ATTACHMENT D

U.S. Fish and Wildlife Service
Estimating the Effects of Auditory and Visual Disturbance to Northern Spotted Owls and Marbled Murrelets in Northwestern California.

July 26, 2006

Executive Summary

The issue of project-induced noise disturbance to northern spotted owls and marbled murrelets has drawn increasing attention in recent years, yet remains a complex, controversial, and poorly understood subject. The data available to assess impacts to terrestrial wildlife from these effects are limited, and fewer data yet are specific to these listed species. This guidance document builds upon and consolidates prior efforts (see Appendices) to interpret the limited available data to draw objective conclusions about the potential for these effects to rise to the level of take.

Through this guidance, the US Fish and Wildlife Service (Service) describes behaviors of these two forest species that reasonably characterize when disturbance effects rise to the level of take (i.e., harass), as defined in the implementing regulations of the Endangered Species Act of 1973, as amended (the Act). These behaviors include:

- Flushing an adult or juvenile from an active nest during the reproductive period.
- Precluding adult feeding of the young for a daily feeding cycle.
- Precluding feeding attempts of the young during part of multiple feeding cycles.

We have attempted to provide objective metrics based on a substantial review of the existing literature, as it pertains to these species and appropriate surrogate species. Our recommended methodology relies on a comparison of sound levels generated by the proposed action to pre-project ambient conditions. Disturbance may reach the level of take when at least one of the following conditions is met:

- Project-generated sound exceeds ambient nesting conditions by 20-25 decibels (dB).
- Project-generated sound, when added to existing ambient conditions, exceeds 90 dB.
- Human activities occur within a visual line-of-sight distance of 40 m or less from a nest.

To simplify the analysis of these potential effects, and to promote consistency in interpretation of the analytical results, we established sound level categories of 10-dB increments. The analysis relies on a simple comparison of project-generated sound levels against ambient conditions. Our recommended analysis includes a simple comparison of project and pre-project sound levels within a matrix of estimated distances for which available data support a conclusion of harassment. We provide a real-world example to assist the reader in understanding the correct application of the methodology.

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Finally, we provide additional information the analyst should consider in conducting the analysis, as well as guidance on interpretation the final numbers derived from the analysis. We describe site-specific information that is important to include in project analyses, caution against inappropriate inclusion of information and circumstances not relevant to the results, and provide context to the final interpretation.

Introduction

The issue of elevated sound and visual disturbance of forest wildlife species, especially as it affects the northern spotted owl (owl) and the marbled murrelet (murrelet), has received increased attention in recent years, yet remains a complex, controversial, and poorly understood subject. In an effort to provide objective criteria for determining when disturbance of these species might rise to the level of "take", and to promote consistency in the interpretation of analytical results, the Arcata Fish and Wildlife Office (AFWO) developed the following guidance. The purposes of this guidance are (a) to describe the scientific basis for considering the effects of auditory and visual disturbance to owls and murrelets, and (b) to provide a methodology to simplify the analysis of these effects for the large majority of project circumstances typically encountered in or near owl and/or murrelet habitat.

This guidance attempts to quantify the effects of elevated sound levels and visual proximity of human activities to owls and murrelets, and primarily applies to these species within their suitable forest habitats in northwestern California. It may have some applicability to other forest nesting avian species, but was not developed with other species specifically in mind. Future updates of this guidance may address other forest birds.

This guidance has been developed through an extensive consideration of the available literature, incorporating species-specific information as available, but relying substantially on data from a variety of other surrogate avian species and local applications, as appropriate. This guidance is adapted from information compiled and distributed by the Service's Pacific Region, Office of Technical Support, while allowing for local conditions. Appendices A and B of this document include that information. The reader is referred to those documents for important and extensive background information regarding this issue, methods used to estimate the physical attenuation of sound in the forested landscape, and a complete list of cited material supporting our analysis. However, this guidance is intended to stand alone; the user need not read and digest the extensive appended material to fully implement this guidance.

Behaviors Indicating Harassment

The definition of "take" prescribed by the Act includes "harass". The Act's implementing regulations further define harass as "… an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding or sheltering" [50 CFR §17.3]. Activities that create elevated sound levels or result in close visual proximity of human activities at sensitive locations (e.g., nest trees), have the potential to significantly disrupt normal behavior patterns.

While owls and murrelets may be disturbed by many human activities, we anticipate that such disturbance rises to the level of harassment under a limited range of conditions. For purposes of this guidance, we assume harassment may occur when owls or murrelets demonstrate behavior suggesting that the safety or survival of the individual is at significant risk, or that a reproductive effort is potentially lost or compromised. Examples of this behavior include, but are not limited to:

- An adult or juvenile is flushed from a nest during the incubation, brooding, or fledging period, that potentially results in egg failure or reduced juvenile survival.
- An adult abandons a feeding attempt of a dependent juvenile for an entire daily feeding period, that potentially results in malnutrition or starvation of the young.
- An adult delays feeding attempts of dependent birds on multiple occasions during the breeding season, potentially reducing the growth or likelihood of survival of young.

Other essential behaviors, if disrupted, may also indicate harassment.

