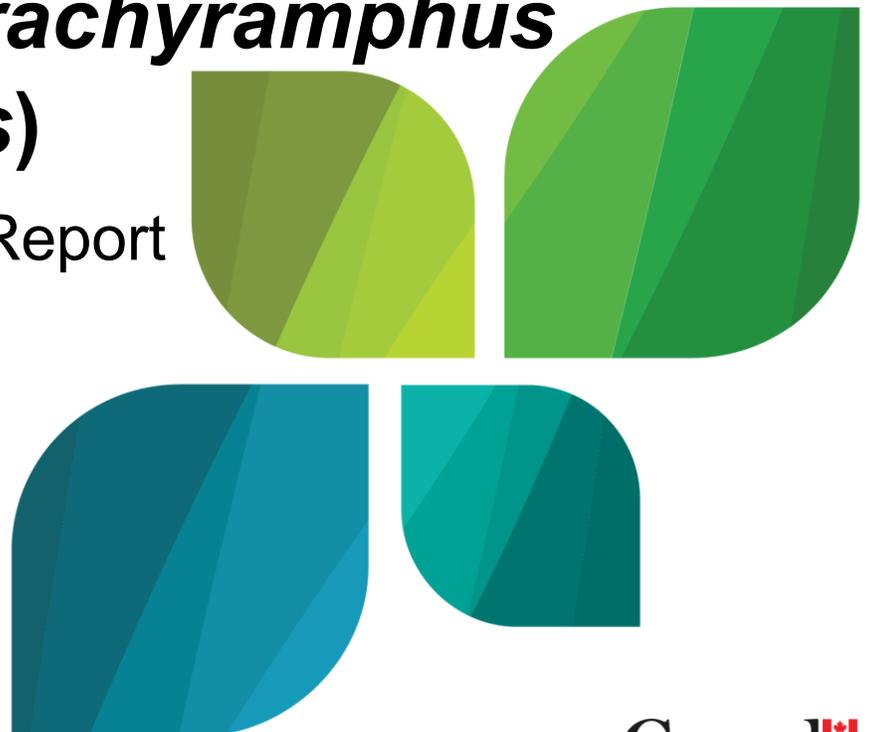




Scientific Review of Terrestrial Habitat Modelling to Support the Identification of Terrestrial Critical Habitat for the Marbled Murrelet (*Brachyramphus marmoratus*)

Science Advice Report



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Executive Summary

- Marbled Murrelet (*Brachyramphus marmoratus*) are listed as Threatened under the *Species at Risk Act*. To support the identification of terrestrial (nesting) critical habitat for Marbled Murrelet, a new approach was developed by Environment and Climate Change Canada's (ECCC) Canadian Wildlife Service (CWS) which included a new (2025) habitat suitability model (hereafter, the '2025 Model') and the development of an algorithm for selecting terrestrial critical habitat that could inform the next amendment of the recovery strategy. Further, the new modelling approach was intended to provide a direct comparison of current habitat availability to that available in 2002.
- ECCC's Science and Technology Branch struck an Expert Working Group to conduct a scientific review of the 2025 Model and the critical habitat identification algorithm, with the objectives of providing an assessment of their suitability and suggestions for improvement.
- The 2025 Model was based on a random-forest statistical approach that was developed using habitat suitability polygons produced from low level aerial surveys (LLAS, using helicopters) and applied to remote-sensing data from the National Terrestrial Ecosystem Monitoring System (NTEMS) and other sources. The 2025 Model was intended to apply across the entire range of Marbled Murrelets in British Columbia.
 - The Expert Working Group noted that the polygons used to develop and validate the 2025 Model were too coarse to do this reliably. The use of other data types (such as observations of nest sites or fine-scale LLAS surveys) could increase confidence in model predictions.
 - The Expert Working Group noted that the relationships between environmental variables and habitat suitability within the 2025 Model were inconsistent with some known ecological predictors of nesting habitat and the resultant mapping misclassified some suitable habitat.
 - Furthermore, there was also concern that the 2025 Model did not sufficiently account for regional variation in habitat use of Marbled Murrelets.
- Because of these and other model limitations, the Expert Working Group suggested that the pre-existing approach to the identification of suitable habitat (i.e., the Province of British Columbia's approach based on the combination of data primarily from LLAS, Air Photo Interpretation, API, and the Vegetation Resources Inventory, VRI) should be used at the current time. The LLAS and API use a six-class ranking system (1 = very high, 6 = nil) with classes 1-3 considered suitable habitat.
 - This modelling approach requires the use of different habitat parameters across the Marbled Murrelet Conservation Regions (as not all parameters are available across the province) and includes different thresholds for environmental variables intended to capture differences in habitat use across regions.
- To meet the population and distribution objectives for Marbled Murrelets, forest habitat depletion data are needed for each Marbled Murrelet Conservation Region to determine the amount of suitable habitat which can be identified and maintained as critical habitat. Tracking losses in the amount of suitable habitat since 2002 can be accomplished using the Province of British Columbia's forest harvest and other disturbance data at the current time.

