Marbled Murrelet

Brachyramphus marmoratus

Original[1] prepared by Alan Burger

Species Information

Taxonomy

The Marbled Murrelet, *Brachyramphus marmoratus,* is a member of the auk family (Alcidae). No subspecies are recognized in North America (AOU 1997). Some intraspecific morphological and molecular variation has been found among populations of Marbled Murrelets (reviewed in Burger 2002). The small population in the western Aleutian Islands, Alaska, shows some genetic differences from the rest of the North American population, but samples from British Columbia, southeastern Alaska, Washington, and Oregon showed no consistent genetic differences or evidence of subspecies.

Description

Small seabird (length 24–25 cm; mass 190–270 g; Nelson 1997). There is no sexual size or colour dimorphism. Adults in breeding plumage have a marbled grey-brown plumage that provides good camouflage at nest sites. The non-breeding (basic) and juvenile plumages are black and white, typical of most seabirds.

Marbled Murrelets forage by diving, using its wings for underwater propulsion (Gaston and Jones 1998). Adaptations for this mode of foraging include increased flight muscles and reduced wing area, resulting in high wing-loading. The consequences are that Marbled Murrelets need to fly fast (generally more than 70 km/h), are not very maneuvrable in flight, and have difficulty landing and taking off. This in turn affects their choice of nest site and vulnerability to terrestrial predators (details below).

Distribution

Global

The Marbled Murrelet occurs from the Aleutian Islands, Alaska, along the southern coast of Alaska south to central California.

British Columbia

Murrelets are likely to be found anywhere along the coast of British Columbia within 30 km of the Pacific coast. A few birds venture farther inland, up to 80 km from the coast. At sea, they tend to remain within sheltered waters or within 500 m of exposed open coasts.

Forest regions and districts

Coast: Campbell River, Chilliwack, North Coast, North Island, Queen Charlotte Islands, South Island, Squamish, Sunshine Coast

Northern Interior: Kalum, Skeena Stikine

Ecoprovinces and ecosections

Terrestrial:

COM: CBR, EPR, HEL, KIR, MEM, NAB, NAR, NBR, NIM, NPR, NWC, NWL, OUF, QCL, SBR, SKP, SPR, WQC, WIM

GED: FRL, GEL, LIM, NAL, SGI, SOG

Marine:

COM: DIE, HES, QCS, QCT, VIS

GED: JDF

Biogeoclimatic units

CDF, CWH, MH

Broad ecosystem units

Terrestrial:

CD, CG, CH, CP, CS, CW, DA, FR, HB, HL, HS, MF, RR, SR, YM

1 Volume 1 account prepared by A. Derocher and others.

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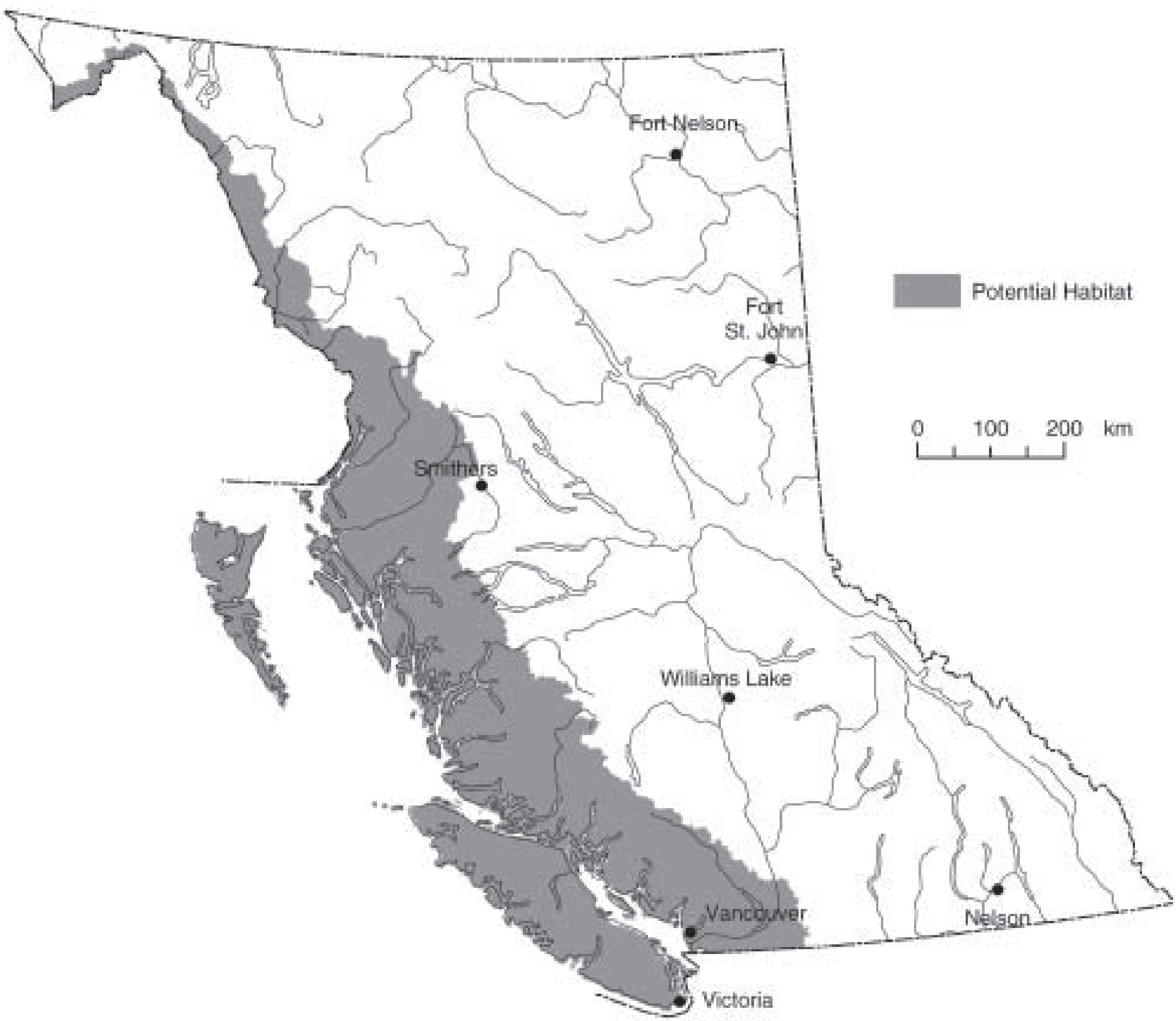
(Brachyramphus marmoratus)



