

Marbled Murrelet Technical Report Draft

April 25, 2018



Photo Credit: Gus van Vliet, USGS

Report developed by Jennifer Weikel, Wildlife Biologist
Private Forest Program, Oregon Department of Forestry

Table of Contents

EXECUTIVE SUMMARY	3
BACKGROUND	5
Requirements for Rule Development	5
MARBLED MURRELET BIOLOGY & HABITAT CHARACTERISTICS.....	6
General Life History & Characteristics	6
Population Status and Trends.....	9
Overall population trends	9
Oregon-specific population trends	10
Listing status	11
Marbled murrelet habitat quantity and trends in Oregon	11
Marbled Murrelet Nesting Habitat Characteristics	13
Nesting platform/ actual nest site location	13
Nest tree and nest patch	15
Nesting stand	15
Landscape pattern; relationship to nest selection and success	16
Habitat use and nest site selection	16
Nest Success, Nest Predation & Landscape Conditions	17
Landscape condition and off-shore distribution of marbled murrelets.....	18
Existing Marbled Murrelet Survey Methods.....	19
Information Gaps	20
Relationship between occupied behaviors and actual nesting	20
Long term patterns of habitat use	21
Nest site fidelity and spatial distribution.....	21
TECHNICAL REPORT—REQUIRED CONTENT FOR RULE ANALYSIS FOR A T&E LISTED SPECIES--	
EVALUATION OF OAR 680 CRITERIA	22
Identification of the resource site(s) used by the species	23
Identify the forest practices that conflict with the resource sites & evaluate the biological	
consequences of the forest practice conflicts.....	27
Protection requirements—range of options.....	28
Prescriptive Approaches to Protection	29
Prescriptive Approaches—Summary and Additional Work.....	31
Programmatic Approaches to Protection	31
Programmatic Safe Harbor Agreement	31
Stewardship Agreement Program	32
NEXT STEPS	33
REFERENCES.....	34

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. 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 one of the only seabirds and the only species in the alcid family that nests in forested environments. They spend most of their life at sea, but rely on very old conifer trees for nesting. While most nesting is limited to old growth conifer forests, they are also known to nest in residual old trees within younger stands and in younger hemlock-dominated stands heavily infested with mistletoe in NW Oregon. 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 about 100 feet above the ground and with vegetative cover adjacent or above the nest. The presence of suitable platform limbs is considered one of the most important habitat features for this species.

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. They are difficult to detect, and tend to nest high up in the canopy. Thus, nests are extremely difficult to find. Because of this, there are still 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 may tend to locate nests near forest edges (natural and human-created), but that in some situations they experience lower rates of nest success near edges, especially human-created "hard" edges.

Oregon population surveys conducted in between 2000 and 2016 indicate that the population trend is likely stable. Results for the state-wide population trends for Oregon through 2015

indicate an increase of +1.7% per year (95% CI from -0.3 to +3.7) between 2000 and 2015. The data indicates an upward trend in Oregon, however because the confidence interval overlaps zero and this trend was not statistically significant (P=0.088) there is uncertainty about the actual trend.

Because additional analysis will need to be considered at a later date, and because identification of the resource site is the first key question that must be decided by the Board before other policy work can occur, 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 existing birds with 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. Thus, identification of only the nest tree as the resource site for this species is likely to be insufficient. Another option is to include locations of occupied detections as a proxy for nest sites. The technical report also discusses an option to use designated potential suitable habitat as a resource site. In this context, the habitat would be presumed occupied by the species until additional work is conducted to determine that the area is not actually suitable nesting habitat (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 loss of nests during logging or due to disturbance to nesting birds or increased risks to nesting birds from increased exposure to the elements or increased risk of depredation of nests by predators.

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 addressed in this report. Instead, a range of possible protection strategies for this species are discussed. Both prescriptive approaches and programmatic approaches are addressed in the report. Prescriptive approaches would describe best management practices to protect sites and could be codified as regulations or as voluntary measures. Programmatic approaches include use of Safe Harbor Agreements and Stewardship Agreements to encourage voluntary 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 must undergo a formal "Expert Review". Feedback from the review will be summarized and included in a subsequent report that will be delivered to the Board.

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 36 and 49 which require compensation or waiving 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.

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 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 almost exclusively in trees in coastal forests. They do not build a nest, but instead lay their egg directly on mossy limbs or other suitable flat platforms in the forest canopy. For this reason, they tend to nest predominantly in very old conifer forests where large-diameter trees with broad, horizontal branches suitable for nesting are most abundant. Throughout most of Oregon, nesting habitat is characterized as very old conifer forests (typically Douglas-fir) or younger forests with a component of residual old conifer trees. In the north coast of Oregon, they are also known to nest in mid-aged (60+ year old) conifer stands, primarily in hemlock stands with a component of mistletoe defect. The mistletoe infections cause branch deformity

and creates flattened areas with debris that can function as suitable nesting platforms. See the Nesting Habitat section of this report for additional information.

