelet nests and capturing birds for telemetry, ratios of newly-fledged juveniles (hatch-year birds) to after-hatch-year birds (adults and subadults) at sea, or juvenile:adult ratios, are sometimes used as an indirect measure of breeding success. The reliability of juvenile:adult ratios measured at sea has long been debated (Ralph and Long 1995, Kuletz and Kendall 1998, Loughheed et al. 2002), and while adjustments are often applied in an attempt to reduce biases, such adjustments remain largely unverified (McShane et al. 2004, Piatt et al. 2007, Crescent Coastal Research 2013). Therefore, these ratios are best treated as indices of reproductive performance. It is also important to note that juvenile:adult ratios differ from nest success estimates since the ratios incorporate early post-fledging mortality (Piatt et al. 2007).

Modeling by Beissinger and Nur (1997) has indicated that juvenile:adult ratios of 0.18-0.28 are required to maintain recruitment sufficient for stable populations. Estimated juvenile:adult ratios vary widely across the range, though all within Washington, Oregon, and California suggest very low breeding success relative to British Columbia (see USFWS 2009, p. 5 and p. 22), and in comparison to other bird species (Beissinger and Peery 2003). Recent adjusted and unadjusted values range from 0.0254-0.0598 for Oregon (Crescent Coastal Research 2008, see “state” estimates in Table 9) and 0.010-0.078 for Conservation Zone 4 (Crescent Coastal Research 2013).

Table 9. Productivity indices of Marbled Murrelets in Oregon from 1992 to 2008. Values represent the percentage of hatch-year to after-hatch-year Marbled Murrelets counted at sea for each of 3 regions of the Oregon coast (northern, central, southern) and for all regions combined (state) (data from Crescent Coastal Research 2008, Table 5, p. 13). Note that data include all aged birds observed on boat-based surveys after 20 July, 1992 to 2008; 2004 and 2006 data also include shore-based observations.

Year	Northern	Central	Southern	State
1992	6.60	3.04	2.03	2.86
1993	1.56	0.99	No data	1.11
1994	5.04	2.54	3.31	2.99
1995	12.28	2.68	4.34	3.80
1996	7.14	2.58	2.98	2.81
1997	7.27	2.01	4.76	2.76
1998	8.82	1.96	2.44	2.40
1999	8.14	2.44	3.03	2.82
2000	5.77	7.14	11.55	8.04
2001 ¹	1.77	3.81	6.52	4.26
2002	18.33	4.81	4.59	6.52
2003	8.93	3.33	8.28	4.64
2004	1.96	2.57	2.56	2.54
2005	No data	No data	No data	No data
2006	4.00	1.76	7.21	3.78
2007	No data	2.76	8.56	5.98
2008	No data	2.39	7.48	3.00

¹ Includes all data after 10 July.

Beissinger and Peery (2007) provide a unique perspective on how juvenile:adult ratios may have changed over time, at least in central California. They estimated historical (1892-1922) demographic rates reconstructed from museum specimens and compared them to contemporary (1997-2003) values from field studies. While adult survival estimates were similar among both periods, historical age ratios were 8-9 times greater than contemporary values (0.297 vs. 0.032-0.035), signaling a major depression in productivity.

Nest Success, Breeding Propensity, and Other Measures of Fecundity

In Oregon, telemetry data on nest success are not available, but of 22 nests with known outcomes, 8 were successful (36%; S.K. Nelson, pers. comm.). High nest predation, particularly by corvids, is widely

recognized as a leading cause of nest failure in the federally-listed range (Nelson and Hamer 1995b, USFWS 1997, McShane et al. 2004, USFWS 2009), and the general consensus is that predation pressure is increasing (see Predation below for more information). Other causes of nest failure include abandonment by parents, chicks falling from nests, and chick death (Nelson and Hamer 1995b). More robust estimates of Marbled Murrelet nest success, breeding propensity, and fecundity are available outside of Oregon. Bradley et al. (2004) inferred measures of breeding success using radio telemetry from 1998-2001 in British Columbia. Their estimates of 0.19-0.23 female offspring per adult female per year are among the highest reported for the species. They also documented average annual minimum breeding propensity at 0.65 (range: 0.55-0.79) and a nest success rate of 0.38-0.48.

Demographic models by Beissinger and Nur (1997) estimated that fecundity values of 0.20-0.46 are required to maintain stable murrelet populations within the federally-listed range. Extremely poor breeding success has been documented in Washington and California in recent years and may be linked to changes in the marine environment. In central California, Peery et al. (2004) reported low breeding propensity (0.31), a nest success rate of 0.16, and fecundity estimates of 0.042 from at-sea surveys and 0.027 from radiotelemetry in 2000 and 2001. They concluded that reproduction in central California was limited by food availability in some years and nest predation in others. In Washington, Lorenz et al. (2017) estimated breeding propensity at 0.131-0.200 in radio-marked birds from 2004 to 2008. Only 4 of 157 tagged murrelets successfully fledged young. They documented lengthy nest-sea commuting distances and large marine ranges, suggesting poor foraging conditions in Puget Sound and the Strait of Juan de Fuca.

Mortality

Predation

Marbled Murrelets exhibit many strategies that likely evolved as antipredator defenses. Behavioral and morphological traits that may help murrelets avoid detection at or around nests include limited parental care at nests, nest visitation primarily at dawn or dusk (low light conditions), rapid flights to/from nests and within the nesting area, cryptic coloration of eggs, cryptic plumage of chicks and adults, minimal or muted vocalizations from nests, remaining still or flattening against tree branches in response to predators, and selection of sites with high amounts of cover above or adjacent to nests (reviewed in Nelson 1997). Moreover, murrelet nests are dispersed on the landscape, and they are typically placed high in the upper canopy of older conifers.

All life stages of Marbled Murrelets are vulnerable to predation (Nelson and Hamer 1995b, Nelson 1997, Burger 2002, Piatt et al. 2007). As summarized by Piatt et al. (2007), known or suspected avian predators of adult murrelets include Bald Eagle (*Haliaeetus leucocephalus*), Peregrine Falcon (*Falco peregrinus*), Northern Goshawk (*Accipiter gentilis*), Sharp-shinned Hawk (*A. striatus*), and Common Raven (*Corvus corax*). Known or suspected avian nest predators include Common Raven, Steller's Jay, Sharp-shinned Hawk, Great-horned Owl (*Bubo virginianus*), Barred Owl (*Strix varia*), Cooper's Hawk (*A. cooperii*), Northwestern Crow (*C. caurinus*), American Crow (*C. brachyrhynchos*), and Gray Jay (*Perisoreus canadensis*) (reviewed in McShane et al. 2004), and corvids are the suspected cause of most nest losses (Nelson and Hamer 1995b, Raphael et al. 2002). Small mammals (e.g., mice, squirrels) are also suspected

nest predators (Nelson 1997, Burger 2002, McShane et al. 2004). Occasional predators at sea may include Western Gull (*Larus occidentalis*), Steller sea lion (*Eumetopias jubatus*), California sea lion (*Zalophus californianus*), or even large fish (Nelson 1997, Burger 2002, McShane et al. 2004). Corvids are believed to have the greatest impact on the species (USFWS 2009), though recovering populations of Peregrine Falcons and Bald Eagles have been identified as an emerging concern (RIT 2012).

Habitat fragmentation has been linked to greater predation risk for Marbled Murrelets. Nesting in marginal habitat, higher predator densities, and/or preferential predator foraging along edges in fragmented forests are among mechanisms that could result in heavier predation pressure (Marzluff and Restani 1999, Raphael et al. 2002, Marzluff et al. 2004). Corvids, in particular, have increased in many areas, benefitting from changes to the landscape, such as clearing that creates shrublands rich in berries and insects (Marzluff et al. 2004), and anthropogenic food sources (Marzluff et al. 2001, Marzluff and Neatherlin 2006). Several studies have reported higher rates of murrelet nest predation near forest edges (e.g., Nelson and Hamer 1995b, Manley and Nelson 1999, Raphael et al. 2002). For example, in an artificial nest study in Washington, Raphael et al. (2002) found that 80% of nests were visited by potential predators within 30 days. Nests close to forest edges experienced higher rates of predation, particularly near human habitation and campgrounds. Recreation in forested areas (and their associated campgrounds, picnic areas, and human refuse) and development or agriculture near murrelet nesting habitat provide supplemental food sources for predators, so controlling access to anthropogenic food in the landscape has been recommended to reduce predation threats (Marzluff and Neatherlin 2006).

Disease/Parasites

Disease has not been identified as a major threat to the Marbled Murrelet (McShane et al. 2004). However, seabirds can be affected by a range of bacterial, fungal, parasitic, and viral diseases. Small or declining populations and/or those stressed by other factors may be especially vulnerable to disease impacts. Highly Pathogenic Avian Influenza (HPAI) and West Nile Virus have been detected in wild birds in Oregon and represent emerging concerns. Given their forest nesting habits and presumed increased exposure to mosquito vectors, Marbled Murrelets may be more susceptible to West Nile Virus than other seabirds (McShane et al. 2004).

Alcids are believed to be susceptible to aspergillosis in captivity (Muzaffar and Jones 2004; C. Gillin, pers. comm.). While aspergillosis is not known to be a mortality factor for Marbled Murrelets in Oregon, available records from the USFWS indicate that at least five murrelets entered rehabilitation facilities in Oregon from the 1990s to present (L. Henry, pers. comm.), providing a potential avenue for exposure to aspergillosis.

Parasites have also been reported in many alcids, including Marbled Murrelets (Muzaffar and Jones 2004).

Other Mortality

Starvation likely accounts for some birds discovered washed up on beaches (Nelson 1997). Data sent to ODFW by the Coastal Observation and Seabird Survey Team (COASST) included records for a total of 63

Marbled Murrelet carcasses found on beached bird surveys conducted from 2001 to 2016 along the Pacific Coast from northern California to southern Washington; 28 carcasses were from Oregon. Carcass deposition followed a bimodal pattern, with peaks in carcass abundance in August (presumably associated with breeding/post-breeding mortality) and November-January (winter mortality). Beaching rates were low overall, with peak mean carcass encounter rates in August of approximately 1 bird per 200 km [124 mi] of beach surveyed. After accounting for survey effort, periods with higher-than-usual carcass encounter rates occurred in fall and winter of 2007-2008 and 2014-2015 in Oregon (plus fall and winter of 2015-2016 when including northern California and southern Washington) (COASST, unpubl. data). Marbled Murrelet mortality in 2014-2016 may have been associated with a warm water anomaly in the northeast Pacific that was also linked to mass stranding of dead or starving Cassin's Auklets (*Ptychoramphus aleuticus*) (COASST, unpubl. summary).

As discussed above, causes of chick mortality can include nest abandonment by parents, falling from the nest, or grounding of fledglings attempting to reach the ocean (Nelson and Hamer 1995b). Additional known or potential sources of mortality (entanglement, oiling, bird strikes, barotrauma, contaminants, and biofouling and domoic acid poisoning from harmful algal blooms) are discussed in Chapter 3.

Summary

- The Marbled Murrelet has a unique life history in that it uses inland forests for nesting across much of its range and the ocean for foraging, loafing, courtship, molting, and preening.
- The species is primarily associated with old-growth and mature forests with specific attributes (e.g., platforms with moss or other substrate). Nest-site selection has likely been influenced by predator avoidance and by the flight and energetic capabilities of murrelets.
- The Marbled Murrelet breeding range extends from Alaska to central California along the Pacific Coast. Within this range, there is evidence of three genetically distinct populations: 1) western and central Aleutian Islands, 2) eastern Aleutian Islands to northern California, and 3) central California. There is also evidence of some local genetic variation within the core of the species' range. In Oregon and elsewhere in the federally-listed range, large gaps in breeding distribution have been attributed to anthropogenic habitat loss.
- Marbled Murrelets feed on small schooling fish and marine invertebrates. Adults prefer mostly larval and juvenile fishes but select larger fish for their chicks, presumably to maximize energetics or minimize predation risk since they must commute between inland nest sites and at-sea foraging locations.
- Variability in the marine environment can affect prey abundance, distribution, timing, and quality, with consequences for murrelet diet and breeding success. While murrelets are flexible foragers, they may be unable to adapt to environmental changes that reduce prey quality and availability over the long-term.
- Marbled Murrelets are long-lived and have delayed sexual maturity. They have low fecundity and may not breed every year.
- Marbled Murrelets experience high levels of predation. Nest success may be limited by increasing predator numbers and predation rates, particularly near human activities and in fragmented forests. Recovering raptor populations may also impact adult and juvenile survival, but mortality rates are unknown.

- Changes in late-successional forests in Oregon since European settlement, due to timber harvest, fire, wind, and other factors, have significantly reduced Marbled Murrelet nesting habitat. Since 1993, further habitat losses have occurred, mainly due to timber harvest on nonfederal lands and wildfire on federal lands.
- Fragmentation of forest nesting habitat not only reduces the total amount of habitat available, but also the quality of areas that remain.
- The current Oregon Marbled Murrelet population is thought to be much smaller than existed historically. There are no available surveys that provide a continuous assessment of population trends from 1995 to the present. A significant decline (>50%) on Oregon's central coast was first detected in 1996 through at-sea surveys conducted from 1992-1999. However, surveys conducted for the NWFP Effectiveness Monitoring Program from 2000-2015 had an inconclusive trend. It appears that the Oregon population may now be fluctuating around a new, lower baseline. Based on densities of Marbled Murrelets at sea, the Oregon population was estimated at 10,975 birds in 2015 and is likely somewhere between a wide range of 2,276 and 19,674 birds.
- In the last few decades, habitat loss and Marbled Murrelet declines have been documented in parts of Alaska and British Columbia, where the bulk of the North American population resides. In Washington, there is evidence of a 44% population decline from 2001 to 2015, and a net loss of 13.3% of suitable habitat acreage from 1992 to 2013. In northern California, there was a slightly positive population trend from 2001 to 2015, but a net loss of 17.8% of suitable habitat acreage from 1992 to 2013. Only very small numbers of murrelets remain in central California (estimates ranged from 174-699 birds from 2001-2016).
- Available measures of breeding success and demographic models do not lead to the conclusion that fecundity is sufficient to yield a stable or increasing population in Oregon.

Chapter 3: Factors Influencing Survival and Reproductive Potential

Introduction

At the time that the Marbled Murrelet was listed as state-threatened in 1995, ODFW identified a variety of natural and human-induced factors that could affect the species' "natural reproductive potential"⁵ and continued existence in Oregon. These were termed "influencing factors" and included:

- Limited geographic distribution
- Nesting habitat alteration (habitat loss and degradation)
- Natural large-scale disturbances (e.g., fires, wind storms)
- Small population size
- Declining population
- Predation
- Adverse ocean and weather conditions (effects of variability on prey resources)
- Gillnet fisheries
- Other fisheries (i.e., competition for prey resources with fisheries)
- Oil spills
- Pollution (mainly, effluent discharges from pulp and paper mills)

Small population size and declining population were understood to be results of other factors but were included since they themselves also affect the "natural reproductive potential" of the Marbled Murrelet. ODFW (1995) concluded that the most important influencing factors were nesting habitat alteration, small population size, declining population, and oil spill events.

Since 1995, some threats or risks to the Marbled Murrelet have increased, some have remained about the same, others have been reduced, and some new ones have been identified. In their 2004 and 2009 5-year reviews for the federally-listed distinct population segment, the USFWS reported that threats from habitat loss, predation, and oil spill mortality remained high (McShane et al. 2004, USFWS 2009; Tables 10 and 11). In their 2009 review, they also identified many new or increasing threats, including changes in prey availability and quality, harmful algal blooms and biotoxins, low-oxygen "dead zones" in the ocean, climate change effects, elevated levels of polychlorinated biphenyls (PCBs) in murrelet prey species (mainly a concern in the Salish Sea), entanglement from derelict fishing gear, energy development, and disturbance in the marine environment (USFWS 2009; Table 10). More recently, in 2012, the Marbled Murrelet Recovery Implementation Team (RIT) convened by the USFWS identified the following top five mechanisms, in ranked order, for sustained low recruitment of murrelets in Oregon and the south coast of Washington: 1) loss of terrestrial habitat, 2) nest predation, 3) changes in

⁵ In order to list a species as threatened or endangered under the Oregon Endangered Species Act, ORS 496.176(3) and OAR 635-100-0105 require a determination by the Commission that the natural reproductive potential of the species is in danger of failure. Natural reproductive failure is reached when a species or population is not replacing itself.

marine forage, 4) cumulative and interactive effects, and 5) post-fledging mortality (RIT 2012). The purpose of this chapter is to examine these and other current “influencing factors” for the Marbled Murrelet in Oregon, with an emphasis on new scientific information or analysis since initial state-listing.