Note: This map represents a broad view of the distribution of potential habitat used by this species. The map is based on several ecosystem classifications (Ecoregion, Biogeoclimatic and Broad Ecosystem Inventory) as well as current knowledge of the species' habitat preferences. This species may or may not occur in all areas indicated. More detailed maps are available for this species from the Ministry of Sustainable Resource Management.

Aquatic:
ES, IM, LL, LS

Elevation

0–~1500 m (but see "Habitat" below for preferred elevations)

Life History

Diet and foraging behaviour

Murrelets eat small schooling fish (predominantly Pacific Sand Lance *Ammodytes hexapterus*, and immature Pacific Herring *Clupea harengus*), and large pelagic crustaceans (euphausiids, mysids, amphipods) (Burger 2002). In many areas the distribution, abundance, and movements of murrelets at sea seem closely linked to those of sand lance, especially during the murrelet's breeding season.

The Marbled Murrelet forages by diving, using its wings for underwater propulsion. Adaptations for this mode of foraging include increased flight muscles and reduced wing area (Gaston and Jones 1998). Most murrelets forage in relatively shallow water (<30 m deep), either in sheltered sea or within 500 m of exposed shores. They tend to avoid the centres of deep fjords and channels. Adults eat a range of prey types, but select a larger fish (e.g., mature sand lance) to carry back to the nestling. Proximity to good foraging sites is likely to influence selection of inland nest sites. Most nests were within 50 km of foraging sites, although breeding murrelets are known to commute 100 km or more to feed at prey concentrations (Whitworth et al. 2000; Hull et al. 2001; Burger 2002).

Reproduction

Reproduction and demography are reviewed in Ralph et al. (editors, 1995), Nelson (1997), and Burger (2002). Breeding probably begins at age 2–5 years, and the generation time was estimated to be about 10 years. Estimates of the proportion of mature adults in the population range from 55 to 95%, and are more likely near the upper part of this range. In common with most seabirds, murrelets have low reproductive recruitment (fecundity), balanced by high adult survival. Fecundity (number of female fledglings raised per female of breeding age) ranged from 0.17 to 0.22 from studies of nesting success and radio-telemetry, and was 0.13 based on adjusted counts of juveniles and adults at sea. Mark-recapture studies in Desolation Sound indicate local annual adult survival of 0.83–0.92 (Cam et al., in press).

The breeding season is prolonged (late-April through early September) and some failed breeders may lay a replacement egg (McFarlane Tranquilla 2001; Lougheed et al. 2002b). Most nests are on platforms (limbs or deformities >15 cm diameter) in old conifers (details below), but a few are on mossy cliff-ledges and one has been found in a deciduous tree (Burger 2002). The nest is a simple depression in the moss or duff. The clutch is a single egg. Both sexes incubate the egg and feed the chick. The incubation period is ~30 days and chicks fledge when 30–40 days old. Adults exchange incubation shifts and deliver most meals to the chick in dark twilight before dawn. Some meals are also delivered at dusk and a few in daylight hours. Chicks fledge by flying to the sea and are not attended by parents after fledging.

Site fidelity

Site fidelity is not well known, but evidence suggests that suitable stands will be repeatedly used for nesting (Manley 1999; Burger 2002; Simon Fraser Univ., unpubl. data). Nests and nest trees are generally not re-used in subsequent seasons, but a few radio-tagged birds returned to nest in different trees within the same stand. A few trees have been found with more than one nest from different seasons. One banded bird that bred in Desolation Sound, British Columbia, wintered in the San Juan Islands, Washington, but was re-captured in Desolation Sound in the following breeding season (Beauchamp et al. 1999). Watersheds generally support similar numbers of murrelets from year to year, but there might be some interannual movement by murrelets among adjacent watersheds (Burger 2001, 2002).

