WASHINGTON DEPARTMENT OF FISH AND WILDLIFE

outline of

6 JANUARY 2003

METHODS FOR SURVEYING MARBLED MURRELETS IN FORESTS: A REVISED PROTOCOL FOR LAND MANAGEMENT AND RESEARCH

Pacific Seabird Group, Marbled Murrelet Technical Committee

[Additional guidance for surveys in WA appear in bracketed, bold, italicized print]

TABLE OF CONTENTS

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INTRODUCTION

I. Marbled Murrelets *(Brachyramphus marmoratus)* are (Alcidae family) seabirds that occur only in North America and nest in old-growth and mature forests from Alaska south to Santa Cruz, California; murrelets winter as far south as Baja California, Mexico. [Long-billed Murrelets *(Brachyramphus perdix)* are a separate species that occurs in Asia.]

- **A.** Population declines are attributed in part to loss or modification of forest habitat.
  - **1.** In Sept. 1992, marbled murrelet was listed by USFWS as federally threatened in WA, OR and CA; not listed in Alaska. (CA: state endangered; WA and OR: state threatened).
  - **2.** Species listed as nationally threatened in Canada; it occurs only in BC.
- **B.** Unlike most Alcidae family members, murrelets most often nest in trees; a few ground nests found in forested and non-forested areas in south-central and western AK and northern BC, Canada.
  - **1.** As of 2002,at least 300 tree nests had been located.
    - **a.** Nest sites and 15 years of data show murrelets nest in old-growth and mature coniferous forests throughout most of their range.
  - **2.** Murrelets also found in younger forests with:
    - **a.** Remnant old-growth trees or
    - **b.** Structural elements similar to old growth (e.g. platforms created by deformities or dwarf mistletoe infestations).

II. To maintain adequate nesting sites, forest land managers need to determine murrelet inland distribution/habitat use patterns.

- **A.** Few forest surveys before 1984.
  - **1.** Fixed-location survey methods evaluated/modified through OR/CA research.
- **B.** Pacific Seabird Group (PSG), a professional scientific organization, has taken a lead role in coordinating/promoting murrelet research. PSG protocol surveys conducted since 1992 on federal, state, and private lands.
  - **1.** Protocols provided standardized techniques to detect murrelets in forests.
  - **2.** Since 1994, continued inland surveys and research have generated new insights on nesting behavior, activity patterns, and habitat use.
  - **3.** This document is a revised protocol that:
    - **a.** Compiles information from previous protocols.
    - **b.** Provides new recommendations for survey visits based on analyses of 1989-1998 surveys.
    - **c.** Provides supporting documentation for many recommendations.
    - **d**. Clarifies some aspects of protocol use and application.
  - **4.** 2003 protocol will be revised in the future as new information is learned.

PURPOSE AND OBJECTIVES

I. Objectives of 2003 protocol are to provide scientifically-based methods for biologists, managers, and researchers to:

A. Document the occurrence or probable absence of murrelets in forest stand at time of surveys.

B. Interpret biological significance of observed behaviors to evaluate murrelet stand use (i.e. classify sites as "presence", "occupied", or "probable absence"). ***[In WA, WDFW makes official interpretation of murrelet behaviors for regulatory/conservation needs]***

C. Identify geographic distribution of murrelets.

D. Provide consistency in surveys.

II. This protocol is based on analyses of 10 years of survey data to provide statistical reliability for classifying sites. Protocol was primarily developed for management purposes, but generally applicable to research. Protocol methods:

A. Are applicable in Washington, Oregon and California.

B. May need modified for British Columbia and Alaska.

C. May not apply in years with abnormal oceanographic events, e.g. El Nino.

III. This protocol does not cover all possible scenarios; additional state, provincial, or federal agency requirements may apply. Consult with appropriate regulatory agency for all aspects of surveys for forest management purposes. ***[Consult with WDFW regarding murrelet surveys involving WA Forest Practices activities or other forest conservation-based activities.]***

PLANNING AND CONDUCTING SURVEYS

I. Definitions

A. Potential habitat: Murrelets nest stands have predominately Douglas-fir, coast redwood, western hemlock, western redcedar, yellow cedar, mountain hemlock, and Sitka spruce. Potential habitat is:

1. Old growth coniferous forests.

2. Mature coniferous forest (with or without an old growth component).

3. Younger coniferous forests (60-80 years) with nest platforms created by dwarf mistletoe or other deformations or structures.

Potential habitat includes larger forested areas of unsuitable habitat containing small patches of suitable habitat. It also includes any forested area with a residual tree component and any area having $\geq$1 platform. Some occupied sites have included $\leq$1 residual, larger coniferous tree(s) per acre.

B. Continuous potential habitat: Potential habitat with no gaps >100 m (>328 ft).

C. Platform: Relatively flat surface $\geq$10 cm ($\geq$4 in) diameter $\geq$10 m ($\geq$33 ft) high in the live crown of a coniferous tree [OR: 4 nests <15 m (49 ft) from ground]. ***[In WA Forest Practices Rules, platforms are $\geq$ 7 in diameter and $\geq$ 50 ft high in trees $\geq$ 32 in dbh.]***

1. Created by wide bare branch, moss or lichen on branch, mistletoe, witches brooms, other deformities (e.g. old squirrel nests).

2. Presence of platforms is the *most important* characteristic for predicting murrelet presence in an area; tree size alone is not a good indicator of platform abundance.

D. Audio-Visual Survey: Process of determining murrelet presence, probable absence, and occupancy of a site by visiting it on the ground and observing for murrelets.