During most 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 northern anchovy (*Engraulus mordax*), smelt (*Osmeridae sp*), and Pacific herring (*Clupea pallasii*) (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). 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 (ODFW 2018). One study on this topic in British Columbia used isotopic analysis of museum specimens to examine changes in likely diet quality of murrelets over a 107-year period ranging from the 1889 – 1996 (Norris et al. 2007). They 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 this time period. Furthermore, they found evidence that populations of murrelets in this region may have been limited by diet quality over the time period studied.

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 they are molting

(spring and 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.

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 75 nests have been confirmed in Oregon (ODFW 2018). In Oregon, murrelets have been detected as far inland as 80 miles, but the furthest inland nest known was at 31 miles and the furthest inland observation of an occupied behavior was at 40 miles (Nelson 2003, ODFW 2018). Most of the early known nests in Oregon were located by accident or by chance when eggshells or chicks were located on the ground, when nest trees were felled during logging, or when birds were observed landing in trees. More recently, nests have been located by climbing potential nest trees during research projects or as an alternative survey method (Pacific Seabird Group 2013). In other regions, many 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. 2007, Burger et al. 2009, Silvergieter and Lank 2011, Lorenz et al. 2017). These methods are currently being used for a study in Oregon, but during the first year of the study, no murrelets came inland to nest (Rivers pers. comm. 2017).

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 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). 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 reneest. In their review of the literature for this topic, Plissner et al. (2015) found only five studies that explicitly discussed reneesting attempts. In those studies, it appeared the percentage of pairs that attempted to reneest after a failure ranged from roughly 16% to 34%. When nesting attempts fail, there is evidence birds may return to the same stand when reneesting (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 nesting habitat is limited (Burger et al. 2009).

Unlike many other species of seabirds, murrelets do not nest in colonies (multiple nests in very close proximity), but instead are 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. 2007). Using nests from a large number of radio-tagged murrelets in BC, Zharikov et al. (2007) 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 are considered rough estimates, however, as it is unlikely all of the nests were located in any of the studies.

Population Status and Trends

Overall population trends

In Oregon, as well as California and Washington, 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 Lynch et al. 2017). Surveys are conducted within conservation zones, as established by the Marbled Murrelet Recovery Plan (USFWS 1997). Surveys in Oregon include conservation zone 3 and a portion of conservation zone 4 (Figure 1). The overall population estimate for murrelets in Washington, Oregon and California as of 2015 is 24,100 birds (95% confidence interval [CI] of 19,700 to 28,600). The overall population trend from 2001 – 2015 is a decline of 0.13% per year (95% CI from -1.7 to +1.4), however this trend is inconclusive as the confidence interval overlaps zero and the trend is not statistically significant (P=0.863). Population trends vary by state and conservation zone. There is statistically significant evidence of population declines in Washington (-4.4%/year [CI of -6.8 to -1.9]; P=0.002), no evidence of a trend in Oregon (see below), and statistically significant evidence of a population increase in California (+0.9%/year [CI +0.9 to +6.8]; P=0.013).

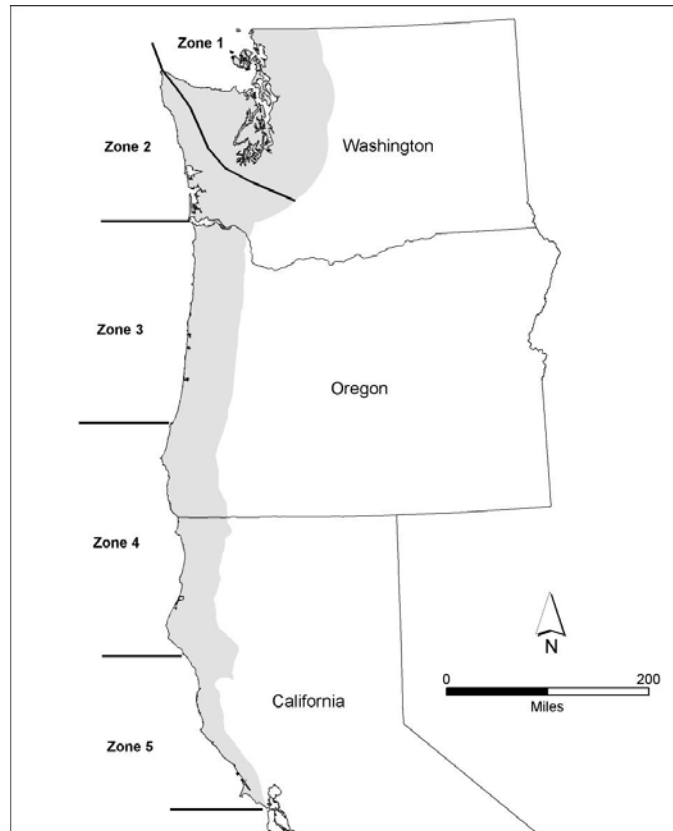


Figure 1: The five at-sea marbled murrelet conservation zones adjacent to the Northwest Forest Plan area (from Lynch et al. 2017).

