REGULATION AND OBSERVATIONS OF HUMAN DISTURBANCE NEAR NESTING MARBLED MURRELETS

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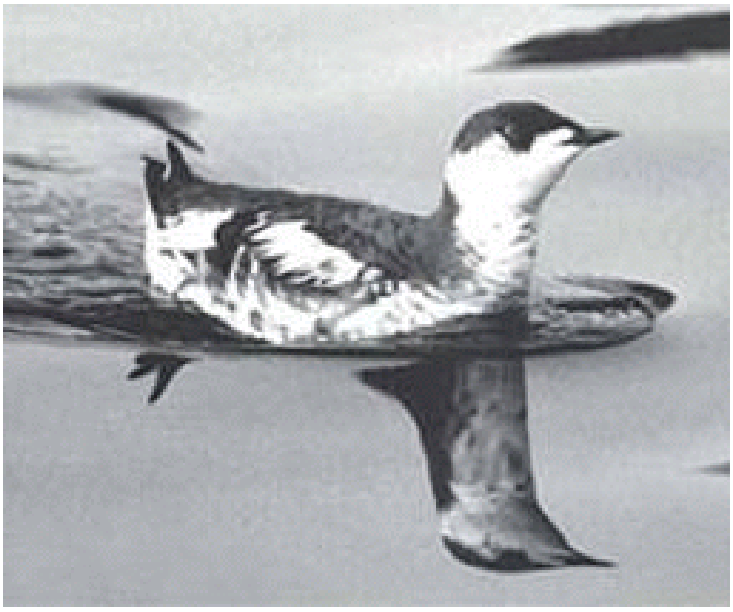

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The Marbled Murrelet is unique among North American alcids in its breeding habits, nesting in trees instead of on the ground (De Santo and Nelson 1995). Current research indicates that murrelets nest almost exclusively in forests with an element of old-growth trees (Ralph et al. 1995b), therefore regulations have focussed on the preservation of habitat in areas like the late-successional reserves delineated in the Northwest Forest Plan (USDA and USDI 1993).

Appropriate habitat is not the only requirement for successful nesting of birds. Disturbance caused by human activity around nests has the potential to change behavior patterns of adults either while on the nest or on the way to the nest (Evans and Nettleship 1985). Studies of other alcids have shown that if a nest area is disturbed by human activity, or by increased boat and airplane traffic, adults may feed the young less frequently, or desert the nest entirely (Evans and Nettleship 1985). Among other species, Trumpeter Swans that were disturbed by vehicle or foot traffic near their nests left the nest more abruptly, and left them unattended for longer than a normal rest period, increasing the potential for predation (Henson and Grant 1991).

More specifically in the case of murrelets, logging and other timber-related activities may continue in areas near the nest that are adjacent to but not within the reserves or parks. There also is potential for disturbance of nesting birds during road, facility, and trail maintenance in state and national parks. The activities of visitors to the parks and forests, from walking or driving along trails and roads under nests, to picnicking in nearby open meadows, have a potential for disturbance to nesting murrelets. Activities of biologists may also increase disturbance to murrelets, either from training for murrelet surveys in high murrelet activity areas, or searching for nests, especially when climbing trees.

Human disturbance of nesting Marbled Murrelets (*Brachyramphus marmoratus*) has undoubtedly been occurring for a great number of years. Only recently has this become a concern with the listing of the murrelet as federally threatened, and the increased potential for impact on the species with the decrease in nesting habitat. We will cover this topic in two sections.

The first section is a review of regulations pertaining to disturbance of nesting Marbled Murrelets, compiled in 1996. We outline the evolution of the regulations, then detail how each agency restricts timber harvest activities, park maintenance, and other activities that occur in or near nesting habitat during the breeding season. We also review some definitions used by different agencies, such as those for breeding habitat and season, and buffer zones. At the end of the section, we outline some of the current literature used by agencies in setting regulations.

In our second section, we relate some of the current research on nesting Marbled Murrelets and other alcids and waterbirds as it pertains to disturbance. There have been many Marbled Murrelet nests observed, either in person or by video tape. Though disturbance effects was not the primary concern of the observations, there have been numerous incidental human disturbances during the course of observations that we detail here. We also include reactions to potential predators, primarily avian predators such as ravens and jays as a contrast to the impacts of human disturbance.

REGULATION OF HUMAN DISTURBANCE NEAR MARBLED MURRELET NESTS

We will first review the status of current federal and state regulations and guidelines intended to decrease disturbance of nesting Marbled Murrelets in Washington, Oregon, and California. These regulations and communications are summarized in *Appendices A-E*. Then, we will outline the details of the various restrictions, along with some cases of potential disturbance. At the end of the section, we detail some of the current literature and sources of information used by agencies for determining regulations.

We found that regulations regarding disturbance of nesting murrelets are still in a state of development. Unfortunately, it is our judgment that they are now based on virtually no data. Rather, they are based on the empirical judgement of the agencies and their biologists. We feel that something that is of such fundamental importance to all concerned should be based on solid, hard evidence, to the full extent possible. When such data are lacking, it should be a high priority to acquire them.

There are very few Federal regulations in place for disturbance, instead, most regulations address habitat conservation. Guidelines to regulate disturbance that were developed by the USFWS with other federal agencies have formed the basis of project plans, and are later negotiated in consultations. These consultations then form the basis of subsequent project plans. Washington and Oregon are

in the process of developing management plans, which include regulation for disturbance along with habitat preservation. California requires surveys to determine occupancy, but otherwise depends on precedents from previous consultations, and has no plans for further regulations.

The regulations and consultations of various agencies agreed on many issues, though there were slight variations. *Breeding season* was 1 April - 15 September, with the exception of the Washington Department of Natural Resources (WDNR) which has a "critical nesting season" of 1 April - 15 August. Within the breeding season, some agencies allowed some activities within a boundary of *daily time restrictions*. Morning starting times varied from 90 min. to 2 hr. after sunrise, while evening end times varied from 1 to 2 hr. before sunset. WDNR also allowed work during the night, since their restrictions applied to avoiding the two peaks of daily activity (Washington State Forest Practices Board [WSFPB] 1995b). USFWS regulations also allowed some activities after 5 August with time restrictions.

Occupied behaviors, when defined, followed those outlined in Ralph et al. 1994: through and in canopy behaviors, presence of eggshell fragments, chick, or nest. Most agreed that the presence of circling above the canopy may determine occupancy, but required further surveys to confirm occupancy. *Occupied sites* were generally considered to be those areas with occupied behaviors, though the Redwood National Park and State Parks complex in northern California designated all old-growth as occupied areas (US National Park Service 1994).

Suitable habitat was not often defined in consultations. However, the regulations of the Washington State Forest Practices Board and Oregon Department of Forestry (ODF) have very detailed definitions, including distance to marine water, 8 trees/acre, tree d.b.h. (which varied), and the presence of platforms (WSFPB 1995b; ODF, in prep.). Oregon includes a patch size minimum of 5 acres, while Washington state had no size requirements.

The *buffer zone* around occupied sites was usually 0.25 mi. All three state agencies added a 300-ft vegetation management zone, which was contained within the 0.25 mi. zone. There was also a 1-mile zone for louder noises such as blasting (USFS et al. 1994).

Activities in occupied sites that would degrade or remove habitat were restricted (USFS et al. 1994; WSFPB 1995b; ODF, in prep.; USFWS and California Department of Fish and Game [CDFG] 1995). No timber harvesting, road construction, or operation of heavy machinery was allowed by most agencies in these areas in the breeding season. Activities which were mainly noise disturbance, such as park and road maintenance, were subject to consultation, and were sometimes allowed with some restrictions such as starting later in the breeding season (after 6 August) or within daily time restrictions. After the breeding season, down timber could be removed if machinery remained on existing roads (WSFPB 1995b, CDFG 1995) and some partial cutting on a site-specific basis was allowed (ODF, in prep.).

Regulations and consultations for activities in buffer zones during the breeding season were usually less restrictive than for occupied sites. Most agencies considered allowed some activities within daily time restrictions and later in the season (USFS et al. 1994; WSFPB 1995b; ODF, in prep.). The main difference in the regulations between agencies was in the types of activities they restricted. Some listed these activities (WSFPB 1995b; ODF, in prep.) while others defined restrictions on noise levels ("above ambient noise levels") duration, and placement near other noise sources, and called for further consultation (USFS et al. 1994; USFS 1993; FWS 1995). California (CDFG 1995) did not allow any timber harvest or salvage activities within the buffer zone during the breeding season (USFWS and CDFG 1995, CDFG 1995).

There is definitely a need for a better understanding of the effects of disturbance to nesting Marbled Murrelets, so that agencies and other land managers can more effectively adjust timber and visitor activities, while minimizing the impacts to murrelet populations. Some researchers have found nests and made records of the activities of the adult and chicks. These have shed some light on the potential impact of humans in the vicinity of the nest. However, relatively few nests have been found to date, and so we presently have a very small sample of potential effects. Insight may also be gained from studies on similar species of alcids. We address these points in the second section 'Observations of human disturbance.'

The Origin and Status of Current Regulations

In 1992, the Marbled Murrelet was listed as a federally threatened species in Washington, Oregon, and California (U.S. Fish and Wildlife Service [USFWS] 1992). The Endangered Species Act of 1973 (ESA) then required that action be taken to help the species recover. One of these requirements is the prohibition of “take” of a threatened species. “Take” is defined in Section 3 of the ESA as “harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect”. Disturbance of nesting murrelets would fall under these take regulations as potential

harassment.

Regulations controlling human activities near potential nesting areas of Marbled Murrelets are in a state of development by regulatory agencies. There are very few regulations that specifically target disturbance of nesting murrelets. We have learned that the first regulations used by many state and federal agencies were drawn from guidelines developed in conjunction with Northern Spotted Owl habitat management. These regulations have been applied in the method outlined in the Record of Decision (ROD) (USDA and USDI 1994b). The ROD primarily addresses harvest of murrelet habitat. For instance, for Late-Successional Reserves, "if behavior indicating occupation is documented..., all contiguous existing and recruitment habitat for marbled murrelets... within a 0.5-mile radius will be protected" (p. C-10, USDA and USDI 1994b). The document does not actually specifically address the issue of disturbance to nesting murrelets from the noise and activity that accompanies timber harvest or other activities.

The draft Marbled Murrelet recovery plan, published in July of 1995 (USFWS 1995a), is the first attempt to outline regulation of activities in the forest, as it specifically relates to the murrelet. The Recovery Team used the Northwest Forest Plan (USDA and USDI 1993) as a preliminary guide in delineating regulations, such as inclusion of the 0.25 mile buffer zone around harvest activities, then it integrated the most current research on the murrelet. The plan has been used by several agencies in regulating disturbance of nesting murrelets. It is expected that it will be finalized soon.

Federal agencies

The USFWS oversees the implementation of all regulations pertaining to the ESA on all federal, state, and private lands. In order to aid with project planning and design, the USFWS in Portland, Oregon, in conjunction with the U.S. Bureau of Land Management (BLM) and U.S. Forest Service (USFS), developed a dichotomous key to assess the potential impacts of various activities on murrelets (USFS et al. 1994) (*Appendix A*). The key was introduced in an interagency memo dated February 3, 1994, and contains the basis of most of the current federal regulations, including buffer zones, and seasonal and daily time restrictions. The key was designed for biologists to help shape their analyses of a project, and to determine when a formal or informal consultation with USFWS would be needed to determine further regulation of activities. It has been used by federal agencies, including the Siuslaw National Forest for its watershed restoration plans, and Redwood National and State Parks for various maintenance projects (includes Jedediah Smith, Del Norte, and Prairie Creek Redwoods State Parks). It separates the effects of activities into three levels: (1) no effect; (2) may effect, but not likely to adversely affect; and (3) likely to adversely affect. Any activity which falls into the latter two categories requires further consultation with USFWS before it can proceed. The key evaluates actions ranging from degradation of suitable habitat to increased noise levels during the breeding season.

There are three major National Park units with nesting Marbled Murrelets. They are Redwood, Mt. Rainier, and Olympic National Parks. All of them have relied primarily on consultations with the USFWS for guidance (Sakai, pers. comm.; Lechleitner, pers. comm.; Seaman, pers. comm.) (*Appendix B*). Redwood National Park is the only one of the three currently with plans to develop management guidelines for future activities, according to Sakai (pers. comm.).

Within the Forest Service, letters and memoranda from Regional Offices also outline the most current regulations, such as the timing of activities during the breeding season (USFS 1993) (*Appendix B*). Specific examples are detailed under 'Specific regulations and guidance from consultations' below.

State Agencies

Washington.--When the murrelet was listed as a federally threatened species, the state automatically listed it as threatened in the state (Turley, pers. comm.). In 1992, the Washington State Forest Practices Board (WSFPB) of the State Department of Natural Resources developed interim regulations for timber-harvesting and disturbance of murrelets. The Department of Natural Resources enforces the regulations on state and private lands. The interim regulations are reauthorized for 90 days at a time until final rules are approved (WSFPB 1995b) (*Appendix C*). WSFPB has written the "Draft Environmental Impact Statement on Forest Practice Rule Proposals" for the Marbled Murrelet, (WSFPB 1995a) and expects to have a final draft by 1997. In it, there are several alternatives for the final rules, including the potential impact of each alternative.