E. Survey Area: Entire area being surveyed; divide large areas into survey sites.
F. Survey Site: Subunit of a larger survey area; size is ≤51 ha (≤125 ac); a site has 1 or more survey stations. Requisite number of survey visits apply to every site. ***[In Washington, survey sites should not exceed 51 ha (125 ac) in size due to compromising of sampling intensity/coverage of site; most sites are < 51 ha due to terrain and other onsite considerations.]***
G. Survey Station: Location where observer stands when conducting survey visit.
H. Survey Visit: A single morning's survey.
I. Survey Period: 2-hour [morning] period in which survey is conducted.
J. Detection: The sighting and/or hearing of one or more birds acting in a similar manner and initially occurring at the same time. A A5-second rule≅ separates detections; e.g. a bird seen circling overhead and continuously calling is 1 detection, but if the bird flies out of sight for >5 seconds and stops calling, and another bird is heard and/or seen after this time, then this subsequent bird activity is counted as another detection. Examples:

1. Two initially separate birds or 2 initially separate groups of birds that join together = 2 detections
2. Birds initially seen as a group that later splits apart = 1 detection

K. Presence site: Site of potential habitat where at least 1 murrelet has been detected (includes occupied sites).

[WDFW and WA Forest Practices Rules define "Presence" according to 2003 PSG survey protocol, i.e. a detection indicating murrelet(s) seen and/or heard but occupied behaviors not detected (in Washington, this includes circling at ≤2 canopy heights).]

L. Occupied site: Site where murrelets were observed exhibiting subcanopy behaviors

[WDFW and WA Forest Practices Rules include circling at ≤2 canopy heights as evidence of stand occupancy; see WAC 222-16-010 re: third-year surveys.]

M. Subcanopy behaviors: Behaviors that occur at or below the forest canopy and that strongly suggest site has some importance for breeding (e.g. subcanopy behaviors seen associated with potential habitat vs. non-habitat).

[WDFW processes statewide survey data and makes official determinations for classification of murrelet sites in WA for conservation and regulatory purposes.]

N. Nest site: Site with an active nest or evidence of a nest, including eggs, eggshell fragments, or a downy chick.

[WA nest site information is recorded in WDFW murrelet database. Stands with current and "historic" nest sites are classified as Occupied.]

II. Inland Limit For Surveys

The following is the extent of inland range [from marine waters] as currently known. This provides guidelines for planning inland surveys. Use the farthest inland detection for planning surveys. Consult with regulatory agency if unsure how far inland to survey.

A. Alaska: Most distant nest was <10 km (<6 mi) inland.
B. British Columbia:

1. Most distant nest was 35 km (22 mi) inland.
2. Fledgling with egg tooth found on ground at 101 km (63 mi) inland.

C. Washington: ***[In WA Forest Practices Rules, 50 miles inland is extent used]***

1. Most distant nest was 35 km (22 mi) inland.
2. Farthest inland occupied site was 84 km (52 mi) in northern Cascade Mtns.
3. In Cowlitz Co., farthest occupied site was <32 km (<20 mi) inland.
4. In S. Cascade Mtns., a detection was 113 km (70 mi) inland.

D. Oregon:

1. Most distant nest was 49 km (30 mi) inland in south-central Coast Range.
2. Farthest inland occupied site was 65 km (39 mi).
3. In Cascade Mtns, farthest inland detection was129 km (80 mi).
4. In Siskyou Mtns, farthest inland detection was 51 km (32 mi).
    a. Study showed murrelet occurrence associated with hemlock/tanoak vegetation zone, which occurs 16-51 km (10-32 mi) inland. For consultation purposes, USFWS does not require surveys beyond this zone.

E. Northern California:

1. Most distant nest was 28 km (17 mi) inland.
2. Farthest inland occupied site was 39 km (23 mi).
3. In Siskiyou Co., farthest detection was 59 km (37 mi) inland.
    a. Extensive surveys elsewhere in Siskiyou Co. yielded no detections.
4. In Humboldt Co., farthest detection was 40 km (25 mi) inland.
5. In Santa Cruz Mtns, farthest inland nest was 16 km (10 mi) inland.

III. Habitat Assessment

Need to evaluate potential habitat on-the-ground within an area of proposed management activity.

A. Regional variation in potential habitat.

B. Use maps and aerial photos.

C. Walk through the entire project area.

1. Look for suitable nest platforms; *[see "platform" in **Definitions**, p.2]*.
    a. Look for moss cover or deformities on small diameter limbs.
    b. Look for duff platforms; moss does not have to be present.
2. In younger-aged areas look for small patches of suitable habitat or remnant, large trees although large-diameter trees do not have to be present.
3. Do not eliminate areas based on perceived lack of flight access; stands on ≥20% slopes often create access due to tree layering and streams are natural flyways.
4. Aspect is not a limiting factor for nesting.

D. Failure to identify potential habitat, and thus >clear= an area for management activities could have a substantial negative impact on the murrelet population.

1. When defining habitat, there may be local or region-specific considerations.
2. Confer with appropriate regulatory agency for habitat assessments.

[WA Forest Practices Board Manual has habitat assessment guidelines.]

IV. Survey Type

Ralph et. al (1994) described 2 survey types: General and Intensive. General not designed to document "probable absence," so not recommended. Radar surveys have very specific and limited objectives; do *not* substitute radar surveys for intensive surveys for determining occupancy.

A. **Radar Survey** (See Appendix H) *[NOTE: Currently, there is no official radar survey protocol.]* A radar survey:

1. Employs stationary marine radar system to detect and track murrelets in flight.

2. Cannot determine occupancy.

3. In some cases, can reliably determine presence in shorter time than current audio-visual protocol (Intensive Surveys). Can be a "coarse filter" to quickly and accurately determine if murrelets are present near or adjacent to a forest stand and help identify where intensive survey efforts could be most effective for determining occupancy.

4. If applied with intensive surveys, requires consultation with appropriate state and federal agencies and a rigorous sampling design.

B. Intensive Survey

1. Designed to:

a. Determine probable absence or presence of a specific site.

b. Document occupancy.

c. Monitor murrelet activity levels at a site (e.g. pre-harvest inspection).

d. Locate nests *(See PSG nest search protocol on next page)*.

e. Establish murrelet use patterns.

2. Observer visits one station per morning.

3. Recommended for all proposed timber harvest and management activities.

Intensive surveys incorporate a 3-step process:
(1) Design survey, including habitat assessment; define survey area, establish survey sites and stations.
(2) Conduct survey visits in accordance with protocol to determine if murrelets occur at the site.
(3) Interpret the activity observed to classify the site as "probable absence", "presence", or "occupied."