Oregon-specific population trends

Oregon surveys were conducted in between 2000 and 2016, however, only conservation zone 3 was surveyed in 2016 (see Figure 1). Because of the difference in the time span for results between these two zones, results are reported separately. Results for the state-wide population trends for Oregon through 2015 indicate an increase of +1.7% per year (CI from -0.3 to +3.7) between 2000 and 2015. The data indicates an upward trend in Oregon, however because the confidence interval overlaps zero and this trend was not statistically significant (P=0.088) there is uncertainty about the actual population trend (Figure 2; Lynch 2017).

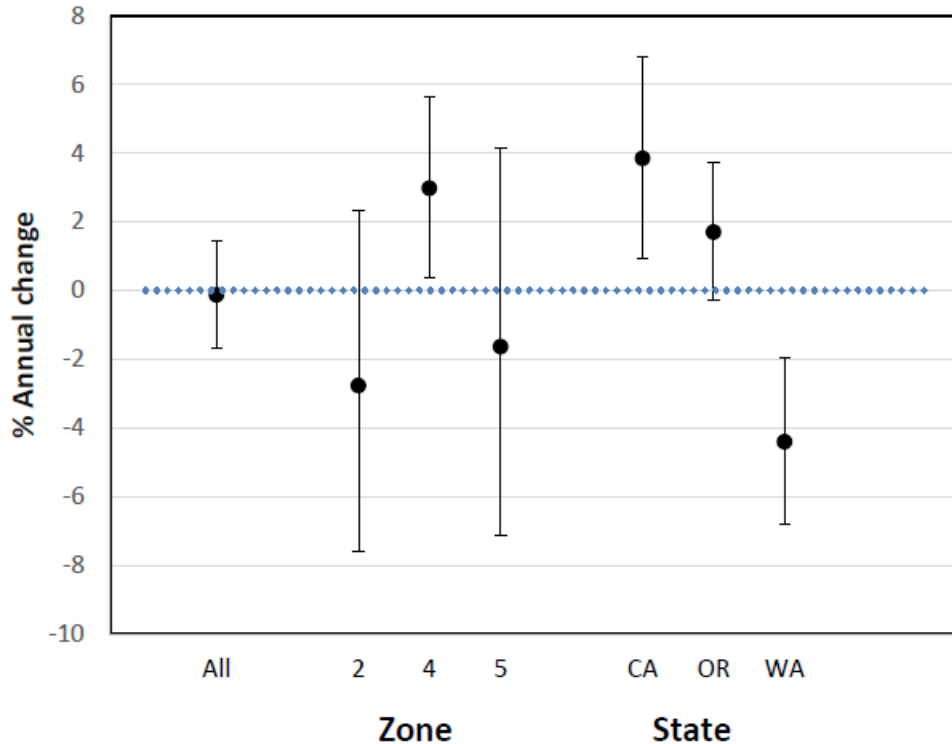


Figure 2: Trend results for units with populations through 2015 only: average rate of change with 95 percent confidence (rom Lynch et al. 2017). Zones 1 and 3 are not displayed because data was available for these zones through 2016; see text for results for zone 3 in Oregon.

Because conservation zone 3 data extends through 2016, Lynch et al. (2017) reported results for this conservation zone separately from the state-wide results shown in Figure 2. Data for conservation zone 3 indicates that the population trend within only this zone was likely also stable through 2016. The rate of change for this zone through 2016 was +1.1%/ year (95% CI = -0.9 to 3.3%); however because the confidence interval overlaps zero and the trend was not statistically significant (P=0.266), there is uncertainty about the actual population trend (Lynch et al. 2017).

Listing status

Marbled murrelets are currently listed as a threatened species under the federal Endangered Species Act. They are listed as Endangered under the Washington and California state Endangered Species Acts. The Oregon Fish and Wildlife Commission recently decided to change the status of the marbled murrelet to endangered under the Oregon Endangered Species Act. Rulemaking regarding this change, including development of survival guidelines for the species, is ongoing and is expected to be completed by June 2018.

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 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) 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 greatest 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.