- An algorithm based on habitat attributes from VRI (stand age, stand height), elevation, and distance from ocean, was used to estimate potential habitat at a coarse scale from baseline year 2002 for all Marbled Murrelet Conservation Regions. Forest depletions were applied to this mapped layer to estimate the proportion of habitat loss to 2024. The proportions were calculated for each conservation region and applied to a map of the current suitable habitat to calculate habitat amounts required to meet the recovery objectives.
- The Expert Working Group reviewed CWS's original proposed approach for selecting critical habitat, which was based on prioritization of suitable habitat mapped using the 2025 Model considering habitat quality, patch size, patch-level fragmentation, and landscape-level fragmentation. Concerns were raised about the use of habitat quality (as predicted by the 2025 Model) and about the way in which fragmentation was considered in identifying critical habitat.
- An alternative, tiered approach to identifying critical habitat was proposed by the Expert Working Group, which includes:
 - The use of field-verified high-quality habitat as indicated by occupied detections, known nest sites, and other information used to verify reserves for Marbled Murrelets,
 - The prioritization of class 1 and 2 habitat, where identified by the British Columbia's habitat suitability mapping,
 - The selection of class 3 (or the next most suitable) habitat with higher priority for mapping units that:
 - have greater area,
 - are nearer to class 1 and 2 habitat, where identified,
 - have a high amount of interior habitat (high area-to-edge ratio),
 - have a high amount of suitable habitat within a given radius,
 - The consideration of the effect of the spatial distribution of critical habitat on the species' recovery (known factors that affect demography of Marbled Murrelets)
- The review and advice provided here are based upon scientific information available at the time to the Expert Working Group (March 18th-20th, 2025). Revising and updating this advice may be warranted as new information becomes available.
- The information presented in this Executive Summary represents the consensus of the Expert Working Group.

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Introduction

The Marbled Murrelet (*Brachyramphus marmoratus*) is a small (~220 g) seabird that spends most of its time at sea close to shore. Marbled Murrelets are secretive and nest as solitary pairs at low densities, typically in old-growth forests within 30 km of the sea (Burger & Waterhouse, 2009; Nelson, 2020). Females lay a single egg in each clutch, juvenile recruitment is low, and adult survival is high (Burger, 2002; Cam et al., 2003; Sealy, 1974).



Marbled Murrelet. © Mike Danzenbaker

In Canada, Marbled Murrelets are found on the Pacific coast of British Columbia (B.C.), with a range that extends from the Alaskan border in the north, to the southern mainland, and that includes Vancouver Island and Haida Gwaii. For management purposes, the B.C. range of Marbled Murrelets has been subdivided into 7 conservation regions (Figure 1), with the 6 southernmost conservation regions considered as the ‘primary’ conservation regions, since the number of Marbled Murrelets in the Alaska Border region is thought to be small (ECCC, 2023).

Marbled Murrelets have been assessed as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) since 1990. This designation is due to past and continuing population declines, largely due to loss of nesting habitat, with the species being considered to have met the criteria for designation under indicator A4c (COSEWIC, 2012, 2021). Marbled Murrelets have been listed on Schedule 1 of the *Species at Risk Act (SARA)* since the act came into effect in 2003.