At occupied sites: Searching for nests or attempting to determine birds' spatial and temporal use patterns through entire stand requires intensive effort with numerous people conducting simultaneous visits. For locating nests, use PSG's "Techniques for finding tree nests of the Marbled Murrelet" (Naslund and Hamer 1994).

V. Defining Survey Area and Sites

A. Survey Area (See Figures 1 and 2 for examples)

1. Minimum area surveyed should be potential habitat that falls within proposed project area and within 1/4 mi (492 m) of project area boundary that is continuous with the project area. (Figure 1)

a. Reason for surveying continuous habitat based on murrelet nesting behavior and alcid behavior in general:

i. Murrelets nest solitarily, but usually more than 1 pair in a continuous [stand] for social/breeding interactions.

ii. 2 or more pairs might nest asynchronously in a stand or may re-nest, so different nest locations through season.

iii. Over several years, birds may use more than 1 tree or different parts of a stand for nesting. High nest site fidelity; some stands have 20+ yrs of known use. Most nest trees are not used in consecutive years. Birds may not nest every year.

1. Consider surveying any continuous habitat beyond the 1/4 mi minimum survey area size especially when:

a. Potential habitat is long and linear, or

b. A project area is at the edge of a large block of potential habitat, a 1/4 mi boundary may not include entire stand of potential habitat (Fig.2).

Previous protocol recommended the survey area include continuous habitat within 1/4 mi *or 51 ha (125 ac)*, whichever is greater. This guideline allowed for a larger portion of potential habitat to be surveyed when a relatively small portion occurred within 1/4 mi zone. It also provided a limit over a large landscape.

3. In conjunction with 1/4 mi zone, use topographic features like ridgelines to help define the survey area.

4. If disturbance is an issue, consider including other potential habitat within 1/4 mi that is *not* continuous. Consult with regulatory agency.

5. The survey area should be defined by occurrence of potential habitat.

a. In forested areas without scattered individual remnant trees or habitat patches, potential habitat separated by >100 m (328 ft) from other potential habitat should be its own survey area.

b. In young forested areas with uniformly scattered remnant trees, the potential habitat is this combination of young and remnant trees. Do not include large expanses of non-habitat in survey area.

B. Survey Site

Survey site is the unit by which surveys are designed and carried out, and the unit to which the requisite number of visits applies.

1. Limit size of site to 61 ha (150 ac). When survey area is <61 ha, the site and survey area can be the same. Size corresponds to the minimum number of visits needed to determine presence (5) per year and the average area covered by 1 survey station (~12 ha or 30 acres). ***[In WA, limit size of site to 51 ha (125 ac).]***

2. Divide large survey areas (>61 ha) into sites (Figure 3).

a. Some flexibility is allowed in exceeding 61 ha, but sampling intensity and coverage are compromised when site is >69-71 ha (170-175 ac). ***[In WA, survey sites should not exceed 51 ha (125 ac) in size due to compromising of sampling intensity/coverage of site; most sites will be < 51 ha due to terrain and other onsite considerations.]***

3. Do not confuse survey site boundary with management project or larger survey area boundaries (Figure 3).

4. The survey site contains ≥ 1 survey station that collectively are surveyed to determine site status which ultimately influences survey area status. See Distribution of Visits Among Survey Stations for details regarding number of survey visits per station per site.

5. Identify each site with unique name or number and legal description (Figure 3)

a. Clearly delineate site boundary on a topographic map or aerial photo.

b. Clearly identify multiple sites; share survey area name/number.

c. Clearly identify stations with sites; share site name/number.

VI. Survey Stations and Their Placement

Survey station placement is crucial aspect of survey implementation:

- Murrelets are hard to detect due to small size, rapid flight, cryptic plumage and crepuscular behavior.
- Good station placement is imperative if murrelet use of the stand is to be correctly classified.
- Number of visual detections are strongly influenced by location of observer.
- 2 radar studies showed ground observers missed 71-100% and 77-90% of murrelets detected on radar, even when provided with bearings and directions of the birds.
- Sensible station placement can help overcome site characteristics that may influence the observer's ability to hear and see.

There are **3 steps** involved in station layout:

(1) Determine adequate coverage and establish preliminary station locations by overlaying circular Mylar disks on aerial photos or topographic maps. Identify topography; openings or gaps in canopy; habitat patchiness; and flight corridors [streams, lakes, rivers, meadows, avalanche chutes, landslides, *[adjacent clear cuts]*, paths and roads.

(2) Locate stations on the ground and refine placement based on site-specific factors. Identify openings not on maps and potential sources of localized noise. Most detections are audio, so it is optimum to place stations in quieter locations than by loud noises, e.g. busy roads. Consider foliation of vegetation, snowmelt runoff in spring and viewing window. Silent birds are easier to see as silhouette in sky at dawn.

(3) Before and/or during the season, consider adding new or supplementary stations which may not conform to protocol, e.g. station >50 m from survey area edge. Use stations to augment effort; follow up on presence activity. Stations could be visited in tandem with another observer, e.g. 1 observer at a stream opening with noise is offset by 1 observer at a quieter location. Two stations surveyed in tandem count as 1 visit for the site. *(NOTE: Visits to non-protocol placed stations do not count toward the requisite number of visits.*)

1. Station Effective Area: this is the distance at which observers conducting audio/visual surveys detect murrelets; this determines number of stations to cover site.

a. Observers generally see birds within 100 m (328 ft) or hear birds within 200 m (656 ft). Detections are often missed at greater distances and classifying behavior is more difficult.

b. Some locations have restricted visibility

c. Radar studies found a steep, steady drop in observer's detections beyond 100 m; observers missed ~70 to 100% of murrelets detected on radar even when provided with bearings and distances

d. Based on station's effective area, up to 12 ha (30 ac), [roughly equivalent to a 200 m (656 ft) radius circle] can be surveyed from a single station. In many cases, stations cover <200 m radius due to topography, stand shape, canopy closure, understory denseness, location of survey area and station placement. Many more stations area needed at survey areas with closed canopy, limited visibility and/or steep terrain with many drainages.