Because Raphael et al. (2016a) reported amounts of modeled higher suitable habitat only to the ownership classes of federal and non-federal, the amount predicted to occur on private lands was not reported. However, in their species status review, ODFW (2018) used the data available from Raphael et al. (2016a) to further estimate habitat conditions as of the 2012 modeled habitat year by land ownership class in Oregon. Their analysis predicted that as of 2012 (the modeled habitat year), amounts of modeled higher suitable habitat by land ownership or management class is 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. For example, the relative distribution of suitable habitat on private industrial versus private non-industrial lands is not known. In addition, a more detailed analysis of forest conditions and anticipated recruitment of suitable habitat on all forest ownership classes in Oregon is

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

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). Plissner et al. (2015) provided a summary of habitat associated with nesting of marbled murrelets, across their range.

Table 1: Selected marbled murrelet nest tree (table 1a) and nest (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	55	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	3 – 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 above the ground (range 33 – 246') and with vegetative cover adjacent or above 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 five to 28 inches (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). Only conifers are known to be used for nesting in Oregon, Washington, and California, but nests have been documented in red alder in British Columbia (ODFW 2018). One ground nest has been documented in Washington (Wilk et al. 2016). Most known nests are in large-diameter trees in old-growth forests (> 200 years old; Nelson 1997, McShane et al. 2004). However, murrelets have also been found to nest in residual mature to old-growth-aged trees that occur within younger forests and in mature hemlock trees (66-150 yrs. old) that have heavy infections of mistletoe. 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 that serve as platforms or cause branch deformity, resulting in fattened limbs. Nests have been found on platforms and limbs of these 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 foraging in 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. Thus, having an unobstructed area for approaches and take-offs from the nest are important.

Nesting stand

Because of their reliance on platforms for nesting which occur mostly on large limbs in large trees, suitable nesting habitat occurs primarily in old-growth or mature forests (McShane et al. 2004). 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 hemlock stands with heavy infestations of 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). Density of trees with suitable nesting platforms in stands used for nesting by murrelets ranged from nine to 50 trees per acre; the minimum number reported was two platform trees per acre (Plissner et al. 2015). 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, but also near gaps in the canopy to allow for access to and from their nesting platform (Nelson 1997).

Landscape pattern; relationship to nest selection and 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 in Oregon. Of the studies available, there is conflicting information with regards to whether marbled murrelets tend to nest in large interior blocks of habitat, far from forest edges² or if they are more general in their nest placement preference. Although murrelets are generally thought of as being negatively impacted by edge effects, a majority of nests 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 flying room for adults coming into the nest site or for juveniles when they fledge (McShane et al. 2004). The relationship between murrelet nests and forest edges may vary with the extent of

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).

habitat available in an area, with murrelets nesting near edges or in isolated fragments more frequently where habitat, particularly interior forest habitat, is limiting (McShane et al. 2004, Plissner et al. 2015).

Nest Success, nest predation & landscape conditions

Marbled murrelets are believed to have low reproductive success, meaning that a large majority of nesting attempts fail to result in successfully fledged young. The primary theory for low rates of success is that nests have high rates of nest depredation, primarily by corvids (jays, ravens, and crows) (ODFW 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 regenerating 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. Plissner et al. (2015) provides the most current review of available research on this topic (see Table 13 for additional information). Key information includes the following:

- There were no statistically significant results to indicate that rates of nest success was associated with stand size (Marzluff et al. 1999, Raphael et al. 2002, Zharikov et al. 2006, Zharikov et al. 2007, 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 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. (2007) found that nest success (measured through tracking bird activity with telemetry) was negatively associated with the amount of young forests in the landscape.
- Conflicting results were found for the relationship between nest success and edges. Overall, five of nine 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.

- One study found that murrelets nesting closer to a “hard” edge³ had lower nest success than murrelets nesting further from edges (Malt and Lank 2007). Another study, however, found murrelets nesting near hard edges had greater nest success (Zharikov et al. 2006) than murrelets further in the interior. At the landscape scale, however, Zharikov et al. (2007) 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. (2007) 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.

In general, it is documented that marbled murrelets locate their nests near canopy gaps, including forest edges, presumably to aid in the ability of the adult birds to access the nest as they fly in from the ocean. 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 and less fragmented older forests (Raphael et al. 2015, Raphael et al. 2016b). This is thought to 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). However, a recent study in Washington and British Columbia (Lorenz et al. 2017) found that some individuals not only travelled long distances inland, but 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 latter study suggests that 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 indicate that 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.

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.

Existing Marbled Murrelet Survey Methods

The Pacific Seabird Group⁴ has developed a survey protocol to determine if murrelets are using a forested area (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 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 indicate the area being surveyed is occupied by marbled murrelets and likely used for nesting. Other types of observations of murrelets such as flying above the canopy and non-stationary vocalizations indicate that 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.