Discussion of Influencing Factors

Limited Geographic Distribution

At a broad scale, the distribution of the Marbled Murrelet is fairly continuous from the Aleutian Islands to California. There are, however, gaps within that distribution. At the extreme ends of the range (e.g., California and the Aleutian Islands), murrelets are sparse. Although Oregon is in the southern part of the species’ range, it is not at the extreme southern limits of the range.

The smaller populations at the limits of the species’ range may be particularly vulnerable to extirpation. There is also evidence that they have distinct genetic characteristics (Piatt et al. 2007, Peery et al. 2010). In central California, human-caused habitat fragmentation may be responsible for the recent genetic differentiation detected in that murrelet population (Peery et al. 2010). The loss of these peripheral populations could potentially reduce the capacity of the species overall to adapt to long-term environmental changes (see Piatt et al. 2007). Recent work by Vásquez-Carrillo et al. (2014) indicates that there is some population-level genetic differentiation within the core of the range as well.

Historically, it is likely that there were always gaps within the species’ range due to effects of fire, wind, distribution or availability of prey, and other factors. However, large gaps in the species’ distribution today, particularly in southwest Washington, northwest Oregon, and central California, have been attributed to anthropogenic habitat loss and conversion (Ralph et al. 1995a, USFWS 1997, RIT 2012). Once suitable habitat is removed, there is no evidence that Marbled Murrelets nest in small diameter trees, fly further inland to nest in other forested areas (e.g., the Cascades), or “pack” into remaining areas at higher densities. High breeding site fidelity and energetic and flight constraints may preclude colonization of new areas, though breeding in new areas may be more likely if other suitable habitat is nearby (RIT 2012).

Unlike many other seabirds, Marbled Murrelets also have a limited distribution in the ocean. They use nearshore marine waters for foraging, courtship, loafing, molting, and preening. During the breeding season, they have to make daily flights to and from the ocean to provision their chicks. Their at-sea distribution during the breeding season tends to be correlated with the amount and cohesion of suitable nesting habitat nearby, suggesting an important connection between high quality terrestrial and marine habitat (Raphael et al. 2015, Raphael et al. 2016b, Lorenz et al. 2016). More research is needed to determine the full extent of wintering range, however.

Further contraction of an already limited distribution, combined with the potential for catastrophic events, present additional risk factors to the species.

Table 10. Summary of Marbled Murrelet threats and threat levels as assessed by the U.S. Fish and Wildlife Service. At the time of federal listing in 1992, loss and modification of older forest nesting habitat were identified as the primary threats to the Marbled Murrelet, with mortality from oil spills and gillnet fisheries (entanglement) identified as secondary threats. Since 1992, the U.S. Fish and Wildlife Service has conducted two status reviews for murrelets in Washington, Oregon, and California (McShane et al. 2004, USFWS 2009). Threats and threat levels evaluated in these reviews are briefly summarized below.

Review	Threat Level Relative to 1992			New Threat(s) Identified
	Greater	Similar or Unchanged	Reduced	
McShane et al. 2004	Predation	Ongoing and past habitat loss, oil spill mortality, unpredictable and stochastic events (e.g., fires, insect outbreaks, windstorms), Pacific Decadal Oscillation and El Niño/La Niña events, marine contaminants, noise disturbance, genetic viability, research impacts	Annual rate of habitat loss (due to regulatory mechanisms), loss of occupied sites due to survey error, gillnet mortality	Increased risk of disease (considered potential threat only)
Review	Threat Level Relative to 2004			New Threat(s) Identified
	Greater	Similar or Unchanged	Reduced	
USFWS 2009	Changes in the marine environment, particularly those that reduce prey availability and quality (see also new threats to right)	Habitat loss and degradation, predation, oil spill mortality, gillnet mortality, disturbance from boat traffic or noise, predation	Inadequacy of regulatory mechanisms	Energy development and production, entanglement from derelict fishing gear, exposure to elevated underwater sound levels, harmful algal blooms and biotoxins, oceanic “dead zones”, climate change effects, elevated contaminant levels in murrelet prey, disease again acknowledged as potential threat (with addition of highly pathogenic avian influenza an emerging concern)

Table 11. Threat of habitat loss to murrelets in 1997 compared with 2003 (reproduced from Table 4.6-1, p. 4-108, McShane et al. 2004). In their 2004 5-year review, the U.S. Fish and Wildlife Service concluded that there was continued loss of suitable habitat since federal listing in 1992. They summarized the state of the knowledge on this topic in 1997 (when the federal Recovery Plan was published) and in 2003.

Recovery Plan - 1997	Status in 2003
Murrelets use forests that primarily include old-growth, but also use mature forests with old-growth component (remnant trees).	Similar understanding of habitat use. Further study has shown a more restricted inland distribution in northern California and southern Oregon than previously known.
Recovery time for habitat once lost is generally 100-200 years.	Similar understanding.
Population still suffers from large-scale loss of habitat in the past, primarily due to timber harvest.	Habitat loss has continued, without appreciable development of new habitat. The population is still likely to be suffering from the effects of habitat loss.
Habitat loss is a threat to the recovery of the species. Recovery actions recommend maintaining occupied sites and minimize loss of suitable habitat.	Habitat loss has continued. Known occupied habitat has been lost. Loss of suitable habitat is expected to continue in the future based on ongoing Section 7 consultations and full implementation of approved HCPs. Since 1994, the rate of habitat loss has declined substantially on federal land under the NWFP, and the rate has likely declined in Washington where state protection guidelines have been developed. The relative threat of habitat loss has not changed on nonfederal land in Oregon, which has no ⁶ protective measures, or California, which protects the murrelet under state ESA.
Recommend increasing habitat amounts, but will likely take 50-100 years or more.	No estimated appreciable development of new habitat.
Historical loss of habitat resulted in reduced vigor of the species that now makes the murrelet more vulnerable to environmental fluctuations and catastrophes. Chance events such as floods, fire, oil spills, and windstorms could now cause or facilitate the extirpation of the entire listed species or specific zone populations.	Since development of the Recovery Plan, the largest single natural stochastic event resulting in murrelet habitat loss was the Biscuit Fire (14,878 acres of murrelet habitat lost) in southwestern Oregon. This chance event has caused further habitat reduction that may further increase the vulnerability of the species to future stochastic events or management projects.

⁶ Footnote added by ODFW (not part of original table): However, the federal ESA does apply to habitat protection on nonfederal lands in Oregon.

Forest Habitat Alteration

Marbled Murrelets in Oregon are closely associated with forests with certain characteristics for nesting (see Chapter 2). Habitat loss and degradation were primary reasons for federal and state listings of the species in the 1990s, and several recent studies show a positive correlation between murrelet abundance and the amount and cohesion of suitable habitat (e.g., Raphael et al. 2015, Raphael et al. 2016b, Lorenz et al. 2016). Examples of alteration of forest habitats associated with human activities include:

- Direct elimination of habitat
- Conversion of habitat to other uses
- Fragmentation of habitat
- Direct or indirect changes in forest composition or characteristics
- Shrinkage of range or change in distribution of habitat, creating gaps in habitat

Marbled Murrelet old-growth and late-successional forest nesting habitat in the Pacific Northwest has been substantially reduced since European settlement (Perry 1995, USFWS 1997). While the NWFP and other regulations have slowed rates of habitat loss on federal lands since the 1990s, some losses have still occurred, and considerable timber harvest has continued on nonfederal lands. Raphael et al. (2016a) estimated that higher-suitability habitat in Oregon declined from 853,400 ac in 1993 to 774,800 ac in 2012, a net loss of 78,600 ac (-9.2%). On federal lands, losses were mostly due to wildfire, whereas those on nonfederal lands were largely the result of timber harvest.

It is not only the quantity of habitat available that may affect Marbled Murrelet breeding success or survival, but also the distribution and quality of this habitat which are important. Remaining habitat is highly fragmented in Oregon, and most of it persists on public lands. Raphael et al. (2016a) classified nearly 90% of potential habitat on nonfederal lands as “edge”, whereas federal lands had lower (>70-80%) but still high proportions of edge. Edge effects can degrade otherwise suitable forest remnants through changes in abiotic or biotic conditions. Examples of adverse edge effects that could result from recent clearcuts include elevated predator densities and predation levels, greater windthrow damage, and reduced epiphyte abundance needed for nesting substrate relative to forest interiors (Nelson and Hamer 1995b, McShane et al. 2004, van Rooyen et al. 2011). Raphael et al. (2016a) noted that the large amount of younger, “lower-suitability” forest lands currently in reserved (protected) areas holds potential to offset habitat losses and reduce fragmentation in the future if it is allowed to grow and mature.

Large-Scale Disturbances

Periodic wind, fire, tree disease, and insect infestations have always played a role in shaping forests within the range of the Marbled Murrelet. These events can destroy large areas of nesting habitat and increase forest fragmentation. On the other hand, in particular circumstances at the local level, disturbances sometimes create suitable nesting habitat by stimulating development of particular structural features or small, natural canopy gaps. In addition, old-growth trees can often survive low to moderate severity fires, unlike younger trees.

Because current habitat is now limited and disconnected, severe disturbances have the potential to remove key patches that cannot be replaced in the near-term. For example, the 2002 Biscuit Fire in southern Oregon removed over 20,000 ac of higher-suitability habitat (Raphael et al. 2016a). While multiple factors (e.g., climate, weather, topography, vegetation structure/composition/fuels, fire suppression) affect the duration and intensity of fire across the landscape, many studies have concluded that fires are becoming larger and more frequent in the West (e.g., Stephens 2005, Westerling et al. 2006, Kitzberger et al. 2007, Littell et al. 2009, Miller et al. 2009, Westerling 2016). According to Westerling (2016), fire season length in the Pacific Northwest increased from 23 days in the 1970s to 116 days in the 2000s due to declining snowpack and earlier spring snowmelt. Oregon, unlike parts of California and Washington, is not generally subject to large-scale windstorms. However, there have been exceptions (e.g., the Columbus Day Storm of 1962), and fragmented forests may be more vulnerable to windthrow (Franklin and Forman 1987, Burton 2002).

Climate change is expected to increase potential for habitat loss due to wildfire, insect infestations, disease outbreaks, and severe storms (reviewed in Dalton et al. 2017). Habitat quality could also be impacted through changes in temperature, moisture, or other conditions that affect moss growth (RIT 2012, van Rooyen et al. 2011). The magnitude of these effects on murrelets in Oregon is uncertain at this time.

Small Population Size

Small population size is both a result of other factors, and itself a factor influencing the natural reproductive potential of the Marbled Murrelet.

Marbled Murrelets were once “common” in Oregon, but it appears that the population has declined significantly since scientific observations began in the early 1900s (Nelson et al. 1992). Compared with population sizes in Alaska and British Columbia, Oregon’s population is small. Based on 2015 at-sea surveys, the Oregon population is roughly 10,975 birds, and likely somewhere between 2,276 and 19,674 birds (Lynch et al. 2017).

Generally speaking, small populations are more vulnerable to events such as storms, fires, and oil spills, and could even be entirely eliminated in large events. Small populations may take longer to recover from such events, if they are even able to recover. This is particularly true for a species like the Marbled Murrelet, whose life history characteristics include elements such as: lays only one egg, does not breed every year, and does not become reproductively active until 2-5 years of age.

In addition to vulnerability to catastrophic events, small populations are increasingly vulnerable to loss of genetic diversity, environmental and demographic variation, inbreeding depression, and possibly increased difficulty in finding mates. The combined effects of these risks has been likened to a vortex that tends to drive small populations to extinction (Gilpin and Soulé 1986).

It is not known whether recolonization would occur from populations outside Oregon if Oregon’s population were to be extirpated, or if a catastrophic event were to significantly reduce Oregon’s population. Current assumptions about high breeding site fidelity suggest recolonization is unlikely.

Although small population size is of concern, it is uncertain to what level Oregon's population can decline before it poses a significant threat to its natural reproductive potential and continued population viability. All available demographic information indicates that recruitment is too low for birds to replace themselves. Based on predictions of demographic models by McShane et al. (2004), using what may be optimistic population parameters (e.g., survival = 83-92%, breeding propensity = 90% in most years, nest success = 23-46%), extinction probability is high in Oregon (over 80% by 2060 for Zone 4, over 80% by 2100 for Zone 3). McShane et al. (2004) defined extinction as fewer than 30 individuals per zone but cautioned that "extinction may be almost certain at higher zone sub-population sizes". Recent genetics research suggests that there is at least some population-level differentiation in the core of the Marbled Murrelet range and that Oregon murrelets may be more vulnerable to novel diseases or pathogens (Vásquez-Carrillo et al. 2014).

Declining Population

Declining population is both a result of other factors, and itself a factor influencing the natural reproductive potential of the Marbled Murrelet. Past declines can also alter population dynamics and population resiliency (RIT 2012).

Demographic data are sparse for Oregon, and there are known limitations to at-sea surveys and modeling approaches used to determine population size and trends. Telemetry studies currently underway in Oregon will help to fill some data gaps, but that information is not yet available.

In evaluating trends in the Oregon Marbled Murrelet population, we briefly summarize the available information presented in Chapter 2 below. We consider evidence for declines across multiple time scales (historical, 1990s, 2000s):

- There is widespread agreement that Marbled Murrelet populations in Washington, Oregon, and California have undergone considerable declines since European settlement (Ralph 1994, McShane et al. 2004). Declines from historical levels have been largely inferred from anecdotal information and large-scale loss of older forest nesting habitat.
- At-sea surveys conducted by Strong (2003) from 1992-1999 detected a significant decline in murrelets along the central Oregon coast in 1996, where the bulk of the Oregon population is found.
- Based on at-sea surveys conducted for the NWFP Effectiveness Monitoring Program from 2000-2015, evidence for a trend was inconclusive at the scales of the NWFP area (Washington, Oregon, and northern California combined) and Oregon (Falxa et al. 2016, Lynch et al. 2017). A prior review by Miller et al. (2012) reported a 30% decline in the federally-listed Marbled Murrelet population of Washington, Oregon, and California for the 2000-2010 period. It is unclear what is driving population levels since 2011. Habitat growth is an unlikely explanation given that murrelet habitat takes many decades to centuries to develop (see Falxa et al. 2016).
- Very low juvenile:adult ratios (indices of productivity) have been observed at sea over the last two decades.
- High nest predation rates, in combination with reductions in prey availability or quality that can adversely affect breeding propensity and success, support the idea that recruitment is low and may be insufficient to maintain a stable population.

- Demographic models, many of which have relied on fecundity estimates higher than recently published values from within the federally-listed range, signal that the probability of extirpation may be high in Oregon.
- The best available data suggest that habitat loss is contributing to contemporary Marbled Murrelet population trends (Raphael et al. 2016b). Loss and degradation of older forest nesting habitat occurred at unprecedented levels over the last 150-200 years. While rates of loss have been lower since the 1990s, losses have continued, particularly on nonfederal lands.
- There may be a time lag before population response due to habitat change is detected by current at-sea monitoring methods. Since Marbled Murrelets are long-lived and assumed to have high breeding site fidelity, adults may survive at sea for years as non-breeders or failed breeders (Ralph et al. 1995a, Miller et al. 2012, Raphael et al. 2016b). Genetics research in central California has also shown that dispersing individuals from the north seldom recruit into the breeding population or successfully produce young, thereby masking underlying declines in the resident population (Peery et al. 2010).

There is considerable uncertainty in the current size and trend of the Marbled Murrelet population in Oregon. However, the weight of evidence suggests that the population remains depleted (relative to historical levels), experienced a significant (>50%) decline in the 1990s, and may now be fluctuating around a new, lower “baseline” level.

Predation by Corvids and Other Species

Throughout the Marbled Murrelet’s evolutionary history, the species has survived with some level of predation and still sustained its population. However, contemporary predation rates are considered high for a species that has low fecundity and delayed sexual maturity.

Predation, particularly by corvids, was recognized as a major cause of Marbled Murrelet nest failure in the 1990s. Recent reviews confirm the importance of predation in murrelet nesting outcomes (McShane et al. 2004, USFWS 2009). As discussed in Chapter 2, corvid and other generalist predator populations continue to increase as a result of human activities and land use changes. Forest fragmentation and “edge effects” may contribute to elevated predation rates by increasing predator densities, allowing them easier access into stands and/or influencing predator foraging behavior along edges. Anthropogenic food sources from campgrounds, trails, picnic areas, or other human settlements in or around murrelet nesting habitat can also support more predators and affect predator activity.

Recovering raptor (e.g., Bald Eagles, Peregrine Falcons) populations pose a new potential threat to adult and juvenile murrelet survival (RIT 2012). This is of particular concern given that murrelet population growth is thought to be influenced most by adult and subadult survival (McShane et al. 2004). Depredation of adult murrelets by Peregrine Falcons, Sharp-shinned Hawks, Common Ravens, Northern Goshawks, and Bald Eagles has been documented, but there is no information on mortality rates (McShane et al. 2004).