We conclude, based on our interpretation of the available literature, that these behaviors may occur when owls or murrelets are subject to elevated sound levels or visual detection of human activities near their active nests or dependent offspring. We interpret the available published data on owls, murrelets and appropriate surrogate species as indicating that the above behaviors may manifest when: (a) the action-generated sound level substantially exceeds (i.e., by 20-25 dB or more as experienced by the animal) ambient conditions existing prior to the project; (b) when the total sound level, including the combined existing ambient and action-generated sound, is very high (i.e., exceeds 90 dB, as experienced by the animal); or (c) when visual proximity of human activities occurs close to (i.e., within 40 m of) an active nest site. Sound levels of lesser amplitude or human presence at farther distances from active nests have the potential to disturb these species, but have not been clearly shown to cause behaviors that meet the definition of harassment. We estimate distances at which conditions (a) and (b) occur by calculating attenuation rates of sound across habitat conditions representative of the forest habitats occupied by owls and murrelets. We describe this calculation in detail in a later section.

These behaviors are difficult to witness or quantify under field conditions. The difficulty associated with documentation of these behaviors, especially in species such as the marbled murrelet that rely on cryptic coloration and behavior to avoid detection, warrants a conservative interpretation of the limited data available on this subject. However, at this time, we have identified only those behaviors associated with active nest sites during the nesting season as potentially indicating harassment.

Sound Level Categories

The analysis of auditory and visual disturbance provided herein relies substantially on a simple comparison of the sound level generated by sources (e.g., chainsaws, dozers, trucks, power tools, etc.) anticipated for use in a proposed action against ambient sound conditions prevalent in the action area prior to implementing the project. The analysis compares the sound level that a nesting owl or murrelet is likely to be subject to as a result of implementing a proposed action against the sound levels to which the species may be exposed under existing, pre-project conditions.

Note that in this guidance we define the "ambient" sound level as that sound environment in existence prior to the implementation of the proposed action, and may include any and all human-generated sound sources when they constitute a long-term presence in the habitat being analyzed. Temporary, short-term sources, even if in effect during or immediately prior to the proposed action, would generally not be considered as part of the ambient but would instead be considered as a separate effect, or considered in combination with the sources from the proposed action. A special case of ambient is the "natural ambient", which includes sound sources native to the forested habitat being considered, such as wind in trees, bird calls, and distant water flow. Human-generated, "white noise" sources, such as a distant highway, may also be part of the natural ambient if (a) distant to the area being considered, (b) relatively low in volume (i.e., <50 dB), and (c) relatively uniform in sound level over the area of consideration. Ambient sound should be estimated based on typical sources experienced on a daily or more frequent basis. For other than "natural ambient", sources are generally located within or near the footprint of the proposed action.

The analytical comparison is provided graphically in Table 1. However, before discussing the methodology incorporated into this table, and the interpretation of numeric values derived from its use, we define and describe the sound level categories used in this analysis. We created sound level categories of 10-dB increments as a means to simplify the analysis. Each sound level category is described in terms of the conditions, equipment, tools, and other sound sources common to the particular level.

The following subsections provide concise descriptions of sound levels typically encountered under pre-project ambient conditions or during project implementation (including post-project use, if future use of the project area results in a long-term alteration of the sound/visual environment). Each description includes the decibel range, a general description, and examples of equipment or tools that typify that sound environment. Measurements and estimates from a broad range of tools and equipment are provided for reference purposes in Table 2.

It should be noted that many tools and equipment demonstrate a range of sound production substantially wider than the 10-dB sound level categories provided here. That range of sound production represents the inherent variability among similar sources, and the variation that typically occurs among measurements of even identical sources. This can easily be seen in a cursory examination of Table 2. When the range of sound measures for a source exceed the 10-dB range of a single sound level category, the analyst should consider the sound source in the context of other sources typical to the proposed activity. For example, chain saws used in timber harvest operations would include those in the higher sound measures, and would not include lower sound levels more representative of homeowner applications. In a related issue, the sound of small trees being felled is not anticipated to be substantially higher than the sound of the saws and other activities. However, the felling of larger trees may exceed the sound of the equipment used to fall and yard them; we have addressed this situation in the sound level descriptions.

We have attempted to create categories here that include similar sound sources, and have generally applied more median values (that is, we have discounted outliers) where multiple values for similar sound sources are encountered. While there may be exceptions within and among these categories, we have attempted to address this variability through an otherwise conservative approach to estimating distances at which harassment behaviors may manifest.

Natural Ambient: Refers to ambient sound levels (generally < 50 dB) typically experienced in owl or murrelet habitat not substantially influenced by human activities, and includes sources native to forest habitats. Human-generated "white noise", such as from a *distant* highway, may apply when < 50 dB and relatively uniform across the action area.

Very Low: Typically 50-60 dB, and generally limited to circumstances where human-generated sound would never include amplified or motorized sources. Includes forest habitats close to less-frequently encountered natural sources, such as rapids along large streams, or wind-exposure, and may include quiet human activities such as nature trails and walk-in picnic areas.

Low: Typically 61-70 dB, and generally limited to sound from small power tools, light vehicular traffic at slow speeds on paved surfaces, non-gas-powered recreational activities, and residential activities, such as those associated with small parks, visitor centers, bike paths, and residences. Includes most hand tools and battery operated, hand-held tools.

Moderate: Typically 71-80 dB, generally characterized by the presence of passenger vehicles and street-legal motorcycles, small trail cycles (not racing), small gas-powered engines (e.g., lawn mowers, *small* chain saws, portable generators), and high-tension power lines. Includes electric hand tools (except circular saws, impact wrenches and similar).

High: Typically 81-90 dB, and would include medium- and large-sized construction equipment, such as backhoes, front end loaders, large pumps and generators, road graders, dozers, dump trucks, drill rigs, and other moderate to large diesel engines. Would include high speed highway traffic including RVs, large trucks and buses, large street legal and trail (not racing) motorcycles. Also includes power saws, large chainsaws, pneumatic drills and impact wrenches, and large gasoline-powered tools.

