Marbled Murrelet Technical Report
Final

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Photo Credit: Gus van Vliet, USGS

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Executive Summary

In 2016, the Board of Forestry (Board) received a Petition to Initiate Rulemaking for the marbled murrelet under Forest Practices Act (FPA) specified resource site rules for threatened and endangered species (OAR 629-665-0200). The Board directed the Department to begin work on this rule analysis and received an update and an initial timeline for work to be completed at their meeting in April 2017. The Board's evaluation for possible rule-making is to be based on best available information summarized in a technical review paper. The technical review paper must include information on identification of the resource site(s) used by the species, identification of forest practices that conflict with the resource sites, evaluation of the biological consequences of those conflicts, and include information on protection requirements and exceptions (from OAR 629-680-0100(1)(a)). This technical report was developed to evaluate this required information as well as to provide information on the ecology and habitat use of marbled murrelets. While this report is intended to inform the rule analysis project and the Board's decision making process, additional work and analysis will be needed prior to decisions on possible rule-making.

The marbled murrelet is listed as threatened on both the federal and state Endangered Species Act lists. It is one of the only seabirds and the only species in the alcid family that nests in forested environments. Nests are located on a suitable platform, usually on a large, mossy, horizontal tree branch (average 9" and minimum 4" diameter). Nests are normally in the mid to upper portion of the tree, over 100 feet above the ground and with vegetative cover above and also sometimes adjacent to the nest. The presence of suitable platform limbs is considered one of the most important nesting habitat features for this species. Because of their reliance on large limbs, high in trees for nesting, murrelets and their nests are most commonly found in very old conifer stands where suitable nesting platforms are most abundant. They are also known to nest in younger forested stands where pockets or individual trees with suitable platform limbs are present (often old, residual trees from a past old-growth stand), and in younger spruce/ hemlock stands where dwarf mistletoe infections result in suitable platforms being present in relatively young trees (as young as 66 years).

Marbled murrelets have narrow habitat requirements and are secretive in nature when inland. They primarily visit their nest sites at dawn and dusk when they are less likely to be detected by potential predators. Because they are difficult to detect and tend to nest high up in the canopy, nests are extremely difficult to find. Because of this, there are gaps in our knowledge of habitat use by this species, especially for nesting birds in Oregon.

The relationship between marbled murrelet nest site selection, nest success and landscape characteristics is complicated and available information does not allow us to determine a consistent trend. There is little information available in Oregon. Research from across the entire range of the species has found various patterns for how landscape pattern (i.e., amount and fragmentation of suitable habitat) impacts murrelets. There is some evidence that murrelets tend to locate nests near forest edges (natural and human-created), but they often

experience lower rates of nest success near edges, especially human-created “hard” edges between nesting habitat and recent clearcuts.

Since 2000 a team of researchers from several state and federal agencies have collaborated to monitor murrelet populations across Washington, Oregon, and California. The monitoring was designed to estimate population size and trends in these areas (Pearson et al. 2018). Results for population trends for Oregon indicate the population increased at a rate of +1.8% per year (CI from 0.1 to 3.6%) between 2000 and 2016.

Identification of the resource site is a key question that must be decided by the Board before other policy work can occur. However, this technical report does not include policy recommendations. Rather a range of options is included, where appropriate. Details for protection strategies will be included in a future rule-analysis report.

The technical report includes a range of options for the definition of a resource site for marbled murrelets. Unlike bird species with existing rules under the FPA that are highly visible or that have established methods to locate nests, marbled murrelet nests are extremely challenging to locate and there is no efficient and effective method to locate nests. Identification of only the nest tree as the resource site for this species is likely to be insufficient because most nests are likely to go undetected. Another option is to include locations of occupied detections (as per protocol surveys; Evans Mack et al. 2003) as a proxy for nest sites and thus resource sites. A third option would be to use designated potential suitable habitat as a resource site. In this context, the designated suitable habitat would be presumed occupied by the species until additional work is conducted to determine that the area is not actually suitable (e.g. trees with suitable nesting platforms are not present) or not occupied by murrelets (i.e., as determined through surveys).

Because marbled murrelets nest in forested environments, conflicts between forest practices and marbled murrelets are likely to occur. Most conflicts will occur from forest harvesting, with conflicts likely due to potential loss of nests during logging, disturbance to nesting birds, or increased risk of depredation of nests by predators (due to increased exposure of nests near harvest edges).

Protection strategies for marbled murrelets may vary greatly depending on the Board’s decision regarding definition of a resource site. Specific strategies are not addressed in this report. Instead, a range of possible protection strategies are discussed. Both prescriptive approaches and programmatic approaches are addressed in the report. Prescriptive approaches describe best management practices to protect sites and could be codified as regulations or as non-regulatory measures. Programmatic approaches include use of Safe Harbor Agreements and Stewardship Agreements to encourage non regulatory protection and development of suitable habitat for marbled murrelets.

Future policy work is needed to inform this discussion (ODF 2017a). As per OAR 629-680-0100 (1)(b), this technical report went through a formal “Expert Review”. Feedback from the review has been incorporated in this version of the report.

Background

In June 2016, the Board received a Petition to Initiate Rulemaking for the marbled murrelet under Forest Practices Act (FPA) specified resource site rules. The Board considered the petition during their meeting on July 20. Acting within its authority under the Administrative Procedures Act, the Board denied the petition. In September, the petitioners submitted a Petition to Review an Agency Order through the Lane County Circuit Court to request the court compel rulemaking. In November, the Board held a public meeting and accepted public comment to reconsider their decision to deny the petition for rulemaking. After consultation with the Oregon Department of Justice, the Board voted to withdraw and reverse its previous decision on the rulemaking petition.

In March 2017, the Board received an update on this rule analysis. A report was presented to the Board that included a review of the petition and a summary of work needed to be conducted as part of any rule-analysis process (ODF 2017a). It was determined the petition did not include adequate information for purposes of a rule analysis. The Board directed ODF Department staff (hereafter Department) to initiate development of a Technical Report on marbled murrelets as per OAR 629-680-0100.

This report was developed to meet the requirement for a Technical Report for purposes of informing the rule analysis process for marbled murrelets. The progress report presented to the Board in March of 2017 (ODF 2017a) outlined additional work to be conducted as part of this rule analysis project. Much of the additional work that needs to be conducted is related to statutes, rules, or measures put into effect after the Specified Resource Site process rules (OAR 629, Division 680) were enacted. Examples include 1) passage of the ORS 527.714 statute that requires additional analysis prior to adoption for some new Forest Practices Act rules, and 2) passage of Ballot Measures 37 and 49 which may require compensation or waiving certain new rules that result in lost real estate value. This technical report is meant to fulfill only the needed information for a Technical Report under OAR 629-680-0100 (1)(a). The Department envisions the rule analysis project, as a whole, will involve multiple steps and decisions by the Board. The decision on protection measures for marbled murrelets is likely to occur at a later date, after the Board has heard all of the pertinent information on this topic and considered input from stakeholders. Thus, specific protection measures for marbled murrelets are not recommended in this report. Instead, a general discussion of a range of possible protection measures is included.

Current process for marbled murrelets under the FPA

Although there are no rules specific to marbled murrelets in the Forest Practices Act, the department has data for known murrelet sites. Proposed 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 (T&E) lists. OAR 629-605-0170 (5)(d) requires statutory written plans for operations within 300 feet 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 T&E 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. There are no formal guidelines for ODF staff to use to evaluate written plans to determine if conflicts are likely, however we use professional judgement to make this determination. Currently, written plans are evaluated to determine 1) if they are complete, 2) if they describe actions to be taken to protect murrelets. A conflict is generally considered likely for operations within ¼ mile 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 Endangered Species Act (ESA) and that compliance with the FPA does not ensure compliance with the 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.

Requirements for Rule Development

When a species is added to either the federal or state Endangered Species Act lists (T&E), protection rules under the FPA may be warranted. However, every listed species does not necessarily warrant development of FPA rules. Instead, the focus is on species that occur in forestland and that may be negatively impacted by forest practices. The process to evaluate T&E listed species for possible rule-making under the FPA is laid out in statute (ORS 527.710) and in administrative rule (OAR 629-680-0100).

For a species to qualify for rules under the FPA, the following criteria must be met:

1) The species must be on state or federal Endangered Species Act lists.
2) One or more forest practices must conflict with the sites used by the species.

Forest Practice in this context can be any kind of operation regulated under the FPA such as timber harvest, road construction, application of chemicals, etc. (see OAR 629-605-0050 (26)). Conflict would occur if the resource site is abandoned, or if productivity (e.g., nesting success) at the site is reduced (OAR 629-600-0050 (14)). In most cases, conflict for a resource site occurs from habitat modification or disturbance near active nests during key periods of use.

The Board's evaluation for possible rule-making is to be based on best available information summarized in a technical review paper. The technical review paper is to include the following information (from OAR 629-680-0100(1)(a)):

1) Identify the resource sites used by the species

2) Identify the forest practices that conflict with the resource sites
3) Evaluate the biological consequences of the forest practice conflicts
4) Propose protection requirements and exceptions for the resource sites

This report provides information on the general ecology and habitat use of marbled murrelets, but also addresses the specific criteria that must be included in a Technical Report. The report builds off of the original Petition for Rulemaking (Cascadia Wildlands et al. 2016) and also draws from the ODFW Draft Status Review report (ODFW 2018), the 20-year update on the NW Forest Plan (Falxa et al. 2016), the ODF-sponsored systematic evidence review for marbled murrelets (Plissner et al. 2015), and other available literature as appropriate. This report is not meant to be a complete literature review on marbled murrelets, but a targeted summary of available information pertinent to the rule-analysis project and the specific requirements of a Technical Report under OAR 629-680-0100 rules.