Home range

Most nests in British Columbia were within 30–50 km of marine capture sites (for radio-telemetry studies) and foraging aggregations (reviewed by Burger 2002). In some situations, such as nest sites inland of long, deep fjords, murrelets commute large distances (occasionally >100 km) to feed at prey concentrations. Murrelets show diurnal and seasonal movements among foraging sites, but often aggregate predictably at favoured sites. Unlike most other seabirds, murrelets are not colonial; nest sites appear to be scattered across suitable forest habitat. Some individuals breeding on Vancouver Island foraged in both Clayoquot Sound and the Strait of Georgia within the same season (Simon Fraser Univ., unpubl. data).

Movement and dispersal

Marbled Murrelets are somewhat migratory, and in many parts of British Columbia both adults and newly fledged juveniles tend to move away from breeding grounds at the end of the breeding season, from late July through September (Burger 2002; Lougheed et al. 2002a). A portion of the population often remains near the breeding grounds through winter. Beauchamp et al. (1999) provided the only proof of migration, between Desolation Sound and the San Juan Islands, Washington (see previous section). Other marked murrelets from Desolation Sound, however, seemed to remain there after breeding (Beauchamp et al. 1999). Migration between the breeding areas on the outer west coast of Vancouver Island to more sheltered wintering areas in the Strait of Georgia and Puget Sound seems to occur (Burger 2002).

Habitat

Structural stage

7: old forest (>250 yr – age class 9, but 8 is acceptable if older forest is not present and the age class 8 provides platform limbs and other nest attributes; see Tables 1 and 3 below).

Important habitats and habitat features

Nesting

In the *Conservation Assessment of Marbled Murrelets in British Columbia: A Review of the Biology, Populations, Habitat Associations, and Conservation*, suitable nesting habitat is defined as the habitat in which Marbled Murrelets nesting in British Columbia are likely to nest successfully. In general, suitable habitat is old seral stage coniferous forest, providing large trees with suitable platforms (limbs or deformities >15 cm diameter), and a variable canopy structure allowing access to the platforms. More detailed descriptions of the tree and stand attributes are given below. Some Marbled Murrelet nests in British Columbia have been found in habitat that differs somewhat from the defined suitable habitat (e.g., cliffs, a deciduous tree, isolated veterans in stunted stands), but inclusion of all the possible habitat types likely to be used by murrelets becomes unworkable. This account focuses on forest habitat most likely to be occupied by nesting murrelets.

Over 200 nests have been found in British Columbia, with the vast majority in old conifers (Nelson 1997; Burger 2002; Simon Fraser Univ., unpubl. data). About 3% of nests found in Desolation Sound were on mossy cliff-ledges (Bradley and Cooke 2001), and similar sites have been found near Clayoquot Sound. One Desolation Sound nest was in a large red alder (*Alnus rubra)* (Bradley and Cooke 2001). Most B.C. nests were found in yellow-cedar (*Chamaecyparis nootkatensis*), western hemlock (*Tsuga heterophylla*), Sitka spruce (*Picea sitchensis*), Douglas-fir (*Pseudotsuga menziesii*), and western redcedar (*Thuja plicata*), with fewer in mountain hemlock (*Tsuga mertensiana*) and amabilis fir (*Abies amabilis)* (Burger 2002). It is unlikely that murrelets select particular tree species, but certain species are more likely to provide large horizontal platforms suitable for nesting, and this varies regionally and with elevation.

Microhabitat requirements for Marbled Murrelet nest sites are summarized in Table 1. The first four conditions are commonly found in dominant old forest trees which explains the overwhelming majority of nests in such trees. Most nest trees in

British Columbia were >200 years old (Burger 2002). In Oregon, a few nests have been found in younger western hemlock trees deformed by mistletoe (Nelson 1997), but no nests have been found in such sites in British Columbia.

Two studies in British Columbia compared forest patches containing nests with adjacent randomly selected patches. Manley (1999) found that nest patches had significantly more large trees (>60 cm diameter) and more trees with platforms (limbs with diameter >15 cm including epiphytes) than random patches. Waterhouse et al. (2002) found that forest polygons with murrelet nests were significantly older, and had taller trees, larger mean basal area, and greater vertical complexity than adjacent randomly selected treed polygons. Numerous other studies involving audiovisual surveys, vegetation analysis, tree climbing, and radio-telemetry have confirmed the association of nesting murrelets with a combination of large old trees, availability of large moss-covered limbs providing nest platforms, and variable canopy structure with gaps providing access to the platform limbs (Burger 2002).