Surveys conducted using the existing protocol surveys result in three different scales of data⁵:

- 1) The Survey Station where the occupied behavior was observed,
- 2) The Survey Site within which one or more Survey Stations had occupied behaviors observed,
- 3) The larger Survey Area within which one or more Survey Sites had occupied behaviors.

These three scales are based on the design of the survey protocol. The Survey Area typically includes the area of interest (usually 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 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

⁴ 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/>

⁵ 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

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 that 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 protocol survey, 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 protocol is to conduct the extrapolation and to consider the entire Survey Area occupied if 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. Given the secretive nature and camouflage of marbled murrelets when nesting inland, this is not surprising. 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 that is 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.

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). To our knowledge, there are no long-term studies that have looked at long-term patterns of habitat use. Specifically, it is not known if stands are used annually or if breaks occur in nesting or occupancy of a stand. Furthermore if breaks in use do occur, how often and how long of a break in use occurs before the area is reused 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 of a bird are needed to be relatively certain that the area is actually abandoned (as defined in the FPA). This information would help inform development of criteria to distinguish an abandoned versus an active resource site under the FPA.

Nest site fidelity and spatial distribution

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) 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.

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 are, how many pairs may use a stand in a given year or among years and whether presence of one nest indicates that additional nests are also likely present. There is

also no information on tagged or radio-collared birds between seasons to indicate if marbled murrelets also exhibit plasticity in habitat selection. For example, if a previously used area is no longer suitable nesting habitat (e.g., loss from logging or natural disasters) will murrelets move to a new area or do they cease to nest? Meyer et al. (2002) showed that there was a time lag in response to habitat fragmentation and that murrelets would continue to use an area for some time before abandoning the fragmented parcel (based on patterns of occupied detections—not confirmed nesting). Zharikov et al. (2007) found that nesting murrelets were more abundant in a fragmented area, suggesting that murrelets may have been “packing” into remaining 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.

Also not well understood is whether or not the number of detections is indicative of local abundance 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

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). This section provides additional information to help inform the Board of options for identification of the resource site for protection.

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 yet 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 (75) have been found to date in Oregon (ODFW 2018). 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 because there is no protocol or method currently available to effectively and efficiently locate nests of marbled murrelets. 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 tool 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 of marbled murrelets.

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

It can be argued 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 other, undetected nest sites not being protected. Another option 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 that suitable nesting platforms did not actually occur, or other key components of suitable habitat were lacking. Alternatively, surveys could be conducted to document that murrelets were not occupying the area (e.g., probable absence or presence only from protocol surveys).

Because 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 characteristics to define 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	<ul style="list-style-type: none"> • Known use for reproduction • Fixed point to center protection around • Similar to existing rules 	<ul style="list-style-type: none"> • 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)	<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • May identify habitat with murrelet sites not otherwise known to occur 	<ul style="list-style-type: none"> • 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)).

Harvesting of forest trees may conflict with marbled murrelet resource sites by causing direct loss (e.g., removal) of nest trees, by increasing risk of windthrow of nest trees, or by increasing exposure of nests to the elements or to predation. In cases where a hard edge is created near actively nesting murrelets, even if murrelets are not directly harmed by nearby harvest operations and continue to nest, there may be risk of negative effects on the young due to thermal stress and dehydration if adults or chicks are exposed to direct sunlight or increased winds (based on professional judgement). This may result in reduced productivity, however this topic has not been researched. Creation of hard edges may also have an indirect impact on marbled murrelets. Changes in microclimate (due to increased sun, exposure to wind, etc.) can have a negative impact on mosses (Van Rooyen et al. 2011). This is pertinent to murrelets because they largely rely on moss for nest substrates. Microclimate effects on moss may extend 150 feet into the forested stand, possibly further in areas with greater wind exposure. Any changes in moss cover would likely occur at longer time scales—not immediately after creation of a new hard edge. Impacts of changes in microclimate on murrelet nest site selection or nesting success have not been studied. There is evidence timber harvest may result in reduced productivity by increasing risk of predation of nests. As discussed previously, predation of nests is thought to be a significant concern and limiting factor for successful marbled murrelet reproduction. Timber harvesting has a potential to pose a conflict indirectly by increasing exposure of nests to predators, especially near hard edges.

The topic of disturbance has not been well studied and most available information is anecdotal in nature. However, 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 review includes information on known impacts of marbled murrelets to disturbance activities, although all

available information on actual murrelets is anecdotal in nature. The 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 unintended, 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 and thus reduced productivity, or by causing abandonment of the nest.

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 2017). 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 within close distances 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 addressing specific protection strategies 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 voluntary 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 forestry activities within a certain distance of the point location to protect any nesting birds from disturbance during a critical use period.