Marbled Murrelet Biology & Habitat Characteristics

General Life History & Characteristics

The marbled murrelet is a small seabird that spends most of its life on the ocean, but in Oregon, nests exclusively in trees in coastal forests. They do not build a nest, but instead lay a single egg directly on mossy limbs or other suitable flat platforms (average 9" and minimum 4" diameter) high (over 100') in the forest canopy. For this reason, they tend to nest predominantly in very old conifer forests (often more than 200 years old) where large-diameter trees with broad, horizontal branches suitable for nesting are most abundant (Hamer and Nelson 1995, Raphael et al. 2011). Throughout most of Oregon, nesting habitat is often described as occurring in old-growth conifer forests or stands with either a component of residual old-growth conifer trees or trees that are old enough to have suitable platform limbs present (Nelson and Hamer 1995, Nelson and Wilson 2002). Forests used for nesting in the north coast of Oregon include western hemlock stands with a component of dwarf mistletoe defect (Nelson and Wilson 2002). The mistletoe infections cause branch deformity (fattened limbs) and brooms that can function as suitable nesting platforms (if suitable moss or debris is present). See the Nesting Habitat section of this report for additional information.

During much of the year, murrelets have white and black plumage that is typical for many seabirds. During the nesting season, they molt into a light brown, mottled plumage. It is thought that this plumage is an adaptation to camouflage in their forested nesting environment.

Marbled murrelets spend most of their time at sea, where they are typically found foraging nearshore (within 3.1 miles of shore) or in bays and inlets (Nelson 1997, ODFW 2018). During the breeding season, murrelets feed on primarily on small fish, including sandlance (Ammodytes sp), northern anchovy (*Engraulus mordax*), smelt (*Osmeridae sp*), and Pacific herring (*Clupea pallassi*) (ODFW 2018). Whereas adult murrelets tend to consume larval or

juvenile fish, they tend to deliver larger sized adult fish to chicks. This is likely a mechanism to maximize the nutritional value delivered to chicks while also minimizing energetic costs due to long flights inland as murrelets feed whole prey to their young. Murrelets are considered an opportunistic forager in that they consume a variety of prey species and will switch prey species depending on availability (ODFW 2018, Raphael et al. 2018). However, there is growing evidence that poor ocean conditions may be having a negative impact on the quality of diet for murrelets, which in turn may be linked to poor reproductive output (Becker and Beissinger 2006, Norris et al. 2007, Lorenz et al. 2017). Two recent studies used isotopic analysis of museum specimens to examine changes in likely diet quality of murrelets over 100 year time periods (Norris et al. 2007, British Columbia, 1989-1996 time period and Becker and Beissinger 2006, California, 1895-1911 compared to 1998-2002 time periods) . Both studies found evidence of a reduction in nutrient-rich forage fish and in increase in zooplankton (a lower trophic food item that is less nutrient rich) in the diet of murrelets over the time periods studied. Furthermore, Norris et al. (2007) found evidence that populations of murrelets in this region may have been limited by diet quality over the time period studied and Becker and Beissinger (2006) speculated that decreased prey resources may be partially responsible for poor reproductive rates.

Life history traits for marbled murrelets are described in Nelson (1997). When nesting, the female lays a single egg. Adults share incubation duties, switching roughly every 24 hours. The eggs hatch in 28-30 days. Adults typically brood the chick for only one to two days, although some will brood for up to five days but only at night. Both adults then begin to spend much of their time at sea foraging, leaving the chick unattended in the nest. Adults bring one whole fish inland to feed the chick, one to eight times per day. Young birds fledge 27-40 days after hatching. Young fledge on their own and fly to the ocean.

Marbled murrelets have a relatively long and asynchronous nesting season (meaning that individuals do not all nest at the same time). The murrelet nesting season in Oregon is thought to begin in mid-April and extend through mid- to late September (Hamer and Nelson 1995, Hamer et al. 2003, McShane et al. 2004). In Oregon, the incubation phase ranged from mid-April through August 15 and the nestling phase ranged from approximately May 15 to September 15. Approximate time period for fledging of young ranged from mid-June to mid-September (Hamer et al. 2003).

Although murrelets only use inland habitats for nesting, adult murrelets have been documented flying inland during most months of the year except for when molting flight feathers (fall). The reason for the non-breeding season flights inland are not well understood, but it is thought that birds are possibly establishing pair bonds or prospecting for nesting sites. Most inland activity occurs during the breeding season. The peak period of inland flights is typically in July. Although inland flights can occur at any time of day, most of the inland activity occurs around dawn and dusk (Cooper et al. 2001).

Because marbled murrelets are rare, cryptic, and secretive, locating their nests is extremely difficult. The first marbled murrelet nests were not found until the 1970's and as of 2017, only

29 active nests and 75 total nests (active and older nests combined) were confirmed in Oregon (ODFW 2018, Rivers 2019). A new study in Oregon located eight additional nests in 2018 (Rivers 2019), bringing the total number of known nests in Oregon to 81. In Oregon, murrelets have been detected as far inland as 80 miles, but the furthest inland nest known was at 32 miles and the furthest inland observation of an occupied behavior was at 47 miles (Nelson 2003, ODFW 2018, Raphael et al. 2018). Many of the early known nests in Oregon were located incidentally when eggshells or chicks were located on the ground, nest trees were inadvertently felled during logging, or when birds were observed landing in trees (Nelson 1997). Nests have also been located by climbing potential nest trees during research projects or as an alternative survey method (Pacific Seabird Group 2013). In other regions, nests have been located by capturing and placing tracking devices (telemetry receivers) on birds, and then locating them inland when they are at their nest sites (e.g., Zharikov et al. 2007a, Burger et al. 2009, Silvergieter and Lank 2011, Lorenz et al. 2017, Wilk et al. 2016). This method is currently being used for a new study in Oregon; no tagged murrelets came inland to nest in 2017, but eight new nests were located in 2018 (Rivers 2019).

Marbled murrelets are thought to exhibit some level of site-fidelity. Fidelity is the propensity of individuals to use the same area for nesting repeatedly. However, the topic of site fidelity by marbled murrelets is not well studied using rigorous studies (Plissner et al. 2015). Plissner et al. (2015) provides a comprehensive review of studies that included information on site fidelity and their results are summarized here. They found evidence that murrelets may return to the same watershed, stand, and even the same tree to nest in subsequent nesting seasons (Plissner et al. 2015). This is largely based on studies that have used tree-climbing to find and characterize nests of murrelets, however evidence for fidelity exists across multiple studies across the range of the species. Because of the difficulty in reading bands on marked birds and the lack of telemetry receivers that allow for tracking of individuals over multiple seasons, information on fidelity of specific individuals is lacking. One study in California documented a single marked bird returning to the same nest annually for over a decade (Golightly and Schneider 2011). In a 2006 unpublished report from the same study, Herbert and Golightly (2006) followed a total of ten known nests (nest cups) that were surveyed during one or two subsequent years to look for evidence of between-year use of the nest cup. They found evidence of nesting during subsequent years for three out of the ten nests observed; it was not reported if renesting birds were identified as same individuals as the original nesting pair. No evidence of subsequent use was observed for seven of the ten nests, however survey methods may have missed early nesting attempts (with failure) or if the birds used a different nest in the same tree or a nearby tree. One marked individual in British Columbia was tracked using telemetry in two years (1999 and 2001) and was found nesting in the same stand; the two nests were approximately 650 feet apart (Burger et al. 2009).

There is evidence that if a nesting attempt fails, particularly if failure occurs during the incubation phase, some proportion of pairs will attempt to renest. In their review of the literature for this topic, Plissner et al. (2015) found five studies that explicitly discussed renesting attempts (Burger et al. 2009, Barbaree et al. 2014, Drever et al. 1998, Herbert and Golightly 2006, and Herbert et al. 2003). In those studies, it appeared the percentage of pairs

that attempted to renest after a failure ranged from roughly 16% to 34%. When nesting attempts fail, there is evidence birds may return to the same stand when renesting (Plissner et al. 2015). Reuse of a nest tree or stand may be higher in areas where habitat is limited. One study looked at relative rates of re-use across three regions in British Columbia found greater evidence of multiple nests or reuse of nest sites in all three regions. The authors noted that the two study areas with a greater history of logging had greater evidence of multiple nests and reuse than the study area with little to no logging history and surmised that nest reuse may be more likely in areas where potential nesting habitat is limited (Burger et al. 2009). However, many unqualified factors differ between the two study areas as well, notably biophysical setting and prey resources. There is no research available in Oregon on this topic.

Unlike many other species of seabirds, murrelets may not nest in colonies (multiple nests in very close proximity), and are generally expected to be somewhat solitary. However, there are documented occurrences of multiple nests (active or older nests) within the same general area (e.g., within 300 feet of each other) or within the same stand or watershed. One study in Oregon found two active nests located within 98 feet of each other (Nelson and Wilson 2002). Most of the available information of this topic is based on finding nests of various ages (active or older nests). In their review of the literature on this topic, Plissner et al. (2015) found five reported examples of nests being located within 330 feet of each other. They also reported four examples of nests located between 660 feet and 0.6 miles of each other, and five examples of nests located at a greater distance of up to 7.5 miles from each other which may indicate a broad distribution of nests (rather than evidence of a clumped distribution). Plissner et al. (2015) found only one robust study on this topic (Zharikov et al. 2007a). Using nests from a large number of radio-tagged murrelets in BC, Zharikov et al. (2007a) found the mean nearest nest distance (n = 157 nests) was over 2.5 miles in their two study areas. All of the inter-nest distances reported above are rough estimates. Actual inter-nest distances may be smaller as it is unlikely all nests were located in any of the studies.