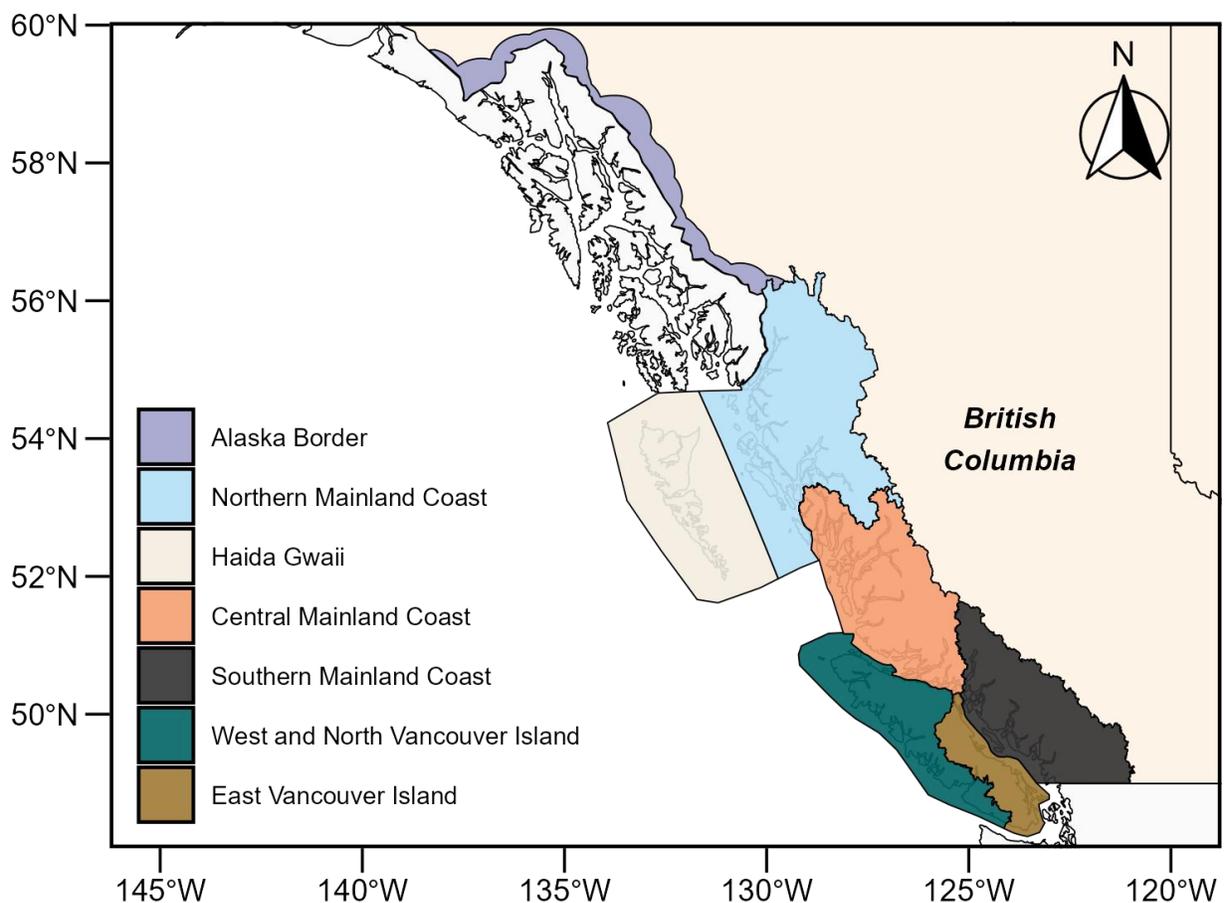


Figure 1. The B.C. range of Marbled Murrelets showing the 7 conservation regions.

To address ongoing population declines, the Amended Recovery Strategy for the Marbled Murrelet in Canada (ECCC, 2023) set out the following population and distribution objective: “over the 30 year period 2002-2032 (three generations) any decline of the B.C. population and the area of its nesting habitat will have slowed to a halt and the total population and nesting habitat area will have stabilized above 70% of 2002 levels, with sufficient areas of nesting habitat remaining in the six primary conservation regions, and corresponding sufficient area of suitable marine habitat to support all life stages of nesting and wintering birds.”

