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Prioritization of Threatened and Endangered Species Sound Research on Army Installations

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Executive Summary

This report represents the first year of a continuing study addressing the effects of military training sound on Threatened and Endangered Species (TES). The purpose of this study was to prioritize specific TES of concern from the U.S. Army Environmental Requirement and Technology Assessment (AERTA) species list.

The primary objective for this project was to develop a prioritized list of TES for future sound research relative to military training sound effects. From these recommendations, future sound research could be developed, initiated, and established with the goal of protecting TES, while also allowing Department of Defense (DoD) installations to train to standard and maintain operational readiness.

The primary research objective for future sound research will be to determine the impact of certain types of military training sound on TES. This will require the development of a dose-response threshold relationship for quantifying animal response to sound levels and stimulus distances, and relate these to reproductive fitness parameters.

A second objective is to develop and disseminate cost effective techniques for documenting the effects of training sound on TES populations. These techniques include the capability to characterize sound stimuli, to document behavioral responses, and to determine resulting population level effects due to military sound. Achieving these objectives will provide a means to manage impact on both military training capability and TES, but will also provide a factual basis for mitigation and management protocols and guidelines. This research will directly address the #1 Army Conservation Pillar User Requirement, which is concerned with impacts of military operations on TES.

Ten primary factors were used to develop a prioritized list of TES for future sound research on U.S. Army installations. These factors included:

1. Number of installations with verified occurrences of AERTA-listed TES;
2. Level and type of military-based restrictions and their affect on installation-wide training capability. Both temporal (e.g., land-use restrictions during the breeding season) and spatial (e.g., back off distances from known TES use areas with restricted activity zones) restrictions were taken into account in rating overall training level restrictions for each installation(s) where specific species occurred.

3. Relative importance of the above listed installation(s) to the overall training capability of the Army. Some installations represent unique training opportunities (e.g., force-on-force training at the National Training Center at Fort Irwin) for the Army and therefore rated higher than other installations;
4. Level and quality of previous sound research for each of the 13 AERTA listed species of concern;
5. Amount and quality of hearing sensitivity research;
6. Acres of Army land off-limits to training;
7. Acres of Army land with some level of training restrictions;
8. Degree of overlap between animal hearing sensitivity and acoustic emissions for military sound source data (i.e., does the animal perceive military sound sources);
9. Applicability to the other listed TES in the AERTA document;
10. Immediacy of Army need for sound mitigation research.

AERTA-listed TES were described based on four categories:

1. Status and breeding range – presents state and Federal status and breeding range for each species;
2. Impacts on training capability – categorizes training restrictions for Army installations by species based on impact rating criteria developed by Schreiber et al. (1997a, b) and Shaw et al. (1997a,b). "Green (low) = species has no impact on a unit's ability to train/test to standard nor does it impact the training readiness of units or testing mission accomplishments; Amber (moderate) = species has an impact on unit's ability to train/test to standard but does not impact training readiness of units or testing mission accomplishments; Red (high) = species has an impact on unit's ability to train/test to standard and units have a difficult time meeting training readiness of units and testing mission accomplishments."
3. Threats to species survival – summarizes human-based and natural impacts that negatively affect TES viability;
4. Hearing sensitivity – presents available research on hearing sensitivity for each specific species or surrogate species, if applicable.

The following priority list of terrestrial TES for future sound studies on Army lands is recommended: (1) Desert Tortoise; (2) Indiana Bat; (3) Gray Bat; (4) Gopher Tortoise; (5) Black-capped Vireo; (6) Golden-cheeked Warbler; and (7) Lesser Long-nosed Bat. It is also recommended that the Red-cockaded Woodpecker be removed from the list of candidate species for any future sound research and that the Least Bell's Vireo, Mexican Spotted Owl, Northern Spotted Owl, Northern Aplomado Falcon, and Wood Stork be removed from consideration for future sound work based on low population levels and limited conflicts with training on Army installations.