Key components of a marbled murrelet resource site 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 include replacement trees and a buffer of additional habitat to help protect nests from the elements, risk of blowdown, and to help minimize risk of nest predation due to edge-effects. A replacement tree is typically a tree with the suitable features to be used for nesting, either as an alternate nest tree or as a replacement 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, significant 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 and not included in Table 3.

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	<ul style="list-style-type: none"> • Based on surveys using a standardized protocol 	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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. 	<ul style="list-style-type: none"> • 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

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 sites⁶
- 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
- If suitable, or presumed occupied, habitat is used to define a resource site, a significant amount of new work is needed (see text of document)

Programmatic Approaches to Protection

Programs that encourage or incentivize maintenance or development of suitable marbled murrelet habitat on their lands are an option to encourage voluntary actions by landowners. Possible voluntary, 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 voluntary actions to conserve habitat. These voluntary 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 voluntary 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 already a precedent for

⁶ 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.

using this approach. Currently there are 13 properties and 3,484 acres enrolled in the Programmatic Safe Harbor Agreement for spotted owls.

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. 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 voluntary 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 voluntary 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.

Although regulatory certainties cannot be granted at this time for any future rules for marbled murrelets, a landowner may still enroll in this program now to conserve habitat for marbled murrelets. The landowner may still obtain other benefits of this program, such as regulatory efficiencies (exemption from written plan requirements) and regulatory certainty for rules already in place (e.g., stream protection rules). Should the Board develop rules for marbled murrelets after the time an Agreement is already in place, the Agreement can be re-evaluated and amended as needed to obtain certainties for murrelets under the FPA.

Next Steps

A general summary of next steps was presented to the Board of Forestry in April of 2017 (ODF 2017b). However, subsequent work may depend on decisions made by the Board of Forestry during this rule analysis process.

As described to the Board in April 2017, this Technical Report will undergo a review by subject experts. The purpose of the review is to evaluate the literature used and content of the report, to ensure that the “best available information” is presented to the Board for their decision-making process.

Following the Expert Review, the Department will summarize the input received and create an amendment to the Technical Report, if needed. This information will then be presented to the Board at a subsequent meeting. Also, as described in the March 2017 Progress Report to the Board of Forestry, additional work is needed to help inform the decision-making process. This includes consultation with other agencies, additional analysis as required per ORS 527.714, and consideration of impacts from ballot measure 49 and associated statutes (ORS 195.305). ORS 527.714 requires additional review and that certain standards are met before new Forest Practices Act rules can be enacted. ORS 195.305 resulted from ballot measure 49 and allows claims to be made for compensation if new regulations affect the fair market value of a property; alternatively the claimant may request an exemption from the new rule. Thus, additional work will be needed to 1) conduct the required analysis under ORS 527.714 and 2) to understand the implications of ORS 195.305 on any new regulations for marbled murrelets.

References

- Burger, A.E., I.A. Manley, M.P. Silvergieter, D.B. Lank, KmM. Jordon, T.D. Bloxton, and M.G. Raphael. 2009. Re-use of nest sites by Marbled Murrelets (*Brachyramphus marmoratus*) in British Columbia. *Northwestern Naturalist* 90: 217-226.
- Cascadia Wildlands, Center for Biological Diversity, Coast Range Forest Watch, Oregon Wild, Audubon Society of Portland, and Oregon Chapter of the Sierra Club. 2016. Petition to initiate rulemaking and identify resource sites to establish an inventory and protect existing marbled murrelet sites.
- Evans Mack, Diane, William P. Ritchie, S. Kim Nelson, Elana Kuo-Harrison, Peter Harrison, and Thomas E. Hamer. 2003. Methods for surveying marbled murrelets in forests: A revised protocol for land management and research. Technical Publication Number 2: Pacific Seabird Group.
- Falxa, Gary A. and Martin G. Raphael (tech. cords.). 2016. Northwest Forest Plan—the first 20 Years (1994-2013): status and trend of marbled murrelet populations and nesting habitat. USDA Forest Service, Pacific Northwest Research Station, General Technical Report PNW-GTR-933. Portland, OR.
- Golightly, R.T. and S.R. Schneider. 2009. Observations of incubation in Year 8 of a long-term monitoring effort at a Marbled Murrelet nest in northern California. Report by Department of Wildlife, Humboldt State University, Arcata CA. 37 pp.
- Hamer, T.E. and S.K. Nelson. 1995. Characteristics of marbled murrelet nest trees and nesting stands. Pp 69-82 in in C.J. Ralph, G.L. Hunt Jr., M.G. Raphael, and J.F. Piatt (Tech eds.). Ecology and conservation of the marbled murrelet. USDA Forest Service, Pacific Southwest Research Station, General Technical Report PSW-GTR-152, Albany, CA.
- Hamer, T.E., S.K. Nelson, and T.I. Mohagen II. 2003. Nesting chronology of the marbled murrelet in North America. Unpublished report. Obtained from the USFWS office, Portland, OR.
- Lorenz, T.J., M.G. Raphael, T.D. Bloxton, and P.G. Cunningham. 2017. Low breeding propensity and wide-ranging movements by marbled murrelets in Washington. *Journal of Wildlife Management* 81: 306-321.
- Lynch, D., J. Baldwin, M. Lance, S.F. Pearson, M.G. Raphael, C. Strong, and R. Young. 2017. Marbled murrelet effectiveness monitoring, Northwest Forest Plan: 2016 summary report. USFWS, Lacey WA 19 pp.
- Malt, J. and D. Lank. 2007. Temporal dynamics of edge effects on nest predation risk for the Marbled Murrelet. *Biological Conservation* 140: 160-173.