Section 41(1)(c) of *SARA* requires that recovery strategies include an identification of the species’ critical habitat, to the extent possible¹. The critical habitat identification in the 2014 Marbled Murrelet Recovery Strategy (Environment Canada, 2014) mapped all potential nesting (‘suitable’) habitat without specifically identifying spatially how much, and which areas, should be defined as critical habitat (as defined by *SARA*). There was also a small region that was not included due to a lack of spatial data. In addition, some of the modelling used to map suitable habitat in 2014 was based on coarse-grained

¹ Under *SARA*, critical habitat is defined as “the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species’ critical habitat in the recovery strategy or in an action plan for the species”.

landscape data that could be replaced with modelling based on more fine-scale data that is now available (Burger et al., 2018; Mather et al., 2010).

To address issues with the 2014 nesting critical habitat identification, a new (2025) identification approach was developed by ECCC's Canadian Wildlife Service (CWS) that uses a new habitat model (hereafter, the '2025 Model') to replace modelling efforts based on older methods, adds missing data (as per the Schedule of Studies), and includes the use of an algorithm for determining what suitable habitat could be identified as critical habitat in the next amendment of the recovery strategy. Importantly, the 2025 Model was intended to include a backcast of habitat availability to allow for direct assessment of habitat relative to 2002 levels.

CWS requested that ECCC's Science and Technology Branch coordinate a Review and Science Advice process focused on the 2025 Model and the new mapping algorithm. To achieve this goal, the Steering Committee for this advisory process struck an Expert Working Group and tasked them to:

1. Review (by providing an assessment of suitability and suggestions for improvement, as appropriate) the new modelling approach to identify biophysical attributes and map suitable nesting habitat for Marbled Murrelet in the terrestrial environment.
2. Review (by providing an assessment of suitability and suggestions for improvement, as appropriate) the new algorithm that will be used to delineate what suitable habitat could be identified as candidate critical habitat.

This review occurred between March 18th and 20th, 2025 and was based on scientific information available to the Expert Working Group at that time. Socio-economic considerations were not included within the scope of this advisory process.

Review

2025 Habitat Suitability Model

The Expert Working Group reviewed a Marbled Murrelet habitat suitability model developed by CWS in collaboration with an external contractor (Rickbeil et al., 2025, the 2025 Model). This model was developed to classify suitable habitat across the entire B.C. range of Marbled Murrelet by using remote-sensing data products that are available province-wide (e.g., from the National Terrestrial Ecosystem Monitoring System; Hermosilla et al., 2016), and also intended to be able to backcast habitat availability from historical periods to allow for direct comparisons between current levels of habitat availability and those in 2002.

The 2025 Model used a random-forest statistical approach that was trained on habitat suitability polygons produced from low level aerial surveys (LLAS). LLAS polygon data was provided by the B.C. Ministry of Water, Lands and Resource Stewardship, and was collected using helicopter-based assessments of microhabitat and stand-level features important for Marbled Murrelet nesting (Burger et al., 2004; Burger et al., 2009). These assessments are conducted in polygons (typically tens to hundreds of ha; Burger et al., 2018) that are pre-defined based on stand attributes available on mapping products used for forest management and thus represent a particular subset of the landscape.

As a result of each assessment, polygons are assigned to one of six categories, with values of 1 indicating 'very high' habitat value and values of 6 indicating 'nil' habitat value.

For training the 2025 Model, category 1 and 2 LLAS polygons were considered 'suitable habitat' while categories 5 and 6 were considered 'non-suitable'. A few polygon assessments used category 7 (logged areas); these were also included as non-suitable habitat. The value of eight environmental predictor variables (elevation, northness [aspect], terrain roughness, tree height, leading tree species, distance from coast, wetlands, and second-growth forest), taken from remote-sensing data, were assessed at 5000 random points generated within each of the suitable and non-suitable habitat types. Relationships between these environmental predictor variables and habitat suitability within the training data were then used to produce a coast-wide, 30 x 30 m raster output in which each cell contained a value from 0-1 indicating the proportion of decision-trees in which the cell was assigned as suitable habitat. Binary assignments of each cell as 'suitable' or 'unsuitable habitat' were made using the True Skills Statistic, which attempts to balance type I and type II error rates. Model validation was conducted by comparison of model-assigned habitat suitability with the distribution of LLAS category 1 and 2 (suitable) and 5, 6 and 7 (unsuitable) polygons.