Population Status and Trends

Overall population trends

Marbled murrelet population numbers and trends are evaluated and monitored by counting birds at sea. As a component of the Northwest Forest Management Plan Effectiveness Monitoring Program, a large-scale effort has been conducted to estimate populations annually across Washington, Oregon, and California since the 1990's (see Falxa and Raphael 2016 and Pearson et al. 2018). Surveys are conducted within conservation zones, as established by the Marbled Murrelet Recovery Plan (USFWS 1997). Surveys in Oregon include conservation zone 3 (Oregon-Washington boarder to Coos Bay) and a portion of conservation zone 4 (Coos Bay to the Humboldt/Mendocino County line in California) (Figure 1). The survey-wide population estimate for murrelets in Washington, Oregon and California as of 2016 is 22,600 birds (95% confidence interval [CI] of 18,200 to 27,100). The survey-wide population trend from 2001 – 2016 indicates no evidence of a trend with an increase of 0.15% per year and a confidence interval that overlaps zero (95% CI from -1.2 to +1.5). Population trends vary by state and conservation zone. There is statistically significant evidence of population decline in

Washington (-3.9%/year [CI of -6.1 to -1.7]; P=0.002), statistically significant evidence of population increases in Oregon (see below) and California (+4.5%/year [CI +2.2 to +6.9]; P=0.001). Recent information from radio tagged murrelets in Oregon has shown that long range movements of non-nesting birds during the breeding season occurs (Rivers 2019). Birds captured and tagged near Newport Oregon were found as far as northern Washington and Central California during both 2017 and 2018. Although these results are preliminary, it is possible that within-zone or within-state population numbers may not reflect actual trends for breeding populations.

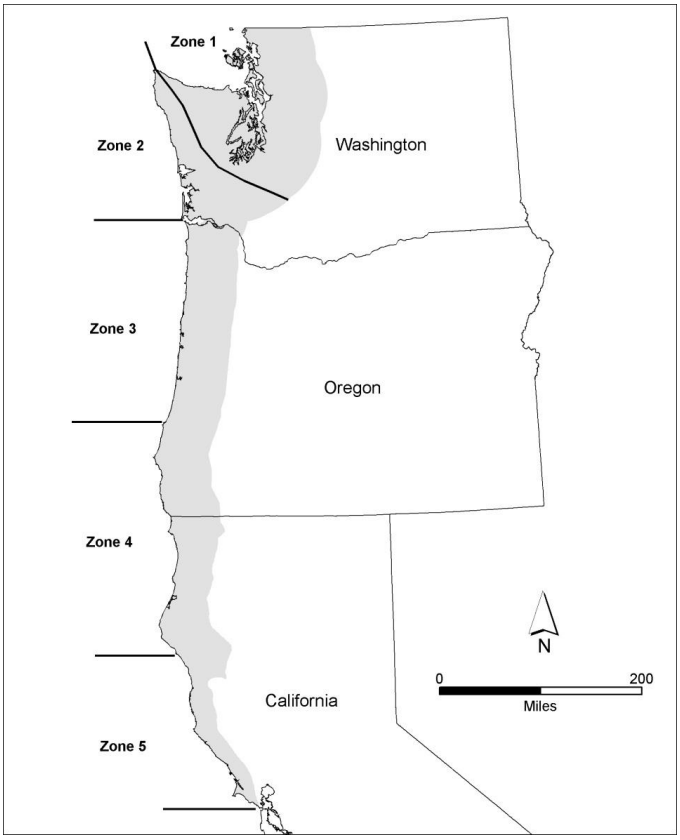

Figure 1: The five at-sea marbled murrelet conservation zones adjacent to the Northwest Forest Plan area (from Lynch et al. 2017).

Oregon-specific population trends

Oregon surveys were conducted in between 2000 and 2017, however, only conservation zone 3 was surveyed in 2016 and only conservation zone 4 was surveyed in 2017 (see Figure 1). Results for population trends for Oregon through 2016 indicate that the population increased at a rate of +1.8% per year (CI from 0.1 to 3.6%) between 2000 and 2016 (P=0.042). Data through 2017 is only available for Conservation Zone 4, which includes the portion of the population in California to the Mendocino County line (see Figure 1). Conservation Zone 4 exhibited a positive trend through 2017 with an increase of 3.7% per year (CI 1.4 to 6.1%; P=0.004).

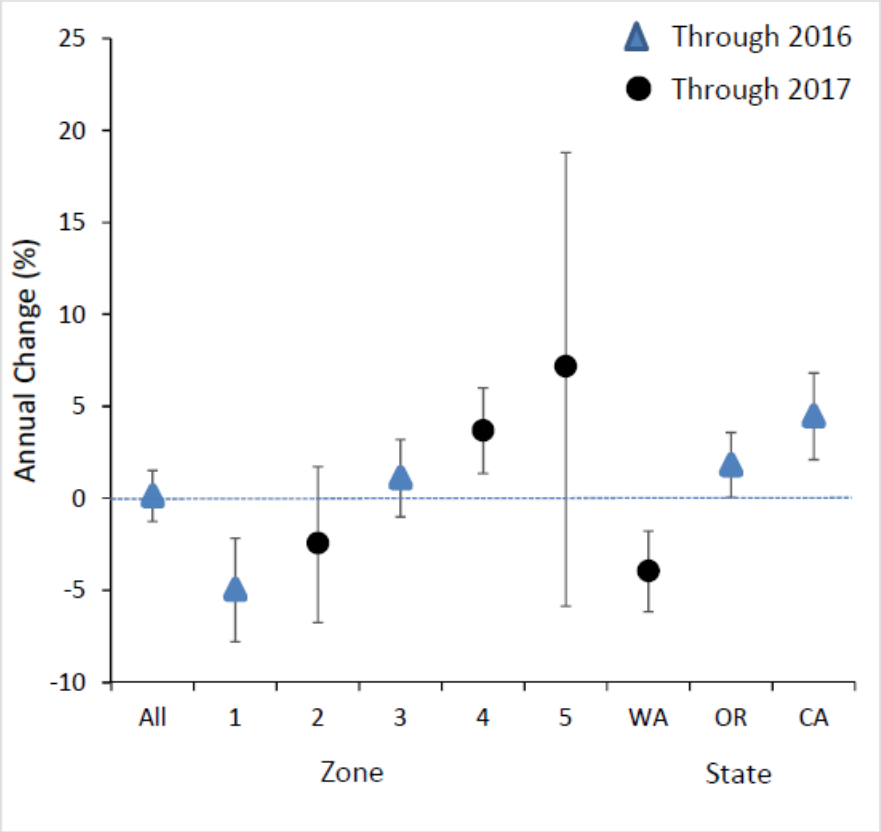

Figure 2: Percent annual change (95% confidence interval) by conservation zone, All zones combined, and by state. Trends are through 2016 for the blue triangles and through 2017 for the black circles. If the confidence intervals do not overlap zero, then there is support for either a positive (e.g., zone 4) or a negative (e.g., zone 1) trend. (from Pearson et al. 2018)

Population viability analysis

McShane et al. (2004) conducted a population viability analysis for marbled murrelets as part of the 5-year status review for the Recovery Plan for the Marbled Murrelet (USFWS 1997). This is a modeling exercise where key population and demographic parameters are input to estimate & predict future population trends and probability of extinction. They used a Leslie Matrix model which relies on estimates of demographic parameters such as annual survival rates, reproductive success, and juvenile-to-adult bird ratios (an index of breeding success). In their analysis, they estimated populations would decline by 2-6% per year over the entire range. They predicted within 100 years, there was a 16% probability of extinction over the entire range. Within only the Oregon portion of the range, the probability of extinction was 80% by the year 2060 for zone 4 and 80% by 2100 for zone 3.

Results of the McShane et al. (2004) appear to be in conflict with recent population trends from at-sea surveys (Pearson et al. 2018) which indicate an increasing population in Oregon and California. Both population viability analyses and population estimates from surveys both can have a high degree of variability depending on methods used or model inputs. Additional research to better refine estimates of immigration, fecundity, and other demographic parameters and continued population monitoring are needed. This will inform future estimates of population trends and modeled/predicted rates of extinction.

Listing status

Marbled murrelets are listed as a threatened species under the federal Endangered Species Act (ESA). They are listed as endangered under the Washington and California state Endangered Species Acts and as threatened under the Oregon Endangered Species Act. The Oregon Fish and Wildlife Commission recently enacted new survival guidelines for marbled murrelets under the Oregon ESA. These guidelines describe actions to survey for and protect habitat for murrelets, are non-regulatory and only apply to state-owned or managed lands in Oregon.

Marbled murrelet habitat quantity and trends in Oregon

The recent Marbled Murrelet Status Review for Oregon (ODFW 2018) provides a summary of trends in habitat for marbled murrelets from the time of listing to now. Most of the discussion in the Status Review is from a habitat modelling effort conducted as part of the federal Northwest Forest Plan Effectiveness Monitoring (Raphael et al. 2016a). As with all models, the outputs represent predicted habitat, not actual habitat. The model used in Raphael et al. (2016a) separated potential habitat into four broad categories. Each category reflects a bin of habitat with varying scores on their habitat suitability index. The four bins are assigned Classes and names, using the terminology of Class 1--lowest suitability; Class 2--marginal suitability, Class 3--moderate suitability, and Class 4--highest suitability. Raphael et al. (2016a) considers Class 3 and 4 to represent higher suitability habitat and uses these two categories for their estimates of predicted habitat where the likelihood of detecting murrelets (presence) or the likelihood of nests or occupied detections is greatest. While there are criticisms with the habitat model used in Raphael et al. (2016a) (see public comments for ODFW 2018), these models represent best available information at this time.

Total amount of suitable marbled murrelet habitat is widely believed to have declined significantly in the last 100 years due primarily to logging and wildfire (see ODFW 2018 for review). Since the time of listing, Raphael et al. (2016a) estimated that amounts of modeled higher suitability habitat (Class 3 and 4) in Oregon declined by 9.2% (78,600 acres) between 1993 and 2012. Although total modeled higher suitability habitat was predicted to be much more abundant on federal ownership classes, relative reductions were greater on the non-federal ownership class (59,000 acres) as compared to the federal ownership class (19,000 acres). Most of the estimated loss on non-federal ownership class was due to logging whereas most of the estimated loss on the federal ownership class was due to fire.