2. Topography and Stand Shape

a. Topography influences number of survey stations. 1 station will ***[theoretically]*** cover 12 ha (30 ac) for a square stand on flat ground; based on horizontal distance and ability to see/hear birds. Slope distance is not equivalent to horizontal distance. Can use a stereoscopic analysis or ground measurements; derive horizontal distance from standard slope conversion tables.

b. Stand shape influences number of survey stations. If stand is rectangular or irregularly shaped, be sure stations cover the area (See Figure 5); e.g. a 12-ha (30 ac) stand that is long and narrow will need >1 station for adequate stand coverage.

c. General Rule of Thumb: locate stations throughout site. Incorporate topographic features and cover all of site. If site has ridge top, mid-ridge, and river bottom, make sure stations cover these areas. Additional number of stations will depend on slope. **Remember:** If station is on the edge of site, coverage may be <12 ha of site.

d. Stations located up-slope with a broad view of site may limit chances to see murrelets below ridge top elevation. Consider that a dark bird is easier to see against sky vs. a dark background such as a forest slope when viewed from a ridge top or high point.

3. Location With Respect To Openings

a. Generally, murrelets remain unseen to the observer; 80% of detections were audio, compared to 13% visual and 7% both seen and heard
(n=8376; WDFW interagency database). Rates similar in OR and CA.

b. Occupancy behaviors derived almost exclusively from visual observations, therefore, stations should be located with **unobstructed view of the sky**.

i. Where possible, use openings (forest clearings, quiet roads, edge of the site, locations in or near rivers or streams). Streams may create noise disturbance, but visibility is important. ***[In WA, both good visibility and audibility at a station are important since "Occupancy" or "Presence" detections have management implications under WA Forest Practices Rules.]***

c. Stations should not be >50 m (164 ft) from edge of survey site (e.g., see Figure 6).

d. Common error is inadequate coverage of the interior of a site. Generally, a site cannot be surveyed adequately if all stations on the perimeter; also locate stations within the site for entire survey coverage. ***[It is important to remember that stations with limited views of the sky decreases chances of seeing occupied behaviors; birds may be heard but not seen.]*** Increase number of stations to offset stations placed in areas without a good view of the sky or other placement problems.

e. Consult with wildlife resource agency for direction regarding problems with station coverage ***[See Summary below for WDFW guidance]***.

4. Location With Respect To Potential Habitat

a. In younger-aged forest, potential habitat is often in small patches ("micro-sites") separated by unsuitable habitat. Place stations to cover the most likely nesting habitat and distribute to cover all potential habitat.

b. If more than 1 visit is needed to stations within a site, conduct additional visits at stations with the best habitat or combination of the best habitat, visibility, and proximity to previous detection.

5. Modifying Station Placement

a. To maximize observer's chance of seeing birds, observer can move up to 50 m (164 ft) from station during visit; *(remember: do not survey >50 m from the site edge unless conducting a supplementary visit).* The new location must be <1-minute walk; record time and direction of movement from station.

b. In subsequent visits, stations can be added to existing station layout to obtain visual observations; e.g. birds are heard in gully, so on the next visit, survey in gully. Assign unique station identifiers to new locations >50 m from existing stations.

c. Additional visits can be made to a particular station if observer thinks there is a good chance of observing murrelets, however, *all* potential habitat within the site must be surveyed.

6. Summary

a. The goal of station placement is to maximize the opportunity to observe murrelets and specifically murrelet behaviors indicative of nesting, if they occur.

b. You must have at least 1 station per 12 ha (30 ac); **in almost all cases you will need more than 1 station per 12 ha.**

c. Stations must be distributed throughout site to address specific topographic features; i.e. if site has ridge-top, mid-ridge, and river bottom, place stations at or near these locations to cover all potential habitat in that area. ***[Consult with WDFW Wildlife Program regarding any questions about station placement; pre-season planning is advised.]***

i. If placing a station in or adjacent to rivers/creeks, there may be noise concerns. [***If hearing is impaired up to 200 m (656 ft) due to station placement, a mitigation visit is advised to provide effective survey coverage of the area in question; a mitigation visit should be at quieter location; ideally a mitigation visit should be a tandem visit, but a separate morning visit is acceptable if conducted within < 6 days to maintain temporal coverage; identify visit as "mitigation" visit for audibility problem at station # on date of affected visit" on data form. Plan visits so requisite number and timing/distribution are observed.]***

d. Stations should be located in an opening, if possible; but distribution *of stations throughout the site is equally important, so some stations* may not have excellent viewing opportunities.

i. If placing a station in a location with dense overhead cover or complex terrain; there may be viewing concerns.
[If overhead cover is 76-100% due to station placement, a mitigation visit is advised to provide effective survey coverage of the area in question; a mitigation visit should be at a location with a good view of the sky; ideally a mitigation visit should be a tandem visit, but a separate morning visit is acceptable if conducted within < 6 days to maintain temporal coverage; identify visit as "mitigation visit for viewing problem at station # on date of affected visit" on data form. Plan visits so requisite number and timing/distribution are observed.]

e. When surveying a heterogeneous site, be sure to place some stations *within* patches that have the most suitable characteristics for nesting while maintaining appropriate station distribution.
[Stations should be within patches or ≤50 m of patch edge with a view of the highest quality suitable habitat of the patches.]

f. Surveys can be labor intensive.

i. In areas with difficult access (steep slopes, cliffs, thick brush, long distances from roads), consider brushing wide trails through the stand, outside of nesting season if power equipment is used. Trails can provide access to several stations (Figure 7).

ii. In extreme cases, it may be necessary to hike to a station before dark and camp overnight before a survey.

VII. A Simple Technique For Delineating Site Boundaries and Determining Station Location

A. Stereoscope analysis of aerial photos can be used to:

1. Delineate site boundaries.

2. Locate canopy gaps, road landings and other potentially suitable station locations.

3. Identify topographical features.

B. Use overlay Mylar template at scale of aerial photos/maps for 12, 8 and 6 ha (30, 20 and 15 ac) areas to estimate ground (horizontal distance) based on topography.