Oregon.--A management plan for state lands by the Oregon Department of Forestry (ODF), in conjunction with the Oregon Department of Fish and Wildlife (ODFW) and the USFWS, is currently in the draft stages (Smith, pers. comm.; ODF, in prep.) (*Appendix D*). This document is an interim strategy until a Forest Management Plan and a Habitat Conservation Plan are approved by the USFWS. It defines occupied behaviors, suitable habitat, and

disturbance activities, and outlines measures to protect suitable habitat around identified murrelet sites. To date, ODF has relied on guidance from USFWS on individual timber sales to avoid take of murrelets.

Oregon State Parks rely on the ODFW, which follows the same guidelines as ODF (Nugent, pers. comm.). State Parks have not been well surveyed (Nugent, pers. comm.), and the status of occupancy by murrelets is unknown for most parks. In general, the parks have continued operations with few changes in management.

Private timber lands fall under the jurisdiction of the Forest Practices Division of ODF (Krahmer, pers. comm.). The landowner writes a plan for compliance with the Endangered Species Act, then consults with USFWS and ODFW.

California.--California Department of Fish and Game's (CDFG) only formal regulation, which is contained in the timber harvest regulations, requires that surveys be conducted prior to consultation for a timber harvest plan to determine occupancy on either state or private forest lands (Burkett, pers. comm.). Otherwise, state agencies, such as California Department of Forestry, have followed the guidelines from USFWS and in the ROD (USFS et al. 1994; USDA and USDI 1994b), or consulted with USFWS or Marbled Murrelet researchers on specific projects (Burkett, pers. comm.; Moore, pers. comm.).

Similar to the federal agencies, some state agencies in California also rely on internal memos from previous consultations for guidance on later projects (e.g. USFWS and CDFG 1995) (Burkett, pers. comm.; Moore, pers. comm.) (*Appendix E*). There are also internal memos between California agencies. For example, seasonal restrictions were outlined in a memo on November 22, 1993 (CDFG 1993), increasing by 30 days the recognized length of the breeding season from its previous period of 15 April to 31 August, to between 1 April and 15 September.

Jedediah Smith, Del Norte, and Prairie Creek Redwoods State Parks all have an agreement with Redwood National Park to jointly consult with USFWS for projects on a yearly basis, as "Redwood National and State Parks" (Gizinski, pers. comm.). Otherwise, regulations for most state parks, where no timber harvest generally occurs, tend to be on a case-by-case basis with the regulating agencies, primarily California Department of Fish and Game (Moore, pers. comm.; Gizinski, pers. comm.).

SPECIFIC REGULATIONS AND GUIDANCE FROM CONSULTATIONS

Federal Regulations and Guidelines

No single document has defined the overall guidelines from USFWS for regulation of disturbance, however the main elements are summarized in the decision tree or "key" which was developed for watershed restoration projects in conjunction with other agencies (see also 'Origin and Status of Current Regulations, Federal agencies' above)(USFS et al. 1994) (*Appendix A*). However, much of the terminology is not defined, so other USFWS documents need to be referenced (e.g., USFWS 1994a, USFWS and CDFG 1995, USFWS 1995b). The USFWS focuses on the breeding season, and restrictions differ between the occupied or suitable habitat, and the area within 0.25 miles of the suitable habitat (buffer zone) (USFS et al. 1994). The size of this buffer zone was derived from the Record of Decision (USDA and USDI 1994). According to USFWS 1994a, the breeding season is designated as 1 April to 15 September, with the "core" breeding season occurring from 1 April to 5 August. "Suitable habitat" is not specifically defined, but USFWS and CDFG 1995 indicates that field inspections may be used to determine if an area is suitable habitat, and that area may include some partially-harvested stands. The USFWS appears to consider any suitable habitat to be occupied unless determined to be unoccupied by two years of surveys to the standard protocol (as developed by Ralph et al. [1994]) (USFS et al. 1994). During the core breeding season, any activity with motorized equipment that generates noise above ambient levels, such as logging and yarding, is not allowed in buffer zones unless cleared by consultation with the USFWS. During the breeding season, but after 5 August, activities may occur within daily time restriction of two hours after sunrise until two hours before sunset, but only if USFWS concurs after consultation. Such daily time restrictions are designed to "minimize the potential that adult murrelets will be disturbed when visiting the nest to feed offspring" (p. 8, USFWS 1995b).

Timber harvesting and watershed restoration.--While the USFWS ensures that ESA regulations are adhered to for many types of projects, the USFS has set down some guidelines for timber harvest activities. Ronald Stewart (former Region 5 Regional Forester) in a letter to northern California Forest Supervisors outlined guidelines developed between the Region and the USFWS to protect murrelets from noise disturbance (USFS 1993) (*Appendix B*). Most of these guidelines are the same as those outlined in the key

(USFS et al. 1994), including the need for 2 years of murrelet surveys to ascertain presence of murrelets in an area, and a 0.25-mile buffer zone around suitable habitat. Stewart states that "all timber sales projects that have a 'may affect' determination be submitted to the Regional Forester with a request for formal consultation" (p. 1, USFS 1993) with the USFWS. However, in addition, Stewart outlines two specific activities with a "may effect, not likely to adversely effect" determination under USFWS regulations. The first is limited use of single chain saws, if operations occur within USFWS daily time restrictions, even during the core breeding season. The second was projects with larger machinery with short periods of operation with USFWS daily time restrictions, but only after the core breeding season. Also, if these projects occur along roads with high amounts of background noise, then the potential effect determination decreases to "no effect."

Additional restrictions may be placed on a timber harvest after consultations. For example, in California, guidance on timber harvest from a 1995 consultation between USFWS and CDFG (USFWS and CDFG 1995) details somewhat more stringent requirements than outlined in the USFWS determination key (*Appendix E*). They allow no noise above ambient levels within a disturbance zone of 0.25 mile from the habitat during the entire breeding season (1 April to 15 September), rather than just during the core breeding season. Additionally, harvesters are required to leave a 300-foot vegetation buffer zone, with no removal of standing timber, in order to reduce noise into the stand as well as to protect the stand's microclimate. Use of helicopters is also restricted, and they may not fly within 500 feet above the canopy of stands, or the buffer zone of the stand during the breeding season.

There are many other activities associated with timber production on forest lands, other than the harvest of trees. In a biological opinion from the USFWS to the Siuslaw National Forest on watershed restoration projects, Russell Peterson (USFWS 1995b) states that in order for certain species of conifers to grow, competing hardwood trees and bushes sometimes need to be removed, usually alders, maples, and currents. This is called "seedling release", and requires the use of chain saws. Such activities in areas near potential murrelet habitat were, in the past, restricted to after the breeding season. However, Peterson states that control of these species is more effective in the middle of the growing season of June and July due to the physiology of these plants. Therefore, this project was allowed to occur with the addition of daily time restrictions of two hours after sunrise until two hours before sunset to minimize incidental take, as a result of disturbance (USFWS 1995b) (*Appendix B*).

Federal lands have additional projects for watershed restoration, wildlife habitat enhancement, and maintenance, some of which have the potential for adversely impacting murrelets and include: meadow revegetation and maintenance requiring gas-powered mowers, road work with heavy machinery, and placement of new fish structures using small generators and drills. As Russell Peterson stated in the above biological opinion, for a variety of reasons, these activities also need to be done during the murrelet breeding season (USFWS 1995b). Mowing for meadow revegetation needs to be done while the ground and vegetation are dry enough for the mower to operate. Similar to alders, vegetation should be cut when growth is at its peak between June and August. He also states that, to avoid impacts to fish, road work near streams should be done in dry weather during the summer months. For the fish structures, state and federal regulations limit in-stream operations to 15 June to 15 September. After this consultation between the Siuslaw National Forest and the USFWS, the outlined activities were allowed during the breeding season with the restriction of limiting operations the period from two hours after sunrise to two hours before sunset. This measure was "designed to minimize incidental take that might otherwise result from the proposed action" (p. 13, USFWS 1995b). The incidental take was offset by the possibility that the development of late-successional forest conditions might be accelerated, and that the project as proposed was "not likely to jeopardize the continued existence of ... the Marbled Murrelet" (p. 11, USFS 1995b).

Park operations and maintenance.--The Redwood National and State Parks in northern California have many projects for maintenance of public use facilities, trails, and habitat restoration. They formerly had the most restrictive dates (15 March to 15 September) for reduction of noise disturbance to Marbled Murrelets because they are in critical habitat for the bird in California (U.S. National Park Service (USNPS) 1994a), but this was reduced to 1 April to 15 September, in accordance with USFWS regulations (USFWS 1994b) (*Appendix B*). Park staff and USFWS are assuming that all old-growth within the parks is occupied (USNPS 1994a), and "projects implemented within 0.25 mile of Marbled Murrelet nesting habitat located within the Redwood Park complex that will create a significant disturbance during the Marbled Murrelet breeding season (April 1-September 15) are likely to adversely affect Marbled Murrelets" (p. 3, USFWS 1994b). Therefore, noise disturbance above ambient levels is not allowed within 0.25 miles of old-growth during the

breeding season. After this 1994 consultation, the Park made adjustments in their projects to reduce noise levels on projects, such as conducting trail clearing in the National Park with only hand tools in the 0.25-mile zone according to a letter (USNPS 1994c). Additional changes outlined in this letter included moving trail construction and some tree-cutting projects to the period after 15 September.

Road-rehabilitation projects, which remove and recontour old roads, have the potential to create noise disturbance in the short-term, but have the potential for long-term benefits with the reduction of human disturbance (USFWS 1995c). Most of these projects were near marginal habitat or near areas of high ambient noise, so they were allowed to start after 1 August. One exception is the Ah Pah Road rehabilitation project, which is in, or immediately adjacent to, occupied murrelet habitat (USNPS 1995b). The Park requested a start date of 1 September for this project to allow it to be completed within one season, rather than leaving unstable (partially treated) slopes over the winter. The USFWS allowed the project to start at the requested date if the project began at the end closest to Highway 101, where there is high ambient noise (USFWS 1995c). Other exceptions to the 15 September starting date were made for projects occurring near areas with high ambient noise. These included a restoration project near the town of Orick, elk fence maintenance near the park's operations center, a mowing project near Highway 101, and road-side thinning near Bald Hills Road, another major road often used by logging trucks (USFWS 1994c, 1995c).

Maintenance of some habitats require periodic prescribed burns. A burn of oak woodland and prairie near old-growth was scheduled for the National Park during July (USFWS 1994b). Similar to the seedling release project on the national forests (above), the effect of the burn would be greatest in the summer. It was decided by the USFWS that with good smoke control (favorable winds to vent smoke away from the stand), the burn could proceed during the scheduled time.

Other park uses.--Though most of the disturbance issues in the parks involve noise due to maintenance, disturbance by human activity has also been addressed. A one-time request was made by the National Geographic Society to climb old-growth trees in the Park (USNPS 1995a) (*Appendix B*). The climb was allowed before 1 April, the start of the breeding season. Also, there has been some speculation that the large number of people involved in murrelet survey training may have some impact on murrelet behavior (Sakai, pers. comm.). Though there are no regulations in place for this activity, the park requires commercial use license for trainers since they are using park lands for commercial uses (USNPS 1994b). Federal regulations (Section 5.3 of Title 36, U.S. Code) prohibit the engaging in or solicitation of any business in National Park areas, except in accordance with the provisions of a permit with the United States, and the commercial permit constitutes this agreement. The operating requirements of the license specifies that, under the oversight of the Northern California Coordinator for the Redwood National Park (the holder of the license), no more than one contractor will be allowed per day per park location (attachment to USNPS 1994b). This will be aided by submitting a training schedule to the Superintendent of the Park two weeks prior to commencing training. Trainees are notified of potential murrelet harassment, such as making no loud noises, walking (rather than driving) to survey locations, and limiting both group size and excessive movement at the survey site. The trainees are then monitored during the courses for compliance. At the end of training, a report is submitted detailing the number of people involved in the training, including group sizes, length of training, and training locations used.

State Regulations and Guidelines

Washington.--Current policy by the Department of Natural Resources (WDNR) is for no harvest of suitable habitat (very old growth sites with 8 stems of dominant trees/acre) up to 40 miles inland (Cummins, pers. comm.). Additionally, the Washington State Forest Practices Board has adopted Emergency Rules to regulate activities on state and private lands according to time of year and location relative to occupied sites (WSFPB 1995b) (*Appendix C*). In occupied areas, no timber harvesting can take place at any time of the year. An occupied area is defined as a contiguous area of suitable murrelet habitat with observations of occupied behaviors. Contiguous habitat is defined as "habitat distinguishable from the adjacent forest based on vegetative characteristics important to nesting Marbled Murrelets" (p. 3, WSFPB 1995b), with a gap of 300 feet from other sites forming the outer perimeter. During the "critical nesting season" of 1 April-15 August, other activities are curtailed in occupied areas which are allowed in the non-breeding season, including use of heavy equipment, road construction, removal of downed trees, and use of aircraft below 1300 feet. These activities are also curtailed within 0.25 miles of occupied sites (referred to as an "unmanaged buffer zone" to distinguish it from the managed buffer zone discussed later), but only during the "daily peak activity period" of one hour before, to two hours after, sunrise, and one hour before, to two hours after, sunset during the critical nesting season. Additional

restricted activities within these time periods include any timber hauling and harvesting. Blasting and slash burning are restricted at all times during the critical breeding season in the unmanaged buffer zone. Regulations also require a managed buffer zone within an average of 300 feet (900 m) of the occupied stand, with 75 trees of specified sizes to maintain the microclimate of the stand (Cummins et al. 1993).