The Expert Working Group noted that the polygon-level LLAS data used to develop and validate the 2025 Model were too coarse to do this reliably. This conclusion included discussion of how the polygon-level LLAS data have some inherent classification error (Burger et al., 2018), how they are not independent of the underlying mapping data used to define the polygons, and how the training of a new model on these data may compound these errors. Additionally, the Expert Working Group noted a recent analysis found only 48% of Marbled Murrelet nests have been located within suitable habitat as defined by polygon-level LLAS surveys (Burger et al., 2018), making them a coarse indicator of nesting suitability. Other information on habitat suitability, such as observations of nest sites or fine-scale LLAS surveys (i.e., increased helicopter survey effort within plots ~ 3 ha in size, which correctly predicted 85% of nest locations; Burger et al., 2018) could be used in model development, or as a model-independent dataset for validation, to increase confidence in model predictions.

The Expert Working Group also noted that the relationships between environmental variables and habitat suitability within the 2025 Model were inconsistent with some known ecological predictors of nesting habitat. Modelled relationships of the impact of leading tree species, and distance to ocean, differed from expert expectations. Relatedly, the Expert Working Group noted that the mapping of suitable habitat produced by the 2025 Model seemed to have misclassified areas of suitable habitat known to the Expert Working Group members. Furthermore, the total amount of suitable habitat predicted by the 2025 Model (2.7 million ha) was significantly greater than earlier habitat suitability estimates (1.98 million ha; Mather et al., 2010), and those produced by the Province of B.C.'s habitat suitability model (described below). This overprediction may have resulted from exclusion of class 3 and 4 polygons in the model building, and these polygons can make up most of the landscape and uncertain habitat.

Furthermore, there was also concern that the 2025 Model did not sufficiently account for regional variation in habitat use by Marbled Murrelets. Marbled Murrelets have different patterns of terrestrial habitat use across regions, owing to differences in geological and bioclimatic factors, and habitat availability. While the 2025 Model predicted habitat suitability across B.C., it was developed using LLAS polygon data from only four of the seven Marbled Murrelet Conservation Regions (East Vancouver Island, West and North Vancouver Island, Southern Mainland Coast, Central Mainland Coast). Additionally, no bioclimatic variables were included as predictors in the 2025 Model. As such, the 2025

Model may poorly predict habitat use in areas in which training data were not available, including across several complete conservation regions.

Finally, the 2025 Model was not able to produce a backcast of habitat availability over time. Technical issues associated with historical tree height values from remote-sensing products produced inconsistent and unreliable trends in habitat suitability over time. As such, the 2025 Model did not allow for a comparison of current and 2002 habitat availability.

B.C. Habitat Suitability Model

The Expert Working Group discussed the approach used by the Province of B.C. to estimate losses of Marbled Murrelet nesting habitat, and to map suitable nesting habitat.

For the purpose of estimating proportions of habitat loss since 2002, the Province of B.C. uses a variety of forest cover data, including a habitat algorithm for most of the range, as well as API in Haida Gwaii and most of the Central and Northern Mainland Coast Conservation Regions, and regional models (in Clayoquot Sound and private lands in the East Vancouver Island Conservation Region) (Mather et al., 2010). The habitat algorithm relies on information from the VRI, a large forest inventory dataset managed by the B.C. Ministry of Forests. Estimates of the 2002 area of habitat within each Marbled Murrelet Conservation Region were produced by identifying areas with a stand age of greater than 140 years, a stand height of greater than 28 m, and areas with an elevation below threshold values (900 m in the Southern Mainland Coast and Vancouver Island conservation regions, 600 m in the Northern and Central Mainland Coast and Haida Gwaii conservation regions) and within a given distance from the ocean (within 50 km for all regions and methods of estimating habitat). Depletions (i.e., forest habitat losses) to these areas are estimated based on provincially-held spatial data on forest harvest (i.e., areas of cutblocks) and are being updated to include losses due to wildfire mapped since 2015. This method has been applied to estimate losses in the Vancouver Island and Southern Mainland Coast conservation regions up to 2024, and in northern conservation regions up to 2021, with further updates expected.