Very High: Typically 91-100 dB, and is generally characterized by impacting devices, jackhammers, racing or Enduro-type motorcycles, compression ("jake") brakes on large trucks, and trains. This category includes both vibratory and impact pile drivers (smaller steel or wood piles) such as used to install piles and guard rails, and large pneumatic tools such as chipping machines. It may also include largest diesel and gasoline engines, especially if in concert with other impacting devices. Felling of large trees (defined as dominant or subdominant trees in mature forests), truck horns, yarding tower whistles, and muffled or underground explosives are also included.

Extreme: Typically 101-110 dB. Generally includes use of ground-level, unmuffled explosives, pile driving of large steel piles, low-level over flights or hovering of helicopters, and heavily amplified music.

Sound Levels Exceeding 110 dB: These sound levels, typified by sources such as jet engines and military over flights, large sirens, open air (e.g., treetop) explosives, and double rotor logging helicopters, are special situations requiring site- and situation-specific analysis, and are not covered by the analytical methods provided herein.

Derivation of Harassment Distances

As indicated earlier, available data suggest that harassment occurs when sound levels resulting from project-based sound sources exceed ambient conditions by relatively substantial levels, or when those sound sources exceed a high absolute threshold. Since sound attenuates as a function of the distance from the source (within typical forest habitat, at a rate of approximately 6 dB per doubling of distance from a point source), the analyst can estimate the distance at which various sound sources exceed ambient conditions by anticipated threshold values. We estimated these distances using a spreadsheet model that simulates sound attenuation in typical forest habitats, reasonably accounting for ambient environmental conditions and sound source characteristics. As a means of simplifying the analysis process, we used reasonable median sound values within the above-described categories for both source and ambient sound conditions. Table 1 reports the distances within which elevated, project-generated sound is reasonably expected to exceed ambient conditions to such a degree as to result in harassment of murrelets or owls. The reader is referred to Appendices 1 and 2 and their references for additional, detailed discussion of sound metrics and the model used to derive these distances.

Time of Day Adjustment for the Marbled Murrelet

The disturbance take threshold distances provided in Table 1 are based on a comparison of project generated sound levels with existing (ambient) sound levels, which themselves represent average daytime sound conditions. We recognize, however, that ambient sound level often has a substantial time-of-day component, with nighttime, dawn and dusk ambient sound levels generally 5-10 dB lower than typical midday levels (see Appendix A *in* EPA 1974). It is also known that murrelet flights into nests to feed nestlings and for nest-tending exchanges are concentrated around dawn and dusk (Nelson and Hamer 1995), during the period when ambient noise levels tend to be lower than average daytime levels (EPA 1974).

Therefore, for marbled murrelets, the harassment threshold distances provided in Table 1 apply to noise-generating activities occurring during the midday period, when the risk of harassment is lower. Specifically, for murrelets, the harassment distances in Table 1 apply to noise-generating activities that are not within 2 hours of sunrise or sunset. If proposed activities will occur within 2 hours of sunrise or sunset, and if the ambient sound environment during the dawn and dusk period can reasonably be expected to be 5 dB or more quieter than the midday sound environment, then the estimated harassment distance threshold should be calculated based on an ambient level 10 dB lower (i.e., one row up in the table) compared to the normal ambient rating in Table 1. In some cases, this will result in a larger harassment threshold distance. This time-of-day measure provides a more consistent application of the threshold criteria to the known biology of the murrelet and the anticipated sound environment during dawn and dusk periods.

Similar time-of-day considerations and adjustments are not required for the northern spotted owl.

Application of Harassment Distances to Project Conditions

The following methodology may be used to estimate the approximate distance at which project-generated sound exceeds ambient conditions to such an extent that northern spotted owls or marbled murrelets may be subject to harassment due to sound or visual disturbance.

Step 1: The analyst reviews the environment in the action area to determine the existing ambient sound level. The analyst should include any sound sources occurring in the action area, prior to and not part of the proposed action, that create ambient sound levels higher than the "natural" background. For example, if the proposed action would add a passing lane to a high-use major highway, the ambient condition should include the existing traffic and maintenance on the highway itself, in addition to other sounds native to the adjacent forest environment. As a second example, a proposed action to maintain a remote hiking trail would not include sound sources other than the "natural background" and infrequent human use as part of the existing ambient. Based on this review, the analyst assigns a sound level category to the ambient condition (equivalent to a row of Table 1).

Step 2: The analyst reviews the proposed action to determine the types of equipment, tools, etc., anticipated to be used during the project. Based on the descriptions of sound level categories, above, the analyst assigns a sound level category to the action-generated sound sources (corresponding to the columns in Table 1). Action-generated sound sources should include all major sources necessary to complete the proposed action. When project-specific sound measures are not available, the reader should refer to Table 2 for typical values for equipment, tools, and other sound sources. For projects where distinctly different sound environments (for either ambient or action-generated) may occur within the overall action area, the analyst may complete separate analyses for each distinct sound environment.

Step 3: From Table 1, the analyst finds the cell corresponding to the appropriate row and column for existing ambient sound and action-generated sound, respectively. This cell provides an estimate of the distance within which increased sound level may harass an owl or murrelet. The cell values are generally reported as a distance from the outer edge of the project footprint into occupied or presumed occupied suitable habitat, unless site-specific information indicates sound sources may be more localized within the project footprint (see also "Other Considerations", below).