Predation pressure is expected to remain high or even increase in the future.

Competition

Very little information is available on possible competitive interactions between Marbled Murrelets and other piscivorous species. Reviews by Burger (2002) and COSEWIC (2012) acknowledged potential for competition with Common Murres (*Uria aalge*) and Rhinoceros Auklets (*Cerorhinca monocerata*) due to similar diets. They speculated that invasions of warm water predatory fishes or other piscivores (e.g., Pacific mackerel, *Scomber japonicus*; jack mackerel, *Trachurus symmetricus*; Humboldt squid, *Dosidicus gigas*) might also reduce forage fish availability for murrelets in some years in British Columbia.

Murrelets are known to both initiate foraging flocks and to follow other birds to foraging flocks (Mahon et al. 1992, Hunt 1995, Ostrand 1999), but they have rarely been seen in mixed flocks in the southern part of the range (Hunt 1995, Strachan et al. 1995). In Oregon, murrelets have been observed feeding near Common Murres and Pigeon Guillemots (*Cepphus columba*), but they seem to avoid large feeding flocks of murres, cormorants, or other species (Strong et al. 1993 in Strachan et al. 1995). Marbled Murrelets might avoid other species when foraging to minimize impacts of aggression or competition by larger alcids (Burger et al. 2008, Ronconi and Burger 2011), kleptoparasitism or predation by gulls (Strong et al. 1993 in Strachan et al. 1995, Hunt 1995), or disruptions in cooperative murrelet foraging behavior (Strachan et al. 1995).

Despite some public perceptions, there is currently no evidence that Marbled Murrelets are adversely affected by competition with Double-crested Cormorants (*Phalacrocorax auritus*) in Oregon. Unlike nearshore-foraging murrelets, estuaries are thought to be the most important foraging areas for Double-crested Cormorants in Oregon. Cormorant distribution is clumped spatially along the coast near major estuaries, with most colonies occurring either within estuaries themselves, or within 10 km [6.2 mi] of the nearest major estuary (Adkins and Roby 2010; ODFW, unpubl. data). ODFW surveys confirm high use of estuaries by cormorants (ODFW, unpubl. data). A preference for estuarine habitat is also supported by the only telemetry study of Double-crested Cormorants in Oregon (Anderson et al. 2004), which found that radio-tagged cormorants nesting on East Sand Island remained exclusively within the Columbia River estuary to forage, even though foraging habitats in nearshore waters outside the estuary were located within 8 km [5 mi] of the colony site, well within the foraging range for both male and female cormorants (Anderson et al. 2004).

Human Disturbance

Boat Disturbance

Several studies have reported behavioral responses of Marbled Murrelets to boat traffic (reviewed in McShane et al. 2004, Piatt et al. 2007, USFWS 2009, COSEWIC 2012). Boat disturbance can disrupt foraging or resting birds on the water, potentially increasing energetic costs or displacing them from preferred at-sea areas.

At Pacific Rim National Park Reserve, British Columbia, Bellefleur et al. (2009) observed murrelet-boat interactions. Most murrelets reacted (by diving or flying) to boats when they came within 40 m [131 ft]; murrelet age, boat speed, and boat density were important predictors of flushing response. Specifically,

murrelets flushed at greater distances when boats were traveling at higher speeds, and they tended to fly out of the foraging area altogether when boats were traveling >28 kph [17 mph]. Juveniles also flushed more readily than adults. Flushing distances actually decreased in areas with high boat density, but more murrelets flushed in these areas, leading the authors to conclude that murrelets were less committed to feeding in areas with high boat traffic.

In another study in Auke Bay, Alaska, Speckman et al. (2004) observed that adult murrelets holding fish in their bills, presumably for later delivery to chicks, often dove and swallowed these fish when repeatedly approached by boat. They concluded that loss of prey from disturbance could incur energetic costs to breeding murrelets.

The degree to which murrelets can habituate to repeated disturbances, and the extent to which vessel traffic has large-scale or long-term consequences on murrelet populations or fitness, remains unknown. The above information suggests that many or fast-moving boats in murrelet habitat can cause energetic impacts or force birds to feed in less productive areas. Areas outside of Oregon, such as Puget Sound or Monterey Bay, are of particular concern (USFWS 2009).

Other Disturbance

In their last review, the USFWS (see USFWS 2009) identified “exposure to elevated sound levels” as a factor affecting the continued existence of the Marbled Murrelet. High underwater sound pressure levels, such as those produced by pile driving and underwater detonations, can cause mortality or sublethal injuries or impairment known as barotraumas to murrelets or other vertebrates. Barotrauma can include hemorrhage or rupture of internal organs, hemorrhaged eyes, ruptured eardrums, etc. Currently, this factor is of primary concern in Washington, mainly Puget Sound (USFWS 2009).

At nest sites, there is little information on the effects of noise disturbance on Marbled Murrelets. Impacts are generally thought to be minimal, based largely on anecdotal observations, but McShane et al. (2004) emphasized that noise disturbance cannot be dismissed. Golightly et al. (2009) in USFWS (2009) reported that murrelets were more likely to nest further away from paved roads than random sites.

Disease/Parasites – This topic is discussed in Chapter 2 and is considered a potential threat to the Marbled Murrelet.

Energy Development

The potential for wave and offshore energy projects to impact seabirds, including murrelets, depends largely on their location and the type of equipment installed. If placed in sensitive areas, projects may adversely affect marine habitat through night-lighting, changes in prey abundance, and/or increased human disturbance (USFWS 2009). Projects may also degrade onshore habitat through construction and operation of ancillary facilities within or adjacent to forested onshore habitat. Bird strikes or entanglement, exhaustion due to attraction to night-lighting, reduced attentiveness to young at the nest, or other impacts to survival or fitness are possible. Conversely, in cases where projects are sited

outside the species' foraging area, there may be little or no impact to murrelets. Since the Marbled Murrelet's winter distribution (when they may be found further offshore) is largely unknown, some potential impacts cannot be ruled out at this time.

Wave Energy Projects

In Oregon, one wave energy test center was established in 2012 to test off-grid small-scale devices and has supported testing of one wave energy conversion device. This test center is located approximately 2 mi off of Newport within Oregon's Territorial Sea. A second test center is being considered for a Federal Energy Regulatory Commission (FERC) license and would support testing of commercial-scale devices and arrays approximately 6 nautical mi off of Newport on the outer continental shelf. Other short-term, small-scale tests have occurred within Oregon's Territorial Sea off of Warrenton, Newport, and Charleston, as authorized by state and federal permits. The Reedsport Ocean Power Technologies Wave Park was authorized in 2012 by a FERC license to install a 10-buoy array approximately 2.5 nautical mi off of Reedsport in Douglas County. Construction was initiated, however in 2014 Ocean Power Technologies announced that the project would not be built and filed for surrender of license.

Offshore Wind Projects

One offshore wind project proponent applied for a Bureau of Ocean Energy Management lease in a 15 mi² area approximately 16 nautical mi off of Coos Bay, but announced in 2016 that the project would not be built and withdrew their commercial lease request. One or more large commercial-scale offshore wind projects have been proposed approximately 26 nautical mi off of Point Estero, California, but no lease has been issued at this time.

Onshore Wind Projects

We are not aware of any onshore wind energy projects currently proposed along the coast of Oregon.

Transmission Lines

Electrical transmission lines require permanent vegetation removal within their right-of-way, which can range from 100 to 1000 ft in width, depending on the voltage of the line. This could remove nesting habitat if the transmission line must go through late-successional forest within the range of the murrelet. There is currently a 115kV transmission line proposed from Tillamook to Oceanside. This right-of-way would be permanently cleared of vegetation for 13 mi in a 100-ft width, some of which passes through forest habitat. However, the majority of the forests in this area are second-to-third growth timber production areas not likely to be used by nesting murrelets.

Liquefied Natural Gas Terminals and Pipelines

There is currently one liquefied natural gas terminal and pipeline proposed in Oregon through the inland range of the Marbled Murrelet, the Jordan Cove Energy Project. The Jordan Cove Energy Project is a proposed liquefied natural gas export facility in Coos Bay, Oregon, and an associated Pacific Connector

Gas Pipeline would run roughly 233 mi from Coos Bay across the Coast Range to Malin, Oregon, in the Klamath Range. The joint project was originally initiated with a notice of intent in November 2004. Since that time, the project has gone through two different iterations with FERC, which ended in March 2016 with a denial of the project by FERC, who cited a lack of a buyer for the export material as well as insufficient agreement from affected landowners. In January 2017, the development company resubmitted a proposal to FERC with a modified plan for the export facility in Coos Bay, an established buyer in Asia, as well as a realigned plan for the pipeline. Project scoping is underway, the development company is preparing its preliminary documents for FERC and working to secure right-of-way agreements with the affected landowners along the pipeline route. The Jordan Cove Energy Project portion of the project has little potential for impact to murrelets aside from temporary construction activities in Coos Bay (in-water blasting, dredging). The Pacific Connector Gas Pipeline portion of the project would traverse the murrelet inland range, with potential for some loss or fragmentation of current or future murrelet nesting habitat. Protocol surveys were conducted along the proposed routes by the development company's representatives in multiple years from 2007-2015. Current estimated acreage of impacted murrelet habitat is unavailable since the route is not final yet. In the previous iteration, the estimate was for roughly 600 ac of direct impact through vegetation removal.

Adverse Oceanic Conditions (Changes in Prey Distribution, Abundance, Timing, and Quality)

As described in Chapter 2, variability in ocean conditions (winds, temperatures, upwelling patterns) can affect marine productivity, and ultimately, the distribution, abundance, timing, and quality of prey available to murrelets. Marbled Murrelets consume a diverse group of prey, suggesting some degree of flexibility in prey choice and the capacity to switch when necessary. This makes sense from an adaptive standpoint since prey populations are naturally dynamic. Nevertheless, the evidence indicates that the flexibility to switch prey and alter their activity budget are not adequate to ensure reproductive success during years when ocean productivity is extremely poor (Ronconi and Burger 2008). Because murrelets are long-lived, short-term phenomena such as typical El Niño events or a year with poor ocean productivity would not be expected to adversely affect murrelet populations over the long-term. However, murrelets may not be able to compensate for long periods of unfavorable conditions or increased variability in prey resources, especially in combination with other anthropogenic threats and stressors. Climate change is expected to exacerbate these impacts.

A growing body of evidence indicates that low recruitment in the murrelet is linked, in part, to changes in the marine environment (Peery et al. 2004, Becker and Beissinger 2006, Becker et al. 2007, Norris et al. 2007, Gutowsky et al. 2009, USFWS 2009, Lorenz et al. 2017). During the breeding season, reductions in prey quality or quantity may lead to nest abandonment or failure. During the pre-breeding season, murrelets may fail to initiate nesting altogether without sufficient food resources. Centennial shifts toward lower quality prey types have been documented in both central California and the Salish Sea (Becker and Beissinger 2006, Norris et al. 2007, Gutowsky et al. 2009). Murrelet breeding success appears to be positively associated with an abundance of mid-trophic level prey and cooler ocean temperatures (Becker et al. 2007). Oregon's coastal surface waters have warmed an average of 0.5°F per decade over the latter half of the 20th century and are expected to increase by approximately an additional 2.2°F by the mid-21st century (Mote et al. 2010). The waters off Oregon are also becoming

more stratified. The thermocline is 10-20 m [33-66 ft] deeper off Oregon in the early 21st century than it was in the middle of the 20th century (Huyer et al. 2007). Stronger stratification will make ocean mixing due to wind patterns less effective at bringing nutrients to the surface, thereby reducing primary productivity (Osgood 2008, Hoegh-Guldberg and Bruno 2010).

Habitat loss and degradation in coastal and nearshore areas may also affect Marbled Murrelets and their prey. For example, Lorenz et al. (2016) found that murrelets in Washington tended to avoid areas with higher human footprint, an index based on human population density, light pollution, and transportation infrastructure. In addition, many murrelet forage fish species depend on intact nearshore and estuarine habitat for successful spawning, rearing, or migration. Other threats and stressors in the marine environment, such as harmful algal blooms, dead zones, biotoxins, contaminants, and fishing pressures, are discussed elsewhere in this chapter.

Climate Change Effects on Terrestrial and Marine Habitat

While there will undoubtedly be species “winners” and “losers” in the context of climate change, there are currently few indications that Marbled Murrelets will see benefits from a warming climate (USFWS 2009). Rather, best available information signals increasing stressors and threats unfavorable to the species. Given their low reproductive potential, narrow habitat requirements in both terrestrial and marine systems, breeding site fidelity, and restricted distribution, Marbled Murrelets may not be as resilient as some other species to changing conditions. A recent assessment by Case (2014) described the Marbled Murrelet as highly sensitive to climate change; of the 114 Pacific Northwest bird species analyzed, the Marbled Murrelet had the highest climate-sensitivity score.

There is already strong evidence that climate change is affecting ecosystems in the Pacific Northwest and globally (IPCC 2014, Blunden and Arndt 2016, Dalton et al. 2017). In their most recent climate assessment for Oregon, Dalton et al. (2017) reported that:

- From 1895 to 2015, Oregon’s mean temperature warmed 2.2°F per century.
- The winter of 2015 was the warmest on record and was characterized by a “snow drought”, in which most precipitation fell as rain instead of snow, resulting in record-low snow pack and altered hydrological regimes. Such conditions may occur regularly by mid-century.
- Under even the most optimistic scenarios, Oregon’s climate is expected to warm at least 2-5°F by the 2050s and 2-7°F by the 2080s.
- Increasing wildfire activity due to warmer, drier summers; wetter winters, reduced winter snow pack, and more frequent extreme rainfall events; spread of forest pests and pathogens; and vegetation shifts are among projected impacts of further climate warming in Oregon.

For Marbled Murrelets, climate change effects in the marine environment may be especially important (USFWS 2009). Tillmann and Siemann (2011) reviewed climate change effects in marine and coastal systems within the North Pacific Landscape Conservation Cooperative, which extends from southcentral Alaska to northern California. Among their key findings are that ocean acidity is increasing, sea surface temperatures are rising, storm intensity and extreme wave heights are increasing, sea levels are rising (though effects vary by location), and anomalous hypoxic events in the California Current may be characteristic of future change. They underscored that these trends are expected to continue, with

potential for increased coastal erosion, habitat loss, spread of invasive species, range shifts, and altered phenology (and likely decoupling of some predator-prey relationships due to mismatches in timing of biological and physical processes, see also Sydeman and Bograd 2009).

Effects on nutrient levels, primary productivity, and ultimately, the amount, distribution, and quality of food available to murrelets are of particular concern (USFWS 2009). While murrelets have likely adapted to some variability in ocean conditions, the cumulative or synergistic effects of more frequent, severe, or longer duration events such as El Niño could contribute to population declines or even extirpations (Burkett 1995, USFWS 2009, Tillmann and Siemann 2011). Climate models indicate that ocean warming is accelerating and will continue in the future, though changes in El Niño Southern Oscillation (ENSO) and Pacific Decadal Oscillation are less certain (Dalton et al. 2017). Nevertheless, a reconstruction of ENSO events from 1525 to 2002 found that although extreme ENSO events occurred throughout the 478 year period, there was an increase in strong, very strong, and extreme El Niño events beginning in the late 19th century, and 55% of the extreme El Niño events occurred in the 20th century (Gergis and Fowler 2009). Gergis and Fowler (2009) also found that 28% of all protracted ENSO events (those lasting more than 3 years) occurred during the 20th century and suggested that ENSO may operate differently under industrial age conditions of increased atmospheric carbon dioxide than it did previously. A strong El Niño event occurred in 2009-2010, and an even stronger El Niño occurred in 2014-2016, which suggests that the trends reported by Gergis and Fowler (2009) could be continuing in the 21st century. Similarly, Black et al. (2014) found that variability of winter upwelling in the CCS increased during the latter part of the 20th century and was only equaled twice over the last 600 years. This increase in variability was caused by an unprecedented succession of extreme downwelling-favorable winter climate conditions that reduced productivity for marine predators such as seabirds (Black et al. 2014). Results from a model by Zhang and Delworth (2016) showed that Pacific Decadal Oscillation amplitude was reduced and time scale shortened under a warming climate.

Bakun (1990) proposed that a warming climate would intensify upwelling-favorable winds, particularly during the warm season, in eastern boundary currents like the CCS with potentially dramatic effects on these ecosystems. This theory has shaped scientific research and debate and was updated in 2015 (Bakun et al. 2015), but remains unresolved. A preponderance of published studies provide support for the theory that upwelling-favorable winds have increased in three of the five eastern boundary current systems, including the CCS (Sydeman et al. 2014). These authors noted that observational studies were more likely than modeling studies to show intensified upwelling-favorable winds, that seasonal patterns existed, and that the intensification was greater in higher latitudes, which was consistent with the patterns of warming. Another study also found a poleward shift in upwelling-favorable winds, but the majority of climate models examined projected future weakening of upwelling-favorable winds in the CCS by the end of this century under high emissions scenarios (Rykaczewski et al. 2015).