State parks and other state-owned lands in Washington follow the same regulations as the timber industry (Cummins, pers. comm.; WSFPB 1995b) (*Appendix C*). Any project with the potential for disturbing murrelets must be consistent with the interim forest practices rules.

Oregon.--The Marbled Murrelet Management Plan for State Forest Lands in Oregon is directed toward protecting known occupied sites (ODF, in prep.) (*Appendix D*). The draft regulations propose that occupied stands should be protected from detrimental habitat modifications during all seasons, and from all disturbance activity during the breeding season. The breeding season follows USFWS guidelines of 1 April to 15 September, but with the stipulation that it might be revised based on local knowledge. Disturbance is defined in the plan as "actions that are likely to disrupt reproductive activities" that are "carried out within 0.25 miles of an identified Marbled Murrelet occupied stand during the breeding season" (p. 2, ODF, in prep.). Examples of such activities, as well as examples of non-disturbance, are listed in the document (see *Appendix D*), and generally include most activities which generate loud noises over more than one day. During part of the breeding season, until 5 August, no disturbance is allowed. From 6 August-15 September, operations with the potential of disturbance are allowed based upon a "biological evaluation of the breeding activity in the area" (p. 7, ODF, in prep.), and may be limited by daily timing restrictions, which follow USFWS guidelines (Smith, pers. comm.).

California.--CDFG has consulted with USFWS to detail many of the guidelines now in use (see "Federal timber harvest and watershed restoration" above) (USFWS and CDFG 1995) (*Appendix E*). For example, this consultation between CDFG and USFWS required that no timber operations be allowed, in either the occupied stand, or the surrounding 300-foot buffer zone, during the seasonal restriction of 1 April to 15 September. Other regulations are detailed in biological opinions by CDFG on specific timber harvests, which may then used by the agency in making determinations for subsequent harvests. For example, in a recent biological opinion on a timber harvest plan, CDFG outlined a plan for preventing jeopardy to the continued existence of murrelets in that area, and outlines specifics of retention of suitable nesting habitat (CDFG, draft ms). Also, no timber harvest was to take place in the harvest plan's boundary during the nesting season (15 April-30 August), unless deemed appropriate and agreed to by the CDFG. The opinion does not directly regulate the disturbance of nesting birds. Though not directly related to disturbance, the landowner was instructed to deliver educational materials and instruction to the logging crew and provide adequate means to reduce refuse (food remains, food wrappers, and other garbage) which may attract potential murrelet nest predators.

CDFG also has made an effort to protect murrelet "travel corridors" in a biological assessment for a timber harvest (CDFG 1995) (*Appendix E*). Areas in two harvest units, which were adjacent to a "watercourse that appears to be functioning as a travel corridor for murrelets using the adjacent old growth stands" (p. 3, CDFG 1995), were determined to be travel corridors for murrelets. No further information was given on how this travel corridor was defined. CDFG released these areas to be harvested during the breeding season, with the stipulation that operations in areas adjacent to the travel corridors shall take place only during the period from 90 minutes after sunrise to 90 minutes before sunset.

Informal consultations and meetings have aided regulators to determine adequate regulations. For example, Valerie Gizinski and Doug Correia of the North Coast Redwoods District of the State Parks (encompassing parks from Mendocino to Del Norte counties) met at Prairie Creek State Park with Herb Pierce of CDFG and Ken Hoffman of Six Rivers National Forest to assess the potential for disturbance from power tools near the shop area (Correia, pers. comm.). While one person ran various tools near the shop, the others listened for increased noise along each of the nearby trails. They found that, due to the high ambient noise level, power tools did not appear to add significantly to the surrounding noise levels, and they determined that the tools could be used in that area during the breeding season. However, in other areas with lower ambient levels, such as remote trails, the use of power tools would be limited during what they defined as the breeding season of 15 March to 15 September (Correia, pers. comm.). No report was written on this informal consultation.

References Used for Current Decision-making

Until recently, relatively few references existed on the biology of the Marbled Murrelet. Consequently, most agencies have relied for guidance on regulations outlined in several federal documents on the Northern Spotted Owl (USDA and USDI 1993, USDA and USDI 1994a, USDA and USDI 1994b). Consultation with murrelet biologists also have aided in determination of new regulations (USFWS 1995b; Moore, pers. comm.). Literature on human disturbance of nesting waterfowl (Henson and Grant 1991), seabirds (Anderson and Keith 1980, Burger 1981, Pierce and Simons 1986, Rogers and Smith 1995), gulls (Robert and Ralph 1975), and other bird species (e.g., Knight and Skagen 1988) have been used by the USFWS in several consultations for guidance to the potential effect of human activities and noise on both adults and young (USFWS 1994b, USFWS 1995b).

Two of the earliest nests found were in Big Basin State Park (Singer et al. 1991). Both nests were near foot trails and service facilities, so indirect human disturbance was possible. Singer reported that the "incubating birds only rarely showed behavior suggesting agitation from human presence or noise" (p. 337, Singer et. al 1991). However, both nests were predated by corvids which have been seen to be attracted to leftover food items, leading Singer to suggest that such human activities which attract corvids should be regulated near nest areas.

There have been two symposia on murrelets, both hosted by the Pacific Seabird Group. The first symposium was held in December 1989 and the proceedings entitled 'Status and Conservation of the Marbled Murrelet in North America' (Carter and Morrison 1992). At that time, few nests had been identified, and none had been observed, so the potential threat of human disturbance during nesting was not known. The second symposium was held in February of 1993 and the proceedings entitled 'Biology of the Marbled Murrelet: Inland and at Sea' (Nelson and Sealy 1995). During the time between the two symposia, a considerable amount of effort had been expended in searching for active nests by some researchers (Nelson and Peck 1995). Six of the papers in the second symposium focussed on some aspect of murrelet nests, two of which covered behavior of adults and chicks at the nest with some detail (Nelson and Peck 1995, Singer et al. 1995). Most of the observations chronicled in both papers occurred during the peak activity times around sunrise and sunset, when most of the incubation exchanges and feeding visits took place. Only Singer and his associates reported on murrelet reactions to potential human disturbance, probably due to the location of the nests in a State Park near public use facilities, compared to the more isolated sites in Naslund and Peck's study. During observations of incubating adults, they saw no visible reaction to the presence of humans, including loud talking, yelling, or vehicle noises. By contrast, the calls of the Common Raven would elicit an immediate reaction.

New information on the murrelet is continuing to be published. Two publications have been used by agencies in recent consultations for the information they contain on murrelet biology. In the spring of 1995, the Ecology and Conservation of the Marbled Murrelet was published (Ralph et al. 1995a). It contains some of the most recently compiled information on the biology and habitat use of the bird. Among the chapters most relevant to disturbance issues are those on nesting biology, which describe predator avoidance behaviors of adults and chicks (Nelson and Hamer 1995b). In response to "predators and other disturbances (e.g. airplanes) at nests, adults and chicks often flatten themselves against the tree branch, holding their back and heads low and remaining motionless" (p. 65, Nelson and Hamer 1995b). Another chapter on nest success sheds some light on the impact of humans near nests and potential for attracting predators to the nest area (Nelson and Hamer 1995a). Direct disturbance did not rank high as a cause for nest failure. Of 23 nests that reportedly failed, only two may have been due to human disturbance. Observers at a near-ground-level nest in Southeast Alaska disturbed or flushed the adult five times. The egg or newly-hatched chick then disappeared. In central California, a nest failed from "direct human intervention" (p. 94, Nelson and Hamer 1995a). In contrast, three successful nests were subjected to intensive disturbance by climbing the nest trees, including two that were frequently climbed to gather nestling growth data. The primary cause for nest failure was predation (43%). Nelson and Hamer concluded that human presence at the nest areas was not likely a factor for other nest failures since, at monitored nests, predators were apparently attracted to the observer's location, but not to the nest itself, and precautions were taken to remain at a distance from the nest, along with taking measures to minimize predator attraction and disturbance to the birds. In the overview, the authors suggest that human disturbance might be timed to avoid disruption of reproductive activity (Ralph et al. 1995b). They also state that the effects of disturbance should be evaluated in controlled experiments.

In 1995, the Draft Recovery Plan for the Marbled Murrelet was published (USFWS 1995a). Under the section on Federal Regulation and Habitat Management, it outlines potential threats to murrelets. Most of the disturbance issues addressed are in the protected habitats

of the National Parks and Marine Sanctuaries. It notes that, in the Parks, noise disturbance related to maintenance of visitor facilities, visitor safety, and restoration of natural habitats may adversely affect the birds. Later, in section 2.1.4.1, potential methods for disturbance reduction are addressed. Adjusting the timing of disturbances around nests is suggested to reduce the risk of flushing the adult from the nest and to reduce the potential increase in numbers of avian predators.

Washington state has produced a document used for developing rules. They gathered four wildlife biologists from the public and private sector into a Science Advisory Group to make recommendations on murrelet management for state legislation. They produced a report, 'Marbled Murrelet Protection on Nonfederal Forest Lands in Washington' (Cummins et al. 1993) that has been used in the development of Washington's pending forest practice rules (WSFPB 1995a). It details several options for delineating suitable habitat, including stand characteristics, geographic location, and size. It also outlines recommendations for protecting the stands and reduction of disturbance to nesting murrelets, which we further outlined in the section 'Specific Regulations and Guidance'.

Future Plans

The USFWS Marbled Murrelet Recovery Team is now finalizing the Recovery Plan Draft. The revised plan is due out in 1997. WSFPB is currently receiving comments on the proposed options for forest practice rules in Washington, and will have the final environmental impact statement on the rules in Spring 1997 (Cummins, pers. comm.). The ODFW and ODF currently have an interim Management Plan (ODF 1995) and will be continuing to develop a final plan for the murrelet on Oregon state lands, in accordance with the regulations under the state's endangered species regulations (Nugent, pers. comm.). The guidelines are expected to address both habitat requirements and "take" regulations. In northern California, the Redwood National and State Parks are developing a management plan for the parks, with consultations with the USFWS and local murrelet biologists (USNPS and California State Parks 1994; Sakai, pers. comm.).

Studies on potential human disturbance are being considered. The CDFG and USFWS plan to record decibel levels where logs are being felled along a major highway through the redwoods to determine how distance through the forest affects the noise levels (Moore, pers. comm.). Burkett (CDFG, pers. comm.) is interested in studying decibel levels of outdoor park lectures in the Big Basin State Park in California, and the potential effect on murrelets nesting in nearby old-growth.

Most directly, Paul Henson (USFWS) has proposed a controlled research project on disturbance, including observation of murrelet nests and subjecting them to experimental disturbances (Henson 1996). Tom Hamer and Kim Nelson (pers. comm.) ran preliminary experiments in 1997.

OBSERVATIONS OF HUMAN DISTURBANCE

Disturbance of Nesting Seabirds and Water Birds

The effects of human disturbance to any nesting bird, including Marbled Murrelets and other seabirds, are not easily measured. Systematic studies need to be conducted, comparing similar nesting areas with and without disturbance, in order to isolate the effect of the disturbance.

No systematic studies on human disturbance to nesting Marbled Murrelets have been done, primarily due to the scarcity of nests that have been found and the logistical problems in observing nests that are high in trees. Research on nesting disturbance to other seabirds can be useful to gain insight on the possible effects of human disturbance on Marbled Murrelets. Kittlitz's Murrelets (*Brachyramphus brevirostris*) are closely related and are solitary nesters, so they may react similarly to the presence of humans, even though they do not nest in similar habitats. Black and Pigeon Guillemots (*Cepphus grylle* and *C. columba*) nest in isolated pairs and loose aggregations, as well as in colonies, so may also be useful for study. However, because of the isolated nature of these three species, they are also difficult to study, and research has concentrated on more easily studied seabirds that nest in large colonies, such as Common Murres (*Uria aalge*), puffins (*Fratercula* sp.), cormorants (*Phalocrocorax* sp.), and gulls.

One of the potential problems in comparing studies on colonial seabirds with solitary nesters is that colonial seabirds may react differently to disturbance compared to solitary nesting birds, because of the close proximity of neighbors which can influence an adult's reaction. For

instance, if one bird flushes in response to a stimulus, each of its neighbors may flush whether or not it saw or heard the disturbance. This leads to a "panic flight" in the colony, in which a large group from a colony flushes in reaction to a single disturbance. This is different from the panic flight of an individual bird which leaves its nest quickly in response to a disturbance, and is less likely to occur where birds nest apart from each other.

Systematic studies have also been done on other water birds, such as loons and swans. These species may react similarly to Marbled Murrelets when disturbed, because they are also solitary nesters.

Investigator disturbance

Much of nesting disturbance research has focused on the investigator's effect on productivity studies, which may be the most intrusive of human disturbance. An investigator might check a nest several times in the course of the nesting season to determine the development of eggs or chicks. Even if the eggs or chicks are not handled, the person will be in close proximity to the nest quite frequently. There is a concern that the presence of people in study plots may influence the behavior of both adult and chicks, resulting in data that may not reflect the true productivity of a population (Duffy 1979). There is also concern that this may cause a reduction in overall productivity, either from behavioral changes, such as nest abandonment, or increased predation at the nests (Tremblay and Ellison 1979). The systematic disturbance studies we review below, which compare nesting sites with measured disturbance to control sites (usually with very minimal disturbance), suggest that such disturbance decreases productivity.