Step 4: When significant topographic features occur within the sound environment, appropriate consideration may be given to their sound attenuating capabilities. However, the analyst should have a full understanding of the effects of topography on sound attenuation, especially when the species involved typically nests at a substantial distance above the ground. That is, topography may substantially attenuate sound between the source and the receiver (i.e., owl or murrelet nest site) when that topographic barrier is sufficiently high to block line-of-sight transmission between the source and receiver. For species such as owls and murrelets that normally nest high in tall trees, topography or other barriers provide little attenuation unless very close to the sound source, or very high.

Step 5: Consider the potential for human activities within 40 m of nest branches of owls or murrelets. If no known or likely nest tree, or flight path to the nest itself, occurs this close to the visual disturbance sources, there would be no visual disturbance of owls or murrelets anticipated. Otherwise, assume visual harassment for up to 40 m from human activities.

Table 1. Estimated harassment distance due to elevated action-generated sound levels for proposed actions affecting the northern spotted owl and marbled murrelet, by sound level.

Existing (Ambient) Pre-Project Sound Level (dB)[1,2]	Anticipated Action-Generated Sound Level (dB)[2, 3]			
	Moderate (71–80)	High (81–90)	Very High (91–100)	Extreme (101–110)
"Natural Ambient"[4] (≤50)	50 (165)[5,6]	150m (500)	400m (1,320)	400m (1,320)
Very Low (51–60)	0	100 (330)	250 (825)	400 (1,320)
Low (61–70)	0	50 (165)	250 (825)	400 (1,320)
Moderate (71–80)	0	50 (165)	100 (330)	400 (1,320)
High (81–90)	0	50 (165)	50 (165)	150 (500)

[1]Existing (ambient) sound level includes all natural and human-induced sounds occurring at the project site prior to the proposed action, and are not causally related to the proposed action.
[2]See text for full description of sound levels.
[3]Action-generated sound levels are given in decibels (dB) experienced by a receiver, when measured or estimated at 15.2 m (50 ft) from the sound source.
[4]"Natural Ambient" refers to sound levels generally experienced in habitats not substantially influenced by human activities.
[5]All distances are given in meters, with rounded equivalent feet in parentheses.
[6]For murrelets, activities conducted during the dawn and dusk periods have special considerations for ambient sound level. Refer to text for details

Example Analysis

The following example is provided to assist the reader in understanding the application of this recommended methodology to a hypothetical yet typical project circumstance.

Proposed Project: An agency proposes to construct an informational kiosk, restroom, and six graveled parking slots at an existing, undeveloped, trailhead parking area along a low-speed (<45 mph), paved road closed to large trucks and buses. The footprint of the proposed project is a roughly circular area of approximately 75-foot diameter (about 1/10 acre). The surrounding forest is suitable nesting habitat for marbled murrelets, and the agency proposes to do construction during the nest season. Topography in the action area is low rolling ridges less than 50 feet high. No other sound sources of significance are located nearby. The construction project will not remove any large trees, but requires the use of several pieces of equipment (e.g., backhoe, dump truck), as well as smaller power equipment (e.g., saws, cement mixer, portable generator, small chain saw) and hand tools. No jackhammering, pile driving, or larger diesel equipment is needed. The agency agrees to conduct all on-site activities during the midday time period between 2 hours after sunrise to 2 hours before sunset.

Analysis: The ambient sound level at the proposed kiosk includes the existing passenger vehicle/light truck traffic on a paved surface immediately adjacent to the work area, and existing human presence of hikers. Using the above-described sound level categories, this ambient sound level classifies as "low" (61-70 dB). The large construction equipment (i.e., the backhoe and truck) are the greatest sources of increased sound to be considered here, as they exceed the level of the other tools. From the above-described sound levels, we anticipate that action-generated sound levels will fit into the "high" category (81-90 dB). Choosing the appropriate row (Ambient = Low) and column (Action-generated = High) in Table 1, we estimate that disturbance may rise to the level of harassment over an area within 50 m (165 ft) from the footprint of the project. Since all activities will be conducted during the mid-day period, no further adjustment of the tabled value to account for murrelet activity periods is necessary. This 50-m distance, when used as a buffer around the project footprint, results in an estimate of 2.9 acres (1.2 ha) subject to harassment from auditory disturbance. Large potential nest trees exist immediately adjacent to the work area, so visual harassment may also be a consideration. However, human presence already occurs at the trailhead on a daily basis, and the proposed project will not substantially alter that effect. The topographic features in the action area are unlikely to further attenuate any sound experienced by murrelets, which commonly nest more than 50 feet above ground level. Since construction of the kiosk and restroom would not appreciably change the effects of the existing roadway or parking area, the duration of effects would be for a single breeding season, and would not alter effects already at the site in future years.

Interpretation and Application of the Results

The estimated harassment distance resulting from the analysis of any particular project conditions requires careful interpretation. Although seemingly precise, the reported distance represents a reasonable *approximation* of the distance wherein "the likelihood of injury" occurs, as supported by currently available data. That is, the resultant number estimates the distance within which available disturbance data on owls or murrelets (or surrogate species, as appropriate) show that at least some individuals would demonstrate one or more behaviors indicating harassment as a result of anticipated sound levels or visual detection of human activities near nest sites. Given the many sources of variability in such an analysis, such as differences in individual bird response, variation in actual sound level produced by similar sources, variability in sound transmission during daily weather patterns, and non-standardization in sound metrics reported in the published literature, exact estimates of harassment distances are currently infeasible, and likely will remain so.