There is also evidence that the timing of the annual upwelling cycle may change with changes in climate, and that such changes can affect breeding success of the Marbled Murrelet. Barth et al. (2007) described the one month delay in the spring transition to upwelling-favorable winds during 2005 and the ecological changes observed in much of the food web. They noted that such a delay in the spring transition followed by stronger upwelling winds later in the year as occurred in 2005 is consistent with predictions of the influence of a warming climate (Bakun 1990, Snyder et al. 2003). Reproductive failures

for the Cassin's Auklet and extremely poor reproductive success for the Marbled Murrelet in 2005 were attributed to the change in timing of the wind-driven upwelling, which resulted in low prey resources at a critical time of their reproductive cycle (Sydeman et al. 2006, Ronconi and Burger 2008).

Unusually warm ocean conditions from 2014-2016 provide additional insights into the ecological effects that a warmer future ocean along the Oregon coast might have. An anomalously warm water mass known as "The Blob" (Bond et al. 2015) formed in the Gulf of Alaska in fall 2013 and spread across the entire North Pacific by 2014. These warm waters combined with a strong El Niño the following year, keeping sea surface temperatures elevated off the Oregon coast through 2016. During "The Blob", the zooplankton community off the Oregon coast was dominated by small, lipid-poor tropical and subtropical copepods and gelatinous zooplankton, including new species not previously detected off Newport since sampling began in 1969, krill biomass was the lowest on record, and other unusual reptile and fish species were observed thousands of km outside of their usual ranges (Peterson et al. 2015).

Given the complexity of these systems, it is clear that more research is needed to refine model projections and to improve our understanding of how climate change effects will influence biological communities. At this point, the environmental proxies utilized to characterize oceanographic changes at various scales do not appear to fully capture what drives Marbled Murrelet reproductive success. Further work is needed on direct measures of murrelet prey resources and their effects on recruitment.

Harmful Algal Blooms and Dead Zones

Harmful algal blooms are a natural occurrence but are likely becoming more frequent and severe due to human activities (Lopez et al. 2008, Diaz and Rosenberg 2008, Anderson 2009). Climate change is expected to exacerbate conditions that contribute to harmful algal blooms (Diaz and Rosenberg 2008, Lopez et al. 2008, McKibben et al. 2017). Many harmful algal blooms are caused by dinoflagellates, but some are caused by diatoms.

Impacts of harmful algal blooms vary widely, depending on the causative species (Horner et al. 1997, Lopez et al. 2008). Some microalgae produce potent neurotoxins that can bioaccumulate up the food web, causing neurological impairment, reproductive failure, or death in seabirds and marine mammals when contaminated prey are ingested (Gulland et al. 2002, Shumway et al. 2003, Lopez et al. 2008, Goldstein et al. 2009). *Pseudo-nitzschia* blooms along the Pacific Coast have killed at least small numbers of Marbled Murrelets in the past due to domoic acid poisoning (USFWS 2009). The last couple of years have seen unprecedented closures of fisheries (e.g., Dungeness crab, *Metacarcinus magister*; razor clams, *Siliqua patula*) in Oregon nearshore waters and along the entire West Coast from Alaska to California due to domoic acid concerns for human health.

Other harmful algal blooms are nontoxic but can still have adverse effects on marine ecosystems. Some form large algae masses that later die and decompose, creating hypoxic or anoxic conditions that lead to fish kills or "dead zones" (Diaz and Rosenberg 2008, Lopez et al. 2008). Still others produce compounds that reduce feather waterproofing of seabirds (Jessup et al. 2009, Phillips et al. 2011). Anomalous upwelling conditions in 2009 led to the first recorded seabird mortality in Oregon from *Akashiwo sanguinea*, a dinoflagellate whose cellular breakdown created a proteinaceous foam that coated

feathers much like oiling; based on the hundreds of birds found stranded on public beaches in southern Washington and northern Oregon, at least seven seabird species were affected (Phillips et al. 2011).

Seasonal hypoxic conditions off the Oregon coast are thought to be a recent phenomenon, driven by climatic changes that affect primary productivity and upwelling intensity (Erhardt et al. 2014). Since 2002, this low-oxygen zone or “dead zone” has formed during the summer in nearshore waters along the continental shelf of the central Oregon coast. These extreme, low-oxygen conditions were especially severe and extensive in 2006, covering 3,000 km² [1,158 mi²] occupying up to 80% of the water column in shelf waters <60 m [197 ft] deep, and persisting from June to October (Chan et al. 2008).

Entanglement

Gillnet Fisheries

During the federal listing of the Marbled Murrelet as a threatened species by the USFWS, mortality of Marbled Murrelets due to accidental capture in gillnets was identified as one of the major threats to murrelet populations (57 FR 45328). It was also identified as an important factor in listing of the species in British Columbia and California and Washington states (Ralph et al. 1995a).

Since the 1980s, murrelet bycatch in California and Washington has likely been reduced due to fishery restrictions (McShane et al. 2004, USFWS 2009). Gillnet bycatch was considered “rare” by Desimone (2016) in a recent Washington State status review. Piatt et al. (2007) stated that mortality due to bycatch in British Columbia and Alaska is “difficult to measure” but estimated “in the low thousands per year”.

Murrelet mortality due to gillnet fishing is not considered to be a problem in Oregon, since it has been prohibited in Oregon’s estuaries, bays, and along the outer coast since 1942 (Nelson et al. 1992, Carter et al. 1995). Gill-net fishing is permitted in the Columbia River, but it is highly limited, and few murrelets occur there.

Derelict Fishing Gear

Impacts from derelict fishing nets are not believed to be significant for murrelets in Oregon due to lack of net fisheries along the Oregon coast, but may be greater in other parts of the range (USFWS 2009). There is, however, potential for adverse effects of derelict pots on some murrelet prey species (USFWS 2009).

Plastic and Marine Debris Ingestion

Ingestion of floating bits of plastic, fishing line, and marine debris has been documented in many seabirds, but is not known to be a problem for Marbled Murrelets (Fry 1995, Burger 2002).

Vulnerability to Other Fisheries (Prey Depletion)

Commercial and non-commercial harvest of herring, sardines, and other marine species important to Marbled Murrelets has potential to affect the species' survival and reproductive success (Burkett 1995, Becker and Beissinger 2006, McShane et al. 2004, USFWS 2009). Some forage fish species are not directly targeted by fisheries but are still taken as bycatch. The shift in murrelet diet to lower-quality prey items (trophic level decline) in the Monterey Bay ecosystem over the last century may have been due, in part, to the collapse of the sardine fishery in the 1940s followed by heavy fishing pressure on other forage species since the 1980s (Becker and Beissinger 2006). In southern Washington and northern Oregon, the USFWS-convened RIT expressed some concern over the sardine fishery in the Columbia River Plume due to possible effects on murrelet prey resources (RIT 2012).

There is little information on the relative importance of different prey species to Marbled Murrelets in Oregon, or where fisheries may overlap with murrelet diet and foraging areas. While landings of some commercially and recreationally harvested forage fish stocks have been tracked for decades, interpretation of such data is complicated by variable marine conditions, complex food webs, fishing effort, and uncertain availability to murrelets. Murrelets also prefer small larval and subadult fish, whereas fisheries tend to target larger adult fish (Burkett 1995, Piatt et al. 2007). Long-term data from Common Murres at the Yaquina Bay colony have shown that murre diet tends to be dominated by clupeids in warm water years and sand lance, northern anchovy, and flatfishes in cooler water years (Gladics et al. 2015). Common Murres have similar diet and foraging habits to murrelets, though they may feed further offshore (Burger et al. 2008, Materna et al. 2011).

A brief synopsis of available information on the status of forage fish in Oregon follows:

- For northern anchovy and surf smelt, population trends and abundance are largely unknown. However, there is some information that suggests a decline in the northern substock of northern anchovy from the 1970s to the mid-1990s (Emmett et al. 1997). Anecdotally, the once-plentiful smelt runs in the Yachats area celebrated in annual festivals no longer seem to be present.
- For Pacific herring, the only assessment data available are for spawning stock surveys at Yaquina Bay; 2017 was the first commercial harvest in the roe fishery since 2003. Since the 1980s, most herring were landed in Newport, likely as part of the Yaquina Bay roe herring fishery (ODFW, unpubl. data).
- The northern subpopulation of Pacific sardines occurs in Oregon. It has trended downward in recent years (Hill et al. 2017), and there was no targeted commercial fishery in 2016-17.
- Spawning areas, abundance, and status are largely unknown for forage fish species not regularly harvested in Oregon (e.g., Pacific sand lance, osmerid smelts; ODFW 2016).
- The southern distinct population segment of the Pacific eulachon (*Thaleichthys pacificus*) was listed as threatened under the federal ESA in 2010 (75 FR 13012). Since the 1980s, nearly all eulachon were landed in the Columbia River rather than the ocean in Oregon (ODFW, unpubl. data).
- Since Marbled Murrelet state-listing in 1995, several protection measures have been implemented for forage fish in Oregon, including state (ORS 509.515) and federal (74 FR 33372) bans on directed krill harvest in waters off of Oregon in 2003 and 2009, respectively, the

establishment of marine reserves and marine protected areas in 2012, and the adoption of a state-level management plan for six groups of forage fish in 2016. These topics are discussed further in Chapter 4.

At this time, there is insufficient information to determine whether prey depletion or competition with commercial or recreational fisheries for marine forage species in Oregon is impacting Marbled Murrelets. Forage fish are facing a multitude of their own threats and stressors, from habitat loss and degradation to ocean acidification. Separating out the role of fishing pressures in murrelet diet will require much more study.

Oil Spills

Marbled Murrelets have one of the highest oil spill vulnerability ratings of any Pacific seabird because they feed in local concentrations close to shore and spend most of their time swimming on the sea surface (King and Sanger 1979, Wahl et al. 1981). The threat of oil spills was recognized as an important factor in the initial federal and state listings of the species in the 1990s and remains a significant concern today.

As summarized by Carter and Kuletz (1995), large oil spills may result from oil tanker, barge, or other large vessel accidents (e.g., groundings, collisions, explosions, accidental spillages), offshore oil wells (e.g., blow-outs, accidental spillages), unloading/loading cargo from onshore and offshore facilities, and onshore facility spills that enter the ocean. Small spills are due to cleaning of tanks at sea, bilge pumping, and various other accidental leaks or discharges. All types of boats and marine transportation vessels may be involved (Carter and Kuletz 1995). Both large spills and chronic oiling (from small or unreported spills) can impact seabirds (USFWS 2005).

Multiple large oil spills have occurred along the Pacific Coast (Carter and Kuletz 1995, USFWS 2005, USFWS 2009). Most of these have happened in shipping lanes or near ports (USFWS 2005). In Oregon, the higher vessel traffic and larger commercial shipping volume in the vicinity of the Columbia River put that area at particular risk for a large spill (RIT 2012).

Major oil spills in or around Oregon are summarized in Table 12 below. In 1999, the *New Carissa* cargo vessel that ran aground and split apart on the southern Oregon coast released over 70,000 gallons of fuel, killing or injuring an estimated 2,465 seabirds, including 262 Marbled Murrelets. This spill has had the greatest documented murrelet mortality in Oregon.

One of the largest spills in recent history, the 1989 Exxon Valdez oil spill in Prince William Sound, Alaska, is estimated to have killed about 8,400 *Brachyramphus* murrelets (Carter and Kuletz 1995, Piatt and Naslund 1995). This was the largest single murrelet mortality event in the world (Carter and Kuletz 1995). Of all species affected by that spill, alcids had the highest rate of mortality, and of the six alcid species affected, Marbled Murrelets suffered the highest mortality (Carter and Kuletz 1995).

A spill occurrence off the Oregon coast has the potential to have a major impact on Oregon's Marbled Murrelet population, depending on the location of the spill, its magnitude, season of occurrence, and

speed and effectiveness of cleanup activities. Impacts would be greatest if spills occurred where Marbled Murrelets are in concentrations. Exposure to oil (e.g., ingestion during preening, fouling of plumage) can impair thermoregulation, flight ability, reproductive behavior, and/or physiological functions, with lethal or sub-lethal effects (USFWS 2005). A spill could also cause indirect mortality or effects (i.e., if prey base is negatively impacted) (Carter and Kuletz 1995, Peterson et al. 2003). For example, even low levels of oil can result in developmental defects and mortality in herring embryos (Incardona et al. 2007, 2015).

Table 12. Summary of Marbled Murrelet mortality from oil spills in or around Oregon (adapted from USFWS 2009, Table 11, p. 57 and McShane et al. 2004, Table 5.4-1, p. 5-18).

Month	Year	Oil Spill Name	No. Murrelets Recovered²	Estimated Mortality¹
Feb	1979	Lincoln Co. Coast	[1-10]	[10-200]
Mar	1980	Lincoln Co. Coast	[1-10]	[10-200]
Nov	1983	Blue Magpie	2-4	[20-80]
Jul	1991	Tenyo Maru	[5]	[25-50]
Feb-Mar	1999	New Carissa	26	262
Mar	1999	Oregon/Washington Mystery Spill	2	[20]

¹Numbers in square brackets were roughly estimated by McShane et al. (2004) using a correction factor of 10-20 times those recovered (Ford et al. 2002 in McShane et al. 2004).

²McShane et al. (2004) assumed minimal rates of 1 bird per year.

Although large oil spill events do not have a high probability of occurring, history suggests that the likelihood of effective containment and recovery of oil from large spills is low. Depending on the location of the spill, and distribution, location, and concentration of Marbled Murrelets, these events could have a considerable impact on the survival and reproduction of the Marbled Murrelet in Oregon. Tanker and shipping traffic has increased since federal listing and is likely to increase further as the human population continues to grow on the West Coast (USFWS 1997, 2005, 2009).

Contaminants

The degree to which contaminants affect Marbled Murrelets is uncertain. Some contaminants can be transferred or biomagnified through trophic levels in the food chain, with the potential to increase morbidity or mortality and reduce fitness of top predators like piscivorous seabirds. In Puget Sound, with its high degree of hydrologic isolation and heavy urbanization, contaminants in murrelet prey species are of particular concern (USFWS 2009, RIT 2012). For example, West et al. (2008) found that Pacific herring in Puget Sound were 3 to 9 times more contaminated with PCBs compared to Strait of Georgia herring and 1.5 to 2.5 times more contaminated with levels of dichlorodiphenyl-trichloroethane and its isomers (DDTs).

In Oregon, the Columbia River and several sites in the Coos Bay estuary remain key sources of current and legacy contaminants (Buck 2004, USFWS 2005), but they are not known to be important foraging

areas for murrelets. Elevated contaminant levels (e.g., PCBs, dichlorodiphenyl-dichloroethylene (DDE), mercury) were reported in eggs of most piscivorous birds sampled in the Columbia River estuary in the early 1990s relative to species lower in the food chain (Buck 2004). Concentrations in some piscivorous birds, such as Caspian Terns (*Hydroprogne caspia*), Double-crested Cormorants, and Bald Eagles, exceeded effect thresholds (Buck 2004).

Common Murres, a species with similar foraging habits to Marbled Murrelets, in Oregon are known to accumulate organic and inorganic contaminants in concentrations that may produce sub-lethal or synergistic effects (Materna et al. 2011). Exposure pathways could come from point and/or non-point (e.g., from runoff or atmospheric deposition) sources.

Chlorinated organic effluent discharges from bleach pulp and paper mills identified by Fry (1995) as a potential threat to murrelets feeding in areas of effluent discharge are no longer a major concern. Since the 1990s, discharge from mills has been regulated, and industry has switched to non-chlorine bleaches, thereby reducing release of dioxins and furans into the environment (Buck 2004, USFWS 2005).

Overall Assessment of Influencing Factors

In this chapter, we examined a wide range of threats, stressors, and risk factors that could affect Marbled Murrelet survival and reproductive success in Oregon. Key threats identified in 1995, including forest habitat alteration, large-scale disturbances, small population size, predation, changes in prey quality and availability, and oil spill mortality, have not improved or have worsened since state listing (i.e., they remain high), and many new threats have been identified, particularly in the marine environment. Competition, disease/parasites, human disturbance, entanglement from gillnet fisheries or derelict fishing gear, and plastic and marine debris ingestion do not appear to pose a serious threat to murrelets in Oregon at this time. Changes in threat level posed by limited geographic distribution, declining population, prey depletion due to fisheries, and other pollution or contaminants are difficult to assess due to limited information. There are also indications that incidence or extent of harmful algal blooms, biotoxins, and dead zones is increasing, and that climate change may exacerbate conditions unfavorable to murrelets, but the magnitude of these effects is uncertain.