Cairns (1980) found a decrease in the nesting success of Black Guillemots with an increase in investigator disturbance, in a small island colony with nests 15-30 m apart. He compared areas with light disturbance (1 visit/4 days) to heavily disturbed areas (1 visit/1 day), where investigators passed within 15 m of a nest. In the disturbed area, the number of eggs hatched, chicks fledged per nest, and eggs hatched per eggs laid were all significantly lower than in the less disturbed area. This may have been caused by human disturbance, leading to a decrease in incubation attentiveness, damage to eggs during panic departures from the nest, or nest abandonment. Despite the decrease in hatching success, the maximum weight of fledglings in the more disturbed area was higher than in the less disturbed area. This may have reflected greater attentiveness or more experience on the part of the parents that remained with chicks in the disturbed area compared to the average nesting pair in the less disturbed area. It was also noted that the presence of people was usually signaled by gull alarm calls, and guillemots in more exposed nesting sites tended to flush in response to those calls which may have contributed to the lower success rate at those nests.

Pierce and Simons (1986) also found a decrease in reproductive rate with increased disturbance for nesting Tufted Puffins (*Fratercula cirrhata*). Investigators walked through the heavily disturbed area every 5 days beginning with the onset of nesting to look for active burrows, which were then checked every few days starting 45 days after egg-laying. This area had the lowest fledging success; only 18% of the chicks fledged/eggs laid compared to 94% in the undisturbed area. Some of this was attributed to nest desertion. This disturbed area also had the lowest average age of chicks on 17 August, and so had lower weights and shorter wings than in undisturbed areas. In comparison, in a less disturbed area which was not visited until after the eggs were hatched, age, weight and wing length were similar to the undisturbed nests. Therefore, the differences in the most disturbed area were likely because of disturbance during egg-laying and incubation which resulted in delayed hatching dates. Clearly, the timing of the disturbance is important, and disturbance during incubation may be more likely to lead to low reproductive rates.

In a study of Least Auklets (*Aethia pusilla*) with three disturbance regimes, Piatt and his colleagues (1990) found similar results during the incubation stage. They found that intensive disturbance in a colony (inspecting burrows every day) led to a significantly lower hatching rate (66%) compared to relatively undisturbed sites (entered only to check burrows 4 times) (80%). Most of these egg losses were because of non-hatching and abandonment. Even moderate disturbance (daily visits to the area, but burrows not inspected) resulted in hatching rates somewhat lower than that of undisturbed areas (70%), though most of these losses were due to unknown causes. Similar differences were found during the chick stage, where fledging rates declined significantly with increasing disturbance (81%, 70%, and 54%, least to most disturbed). Most of these losses were because of disappearance of chicks for both disturbed areas, but higher numbers of death and vole predation occurred in the intensive plots. Combining these losses, overall breeding success followed the same pattern (66%, 50%, and 36%, least to most disturbed).

These three studies show a pattern of reproductive decline in alcids with increasing disturbance during nesting, especially during the incubation stage. All three species nest in burrows, which may not accurately reflect the impact of humans on a species that nests above ground. In a study of Western Gulls (*Larus occidentalis*) nesting in a

large colony on the Farallon Islands, Robert and Ralph (1975) found that gulls may become habituated to human presence. Increased disturbance of chicks decreased the death of chicks, partially because chicks became less likely to run greater distances from their territories (and be killed by neighboring adults) as they became used to people in the area. Rather, they walked in front of the investigator, and eventually angled back to their own territories. By contrast, during incubation, increased disturbance increased daily egg loss and reduced hatching success. Especially early in incubation, adults were most likely to fly off and leave the nest unattended when disturbed, which left the eggs exposed to predation by other gulls. Also, flushing from nests caused egg damage and failure to hatch. However, this artificial decrease in the resulting chick population caused lower chick mortality later on in heavy disturbance areas, because there were fewer chicks to compete for possibly limited food resources and fewer adults on territories to attack wandering chicks.

Double-crested Cormorants (*Phalocrocorax auritus*) are colonial, nesting both on the ground and in tree groves. Ellison and Cleary (1978) found no significant differences in mean brood sizes or predation rates in disturbed versus undisturbed plots for either ground or tree nests. However, fledging success was higher in all undisturbed plots, with 0.4-0.8 young fledged per active nest (1975 and 1976, respectively) compared to 1.3-1.4 in control plots. Disturbance may also have contributed to the large number of late nests in controls, suggesting that pairs avoided disturbed areas and nested late or renested in undisturbed areas.

Black-crowned Night Herons (*Nycticorax nyticorax*), which nest in tree colonies, also had no significant differences in brood size between disturbance regimes for those nests with eggs, with the exception of 1976 which had a larger clutch size at the experimental site (Tremblay and Ellison 1979). However, the researchers found that visits early in nesting inhibited laying. Similar to the previous study, there were more late nests in two of three control sites, both on the same island, again indicating a possible connection between disturbance and choice of late nesting sites in areas where disturbance was minimized. Also, disturbance appeared to reduce overall fledging rate, as seen in the greater number of empty nests in the experimental sites, and the high failure rate of nests after hatching (31%). The empty nests indicated that human disturbance either caused abandonment and subsequent predation, or direct predation. Disturbance while chicks were young also caused abandonment, which led to predation of the young.

Additional incidental observations show adverse effects of human disturbance on reduced breeding success through desertion in colonies of Atlantic Puffins (*Fratercula arctica*) (Lockley 1934, Nettleship 1972, both as cited in Evans and Nettleship 1985: 456) and for Dovekies (*Alle alle*) (Evans 1981). Human disturbance was also a factor in reduced growth rates of young Common Murres (Harris and Wanless 1985 as cited in Evans and Nettleship 1985: 456) and Dovekies (Evans 1981).

These studies indicate some effects of human disturbance on individual nesting seabirds and possibly on a colony level, but it is unknown how the population is affected from investigator disturbance. In a workshop on researcher-seabird interactions (July 15-17, 1993, Monticello, Minnesota), the participants discussed disturbance of seabirds caused by research, ranging from non-invasive techniques such as observations to implanting instruments (Fraser 1994). They generally agreed that though there are apparent effects of the researcher on individual birds, there was no objective evidence that there was an effect on a population level, and only limited evidence that there may be an effect on a colony level (p. 10, Fraser 1994). Both of the studies which showed some effect on colony levels (Cooper et al. 1994, Davis et al. 1994) involved handling of birds (petrels and albatrosses, Adélie Penguins (*Pygoscelis adeliae*), respectively). Davis et al. (1994) also found that the presence of a "passive" observer could effect recruitment if the observer was frequently present, and that smaller colonies were especially vulnerable.

General human disturbance

Human disturbance in the vicinity of Marbled Murrelet nests can take many forms. Disturbance concerns in parks include passing vehicles, hikers, recreational facilities, and trail-clearing activities. In public and private commercial forests, nearby logging operations, including chainsaws, heavy machinery, and loud noises, are also potential problems. We review here some studies and incidental observations of these types of disturbance to nesting birds.

Vehicle and boat traffic.--Habituation to traffic may be a matter of volume and consistency of traffic. For example, a San Francisco Bay population of Double-crested Cormorants became habituated to the close proximity of high-volume vehicle traffic and have nested successfully on the support structure of the Richmond-San Rafael Bridge, a major freeway across the bay (Stenzel et al. 1995). The cormorants nested as close as 2-3 m below the lower bridge deck. Disturbance was limited to overhead vehicle noise (other than nest checks), because maintenance was rescheduled until after the breeding

season. Bridge-nesters consistently fledged more chicks/nest than those nesting in the comparatively undisturbed Farallon Islands along the Pacific coast. Boats used to check the colony did not appear to cause the birds to flush.

Such extreme high-volume traffic is generally the exception. Rather, increased tourism and outdoor recreation brings seasonal traffic of boats and vehicles especially during the breeding season, increasing the general traffic in an area to such an extent that it may impact the population (Evans and Nettleship 1985). In Norway, the large numbers of pleasure craft around breeding islands have been speculated to be the cause of the collapse of the Common Murre and Atlantic Puffin populations (Norderhaug et al. 1977, Barrett and Vader 1984, as cited in Evans and Nettleship 1985: 455).

In a study of Trumpeter Swans (*Cygnus buccinator*), Henson and Grant (1991) found that birds nesting on territories without visual barriers were the most impacted by passing vehicles. Also, vehicles stopping or with comparatively louder engines caused the greatest reactions from the swans. For example, heavy trucks elicited a heads-up posture 40-75% of the time, but did not cause birds to leave their nests. However, swans did not have a reaction to smaller passenger vehicles unless a vehicle stopped within view of the wetland, which caused 2 out of 12 birds to leave their nests. Passing motorcycles had a greater impact and caused a bird to leave its nest 2 out of 3 times. Researchers observed 2 interactions between swans and airboats; in both instances the swans left their nests. Most importantly, they found that time spent away from the nest after disturbance was longer than during normal recesses, and usually eggs were left uncovered, indicating a panic flight.

Aircraft.--Aircraft are frequently used for colony counts that cover a long distance and the impact of small-aircraft overflights may be dependent on the volume of similar traffic in the area. For example, during colony counts along the California coast, Takekawa (pers. comm.) noted different reactions between colonies, as some reacted with panic flights while others did not. The colony at Castle Rock in northern California was one of those less likely to flush, and is located near the runway of a small local airport. Evans and Nettleship (1985) similarly noted that regular flights might acclimatize colonial birds to aircraft.

However, though nesting birds may become habituated to regular air traffic, they may continue to be sensitive to lower-flying aircraft, as Henson and Grant (1991) found for Trumpeter Swans. The study area was near a local airport, and the birds were only slightly sensitive to passing aircraft below 615 m, as they reacted with a heads-up posture 19 of 21 times and none left their nest. In contrast, when the investigators circled above two nests at 60 m, both incubating females flushed from their nests.

Seabird colony census flights in California have generally been conducted at heights of 500-700 ft, however sea otter flights are conducted at 200 ft, and have become a cause for concern when conducted over seabird colonies (Carter, pers. comm.).

Pedestrians and observers.--Hikers and bird watchers are increasing in public areas and have a potential for disrupting nesting birds. Of all the measured disturbances, Trumpeter Swans were the most sensitive to foot traffic, when compared to vehicle and air traffic (Henson and Grant 1991). They were immediately aware of people within view or making noise. During the study, interactions with pedestrians along the road (dog-walking, photography, and wildlife-viewing) occurred 16 times. The greatest impact was during incubation, when half of the birds (3 of 6 observed) left the nest rapidly and remained away for 0.5-1.5 hours (no reactions were noted for the remaining three). During pre-laying and brooding, all birds swam away from the pedestrians, and those with broods swam into concealing vegetation on the far side of the marsh. Investigators moving to observation blinds caused about half of all disturbances during the study. Responses were similar to responses to pedestrians. In contrast, movements to blinds with hidden access routes caused no disturbance.

Habituation to human disturbance has been observed for Bridled Terns (*Sterna anaethetus*) in Australia (Dunlop 1996). Dunlop measured approach distances of brooding terns at colonies on 2 islands with different tourist activity levels: Penguin Island (80,000 visitors during the breeding season) and Bridled Island (rarely visited). They found that the birds on the more regularly disturbed island would allow a person to approach significantly closer than would those on the undisturbed island. Modal distance on the disturbed island was from 1.1-2 m, compared to 5.1-6 m on the undisturbed island. The maximum approach distance was also greater, as all birds on the disturbed island allowed approach to within at least 4 m, compared to 27 m on the undisturbed island.

Sporadic foot traffic may cause lower production of Common Murres in more isolated colonies. At Reading Rock off Redwood National Park in Humboldt County, California, visitations by Coast Guard personnel during the breeding season to service the beacon light there has apparently caused gaps in the distribution of nests in the

colony, especially nearest the light. The number of murres in the colony has declined from 1,632 murres in 1989 to at most a few hundred in recent years (Carter et al. 1990; Takekawa, pers. comm.). No murres were seen during the 1996 colony count (Carter, pers. comm.). Despite concerns voiced to the Coast Guard, the practice continues (Carter, pers. comm.).

Noise disturbance.--Nesting birds are sensitive to sounds, as we noted earlier with the greater sensitivity of Trumpeter Swans to passing motorcycles as compared to passenger vehicles (Henson and Grant 1991). Also, swans were first alerted to overhead aircraft by engine noise.

Noise unaccompanied by a visual stimulus can also disrupt nesting. Sydeman (pers. comm.) and Takekawa (pers. comm.) found that Common Murres were sensitive to the noise from air compressors used by sea urchin and abalone divers off the Farallon Islands, which would flush birds from nests. Though part of the disturbance was probably from the noise of boat engines, the compressors near shore caused additional disturbance. Takekawa (pers. comm.) also found that as diving increased, the murres became more skittish, and were flushed by previously tolerated disturbances such as sailboats.

Recreation development and activity.--Increasing development of recreational areas not only increases the potential for people to come in contact with nesting birds, but also may decrease nest sites and attract nest predators. Studies of human impacts on nesting Common Loons (*Gavia immer*) demonstrated a decrease in nesting pairs on islands and hatching success with the increase in human developments (number of campsites, resorts, and cottages) (Vermeer 1973, Heimburger et al. 1983). In the Superior National Forest, loons nested on lakes that were accessible only by canoes, and of the nine nests found on campsite islands, none were known to be successful (Ream 1976). The presence of the campers apparently kept the birds from their nests. Additionally, campers may have attracted predators by leaving fish entrails and garbage near the campsites, causing nest failure. However, some loons have become habituated to human presence (Heimburger et al. 1983). One pair allowed close approach of humans to their nest situated near four cottages, all within 150 m, while others with little previous exposure to people flushed and abandoned nests.