For the purpose of mapping suitable nesting habitat and estimating the amount of suitable habitat relative to recovery objectives, B.C. uses a variety of data sources depending on their availability across conservation regions. This approach replaces much of the habitat algorithm and some of the regional models within the West and Northern Vancouver Island, East Vancouver Island, and Southern Mainland Coast Conservation Regions with LLAS suitable habitat data. Since the LLAS data were collected between 2003 and the present (with many surveys done between 2010 and 2025), the suitable habitat amount in 2002 is not known or mapped, but the amounts by conservation region can be estimated by backcasting using the proportion of potential habitat lost between 2002 and current (determined using the B.C. model described in the previous paragraph), which are then applied to the most recent suitable habitat mapped layer. Habitat retention thresholds (i.e., from the federal recovery strategy; ECCO, 2023) can then be applied to this 2002 suitable habitat amount to determine the minimum suitable habitat required to meet the population and distribution objectives. This approach is further described in the province's Implementation Plan for the Recovery of Marbled Murrelets in B.C. (British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural & Development, 2018), and could be used to estimate current province-wide amounts of suitable habitat relative to the 2002 baseline.

Candidate Critical Habitat Identification

The Expert Working Group reviewed CWS's original proposed approach for identifying candidate critical habitat. This critical habitat identification approach was intended to select a subset of suitable habitat that has high conservation value, with the amounts of candidate critical habitat being determined by retention targets described in the federal recovery strategy (ECCC, 2023). An algorithm to identify which suitable habitat could be classified as critical habitat included:

- i) the areas identified as suitable habitat by the 2025 Model (described above)
- ii) the removal of roads buffered by 10 m on each side
- iii) the size of the habitat patch, with the exclusion of patches < 4.5 ha in size and increasing preference for larger patches
- iv) patch-level fragmentation, calculated based on the edge-to-area ratio with increasing preference for patches with low edge-to-area
- v) landscape-level fragmentation, calculated based on the density of roads within the landscape unit (landscape units are spatial areas used for long-term planning of resource management activities; Government of British Columbia, 2011) with increasing preference for areas within less fragmented landscape units
- vi) habitat quality, calculated based on the mean habitat suitability score of a patch as determined by the 2025 Model.

Within each Marbled Murrelet Conservation Region, areas of suitable habitat were ranked for inclusion as candidate critical habitat based on (equally weighted) scores associated with patch size, patch-level fragmentation, landscape-level fragmentation, and habitat quality.

Because of concerns associated with the 2025 habitat suitability model (outlined above), the Expert Working Group was not supportive of its use in the identification of candidate critical habitat. Also, the algorithm places considerable weight on fragmentation, as it includes two separate scores (at the patch-level and the landscape-level) which, taken together, determine half of the total score used for ranking. The Expert Working Group noted that the influence of fragmentation on nest site selection is complex (for example, a recent analysis showed increased selection for more fragmented sites at the local scale, and decreased selection for more fragmented sites at the landscape scale; Valente et al., 2023) and also discussed how different types of edges may have different impacts on nest site selection for Marbled Murrelets.

Sources of Uncertainty

Thresholds for terrestrial habitat retention set out in the Marbled Murrelet Recovery Strategy (ECCC, 2023) are based on assumptions about the relationship between population abundance and amount (area) of suitable nesting habitat (reviewed in Burger and Waterhouse, 2009). To prevent a decline in population abundance of $\geq 30\%$ over 30 years, the population and distribution objectives call for the retention of at least 70% of suitable terrestrial habitat coastwide (i.e., to maintain a relative abundance of 70% of the 2002 population), with varying regional targets. The Expert Working Group noted that because of process and measurement errors associated with any critical habitat identification scheme, greater than 70% of suitable habitat would need to be conserved to maintain 70% of the Marbled Murrelet population (because some habitat that is designated as suitable will be unsuitable). However, the Expert Working Group further noted that a portion of Marbled Murrelet nests occur within 'unsuitable habitat' (e.g., on rocky cliffs) which are not likely to be disturbed by human activities. As a

result of these additional nests, habitat retention targets could potentially be decreased while still achieving population objectives. For the present review, the Expert Working Group considered that the impacts of uncertainty in identifying suitable habitat, and in the accounting of nests in unsuitable habitat, cancelled each other out – such that a 1:1 ratio of habitat to population abundance was appropriate. Further discussion on the impacts of uncertainty (and possible adjustments to retention goals) can be found in Burger et al. (2014).