Individually, many of these influencing factors may represent a significant threat to the natural reproductive potential of the Marbled Murrelet. However, we have not been able to determine the significance of each factor relative to each of the others. It is likely that the cumulative or synergistic effects of these factors pose an even greater threat to the species (RIT 2012). Under the best of situations, a small population may be able to sustain itself, but if cumulative effects or even a single catastrophic event occurs, a smaller population may be unable to recover to previous levels. This is particularly true for a species like the Marbled Murrelet, whose life history characteristics include such things as: lays only one egg, does not breed every year, and does not become reproductively active until 2-5 years of age.

Recent monitoring and research continue to support the importance of habitat conservation for persistence of the Marbled Murrelet. The main hypothesis resulting from the 20-year review of NWFPC monitoring data was that Marbled Murrelet distribution and trend in the breeding season is determined

primarily by the amount and trend of suitable nesting habitat (Raphael et al. 2016b). Raphael et al. (2016a, p. 87) further explained that:

Over the long run, it is not unreasonable to expect to see some net increase in total amount of higher-suitability habitat; however in the short term, conservation of the higher-suitability habitat (Classes 3 and 4) is essential. If losses of suitable habitat are reduced, old forest suitable for nesting is allowed to develop, and fragmentation of older forest is reduced throughout the reserved federal lands, then meeting murrelet population objectives will be more certain. Given declining murrelet population trends as well as habitat losses, in many areas, it is uncertain whether their populations will persist to benefit from potential future increases in habitat suitability. This underscores the need to arrest the loss of suitable habitat on all lands, especially on nonfederal lands and in the relatively near term (3 to 5 decades).

Several authors have also recommended protection of marine habitat (Becker et al. 2007, Norris et al. 2007, Hazlitt et al. 2010, Lorenz et al. 2016). In a recent investigation of marine resource selection by Marbled Murrelets in Washington, Lorenz et al. (2016) found that areas with higher amounts of nesting habitat that were close to shore and in cool waters with low human footprint had greater probabilities of murrelet use. They called for prioritized protection of marine areas in close proximity to old-growth Marbled Murrelet nesting habitat.

Summary

- Marbled Murrelets have narrow habitat requirements and limited geographic distribution. Past and present habitat loss remains a serious threat to Marbled Murrelets in Oregon. Once nesting habitat is lost, high breeding site fidelity and energetic and flight constraints are thought to further restrict distribution.
- Remaining habitat is highly fragmented and contains a high proportion of edge. Forest fragmentation and “edge effects” can increase predation rates and may result in other adverse effects to forest remnants (e.g., greater windthrow damage, microclimates less suitable to epiphyte growth).
- While natural disturbances have always shaped Oregon forests, contemporary events that remove old-growth or mature forests may be difficult or impossible for murrelets to compensate for since habitat takes many decades or centuries to develop. Climate change is expected to increase potential for habitat loss from wildfires, insect infestations, disease outbreaks, and severe storms.
- Available information indicates that the Oregon Marbled Murrelet population remains depleted (relative to historical levels), experienced a significant decline in the 1990s, and may be fluctuating around a new, lower baseline. In general, small populations are more vulnerable to environmental and demographic stochasticity, catastrophic events, and loss of genetic diversity.
- Predation, particularly by corvids, is a leading cause of nest failure. Recovering raptor populations are an emerging concern, particularly if adult mortality is increased. Higher predator numbers and predation rates are associated with human activities and anthropogenic food sources.

- Disturbance from boat traffic has been documented in other parts of the range. While impacts in Oregon are unknown, they are assumed to be relatively less than high-traffic areas like the Salish Sea and Monterey Bay.
- Murrelets may be vulnerable in localized areas to energy development projects. Depending on siting location and equipment, projects have potential to increase loss or fragmentation of nesting habitat, expand human activity and disturbance in sensitive areas, impact prey base, and/or cause mortality through bird strikes.
- Oceanic conditions influence the abundance, distribution, and timing of prey available to murrelets, and prey quality and availability in turn affect breeding success. A centennial shift in murrelet diet to lower (poorer quality) trophic levels has been documented in parts of the range. As with many other seabirds, low recruitment has been associated with El Niño or other warm water years. As the climate continues to warm, changes in the marine environment are expected to exacerbate conditions unfavorable to murrelets.
- Harmful algal blooms are now occurring frequently along the Pacific Coast. They can produce biotoxins, surfactant-like compounds, and low-oxygen “dead zones” that negatively affect seabirds and marine ecosystems. Domoic acid poisoning is known to have killed small numbers of Marbled Murrelets.
- Entanglement in gill-nets or in derelict fishing gear is not known to be a problem in Oregon but remains a serious threat in Alaska and British Columbia.
- While prey depletion linked to commercial fisheries is of some concern, there is insufficient information to determine whether this is a problem for murrelets in Oregon.
- A catastrophic oil spill (e.g., Exxon Valdez, New Carissa) is a serious threat and could kill hundreds or thousands of birds in Oregon.
- Contaminants have been shown to bioaccumulate in other seabirds in Oregon, but their effects on Marbled Murrelets have not been examined. Based on information from Common Murres in Oregon, sublethal or synergistic effects are probable.
- Since state listing in 1995, several key threats and stressors have continued unabated or increased, and many new threats have been identified. Survival and reproduction of the Marbled Murrelet in Oregon is thought to be most affected by – and is likely to continue to be affected by – forest habitat alteration; large-scale disturbances; small population size; predation; changes in prey quality, timing, and availability; and oil spills.

Chapter 4: State Endangered Species Act Reclassification Criteria

This chapter presents the legal reclassification criteria which must be met in order to uplist the Marbled Murrelet to endangered status under the OESA, and biological or other information relevant to those criteria.

Summary of Criteria in Administrative Rule

The Commission must determine, based on the best available scientific and other information, that the likelihood of survival of the species has diminished such that the species is in danger of extinction throughout any significant portion of its range within Oregon (OAR 635-100-0111(1)). In addition, the Commission must determine that at least one of the following factors exists:

- (a) that most populations are undergoing imminent or active deterioration of their range or primary habitat;
- (b) that overutilization of the species or its habitat for commercial, recreational, scientific, or educational purposes is occurring or is likely to occur; or
- (c) that existing state or federal programs or regulations are inadequate to protect the species or its habitat (ORS 496.176(3), OAR 635-100-0105(6)).

In making a determination of whether to reclassify a species, the Commission shall consider:

- (a) the total geographic area in this state used by the species for breeding, resting, or foraging, and the portion thereof in which the species is or is likely within the foreseeable future to become in danger of extinction;
- (b) the nature of the species' habitat, including any unique or distinctive characteristics of the habitat the species' uses for breeding, resting, or foraging; and
- (c) the extent to which the species habitually uses the geographic area (OAR 635-100-0105(5)).

The Commission may decide not to list a wildlife species as threatened or endangered that would otherwise qualify to be so listed within this state if the Commission determines that:

- (a) the future of the species is secure outside this state;
- (b) the wildlife species is not of cultural, scientific, or commercial significance to the people of this state;
- (c) the species has been listed as threatened or endangered pursuant to the federal ESA;
- (d) the species is a candidate species under the federal ESA;
- (e) the species has been petitioned for listing under the federal ESA;
- (f) the responsible federal agency has determined that the species does not warrant listing as a threatened or endangered species under the federal ESA; or
- (g) the species is currently on the Department's sensitive species list (OAR 635-100-0105(7)).

In addition, before making a determination not to list pursuant to subsections (c) through (f), the Commission shall evaluate whether the federal listing, categorization, or other action regarding the species adequately protects that species in Oregon (OAR 635-100-0105(8)).

Information about the Marbled Murrelet Pertaining to Reclassification Criteria

In this section, information relevant to each of the reclassification criteria is presented. In the discussion below, criteria for uplisting are in bold print.

Risk of Extinction in Oregon

The Commission must determine whether the likelihood of survival of the species has diminished such that the species is in danger of extinction throughout any significant portion of its range within the state (OAR 635-100-0111(1)).

An evaluation of those factors which can influence the survival and breeding success of the Marbled Murrelet, and therefore its risk of extinction in Oregon, was presented in Chapter 3. Key threats identified at the time of state listing appear to have continued or increased, and many new threats have been identified since the 1990s. The most significant factors affecting the species are believed to be: forest habitat alteration; large-scale disturbances; small population size; predation; changes in prey quality, timing, and availability; and oil spills. The nesting habitat requirements and life-history strategy exhibited by this species provide little opportunity for the population to rapidly increase in number, even under the most optimal conditions.

Marbled Murrelets in Oregon are dependent upon a narrow band of older coastal forests for nesting. They nest up to about 40 mi inland and rely on productive nearshore marine waters nearby for foraging and provisioning their chicks. Much of the murrelet's older forest nesting habitat in Oregon was removed by wildfire and industrial logging in the last century. Today, Marbled Murrelets persist in highly fragmented forest remnants and mostly on public lands, including the Siuslaw and Rogue River-Siskiyou National Forests, forests owned by the BLM, and the state-owned and managed Tillamook, Clatsop, and Elliott State Forests. Collectively, management programs, plans, and regulations have slowed but not halted further nesting habitat loss and degradation since the 1990s.

Recent at-sea surveys (2000-2015) are inconclusive in terms of population trend in Oregon, but a growing body of evidence indicates that Marbled Murrelet distribution and trend are most closely tied to the amount and trend of suitable nesting habitat (see Raphael et al. 2016b). Other evidence suggests that the Oregon Marbled Murrelet population is greatly reduced relative to historical levels, experienced a significant decline (>50%) in the 1990s, and is now fluctuating around a new, lower baseline. Demographic models and available breeding success estimates do not support the conclusion that recruitment is sufficient for birds to replace themselves. Using what may be optimistic parameters, McShane et al. (2004) found that extinction probability is high in Oregon (over 80% by 2060 for Conservation Zone 4, over 80% by 2100 for Conservation Zone 3). They defined extinction as fewer than 30 individuals per zone but cautioned that "extinction may be almost certain at higher zone sub-population sizes".

Conclusion: The life history traits and narrow habitat requirements of this species make it vulnerable to a broad array of threats and stressors. Much of the Marbled Murrelet's historical older forest nesting habitat has already been lost in Oregon, and further near-term losses are anticipated. The available information on recent breeding success suggests that recruitment is too low to sustain the population. However, there is considerable uncertainty surrounding the current population size and trend of Oregon's Marbled Murrelet population.

In addition, the Commission shall determine that one or more of the following factors exist [in Oregon] (OAR 635-100-0111(1)):

- (a) that most populations are undergoing imminent or active deterioration of their range or primary habitat;**
- (b) that overutilization of the species or its habitat for commercial, recreational, scientific, or educational purposes is occurring or is likely to occur; or**
- (c) that existing state or federal programs or regulations are inadequate to protect the species or its habitat (ORS 496.176(3), OAR 635-100-0105(6)).**

(a) Deterioration of Range or Habitat

Marbled Murrelets in Oregon are dependent upon coastal old-growth and late-successional forests for nesting. Suitable nesting habitat has declined from historical levels, and since state listing in 1995. Older forest habitat is still being harvested, particularly on nonfederal lands, and wildfire and other disturbances can remove key patches of otherwise protected habitat. Raphael et al. (2016a) estimated that higher-suitability habitat declined in Oregon from an estimated 853,400 ac in 1993 to 774,800 ac in 2012, a net loss of 78,600 ac (-9.2% change); on nonfederal lands, 21.1% of higher-suitability habitat was lost during this period compared to 3.4% on federal lands. Remaining habitat is highly fragmented and contains a high proportion of edge. Forest fragmentation and "edge effects" can increase predation rates and may result in other adverse effects to forest remnants (e.g., greater windthrow damage, microclimates less suitable to epiphyte growth).

Variability in ocean conditions and anthropogenic threats and stressors are also affecting marine habitat off of Oregon's coast. Marbled Murrelets use marine waters for foraging, loafing, courtship, molting, and preening. They require sufficient prey resources for survival and successful reproduction. While some recent government programs and regulations may help to protect certain marine areas and forage species, it is too soon to know their effectiveness. Climate change is expected to exacerbate conditions unfavorable to murrelets in both the marine and terrestrial environments.

Conclusion: Marbled Murrelets have experienced past and ongoing deterioration of their range or primary habitat. Available nesting habitat has continued to decline in Oregon since state listing. Threats and stressors in the marine environment have also increased since state listing.

(b) Overutilization

The Marbled Murrelet is a nongame species and is not hunted. No evidence suggests that the Marbled Murrelet has been subject to overcollecting for educational purposes, and the available information on

scientific research indicates that impacts to murrelets are unlikely to have population-level effects in Oregon.

From 1992 to 2016, the USFWS issued four 10(a)(1)(A) recovery permits under the federal ESA that included Marbled Murrelet research activities in Oregon (C. Henson, pers. comm.). Primary activities were capture, tagging, and handling at sea. Overall, a single adult was reported as incidentally killed (during capture) (Table 13).

Table 13. Summary of species actions and take (purposeful and incidental) reported under U.S. Fish and Wildlife Service recovery permits for Marbled Murrelet research occurring in Oregon from 1992-2016 (data provided by C. Henson, USFWS). Some permits covered activities in Washington as well as Oregon. Therefore, take is reported as a combined total (Total Take Reported) and for Oregon only (Oregon Take Reported).

Action	Total Take Reported	Oregon Take Reported
Band/Mark/Tag	172 adults	68 adults
Kill	1 adult	1 adult
Radio Telemetry	148 adults	10 adults
Salvage	1 adult	1 adult
Survey/Monitor	18 juveniles or adults	0 juveniles or adults

Prior rangewide assessments by the USFWS concluded that there may be some localized impacts of research on murrelets (McShane et al. 2004, USFWS 2009). Transmitter effects (e.g., higher underwater drag, increased predation risk) were identified as the greatest concern since they could affect adult survival, particularly in central California where the population is very small (USFWS 2009). Per USFWS (2009), the USFWS has been giving more scrutiny to take authorized under both Sections 7 and 10 in recent years.

There is little evidence that overutilization of murrelet habitat is occurring or is likely to occur due to recreational purposes in Oregon. However, it is clear that in some state and national parks in California, crows, jays, and other predators have been attracted by food and garbage from picnickers and campers, which can contribute to elevated predation rates of murrelets in those areas. Unauthorized, recreational tall tree climbing is also of concern in some parks. Volunteer trails, trampling of vegetation, spread of pests or pathogens (e.g., sudden oak death), and human disturbance are among other local impacts to habitat from recreational users.

Trash management and associated outreach have been expanded in California parks in recent years. The “Crumb Clean” educational campaign is aimed at park visitors and reminds people to dispose of garbage and food waste properly, store food in animal-proof containers, and avoid feeding wildlife. Many of these efforts are due to a 2014 lawsuit settlement agreement between the Center for Biological Diversity and the California Department of Parks and Recreation pertaining to the general plan for Big Basin Redwoods State Park. The Center for Biological Diversity challenged that the park’s management plan contained inadequate measures to protect murrelets on the central coast from predation

stemming from visitor use and garbage in sensitive areas. The “Crumb Clean” campaign is being expanded to Washington but has not yet been adopted in Oregon.

Commercial utilization of Marbled Murrelet habitat is mostly restricted to forest practices activities. Suitable murrelet habitat continues to be harvested in Oregon. Future levels of utilization of Marbled Murrelet habitat will depend on protection measures and activities that are ultimately adopted by the federal government, the Oregon Board of Forestry, and the State Land Board.

While there are concerns about fishing pressure (past or present) and stressors faced by forage fish species, there is currently no direct evidence that overutilization of murrelet prey by commercial or recreational fishing is occurring in Oregon.

Conclusion: There is evidence of overutilization of Marbled Murrelet nesting habitat (older forests), mainly due to timber harvest. Some recreational impacts to habitat due to visitor use in parks, trails, campgrounds, etc. are likely, but we have no quantitative information for Oregon. Some murrelet prey species are taken in commercial and recreational fisheries, but there is no direct evidence that fishing practices are overutilizing Marbled Murrelets or their prey resources to the point of negatively impacting the population; we have insufficient information to evaluate with certainty whether this will likely occur in the future. However, current state and federal fishery management practices prioritize sustainable fisheries.

(c) Adequacy of State and Federal Programs or Regulations

The following is an overview of key state and federal programs and regulations pertinent to the status of the Marbled Murrelet and/or its habitat in Oregon. It is not a detailed or exhaustive list of all possible laws, regulations, plans, or programs that could possibly affect uses or natural resources in Oregon’s forest lands, coastlines, or marine waters.