It is reasonable to assume that owls or murrelets closer to sources of disturbance have a higher likelihood of suffering significant disruption of normal behavior patterns than those at the outer limits of the estimated harassment distance, due to louder sound levels or a visually closer perceived threat to the nest. Further, not all owls or murrelets, except those in the very closest proximity to the disturbance source, may respond to a degree indicating harassment. Thus, the likelihood of injury for any particular individual would range from some low proportion to a higher value depending on its actual proximity to a particular sound/visual source. It is neither reasonable nor necessary for purposes of analysis and estimation of take to predict that all (or even a high proportion of) owls or murrelets within this distance show harassment behaviors. Conversely, it is also unreasonable to conclude that owls or murrelets beyond this distance would never be harassed. A more supportable interpretation is that currently available information does not support a conclusion that owls or murrelets more distant to the anticipated sound/visual disturbances are likely to suffer a significant disruption of normal behavior patterns.

The reporting of take associated with auditory and visual disturbances is necessary, even if somewhat imprecise. It is appropriate to consider all reasonable means to minimize take including, but not limited to, seasonal restrictions and substitution of equipment type to reduce the likelihood of injury, so long as those means are consistent with the “minor change rule” [50 CFR §402.14 (i)(2)]. When considering measures to reduce the effects of harassment, the analyst should bear in mind not only the spatial extent of the disturbance, but also the timing and duration of the disturbance.

Finally, activities which result in estimated distances of zero meters would be expected to have no effect on either owls or murrelets. Activities resulting in estimates of 50 m or less may, under some circumstances, be considered not likely to adversely affect, due in part to the species preference of nesting high up in large trees. However, the analyst should be prepared to describe and justify reasons for these findings.

Other Considerations

This guidance does not consider the direct effects of predation by corvids (ravens, crows and jays) and other predators as a result of human activities in murrelet and owl habitat. That is, while corvids may increase in number in murrelet and owl habitat in response to human activities, the resulting increased take due to predation (injury) is not addressed here. Distance estimates reported in this guidance reflect only the effects of sound attenuation and visual detection on behaviors appropriately interpreted as harassment. We have considered predation only in the sense that detection of the nest as a result of owl or murrelet harassment behavior (e.g., flushing from the nest) may increase the risk of predation, regardless of density of predators, and thus represents a “likelihood of injury.”

This analytical method addresses most forest habitat conditions that affect the attenuation rate of sound (and thus the level of sound detected by the owl or murrelet at its location). These conditions include dampening effects of forest vegetation, variability in natural ambient sound typically encountered under forest conditions, use of multiple pieces of identical equipment, and the effect of elevated nest sites on sound attenuation. Departure from the tabled values in this guidance to account for special forest conditions is generally inappropriate except under highly unusual circumstances. A factor *not* considered in this methodology is the effect of topography on sound attenuation. Therefore, a site-specific assessment of topography should be considered. Steep slopes, ridges, and designed sound barriers may increase sound attenuation when they form complete barriers to the direct line of sound transmission between source and the location of the receiver (here, the actual location of the potentially harassed animal). In general, small ridges or walls not clearly blocking the sources from a highly elevated nest would provide little or no attenuation. When clearly supported by site-specific information regarding topography, action-generated sound may be reduced by one or two levels in the analysis, when compared to existing ambient sound levels.

For some projects, elevated sound levels may cease following completion of the project. For example, sound level following the completion of timber harvest is likely to return to pre-harvest levels, and so would not result in long-term or permanent sound and visual disturbance to owls and murrelets. On the other hand, actions such as the creation of a new road may result in elevated sound levels both during construction and during future use and maintenance of the road. The analyst should carefully consider both spatial and temporal aspects of noise and visual disturbance for each project.

Activities producing sound levels of 70 dB or less (estimated at 15.2 m from the sources), such as use of hand tools, small hand-held electric tools, or non-motorized recreation, would not generally rise to the level of harassment, except in certain circumstances, such as when used in very close proximity (i.e., <25 m) to an active nest. However, under these circumstances, visual detection of human activities by the species near its nest is assumed to be of more consequence than auditory disturbance, and take should be described in such terms.

Activities producing sound levels greater than 110 dB (estimated at 15.2 m from the sources), such as open-air blasting, aircraft, or impact pile-driving, are not addressed in this analysis, and should be evaluated through a more detailed site-specific analysis.

Table 2. Some Common Sound Levels for Equipment/Activities.