Management of human disturbance

With the increase in recreation comes an increase in the potential for disturbance of nesting birds. The Great Barrier Reef complex of islands in Australia, home to many seabird colonies, is an example of a location of intense management of a variety of human activities while preserving bird populations (Stokes et al. 1996). The islands are managed for semi-permanent habitations, tourism, and commercial interests (fishing, mariculture). Each island is managed separately, ranging from complete sanctuary (no visitation, no research unless proven necessary) to partial closure during breeding season, to open to all tourist activities. These decisions are based on the likelihood of disturbing nesting adults, which might lead to predation of eggs or young by gulls. Generally, the smallest islands are placed off limits because landing without scaring adults off nests proved difficult. No data was given on the impact of these policies.

In the Farallon Islands, the observation of the impact of air compressors on nesting birds has led to a buffer zone of 300 ft around the island during the nesting season, as well as modifications in the air compressor exhaust (Takekawa, pers. comm.).

However, it is not always possible to determine the effect of human disturbance compared to other environmental variables (Fraser 1994: 10). For example, Litchfield Island off Antarctic Peninsula was declared a Specially Protected Area in 1978, which ended tourism and much of the research activity there (Fraser and Patterson 1994). Since then, the Adélie Penguin population on the island has decreased by 56%, compared to only 13% on nearby Torgerson Island, where tourism and research continues. The researchers suggest that tourism and research may have had negligible effects compared to other environmental variables. In some cases, the presence of humans may not affect breeding at all. In the Great Barrier Reef, Australia, there has been an exponential increase in breeding Black Noddies (*Anous minutus*) on Heron Island since humans have begun living and vacationing there, though this may have also been at the expense of other species of seabirds (Stokes et al. 1996).

Habitat and Biology of Nesting Marbled Murrelets

In order to relate potential effects of disturbance to nesting Marbled Murrelets, it is essential to understand the biology of the bird. Here, we will review some of the nesting habitats, nesting biology, habits of adults and chicks on the nest, and predator avoidance strategies. More detailed information can be found in Ralph et al. (1995a).

Nesting habitat

Marbled Murrelets primarily nest in trees throughout their range, with less than 5% nesting on the ground in northern Alaska (Ralph et al. 1995b). Tree nests are usually found on moss- or duff-covered, large limbs of old-growth trees (>81 cm d.b.h.) (Hamer and Nelson 1995). Most of these nests have a high amount (>75%) of overhead cover, though some can be very open (one nest in California had 5% cover). Nest concealment is important to reduce predation, and was significantly greater at successful nests compared to failed nests (87.2% vs. 67.5%) (Nelson and Hamer 1995b). Habitat variables, including forest fragmentation, might affect predation rates, but analyses of habitat characteristics and nest success found only distance to edge (such as nearest road) to be significantly different for successful nests (Nelson and Hamer 1995b). Successful nests averaged 166 m from a forest edge, while depredated nests averaged 27 m from an edge.

Nesting biology

After the eggs are laid, adult murrelets shared incubation duties (Nelson and Hamer 1995a). Incubation exchanges occurred every 24 hours, one bird remained on the nest while the other foraged on the ocean. Exchanges usually occurred in the morning hours before official sunrise and the bird on the nest departed within one minute of the arrival of its mate. During the nestling stage, adults rarely brooded the chick for more than one day, then they left the chick on its own at the nest while both parents foraged at sea. Feedings occurred during the day, with up to 8 per day (mean = 3.2 trips/day) and peaks at both dawn and dusk. The largest peak occurred from 39 minutes before sunrise to 65 minutes after sunrise when most chicks were fed their first meal of the day. Adults spent from 13 seconds to 80 minutes at the nest (median 13 minutes) during each feeding. The chick usually vocalized with a soft begging call (not usually heard on the ground) during feeding bouts. Chicks were fed until fledging occurred, though at least one pair stopped feeding 2 days before fledging.

Fledging at observed nests occurred at night, though only 8 fledgings were observed (Nelson and Hamer 1995a). Adults may or may not visit the nestling prior to fledging. It is believed that the chick flies directly to the ocean unaccompanied by an adult, though there are few data on movement of chicks from the nest. A few observations have been made of fledglings swimming in nearby creeks, but it is unknown if they used the creeks to access the coast or if they fell from nests.

Adults often traveled to and from the nest by the same flight paths (Kerns 1994; Nelson and Hamer 1995a; Singer et al. 1995; Chinnici, unpubl. data). Most of these were related to openings in the forest surrounding the nest tree, such as creeks, roads, or other clearings. They approached the nests below the canopy and ascended steeply to the nest.

Murrelets are generally thought to be solitarily nesters, or possibly loosely colonial (De Santo and Nelson 1995).

Predator avoidance strategies

Murrelets were usually secretive near the nests, probably to avoid predators (Nelson and Hamer 1995a). As described above, the majority of nest visits by adults tended to be during dawn and dusk, thus making it harder for predators to see the birds. Vocalizations at the nest by chicks and adults were primarily very soft or muted calls and were rarely heard by observers on the ground. The few times loud 'keer' vocalizations were heard they were given by the adults, and occurred during incubation exchanges or during feeding visits.

The cryptic plumage of adults and chicks allow them to blend in with their surroundings. In addition, there are behavioral adaptations that keep them from detection. Both adults and chicks remained motionless (or sleeping) 80-94% of the time (Nelson and Hamer 1995a). When a predator was detected, the bird usually crouched down, which lowered its profile. If the predator did discover the nest, the bird often turned to face the intruder and aggressively defended itself, including pecking at the predator.

Additionally, murrelets often placed nests in trees with overhead concealment (Nelson and Hamer 1995b). As noted earlier, nests that were depredated had a lower percentage of overhead cover compared to successful nests.

Observations of Disturbance to Nesting Murrelets

The number of nest observations of Marbled Murrelets has increased in recent years. Most of these investigations have not centered on disturbance issues, but we have gathered data from literature and communications with investigators detailing observations of birds' reactions to incidental disturbances at the nest (*Table 1*). Disturbances have included investigators climbing trees, handling chicks, and moving to observation posts, as well as the use of video cameras in or near nest trees. Disturbance from outside influences such as hikers, timber operations, vehicles, and aircraft were also noted.

Observations were in a variety of habitats in the

murrelets' range, from the redwoods in California (Singer et al. 1995; Chinnici, unpubl. data) to a ground nest in northern Alaska (Simons 1980). Public access to these sites also varied from high public use areas such as Big Basin Redwoods State Park in California (Singer et al. 1995) to nature reserves such as the Valley of the Giants in Oregon (Nelson and Peck 1995) and totally remote islands off the Alaska coast (Naslund, pers. comm.). It should be noted that previous exposure to people may influence the reaction of murrelets to disturbances (Singer, pers. comm.).

Investigator disturbance

In nest trees or near ground nests.-- With the increasing need for research on nesting Marbled Murrelets, there will be increasing disturbance by researchers. Handling eggs or chicks has the highest potential for impact, as we have noted earlier for seabirds. One of the first recorded instances of direct disturbance of a chick is recorded by Binford et al. (1975) when Hoyt Foster, a tree surgeon, was removing limbs from a tree in the Big Basin Redwoods State Park in central California in August, 1974. He had been working in the tree for nearly 4 hours before sighting the chick. The chick was "squatting motionless" and facing the person (Binford et al. 1975: 307). As it was prodded and wings lifted with a pruning saw, the chick turned, shifted up and down, and "vigorously" pecked at the saw. When Foster tried to capture it by putting a shirt over it, the chick quickly moved backwards and fell off the limb. Thereafter the chick was in captivity where it was "alert and active", and "demonstrated no aggressive behavior when handled" (Binford et al. 1975: 308). In contrast, Hamer (pers. comm.) found that chicks did not habituate to being handled, and continued to rear up or snap the bill at the investigator. He took weights of two chicks every day over a period of about a week during 1991 and 1992 in the Mt. Baker/Snoqualmie National Forest located in Washington state.

Adults appeared to be more sensitive to people climbing trees or approaching the nest closely than were chicks. More nests have been observed after the chick has hatched, so data are limited on incubating birds. In 2 of 3 incidents during incubation, adults flushed from nests when approached. In the Naked Islands, Alaska, in 1991, a tree nest was discovered by Naslund (pers. comm.) when an adult was flushed from a previously undetected nest when the researchers approached "too closely". Trees on Naked Island are much shorter than those in southerly states, thus the nests are closer to the ground, and are therefore likely more susceptible to disturbance than those in the taller trees (Naslund, pers. comm.). Similarly, ground nests are more susceptible to disturbance. At one such nest on a tree root near ground level at the top of an 11 m cliff, adults were reported as flushed or disturbed five times (Brown, pers. comm. as cited in Nelson and Hamer 1995b: 94). However, Simons (1980) was able to approach within 5 m of a ground nest in the Barren Islands, Alaska, by circling around the side and looking over an overhang. The adult did not appear to notice the presence of the observer, but it did become alert at any noise, such as shuffling of feet or camera clicking. It would come to an erect posture, as if in preparation for flight, and look about cautiously from side to side, but did not flush due to the noises.

Adults were also easily disturbed during feeding activities. Adults came in with fish three times while Hamer was in the tree near the nest (Hamer, pers. comm.). The first two times occurred on the same day at a nest in the Mt. Baker/Snoqualmie National Forest, Washington in 1991. While he was at the nest, the adult landed less than 3 m away on the nest limb. The bird watched him for less than a minute before leaving with the fish. It circled and landed again before the investigator had left the tree, but quickly left again with the fish. The incident did not cause abandonment, since the chick continued to be fed and fledged successfully. The third incident occurred at a nest in Siuslaw National Forest, Oregon in 1992. Hamer had climbed the nest tree and was 3 m away on a limb above and to the side of the nest when the adult came in with a fish (Hamer, pers. comm.; Nelson, pers. comm.). The adult aborted its landing and circled about three times. During this time, Hamer was able to maneuver to the opposite side of the trunk from the nest so he was out of sight of the nest. The adult subsequently landed and fed the chick, and did not appear to notice the person still in the tree.

In comparison, a slightly different response was observed in 1993 in the Caren Range, British Columbia when Jones (pers. comm.) had climbed an adjacent tree and was about 10 m from a nest. The chick made no response to the presence of the investigator, but when the adult came in with a fish, the adult froze on the limb and remained in that position until the person climbed down the tree. Then the adult moved in and fed the chick.

Chicks appeared less wary of people near the nest and appeared to become habituated to disturbance, however they continued to defend some of the area around the nest. At one nest in Big Basin Redwoods State Park, California, was found in 1996 by climbing a tree, the chick did not react to the presence of the observer (Singer, pers. comm.). Investigators also climbed to within about 1 m of the chick to mount and subsequently remove a video camera and later to take photos. The chick did not react (and was apparently asleep during the photo shoot) unless the person

came to within 1 ft, when it would attempt to defend itself.

Hamer (pers. comm.) climbed 2 different nests in 1991 and 1992 in Washington State, and found that the chicks became habituated to his presence when he was changing tapes in a video camera 1 m away. At the beginning, the chick would snap its bill at him, and with each encounter the bird responded less until by the end it did not even turn to face the person on the limb. However, the chicks did not become habituated to a person reaching for them.

The reaction of a chick at a ground nest was similar (Simons 1980). When the investigator approached, the chick would regard him intently, and would move to keep the investigator in sight while remaining in the nest. When approached "too closely", the chick would defend itself by rearing up on its legs and pecking with an open gape.

Investigators near nest trees.-- Responses to observers near the nest trees varied from site to site, and might be relative to the amount of exposure to public use of the site. Big Basin Redwoods State Park in central California is a heavily used area, and the nests in 1991, 1992, and 1994 were adjacent to a main trail with 25,000 visitors each year (Singer, pers. comm., Singer et al. 1995). The observers at these nests were generally well-shielded from the nest by vegetation, but during changes in observers, they were visible to the birds. There was no visible response by the birds.

At more remote areas, responses varied from none to looking toward the person. During 1992 in Humboldt County, California, Kerns (1994) stated that the "chick did not seem to pay attention to activity beneath the nest". However, one observer wrote that he felt that "observation is disturbing feeding", but no further information was given to clarify the note (Chinnici, unpubl. data). Observers were behind a blind (Chinnici, pers. comm.) and they changed observers several times a day during 17 continuous days of observations. This nest was on private timber land and 70 m from a dead-end logging road, so no other people would have been near the nest.

Nelson (pers. comm.) has observed and photographed several nests in the coastal mountains of Oregon from viewing platforms and found that the murrelet chicks generally had very little reaction to movement of observers to or at the platform. The closest platform was 6 m from a nest, located on the Elliot State Forest nest during 1995. The chick occasionally looked around toward disturbances or was in a crouched position (probably sleeping according to Nelson [pers. comm.], since young tend to do that 80-95% of the time [Nelson and Hamer 1995]). Other platforms were located at Valley of the Giants in 1990 with both a chick and adult on the nest (35 m away across a road) and Copper Iron nest in 1992 with only a chick (20 m away in an adjacent tree). At both sites, there was no reaction from birds other than looking in the direction of the viewer. All three sites were not accessible by the general public.