- Manley, I.A. 2003. Characteristics of marbled murrelet nest sites in Desolation Sound and Clayoquot Sound, BC. Unpublished report, Simon Fraser University, Burnaby, BC. 27pp.
- Marzluff, J.M, J.M Luginbuhl, J.E. Bradley, E. Neatherlin, M.G. Raphael, D.M. Evans, D.E. Varland, L.S. Young, S.P. Horton, and S.P. Courtney. 1999. The influence of stand structure, proximity to human activity, and forest fragmentation on the risk of predation to nests of marbled murrelets on the Olympic Peninsula. Unpublished report by Sustainable Ecosystems Institute and College of Forest Resources, University of Washington, Seattle, WA. 75 pp.
- McShane, C., T. Hamer, H. Carter, G. Swartzman, V. Friesen, D. Ainley, R. Tressler, K. Nelson, A. Burger, L. Spear, T. Mohagen, R. Martin, L. Henkel, K. Prindle, C. Strong, and J. Keany. 2004. Evaluation report for the 5-year status review of the marbled murrelet in Washington, Oregon, and California. Unpublished Report. EDAW Inc., Seattle, Washington. Prepared for the U.S. Fish and Wildlife Service, Region 1. Portland OR.
- Meyer, C.G. and S.L. Miller. 2002. Use of fragmented landscapes by marbled murrelets for nesting in southern Oregon. *Conservation Biology* 16 (3): 755-766.
- Meyer, C.B., S.L. Miller, and C.J. Ralph. 2002. Multi-scale landscape and seascape patterns associated with marbled murrelet nesting areas on the U.S. west coast. *Landscape Ecology* 17: 95-115.
- Nelson, S. Kim. 1997. Marbled Murrelet (*Brachyramphus marmoratus*). In *The Birds of North America*. No 276. (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and the American Ornithologists Union, Washington D.C.
- Nelson, S. Kim. 2003. Marbled Murrelet (*Brachyramphus marmoratus*). Pp 290 – 293 in *Birds of Oregon: A General Reference*. Marshall, D.B., M.G. Hunter, and A.L Contreras (eds). Oregon State University Press, Corvallis, Oregon.
- Nelson, S.K. and T.E. Hamer. 1995. Nest success and the effects of predation on marbled murrelets. Pp. 89-97 in C.J. Ralph, G.L. Hunt Jr., M.G. Raphael, and J.F. Piatt (Tech eds.). *Ecology and conservation of the marbled murrelet*. USDA Forest Service, Pacific Southwest Research Station, General Technical Report PSW-GTR-152, Albany, CA.
- Nelson, S. K. and A.K. Wilson. 2002. Marbled murrelet habitat characteristics on state lands in western Oregon. Corvallis, OR, Oregon Cooperative Fish and Wildlife Research Unit, Oregon State University, Department of Fisheries and Wildlife, 151 pp.
- Oregon Department of Fish and Wildlife (ODFW). 2018. Marbled Murrelet species status review. Oregon Department of Fish and Wildlife, Salem, Oregon.