	Range of Reported dB Values @ Distance Measure *(Distance measured @ 50 ft (15.2 m) unless otherwise indicated)*		
Measured Sound Source	**Reported Decibel Value**	**"Standardized" Value @ 50 ft [/1]**	**Relative Sound Level [/2]**
Quiet Whisper	30 @ 3 ft	6	Ambient
Ambient Sound Level - Forest Habitats (low end[/3])	25	25	Ambient
Library (ambient sound level)	30 @ ambient	30	Ambient
Conversation (low end)	55 @ 1 m	31	Ambient
Conversation (high end[/4])	62 @ 2 ft	34	Ambient
Conversataion	60 @ 3 ft	36	Ambient
Speech (normal)	65 @ 1 m	41	Ambient
Ambient Sound Level - Forest Habitats (high end)	43.8	44	Ambient
Home Vacuum Cleaner	70 @ 1 m	46	Very Low
Loud Singing	75 @ 3 ft	51	Very Low
Generator (light home/recreational, 900-2,800 W)	59 @ 7 m	52	Very Low
Air Conditioner Window Unit	60 @ 25 ft	54	Very Low
Generator (light commercial, 4,000-5,000 W) (low end)	61 @ 7 m	54	Very Low
Pickup Truck (idle) (low end)	55	55	Very Low
Garbage Disposal (low end)	80 @ 1 m	56	Very Low
Garbage Disposal (high end)	80 @ 3 ft	57	Very Low
Generator (light commercial, 4,000-5,000 W) (high end)	65 @ 7 m	58	Very Low
Conversation (indoor)	60	60	Very Low
Chain Saw Running (rain) (low end)	61	61	Low
Food Blender (low end)	85 @ 1 m	61	Low
Generator (heavy home, 3,300-5,500 W) (low end)	68 @ 7 m	61	Low
Generator (light industrial, 2,600-9,500 W) (low end)	68 @ 7 m	61	Low
Milling Machine	83 @ 4 ft	61	Low
Pickup Truck (idle) (high end)	77 @ 8 ft	61	Low
Motorcycle on Trail (620 cc street legal, meter at ground level)	61.9	62	Low
Powerline	50 @ 200 ft	62	Low
Chainsaw (Stihl 025)	46 @ 105 m	63	Low
Generator (economic home, 2,300-4,500 W) (low end)	70 @ 7 m	63	Low
Street Motorcycles < 100 cc (low end)	65	65	Low
Motorcycle on Trail (100 cc, 2-stroke, meter at ground level)	65.7	66	Low
Chainsaw (McCulloch Promac 260, low end)	46.1 @ 150 m	66	Low
Chainsaw (Stihl 025, low end)	53.8 @ 60 m	66	Low
Food Blender (high end)	90 @ 3 ft	66	Low
Motorcycle on Trail (620 cc street legal, meter elevated 15 m)	66.6	67	Low
Generator (welding, 4,000 W)	74 @ 7 m	67	Low
Passenger Car (50 mph)	67	67	Low
Passenger Car (60 kph)	65 @ 20 m	67	Low
Generator (heavy home, 3,300-5,500 W) (high end)	75 @ 7 m	68	Low
Generator (medium commercial, 6,000 W)	75 @ 7 m	68	Low
Power Lawn Mower	92 @ 1 m	68	Low
Motorcycle on Trail (100 cc, 2-stroke, meter elevated 15 m)	68.1	68	Low
Generator (economic home, 2,300-4,500 W) (high end)	76 @ 7 m	69	Low
Chainsaw (McCulloch Promac 260)	59.9 @ 50 m	70	Low
Generator (25 KVA or less)	70	70	Low
Yelling	92 @ 4 ft	70	Low
Pickup Truck (driving)	87 @ 8 ft	71	Moderate
Motorcycle on Trail (300 cc, 2-stroke, meter at ground level)	71.3	71	Moderate
Chainsaw (McCulloch Promac 260)	61.3 @ 50 m	72	Moderate
Gas Lawn Mower	96 @ 1 m	72	Moderate

Measured Sound Source	Reported Decibel Value	"Standardized" Value @ 50 ft [1]	Relative Sound Level [2]
Mowers, leaf blowers (low end)	72	72	Moderate
Chainsaw (Stihl 025, high end)	60.5 @ 60 m	73	Moderate
Generator (light industrial, 2,600-9,500 W) (high end)	80 @ 7 m	73	Moderate
Street Motorcycles 350-749 cc (low end)	73	73	Moderate
Welder	73	73	Moderate
Automobile	80 @ 25 ft	74	Moderate
Jackhammer (muffled)	74	74	Moderate
Pile Driving (1999 ODOT Study, low end)	74	74	Moderate
Roller (low end)	74	74	Moderate
Street Motorcycles >= 750 cc (low end)	74	74	Moderate
Chain saws (low end)	75	75	Moderate
Off-Road Motorcycles < 100 cc (low end)	75	75	Moderate
RVs (small) (low end)	75	75	Moderate
Concrete Vibrator	76	76	Moderate
Passenger Cars/Light Trucks (65 mph) (low end)	76	76	Moderate
Flatbed Pickup Truck	93 @ 8 ft	77	Moderate
Log Truck	67 @ 46 m	77	Moderate
Pump (low end)	77	77	Moderate
Street Motorcycles 170-349 cc (low end)	77	77	Moderate
BPA Powerline	66 @ 200 ft	78	Moderate
Generator (low end)	78	78	Moderate
Off-Road Motorcycles 100-169 cc (low end)	78	78	Moderate
Street Motorcycles 100-169 cc (low end)	78	78	Moderate
Backhoe	69 @ 46 m	79	Moderate
Off-Road Motorcycles 170-349 cc (low end)	79	79	Moderate
Motorcycle on Trail (300 cc, 2-stroke, meter elevated 15 m)	79.6	80	Moderate
Backhoe (low end)	80	80	Moderate
Boat motors (low end)	80	80	Moderate
Cat Skidder	70 @ 46 m	80	Moderate
Chainsaw (McCulloch Promac 260, high end)	59.5 @ 150 m	80	Moderate
Compressor (low end)	80	80	Moderate
Concrete Mixer (low end)	80	80	Moderate
Front-end Loader (low end)	80	80	Moderate
Ground Compactor (low end)	80	80	Moderate
Horizontal Boring Hydraulic Jack	80	80	Moderate
Medium Construction (low end)	80	80	Moderate
Medium Trucks & Sport Vehicles (65 mph) (low end)	80	80	Moderate
Paver (low end)	80	80	Moderate
Rock Drill and Diesel Generator (low end)	58 @ 200 m	80	Moderate
Roller (high end)	80	80	Moderate
Vacuum Street Sweeper	80	80	Moderate
Cat Skidder	59 @ 200 m	81	High
Concrete Truck (low end)	81	81	High
Off-Road Motorcycles < 100 cc (high end)	81	81	High
Pumps, generators, compressors (low end)	81	81	High
Concrete Pump	82	82	High
Dump Truck Dumping Rock	72 @ 46 m	82	High
Ground Compactor (high end)	82	82	High
Rock Drills and Jackhammers (low end)	82	82	High
Slurry Machine (low end)	82	82	High
Street Motorcycles < 100 cc (high end)	82	82	High
Train	90 @ 20 ft	82	High
Chainsaw, large	73 @ 46 m	83	High