Jones (pers. comm.) has also observed no apparent response from either the adult or chick when researchers moved to an observation area during studies at a remote location in the Caren Range of British Columbia (1993 and 1994). They observed the nests for a total of 35 days from a concealed location 110 m from the nest. Observers made an effort to move very slowly and quietly to their posts. The only response noted from a chick was to hunch down in the nest during the more noisy approach of a photographer through nearby bushes in 1993. Even when he climbed an adjacent tree to within 10 m of the nest, the chick did not respond to his presence.

Ritchie (pers. comm.) found that an incubating adult was more aware of the observers' presence than was the chick. In the Coast Range southwestern Washington, at a site along an unused road system, he observed that the adult followed the movements of people to observation posts and continued to look to that vicinity until the people were gone, while the chick did not seem to notice the people. The first observation post was less concealed from the nest and located 100 m away on the road. Ritchie moved to a more concealed position about 75 m away after they noted the reaction of the adult, but the adults' reaction only slightly decreased, as it did not spend as much time looking at the concealed observers.

On remote islands in Alaska, murrelets were also sensitive to intrusion. Naslund (pers. comm.) observed 3 nests in the Naked Islands for 2-3 hours each. The birds were alert and "agitated" when the observer first approached a concealed observation point on the ground (though they remained somewhat visible to the birds). Birds at the two most-watched nests became less agitated as observations continued.

Cameras on nest limbs.--Some researchers have used video cameras in an attempt to observe nests with less disturbance to the birds. However, Singer (pers. comm.), during observations in 1996 in Big Basin Redwoods State Park (central California), found that cameras might have a large impact on nesting activities, depending on size or placement. He used a 5" x 15" camera which had reflective surfaces. It was placed on the nest limb just over 1 m from the nest. Adults came in 2-3 times in the evening with fish to feed the chick, and although they landed on the branch, they left without feeding the chick. The next morning, Singer moved the camera to an adjacent tree

about 5 m from the nest. The adults then resumed feeding the chick regularly.

Hamer (pers. comm) also used cameras during observations of two nests (1991 and 1992) in the northern Cascades of Washington state. Each camera was mounted 4 m from the nest on the nest limb. The only impact he noted was the disturbance of the chick by people coming to change the tapes in the cameras, which occurred a total of 15-20 times during the nesting season. The chick eventually became habituated to the people (see further discussion of chick reactions to people changing tapes under In nest trees or near ground nests).

Outside incidental human disturbance

People near nest tree.-- Hikers were a potential disturbance at two areas: Big Basin Redwoods State Park, California (Singer et al. 1995; Singer, pers. comm.) and the northern Cascade Mountains, Washington (Hamer, pers. comm.). At neither area did hikers or park personnel appear to greatly influence murrelet behavior. For further discussion of influence of people near nests, especially at sites where hikers were not allowed, see also Investigators near nest trees.

Big Basin is a heavily used park in Santa Cruz County. Two nests found in 1979 were located 10 and 25 m from hiking trails. The first of those two was also 35 m from the park's sewage treatment plant while the other was in a picnic area (Singer et al. 1991). The three nests found in 1991, 1992, and 1994 were all located on branches overhanging a major hiking trail used by approximately 25,000 visitors/year (Singer et al. 1995). Though individual encounters from hikers or passing park personnel were not recorded during either study, Singer stated that "incubating birds only rarely showed behavior suggesting agitation from human presence or noise" (Singer et al. 1991: 337) or showed "no visible reaction to loud talking (or) yelling...near the nest tree" (Singer et al. 1995: 61). Naslund (pers. comm.) stated that during her observations at the 1989 nests, the murrelets might sit up and look around at loud noises or other unusual human disturbances, but otherwise were unaffected by people nearby. Neither did Nelson (pers. comm.) observe any response to people at the same nests.

In contrast, the trails in the northern Cascade Mountains in Washington state are less used. Nests observed by Hamer (pers. comm.) in 1991 and 1992 were along the Lake 22 Trail. The Darrington Ranger District Office of the U.S. Forest Service (pers. comm.) estimates that this trail has an average of 30 hikers/day. The 1991 nest was on the trail, and the 1992 nest was 90 m from the trail. Hamer's observations were made with time-lapse video cameras, so no details were possible on bird behavioral responses to hikers. However, Hamer noted that both nests fledged young, so the public use of nearby trail does not appear to have affected the final outcome.

Vehicle disturbances.-- Vehicles were not observed near many nests, but passing vehicles, even heavy trucks, did not appear to influence murrelet behavior on the nest. Described below are the few instances where vehicle passages were noted near the nest.

Singer found no visible response to vehicles, including the occasional large trucks, driving past three nests he observed from 1992 to 1994 (Singer et al. 1995; Singer, pers. comm.). These nests were located 70 m from a paved and "well-traveled park road" in Big Basin Redwoods State Park (Singer et al. 1995). Also in the state park, Nelson (pers. comm.) found no response by birds to cars at the 1989 nests during several days of observation.

Chinnici also found little to no response from murrelets to vehicles (Chinnici, unpubl. data). The nest he observed in Humboldt County, California in 1992 was located in a largely undisturbed private forest, 70 m from a lightly-used logging road (Chinnici, pers. comm.). At least once a day observers drove up to the observation post located on the road in light trucks. One note stated that the chick "opened [its] eyes" and was "alert as truck approached observation site," otherwise there were no responses noted to passing vehicles during 11 days of observation.

In Oregon, few nests that Nelson (pers. comm.) observed were near roads. The two nests on the bank of the Siuslaw River in 1991 and 1992 were across the river from a moderately-traveled highway, perhaps 30 cars/day. Nelson observed no reactions when vehicles passed.

Sharp, loud noises.-- Responses to abrupt noises, such as car doors slamming and gun shots, were varied. Similar to passing hikers, responses (or lack of response) may be related to previous exposure. At three nests observed between 1991 and 1994 in Big Basin Redwoods State Park, murrelets showed no visible response to car doors slamming in a nearby public parking lot for the Headquarters, where at least 20 cars parked on a daily basis (Singer, pers. comm.). In contrast, most other nest sites were located away from public roads or parking areas and investigators were careful to close doors softly when they parked nearby (Chinnici, pers. comm.; Nelson, pers. comm.). However, Nelson did observe one instance in 1990 at the Valley of the Giants when a car door was closed loudly about 150 m from the nest. The adult under observation jumped, but did not abandon the nest.

Ritchie (pers. comm.) heard logging operations about

0.5 miles from the nest site, which included a loud, sharp noise from either blasting or a dump truck gate slamming during his observations of a nest in the Coastal Range of Washington during 1993. There was no reaction from the chick.

Hamer (pers. comm.) videotaped an incident of many rifle reports about 200 m from the 1991 nest in the Baker/Snoqualmie National Forest. He found no visible response to the noise, though since he was using a time-lapse taping he may not have recorded a response to the initial shot.

Prolonged, loud noise.-- Marbled Murrelets overall did not respond to many loud and prolonged noises where there was no visual cue during observations. Such disturbances ranged from logging operations to loud stereos in the park. Several investigators heard logging operations during nest observations. Observers on private timber lands in Humboldt County, California (1992), heard a road grader working "down the road" for about one-half hour (Chinnici, unpubl. data). During this time, they recorded three times that the chick was "alert, but no changes" from previous behaviors of "awake and swatting flies." However, "alert" was also used in other instances in the records where no other surrounding activity was occurring. Earlier on the same day, an observer recorded on two instances that he could "hear chainsaws" or "truck noise" from a logging operation, but that the "chick [was] sleeping" or preening. In Oregon, Nelson (pers. comm.) noted that logging was occurring 0.5 mile from the 1990 Valley of the Giants nest. She recalled hearing trucks and a boom whistle with no visible reaction from the birds. Ritchie (pers. comm.) in southwestern Washington also heard logging operations with heavy machinery and large trucks 1-2 miles from the nest, and observed no reaction from the chick. However, since observations were sporadic, he did not know when operations had begun. During his nest observation one week later, no logging was occurring and may have been completed. At Big Basin Redwoods State Park, Singer (pers. comm.) observed no reaction from one murrelet when a loud portable stereo was heard in a nearby parking lot.

Aircraft passing overhead.--Murrelets did not respond to either airplanes or helicopters flying overhead, except perhaps when they passed at a low altitude. In Humboldt County, California (1992), observers noted overhead airplanes four times and helicopters three times (Chinnici, unpubl. data). Either no response was noted (n = 3) or the chick did not react to the aircraft (n = 4). Other than one instance when the height of an airplane was "three times the canopy height" (about 270 m (Chinnici, pers. comm.)), no heights were given. However, personal observations by Kerns (1994) at the same nest indicated that he observed that the chick "would lay flat" when an aircraft passed at low altitudes. Ritchie (pers. comm.) found no response from the murrelet chick he was observing when a single-engine airplane passed twice within 0.25 mi at a height of about 1000 feet.

Disturbance by corvids and other potential nest predators

During nest observations, behavioral responses to potential avian predators included no response, remaining still and alert, aggressive attacks, and leaving the nest. Naslund (1989, pers. comm.) also observed that even if a murrelet remained still at the approach of an avian predator, the respiration rate increased, which would indicate an increase in anxiety level.

Common Ravens (*Corvus corax*), and Steller's Jays (*Cyanocitta stelleri*) are known to be murrelet nest predators. Sharp-shinned Hawks (*Accipiter striatus*) have depredated nests in Alaska and Oregon (Nelson, pers. comm.). It is suspected that a Great Horned Owl (*Bubo virginianus*) might have depredated a nest (Nelson and Hamer 1995b). Other corvids, raptors, and mammalian predators may be added to the list, but no other cases of predation have been reported.

Below is a summary of encounters of potential and known predators and murrelets during nest observations.

Common Ravens.-- Responses to Common Ravens varied from no reaction to attacks. The most common response was to remain still or hunch down in the nest.

Lack of response to this potential predator were by chicks that possibly did not see the raven when there were only visual cues. Chicks spend most of their time sleeping (Nelson and Hamer 1995a) and could be vulnerable in this way. For example, Ritchie (pers. comm.) found that the chick he observed in the coastal range of Washington (1993) had no reactions to ravens flying through the canopy. It is unknown if the chick was awake or could see the ravens.

More typically, murrelets are at least alert when ravens are known to be in the vicinity. Ravens are a common sight at Big Basin Redwoods State Park in central California. During observations there at two nests in 1989, Naslund (1993) observed several encounters with ravens about 50 m from an incubating adult. This frequently caused the murrelet to raise itself up to a moderate or erect posture to watch the raven. She speculated that this was not aggression or an attempt to confront the larger bird on the part of the adult, but rather to allow a quick escape.

Singer (pers. comm.; Singer et al. 1995) noted that murrelet adults and chicks, observed during 1991-1994, responded to raven calls every time the call was noted even if it was not a loud call. The bird would either crouch down or assume an alert posture (Singer, pers. comm.).

Crouching down may lower the bird's profile and hide it from the predator. In Humboldt County, California, during three out of four interactions with ravens, the chick became still or crouched down in the nest (Chinnici, unpubl. data). In one of the accounts, the chick's activity was not noted with the first detection of the ravens, but 4 minutes later, it was "hunkered down" when the ravens left. The bird apparently remained in this position for some time, because the observers noted several times they could not see the bird until its head became visible 50 minutes later. Kerns (1994) also noted that the bird would lie flat when a bird passed overhead at low altitude. Jones, while observing a nest in the Caren Range, British Columbia, observed an adult and chick on the nest while a raven was flying and calling near the nest. Both froze for 45 minutes, long after the raven had left. At a ground nest in Alaska in 1978, Simons (1980) witnessed several times when the incubating adult flattened itself against the ground in response to the calls or silhouettes of ravens. Later, while the adult was feeding the chick, 2 ravens flew overhead calling and the adult moved "approximately 25 cm from the nest facing the water, motionless, and pressed flat against the ground" (Simons 1980: 5), while the chick remained still and hunched up in the nest. They held their positions for 6 minutes.

Only one instance was recorded of a murrelet attacking a raven. Singer (as cited in Nelson and Hamer 1995a: 65) observed an incubating murrelet fend off an approaching raven by lunging at it with an open bill, causing the raven to veer off instead of landing.

A raven also caused an adult to leave the nest. On Naked Island, Alaska, Naslund (pers. comm.) observed an incubating murrelet leave its nest after a fledgling raven circled the nest tree above the canopy and landed on top of the nest tree, continually calling. The adult returned later, but the nest eventually failed for unknown reasons.

Naslund (1993) also observed a raven depredating a nest at Opal Creek in Big Basin Redwoods State Park. In 1989, an incubating adult began to look around just before a raven landed on the nest branch. At this point, the murrelet faced away from the raven in a flattened posture and did not make any aggressive movements. The raven quickly approached the adult and both left the branch shortly afterwards. The raven was later observed eating either the remains of the adult or the embryo.