1. Gaps or open locations should be selected first.

2. Then determine other station locations using Mylar template.

3. Survey sites ***[≤51 ha (≤125 ac) in WA]*** can then be delineated by circumscribing the area covered by a set of adjoining stations. Consider natural features such as ridgelines or drainages when delineating sites.

C. Finalize station locations, site boundaries, and number of stations **after field review**. Remember to consider:

1. Increase in growth and foliation of adjacent vegetation in spring and summer that may affect visibility.

2. Increase in snowmelt runoff in early spring that may affect audibility.

VIII. Number Of Survey Visits

The objective of the survey design is:

(1) To achieve a high confidence that occupied sites are classified correctly.

(2) To achieve survey efficiency, i.e., optimize the number of surveys needed to classify occupancy.

The survey design has 2 components:
(1) The number of visits needed to achieve desired level of reliability.
(2) The distribution of visits over time, both within a year and across years.

A. 2-Year Protocol: Intensive surveys should be conducted for at least 2 consecutive years. A 1-year protocol survey risks misclassifying sites.

1. Nelson found murrelets occupied several stands in year 1, were absent in year 2 and occupied stands again in year 3.

2. A subsequent analysis of pairs of years from 1989-1998, 3-state dataset showed:

a. An average of **39%** of occupied sites changed status over a **2-year** period; i.e. these sites were occupied in 1 year, but not the other.

b. Status was not independent between years.

3. The underlying causes of change in site status are unknown, but between-year variation could be due in part to ocean conditions and food supplies.

4. Surveys at long-term, monitored sites may show atypically low inland detections.

a. Regulatory agencies should assess reliability of surveys based on patterns from long-term, monitored sites.

B. Number of Visits

1. Survey effort recommendations are based on: (a) **95%** confidence target of survey outcome; i.e. no more than **5%** misclassification error of occupied sites, and (b) the **~40%** weighted average of occupied sites changing status in **2-year** period.

a. 2-stage sampling approach recommended:

i. **Minimum** of **5 visits**, and expectation of **9**, in each of **2 years**

ii. This scenario assumes: (1) surveyed area has same "average" detection probability as sites from 3-state dataset used in analysis;
(2) no additional info is available re: site's likelihood of being occupied or having no murrelets; (3) objective is to detect occupancy if site is occupied (not merely presence).

2. Sites used in analyses varied by habitat type and geographic location, so year-only effect could not be assumed, therefore a weighted average **(~40%)** was used for calculated number of recommended visits.

3. Recommended approach for average cases includes **stopping rule of 5 visits**.

C. Recommended Approach

1. Assuming **95%** confidence target and assumptions above, then to determine occupancy at site, plan **2-year** surveys with **5 minimum visits**, and expectation of **9**, in each year. Recommended approach is:

a. If, in year 1, detections are made in *first* **5 visits** but **no subcanopy behaviors** are observed, full **9** visits are made in year 1 and year 2, for **2-year** total of **18** visits (unless occupancy occurs in fewer visits).

b. If, in year 1, **no detections** are made in *first* **5 visits**, surveys can stop for year 1. If, in year 2, **no detections** are made in first **5** visits, survey can stop with **2-year** total of **10** visits and site is classified as "probable absence."

2. Following this approach is based on a 0.9546 probability of detecting occupancy, given that a site is occupied.

3. If the assumptions do not apply to a site, a greater number of survey visits may need done in each of **2-years** to have **< 5%** site classification error, assuming a **95%** probability of detecting occupancy is desired. This is if there is reason to believe that:

a. The detection probability is < average for sample sites used to estimate *q*, and/or

b. Additional site info suggests occupancy is low.

4. Visits can be discontinued once subcanopy detections are confirmed, unless further visits are desired; ***NOTE: this will not change occupied status of site***.

5. **Caution:** If the expected **9** visits cannot be completed and the first "presence" detection occurs near the end of year 1 or 2, increased survey effort (within the prescribed survey window) should begin immediately to avoid additional years of surveys.

6. Survey recommendation is based on calculated averages from data and does not mean that, for any individual site, one is assured of 95% probability by doing 9 visits in each of 2 years. Sites may require fewer or greater number of visits.

a. Any individual site's unknown true probability is uncertain

b. Site's likelihood of status change from year to year is uncertain

7. To achieve a higher probability of correctly classifying a site, a different survey approach could be applied, in consultation with appropriate regulatory agency. See formulas for calculations in Appendix A, Table A-3.

a. Calculate average probabilities for variety of situations using:

i. Different probabilities for detecting "probable absence," "presence," or "occupancy" on a single visit, assuming site is occupied that year;

ii. Different number of planned visits;

iii.Different stopping rule; and/or

iv. Different assumption of proportion of occupied sites that change status between years.

b. To design a different sampling protocol, one must get assistance from a **qualified statistician** to determine sample size needed and to help with derivations. Different values and assumptions might be derived from:

i. Previously collected survey data from a particular geographic area (i.e. data from sites with higher or lower detection probabilities).

ii. Habitat suitability models that assess a site's probability of being occupied.

D. Distribution of Visits Among Survey Stations

1. Visit each station at least once per year or a minimum of 5 *(with a planned number of 9)* visits per year to each site; whichever is the greater number of visits.

a. The number of visits per station varies with number of stations at sites.

If **1 to 3 stations** at a site, divide number of visits among stations so survey effort equals requisite number of visits/yr for 2-consecutive years: (i.e., 1 station = at least 5 and possibly 9 visits/yr; 2 stations = at least 3 visits/1 station/yr and 2 visits to the other/yr; 3 stations = at least 2 visits to 2 stations and 1 visits to 3rd station/yr).

b. Additional visits should be conducted at station(s) of highest quality; i.e. those with:

i. The greatest detection numbers.

ii. The best view of the sky or stand.

iii.Habitat with the highest *(nesting)* potential.

c. If ≥ **5 stations**, do at least 1 visit/station/year for 2-consecutive years.

d. If murrelets are detected at a site, but **no subcanopy behaviors** were observed, do **at least 9 visits/year** to determine occupancy.