Federal Programs and Regulations

Federal Endangered Species Act

The purpose of the federal ESA (16 USC 1531-1544; 50 CFR 17) is to protect and recover threatened and endangered species and their habitats. As noted previously, Marbled Murrelets in Washington, Oregon, and California were listed as threatened under the federal ESA in 1992. One effect of this listing is that “take” is prohibited wherever the species occurs under Section 9, unless authorized by the USFWS. Take is defined as “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct” (16 USC 1532(19)). Through regulations, “harm” is defined as “an act which actually kills or injures wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering” (50 CFR 17.3).

There are various mechanisms for authorizing take of listed species under the federal ESA,

including:

Incidental Take Permits: The USFWS may issue an Incidental Take Permit for take incidental to otherwise legal activities by nonfederal entities. To obtain a permit, the applicant must first develop a Habitat Conservation Plan (HCP) demonstrating that the activities will not appreciably reduce the likelihood of the survival and recovery of the species in the wild. The HCP must include measures to minimize and mitigate the effects of incidental take (16 USC 1539(a)(1)(B) [Section 10(a)(1)(B)]; endangered wildlife species: 50 CFR 17.22; threatened wildlife species: 50 CFR 17.32). We are not aware of any current Incidental Take Permits for Marbled Murrelets in Oregon, though ODF has indicated that they plan to pursue such permits for the Elliott and Northwest Oregon state forests that would provide coverage for multiple listed species (L. Dent, pers. comm.).

Recovery and Interstate Commerce Permits: Recovery and Interstate Commerce Permits allow for take as part of efforts to recover a listed species. They may be issued for scientific research or to allow transport and sale of listed species across state lines for a breeding program or similar purpose (16 USC 1539(a)(1)(A) [Section 10(a)(1)(A)]; endangered wildlife species: 50 CFR 17.22; threatened wildlife species: 50 CFR 17.32). For details on take of Marbled Murrelets for scientific purposes in Oregon, see Overutilization above.

Enhancement of Survival Permits: Enhancement of Survival Permits are issued to nonfederal landowners participating in Safe Harbor Agreements or Candidate Conservation Agreements with Assurances (16 USC 1539(a)(1)(A) [Section 10(a)(1)(A)]; endangered wildlife species: 50 CFR 17.22; threatened wildlife species: 50 CFR 17.32). Such agreements allow landowners to improve habitat for listed species while protecting them from additional regulatory restrictions that could result from their conservation actions. We are not aware of any current Safe Harbor Agreements pertaining to Marbled Murrelets for nonfederal landowners in Oregon.

Interagency Cooperation: Under Section 7, federal agencies must consult with the USFWS to ensure that any action they authorize, fund, or carry out with potential to affect a federally-listed species or its federally-designated critical habitat is not likely to jeopardize the continued existence of the species or result in the destruction or adverse modification of its critical habitat (16 USC 1536(a) [Section 7(a)]; 50 CFR 402). After formal consultation, the USFWS writes a biological opinion, which describes the expected impacts of the project on the species, and makes a jeopardy determination. If a non-jeopardy determination is made, the USFWS may recommend measures to minimize adverse effects, set project terms and conditions, and establish limits on allowable take.

From October 1, 2003 to August 5, 2017, the USFWS authorized incidental take associated with removal of 8,192 ac; these 8,192 ac consisted of 7,058 ac of intact habitat and 1,134 ac of stands with remnant trees (Table 14). A total of 2,580 ac of intact habitat was reported removed during this period (Table 14).

Table 14. Suitable habitat (acres) affected by Section 7 consultation for the Marbled Murrelet in Oregon; summary of effects by Conservation Zone and habitat type from October 1, 2003 to August 5, 2017 (data and footnotes adapted from table provided by B. Tuerler, USFWS).

Location	Authorized Habitat ¹ Effects		Reported Habitat ¹ Effects	
	Stands ²	Remnants ³	Stands ²	Remnants ³
Conservation Zone 3	-3,226	-1,050	-2,352	0
Conservation Zone 4	-3,830	-84	-228	0
Outside Conservation Zone Area in Oregon	-2	0	0	0
Total	-7,058	-1,134	-2,580	0

¹Habitat includes all known occupied sites, as well as other suitable habitat, though it is not necessarily occupied. Importantly, there is no single definition of suitable habitat, though the Marbled Murrelet Effectiveness Module is in the process of addressing this topic. Some useable working definitions include the Primary Constituent Elements as defined in the Critical Habitat Final Rule, or the criteria used for Washington State by Raphael et al. (2002).

²Stand: A patch of older forest in an area with potential platform trees.

³Remnants: A residual/remnant stand is an area with scattered potential platform trees within a younger forest that lacks, overall, the structures for murrelet nesting.

Critical Habitat

The USFWS first designated 3,887,800 ac of critical habitat for the Marbled Murrelet in Washington, Oregon, and California in May 1996 (61 FR 26256). This designation included a description of the Primary Constituent Elements that support nesting, roosting, and other normal behaviors that are essential to the conservation of the Marbled Murrelet. The Primary Constituent Elements include: 1) forested stands containing large-sized trees, generally more than 32 in in diameter with potential nesting platforms at sufficient height, generally greater than or equal to 33 ft in height; and 2) the surrounding forested areas within 0.5 mi of these stands with a canopy height of at least one-half the site-potential tree height. Designated critical habitat also includes habitat that is currently unsuitable, but has the capability of becoming suitable habitat in the future. The 1996 designation was revised in 2011, removing approximately 189,671 ac in northern California and southern Oregon not considered essential for conservation of the species (76 FR 61599). The 2011 designation was reaffirmed in 2016 (81 FR 51348). Critical habitat has not been designated in the marine environment.

Recovery Plan

The USFWS completed a recovery plan for the Marbled Murrelet in September 1997 (USFWS 1997). The main objective of the plan was to stabilize the population by maintaining and/or increasing productivity and removing and/or minimizing threats to survivorship (USFWS 1997). The recovery plan built upon the NWFP, an interagency Conservation Assessment sponsored by the USFS (see Ralph et al. 1995b), and earlier efforts by various organizations and researchers (USFWS 1997). It placed special emphasis on habitat-based conservation actions in the terrestrial environment.

Only interim delisting criteria were identified in the recovery plan, but these included: 1) trends in estimated population size, densities, and productivity have been stable or increasing in four of the six Conservation Zones over a 10-year period and 2) management commitments and monitoring have been implemented in each of the six Conservation Zones to provide adequate protection of Marbled Murrelets for at least the near future (50 years) (USFWS 1997, p. vi, 113).

Status Reviews

Since federal listing, the USFWS has completed two 5-year reviews focused on new information and analysis relevant to the species' status (McShane et al. 2004, USFWS 2009). Both of these reviews reaffirmed the threatened status of the Marbled Murrelet. A third 5-year review is currently underway (82 FR 18665).

Recovery Implementation Team

The USFWS formed a RIT comprised of scientific experts in 2011 to assist with Marbled Murrelet recovery. They subsequently convened a RIT meeting and stakeholder workshop focused on evaluating causes of murrelet decline across the federally-listed range and the relative importance of various threats, and developing a prioritized list of protection and management actions (RIT 2012).

Migratory Bird Treaty Act

The Marbled Murrelet is protected under the Migratory Bird Treaty Act (16 USC 703-712; 50 CFR 20 and 21). The Migratory Bird Treaty Act and its associated regulations implement conventions between the United States and Canada, Mexico, Japan, and Russia, and address aspects of taking, possession, transportation, sale, purchase, barter, exportation, and importation of migratory birds. They prohibit take of certain migratory bird species as well as their eggs and nests, unless authorized by permit from the USFWS. Take is defined as "to pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to pursue, hunt, shoot, wound, kill, trap, capture, or collect" (50 CFR 10.12). Unlike the federal ESA, protections under the Migratory Bird Treaty Act do not generally extend to habitat (USFWS 2009).

Northwest Forest Plan

In the early 1990s, controversy over harvest of old-growth forests led to sweeping changes in management of federal forests in western Washington, Oregon, and northwest California. These changes were prompted by a series of lawsuits in the late 1980s and early 1990s that effectively shut down federal timber harvest in the Pacific Northwest. In response, President Clinton convened a summit in Portland, Oregon, in 1993. At the summit, President Clinton issued a mandate for federal land management and regulatory agencies to work together to develop a plan to resolve the conflict. Immediately after the summit, a team of scientists and technical experts were convened to conduct an assessment of options (FEMAT 1993). This assessment provided the scientific basis for the environmental impact statement and record of decision (USDA and USDI 1994) to amend USFS and BLM planning documents within the range of the Northern Spotted Owl. The President's guiding principles

followed shortly thereafter in his *Forest Plan for a Sustainable Economy and Sustainable Environment* otherwise known as the NWFP (Tuchmann et al. 1996).

The NWFP is a large-scale ecosystem management plan for federal land in the Pacific Northwest. The basis for the NWFP was established in 1993 by work groups of the Forest Ecosystem Management Assessment Team. The team's specific objectives were to "identify management alternatives that attain the greatest economic and social contribution from the forests of the region and meet the requirements of the applicable laws and regulations [...] and base its work on the best technical and scientific information currently available" (FEMAT 1993, p. ii). The team's milestone report, titled *Forest Ecosystem Management: An Ecological, Economic, and Social Assessment* (FEMAT 1993), fundamentally changed federal land management in the Pacific Northwest. In 1994, the USFS and BLM first issued a final supplemental environmental impact statement (FSEIS) largely based on the management options and land allocations from the FEMAT report (USDA and USDI 1994). This was followed by the NWFP, a two-part decision document that: 1) identified the selection of Alternative 9: the *Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Northern Spotted Owl*, and 2) provided specific management direction in the *Standards and Guidelines for the Management of Habitat for Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl* (USDA and USDI 1994).

Although the NWFP had an integrated approach to conservation, it was divided into three main components: terrestrial, aquatic, and social (USDA and USDI 1994). Broad conservation objectives were established for each component, respectively, to: 1) protect and enhance habitat for late-successional and old-growth forest related species; 2) restore and maintain the ecological integrity of watersheds and aquatic ecosystems; and 3) provide a predictable sustainable commodity resource production, maximizing the social economic benefits, and assist long-term economic development and diversification.

The NWFP affected about 24.4 million ac of federally-managed forests in 18 national forests and 7 BLM districts in northwestern California, western Oregon, and western Washington. To facilitate implementation of the NWFP, the federal land base was separated into land allocations: late-successional reserves, congressionally reserved areas, administratively withdrawn areas, managed late-successional areas, riparian reserves, adaptive management areas, and matrix - federal land outside the previous six designations (USDA and USDI 1994). Each land allocation has specific management objectives and requirements described in the standards and guidelines, which must be adhered to while implementing the NWFP. In reserved lands, commercial timber harvest is generally not permitted, and younger stands, if managed, are managed to attain tree size and stand structure resembling old-growth. Reserved lands include such areas as national forest and BLM lands designated as late-successional reserves and designated wilderness areas. In most cases, on nonreserved federal lands, commercial timber harvest is permitted.

A more specific conservation goal of the NWFP was to stabilize and increase Marbled Murrelet populations by maintaining and increasing nesting habitat (Madsen et al. 1999). The NWFP (USDA and USDI 1994) identified the following as a primary question for evaluating the plan's effectiveness in achieving this goal: *Is the Marbled Murrelet population stable or increasing?* Ecological monitoring

programs were established to evaluate the effectiveness of the NWFP in meeting conservation objectives, and to inform management decisions (Mulder et al. 1999).

The NWFP identified several goals for Marbled Murrelet nesting habitat, including providing substantially more suitable habitat for Marbled Murrelets than existed at the start of the plan, providing large contiguous blocks of murrelet nesting habitat, and improving or maintaining the distribution of populations and habitat (Madsen et al. 1999). Monitoring murrelet population trends provides a key indicator of whether the NWFP is successfully providing nesting habitat to support a stable and well-distributed murrelet population (Madsen et al. 1999). In their review focused on the first 20 years of the NWFP, Raphael et al. (2016a) concluded that the NWFP has largely been successful at conserving Marbled Murrelet habitat on federal lands, but that the Marbled Murrelet population in Washington, Oregon, and California is not yet stable or increasing (Falxa et al. 2016).

Western Oregon Resource Management Plan

On August 5, 2016, the BLM signed the Records of Decisions (RODs) for the *Resource Management Plans (RMPs) of Western Oregon*. The completion of the RODs marked the end of a four-year planning process by the BLM to use new science, policies, and technology to protect natural resources and support local communities. This RMP revision replaced the 1995 RMPs developed for consistency with the 1994 NWFP and which the U.S. Department of Interior and the U.S. Department of Agriculture adopted for federal forests within the range of the Northern Spotted Owl, thereby also revising the NWFP for the management of BLM-administered lands in western Oregon. The purpose and need for this RMP were different from the purpose and need for the NWFP. As such, this RMP does not contain all elements of the NWFP.

The RMP is intended to maintain protections for the Northern Spotted Owl, Marbled Murrelet, listed fish species, and water resources, and to offer predictable and sustainable outcomes for local communities by increasing job opportunities, tourism and recreation, and timber harvest. Once these plans are fully implemented, the BLM estimates that it will be able to provide 278 million board ft per year in total timber harvest. Out of 2.5 million ac in the planning area, nearly three-quarters will be protected in reserves for fish, water, wildlife, and other resource values.

The RMP is expected to contribute to the conservation and recovery of the Marbled Murrelet. The RMP will reserve more acres of Late-Successional Reserve than the 1995 RMPs, and will result in an increase in the amount of high-quality Marbled Murrelet nesting habitat. The RMP will protect older, more structurally-complex forest, which approximates high-quality nesting habitat for Marbled Murrelets, and the approach in the RMP to identifying older, more structurally complex forest for protection was consistent with the recommendation of the USFWS in their comments on the Draft RMP/Environmental Impact Statement. The RMP will require pre-project surveys for Marbled Murrelets and protection of occupied sites in Zone 1 (from the coast to approximately 35 mi inland) and in the Late-Successional Reserve and Riparian Reserve in Zone 2 (from the eastern boundary of Zone 1 to approximately 50 mi inland from the coast), but not in the Harvest Land Base in Zone 2. Based on the results of Marbled Murrelet surveys over the past two decades, the vast majority of Marbled Murrelet sites in the decision area are within Zone 1. By not requiring protection of occupied sites in the Harvest Land Base in Zone 2,

the RMP will have a minor adverse effect on Marbled Murrelets, as demonstrated by the analysis in the Proposed RMP/Final Environmental Impact Statement, and will allow for management for sustained-yield timber production and simplify implementation and reduce costs associated with surveys in Zone 2.

On July 20, 2016, the USFWS issued a biological opinion that found that the Proposed RMP was not likely to jeopardize the continued existence of any of the species [including Marbled Murrelet] under their jurisdiction, or adversely modify their critical habitat. In addition, the USFWS (2016, p. 426) concluded:

Although there are likely to be some adverse effects to murrelets and murrelet critical habitat in portions of the species' range, the overall outcome of [Proposed RMP] implementation will be the protection of the vast majority of extant murrelet nesting habitat, and a large long-term net increase in total area and amount of murrelet habitat during the life of the plan. This approach builds on and continues the basic approach of the original conservation strategy for the murrelet first articulated in the NWFP and the recovery plan.

The Oil Pollution Act of 1990

Following the 1989 Exxon Valdez oil spill in Prince William Sound, Alaska, U.S. Congress passed the Oil Pollution Act of 1990 (33 USC 2701-2761). This federal legislation amended the Clean Water Act and created an integrated prevention, response, liability, and compensation regime that addresses vessel- and facility-caused oil pollution in U.S. navigable waters (USFWS 2009). Since the 1990s, some additional measures further improve oil spill prevention. For example, the Oil Pollution Act required phase-out of single-hull tankers and tank barges carrying oil as cargo by 2015. However, this requirement does not apply to container ships, freighters, cruise ships, or other types of vessels.

Once a spill occurs, damages to natural resources (or the services they provide to humans or ecosystems) and restoration of injured resources are jointly guided by the Oil Pollution Act and the National Environmental Policy Act. The Oil Pollution Act provides the framework for natural resource damage assessment and restoration, whereas the National Environmental Policy Act lays out the process for impact analysis and public review (*M/V New Carissa* Natural Resource Trustees 2006, p. 83).

Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 USC 1801 et seq.) is the main law that governs management of marine fisheries in the United States. The MSA was amended and reauthorized in 1996 and 2006. The MSA establishes the United States' jurisdiction over marine fisheries management throughout the Exclusive Economic Zone (EEZ; offshore to 200 nautical mi), beyond the EEZ onto the continental shelf, and over anadromous fisheries throughout the migratory range of these species beyond the EEZ. The MSA also establishes an inner boundary for the U.S. EEZ that is coterminous with a coastal state's territorial sea. The MSA sets national standards for fishery resource conservation, fishery management, and the development of fishery management plans based on the best available science to achieve optimum yields while preventing overfishing. To manage U.S. fisheries by region and to promote the conservation of fish stocks, the MSA created eight regional fishery management councils

authorized to develop and implement fishery management plans and policy. The Pacific Fishery Management Council is responsible for fisheries off the West Coast of the continental United States. The MSA gives the Secretary of Commerce authorization to evaluate, approve, and implement federal fishery management plans. The National Oceanic and Atmospheric Administration-National Marine Fisheries Service is the lead agency charged with implementing the MSA. The original Act promoted the development of a domestic fishing industry by phasing out foreign fishing fleets in the U.S. EEZ. The 1996 Sustainable Fisheries Act amendment to the MSA focused on defining measurable criteria for overfished stocks, rebuilding overfished species, protecting essential fish habitat, promoting recreational catch and release programs, and reducing bycatch. The 2006 amendment strengthens the mandate to end and prevent overfishing, promotes market-based management approaches, provides a larger role for science in decision making, and promotes enhanced international cooperation in fisheries management. Key provisions include annual catch limits based on scientific advice and accountability measures for all fishery management plan species. The Pacific Fishery Management Council has developed approved fishery management plans that include many of the species that make up the forage base for the Marbled Murrelet, such as anchovies, sardines, krill, osmerids, and many groundfish species. There has been a ban on directed krill harvest since 2009 (74 FR 33372). A ban on new commercial forage fish fisheries for several previously unmanaged forage species, including Pacific sand lance and osmerid smelts, took effect in 2016 (81 FR 4 19054).

State Programs and Regulations

Oregon Endangered Species Act and “Protected” Species

The Oregon Legislature enacted the OESA (ORS 496.171 to 496.192 and 498.026) in 1987 and amended it in 1995 through House Bill 2120. The Oregon Fish and Wildlife Commission adopted amendments to administrative rules to implement House Bill 2120 (OAR 635-100-0001 through 0180) in 1997.

ODFW is responsible for fish and wildlife under the OESA, and the Oregon Department of Agriculture is responsible for plants. Once a wildlife species is placed on the state list as threatened or endangered, Oregon statutes prohibit the “take” (kill or obtain possession or control, per ORS 496.004 (16)) of the listed species without a state permit. The OESA provides the agency additional responsibility and authority for conservation of listed species.

The OESA primarily applies to actions of state agencies on state-owned or leased lands. Private lands are not directly affected by the OESA (ORS 496.192) except through applicable provisions of the Oregon Forest Practices Act (FPA) (ORS 527.610-527.610.992, OAR Chapter 629 Divisions 600-680). In contrast, the federal ESA directly affects federal, state, and private lands. In general, the OESA is much more limited in scope than the federal law.

Because the OESA primarily affects the actions of state agencies on state-owned or leased lands, and because less than 2% of Oregon’s land base is state-owned, the burden of recovering threatened and endangered species is primarily on the federal government in Oregon. However, because state lands are sometimes important to species recovery, the value of the OESA to species protection can be significant.

The OESA sets a policy of encouraging cooperation and avoiding duplication between state and federal conservation efforts. It requires other state agencies to work with ODFW in an effort to make their management actions consistent with survival guidelines and endangered species management plans for listed species. Pursuant to ORS 496.172(4), an incidental take permit or statement issued by a federal agency for a species listed under the federal ESA can serve as “a waiver of any state protection measures or requirements otherwise applicable to the actions allowed under the federal permit”.

The listing of a species by the Commission, in and of itself, does not automatically trigger any regulatory action by ODFW or other state agencies. At the time of listing, the Commission is required to establish “quantifiable and measurable guidelines” otherwise known as survival guidelines that it “considers necessary to ensure the survival of individual members of the species” (OAR 635-100-0100(13)). These guidelines may include protection of specific resource sites such as nest sites.

For threatened and endangered species, all state agencies are required to follow the survival guidelines established by the Commission. If an agency determines that its actions on state lands would violate the guidelines, it must notify the Oregon Fish and Wildlife Commission, which then has 90 days to recommend reasonable and prudent alternatives that are consistent with the Commission’s guidelines. If the state agency does not adopt these recommendations, it must justify (after consultation with ODFW) that the potential public benefits of the action outweigh the potential harm of not adopting ODFW’s recommendations, and that reasonable mitigation and enhancement measures will be taken.

For endangered species, the process is somewhat different. The Commission still must adopt survival guidelines when it lists a species. However, within 4 months of listing an endangered species, the Commission must determine whether state land can play a role in the conservation of that species. If so, the land-owning or managing agency must determine (in consultation with ODFW) what role its lands will play in the conservation of the endangered species. To do so, the agency must consider the survival guidelines adopted by the Commission, additional information provided by the Department on the conservation needs of the endangered species, the social and economic impacts of implementing needed conservation measures, and the agency’s statutory obligations. The agency must then develop an endangered species management plan and submit it to the Oregon Fish and Wildlife Commission for approval. Commission approval is based on whether the plan achieves the role defined by the agency. Based on the biological needs of the species, and in consultation with state agencies, the Commission may modify the endangered species management plan to make it consistent with the agency’s role. In any case, the Commission must approve the endangered species management plan within 24 months of listing the species as endangered. In the absence of an approved endangered species management plan, state land-owning or managing agencies will follow the procedure described above for threatened species. Other state agencies are not required to develop species management plans, but must ensure their actions are consistent with their identified role.

Besides the OESA, other state agency statutes and administrative rules may require protection for federal and state-listed species on private lands. For example, the FPA requires the Board of Forestry to adopt rules appropriate to protect the sites of federal- and state-listed species on private lands (see Oregon Forest Practices Act below). ODFW works with ODF to provide advice on the development of such rules.

The Marbled Murrelet is listed as threatened under the OESA. The Marbled Murrelet is also a "protected" species under OAR 635-044-0430, meaning it is unlawful for any person to take, capture, hold, release, or have in possession, either dead or alive, whole or in part, any Marbled Murrelet without a Scientific Taking Permit issued by ODFW. As above, "take" means "to kill or obtain possession or control of any wildlife" (ORS 496.004(16)). None of these state regulations has been interpreted to apply to habitat destruction or modification.

State Forest Plans

ODF manages approximately 700,000 ac of forest lands in western Oregon. These state forest lands are actively managed under forest management plans to provide economic, environmental, and social benefits to Oregonians. Timber sales on these forests produce jobs and revenue that fund counties, local districts, and schools throughout the state. These forests also offer recreation and educational opportunities, and provide essential wildlife habitat and clean water.

State forests in Oregon were acquired in different ways, and the two types are owned by different entities within state government. Lands owned by the Board of Forestry are known as Board of Forestry Lands. Some state parcels were granted to the state by the federal government when Oregon became a state in 1859. These lands are owned by the State Land Board and are known as Common School Fund Lands. Each land ownership has its own set of legal and policy mandates. The goal for management of Board of Forestry Lands is to secure the *Greatest Permanent Value* (ORS 530.010 through 530.170 and OAR 629-035). The goal for management of Common School Fund Lands is the maximization of income to the Common School Fund over the long-term (ORS 530.450 through 530.520).

Northwest Oregon state forests include two large blocks of land in the Tillamook and Clatsop State Forests. The Tillamook and Clatsop State Forests are in the northern end of the Oregon Coast Range. Much of the area that is now the Tillamook State Forest was burned in a series of wildfires known as the Tillamook Burn. The Tillamook State Forest is 364,000 ac, and the Clatsop State Forest is 154,000 ac. Another 38,000 ac of smaller tracts of state forest land are scattered in western Oregon.

The 93,000 ac Elliott State Forest located in south coastal Oregon became the first state forest in 1930, when scattered tracts of Common School Fund Land within national forest boundaries owned by the State were traded for one contiguous block of forest land. The creation of the forest was the culmination of the 1912 vision of Governor Oswald West and State Forester Francis Elliott. About 90% of the forest is managed by ODF on behalf of the State Land Board and the Oregon Department of State Lands. Net revenues from timber sales on these lands benefit the state's Common School Fund. The prospects of fulfilling that obligation have faded in recent years as environmental regulations and lawsuits over protected species such as the Marbled Murrelet and Northern Spotted Owl have reduced logging revenue from the forest. In 2015, the State Land Board initiated a process to sell Common School Fund Lands in the Elliott State Forest (about 82,500 ac) and use the proceeds to benefit the Common School Fund. However, in

May 2017, the State Land Board reversed its previous direction, and voted to terminate the protocol to seek alternative ownership of the forest. Although the status of the Elliott State Forest remains uncertain, the State Land Board also directed the Department of State Lands to move forward with a new planning effort to keep the forest in public ownership.

The ODF *Northwest Oregon State Forests Management Plan* (ODF 2010) provides management direction for all Board of Forestry Lands and Common School Fund Lands in northwest Oregon. The Board of Forestry owns 97% of these lands, and the State Land Board owns the other 3%. The ODF *Elliott State Forest Management Plan* (ODSL and ODF 2011) provides direction for Common School Fund Lands and Board of Forestry Lands in the Elliott State Forest. The State Land Board owns about 91% of these lands, and the Board of Forestry owns the other 9%.

The *Northwest Oregon State Forests Management Plan* and *Elliott State Forest Management Plan* take a multi-resource approach to forest management, and present guiding principles, a forest vision, and resource management goals that set the long-term direction for these lands. The resource management goals and strategies are intended to achieve a balance between the resources, and achieve the greatest permanent value through a system of integrated management that will likely benefit murrelets and other species of concern.

The *Northwest Oregon State Forests Management Plan* and *Elliott State Forest Management Plan* are founded upon an approach called structure-based management. Structure-based management is designed to produce and maintain an array of forest stand structures across the landscape in a functional arrangement. Structure-based management is intended to emulate many aspects of natural stand development patterns and to produce structural components found in natural stands. Four key concepts are the foundation for landscape management under structure-based management: 1) active management for a diverse array of forest stand types, 2) landscape design to provide for a functional arrangement of the stand types in terms of habitat values, 3) active management to provide for key structural components within stands and on the landscape (snags, down wood, legacy trees, etc.), and 4) active management for social and economic benefits.

The integrated management strategies are intended over time to result in habitat conditions on the landscape and in aquatic and riparian areas that will provide functional habitat conditions for native species. The long-range desired future condition for older forest is 15-25% of the landscape. While moving the landscape toward a more diverse habitat condition, there are expected to be individual species, referred to as "species of concern" (including Marbled Murrelet) or habitats that require special consideration. Additional conservation tools are implemented where determined necessary for species of concern, including the use of anchor habitats and site protection.

ODF has developed policies specific to Marbled Murrelets on state forest lands, including the Tillamook/Clatsop State Forest and Elliott State Forest. These policies provide a process for avoiding "take" and protecting suitable habitat around identified occupied sites. The state forests management plan allows short-term loss of suitable habitat in as much as areas deemed

suitable habitat and for which Marbled Murrelet occupancy has not yet been determined can be logged. The ODF, State Forests Division, designates protected areas for Marbled Murrelets in state forest lands, including “occupied habitat” and “buffers”, and coordinates with the USFWS on management decisions affecting Marbled Murrelet habitat. Marbled Murrelets currently nest in some areas of northwest Oregon state forests and the Elliott State Forest in the Coast Range, and 22,708 ac are in designated MMMAs.

Oregon Forest Practices Act

In Oregon, the FPA (ORS 527.610 to 527.992 and OAR Chapter 629, Divisions 600 to 665) lists protection measures specific to private and state-owned forest lands in Oregon. These measures include specific rules for resource protection (OAR 629-665), including some threatened and endangered species such as the Northern Spotted Owl, but the rules do not address protection of Marbled Murrelet habitat. The ODF is responsible for administering the FPA.

Although there are no rules specific to Marbled Murrelets in the FPA, ODF has data for known murrelet sites. Proposed forest operations near these sites are addressed through the notification and written plan processes. Marbled Murrelet protections are addressed under FPA rules for written plans for species on federal or state threatened and endangered species lists. OAR 629-605-0170 (5)(d) requires statutory written plans for operations within 300 ft of nesting or roosting sites of threatened or endangered species. OAR 629-605-0190(2) requires non-statutory written plans for operations near habitat sites of any state-listed threatened or endangered species. OAR 629-605-0180 describes the process for addressing threatened and endangered species resource sites in written plans.

Each situation is evaluated on a case-by-case basis to determine if the proposed operation will pose a conflict to the murrelet site. If a conflict is not likely, then a written plan is not needed. If a conflict is likely, then a written plan must be submitted. The written plan must describe reasonable measures to resolve the conflict in favor of the resource (i.e., the listed species). Since the Marbled Murrelet is federally listed, operations cannot be less restrictive than the standards for federal take prevention under the federal ESA. However, there are no guidelines to use to evaluate written plans to determine if conflicts are likely. In general, written plans are evaluated to determine 1) if they are complete and 2) if they describe actions to be taken to protect murrelets. In general, conflicts are considered likely for operations within 0.25 mi of murrelet sites; however, local conditions such as topography, timing of the operation, and other factors are also considered. Comments are provided to the operator on the written plan, and the operator is notified that the murrelet is protected under the federal ESA and that compliance with the FPA does not ensure compliance with the federal ESA.

Enforcement authority is very limited for operations near Marbled Murrelet sites. Enforcement can only be taken if a complete written plan is not submitted. There is no ability for ODF to take enforcement action if written plans are not followed during operations. Prior to 2003, when ODF had the authority to approve or deny written plans, ODF had greater ability to require specific protection standards on the ground and could take enforcement authority for an operator not following their written plan.

In July 2016, the Board of Forestry received and denied a petition to initiate rulemaking and identify resource sites to establish an inventory and protect existing Marbled Murrelet sites. In September 2016, the petitioners submitted a Petition to Review an ODF Order through the Lane County Circuit Court to request that the court compel rulemaking. In November 2016, the Board of Forestry met to reconsider their decision to deny the petition for rulemaking, and voted to withdraw and reverse its previous decision on the rulemaking petition.

The process to consider a listed species for rule-development under the FPA is laid out in OAR 629-680-0100. These administrative rules were adopted in 1990 with the intended purpose to set criteria to inventory and protect special resources described in ORS 527.710(3)(a) on forest lands regulated by the FPA. The ODF reviewed the petition to initiate rulemaking to determine if it contained the information needed to satisfy the requirements of a technical report as described in OAR 629-680-0100(1)(a). The ODF concluded that the petition submitted for Marbled Murrelets does not contain all of the required information, specifically identification of the resource site. The Board of Forestry needs a technical report, including best available information, to help inform policy decisions for Marbled Murrelets.

The ODF will develop the technical report on Marbled Murrelets, using the petition as a starting point. The technical report will include additional background information on Marbled Murrelet ecology and habitat use, as well as explicitly address the required elements relating to the definition of resource sites and identification of potential forest practices conflicts and the consequences of those conflicts (OAR 629-680-0100(1)(a)). In addition, a range of general protection strategies for this species will be identified to help set the framework for further discussion. The technical report will provide the basis of information for subsequent steps and to inform the Board of Forestry throughout this process. At the April 2017 Board of Forestry meeting, staff indicated that the report is expected to take 18-24 months to complete (Tucker and Weikel 2017).

Statewide Planning Goals

Oregon's land use planning program (ORS 197.005 et seq.) is founded upon 19 statewide planning goals covering a range of resources and topics (OAR Chapter 660, Division 015). The statewide planning goals are achieved through local comprehensive planning, whereby cities and counties adopt comprehensive plans consistent with the statewide goals, and zoning and land-division ordinances necessary to implement the plans. The Land Conservation and Development Commission reviews and approves local plans.

In addition to local governments, planning laws apply to special districts and state agencies, and emphasize coordination among different entities to keep plans and programs consistent with one another. Except as provided in ORS 197.277 or 197.180(2), or unless expressly exempted by another statute, ORS 197.180 requires state agencies with programs affecting land use to carry out these programs in accordance with statewide planning goals, and in a manner compatible with local comprehensive plans and land use regulations.

Several statewide planning goals specifically address coastal and ocean uses and resources (Goal 16: Estuarine Resources, Goal 17: Coastal Shorelands, Goal 18: Beaches and Dunes, and Goal 19: Ocean

Resources). Under ORS 196, Oregon's *Ocean Resources Management Plan* and the *Territorial Sea Plan* relate to these goals and provide further clarification on how articulated policies will be implemented by government agencies. The *Territorial Sea Plan* was amended in 2013 to include policies governing offshore renewable energy siting in state waters.

In the terrestrial environment, Planning Goal 4 (Forest Lands) recognizes multiple values of Oregon's forest lands. It requires local governments to inventory, designate, and zone forest lands, and to conserve forest lands for forest uses. Planning Goal 5 (Open Spaces, Scenic and Historic Areas, and Natural Resources) requires local comprehensive plans to protect natural resources, including significant wildlife habitat, but ORS 197.277 specifically exempts forest practices under the FPA from any regulation under Goal 5.