Steller's Jays.-- Murrelets (at least adults) were more likely to defend themselves than hide from Steller's Jays when compared with reactions to ravens. Naslund (1993) observed 24 encounters of incubating adult murrelets with jays at the 1989 nests in Big Basin Redwoods State Park. Each encounter resulted in some form of aggression on the part of the murrelet, either holding its bill slightly open in an aggressive stance or jabbing at the intruder. They generally turned around continuously to keep the predator in sight. During attacks, the murrelet also attempted to hide the nest and its contents with its body by extending its wings slightly, body low in the nest, and ventral contour feathers erect. During two attacks, the murrelet continued to try to drive off a jay which had landed on its back. Naslund also observed the predation of the chick at the Waddell nest by a jay shortly after it was hatched. Three days after hatching, a jay attacked the chick, which responded similarly to the adults: continuously turning to face the jay while repeatedly jabbing at it with an open bill. After less than a minute, the jay pecked at the chick's head and carried it off.

However, chicks may be able to defend themselves from jays. Singer and his colleagues (1995) noted that, in 1992, a large chick successively defended itself from two jays that were calling and posturing aggressively. The chick was also well-protected from approach from the back, since the nest abutted the tree trunk and the jays could only approach it from one direction.

Ritchie (pers. comm.) observed one encounter between a jay and murrelet chick. The jay had perched on another tree limb 50 m from the nest and the chick perked up and looked around to the jay, which apparently flew off without detecting the chick. Otherwise, the chick had no reaction to jays flying through the canopy.

Non-corvids.-- Two other potential avian predators were recorded near murrelet nests: Glaucous-winged Gulls *(Larus glaucescens*) and Spotted Owls (*Strix occidentalis*). Gulls are a known predator of seabirds that nest on offshore colonies (Birkhead 1985, Boekelheide et al. 1990, Ellison and Cleary 1978). When Glaucous-winged Gulls flew over the ground nest in Alaska observed by Simons (1980), the incubating murrelets were aware of the birds and several times they flattened themselves against the ground when they heard or saw a gull. A Spotted Owl was heard once in the vicinity of the nest in Humboldt County, California, and no response was noted by the murrelet chick (Chinnici, unpubl. data).

Marbled Murrelets sometimes responded to species of birds that were unlikely predators. No murrelets were flushed by non-corvids; however, they may respond

aggressively to other species. Naslund (1993) recorded the only aggressive response to a non-corvid. At Big Basin Redwoods State Park, an incubating adult attacked a Pygmy Nuthatch *(Sitta pygmaea*). Its attack behavior was similar to encounters with jays. It turned continuously to face the intruder and jabbed at it with an open bill.

Behavioral responses such as crouching still on the nest and alertness were recorded, which are similar to those observed when corvids were near nests. In Humboldt County, California, observers noted the chick was "still" when a Cedar Waxwing (*Bombycilla cedrorum*) was in the vicinity of the nest (Chinnici, unpubl. data). Also, the chick was alert and watched a nuthatch (*Sitta* sp.) foraging on the nearby tree bole (Kerns 1994; Chinnici, unpubl. data).

Some murrelets did not respond to non-predators. Observers at the nest in Humboldt County, California noted the presence of a woodpecker (*Picoides* sp.) and an unknown passerine, but no response from the chick was noted (Chinnici, unpubl. data).

Responses varied to alarm and mobbing calls by passerines. In southwestern Washington, Ritchie (pers. comm.) heard mobbing calls from American Robins (*Turdus migratorius*) and other small birds three times, and observed no response from the murrelet. In contrast, one murrelet chick did appear to react to the presence of a Red-breasted Nuthatch (*Sitta canadensis*)(Jones, pers. comm.). The chick remained still when the bird gave alarm calls, a response similar to behaviors given when corvids are present as described above.

DISCUSSION

We found in the seabird and waterfowl literature that humans can have an impact on nesting success. The most profound impacts often occurred during incubation. When flushed from a nest, adults might damage an egg (Cairns 1980, Robert and Ralph 1975) or decrease attentiveness at the nest (Cairns 1980, Henson and Grant 1991, Piatt et al. 1990, Robert and Ralph 1975) which could lead to a decrease in hatching rates (Cairns 1980, Robert and Ralph 1975, Piatt et al. 1990) and increased exposure to predation (Henson and Grant 1991, Robert and Ralph 1975). This can also lead to later hatching dates (Pierce and Simons 1986) which might put the younger chicks at a disadvantage compared to older chicks. At the extreme, disturbance might cause nest abandonment (Cairns 1980, Piatt et al. 1990, Pierce and Simons 1986).

Disturbance can also have an impact prior to incubation by influencing the choice of a nesting site. Both Ellison and Cleary (1978) and Tremblay and Ellison (1979) found that birds that nested late chose areas of lower human disturbance, possibly because they had earlier abandoned nests in the more disturbed areas. Disturbance during chick development led to lower fledging rates in some studies (Cairns 1980, Ellison and Cleary 1978, Piatt et al. 1990, Tremblay and Ellison 1979), including abandonment which may have led to increased predation (Tremblay and Ellison 1979). However, in at least one study chicks of Western Gulls became habituated to the presence of investigators (Roberts and Ralph 1975).

Most of the above impacts were due to the more intrusive influence of investigators. Passing vehicles, aircraft, pedestrians, and loud noises also impacted on nesting seabirds and waterbirds. Pedestrians had the greatest impacts, especially if there were no visual barriers between the people and nests (Henson and Grant 1991; Carter, pers. comm.). However, some birds became habituated to humans (Dunlop 1996, Robert and Ralph 1975). Passing vehicles had a greater impact when they had loud engines (such as motorcycles) or were stopped along the road (Henson and Grant 1991), though birds did become habituated to them if the cars continued by the nesting area without stopping (Henson and Grant 1991, Stenzel et al. 1995). Birds may also become habituated to aircraft, except when they pass at lower than normal altitudes (about 500 ft.) (Evans and Nettleship 1985; Henson and Grant 1991; Takekawa, pers. comm.).

We found that Marbled Murrelets did respond to some nesting disturbances, sometimes in ways that could disrupt nesting activities. People in the nest tree and especially at the nest cup caused some of the greatest disruptions, including adults not landing to feed a chick, flushing from nests, and attack behavior by adults and chicks. Similar to other species, some of the greatest potential for negative impact occurred during incubation. Two of the three investigators who observed nests during the incubating period flushed an adult at least once when they approached the nest closely (Brown, pers. comm. as cited in Nelson and Hamer 1995b: 94; Naslund, pers. comm.; Simons 1980).

Adults feeding chicks were also sensitive to disturbance. While investigators were at the nest, adults would not land with a fish during all three recorded incidents, although the adult resumed feeding the chick when the investigator was out of view, even if in the tree (Hamer, pers. comm.). An investigator in an adjacent tree 10 m away also disrupted feeding activities while the adult froze on the limb until the person left the tree (Jones, pers. comm.). The presence of a video camera on the nest limb 1.3 m away from the nest at one nest inhibited feeding

behavior (Singer, pers. comm.), although at two other nests a similarly situated camera did not disrupt feeding (Hamer, pers. comm.).

Murrelets did not appear to be disturbed by other, less intrusive human activities. The most common reactions of both adults and chicks to people walking near the nest tree (such as hikers or investigators moving to observation areas) were either no reaction or alert and watching the person (Chinnici, unpubl. data; Kerns 1994; Jones, pers. comm.; Naslund, pers. comm.; Nelson, pers. comm.; Ritchie, pers. comm.). Only two of probably dozens of instances were recorded where the chick hunched down in the nest (Jones, pers. comm.; Nelson, pers. comm.).

Murrelets appeared generally undisturbed by passing vehicles, or sharp or prolonged loud noises. One instance of a chick jumping was recorded at the sound of a car door slamming 150 m away, however this was in an area where roads are closed so car door sounds are unusual (Nelson, pers. comm.). Loud noises such as boom box portable radios, car doors slamming, and loud visitors hiking nearby at the Big Basin Redwoods State Park nests (California) did not disturb either the adults or chicks (Singer, pers. comm.). However, this level of noise disturbance is unique to the park, and has not been observed at any other nests, and therefore can not be translated as acceptable disturbance in other areas.

Overall, it appears that Marbled Murrelets are not easily disrupted from nesting attempts by human disturbance except when confronted at or very near the nest itself. Both adults and juveniles watched people near the nest tree, but otherwise did not appear concerned with the proximity of people, especially in areas where public use is high where they are probably habituated to noises.

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Table 1. Contributions of collaborators, including dates, locations, and references of nests under observation.

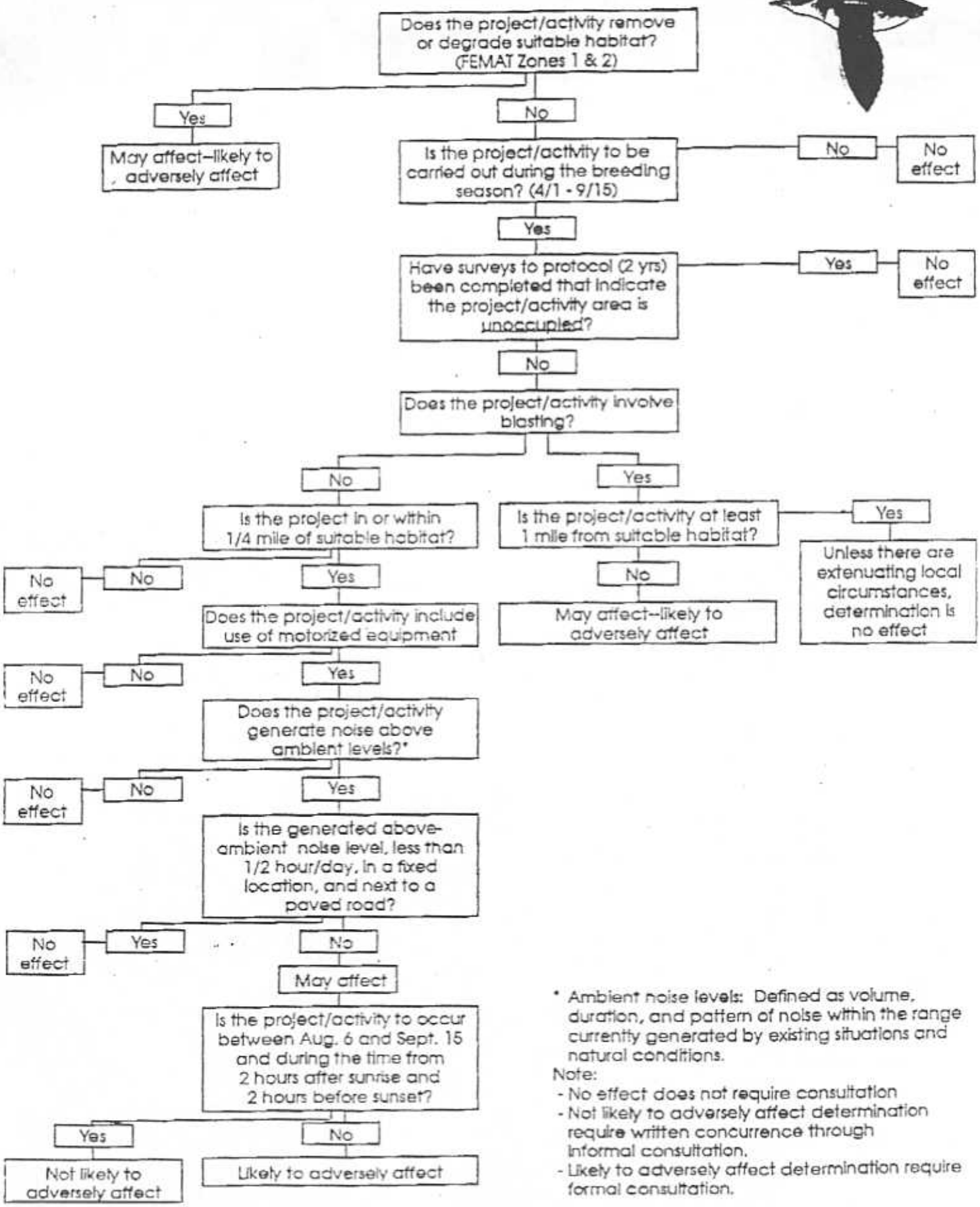
Location (*n*)	Year	References
Alaska		
East Amatuli Island (1)	1978	Simons 1980
Naked Island (3)	1991, 1992	Naslund, pers. comm.
British Columbia		
Caren Range (2)	1993, 1994	Jones, pers. comm.
Washington		
Lake 22 (1)	1991	Hamer, pers. comm.
Lake 22 (1)	1992	Hamer, pers. comm.
Long Beach (1)	1993	Ritchie, pers. comm.
Oregon		
Valley of the Giants (1)	1990	Nelson, pers. comm.
Siuslaw River (2)	1991	Nelson, pers. comm.
Copper Iron (1)	1992	Nelson, pers. comm.
Elk Creek (1)	1995	Nelson, pers. comm.
California		
Humboldt County (1)	1992	Chinnici, pers. comm., unpub. data; Kerns 1994
Waddell Creek (1)	1989	Naslund 1993, pers. comm.; Singer et al. 1991; Nelson, pers. comm.
Opal Creek (1)	1989	Naslund 1993, pers. comm.; Singer et al. 1991; Nelson, pers. comm.
Big Basin Redwood State Park (4)	1974, 1991, 1992, 1996	Singer, pers. comm.; Singer et al. 1995, Binford et al. 1975

Appendix A. Regulation standards and terminology definitions from the federal Interagency Team for reduction of disturbance of nesting Marbled Murrelets. These regulations are outlined in response to consultation needs by agencies for watershed restoration actions. See also "Effects Determination Key for Marbled Murrelets" (USFS et al. 1994) on the following page.