Current (2012) estimates for modeled higher suitable habitat in Oregon indicate that 554,000 acres occur on federal lands; 120,000 acres on state-managed lands, and 102,000 acres on other nonfederal lands (Raphael et al. 2018). ODFW (2018) report further refined estimates for amount of suitable habitat by ownership class in Oregon. Their analysis predicted that as of 2012 (the modeled habitat year), the break-down of modeled higher suitable habitat by land ownership or management class are as follows:

- U.S. Forest Service (55%)
- Bureau of Land Management (16%)
- Oregon Department of Forestry (15%)[1]
- Private (12%)
- Other (2%)

Additional work is needed to further examine the distribution of suitable habitat in Oregon. In particular, the relative distribution of suitable habitat on private industrial versus private non-industrial lands is not known. A more detailed analysis of forest conditions and anticipated recruitment of suitable habitat on all forest ownership classes in Oregon is anticipated to be important to the Board's decision-making process. The Department plans to conduct this work during a later phase of this project.

Marbled Murrelet Nesting Habitat Characteristics

Nesting platform/ actual nest site location

ODFW (2018) summarized nests and nest trees for all known nests in Oregon (see Table 1). Of the 75 nests reported in ODFW 2018, information for 22 are described in Hamer and Nelson 1995 and information for an additional 37 are reported are in Nelson and Wilson 2002. Sixteen nests do not have characteristics reported elsewhere except as included in the summary statistics reported in ODFW 2018. A publication is in prep that describes all known nests to date in Oregon and Washington (S.K. Nelson, personal communication). Plissner et al. (2015) provided a summary of habitat associated with nesting of marbled murrelets, across their range.

[1] ODFW estimates do not reflect the recent change of management of the Elliott State Forest from ODF to Department of State Lands.

Table 1: Selected marbled murrelet nest tree (table 1a) and nest structure (table 1b) characteristics for Oregon. 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), range, and sample size (n, number of nests). Adapted from Table 1 in ODFW (2018); only change is conversion of values from metric to English.

Table 1a. Nest tree characteristics

	Tree DBH (in)	Tree Height (ft)	No. Platforms in Nest Tree	Distance from Ocean (mi)	Distance to Edge (ft)	Elevation (ft)
Mean	56	184	26	14	167	1083
SD	19	46	19	6	148	492
Range	19 – 110	108 – 279	8 – 92	0.6 - 30	0 - 607	174 - 2024
n	70	70	46	75	75	75

Table 1b. Nest Characteristics

	Nest Limb Height Above Ground (ft)	Nest Limb Diameter at Trunk (in)	Limb Diameter at Nest (in)	Distance from Trunk (ft)	Nest Platform Width (in)	Moss Depth Adjacent to Nest (in)	Duff and Litter Depth in Nest Cup (in)	Percent Horizontal Cover (side)	Percent Vertical Cover (overhead)
Mean	118	9	9	3.6	10	1.7	0.9	53	83
SD	46	4	4	3.8	4	0.9	0.7	19	21
Range	33 – 246	3 – 22	4 – 19	0 - 25	3 - 20	0 – 4.3	0 – 3.3	13 – 85	25 - 100
n	66	67	35	67	65	65	54	53	56

Nests are typically located on a suitable platform, usually on a large, mossy, horizontal tree branch. Nests are normally in the mid to upper portion of the tree, typically 100 feet or more above the ground (range 33 – 246') and with vegetative cover above and often also adjacent to the nest (Table 1, ODFW 2018, Plissner et al. 2015).

Recorded diameter of limbs (at tree bole) used for nesting ranged from a minimum of four to a maximum of 29 inches (as reported across the entire range of the species); average limb diameter was more than six inches with most studies reporting an average width of more than ten inches (Plissner et al. 2015). Recorded diameter of actual platforms where birds laid their eggs ranged from four to 28 inches (ODFW 2018, Plissner et al. 2015).

Nest tree and nest patch

A variety of tree species are used for nesting, including Douglas-fir, western hemlock, Sitka spruce, coast redwood, and western red cedar (Nelson 1997). Conifers are used almost exclusively, however nests have been documented in red alder in British Columbia (ODFW 2018) and in big-leaf maple in Oregon (Rivers 2019). One ground nest (on a cliff-face) has been documented in Washington (Wilk et al. 2016). Most known nests are in large-diameter trees in old-growth forests (> 200 years old; Hamer and Nelson 1995, Nelson 1997, McShane et al. 2004). However, murrelets have also been found to nest in residual old-growth-aged trees that occur within younger forests and in mature hemlock trees (66-150 yrs. old) that have heavy infections of dwarf mistletoe (Nelson and Wilson 2002). The youngest recorded tree used for nesting was a 66 year old hemlock infected with mistletoe in the north coast range (Nelson and Wilson 2002). Mistletoe infections can create brooms or cause branch deformity resulting in fattened limbs, both of which can serve as platforms. Nests have been found on platforms and limbs of these dwarf mistletoe-infected hemlock trees (Nelson and Wilson 2002).

Murrelet nests tend to have canopy gaps or other open areas near the nest location (ODFW 2018). This feature is important to allow murrelets access to the nest platform. Because murrelets are adapted for feeding under water, their wings are relatively long and narrow in relation to their body size (termed high wing loading). Thus, murrelets are not well adapted for flying or maneuvering in forest environments. They have to fly at high rates of speed (often > 44 miles per hour) in order to remain airborne and tend to approach their nest from below and "stall out" as they land. They also need ample room when they leave the nest. Thus, having an unobstructed area for approaches and take-offs from the nest is important.

Nesting stand

Because of their reliance on platforms limbs for nesting which occur mostly in large trees, suitable nesting habitat occurs primarily in old-growth or mature forests (McShane et al. 2004, Raphael et al. 2018). Throughout most of Oregon, nesting habitat is characterized by mature to old-growth Douglas-fir stands or younger stands with a component of residual mature or old-growth trees. In the north coast of Oregon, murrelets are known to nest in younger-aged spruce-hemlock stands with heavy infestations of dwarf mistletoe.

The presence of potential nesting platforms is considered the most important characteristic of marbled murrelet nesting habitat (Nelson 1997). Murrelets select trees for nesting with more potential nesting platforms than what occurs on nearby trees. In addition, there is often a greater density of trees with platforms near nests than elsewhere in the stand (Plissner et al. 2015, Wilk et al. 2016). In their summary of the literature, Plissner et al. (2015) noted that the mean number of platform trees in nesting stands ranged from 22 to 123 per hectare with a minimum of five platform trees per hectare. One study reported that the probability of a murrelet using a stand for nesting increased with increasing density of platform trees up to 40 trees per acre, after which there was no additional change (Silvergieter and Lank 2011). Murrelets tend to select nesting locations with vegetative cover over the nest to provide protection from overhead nest predators, but also near gaps in the canopy to allow access to their nesting platform (Nelson 1997).

Landscape pattern; relationship to nest selection and nesting success

Information on the relationship between landscape pattern and fragmentation and nest site selection and nesting success is limited in Oregon. Most studies on this topic are from British Columbia where the forest type and landscape conditions are arguably different than in Oregon. Available information on this topic is summarized below.

Habitat use and nest site selection

Two studies in southern Oregon looked at the relationship between occupied detections and landscape patterns of old-growth forests. They found that the number of occupied murrelet detections were greater in unfragmented old-growth patches (Meyer et al. 2002) and that occupied areas tended to have less fragmented and isolated old-growth patches than did unoccupied areas (Meyer and Miller 2002). Occupied inland habitat also tended to be close to the coast and river mouths (Meyer and Miller 2002). Similar research has not yet been conducted in other regions of Oregon, or in a broader range of age-classes of forests.

Studies examining landscape patterns (e.g., distance from ocean, patch size, core area, and other metrics of fragmentation) using actual murrelet nests are limited in Oregon. Most research on this topic is from British Columbia, where the forest conditions and landscape patterns are arguably different from those in Oregon. One study (Ripple et al. 2003) compared landscape condition around 41 known murrelet nests to conditions around random locations in the Coast Range of Oregon. All murrelet nests used in this study were in mature or old-growth forests (mean dbh > 20 in [50 cm]) and were clustered in three areas (due to study area locations). They found the landscape condition within a 0.5 and 1.0 km (0.3 to 0.6 miles) circle around murrelet nests had less early seral (average dbh < 5 in [13 cm]) and more pole-young aged forest (average dbh 5-20 in [13-50 cm]) than random locations. Murrelet nests also had less edge, less high-contrast edge around nest patches than at random locations. Results of this study suggests that nests in Oregon mature and old-growth stands, where studied, were located in nest patches with less edge and less early seral habitat around them. More work is needed to look at landscape conditions for nests throughout the Coast Range as this study

focused on nests clustered in three discrete study areas. This study did not examine relationships between actual nest location and distance from edge.

Of the studies available that looked at nest placement in relation to edge, there is conflicting information with regards to whether marbled murrelets tend to locate nests in large interior blocks of habitat, far from forest edges[2] or if they are more general in their nest placement preference. A majority of nests (range-wide) have been found near edges, especially natural edges (see review in McShane et al. 2004). In contrast, one recent study in Washington found most nests occur in the interior of forests or in patches with a more interior habitat than at random locations (Wilk et al. 2016). Murrelets may tend to nest closer to edges or gaps as these openings provide ample room for landings and take-offs for adults or for juveniles when they fledge (McShane et al. 2004). The relationship between murrelet nests and forest edges may vary with the extent of habitat available in an area, with murrelets nesting near edges or in isolated fragments more frequently where habitat, particularly interior forest habitat, is limiting (see reviews in McShane et al. 2004 and Plissner et al. 2015).