IX. When To Survey

A. Time Of Year

1. Nesting sites primarily used during breeding season but murrelets are observed at some inland sites during all months of year. Areas most effectively surveyed in spring/summer when greater activity levels, and more consistent and longer attendance.

a. Murrelet activity increases to moderate intensity during spring

b. Activity reaches a peak level from early July to early August in CA, OR, and WA. Increase may be due to nesting birds and non-breeders (prospecting for future nest sites).

c. After this peak, detections markedly decrease presumably due to end of nesting activities and start of flightless molt at sea.

2. Survey season for **management applications** should be:

a. CA: 15 April - 5 August

b. OR, WA and BC: 1 May - 5 August

c. AK (southeast/south-central): 15 May - 5 August

These dates bracket a substantial portion of the incubation to nestling period based on chronologies identified by Hamer and Nelson (1995b).

3. Do not confuse **survey season** with **breeding season** (earliest known nesting and latest known fledge dates). For **breeding ecology research and nest site monitoring**, start surveys 2 weeks earlier and 2 - 3 weeks later than above dates.

a. CA: 24 March - 15 September

b. OR and WA: 1 April - 15 September

4. The survey season misses some nesting activity and potentially some opportunities to determine site occupancy.

a. CA: of 26 nests, 4 (15%) and 13 (50%) were active before and after the survey season, respectively.

b. OR: of 22 nests, 1 and 7 (32%) were active before and after the survey season, respectively.

c. WA: of 9 nests, 1 (11%) and 3 (33%) were active before and after the survey season, respectively.

5. "Occupied" behaviors documented outside the survey season but within the breeding season are valid. "Presence-only" detections and "no detections" outside the survey window are not appropriate for site classification.

6. Winter surveys may be helpful for determining site presence in some areas, but "no detections" does not prove absence at a site. During non-breeding season, murrelet activity at nest areas may be important for:

a. Forming and maintaining pair bonds.

b. Retention of nest sites.

c. Selecting future nest sites.

B. Distribution Of Visits Throughout the Season ***[In WA, survey season is May 1-Aug 5]***

1. Several studies show detection levels fluctuate greatly at the same survey area, or even at the same station, throughout the breeding season.

a. There is usually a peak in detections, but timing varies year to year.

b. Analysis of 1989-98, 3-state dataset supports increased survey effort when detection rates increase.

i. **Presence** detection rates are *higher* during a 2-week period in mid-July.

ii. Detection rates are *lowest* in a 5-week period from beginning/mid-May to beginning/mid-July.

iii. **Occupancy** detection rates are *low* throughout season until about a 1 week period in mid-July, ***[In WA, the "mid-July peak" is July 11-17].***

c. In Alaska, survey emphasis may need shifted to last 3 weeks in July.

2. Start surveys within the first 2 to 3 weeks of the survey season; ***[in WA, complete the first visit on or by May 21.]***

3. To maintain even distribution, observe a **minimum** of **6** and **maximum** of **30 (calendar) days** between survey visits.

4. The objective of protocol is to detect murrelets if they occur at a site, so visits should cover the time of increased [murrelet] activity.

a. Using the **5-Visit Stopping Rule**, do **2** of **5 minimum visits** *after* June 30 and *before* July 18.

i. Do not cluster these 2 visits at the beginning of July to increase chances of surveying during the mid-July peak; ***[In WA, observe a minimum of 6 and a maximum of 30 (calendar) day spacing between survey visits.***

Conduct 3 visits by June 30, with at least the first visit by May 21.

Conduct 2 visits after June 30 and before July 18 with at least 1 of the 2 visits during the "mid-July peak" (July 11-17).

ii. If the first "presence" detection occurs *late in the season* (i.e., *after* June 30) and 9 visits are needed, then ***(up to 4)*** additional visits ***(after a total of 5 visits)*** may be spaced a **minimum** of **2 calendar days** apart. ***[In WA, apply this guidance. Also, if the first "presence" detection occurs by June 30, follow the 9 pre-planned visit approach below.]***

b. For 9 pre-planned visits, allow time to conduct the required number of visits and do some during the peak detection period. ***[In WA, this is July 1-21; the "mid-July peak" is a subset of this time period.]***

i. Space visits as evenly as possible throughout the [survey] season with **at least 4** of the **9 visits** for occupancy *after* June 30, and *at least* **2 of those** within the first 3 weeks of July. ***[In WA, observe a minimum of 6 and a maximum of 30 (calendar) days between survey visits.***

Conduct a minimum of 3 of 9 visits by June 30, with at least the first visit by May 21.

Conduct a minimum of 4 of 9 visits after June 30; and conduct at least 2 visits after June 30 and before July 18 with at least 1 visit during the "mid-July peak" (July 11-17). Visit Spacing Exception: After these 2 visits, are conducted, up to 4 more visits may be spaced at a minimum of 2-calendar days apart]

b. Based on analysis, it was *uncommon* for an **occupied site** to have **no detections** *before* the stopping rule threshold. Expect at least **presence** detection at truly occupied sites within the first few visits, then adjust schedule for **9 visits**.

C. Time of Day

1. BC, WA, OR, CA: survey period starts 45 min. before and continues till 75 min. after **sunrise** or 15 minutes after the last detection, whichever is longer. In southeast AK, survey period starts 60 min. before sunrise and in south-central AK: 90 min. before sunrise.

a. Exception to survey period timing is under "Environmental Conditions"; visit may be longer than 2 hrs, especially on cloudy days or days with fog when detections generally continue longer. If occupancy has unquestionably been detected, extension is not necessary. ***[In WA, continue to extend visit 30 minutes if at end of the standard 2-hour visit there is light to heavy hail rain, hail, or snow and/or moderate to heavy fog <2 canopy heights at the survey area; this ensures survey consistency and may result in important detection information.]***

b. Radar surveys on Olympic Peninsula, WA show an average of 20% of radar detections occurred earlier than 45 min. before sunrise. Many "targets" silent; using PSG audio-visual survey, these murrelets would be undetectable in near dark conditions.

c. Opportunities to observe occupied behaviors can occur after survey period, particularly during chick rearing. Example: Initial wave of fish deliveries at sunrise (in low light), then 2nd feeding occurred an average of 54 min. after sunrise; latest time seen: 225 min. after sunrise.

i. In BC, at 3 nests: 64% of 104 feedings occurred > 1 hour after sunrise.

ii. Later arrival times generally occurred on cloudy mornings.