In British Columbia, murrelet nests have been found from sea level to about 1500 m in elevation (Nelson 1997; Burger 2002). Among 138 nests found by telemetry in British Columbia, 84% were found below 1000 m, and there was a rapid drop-off in nests with increasing elevation above 1000 m (Burger 2002; Simon Fraser Univ., unpubl. data). Where low elevation forests with suitable nesting habitat were still plentiful, 64% of nests were below 600 m, and 93% were below 900 m (n = 55 telemetry nests). In Desolation Sound nesting success increased with increasing elevation, which was probably due to reduced densities of predators at higher elevations (Bradley 2002). There are no comparative studies of nest success versus elevation from elsewhere. In contrast, audiovisual surveys showed declining evidence of stand occupancy by murrelets with increasing elevation, and stand level and micro-habitat features important for nesting (e.g., large trees, presence of potential platform limbs, and epiphyte cover on branches) usually declined with increasing elevation (Burger 2002). In general, preferred nesting habitat in British Columbia is likely to be found at 0–900 m elevation

Table 1. Key microhabitat characteristics for Marbled Murrelets nest site in British Columbia (for more details see Hamer and Nelson 1995; Nelson 1997; Burger 2002)

Murrelet requirements	Key habitat attributes
Sufficient height to allow stall-landings and jump-off departures	Nest trees are typically >40 m tall (range 15–80 m), and nest heights are typically >30 m (range 11–54 m); nest trees are often larger than the stand average.
Openings in the canopy for unobstructed flight access	Small gaps in the canopy are typically found next to nest trees, and vertical complexity of the canopy is higher in stands with nests than in other nearby stands.
Sufficient platform diameter to provide a nest site and landing pad	Nests are typically on large branches or branches with deformities, usually with added moss cover; nest limbs range from 15 to 74 cm in diameter; nests typically located within 1 m of the vertical tree trunk.
Soft substrate to provide a nest cup	Moss and other epiphytes provide thick pads at most nest sites, but duff and leaf litter are used in drier areas.
Overhead cover to provide shelter and reduce detection by predators	Most nests are overhung by branches.

(perhaps 0–600 m in watersheds with more intact old stands), with less suitable conditions at 900–1500 m, and areas above 1500 m are unlikely to be used. In all cases elevation should not be the sole criterion for establishing suitability, and evidence of nesting, occupancy, and/or suitable habitat (e.g., potential nest platforms) is needed for establishing habitat suitability.

Marbled Murrelets readily nest on steep slopes, and many nests found with telemetry were on steep slopes (30–70°) (Burger 2002; Simon Fraser Univ., unpubl. data). In Desolation Sound, nest success was positively correlated with slope (Bradley 2002). Slopes appear to enhance access to nest sites in tree canopies and perhaps reduce predation risk.

Steep slopes are not essential for nesting if forest canopies are non-uniform with small gaps, as typically found in old forest stands. Several studies showed negative or neutral effects of slope on rates of occupied detections and measures of nest habitat quality (Burger 2002). Slope should be treated as a neutral variable in habitat management; suitable habitat is selected regardless of slope. Aspect does not appear to have a strong effect on the placement or success of nests, although south-facing slopes in drier areas appear to have fewer mossy platforms than other aspects (Burger 2002).

Foraging

Marbled Murrelets forage at sea. Important habitats include shallow nearshore and sheltered waters, especially those known to support foraging aggregations, concentrations of prey schools, or marine habitats likely to support prey (e.g., the sand and gravel subtidal substrates in which sand lance bury themselves). It is important to maintain inland breeding habitat associated with known concentrations of murrelets at sea (MMRT 2003).

Wintering

Marbled Murrelets winter at sea. Important habitats are as described for foraging, but are generally more sheltered than those used in summer.

Conservation and Management

Status

The Marbled Murrelet is on the *Red List* in British Columbia. It is designated as *Threatened* in Canada (COSEWIC 2002).

Summary of ABI status in BC and adjacent jurisdictions (NatureServe Explorer 2002)

AK	BC	CA	OR	WA	Canada	Global
S2S3	S2B, S4N	S1	S2	S3	N2	G3G4

Trends

Population trends

The population in 2002 was estimated to be 54 700–77 700 birds of all ages (median 66 000 birds, or 56 000 adults if 85% are mature adults) based on extrapolations from radar and at-sea counts (Burger 2002). Large parts of the range have no counts and there is considerable uncertainty around these population estimates. There are few long-term data to assess population trends, but most data and anecdotal accounts indicate declining populations in some parts of British Columbia, especially in eastern Vancouver Island and the southern mainland (Burger 2002). At-sea surveys in Clayoquot and Barkley sounds on the west of Vancouver Island indicate declines of 20–40% between 1979 and1982 and the mid-1990s, but these trends are complicated by negative responses by murrelets to unusually warm oceans in the 1990s and by the variability in at-sea census data (Burger 2002).