Nest Success, nest predation & landscape conditions

Marbled murrelets have low reproductive success. Studies have documented only about a third of nests result in fledglings (from existing literature reviews; Raphael et al. 2018, McShane et al. 2004). Low rates of success are likely due to high rates of depredation, primarily by corvids (jays, ravens, and crows) (ODFW 2018, Raphael et al. 2018, Plissner et al. 2015). Existing research, primarily using artificial nests, indicates corvid abundance, and predation pressure on nests, is increased in stands near areas that provide additional food resources for corvids such as near human habitation or recreation areas and near stands with high cover of berry-producing shrubs (Plissner et al. 2015).

The relationship between marbled murrelet nesting success and landscape characteristics is complicated and available information does not allow us to determine any consistent trend. Raphael et al. 2018 and Plissner et al. (2015) provide current reviews of available research on this topic. Summaries from these reviews are noted below:

- There were no statistically significant results to indicate that rates of nest success were associated with stand size (Marzluff et al. 1999, Raphael et al. 2002, Zharikov et al. 2006, Zharikov et al. 2007a, Nelson and Hamer 1995), platform density (Manley 2003, Silvergieter 2009), tree density (Manley 2003, Golightly et al. 2009, Silvergieter 2009), or canopy height (Silvergieter 2009, Golightly et al. 2009).
- Relationships have been reported between nest success and patch shape (positive association with compact versus linear shapes) (Marzluff et al. 1999), percent canopy cover (negative association) (Malt and Lank 2007 and Waterhouse et al. 2008) and canopy

[2] The term edge refers to the break between a forested area and a non-forested area. The nonforested area may be natural (e.g., river, meadow, natural gap in the canopy) or human-made (e.g., road, clearcut harvest, development).

complexity (positive) (Waterhouse et al. 2008). Other studies found no relationship for one or more of these variables (Marzluff et al. 1999, Waterhouse et al. 2008).

- Conflicting results were reported on the relationship between stand age and nest success. Most studies did not report a statistically significant result (Manley 2003, Silvergieter 2009, Waterhouse et al. 2008). Malt and Lank (2007) found increased predation of artificial nests in landscapes with greater percentage of old-growth. In contrast, Zharikov et al. (2007a) found that nest success (measured through tracking bird activity with telemetry) was negatively associated with the amount of young forests in the landscape.
- Overall, three studies reviewed by Plissner et al. (2015) reported positive associations between nest success and distance to edge, meaning nest success was higher further from edges (Burger et al. 2004, Malt and Lank 2007, Nelson and Hamer 1995). Three additional studies found no relationship or mixed effects (Raphael et al. 2002, Bradley 2002, Silvergieter 2009)
- Malt and Lank 2007 found that murrelet nests closer to a "hard" edge[3] had lower nest success than murrelets nesting further from edges. Another study, however, reported murrelets nesting near hard edges had greater nest success (Zharikov et al. 2006) than murrelets further in the interior[4]. At the landscape scale, however, Zharikov et al. (2007a) found that nests in landscapes with greater contrast between the nest stand and neighboring units had lower nest success than in landscapes with less contrast (soft edges).
- The type of edge may have implications to nest success, with murrelets having lower nest success if nesting near a hard edge as compared to a soft or natural edge. Zharikov et al. (2007a) reported that nests were more successful in landscapes with lower edge contrast (e.g., soft edges). Similarly, Malt and Lank (2007) reported reduced nest success at hard edges and no edge effects at soft and natural edges.
- Malt and Lank (2009) in a study of nest depredation using artificial nests, demonstrated predator disturbance was more likely at hard edges than in interior habitats but the same relationship was not found at soft edges. Edges with developing forest (>20-40 years old) reduced predation risk.
- Three studies using artificial nests and one study of actual murrelet nests found abundance of corvids was negatively associated with nest success (Luginbuhl et al. 2001, Bradley 2002, Burger et al. 2004, and Malt and Lank 2007). Mixed relationships were found for two other studies. Raphael et al. (2002) found a positive relationship between corvid density and rates of nest depredation in continuous (e.g., intact) forests, but not in fragmented forests where edge effects and human activity may have been more important factors. Marzluff and Neatherlin (2006) found a positive relationship between densities of crows and rates of

[3] The term "hard edge" generally refers to an edge with a large amount of contrast, such as the edge between a meadow or a recent clear-cut and a mature forest stand. The term "soft edge" generally refers to an edge with less contrast. Examples of soft edges include an edge between a mature forest and a mid-aged stand of trees or an edge that has a more variable contrast such as a thinned or feathered boundary between the mature stand and an adjacent open area.

[4] See Burger and Page (2007) for a critique of this study and Zharikov et al. (2007b) for their response.

predation at artificial nests, but only for nests within 1 km of human settlements and no association for densities of jays and rates of nest depredation.

In general, it is documented that marbled murrelets locate their nests near canopy gaps, and forest edges, particularly in natural gaps and edges presumably for access to the nest platform. However, information on effects of landscape condition and fragmentation appears to indicate that those murrelets nesting near edges, especially hard edges, may suffer lower nest success than murrelets nesting further in the interior of a stand. Thus, there is a paradox that edges may improve access for murrelets, but sometimes at the cost of reduced nest success.

Landscape condition and off-shore distribution of marbled murrelets

Range-wide, breeding season murrelet abundance off shore has been reported to be associated with the amount and condition (fragmentation level) of older forest condition inland, with higher densities of murrelets occurring offshore from areas with more older forests and less fragmented older forests (Lorenz et al. 2016, Raphael et al. 2015, Raphael et al. 2016b). These studies indicate that murrelet populations and distribution patterns offshore are influenced by the amount of potential nesting habitat inland with birds tending to forage in close proximity to their nesting stands (Raphael et al. 2015). A recent study in Washington and British Columbia (Lorenz et al. 2017) found some individuals travelled long distances inland and also travelled long distances across marine environments to reach their foraging areas (mean distance travelled for 20 birds = 17.4 miles—range of 0.3 to 82 miles). This study suggests some individuals may travel long distances across marine environments to reach suitable foraging areas rather than to forage immediately offshore from their nesting stand. In addition, recent preliminary information from a study in Oregon indicates individuals that are not nesting may move long distances during the nesting season (Rivers personal communication). Thus, density patterns of birds offshore may not be entirely representative of populations of nesting birds. More work is needed on this topic.

Existing Marbled Murrelet Survey Methods

The Pacific Seabird Group[5] has developed a protocol to survey for marbled murrelets in forested areas (Evans Mack et al. 2003). The protocol focuses on detecting murrelets and characterizing behaviors observed. A set of behaviors, called occupied behaviors, are key to characterizing use of forested areas. These behaviors are identified primarily by visual observation of murrelets and include flying below the canopy (subcanopy flight), landing in a tree, stationary vocalization, and jet dives. Circling above the canopy is not considered an occupied behavior, but is considered indicative of potential occupancy and provides the basis for additional survey effort to attempt to observe subcanopy flights. In addition, some research studies include this behavior in their definition of an occupied behavior (Falxa et al. 2016). Research has documented that actively nesting murrelets exhibit these occupied behaviors near their nests (Plissner et al. 2015). Thus, observation of occupied behaviors are thought to

[5] The Pacific Seabird Group is a society of professional seabird researchers and managers dedicated to the study and conservation of seabirds and their environment. https://pacificseabirdgroup.org/

indicate the area being surveyed is occupied by marbled murrelets and may be used for nesting. Other types of observations of murrelets such as flying above the canopy and non-stationary vocalizations indicate murrelets are present, but not necessarily using the area of interest for nesting.

The existing protocol for surveying for murrelets (Evans Mack et al. 2003) is designed to document the occurrence or probable absence of murrelets, and if murrelets are present, to determine if birds are exhibiting occupied behaviors. This protocol was not designed to locate marbled murrelet nest trees. The existing marbled murrelet survey protocol (Evans Mack et al. 2003) is the most frequently used method to survey for murrelets in forested stands.

Under the existing protocol, surveys result in three different scales of data[6]:

1) The larger Survey Area within which one or more Survey Sites are located
2) The Survey Site within which one or more Survey Stations are located
3) The Survey Station

These three scales are based on the design of the survey protocol. The Survey Area typically includes the area of interest (such as a proposed harvest area) and all contiguous suitable habitat within a ¼ mile. The Survey Area is then broken down into Survey Sites, which are smaller areas within which multiple Survey Stations are located. The size and configuration of each Survey Site vary (e.g., do not necessarily follow habitat or topographic features). The Survey Station is where the observer looks and listens for murrelets. The survey protocol was designed so that, statistically, if surveys are conducted according to the protocol standards including the required number of visits, one will have a 95% chance of observing occupied behaviors should the Survey Site actually be occupied. The analysis that is the basis for the protocol was conducted at the scale of the survey site, thus the statistical probability is appropriately applied to the scale of the Survey Site. The protocol then recommends results be extended to the entire Survey Area, based on an assumption that suitable habitat contiguous with the location where occupied behaviors is observed is important for murrelets for current and future nesting. Applying results to the entire Survey Area may result in additional Survey Sites being designated as "occupied" even when the surveys within that Site indicate murrelets are likely absent or only "present". In the cases where the Survey Area is large or linear in nature, this can effectively result in habitat that is a long distance (e.g., 1/2 mile or more) from the actual locations of occupied detections being designated as "occupied". Thus, when using information derived from Pacific Seabird Group protocol surveys, only data at the scale of the Survey Station(s) and the Survey Site(s) would be based on the location(s) where murrelets were observed exhibiting occupied behaviors. Any additional Survey Sites and Stations (with probably absence or presence) within the larger Survey Area would be considered occupied based on extrapolation. However, the recommended approach in the Pacific Seabird Group

[6] Throughout this document, the terms Survey Area, Survey Site, and Survey Station are capitalized to indicate that these terms relate back to the definitions in the survey protocol (Evans Mack et al. 2003). If not capitalized, the terms area, site, and station are used generically and are not meant to refer to the definitions in the protocol

protocol is to conduct the extrapolation and to consider the entire Survey Area occupied of any occupied detections of murrelets are observed.