Measured Sound Source	Reported Decibel Value	"Standardized" Value @ 50 ft [1]	Relative Sound Level [2]
Chainsaw, large	61 @ 200 m	83	High
Concrete Batch Plant	83	83	High
Dump Truck Dumping Rock	54 @ 400 m	83	High
General construction (low end)	83	83	High
Highway Traffic (uphill, discontinuous traffic, wet)	61 @ 200 m	83	High
Log Loader	73 @ 46 m	83	High
Power Mower	107 @ 3 ft	83	High
Road Grader (low end)	83	83	High
Backhoe (high end)	84	84	High
Dozer (low end)	84	84	High
Dump Truck	84	84	High
Flat Bed Truck	84	84	High
Generator (high end)	84	84	High
Heavy Construction (low end)	84	84	High
Large Truck (low end)	84	84	High
Motorcycle	88 @ 30 ft	84	High
Motorcycle Enduro Event	62.3 @ 180 m	84	High
Pile Driving (1987 WDOT Study, low end)	84	84	High
Rock Drill and Diesel Generator (low end)	55 @ 400 m	84	High
Motorcycle on Trail (200 cc, 2-stroke, meter at ground level)	84.5	85	High
5 Motorcycles	67 @ 120 m	85	High
Auger Drill Rig	85	85	High
Concrete Mixer (high end)	85	85	High
Concrete Truck (high end)	85	85	High
Crane (low end)	85	85	High
Diesel Truck (40 mph)	85	85	High
Drill Rig (low end)	85	85	High
Dump Truck	63 @ 200 m	85	High
Equipment > 5 horsepower	85	85	High
Gradall (low end)	85	85	High
Highway Traffic (uphill, discontinuous traffic, wet)	75 @ 46 m	85	High
Impact Wrench	85	85	High
Large Tree Falling	63 @ 200 m	85	High
Log Loader	63 @ 200 m	85	High
Mounted Impact Hammer Hoe-Ram (low end)	85	85	High
Mowers, leaf blowers (high end)	85	85	High
Passenger Cars/Light Trucks (65 mph) (high end)	85	85	High
Pump (high end)	85	85	High
Road Grader (high end)	85	85	High
Rock Drill (low end)	85	85	High
RVs (large) (low end)	85	85	High
RVs (small) (high end)	85	85	High
Scraper (low end)	85	85	High
23 ft Detonation Cord, on surface (low end)	80 @ 100 ft	86	High
Chain saws (high end)	86	86	High
Chainsaw (Cantor, one chainsaw running)	86	86	High
Dump Truck Dumping Rock	64 @ 200 m	86	High
Gradall (high end)	86	86	High
Large Diesel Engine	100 @ 10 ft	86	High
Motorcycle Enduro Event	68.4 @ 120 m	86	High
Pneumatic wrenches, rock drills (low end)	86	86	High
Rock Drill and Diesel Generator (high end)	64 @ 200 m	86	High
12 ft Detonation Cord, buried (low end)	66 @ 580 ft	87	High

Measured Sound Source	Reported Decibel Value	"Standardized" Value @ 50 ft [/1]	Relative Sound Level [/2]
Diesel Truck (50 kph)	85 @ 20 m	87	High
Front-end Loader (high end)	87	87	High
Hydromulcher (low end)	71 @ 300 ft	87	High
Pumps, generators, compressors (high end)	87	87	High
Crane (high end)	88	88	High
Dozer (high end)	88	88	High
Drill Rig (high end)	88	88	High
Off-Road Motorcycles 350-750 cc (low end)	88	88	High
Street Motorcycles 100-169 cc (high end)	88	88	High
Motorcycle on Trail (200 cc, 2-stroke, meter elevated 15 m)	88.2	88	High
5 Motorcycles	55 @ 760 m	89	High
Chainsaw (Cantor, two chainsaws running)	89	89	High
General construction (high end)	89	89	High
Jackhammer	89	89	High
Large Truck (high end)	89	89	High
Medium Construction (high end)	89	89	High
Medium Trucks & Sport Vehicles (65 mph) (high end)	89	89	High
Motorcycle Enduro Event	73.3 @ 90 m	89	High
Paver (high end)	89	89	High
Scraper (high end)	89	89	High
Street Motorcycles 350-749 cc (high end)	89	89	High
Chain Saw Running (rain) (high end)	80 @ 150 ft	90	High
Compressor (high end)	90	90	High
Concrete Saw	90	90	High
Heavy Trucks and Buses (low end)	90	90	High
Hydra Break Ram	90	90	High
Mounted Impact Hammer Hoe-Ram (high end)	90	90	High
Circular Saw (hand held)	115 @ 1 meter	91	Very High
Highway Traffic (downhill, discontinuous traffic, wet)	81 @ 46 m	91	Very High
Motorcycle Enduro Event	78.8 @ 60 m	91	Very High
Pneumatic Chipper (low end)	115 @ 1 m	91	Very High
Pneumatic Riveter	115 @ 3 ft	91	Very High
Slurry Machine (high end)	91	91	Very High
Track Hoe (low end)	75 @ 300 ft	91	Very High
Highway Traffic (downhill, discontinuous traffic, wet)	70 @ 200 m	92	Very High
Large Tree Falling	82 @ 46 m	92	Very High
Motorcycle Enduro Event	85.8 @ 30 m	92	Very High
Chainsaw	117 @ 3 ft	93	Very High
Clam Shovel	93	93	Very High
Railroad (low end)	93	93	Very High
Street Motorcycles >= 750 cc (high end)	93	93	Very High
Explosives (low end)	94	94	Very High
Hydromulcher (high end)	88 @ 100 ft	94	Very High
Jake Brake on Truck	110 @ 8 ft	94	Very High
Boat motors (high end)	95	95	Very High
Guardrail Installation and Pile Driving (low end)	95	95	Very High
Heavy Trucks and Buses (high end)	95	95	Very High
Impact Pile Driver (low end)	95	95	Very High
Off-Road Motorcycles 350-750 cc (high end)	95	95	Very High
Pneumatic Chipper (high end)	115 @ 5 ft	95	Very High
RVs (large) (high end)	95	95	Very High
Vibratory (Sonic) Pile Driver (low end)	95	95	Very High
Diesel Truck	100 @ 30 ft	96	Very High