Habitat trends

Accurate assessments of the amount of nesting habitat lost to industrial logging are not yet available, because of the difficulties in defining suitable habitat and mapping such habitat across coastal British Columbia. Preliminary mapping by the B.C. Ministry of Forests and by Demarchi and Button

(2001a, 2001b; see Burger 2002) suggests that the amount of potential (capable) murrelet habitat lost by 2000, since the onset of industrial logging, was in the order of 35–49%. Large declines in capable habitat were evident in the following former forest districts: Port Alberni, Campbell River, Duncan, Port McNeill, and Sunshine Coast (Demarchi and Button 2001a, 2001b). The reduction of habitat within the Georgia Depression (southeast Vancouver Island and the southern mainland) is of particular concern (Kaiser et al. 1994; MMRT 2003).

Threats

Population threats

Demographic models indicate that murrelet populations are most sensitive to adult survival, followed by survival of immatures and then fecundity (Beissinger and Nur 1997; Cam et al., in press). The most likely direct threats to adults are from oil spills and entanglement in fishing gear (Burger 2002). Predation of adults (at sea and inland) and disturbance at foraging areas due to boat traffic and aquaculture have also been identified as threats, but their effects are not known (Burger 2002).

Habitat threats

Reduced recruitment due to loss of nesting habitat is widely accepted as the major threat throughout the species' range (Ralph et al. 1995; Nelson 1997; Hull 1999). Radar studies in five regions of British Columbia show significant correlations between numbers of murrelets and existing areas of apparently suitable nesting habitat (Burger 2002). In addition, a radar study in Clayoquot Sound showed reduced populations in watersheds subjected to intensive logging and concluded that murrelets did not pack into remaining old forest patches in higher densities (Burger 2001). For these reasons, breeding populations of murrelets are expected to decline as areas of suitable nesting habitat decrease. The effects on murrelets of habitat fragmentation and creation of forest edges by clearcut logging are less clear.

Populations of murrelets seem more dependent on the area and quality of available nesting habitat than on the size and shape of habitat patches and edge-effects. Risk modelling suggested that edge effects were clearly secondary (but not trivial) to amount and quality of nesting habitat in determining population persistence in British Columbia (Steventon et al., in press). The effects of small patches, forest edges, and fragmentation of habitat on nesting Marbled Murrelets are still unclear, and field data are somewhat contradictory (Burger 2002). Reduced nest success within 50 m of forest edges, attributed to increased predation risk, was reported in one range-wide review (Manley and Nelson 1999). In contrast, nests in Desolation Sound located by telemetry showed no difference in success between edge and interior sites, perhaps because nests proximal to edges predominated at higher altitudes where predation was less prevalent (Bradley 2002). Some common nest predators, such as Steller's Jay (*Cyanocitta stelleri*), favour forest edges bordering clearcuts and roads (Masselink 2001), but a comprehensive study on the Olympic Peninsula, Washington, showed that many potential predators of murrelet nests were not edge-loving species and that other factors affected predation risk, notably proximity to human activities (attracting corvids) and successional stage of vegetation bordering old forest edges (Raphael et al. 2002). Loss of habitat through windthrow along forest edges and roads, and changes to canopy microclimates near forest edges are also likely (Burger 2002). Altered microclimates might affect nesting murrelets directly through thermal stress, or indirectly through removal or inhibition of epiphyte mats used as nest substrates, but there are no field data to test these hypotheses. Edge effects are most likely to occur at "hard" edges, defined as old forest (>250 yr) bordered by clearcuts or young regenerating forest <40 years old, and any negative effects are likely to be greatest within 50 m of such edges (Burger 2002).

The effects of roads on murrelets and their nesting habitat have not been fully investigated. Roads potentially create both benefits (enhanced access to canopy platforms) and risks (attracting predators such as ravens and jays, increasing windthrow, and altering canopy microclimates).

Five radar studies in British Columbia and one on the Olympic Peninsula, Washington, showed significant positive correlations between numbers of murrelets and areas of large-tree old seral habitat per watershed (Burger 2002). These data indicate that watershed populations of Marbled Murrelets are directly proportional to the areas of nesting habitat available. Densities (murrelets per area of habitat) were significantly higher on the west coast of Vancouver Island (0.082 ± 0.034 SD birds per ha) than on the B.C. mainland coast (0.028 ± 0.019 birds per ha) when the habitat classified as *good* was considered in each study (Burger 2002). The underlying cause of this regional difference is not known.

Risk modelling of B.C. populations indicated that the certainty of population outcome was affected by management choices of how much and what type of old forest to maintain (Steventon et al., in press). The modelling also indicated that rate of decline of nesting habitat had little influence on long-term population outcome, but the eventual nesting capacity (area and quality of habitat) when it did stabilize was important.

Legal Protection and Habitat Conservation

Marbled Murrelets and their nests and eggs are protected from direct persecution under the Canadian *Migratory Birds Convention Act*, *1994*, and the provincial *Wildlife Act* (Section 34). As a federally listed species the Marbled Murrelet will come under the jurisdiction of the *Species at Risk Act* (SARA).

Several protected areas are important for the conservation of the Marbled Murrelet including Carmanah-Walbran Provincial Park, Pacific Rim National Park, Strathcona Provincial Park and other coastal protected areas in Clayoquot Sound, Gwaii Haanas National Park Reserve, and several of the larger protected areas on the central mainland coast. Smaller areas of habitat in the water-supply catchments for the cities of Vancouver and Victoria are also important, because surrounding habitat areas have been greatly depleted.