Information Gaps

Despite the marbled murrelet being one of the more well-studied seabirds in the Pacific Northwest, there are still key gaps in our knowledge about the species. Some of the information gaps that have bearing on development of protection measures for this species are discussed below.

Relationship between occupied behaviors and actual nesting

There is consistent evidence that marbled murrelets exhibit occupied behaviors (e.g., subcanopy flights, landings, stationary vocalizations) at locations where active or past-used nests are known to occur (Evans Mack et al. 2003, Plissner et al. 2015). However, there are still key unanswered questions regarding the relationship of these behaviors to active nesting and this topic has not been systematically examined using a rigorous study design. We do not fully understand how often these behaviors occur in suitable habitat not actually used for nesting (e.g., by non-nesting birds prospecting for nest sites or by incidental flights below the canopy). To our knowledge, no studies have examined the spatial relationship between observation of the behaviors and the location of active nests using a rigorous study design. For example, one knowledge gap is how far active nests are typically located from the location(s) where occupied behaviors were observed. The temporal relationship between occupied detections and actual nesting has also not been well studied. Although it has been documented that marbled murrelets exhibit occupied behaviors at locations where past nesting has occurred (Plissner et al. 2015) and it is thought they may visit a stand and exhibit occupied behaviors prior to actual nesting (e.g., prospecting), it is not known how often or for how long marbled murrelets may visit a stand and exhibit occupied behaviors prior to actual nesting—or in the case of an abandoned nesting stand, for how long after the last nesting attempt has occurred. It is also not known how often prospecting occurs, but does not result in use of a stand for nesting.

Research that could provide this information would help inform whether or not occupied detections can be used as a surrogate for a nesting site, when actual nesting or the location of the nest tree is not known. In addition, it would help inform the question of how far from a potential occupied detection a nest might actually occur.

Long term patterns of habitat use

It is well established that murrelet nesting patterns vary, and that poor ocean conditions may result in only a proportion of the population that nests (ODFW 2018). However, short and long term temporal patterns of nesting and use of stands are not well studied. One study in California which looked at relationship between occupied detections and landscape condition found a time lag in response to fragmentation, with birds abandoning fragmented patches a few years after they were isolated (Meyer et al. 2002). In contrast, Zharikov et al. (2007) found that nesting murrelets were more abundant in a fragmented area, suggesting that murrelets may continue to nest in existing, fragmented habitat rather than move to a new area to nest. Thus

there is some evidence that murrelets may attempt to continue to use their historic nesting areas as habitat is reduced, but this topic has not been specifically addressed. It would likely take a robust study of marked individuals over multiple years to fully address this question. Currently the technology does not exist to efficiently track individuals over multiple seasons.

To our knowledge, there are no long-term studies that have looked at long-term patterns of habitat use. Specifically, it is not well understood if stands are used annually or if breaks in nesting or occupancy of a stand are normal. Furthermore if breaks in use do occur, how often do they occur and what is the expected duration of nonuse before nesting or occupancy occurs again. Alternately, information is lacking to indicate if an area is unlikely to be used again after birds are absent for a period of time, and if so, how long of a period of no detections are needed to be relatively certain that the area is actually abandoned (as defined in the FPA). Having this information would help inform development of criteria to distinguish an abandoned versus an active resource site under the FPA.

There is also no information on tagged or radio-collared birds to indicate if marbled murrelets also exhibit plasticity in habitat selection from one breeding season to the next. For example, if a previously used area is no longer suitable nesting habitat (e.g., loss from logging or natural disaster) will murrelets move to a new area or do they cease to nest?

Nest site fidelity

Fidelity is the propensity of individuals to use the same area for nesting repeatedly. For example, bald eagles are considered to have high site fidelity because pairs often return to the same nest year after year. As discussed previously, marbled murrelets are thought to have relatively high site fidelity, but there are key gaps in our knowledge for this topic. In their review of the literature on the topic of site fidelity, (Plissner et al. 2015) reported strong evidence of fidelity of populations of birds at the watershed and stand scales, but noted a gap in our knowledge for fidelity of specific individuals. They found only two studies using marked birds. One study in California documented a single marked bird returning to the same nest multiple times over a decade-long time period (Golightly and Schneider 2011) and the second study in British Columbia documented the same individual returning to the same stand to nest in two non-consecutive years (Burger et al. 2009). Thus evidence of fidelity of specific individuals is poorly known at all scales, but information from at least one marked bird suggests that it can occur.

Spatial distribution of nests

Additional information is needed on spatial distribution of nests, especially in Oregon. Although rigorous studies using marked birds in British Columbia have provided valuable information, including information on spatial distribution of nests, this type of research has been mostly lacking in Oregon. A new study at Oregon State University may provide additional insight. Key questions include, how many pairs may use a stand in a given year or among years and whether presence of one nest indicates additional nests are also likely present.

Also not well understood is whether or not the number of detections is indicative of the number of birds nesting in an area or if the observation of a nest (or occupied behavior) is predictive of whether or not other nests occur nearby and how far away they may occur. Information on these topics would help inform development of protection strategies for marbled murrelets as well as development of criteria to distinguish an abandoned versus an active resource site under the FPA.

Technical Report—Required Content for Rule Analysis for a T&E Listed Species--Evaluation of OAR 680 criteria

A key component of a Technical Report for purposes of a rule analysis is evaluation of the criteria listed in the process rules for Specified Resource Sites (OAR 629, division 680). The Division 680 rules were developed by the Department and the Board of Forestry to define the process to be used for reviewing fish or wildlife species for possible rule development under the Forest Practices Act, and in the case of "recovered" species, for possible removal or revision of the species. For species that have been added to state or federal Endangered Species Act lists, the process for review is laid out in OAR 629-680-0100.

The Technical Report for a review under OAR 629-680-0100 must include the following:

1) Identify the resource sites used by the species.
2) Identify the forest practices that conflict with the resource sites.
3) Evaluate the biological consequences of the forest practice conflicts.
4) Propose protection requirements and exceptions for the resource site.

The information below includes the Department's review of the information on marbled murrelets in relation to these four components of a technical report.

Identification of the resource site(s) used by the species

This section provides additional information to help inform the Board of options for identification of the resource site for protection. The Board of Forestry must determine the resource site to be protected. In the Department's March 2017 assessment of the Petition, it was determined the resource site was not adequately identified (ODF 2017a).

For all wildlife species currently protected under the FPA, the resource site is defined as the nest tree. For the spotted owl, protection can be centered on an activity center if the nest tree is not known. In the recent past, bald eagle winter roost trees and foraging perch trees were protected under the FPA, but those rules are no longer in effect as of September 1, 2017. Thus, protection for all past and present wildlife sites have focused on individual trees or a fixed point location. To date, resource sites have not been defined as patches of habitat (occupied or presumed occupied).

Marbled murrelets only use forested environments for nesting and not for foraging or roosting. Thus it is logical to focus the identification of the resource site on the nest tree. However, because of their cryptic and secretive nature and tendency to nest high in trees, locating nest trees is extremely challenging. Despite efforts, only a small number of nests (87) have been found to date in Oregon (Rivers 2019, ODFW 2018). Because there is no protocol or method currently available to effectively and efficiently locate nests of marbled murrelets, limiting definition of the resource site to only nest trees would likely lead to protection of a small subset of the actual nesting trees on the landscape. Climbing potential nest trees can be used to look for signs of nests after the breeding season is over. However this method is extremely difficult and cost-prohibitive over large areas (Plissner et al. 2015). Tree climbing to find nests is likely only effective in small areas where the approximate area of nesting is known. Even with tree-climbing methods, nests can be missed and this method is not effective for documenting that nesting has not occurred (Pacific Seabird Group 2013). A new research study in Oregon (Rivers personal communication) is exploring the use of drones equipped with infrared cameras to detect nesting murrelets. This technique is being explored within the context of a research study and not as a survey tool. Even if effective, this may not be a suitable survey tool due to the potential for drones to pose a disturbance to nesting birds.

As discussed in the Survey Protocol section, surveys using the existing survey protocol for marbled murrelets result in information on occupied detections of marbled murrelets. It is assumed that birds exhibiting occupied behaviors are likely nesting, however as discussed in the Information Gaps section, there are still untested questions about this assumption.

Absent of an effective and efficient method to locate nests of marbled murrelets, occupied behaviors may be the only available information that could be used as a possible proxy for nests. The scales of information from protocol surveys related to "occupancy" are 1) the actual location of the bird(s) exhibiting occupied behaviors, 2) the Survey Station from which the occupied behaviors were observed, and 3) the larger Survey Site or 4) Survey Area within which birds were observed.

ORS 527.710 (3)(a)(A) indicates the Board should develop an inventory for sites of Threatened or Endangered Species without any specifications of the types of sites to be included in the inventory. OAR 629-665-(62)(a)(A) defines a resource site for Threatened and Endangered Species as the "nest tree, roost tree, or foraging perch and key components". For murrelets, this rule definition would seem to limit the definition of a resource site to the actual nest tree (murrelets do not use roost trees or foraging perches). However, current rules for spotted owls allow for identification of an activity center, when the nest tree location is not known, to be used as the center for protection under the FPA rules. It is also within the Board's authority to modify the definition of a resource site through this rule development process.

Because of the difficulty in finding nests, defining the protected resource site for marbled murrelets is not straight forward. In summary, options relating to actual observations of marbled murrelets would be,

1) Known nest trees only, or

2) Known nest trees and locations of occupied detections.

The pros and cons of options based on known locations of birds are shown in Table 2.