2. Use **Nautical Almanac** to determine sunrise times for survey area; do not use local tide tables, newspapers, or TV stations because sunrise info can vary up to 15 minutes from official time. US Naval Observatory website: **http://aa.usno.navy.mil/AA/data**.

[<u>OR</u> in WA, use WDFW's standardized sunrise table times for geographic area relative to survey area/site]

3. Murrelets can be detected during the evening; radar surveys find consistent but lower volume of flights compared to morning. PSG protocol does not include evening surveys since visits do not count toward determining "probable absence," but "presence" or "occupancy" may be detected.

D. <u>Environmental Conditions Affecting Surveys</u>

1. Effects of environmental conditions are twofold:

(1) Timing, duration and intensity of murrelet activity.

i. Murrelet activity at inland sites begins later, lasts longer, and is often more intense on mornings with overcast conditions, fog, drizzle, or rain than on mornings with clear conditions. In WA, on the Olympic Peninsula, radar showed timing of murrelet movements averaged 10 min. later on overcast or foggy mornings.

ii. Continue visit for an additional **30 minutes** if rainy, cloudy, or foggy conditions.

- Cloudy conditions are defined as >75% cloud cover.
- Fog conditions defined as cloud ceiling <height of tallest tree <u>at the site</u> or by low fog, which decreases horizontal visibility to <100 m.

[In WA, WDFW requires a 30-minute extension when any of the following exists at the end of** the* **2-hour visit: light to heavy hail rain, hail, or snow and/or moderate to heavy fog <2 canopy heights at the survey area.]

(2) Ability of observers to audibly and visually detect birds.

i. If conditions limit murrelet detectability >10% (12 min.) of visit, reschedule and repeat soon after, unless occupancy is detected. Noise from heavy rain, strong wind, hail, and other noise sources (including logging activity, vehicle traffic, aircraft, *[birdsong and streams]*) make it difficult to hear murrelets; low cloud ceilings or thick fog make it difficult to see murrelets. These conditions also include a low cloud ceiling or fog conditions that reduces vertical visibility to <1 canopy height or horizontal visibility to <100 m.

[<u>In WA, repeat visit if you have >12 minutes of the following:</u>
-Vertical viewing is <2 canopy heights or horizontal visibility is <100 m; environmental conditions that impair vertical visibility are moderate to heavy fog, or heavy rain, and snow. Moderate rain may also impair visibility.
-Audibility is <200 m; loud noises will impair ability to hear murrelets up to 200 m; moderate noises may also impair hearing.]

[Estimating conditions at a station can be subjective. To help judge visibility and audibility at some sites, observers can use detections of other birds as murrelet surrogates. To quantify wind speeds, a hand-

held wind meter can be helpful. To quantify the amount of times a visit is disrupted by traffic if surveying on or near a busy road, a hand-held tally counter can be used. To help test observers' onsite ability to hear up to 200 m at a questionable station, a recording of murrelet vocalizations can approximate murrelet audio sounds at measured distances from the station.]

ii. **Unless there are safety concerns**, be sure to complete a visit regardless of weather conditions since birds may still be detected.

INTERPRETING SURVEY RESULTS TO CLASSIFY SURVEY SITES AND AREAS

[In WA, WDFW makes the official state's interpretation of murrelet behaviors as they apply to survey areas/sites for regulatory and/or conservation purposes.]

I. Significance Of Murrelet Behaviors

Murrelet nests are extremely difficult to find. A set of behavioral criteria was established to determine if potential habitat is likely occupied by murrelets. These behaviors are documented at active nest sites. Some behaviors are associated with non-nesting but other breeding-related activities.

A. Flight: Murrelet flight is direct; involves rapid, often continuous wing beats. Average speed is 73-136 km/hr (45-85 mi/hr); maximum speeds of 158 km/hr (98 mi/hr);*[Average speed is 20-38 m/sec (66-125 ft/sec); maximum speed 44 m/sec (144 ft/sec).]* Murrelets generally fly at higher altitudes between nesting and foraging areas and lower at or near nests.

1. Subcanopy flights: includes flights below, through, into, or out of the forest canopy within or adjacent to potential habitat.

a. Adults flying to nests approach from below forest canopy; use corridors/gaps in forest overstory.

b. Nesting birds can use same flight path in a season.

c. Breeding birds can "fly by" nest at nest height.

d. Birds flying subcanopy are often not vocal; wing-beat sounds possible.

e. In general, subcanopy flights seen in areas lacking potential habitat are not an indication of occupancy.

2. Landings: Murrelets have been observed landing in trees:

a. With active nests.

b. With nests active in a previous year.

c. Prior to egg laying.

d. To copulate.

e. Possibly to indicate territorial behavior.

f. To rest or roost.

3. Circling and above-canopy flights: Circling and other above-canopy flights, such as dives, indicate possible occupancy of site; a **red flag** to do additional survey effort to observe subcanopy activity. In evaluating circling, note height of birds relative to forest canopy, circling frequency, and distance to potential habitat.

a. Shallow or steep "jet" dives that start above and end below canopy are observed frequently (67%) near known nests.

b. Circling is common over some nest sites.

c. Circles can be ~10-20 m radius (33-66 ft) to >1 km radius (0.62 mi)

d. Partial circles may be seen or a curving flight path; in most cases, birds were circling but observer visibility was limited.

e. Circling has been seen over young forest or non-forest, but in most cases, detections are near or adjacent to old-growth trees *(suitable habitat)*

B. Vocalizations: (See Appendix E). Interpreting calls relative to site status is difficult.

1. "*Keer"* call is the most audible call at nest sites, in flight, and at sea.

a. Many audible "*keer"* calls are from birds heading to the local area.

2. Vocalizations at nests generally soft and not audible from ground; given by adults at incubation exchange and chicks at feeding. Loud calls from nests are rare.

3. Calling increases with increased social interactions; calls increase in late summer, perhaps related to subadults and nonbreeders visiting stands.