Marbled Murrelets were listed as *Threatened* by the Committee on Status of Endangered Wildlife in Canada (COSEWIC) in 1990. The Marbled Murrelet Recovery Team published the first Recovery Plan (Kaiser et al. 1994), which focused on data gaps and research priorities. Following a second review (Hull 1999), the Threatened status was confirmed in 2000, primarily on the basis of low reproductive rate and continued evidence of declining nesting habitat (D. Fraser, pers. comm.). A revised recovery strategy and action plan are being drafted by the recovery team, based upon the 2001–2002 Conservation Assessment (Hooper 2001; Burger 2002; Steventon et al., in press). The main conservation and management points have already been identified (MMRT 2003).

Identified Wildlife Provisions

Sustainable resource management and planning recommendations

Over the last two years, the provincial ministries and the national Marbled Murrelet Recovery Team (MMRT) have collaborated on a conservation assessment of the Marble Murrelet. Part A[2] of the assessment has recently been published, Part B[3] has been released by the MMRT, and Part C[4] is in press. These documents incorporate the latest science on this species and represent the consensus of the multi-stakeholder MMRT, which has members from government, industry, academia, and ENGOs. The conservation assessment documents will be used by the MMRT in preparing a Recovery Strategy for the

2 Burger, A.E. 2002. Conservation assessment of Marbled Murrelets in British Columbia: a review of the biology, populations, habitat associations and conservation. CWS, Pacific and Yukon Region, British Columbia. Tech. Rep. Ser. No. 387.

3 Canadian Marbled Murrelet Recovery Team. 2003. Marbled Murrelet Conservation Assessment 2003, Part B: Marbled Murrelet Recovery Team Advisory Document on Conservation and Management. Canadian Marbled Murrelet Recovery Team Working Document No. 1.

4 Steventon, D. *et al*. In press. Analysis of Long-term Risks to Regional Marbled Murrelet *(Brachyramphus marmoratus)* Populations Under Alternative Forest Management Policies on Coastal British Columbia.

species as required under the federal *Species At Risk Act*. The completed Recovery Strategy is expected by March 2004.

The conclusions and recommendations contained in Parts B and C of the Conservation Assessment have not been adopted as government policy. Therefore, until there is a new government decision on the management of Marbled Murrelet, government agencies (MSRM, MOF and MWLAP) will continue to work with industry to develop Marbled Murrelet WHAs through policies established since 1999 regarding WHA impacts; that is, overlapping WHAs with old growth management areas (OGMAs) through landscape unit planning and with other constrained areas such as ungulate winter ranges and visual resource management areas, use of a portion of the IWMS one percent timber supply impact cap on the timber harvesting land base (THLB), and establishment of other WHAs on the non-contributing land base (NCLB). Part B of the Conservation Assessment can be consulted for information on the suitable size and characteristics (shape, habitat suitability) of individual WHAs, but the amount of habitat to be established as WHAs remains constrained by existing policy. This direction applies to all areas where WHA establishment is taking place unless new objectives are approved by government.

Forest licensees are encouraged to continue working with agency staff to propose WHAs in accordance with the current policy direction. It is also recognized that, under the *Forest and Range Practices Act*, licensees will have the option of proposing alternative strategies for managing Marbled Murrelet habitat.

Three of the Marbled Murrelet conservation regions identified by the Conservation Assessment – the Central Mainland Coast, the Northern Mainland Coast and the Queen Charlotte Islands) – fall under strategic land use planning exercises (SLUPs). While the current policy direction on Marbled Murrelet habitat applies to all areas in the species' range, it is not intended to impede, delay, or constrain negotiations or forthcoming recommendations of the three coastal SLUPS.

Table 2. Estimates of current (2002) populations of Marbled Murrelets in each conservation region, and Marbled Murrelet Recovery Team recommendations for maximum declines in population and habitat per region by 2032, assuming a decline of no more than 30% in population size and habitat area for all of British Columbia, and having less reduction in regions already thought to have depleted populations (MMRT 2003)

Conservation region	Estimated population in 2002 (birds)[a]	Maximum allowable decline of population and habitat[b] by 2032 (%)
West & North Vancouver Island	19 400–24 500	31
East Vancouver Island[c]	700–1 000	0–10
Southern Mainland Coast	6 000–7 000	15
Central Mainland Coast	10 000–21 000	31
Northern Mainland Coast	10 100–14 600	31
Haida Gwaii (QCI)	8 500–9 500	31
Total for British Columbia	**54 700–77 600**	**30**

a Range indicates the pessimistic and optimistic population estimates. Population estimates are made using birds and not breeding pairs or nests because the at-sea and radar counts used to derive population estimates do not distinguish between breeding and non-breeding birds. Birds are therefore the unit of population measure throughout this account.

b Note that a small proportion of nesting birds may breed outside areas of habitat that are able to be identified through air photo interpretation or helicopter surveys (L. Waterhouse, pers. comm.).

c The Marbled Murrelet Recovery Team (2003) recommended that, if possible, no further habitat reduction should occur in this region, and if that was not possible then the population should decline by no more than 10% in 2002–2032.