Another option for definition of the resource site for marbled murrelets might be the larger polygon equivalent to the Survey Site or Survey Area used to design surveys under the existing Survey Protocol. These are not included as possible options in the definition of a resource site because these larger polygons surrounding known locations are more suitable as a protection standard than as the resource site itself. These larger areas are discussed later in the section regarding Protection.

Although resource sites for all species protected under OAR 629-655-000 (Specified Resource Site Rules) have been based on point locations of nests, activity centers, roost trees, and foraging perches, for some species of wildlife, identification of potential, or presumed occupied, habitat may be appropriate. This may be appropriate in cases where a species does not use a single fixed point location as a key component of its life history (e.g. mammals that range over a large area and use multiple forest structures to meet its needs) or species that are especially rare or difficult to detect. These types of species may require something other than a fixed point as a resource site.

Because of their secretive nature and the challenge in locating nests, the marbled murrelet may be a species where focusing protection on only known nest sites may result in many undetected nest sites not being protected. A third option for the resource site would be to define, identify, and map areas of suitable habitat that would be presumed to be occupied by the species. Under this scenario, the habitat would be presumed occupied unless ground-truthing indicated suitable nesting platforms did not actually occur, or other key components of suitable habitat were lacking. Alternatively, surveys could be conducted to document murrelets were not occupying the area (e.g., probable absence or presence only from protocol surveys).

Identification of suitable habitat as a resource site would be an entirely new approach under OAR 629-665-0000. Additional work would be needed, should the Board wish to consider this option. Additional work would include, but likely not be limited to, determining stand characteristics to define and identify suitable habitat, identification of conditions needed for an area to be considered “presumed occupied” habitat, modeling work to map this habitat, defining appropriate survey strategies to determine lack of habitat, determining appropriate survey strategies to confirm lack of nesting of murrelets, determining appropriate protection strategies, and consultation with the Department of Justice on this new approach.

Table 2: Possible definitions of resource sites for marbled murrelets.

Resource Site	Definition	Pro's	Con's
1: Nest Trees	Individual trees confirmed to be used for nesting by marbled murrelets	• Known use for reproduction • Fixed point to center protection around • Similar to existing rules	• Only a small # of nests known • Potential to miss protection of many existing resource sites • Extremely challenging to locate
2: Occupied Detections	Locations where marbled murrelets were observed exhibiting occupied behaviors during protocol surveys (either location of bird or the survey station from which the bird was observed)	• Based on surveys using a standardized protocol • Based on actual observation of marbled murrelets exhibiting behaviors assumed to indicate likely nesting • Fixed point to center protection around • Similar to existing rules	• Not known if nesting actually occurred; may protect some areas not actually used for nesting • Not known where nests located; may center protection away from actual nest location • Bird location data of occupied detections may not be readily available-may have to rely on survey station locations from which the birds were observed (data more likely to be readily available)
3: Presumed occupied habitat	Area of suitable habitat presumed to be occupied by the species, unless determined that essential nesting components are not present or surveys determined the area is not occupied by murrelets.	• May identify habitat with murrelet sites not otherwise known to occur	• Not based on actual nests or observation of birds • May identify many areas as occupied by the species that are not actually occupied or not used for nesting • New approach; likely would require significant work to develop and implement

Identify the forest practices that conflict with the resource sites & evaluate the biological consequences of the forest practice conflicts

A technical report for rule development must also include information to identify the forest practices that conflict with the resource site and evaluate the biological consequences of the forest practices conflicts. These two aspects are combined below.

The Petition identified forest practices that conflict with marbled murrelets in a general sense (e.g. habitat loss), but did not identify the specific forest practices that might conflict with resource sites. The Petition provided details on the biological consequences of conflicts, but focused primarily on forest harvest and loss of habitat. This report expands on the information in the Petition and describes the full suite of Forest Practices and potential biological consequences of those forest practices.

Forest Practices are defined in rule (OAR 629-600-0100 (28)) and include forest harvesting, reforestation, road construction and maintenance, application of chemicals, disposal of slash, and removal of woody biomass. Conflict defined in rule: "means a resource site abandonment or reduced productivity" (OAR 629-600-0100 (14)).

Forest harvest may conflict with marbled murrelet resource sites by causing direct loss of nest trees through logging or subsequent wind throw. Risk of wind throw is variable and not ubiquitous and is likely influenced by local conditions such as orientation to prevailing wind, topography, soil type, height and density of trees, and "wind-firmness" of the trees (see Raphael et al. 2018 for a review of this topic).

Creation of hard edges may also have an indirect impact on marbled murrelets due to changes in the microclimate in edge areas and corresponding impacts to moss cover (important for murrelet nesting platforms). These impacts have been hypothesized to be either negative due to increased wind exposure and thermal stress, or positive due to increase light exposure for photosynthesis (Raphael et al. 2018). Microclimate effects on moss can occur within 150 feet from hard edges, possibly further in areas with greater wind exposure (Raphael et al. 2018). Effects appear to be lessened near soft edges and there is likely no negative effect of edge near natural edges (e.g., see Van Rooyen et al. 2011). Impacts of changes in microclimate on murrelet nest site selection or nesting success have not been studied. Raphael et al. (2018) notes that murrelet nests have been found within 150 feet of hard edges, suggesting that these edges are not an absolute deterrent to the birds.

There is evidence forest harvest may result in reduced productivity by increasing risk of predation of nests (see Nest Success, nest predation, & landscape conditions for a summary of this topic). As discussed previously, predation of nests is thought to be a significant concern and limiting factor for successful marbled murrelet reproduction. Forest harvesting has a potential to pose a conflict indirectly by increasing exposure of nests to predators, especially near hard edges (Malt and Lank 2009, Malt and Lank 2007, Zharikov et al. 2007a). Forest harvesting also has potential to create a diverse understory, especially of berry-producing

shrubs, which may attract jays and crows, thus increasing risk of exposure of murrelet nests to these predators. Development of berry-producing shrubs post-harvest is likely to vary depending on both harvest type (e.g., clearcut versus light thinning) and post-harvest vegetation management (e.g., use of herbicides). Results from one study using artificial nests to study nest depredation suggests that risk of nest depredation may decrease over time as the adjacent stand ages and develops (Malt and Lank 2009).

The topic of disturbance has not been well studied and most available information is anecdotal in nature. One study in California examined impacts of disturbance (trail activity, chainsaw use) on actively nesting marbled murrelets (Herbert and Golightly 2006) including 13 incubating adults and five chicks. They found no negative impact of human activity near (82-400 feet) the nest (e.g., trail use) and no negative effect of chainsaw use near (82 feet) active nests on either incubating adults or chicks.

A literature review of existing information on known and likely impacts of disturbance on nesting murrelets has been compiled by the US Fish and Wildlife Service (USFWS 2006) and is used, in part, as the basis for this section of the report. This literature review includes information on known impacts of marbled murrelets to disturbance activities, although all available information on actual murrelets is anecdotal in nature. The literature review also includes additional analyses from other species as well as information on decibel outputs from various activities (e.g., chainsaws, aircraft, etc.).

Timber harvesting activities can pose a conflict by creating disturbances that may disrupt normal nesting activities. Disturbance may result in reduced productivity by: 1) causing incubating adults to flush and leave the egg unattended, 2) causing adults delivering fish to the nest to flush and not feed the nestling (resulting in longer duration between feedings), 3) by causing chicks to flush off the nest too soon, before they are ready to fledge, 4) by attracting predators to the nesting area (USFWS 2006). All of these could pose a conflict by causing nest failure or abandonment, and thus reduced productivity.

The US Fish and Wildlife Service developed guidance to evaluate potential for projects to negatively impact nesting activities of murrelets. This guidance is included as a component of various Biological Opinions (e.g., USFWS 2016). The USFWS guidance indicates activities near murrelets may cause a significant disruption of breeding activities such that injury (i.e., harassment) may occur. Activities considered likely to cause a disruption, and hence a conflict, include chainsaw and heavy equipment use, rock crushing, blasting, aircraft use, drone use, tree-climbing, and burning. Distances for disruption effects range from 330 feet for most activities to 1/2 mile for blasting and burning. Because nest sites are not typically known, the disruption distances recommended by the USFWS are typically based on the edge of an occupied habitat patch.

Examples of forest operations and associated activities not likely to pose a conflict would include reforestation, timber cruising and wildlife surveys (that do not involve tree climbing), pre-commercial thinning using non-powered equipment, standard road maintenance (e.g., road

grading) and log hauling. In addition, activities that may cause a conflict during the nesting season would not be expected to pose a conflict if they occur outside of the nesting season or far enough away to not cause a disruption of nesting behavior.

Protection requirements—range of options

As a part of a technical report, under OAR 629-680-0100, protection requirements and exceptions must be proposed. The initial petition (Cascadia Wildlands et al. 2016) included recommended protection requirements including proposed rule language. However, in the Department's review of the petition, it was determined much of the proposed protection was outside the authority of the Board (ODF 2017a).

There are a range of possible protection strategies for marbled murrelets which would vary depending on many factors including how the resource site is defined for this species. The Department believes the Board will need to define the resource site for marbled murrelets prior to or at the same time that protection strategies are developed for marbled murrelets. Thus, rather than recommend one specific protection strategy, a range of general protection strategies that the Board might consider are described below.

Prescriptive Approaches to Protection

One method to protection is to have a prescriptive approach where best management practices and recommended standards are described in detail. These approaches are commonly used in development of regulations, but might also be suitable using a non-regulatory measures approach.

If the resource site is defined as the nest tree, the location of an occupied detection, or some other specific point on the landscape, a strategy where protection is centered around that point (or group of points) might be applied. This would follow a similar method as used for current FPA rules for wildlife (i.e., northern spotted owl, osprey, bald eagle, and great-blue heron). Once the resource site is defined, the Department would need to develop and maintain an inventory of known sites for marbled murrelets. Currently, landowners are not required to conduct surveys for protected species under the FPA. Instead, inventories are developed and maintained using readily available information compiled primarily from other governmental agencies (e.g., ODFW, BLM, USFS). The Department has some data already, but would need to determine availability and request additional information from other entities (e.g., other state and federal agencies, tribal governments, private landowners, etc.) (ODF2017a).