One of the perceived advantages of using National Terrestrial Ecosystem Monitoring System (NTEMS) data in the development of the 2025 Model was that it includes data from historical periods, thereby allowing for analyses of changes in forest structure and composition. Such data could therefore enable the direct assessment of relative Marbled Murrelet habitat availability, as required to evaluate progress towards the population and distribution objectives in the Marbled Murrelet Recovery Strategy (ECCC, 2023). In conducting their review and providing advice (below), the Expert Working Group was uncertain as to whether technical challenges associated with the estimation and interpretation of historical tree height and biomass would be resolved in these products, and if so, over what time periods. Such technical challenges precluded the estimation of historical habitat availability and created uncertainty in the value of the 2025 Model when compared with other approaches.

Advice

Habitat Suitability Modelling

Given the concerns with the 2025 Model, and the fact that this present model is not able to produce a backcast of terrestrial habitat availability, the Expert Working Group recommends that the B.C. Habitat Suitability model be used to estimate current Marbled Murrelet terrestrial suitable habitat. The B.C. Habitat Suitability model estimates can be improved by updating the forest depletion data to the present (i.e., in conservation regions where the current estimates only include data up to 2021) and by including depletions due to fire in addition to those from forest harvest. This work is already being undertaken by the Province of B.C., and ECCC can leverage the ongoing provincial-federal collaboration to improve these estimates. In addition, the Expert Working Group suggested potential approaches to improve estimates of suitable habitat (and its depletion) in areas of private forest lands where LLAS have been done by the forest company but have not been shared with the province to include in their suitability map. These approaches could include working with the forestry company to access their LLAS and depletions.

If future, province-wide habitat suitability models are to be developed based on NTEMS or other remotely-sensed satellite data products, the Expert Working Group suggests that they account for regional variability in Marbled Murrelet habitat use. This could be accomplished through the inclusion of bioclimatic variables known to co-vary with forest structure (e.g., WorldClim bioclimatic metrics; Hijmans et al., 2005), and therefore likely to influence the type and availability of nesting habitat. Additionally, spatial variables (e.g., latitude or longitude, and their interactions with other environmental predictors) can be included in models to account for factors relevant to habitat selection that are otherwise unexplained by environmental predictors. If such approaches result in an excess of predictor variables, model-selection approaches can be used to reduce their number.

Further, the Expert Working Group suggests that data beyond polygon-level LLAS be used for model development and validation including data on known nest sites and fine-scale LLAS surveys (Burger et al. 2018). Ideally, different data sets should be used to validate model predictions from those used for model development. Finally, the Expert Working Group suggests carefully considering tradeoffs associated with over- vs under-estimation of suitable habitat. While the True Skill Statistic used in the 2025 Model is an objective approach to balancing different types of error in the identification of 'suitable' vs 'unsuitable' habitat, it may make sense to explore and refine how error is balanced with regards to different habitat classes (e.g., having different thresholds for including category 1, 2 and 3 LLAS data as suitable habitat in the model building process).

Candidate Critical Habitat Identification

The Expert Working Group recommended an alternative approach to the identification of candidate critical habitat, which did not rely on the 2025 Model to estimate habitat quality. Instead, the alternative approach was based on the inclusion of verified high-quality habitat, sites identified as high quality through LLAS and API data, and sites identified as medium quality that have certain characteristics making them likely to be used by Marbled Murrelets for nesting. In addition, the alternative approach reduces the weight placed on fragmentation and considers fragmentation differently relative to CWS's original proposed approach.