Wildlife habitat area

Because of the unique nature of Marbled Murrelet management direction in British Columbia (i.e., historical reliance primarily on OGMAs for establishing WHAs to protect nesting habitat), the following paragraph is provided as context for Marbled Murrelet WHA development.

To the degree possible within government policy direction limiting impacts on timber supply, areas of suitable Marbled Murrelet habitat (Table 3) should be maintained and protected, in combination with other constrained areas, to achieve the habitat objectives of Table 2 and the spatial distribution recommended for each conservation region by the Marbled Murrelet Recovery Team (MMRT 2003). When calculating total areas of maintained habitat in each conservation region or landscape unit, apply the same habitat selection criteria to protected and to non-protected areas.

Goal

Maintain suitable Marbled Murrelet nesting habitat (Table 3).

Features

Establish WHAs in suitable Marbled Murrelet nesting habitat, as defined in Table 3 and the text below. *Each habitat feature should not be used in isolation but in combination with others to ensure selection of suitable habitat.* Ideally WHAs should be established in habitats identified as "Most Likely" to contain suitable features. Habitat rated as "Moderately Likely" may be considered for WHAs but will require confirmation as suitable habitat using approved methods of ground or helicopter surveys. Areas rated as "Least Likely" should only be considered if there is evidence of nesting (nests, eggshells, or occupied detections), or strong evidence that the particular site provides the necessary microhabitat attributes (Table 1), such as platform limbs (>15 cm diameter including epiphytes) and variable canopy structure, and is within commuting distance of likely foraging areas at sea.

The CWH and CDF biogeoclimatic zones are preferred over MH (Burger 2002). Fine-scale biogeoclimatic attributes are best applied through selection of site index productivity classes (Green and Klinka 1994). Stands classified as age class 8 (140–250 yr) might provide suitable habitat but this needs to be confirmed through ground truthing; stands of age class 7 or less (<140 yr) are unlikely to provide suitable habitat, unless there are suitable old seral veteran trees or other trees with suitable platforms present. Most nests have been found in height class 5 or larger (>37 m tall), but smaller trees can provide suitable habitat especially in higher elevations and latitudes. Height classes on forest cover maps generally reflect average conditions in a polygon and might not be accurate for all parts of a polygon. Some multi-layered polygons with low height class ratings (e.g., class 2 with a veteran layer) might provide suitable trees, but these need to be confirmed by field assessments before accepting such polygons as suitable habitat.

Canopy vertical complexity is an important habitat attribute and is generally a better predictor of suitable habitat than crown closure. Aerial photographs can be used to assess and rank vertical complexity. Slope should be regarded as a neutral feature at the landscape scale, but topographic variability provided by slopes, small rock outcrops, avalanche chutes, gullies, riparian zones, and small ridges are hypothesized to improve forest value as nest habitat by breaking up the continuity of the forest canopy and improving access to the canopy for murrelets.

Aspect, moisture regimes, and exposure to wind and sea-spray need to be considered if there is evidence that these affect the availability of nesting platforms by inhibiting moss development on tree limbs.

Size

Within managed forests, maintain a balanced range of patch sizes. Patch size composition will vary depending on the existing habitat options. Until the effects of patch size are better understood, the Recovery Team recommends maintaining a mix of large (>200 ha), medium (50–200 ha), and small (<50 ha) patches within managed forests.

Table 3. Features of Marbled Murrelet nesting habitat to consider during selection and design of WHAs and other maintained habitat patches. The features are grouped by the likelihood that polygons with these features will contain a large proportion of suitable nesting habitat. Additional features are described in the text. Features should not be used in isolation but in combination with other features.

Feature	Most likely	Moderately likely	Least likely
Distance from saltwater (km): all regions	0.5–30	0–0.5 & 30–50	>50
Elevation (m):			
Central & Northern Mainland Coast	0–600	600–900	>900
Haida Gwaii (QCI)	0–500	500–800	>800
All other regions	0–900	900–1500	>1500
Stand age class: all regions	9 (>250 yr)	8 (140–250 yr)	<8 (<140 yr)
Site index productivity classes: all regions [a]	Class I & II (site index 20+)	Class III (site index 15–19)	Class IV (site index <15)
Tree height class: all regions[b]	4–7 (>28.5 m)	3 (19.5–28.4 m)	<3 (<19.5 m)
Canopy closure class: all regions	Classes 4, 5, & 6	Classes 3 & 7	Classes 2 & 8
Vertical canopy complexity: all regions[c]	MU, NU, & VNU	U	VU

a Productivity classes as defined in Green and Klinka (1994, p. 197); approximate 50-year site index values also given – application of these indices might vary with different tree species and across regions.

b Nests have been found in polygons ranked height class 1 or 2 but the nests were in larger trees than the polygon average.

c Vertical complexity ranked from least to highest (see Waterhouse et al. 2002). VU = very uniform (<11% height difference leading trees and average canopy, no evidence of canopy gaps or recent disturbance). U = uniform (11–20% height difference, few canopy gaps visible, little or no evidence of disturbance. MU = moderately uniform (21–30% height difference, some canopy gaps visible, evidence of past disturbance, stocking may be patchy or irregular. NU = non-uniform (31–40% height difference, canopy gaps often visible due to past disturbance, stocking typically patchy or irregular). VNU = very non-uniform (>40% difference, very irregular canopy, stocking very patchy or irregular).