	Interagency Guidelines (U.S. Forest Service, Bureau of Land Management, and U.S. Fish and Wildlife)
Lands under this authority	All federal lands, as listed in the Northwest Forest Plan
Documentation	"Effects Determination Key for Marbled Murrelets" ("Key") (USFS et al. 1994)
Definitions	
Breeding season / Yearly restrictions	1 April - 15 September; core breeding season: 1 April - 5 August
Daily time restrictions	Activity may be allowed from 2 hrs after sunrise to 2 hrs before sunset, only after 6 August for buffer zones
Occupied behaviors	no definition
Occupied site	"Have surveys to protocol (2 yrs) been completed that indicate the project/activity area is unoccupied?" (no direct information on occupied site definition)
Suitable habitat	no definition, though term is used throughout "Key"
Buffer zones	0.25 mi from suitable habitat; 1 mi. from suitable habitat for blasting projects.
Restricted Activities	
Occupied sites Breeding season	"Does the project/activity remove or degrade suitable habitat?". Such activities are designated as "may affect-likely to affect" and requires formal consultation before proceeding.
Non-breeding season	same as under "Breeding season".
Buffer zones Breeding season	- blasting: no blasting within 1 mi. of suitable habitat - motorized equipment: within 0.25 mi. , consultation needed if noise level is above ambient levels, prolonged (>1/2 hr/day), not in a fixed location, not next to a paved road, and outside allowed daily time restriction after 6 August. "Ambient noise levels: defined as volume, duration, and pattern of noise within the range currently generated by existing situations and natural conditions."
Non-breeding season	no restrictions are described for other than suitable habitat outside the breeding season
Other notes	Above regulations are to determine the likelihood of disturbance effects of certain projects and to guide project managers as to the need for further consultations with FWS, they are not restrictions in themselves. Burn projects are to be analyzed separately.

2/1/94

Effects Determination Key for Marbled Murrelet



* Ambient noise levels: Defined as volume, duration, and pattern of noise within the range currently generated by existing situations and natural conditions.

Note:

- No effect does not require consultation
- Not likely to adversely affect determination require written concurrence through informal consultation.
- Likely to adversely affect determination require formal consultation.

Appendix B. Additional regulations and terminology definitions for reduction of disturbance of nesting Marbled Murrelets on Federal lands. Information is from correspondance between agencies to clarify implementation of guidelines. Note that not all subjects listed were covered by these letters and memorandums (indicated by 'not addressed' or 'NA').

	Corresponding Agency			
	U.S. Fish and Wildlife Service		U.S. Forest Service	Redwood National Park
Lands under consideration by the correspondance	Siuslaw National Forest	Redwood National and Del Norte, Jedidiah Smith, and Prairie Creek Redwoods State Parks	Six Rivers, Klamath, Shasta-Trinity, and Mendocino National Forests	Redwood National Park
Documentation	FWS 1995b	USNPS 1994, FWS 1994b, FWS 1994c, FWS 1995c	USFS 1993	USNPS 1994b
Definitions Breeding season / Yearly restrictions	Not addressed	1 April-15 September, with some activities allowed after 1 August after consultation (see FWS 1995c)	5 August-15 September.	NA
Daily time restrictions	2 hrs after sunrise - 2 hrs before sunset, 1 April-15 September	2 hrs after sunrise - 2 hrs before sunset	2 hrs after sunrise - 2 hrs before sunset	NA
Occupied behaviors	NA	NA	NA	NA
Occupied site	NA	All old-growth in park is assumed to be occupied. (no definition given for old-growth)	NA	NA
Suitable habitat	NA	All old-growth within parks. “Near-suitable” and “marginal” terms are used, but not defined	No definition, however the correspondance was concerning "projects in or within 0.25 mi of unsurveyed suitable habitat"	NA
Buffer zones	NA, all sites were assumed to be within the buffer zone	0.25 mi from suitable habitat	NA	NA
Restricted Activities Occupied sites Breeding season	NA	Use of power tools	NA	NA
Non-breeding season	NA	NA	NA	NA

(contd.)

Appendix B (contd.)

	Corresponding Agency			
	U.S. Fish and Wildlife Service		U.S. Forest Service	Redwood National Park
Buffer zones and "suitable habitat" Breeding season	Broadcast burn in adjacent habitat must be accomplished by the end of the first week of the breeding restriction period	In areas of high ambient noise, certain projects may be implemented through entire breeding season after consultation (e.g. year-round elk fence maintenance near headquarters in Orick was exempted). Otherwise, projects are not implemented until after 15 September. Prescribed burns may occur under wind patterns that will vent smoke away from murrelet habitat.	Further clarification of "may, not likely" to effect in suitable habitat: -Allowed activities: limited use of single chainsaws if during daily time restrictions any time of breeding season. Larger machinery with short periods of operations and during daily time restrictions after 5 August (does not apply to felling trees). With high ambient noise levels, this may be reduced to "no effect"	NA
Non-breeding season	NA	No activities which will remove or degrade the habitat	NA	NA
Other notes	Actions outlined are for watershed restoration projects. All sites were assumed to be within buffer zone, and are for those areas that have ≥3 projects within one mile. Recommends that any nest found should be monitored for behavioral response of birds to noise or human disturbance, and that USFWS be informed of the nest.	The parks use the Interagency Guidelines (*Appendix A*) for preliminary analysis of projects that may need consultation	Correspondance relayed information from Mike Horton of USFWS to Forest Supervisors All timber projects with "may effect" determination must be submitted to the Regional Forester with a request for formal consultation with FWS. For non-timber "may effect" projects, individual forests may have informal consultations directly with FWS.	Requires Marbled Murrelet Trainers to have a commercial use license and submit report at end of training classes since the organization is making a profit using federal lands. Aids in keeping track of numbers of people using high-level detection areas.

Appendix C. Regulations and terminology definitions for protection of Marbled Murrelets on lands under Washington state jurisdiction.

Agency	Washington Deptartment of Natural Resources-Forest Practices Division
Lands under this authority	All state and private lands in Washington
Documentation	"Forest Practices Board Emergency Rule" (Washington State Forest Practices Board 1995b); Charles Turley, pers. comm.
Definitions Yearly restrictions / breeding season	"critical nesting season": 1 April-15 August
Daily time restrictions	"daily peak activity": 1 hour before to 2 hours after sunrise & 1 hour before and after sunset
Occupied behaviors	"Flying below, through, into or out of the forest canopy, birds calling from a stationary location within the area, or birds circling above the canopy"
Occupied site	"Contiguous area of suitable habitat" with one or more of the following: nest, downy chick, eggs, egg shells, occupied behaviors (listed above) -or- "contiguous forested area which is not suitable Marbled Murrelet habitat in which any of the behaviors or conditions listed" above "has been documented by the Dept. Fish and Wildlife and which is distinguishable from the adjacent forest based on vegetative characteristics important to nesting Marbled Murrelets"
Suitable habitat	"A contiguous forested area with all of the following characteristics: within 40 miles of marine water"; 8 trees/acre $\geq$ 32" (81 cm.) dbh/acre; 40% $\geq$ 32" dbh with low elevation trees; and $\geq$ 2 platforms/acre
Buffer zones	"Managed buffer zone": 300 $\pm$ 100 ft. adjacent to occupied site with tree stem density of no less than 75 trees per acre with a certain mixture of sizes. "area within 0.25 mi.": area where certain restrictions may apply
Restricted Activities Occupied sites Breeding season	removal of down trees, road construction, operation of heavy equipment, use of aircraft under 1300 ft.
Non-breeding season	timber harvesting or road construction. Removal of down trees allowed with forest practices application.
Buffer zones Breeding season	"managed buffer zone" of 300 ft adjacent to occupied site: use of aircraft under 1300 ft. "area within 0.25 mi.": all times: blasting, slash burning; daily time restrictions, and outside of critical nesting season: harvesting, road construction, operation of heavy equipment, timber hauling, use of aircraft under 1300 ft.
Non-breeding season	none, except that harvest in "managed buffer zone" requires leaving prescribed number and types of trees
Other notes	Final version of Draft Environmental Impact Statement (Washington State Forest Practices Board 1995a) was due out in late spring 1996

Appendix D. Rregulations and terminology definitions for reduction of disturbance of nesting Marbled Murrelets on lands under Oregon state jurisdiction. Note that not all subjects listed were covered by these communications (indicated by 'not addressed' or 'NA').

Agency:	Or. Dept. Forestry-Forest Practices Div.	Or. Dept. Forestry	Or. Dept. Fish and Wildlife
Lands under this authority	All private lands in Oregon	State forest lands managed by Oregon Dept. of Forestry	Overview of all state and private lands in Oregon, including state parks
Documentation	Rod Krahmer, pers. comm.	ODF, in prep.; Clint Smith, pers. comm.	Martin Nugent, pers. comm.
Definitions			
Yearly restrictions / breeding season	"nesting season" based on USFWS regs.	1 April-15 September May vary by site based on monitoring	NA
Daily time restrictions	Not addressed	2 hrs after sunrise & 2 hrs before sunset	NA
Occupied behaviors	NA	"confirmed occupied behavior": As referenced in Ralph et al. 1993, with possible followup verification surveys generally in July	NA
Occupied site or stand	NA	Observations of occupied behaviors, in consideration of other factors such as identified travel corridors, adjacent forest conditions, topography, drainage patterns and site-specific habitat conditions. "Circling behaviors" will be further examined based on height, frequency and potential habitat	NA
Suitable habitat	NA	Suitable habitat: Within 50 miles of coast that contains suitable nesting platforms; ≥5 acres; and mean dbh>18" or, if less, then large residual trees with suitable platforms. Protection definition: MM Management Area: ≥8 trees/ac >32" dbh for Douglas fir forests, or >20" dbh for Spruce/Hemlock forests; ≥40% of trees of above dbh should be Douglas Fir, w. hemlock, Sitka spruce or w. redcedar; ≥2 platforms/ac.	NA
Buffer zones	NA	within 0.25 mi of identified occupied stand	NA

(contd.)

Appendix D. (contd.)

Agency	Or. Dept. Forestry-Forest Practices Div.	Or. Dept. Forestry	Or. Dept. Fish and Wildlife
Restricted Activities Occupied sites Breeding season	NA	not defined	NA
Non-breeding season	If proposed activity is within 300 ft. of roosting or nesting site, then a written plan is required and negotiations take place with O.D. Fish & Wildlife.	Operations involving detrimental habitat modification, such as clearcutting. Some salvage, thinning or partial cutting on site specific basis	NA
Buffer zones Breeding season	NA	All activities are restricted to non-breeding season with the following exception: 6 August-15 September: operations with potential of disturbance (see below under **other notes**) may occur with daily timing restrictions.	NA
Non-breeding season	NA	none	NA
Other notes	No written regulations for private lands. If proposed activity is within 300 ft. of roosting or nesting site, then a written plan is required and negotiations take place with O.D. Fish & Wildlife. Landowner is responsible for compliance with US ESA requirements.	Disturbance: actions that are likely to disrupt reproductive activities: examples are prolonged use (>1 day) of chainsaws, large machinery, explosives; helicopters at low level. Not classified as disturbance: aerial and ground application of chemicals, trapping, fertilization, forage seeding, manual brush cuttting without chainsaws, snag creation by girdling or injection, routine road maintenance, driving or log hauling on established and commonly used roads.	MM "survival guidelines expected out in 1996. Addresses "take", habitat requirements, survey guidelines.

Appendix E. Additional regulations and terminology definitions for reduction of disturbance of nesting Marbled Murrelets on lands under California state jurisdiction. Note that not all subjects listed were covered by these communications (indicated by 'not addressed' or 'NA').

Agency	California Department of Fish and Game	
Lands under this authority	Private and state-owned lands	Big Basin, Richardson Grove, Humboldt, and Grizzly Creek Redwoods State Parks (see also State Parks with Redwood National Park, Appendix B)
Documentation	Timber harvest evaluations: CDFG 1993, USFWS and CDFG 1995, CDFG 1995	Gizinski, pers. comm.; Moore, pers. comm.
Definitions Yearly restrictions / breeding season	1 April-15 September	1 April-15 September
Daily time restrictions	Operations allowed 90 min. after sunrise-90 min. before sunset near travel corridors	Not addressed
Occupied behaviors	below canopy behaviors, also eggshell fragments in area	NA
Occupied site	Area with occupied behaviors	NA
Suitable habitat	"old growth redwood", potential habitat may include partially-harvested areas ("old-growth residuals") (USFWS and CDFG 1995)	NA
Buffer zones	300-ft. vegetation buffer zone and 0.25 mi. noise disturbance buffer.	NA
Restricted Activities Occupied sites Breeding season	no harvest allowed	NA
Non-breeding season	no harvest allowed, but may remove down timber, without damaging existing old-growth, and equipment must remain on existing roads	NA
Buffer zones Breeding season	in 0.25 mi buffer: harvest operations that produce loud noises (tree falling, log bucking, yarding, log loading and hauling, road construction) not allowed. No helicopter use. No harvest of dead, dying, down timber.	NA
Non-breeding season	NA	NA
Other notes	Reduction of refuse (food remains, other garbage) to decrease attraction of predators. "travel corridor"-no definition, but area along watercourse is designated as a corridor to nearby old growth stands (CDFG 1995)	These state parks are under the jurisdiction of Calif. Dept. Fish and Game. Currently no regulations other than park personnel are required to consult with CDFG if any new projects may commence during breeding season.