The alternative approach suggests identifying sites in a stepwise fashion (i.e., identifying as much habitat as possible under criteria (i) before moving on to criteria (ii), etc.) within each Marbled Murrelet Conservation Region, until the total area of sites meets the regional retention threshold outlined in the recovery strategy (ECCC, 2023). The criteria are:

- (i) The use of field-verified high-quality habitat as indicated by occupied detections of Marbled Murrelets, known Marbled Murrelet nest sites, and other field-based information (i.e., habitat and bird-based data collected to verify areas of known conservation value for Marbled Murrelets such as wildlife habitat areas)
- (ii) The prioritization of class 1 and 2 habitat, where identified by the B.C. Habitat Suitability mapping (i.e., using LLAS and API data)
- (iii) The selection of class 3 (or the next most suitable) LLAS or API habitat with higher priority for including polygons that have greater area, are spatially nearer to class 1 and 2 habitat (where identified), have a high amount of interior habitat (high area-to-edge ratio), and that have a high amount of suitable habitat within a given radius

In addition to these criteria, the Expert Working Group recommends that there be some consideration of how the spatial distribution of critical habitat may impact the species' recovery. For example, additional criteria could be added to ensure that some candidate critical habitat is identified within each landscape unit, thereby spreading candidate critical habitat throughout each Marbled Murrelet Conservation Region. Such an approach could help to maintain the distribution of Marbled Murrelets across their historical range and to protect against catastrophic events that can impact concentrated populations. However, spreading the same amount of critical habitat across a conservation region will also increase fragmentation and edge effects, and can increase the probability of extirpation at the local level. Consideration of the influence of the spatial distribution of critical habitat can leverage the extensive scholarship on conservation planning and the 'single large or several small' debate (e.g.,

McCarthy et al., 2005; Ovaskainen, 2002) and could also include how Marbled Murrelet demographic rates vary with patch size and distribution (where known).

As the alternative approach to candidate critical habitat identification has not yet been implemented, the Expert Working Group was not able to evaluate its performance. Relatedly, the Expert Working Group acknowledged that a variety of analytical decisions would need to be made to identify candidate critical habitat while following the criteria above. As such, the Expert Working Group advised that any implementation of the alternative approach be subject to some validation and sensitivity analysis to ensure that the resultant candidate critical habitat is consistent with expert opinion and known data on where high-quality habitat is located.

Other Considerations

The methods to identify suitable terrestrial habitat and candidate critical habitat discussed above focused on features of the terrestrial environment. However, the identification of terrestrial habitat for Marbled Murrelets could also be informed by patterns of marine habitat use. High-use marine areas may indicate that there is high-quality terrestrial habitat nearby or may be indicative of high-quality foraging habitat that may influence nest site selection. The Expert Working Group identified several information sources related to Marbled Murrelet marine habitat-use that could be incorporated into future terrestrial habitat identification and include radar data on bird movements (Burger et al., 2004; Cooper et al., 2001; Drever et al., 2021; Manley, 2006), at-sea and marine shoreline surveys (Pastran et al., 2025; Ronconi, 2008), and community science data such as that collected and shared by eBird (Sullivan et al., 2009), but which were not considered here.

The Expert Working Group also identified that airborne laser scanning (an application of lidar) data have recently been used to develop Marbled Murrelet habitat suitability models within areas of B.C. (Clyde, 2017; Cosgrove et al., 2024) and elsewhere (Hagar et al., 2014). These data capture a range of forest structural features relevant to Marbled Murrelets and do so at a finer spatial scale than many other remotely-sensed data products. While such data are not currently available for the entire Province of B.C., existing initiatives seek to expand spatial coverage and could make coast-wide airborne laser scanning based habitat suitability models feasible in the future.

Participants

Expert Working Group

The Expert Working Group conducted the review and drafted this report.

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The Steering Committee provided oversight for this Wildlife Science Advisory Process.

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Other Contributors

This science advisory process was supported by Gilles Olivier who facilitated the review meeting. Matthew Huntley, Gregory Rickbeil, and Graham Stinson provided additional information for the consideration of the Expert Working Group. Cory Toth, Melanie Mullin, and Rachel Vallender provided logistical and secretariat support.

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