Measured Sound Source	Reported Decibel Value	"Standardized" Value @ 50 ft [1]	Relative Sound Level [2]
Heavy Construction (high end)	96	96	Very High
Jet Overflight (low end)	80 @ 300 ft	96	Very High
Vibratory (Sonic) Pile Driver (high end)	96	96	Very High
Logging Truck	97	97	Very High
Pneumatic wrenches, rock drills (high end)	97	97	Very High
Rock Drills and Jackhammers (high end)	97	97	Very High
Street Motorcycles 170-349 cc (high end)	97	97	Very High
Door Slamming	98	98	Very High
Dump Truck	88 @ 46 m	98	Very High
Pile Driving (1999 ODOT Study, low end)	98	98	Very High
Railroad (high end)	98	98	Very High
Rock Drill (high end)	98	98	Very High
Helicopter S-61 (large, single rotor, loaded) (low end)	79 @ 500 ft	99	Very High
Rock Drill and Diesel Generator (high end)	70 @ 400 m	99	Very High
Off-Road Motorcycles 100-169 cc (high end)	100	100	Very High
Off-Road Motorcycles 170-349 cc (high end)	100	100	Very High
Rock Drill and Diesel Generator	90 @ 46 m	100	Very High
Exterior Cone Blast w/ sand bags (low end)	72 @ 0.25 mi	101	Extreme
Helicopter S-61 (low end)	77 @ 800 ft	101	Extreme
Impact Pile Driver (high end)	101	101	Extreme
Pneumatic tools, jackhammers & pile driver (low end)	101	101	Extreme
Amplified Rock and Roll	120 @ 6 ft	102	Extreme
Helicopter S-61 (large, single rotor, loaded) (high end)	82 @ 500 ft	102	Extreme
Pile Driving (1987 WDOT Study, high end)	103	103	Extreme
Truck Horn	120 @ 8 ft	104	Extreme
Guardrail Installation and Pile Driving (high end)	105	105	Extreme
23 ft Detonation Cord, on surface (high end)	85 @ 580 ft	106	Extreme
Impact Pile Driving	106	106	Extreme
Track Hoe (high end)	96 @ 150 ft	106	Extreme
Columbia double rotor logging helicopter (reading from road)	79 @ 400 m	108	Extreme
Pave Hawk Military Helicopter	92 @ 105 m	109	Extreme
Columbia double rotor logging helicopter (read in forest)	100 @ 46 m	110	Extreme
Pneumatic tools, jackhammers & pile driver (high end)	110	110	Extreme
12 ft Detonation Cord, buried (high end)	92 @ 500 ft	112	Extreme
Helicopter S-61 (high end)	106 @ 100 ft	112	Extreme
Rock Blast	91 @ 575 ft	112	Extreme
Columbia double rotor logging helicopter (reading from road)	84 @ 400 m	113	Extreme
Engine Exhaust (no muffler)	140 @ 3 ft	116	Extreme
Military Flight (low end)	98 @ 500 ft	118	Extreme
Exterior Cone Blast w/ sand bags (high end)	100 @ 500 ft	120	Extreme
Treetop Blast (low end)	110 @ 200 ft	122	Extreme
Columbia double rotor logging helicopter (read at clearing)	101 @ 200 m	123	Extreme
Jet Overflight (high end)	86 @ 4,000 ft	124	Extreme
Exterior Cone Blast (obstructed)	107 @ 500 ft	127	Extreme
Jet takeoff	120 @ 200 ft	132	Extreme
50 HP Siren	130 @ 100 ft	136	Extreme
Jet Plane	130 @ 100 ft	136	Extreme
Treetop Blast (high end)	116 @ 0.1 mi	137	Extreme
Military Flight (high end)	120 @ 600 ft	142	Extreme
Explosives (high end)	145 @ 330 ft	162	Extreme

[1] "Standardized" values are sound levels converted to 50-foot equivalents (i.e., as though measured at 50 feet distance from source). For comparison purposes.

/2 Relative Sound Level: a general, subjective ranking of relative noise levels created by the sources considered here,when used for analysis of relative noise effects on species.

/3 "Low end" indicates the lower value when a range of values is reported for a sound source.

/4 "High end" indicates the higher value when a range of values is reported for a sound source.

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