- Oregon Department of Forestry (ODF). 2017a. Marbled murrelet specified resource sites: a progress report to the Board of Forestry. March 2017. Agenda Item 7, Attachment 1. Oregon Department of Forestry, Salem, Oregon.
- Oregon Department of Forestry (ODF). 2017b. Rule process relating to marbled murrelet sites (staff report and attachment). April 2017. Agenda Item 2. Oregon Department of Forestry, Salem, Oregon.
- Pacific Seabird Group. 2013. Marbled murrelet nest identification training and certification protocol for tree climbers. August 2013.
- Plissner, Johnathan H., Brian A. Cooper, Robert H. Day, and Peter M. Sanzenbacher. 2015. A review of marbled murrelet research related to nesting habitat use and nest success. Oregon Department of Forestry, Salem.
- Raphael, M.G., G.A. Falxa, D. Lynch, S.K. Nelson, S.F. Pearson, A.J. Shirk, and R.D. Young. 2016a. Chapter 2: Status and trend of nesting habitat for the marbled murrelet under the Northwest Forest Plan, pp. 37-94 in Falxa, Gary A. and Martin G. Raphael (tech. cords.). Northwest Forest Plan—the first 20 Years (1994-2013): status and trend of marbled murrelet populations and nesting habitat. USDA Forest Service, Pacific Northwest Research Station, General Technical Report PNW-GTR-933. Portland, OR.
- Raphael, M.G., A.J. Shirk, G.A. Falxa, D. Lynch, S.K. Nelson, S.F. Pearson, C. Strong, and R.D. Young. 2016b. Chapter 3: Factors influencing status and trend of marbled murrelet populations: an integrated perspective, pp. 95-120 in Falxa, Gary A. and Martin G. Raphael (tech. cords.). Northwest Forest Plan—the first 20 Years (1994-2013): status and trend of marbled murrelet populations and nesting habitat. USDA Forest Service, Pacific Northwest Research Station, General Technical Report PNW-GTR-933. Portland, OR.
- Raphael, M.G., A.J. Shirk, G.A. Falxa, and S.F. Pearson. 2015. Habitat associations of marbled murrelets in nearshore waters along the Washington to California coast. *Journal of Marine Systems* 146: 17-25.
- Raphael, M.G., D.E. Mack, J.M. Marzluff, and J.M. Luginbuhl. 2002. Effects of forest fragmentation on populations of the marbled murrelet. *Studies in Avian Biology* 25: 221-235.
- Rivers, J. 2017. Personal communication—e-mail update on research project from July 18, 2017 and presentation from OR Fish and Wildlife Commission Meeting Feb 9 2018.
- Silvergieter, M.P. 2009. Multi-scale analyses of nest site and fledgling success by marbled murrelets (*Brachyramphus marmoratus*) in British Columbia. M.Sc. Thesis, Simon Fraser University, Burnaby, BC. 149 pp.

- Silvergieter, M.P. and D.B. Lank. 2011. Patch scale nest-site selection by Marbled Murrelets (*Brachyramphus marmoratus*). *Avian Conservation and Ecology* 6 (2): 6.
- US Fish and Wildlife Service (USFWS). 2016. Biological assessment for routine land management activities within the north coast planning province of Oregon with a potential to disturb the northern spotted owl (*Strix occidentalis caurina*) and marbled murrelet (*Brachyramphus marmoratus*). June 21, 2017. USFWS Region 1, Portland OR.
- US Fish and Wildlife Service (USFWS). 2010. Programmatic Safe Harbor Agreement for the Northern Spotted Owl between U.S. Fish and Wildlife Service, Oregon Department of Forestry, and USDA Natural Resource Conservation Service. July 2010. USFWS, Portland, OR.
- US Fish and Wildlife Service (USFWS). 2006. Estimating effects of auditory and visual disturbance to northern spotted owls and marbled murrelets in northwestern California. Unpublished Report. USFWS, Arcata, California.
- US Fish and Wildlife Service (USFWS). 1997. Recovery Plan for the Marbled Murrelet (Washington, Oregon and California Populations). Region 1, US Fish and Wildlife Service, Portland Oregon.
- Van Rooyen, J.C., J.M. Malt, and D.B. Lank. 2011. Relating microclimate to epiphyte availability: edge effects on nesting habitat availability for the marbled murrelet. *Northwest Science* 85: 549-561.
- Waterhouse, F.L, A.E. Burger, D.B. Lank, P.K. Ott, and E.A. Krebs. 2008. Using air photos to interpret quality of Marbled Murrelet nesting habitat in south coastal British Columbia. *BC Journal of Ecosystems and Management* 9(1): 17-37.
- Wilk, R.J., M.G. Raphael, and T.D. Bloxton, Jr. 2016. Nesting habitat characteristics of marbled murrelets occurring in near-shore waters of the Olympic Peninsula, Washington. *Journal of Field Ornithology* 87: 162-175.
- Zharikov, Y.D., B. Lank, and F. Cooke. 2007. Influence of landscape pattern on breeding distribution and success in a threatened alcid, the Marbled Murrelet: model transferability and management implications. *Journal of Applied Ecology* 44: 748-759.
- Zharikov, Y.D., B. Lank, F. Huttman, R.W. Bradley, N. Parker, P.P.-Wen, L.A. McFarlane-Tranquilla, and F. Cooke. 2006. Habitat selection and breeding success in a forest-nesting alcid, the Marbled Murrelet, in two landscapes with different degrees of forest fragmentation. *Landscape Ecology* 21: 107-120.