State-level Forage Fishery Management

ODFW jointly manages commercial coastal pelagic species fisheries in the Pacific Ocean through the Pacific Fishery Management Council process. Administrative rules contained in OAR 635-004-0375 through 635-004-0379 apply to all fisheries in the Coastal Pelagic and Smelt Species section, and are in addition to and not in lieu of Division 004 General Regulations contained in OAR 635-004-0200 through 635-004-0265. The Coastal Pelagic and Smelt Species section includes regulations for the Sardine, Inland Waters Herring, Yaquina Bay Roe-Herring, Pacific Ocean Herring, Anchovy, and Smelt Fisheries. Market squid are managed under the Coastal Pelagic Species Fishery Management Plan and through the regulations adopted by reference in OAR 635-004-0375. However, market squid are managed as a shellfish when landed in Oregon, and are subject to regulations in the Squid Fishery section in OAR 635 Division 005. Some other marine forage species receive special protections in state waters (0-3 nautical mi offshore) through the *Oregon Forage Fish Management Plan*, and a network of marine reserves and marine protected areas restricts or prohibits take of all marine life in certain areas within Oregon's Territorial Sea (see below). Commercial harvest of krill has been banned in state waters since 2003 (ORS 509.515).

The Oregon Forage Fish Management Plan

In September 2016, the Oregon Fish and Wildlife Commission adopted a management plan for six groups of previously unmanaged forage fish, including Pacific sand lance and osmerid smelts, in state waters (ODFW 2016). The plan extends protections to these species through several approaches, including prohibition of new directed commercial harvest and limits on bycatch in other fisheries. As noted above, similar protections were established earlier in 2016 for federal waters by the Pacific Fishery Management Council and the National Oceanic and Atmospheric Administration-National Marine Fisheries Service.

Marine Reserves and Marine Protected Areas

Oregon completed designation of five marine reserve sites within state waters in 2012 (ORS 196.540 to 196.555, Senate Bill 1510). Each site has a no-take marine reserve, and most also have at least one less restrictive marine protected area. Marine reserves are closed to extractive activities and prohibit all take

of fish, invertebrates, wildlife, seaweeds, and ocean development, except as necessary for research or monitoring. Marine protected areas have varying degrees of protection for take and ocean development.

Conclusion: Our review found that the threat posed by inadequate state and federal programs and regulations has decreased since state listing. For example, implementation of the Northwest Forest Plan has greatly reduced the rate of habitat loss due to timber harvest on federal lands. Fisheries management is another example of state and federal programs and regulations that have been strengthened since the 1990s, improving protections for murrelet prey resources in Oregon.

Factors to Consider

In making a determination of whether to reclassify a species, the Commission shall consider:

- (a) the total geographic area in this state used by the species for breeding, resting, or foraging, and the portion thereof in which the species is or is likely within the foreseeable future to become in danger of extinction;**
- (b) the nature of the species' habitat, including any unique or distinctive characteristics of the habitat the species' uses for breeding, resting, or foraging; and**
- (c) the extent to which the species habitually uses the geographic area (OAR 635-100-0105(5)).**

(a) Geographic Area

The geographic area used by the Marbled Murrelet in Oregon for breeding is restricted to that area from the coastline inland about 40 mi, mainly within the Oregon Coast Range and Klamath physiographic provinces. Within that general range, murrelets use only those forested areas having specific characteristics, as described in Chapter 2.

There are gaps in the murrelet's breeding distribution, resulting from major changes in habitat availability. Disjunct distribution reflects the remaining nesting habitat, primarily old-growth and late-successional forests, mostly on public lands (see Chapter 2). Based on historical accounts, Marbled Murrelets are now rare in many areas where they were once considered abundant or common (Leschner and Cummins 1992, Nelson et al. 1992, Speich et al. 1992).

The majority of remaining Marbled Murrelet nesting habitat is on federal lands. Federal lands with murrelet habitat include primarily the Siuslaw and Rogue River-Siskiyou National Forests and land managed by the BLM. The extent of suitable habitat on state lands is mostly restricted to the Elliott, Clatsop, and Tillamook State Forests and other lands managed by ODF. Although private lands comprise roughly 3.4 million ac of potential forest habitat within the range of the Marbled Murrelet in Oregon, less than 3% is thought to contain higher-suitability habitat. These could, nonetheless, make important contributions to maintaining distributed breeding habitat and potential recovery of the species, particularly where there are gaps in federal lands (e.g., between the Siuslaw and Rogue River-Siskiyou National Forests, and north of the Siuslaw National Forest to the Columbia River). The majority of private lands, however, are managed on a short-rotation schedule (i.e., 30-60 years), and are therefore unlikely to become suitable habitat.

Marbled Murrelets' foraging and resting areas in Oregon are restricted to the nearshore ocean (generally within 1.2 mi of the coastline during the breeding season) (Strong et al. 1995, Falxa et al. 2016). The species' energetic and flight capabilities help to determine the proximity of foraging and nesting areas, since adults must commute between nest sites and the ocean to obtain and deliver food to their chicks. In their evolutionary history, murrelets have coped with changes in climatic and oceanic conditions. Today, however, they may be less able to cope due to a combination of anthropogenic stressors and cumulative or synergistic effects.

(b) Nature of Habitat

As discussed in Chapter 2, the Marbled Murrelet has narrow habitat requirements. It is unique among North American alcids in that it nests primarily in coastal old-growth and late-successional forests. Marbled Murrelets do not construct a nest, per se, but rather lay their single egg on a large or deformed tree branch high in the canopy. Large platforms with moss or other substrate, foliage cover above and around the nest, high densities of large trees, multiple canopy layers, and proximity to openings in the canopy that provide flight access are among important habitat features. Marbled Murrelets use nearshore marine waters for resting and feeding.

(c) Extent of Use of Geographic Area

Marbled Murrelets are not known to undertake large migratory movements, and while there may be some seasonal shifts in distribution, murrelets occur in Oregon at all times of the year. They nest primarily in older coastal forests, and may visit nesting areas outside of the breeding season. They are assumed to have high nest-site fidelity, meaning that birds return to the same stand or perhaps even the same tree or platform year after year (Divoky and Horton 1995). Marbled Murrelets use nearshore marine waters year-round for resting and feeding.

Option Not to List

The Commission may decide not to list a wildlife species as threatened or endangered that would otherwise qualify to be so listed within this state if the Commission determines that:

- (a) the future of the species is secure outside this state;**
- (b) the wildlife species is not of cultural, scientific, or commercial significance to the people of this state;**
- (c) the species has been listed as threatened or endangered pursuant to the federal ESA;**
- (d) the species is a candidate species under the federal ESA;**
- (e) the species has been petitioned for listing under the federal ESA;**
- (f) the responsible federal agency has determined that the species does not warrant listing as a threatened or endangered species under the federal ESA; or**
- (g) the species is currently on the Department's sensitive species list (OAR 635-100-0105(7)).**

(a) Security of the Species Outside the State

The Marbled Murrelet is listed as threatened in Washington, Oregon, and California under the federal ESA. It is state-endangered in both Washington and California, and considered threatened by the Canadian Government where it occurs in British Columbia. The species is not currently listed in Alaska, but recent evidence suggests declines of that population by about 70% from the 1980s to 2006 (Piatt et al. 2007).

Conclusion: The future of the species is not secure outside of Oregon.

(b) Cultural, Scientific, and Commercial Significance

It is the policy of the State of Oregon “that wildlife shall be managed to prevent the serious depletion of any indigenous species” (ORS 496.012). This is a recognition that all native species are important to the current and future citizens of Oregon.

Historically, the Marbled Murrelet represented what was perhaps the greatest enigma in Northwest ornithology because its nesting areas were unknown (Binford et al. 1975). The first well-described tree nest was not discovered until 1974 (Carter and Sealy 2005). No other North American bird has such a long and extensive history on the discovery of its breeding habits (Carter and Sealy 2005).

The Marbled Murrelet is still of great scientific interest because of its unique habitat requirements. While it is now one of the best-studied seabirds in North America (Burger 2002), it remains poorly understood in many aspects of its life history. There are numerous basic research questions remaining, among them why birds frequent nesting areas during the non-breeding season (Naslund 1993), many aspects of marine resource use (Lorenz et al. 2016), and the extent of wintering range (Nelson 1997). Due to their association with coastal old-growth and late-successional forests, Marbled Murrelets are also increasingly the focus of applied research and management efforts.

The former Pacific Northwest Bird and Mammal Society (now the Society for Northwestern Vertebrate Biology to address fishes, amphibians, and reptiles as well as birds and mammals) used the Marbled Murrelet as its logo for over 60 years, and its scientific journal was named *The Murrelet* (published three times a year from 1920-1988).

Seabirds feature prominently in the cultures of many indigenous peoples of the Pacific Northwest Coast. They are significant in subsistence, ceremonial, spiritual, and other cultural contexts (de Laguna 1972, Hunn et al. 2002, Moss 2007, COSEWIC 2012). The Marbled Murrelet is recognized as a particularly important figure in the history and mythology of the Tlingit of southeast Alaska (Swanton 1909 in Piatt et al. 2007, de Laguna 1972, Piatt et al. 2007). The murrelet is represented on clan regalia and artwork and in the naming of Tlingit clan houses (de Laguna 1972, Piatt et al. 2007). According to de Laguna (1972), Tlingit did not eat the Marbled Murrelet because “it was Raven’s mother”.

The Marbled Murrelet is a focal species in the contemporary forest management and conservation plans of several Oregon tribes. For example, the Confederated Tribes of Siletz Indians and the Confederated

Tribes of the Coos, Lower Umpqua, and Siuslaw Indians are designated natural resource trustees, along with state and federal agencies, for damages associated with the New Carissa oil spill that occurred in 1999. In 2007, the Confederated Tribes of Siletz Indians were selected to steward nearly 3,900 ac of Coast Range forest in perpetuity for the benefit of Marbled Murrelets and other values consistent with recovery goals. The property was transferred to the tribe as part of a court-approved settlement agreement to mitigate for resources lost to that spill. Funds to acquire property came from the U.S. Coast Guard's National Pollution Fund Center through the OPA, and allowed the tribe to recover some ancestral lands.

There is no evidence of any commercial significance of the Marbled Murrelet, though its forest nesting habitat and some of its prey species are important economically. Outdoor or recreation-based industries may derive (unmeasured) benefits from the species. For example, several Oregon-based ecotourism companies advertise possible sightings of the Marbled Murrelet on guided birding tours.

Conclusion: The Marbled Murrelet has cultural and scientific significance to the people of Oregon.

(c) Federal Status

The Marbled Murrelet is listed as threatened under the federal ESA.

(d)-(g) Not Applicable

Adequacy of Federal Protections

In addition, before making a determination not to list pursuant to subsections (c) through (f), the Commission shall evaluate whether the federal listing, categorization, or other action regarding the species adequately protects that species in Oregon (OAR 635-100-0105(8)).

Under the federal ESA, take (to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct) of Marbled Murrelets is prohibited unless authorized by permit from the USFWS. This definition of take includes harm caused by significant habitat modification or degradation. It applies to private, state, and federal lands. While the federal ESA and other federal protections appear to have reduced the overall rate of habitat loss since the 1990s (see McShane et al. 2004, Raphael et al. 2016a), they have not prevented considerable harvest of potential murrelet habitat on nonfederal lands during that period (Raphael et al. 2016a).

Conclusion: Existing federal protections have slowed but not halted habitat loss on many nonfederal lands in Oregon.

Summary of Information Pertaining to Reclassification Criteria

- Best available information indicates that Oregon's Marbled Murrelet population is considerably smaller than it was historically and may now be fluctuating around a new, lower baseline.

Demographic models and limited data on breeding success imply that fecundity is insufficient to maintain a stable or increasing population and signal high extinction risk in Oregon.

- The survival and reproduction of the Marbled Murrelet are thought to be most affected by – and are likely to continue to be affected by – forest habitat alteration; large-scale disturbances; small population size; predation; changes in prey quality, timing, and availability; and oil spills.
- Raphael et al. (2016a,b) concluded that protection of suitable habitat on nonfederal lands is important to the viability of the species. Marbled Murrelets in Oregon have continued to experience deterioration of their forest nesting habitat, especially on nonfederal lands, since the 1990s.
- There is growing recognition of the importance of marine habitat to the species, including conditions that affect prey abundance, distribution, timing, and quality. The recent establishment of marine reserves and marine protected areas, and additional state and federal oversight of forage fish take, may help to alleviate some impacts, but it is too soon to evaluate their effectiveness.
- Marbled Murrelets have a restricted geographic range for breeding, foraging, and resting. Much of the species' historical nesting habitat has been removed, resulting in fragmentation of its breeding distribution.
- Marbled Murrelets are unique among North American alcids in that they require late-successional forests with certain characteristics for nesting throughout much of their range. They also rely on the nearshore marine environment for resting and foraging.
- Marbled Murrelets are not known to undertake large migratory movements, and they habitually use certain forest and marine environments. They are assumed to have high nest-site fidelity.
- Overutilization of the species and/or its habitat for scientific or educational purposes is not occurring and is not likely to occur. There are some concerns about recreational use of murrelet habitat since campgrounds, trails, and other human activities in or near forests can attract predators, especially corvids, potentially leading to higher nest predation rates. Marbled Murrelet nesting habitat is, however, subject to timber harvest, and some prey species are taken in commercial and recreational fisheries.
- State and federal agencies and organizations in Oregon are probably better equipped to prevent, respond to, and address natural resource damage resulting from spills than they have been in the past. However, high vessel traffic along the Pacific Coast and Columbia River keeps the threat of a spill high. A large spill has the potential to have a major impact on Oregon's Marbled Murrelet population.
- On private lands, "take" avoidance is required by the OESA and federal ESA; the FPA (in and of itself) does not currently require further protection of Marbled Murrelet habitat. The amount of occupied habitat remaining on private lands is unknown, but generally assumed to be low.
- Habitat Conservation Plans are under development for the Elliott State Forest and Northwest Oregon state forests. If approved, some areas of suitable habitat would be logged, while other areas would be protected and managed for future habitat. Over the long-term, these plans must contribute to the recovery of the species.
- Gillnet fishing is illegal in Oregon's estuaries, bays, and along the outer coastal areas. Gillnetting is permitted in the Columbia River on a limited basis, but few murrelets occur there.

- The Marbled Murrelet is listed as federally threatened in Washington, Oregon, and California. It is listed as threatened in British Columbia under Canada's Species at Risk Act, and state-endangered in Washington and California.
- The Marbled Murrelet represented what was perhaps the greatest enigma in Northwest ornithology for many decades because its forest nesting habitat was unknown. It is still of significant scientific interest because of its tree nesting habits and association with old-growth forests.
- The Marbled Murrelet has cultural significance to the people of Oregon.

Concluding Remarks

Marbled Murrelets have experienced declines across much of their North American range in recent decades (Strong 2003, Piatt et al. 2007, Miller et al. 2012, Falxa et al. 2016). These declines have been linked primarily to loss and degradation of older forest nesting habitat, mortality from gillnet fisheries and oil spills, and to heavy predation pressure and changes in prey resources that reduce breeding success. While there is considerable uncertainty surrounding Oregon's current population size and recent trend due to variability in at-sea counts, the population is thought to be greatly depleted relative to historical levels. The Marbled Murrelet's life history strategy (e.g., long-lived, low annual reproductive potential, delayed reproductive maturity) requires that juveniles have high survival rates in order for the population to increase. Available measures of breeding success and demographic models do not support the conclusion that fecundity is sufficient to yield a stable or increasing population.

Marbled Murrelet distribution and trend in the breeding season appear to be most closely tied to the amount and trend of suitable nesting habitat (see Raphael et al. 2016b), but due to the difficulty of monitoring this species, many aspects of its life history and demography remain poorly understood. In Oregon, habitat loss has continued since the 1990s, mainly due to timber harvest on nonfederal lands and wildfire on federal lands. Overall, higher-suitability habitat declined by 9.2% in Oregon from 1993 to 2012. Losses were greatest on nonfederal lands during this period; 21.1% of higher-suitability habitat was lost on nonfederal lands compared to 3.4% on federal lands. Remaining habitat is highly fragmented and contains a high proportion of edge on both federal and nonfederal lands.

Our review found that the threat posed by inadequate state and federal programs and regulations has been reduced since state listing of the Marbled Murrelet in 1995 due, in part, to implementation of the Northwest Forest Plan and strengthened fisheries management in Oregon. Other threats remain high, however, and new threats and stressors have been identified, particularly in the marine environment. Some threats may not independently represent serious risks to the persistence of the Marbled Murrelet in Oregon, but when combined with others, cumulative and synergistic effects may be significant.

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