Design

Where possible, follow the steps in Table 4 for selecting nesting habitat for WHAs.

As much as possible, minimize edge effects in WHAs by avoiding elongated or amoeboid shapes with large "hard" edges (defined above), and by establishing WHA boundaries along natural forest edges or with buffers of older second growth. Maintain windfirm boundaries to WHAs (Stathers et al. 1994) but minimize edge-feathering and topping that might remove potential nesting habitat. WHAs bordered entirely by natural edges (e.g., between avalanche chutes or rivers) need not be restricted by shape or size.

Wherever possible buffer the effects of roads, clearcuts, human communities, logging camps, and recreation sites, by leaving borders of maturing forest (>40 yr) around the old seral nesting habitat.

If there has to be a trade-off between maintaining suitable nesting habitat for WHAs or maintaining maturing buffer zones around WHAs, select the nesting habitat. An exception might be made if there is strong evidence that the buffer zone will mature into old forest with more favourable attributes as nesting habitat than other existing old forest available for WHAs in the same landscape unit cluster.

Forests within 0.5 km of shores that are exposed to open ocean or have high densities of shoreline predators (e.g., corvids) are generally considered less suitable habitat (Burger 2002), but they should be included within a WHA to buffer against wind and sea spray.

General wildlife measures

Goals

1. Maintain important habitat features such as adequate large trees providing suitable nest platforms and vertical canopy complexity.
2. Minimize activities and habitat modifications that might attract predators (e.g., recreational sites may attract nest predators, such as crows, ravens, jays, or squirrels).
3. Minimize "hard edges" (defined in "Habitat threats" section) that might attract edge predators, allow windthrow, or adversely affect canopy microclimates.
4. Minimize disturbance to nesting birds during the breeding season (late-April through early September).

Measures

Access

- Do not construct or widen roads unless there is no other practicable option.

Harvesting and silviculture

- Do not harvest except for salvage.

Pesticides

- Do not use pesticides.

Recreation

- Do not develop recreational structures, trails, or facilities.

Table 4. Recommended steps in selecting WHAs and other maintained nesting habitat for Marbled Murrelets

Goals for each step	Tools and procedures
1. Identify habitat polygons to be considered for WHAs and other maintained nesting habitat	Apply regionally specific habitat algorithms and recognized habitat indicators (see Tables 1 and 3, and associated text) to forest cover maps, or similar recognized GIS databases. See also strategic planning section above.
2. Assess and rank the polygons based on evidence of suitable canopy structure and stand features.	Air photo interpretation (Donaldson, in press), focusing on vertical complexity, tree height, stand age, and other regionally relevant parameters in Tables 1 and 3.
3. Confirm that the ranked polygons are suitable habitat	One or more of the following:(a) evidence of nesting (nests, eggshells); (b) evidence of stand occupancy using audio-visual surveys (RIC 2001); (c) evidence of suitable microhabitat features (Table 1) using ground transects or plots (RIC 2001); (d) evidence of suitable microhabitat features (Table 1) from low-level helicopter surveys (Burger et al., in press).
4. Select among the polygons classified as suitable habitat sufficient to meet the area requirements for the specific landscape unit, landscape unit cluster, or other management unit under consideration.	Maintained habitat can be a combination of polygons classified as Most Likely or Moderately Likely that is confirmed to have nesting, occupancy or suitable habitat. Polygons ranked Least Likely should only be included if there is recent evidence of murrelet nests or occupancy by murrelets likely to be breeding, or strong evidence of suitable canopy attributes within commuting distance of marine feeding sites.

Additional Management Considerations

Partial retention harvesting should not be undertaken in WHAs until its effects on murrelets are known.

Information Needs

1. Criteria and methods for identifying and mapping suitable nesting habitat need to be refined. Standard protocols for using aerial photographs and low-level helicopter reconnaissance to identify suitable habitat need to be confirmed.
2. The distribution and area of suitable habitat across coastal British Columbia need to be accurately mapped.
3. Better information is needed on the size, distribution, and habitat use of regional populations to refine habitat requirements in each conservation region.
4. The effects of forest edges and patch size on nest-site selection and breeding success need to be measured in a wide range of habitats.
5. The effects of partial retention harvesting and roads on nesting Marbled Murrelets need to be investigated.

Refer to the Marbled Murrelet Recovery Team for updates on research priorities.

Cross References

Great Blue Heron, Grizzly Bear, Keen's Long-eared Myotis, "Queen Charlotte" Goshawk, "Queen Charlotte" Northern Saw-whet Owl

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