The potential for direct hearing damage for most TES on Army installations is very small. There does, however, exist the possibility that military training sound could influence the behavior of TES (e.g., fitness, foraging, habitat use, passive animal detection of prey, predator avoidance capability, and social communication). More research is needed in these areas.

Foreword

This study was conducted for Headquarters, U.S. Army Corps of Engineers under project number A896, "Project Title"; Work Unit number, CNNT031, "Prioritization of Threatened and Endangered Species Noise Impact Research on Army Installations." The technical monitor was Stephen E. Hodapp, Chief, Ecological Processes Branch (CN-N), of the Installations Division (CN), Construction Engineering Research Laboratory (CERL).

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1 Introduction

Background

Section 7 of the Endangered Species Act (ESA) requires that all Federal agencies conserve Threatened and Endangered Species (TES), and in consultation with the U.S. Fish and Wildlife Service (USFWS) or National Marine Fisheries Service (NMFS), ensure their actions are not likely to jeopardize the continued existence of any TES or result in the destruction or adverse modification of critical habitat (ESA 1973). TES management on military installations has raised questions about the interaction between Army training and the conservation of TES on military lands. Appendix A is a brief summary of legal requirements. Because sound management has traditionally focused on minimizing human annoyance, loud activities have often been relocated to sparsely populated areas where animals reside. This has led to increased interactions between military activity and wildlife (Holland 1991). Increasing importance has been placed on determining the extent of sound impacts on wildlife (Bowles 1995), especially TES (Delaney et al. 1999, 2000, 2001; Pater et al. 1999).

Environmental Requirements and Technology Assessment

A revised edition of the U.S. Army Environmental Requirement and Technology Assessment (AERTA) document was issued in 1999 and is currently undergoing another review. Under AERTA, specific research and management criteria must be met before any requirement can be resolved for a specific TES. AERTA requirements (listed below) also identify TES and suggest dates for accomplishing specific goals. In these requirements, sound, maneuver training, and smokes and obscurants are the primary disturbance sources listed. The 13 animal species listed in the next paragraph were examined to develop a prioritized list for future sound research on Army installations.

> By FY05, develop training methods and technologies to mitigate for the effects of Army maneuver training, smoke and obscurants, and noise (vehicle and blast) on birds (e.g., Red-cockaded Woodpecker, Black-capped Vireo, Golden-cheeked Warbler, Northern Aplomado Falcon, Least Bell's Vireo, Mexican Spotted Owl, Northern Spotted Owl, and Wood Stork), bats (e.g.,

Indiana Bat, Gray Bat, and Lesser Long-nosed Bat), and tortoises (e.g., Desert Tortoise and Gopher Tortoise).

By FY05, develop maneuver training, smoke and obscurants, and noise thresholds to other T&E birds, bats, and tortoises.

By FY07, develop transition plans for use of FY05 thresholds to other T&E birds, bats, and tortoises.

By FY08, develop training methods and technologies to mitigate the effects of Army maneuver training, smoke and obscurants, and noise (vehicle and blast) on mammals (e.g., San Joaquin Kit Fox), reptiles (e.g., Eastern Indigo Snake and Kirtland Snake), fish (e.g., Maryland Darter), crustaceans (e.g., Oahu Tree Snail and Alabama Cave Shrimp), insects (e.g., American Burying Beetle, Smith's Blue Butterfly, and Oregon Silver-spotted Butterfly), fresh water mussels, and amphibians.

By FY08, develop maneuver training, smoke and obscurants, and noise thresholds for mammals, reptiles, fish, crustaceans, insects, fresh water mussels, and amphibians.

By FY10, develop methods to cultivate or protocols to avoid plants (e.g., Michaux's Sumac, Rough-leaved Loosestrife, Lane Mountain Milk Vetch, and the T&E Hawaiian plant species).

By FY10, develop training methods and technologies to mitigate the effects of Army maneuver training, smoke and obscurants, and noise (vehicle and blast) that also address strategies to mitigate fragmentation effects on the habitat requirements for each species identified in the previous criteria.