4. Non-vocal sounds:

i. Wingbeat sounds can be detected from murrelets flying nearby.

ii. "Jet" sounds are associated with dives and nest sites.

II. Classification Of Sites

A. The behaviors described above lead to **3 classifications** of sites:

1. Probable absence: a site of potential habitat where murrelets were not detected after the requisite number of surveys**.**

2. Presence site: a site of potential habitat where murrelets were detected, but [occupied] behaviors not observed. Additional survey effort is required to determine whether site is occupied. Presence sites include those with:

a. Non-stationary audio-only detections.

b. Birds flying in small- or large-radius circles above the canopy. ***[WDFW and WA Forest Practices Rules consider circling at or below 2 canopy heights as an Occupied behavior.]***

c. Above-canopy dives (that do not end below canopy) or other above-canopy flight.

3. Occupied site: site may include nest site or is used for other purposes essential to bird's complete life history. An occupied site is one where at least one of the following subcanopy behaviors or conditions occur:

a. Discovery of an active nest, or recent nest site with fecal ring or eggshell fragments (See Appendix A) on structures in the forest canopy, or an old nest cup and landing pad.

b. Discovery of downy chick, egg, or eggshell fragments on forest floor.

c. Birds flying below, through, into, or out of the forest canopy within or adjacent to a site of potential habitat.

i. Includes birds flying over or along roads, young stands, or recently harvested areas adjacent ***[up to 100 m]*** of potential habitat; only the adjacent sites of potential habitat should be classified as occupied. If birds are seen along a road where there is more than one site that they could be using, additional surveys may be required in some cases to determine which site is occupied.

ii. Low flying birds observed in steep canyons or crossing ridge lines in non-habitat areas are not associated with a survey site and considered not exhibiting "occupied" behaviors.

d. Birds perching, landing, or attempting to land on branches.

e. Bird eliciting ≥ 3 calls that are heard at <100 m (<328 ft) from observer and position of bird appears stationary; this is a rare event.

[WDFW and WA Forest Practices Rules consider circling at or below 2 canopy heights as an Occupied behavior.]

III. Applying Site Classification

A. The survey area, by definition, is continuous potential habitat and the highest classification of "probable absence," "presence," or "occupancy" among the sites within the survey area applies to the [entire] survey area.

B. The application of the status to the survey area does not, by default, mean the status is applied to all continuous habitat beyond the survey area, although a regulatory agency may decide it does in some cases.

[Under WA Forest Practices Rules, for management purposes, an "occupied" status applies to all contiguous, suitable habitat within a 1.5 mi (~2.5 km) radius around occupied detection point location(s) regardless of survey area boundary.]

C. Delineate survey boundaries using topographical features and other guidelines.

IV. How Long Do Survey Results Apply?

A. PSG has no data for recommending how long results remain valid after surveys are done. Surveys reflect breeding status of sites for time period when they are conducted.

1. Extent of use, re-use, or abandonment of nest areas, or establishment of new areas, is unknown.

a. There have been observations of murrelets in 70-100 year old regenerated forest from heavy timber harvest in Mendicino,CA and NW OR; unknown if immigration is due to habitat maturing to suitability or if birds moved from adjacent, contiguous site or a longer distance away.

2. Treat occupied stands as occupied indefinitely.

a. The detection of occupied behaviors implies that area is a breeding location for murrelets; murrelets may nest there every year, in alternate years, or once in several years.

b. Evidence shows murrelets having strong breeding site fidelity; repeated use of forest stands suggest that these sites play a role in supporting reproduction.

i. Forest patches, nest trees and nest cups have been reused in subsequent years by the same or different birds.

ii. Murrelets have been observed landing in previously used nest tree in a year when it was not used for nesting.

3. For probable absence sites, if activities will modify suitable habitat ≥ 5 years after surveys, additional surveys may be appropriate to support previous results, especially given survey visit numbers to determine occupancy has increased from protocols used before 2003.

a. Consult with regulatory or evaluating agencies.

DATA COLLECTION

I. Training (See Appendices C-F for more details.)

A. It is strongly recommended that trainees receive intensive training and annual review and evaluation in detecting and identifying murrelets and their vocalizations.

1. Conduct minimum of 4 training mornings.

2. Conduct at site with high activity levels (>25 detections per morning).

3. Provide trainees with tape of full range of vocalizations of known murrelet calls; compare with similar calls of other birds. Familiarize trainees with call groups: "keer," "groan," "whistle."

4. Trainees need hearing and vision tested by professionals.

II. Data Quality

A. It is essential that data be accurate. Experienced murrelet field biologists supervising crews should assess the data quality. Data reviewer should ensure that:

1. Correct and consistent site and station identifiers were used.

2. The survey started ***[and ended]*** on time. Be sure watches are set for correct time. Check whether 15-minute detection rule or 30-minute extension rule observed, if applicable.

3. If >12 minutes of a visit had poor survey conditions, a "make-up" visit is done.

4. Detections are accurately recorded.

a. Occupied detections are accurately defined.

*(**b.** Visits are distributed correctly through the season and stations receive correct number of visits.)*

[5. In WA, ensure that "mitigation" visits are conducted for anticipated noisy/poor view stations and "mitigation" visits are identified on survey forms.]

III. Equipment Needed

A. Equipment for surveying should include:

1. Clipboard

2. Pencil

3. Data forms

4. Wrist watch

5. Headlamp or flashlight

6. Binoculars

7. Compass

8. Permanent marker and colored flagging for marking trails and station locations.

[Consider reflective tape in addition to flagging to mark trails and stations.]

9. Tape recorder

*[**10.** Thermometer for recording temperature at sunrise and at end of survey.]*

IV. Reporting Observations

A. Record visit information on data sheet in Appendix G.

B. Record detailed information on murrelet behavior. Include in notes:

1. Location of bird's flight (over drainage, ridge, etc.).

2. Unusual behaviors or interactions.

a. Details on subcanopy behaviors (e.g., "bird flew between two trees and then *(saw it)* heading up Drift Creek drainage").

3. Immediately report observations of chicks, eggs, or eggshells on the forest floor to responsible wildlife agencies in your area. ***[In WA, contact WDFW]***.