Protection standards for a point-centric approach would include 1) protection of the resource site and its key components (e.g., replacement trees and habitat buffer) around the point or points, and 2) seasonal restrictions for some forestry activities within a certain distance of the point or points to protect any nesting birds from disturbance during a critical use period.

Key components of a marbled murrelet resource site would also need to be identified. Key components are the attributes that are essential to maintain the resource site over time (OAR

629-600-0100 (39)). The key components may vary depending on how a resource site is defined. However, they are likely to include replacement trees and a buffer of additional habitat to help protect nests from the elements, risk of blowdown, and risk of nest predation due to edge-effects. A replacement tree is typically a tree with suitable features to be used for nesting, either as an alternate nest tree or as a replacement nest tree if the original nest tree should fall down.

Possible options for habitat protection might range from a fixed buffer around a known point location to identification of a polygon of habitat. Both would need to include adequate habitat area to protect the site(s) to avoid a conflict (i.e. site abandonment or reduced productivity). The extent of the habitat area to be included in protection might be identified using the survey protocol or a user-identified polygon of suitable habitat of a specific minimum size. The latter approach would be similar to the existing rules for spotted owls, where a core area of suitable habitat is required to be maintained around nest sites or activity centers. A summary of these options, including pros and cons of each approach are included in Table 3.

As previously mentioned, should the Board determine to identify suitable habitat (e.g., presumed occupied habitat) as a resource site under the FPA, additional work would need to occur. Included in this additional work would be identification of appropriate protection strategies. Thus, protection strategies for this approach are not described here in detail.

Table 3: Possible options for habitat protecting strategies for marbled murrelet resource sites.

Option	Description	Pro's to this approach	Cons to this approach
1: Polygon of habitat associated with protocol surveys	Polygon that identifies an area surveyed within which occupied detections were observed	• Based on surveys using a standardized protocol • Protection would center on areas with known murrelet use	• Survey boundaries are somewhat arbitrary and typically based on boundary of a proposed operation (e.g., timber harvest) and associated buffer, thus they are not necessarily biologically based. • May include stations with no detections or only presence detections • Not known if nesting actually occurred; may identify polygons for protection that not actually used for nesting • Not available unless surveys conducted based on protocol standards
2: User-Identified Polygon	A polygon of habitat around known nest site(s) or occupied detection(s) that would be identified by the operator	• Protection would center on areas with known murrelet use • Similar to the core area approach used for spotted owls • Approach can be used for data not obtained from protocol surveys • Boundaries can be established based on biological criteria such as extent of suitable habitat, topography, etc.	• Would require additional work to identify the parameters to be used to identify the extent and location of habitat to be protected • Might under or over protect marbled murrelet nesting sites
3: Presumed occupied habitat	Polygon of suitable habitat that is presumed occupied by marbled murrelets unless a habitat assessment indicates that needed habitat components are not present or surveys indicate area not occupied by murrelets	• Likely to protect a large number of areas occupied by murrelets and nest trees	• New approach—needs significant work to determine if allowed and feasible under the FPA. • May create a disincentive for landowners to keep or grow forests into older age classes • Likely to create a significant added financial cost (to both ODF and landowners) • If surveys not conducted, may result in harvest being prohibited in areas not actually occupied by murrelets.

Prescriptive Approaches—Summary and Additional Work

If the Board determines a prescriptive approach should be used for marbled murrelets, additional work would need to be conducted by the Department and subsequent decisions may be needed by the Board of Forestry. This would include but not necessarily be limited to the following:

- Defining suitable habitat for marbled murrelets.
- Identification of key components for marbled murrelet resource sites[7].
- Defining the extent of habitat to be protected, and how it will be identified.
- Describing forest activities to be limited or allowed within protected habitat.
- Defining the critical use period.
- Defining the zone, within which forestry activities would be limited during the critical use period to avoid disturbing nesting birds.

Programmatic Approaches to Protection

Programs that encourage or incentivize maintenance or development of suitable marbled murrelet habitat is an option to encourage non regulatory actions by landowners. Possible non regulatory, programmatic approaches the Department could use include 1) Development of a Programmatic Safe Harbor Agreement (SHA) for marbled murrelets with the USFWS, 2) use of the existing Stewardship Agreement program to encourage non regulatory actions to conserve habitat. These non-regulatory measures are described below.

Programmatic Safe Harbor Agreement

A Safe Harbor Agreement is an option available under the federal Endangered Species Act. This program encourages nonfederal landowners to voluntarily enhance and maintain habitat for a listed species by providing assurances the USFWS will not impose additional restrictions because of their non-regulatory conservation efforts, as long as the result is a net conservation benefit for the species. This program is available now, however individual landowners would need to enroll individually with the USFWS. Under a programmatic Safe Harbor Agreement, the Department would enter into an agreement with the USFWS and would then work with individual landowners to enroll them into the Programmatic SHA. The programmatic approach to the SHA is an efficient way to implement this program. It also allows landowners to work with the Department rather than directly with the USFWS. This can be beneficial because 1) landowners are already used to working with the Department through implementation of the Forest Practices Act, and 2) some landowners have an inherent fear or mistrust of federal agencies. The Department already has a Programmatic Safe Harbor Agreement with the USFWS for the northern spotted owl (USFWS et al. 2010), thus, there is a precedent for using this approach.

[7] Defined in FPA OAR 629-600-0100 (39) as attributes which are essential to maintain the use and productivity of a resource site over time.

While SHAs may take many forms, most SHAs involve three elements: 1) a definition of species populations or habitat conditions at the start of the SHA (baseline), 2) commitments from the landowner to conduct, or refrain from, specific actions affecting the species, and 3) a timeframe over which these actions will occur, after which the landowner is permitted to return the lands to the defined baseline condition. Under a programmatic SHA, the Department would hold the permit. If a landowner wished to be included in the terms of the SHA, they would agree to actions described in the programmatic SHA to conserve or develop habitat for marbled murrelets. A baseline for their lands would be established at the time of enrollment, defining the starting conditions at the beginning of the Agreement. The landowner is then issued a certificate of inclusion which authorizes the landowner to return the property to pre-agreement conditions (baseline conditions) at the end of the commitment period. For example, if a landowner creates habitat for marbled murrelets over the term of the agreement, they can remove that habitat at the end of the agreement without being subject to ESA take regulations. Because marbled murrelet habitat occurs primarily older forest age classes, this program may be best suited to landowners that own partially developed stands (e.g., 30-50 years or older) to ensure that habitat has potential to be developed during the term of an agreement (usually 50 to 100 years). The program may also be applicable to landowners with younger timber that is adjacent to or near older timber as managing on a longer rotation may help buffer against edge effects during the term of an agreement. Even with a programmatic SHA available, individual landowners could still opt to develop their own SHA with the USFWS.

Stewardship Agreement Program

The Department's Stewardship Agreement Program was developed to 1) provide efficiencies for a landowner for implementation of the Forest Practices Act regulations on their property and 2) to encourage landowners to provide for conservation, restoration, and improvement of fish and wildlife habitat and water quality. This program was also intended to be a mechanism to allow for coordination and implementation of incentive programs. The Stewardship Agreement Program is a required component for implementation of the current Programmatic SHA for spotted owls and would also be required under a SHA for marbled murrelets. However, the Stewardship Agreement Program is also a possible mechanism to encourage non regulatory actions for marbled murrelets as a stand-alone program.

The Stewardship Agreement Program allows the Department to provide regulatory certainty to landowners in certain situations (ORS 541.423 (7)). If, in a Stewardship Agreement, a landowner identifies specific non regulatory actions that exceed regulatory requirements, the Board may agree to exempt the landowner from future changes to a specific rule under the Forest Practices Act. Because there are no rules in the Forest Practices Act specific to marbled murrelets, the Department cannot currently grant regulatory certainties relating to rules for murrelets. However, if during this process or at a future time the Board does develop rules for marbled murrelets, regulatory certainties may be granted. Stewardship Agreements may also be a tool that can be used to provide regulatory certainties at a state-level for landowners who have a Habitat Conservation Plan with the USFWS that addresses marbled murrelets, assuming that HCP actions exceed what is required by rule under the Forest Practices Act.

Summary

Marbled murrelets have narrow habitat requirements and are secretive in nature when inland. They primarily visit their nest sites at dawn and dusk when they are less likely to be detected by potential predators. Because they are difficult to detect and tend to nest high in the canopy, their nests are extremely difficult to find. Because of this, there are gaps in our knowledge of nesting biology and habitat, particularly in Oregon.

By the very nature that marbled murrelets nest in mature trees, there is potential for conflicts between forest practices and marbled murrelet nest sites. Most conflicts will occur from forest harvesting, with conflicts likely due to potential loss of nests during logging, disturbance to nesting birds, or increased risk of depredation of nests by predators (due to increased exposure of nests near harvest edges).

Because protection strategies for marbled murrelets may vary greatly depending on the Board's decision regarding definition of a resource site, specific strategies are not recommended in this report. Instead, a range of possible protection strategies are discussed. Both prescriptive approaches and programmatic approaches are included in the report. Prescriptive approaches describe possible best management practices to protect sites and could be codified as regulations or as non-regulatory measures. Programmatic approaches include use of Safe Harbor Agreements and Stewardship Agreements to encourage non regulatory protection and development of suitable habitat for marbled murrelets.

Future policy work is needed to inform this discussion. As per OAR 629-680-0100 (1)(b), this technical report went through a formal "Expert Review". Feedback from the review has been incorporated in this version of the report.

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