By FY10, develop transition plans for use of FY08 thresholds to other T&E mammals, reptiles, fishes, snails, insects, crustaceans, amphibians, and clams.

Objectives

The primary objective for this 1-year project was to develop a prioritized list of TES for future sound research relative to military training sound effects. From these recommendations, future sound research could be developed, initiated, and established with the goal of allowing DoD installations to train to standard and maintain operational readiness, while also protecting TES. The primary research objective for future sound research will be to determine the impact of certain types of military training sound on TES. Reaching this objective will require the development of a dose-response threshold relationship for quantifying animal response to sound levels and stimulus distances, and relating these to reproductive fitness parameters.

A second objective is to develop and disseminate cost-effective techniques for documenting the effects of training sound on TES populations. These techniques include the capability to characterize sound stimuli, to document behavioral responses, and to determine resulting population level effects due to military sound. Achieving these objectives will provide a means to manage impact on both military training capability and TES, but will also provide a factual basis for mitigation and management protocols and guidelines. This research will directly address the #1 Army Conservation Pillar User Requirement, which is concerned with impacts of military operations on TES.

Approach

Chapter 3 details the technical approach used in this report. The chapter includes discussions of the AERTA, the TES listed under the requirements, the dates for resolving those requirements for each species, the criteria used to develop a prioritized list of species for future sound research, examples of sound emission spectral data for various military sound sources, and audiogram information for various listed and surrogate animal species.

Scope

Results from this report apply directly to U.S. Army Installations and the TES that have been verified to occur on Army lands in the United States.

Mode of Technology Transfer

This report will lead to the development of future research plans to address sound-related TES issues on military installations. Information from this project will be disseminated as an ERDC/CERL report to military personnel and other interested parties. This report will also be made accessible through the World Wide Web at:

http://www.cecer.army.mil

2 A Literature Review of Sound Research on Animals

The primary focus of many animal disturbance studies has been the assessment of military training activities on wildlife (Craig and Craig 1984; Stalmaster and Kaiser 1997), especially TES (3D/Environmental 1996a, b; Bowles et al. 1999; Delaney et al. 1999, 2001; Pater et al. 1999). Although a few human-based activities have been found to benefit some wildlife species and plant communities (e.g., prescribed burning; USFWS 1991, 2000; LeBlond et al. 1994; Trame and Harper 1997), most have deleterious effects (USFWS 1982, 1983, 1987, 1990a and b, 1991, 1992, 1994, 1995, 1996, 1998, 2000). Studies have investigated the impacts for many different types of human disturbances on wildlife, such as:

- recreational activity (Grubb and King 1991; McGarigal et al. 1991; Grubb and Bowerman 1997; Swarthout and Steidl 2001)
- vehicle traffic (Awbrey 1993; Brattstrom and Bondello 1994; Benson 1995; Guyer et al. 1995; Grubb et al. 1998) and associated fragmentation effects (Berry 1984; Trombulak and Frissell 2000; Norris and Stutchbury 2001)
- construction projects (Holthuijzen et al. 1990)
- human approach and presence (Fyfe and Olendorff 1976; Steenhof and Kochert 1982; Thomas 1995; Riffell et al. 1996)
- impacts on natural plant communities and soil substrates (e.g., habitat conversion and soil erosion) (Adams et al. 1982; Lathrop 1983a, b; Prose and Wilshire 1986)
- changes in the natural fire regime (e.g., fire suppression; LeBlond et al. 1994).

Often these studies have been anecdotal and fail to quantitatively measure either the stimulus or the behavioral response related to the animal's fitness.

Few studies have experimentally field-tested animal response to sound (Delaney et al. 1999, 2001). Most research has been passive in nature, where animal responses to various human-based perturbations are documented as they occur with no control over the disturbance event itself. Laboratory-based experiments on the effects of sound on animals have occurred (Bowles et al. 1999; 3D Environmental 1996a, b), but their applicability to free-roaming animals is questionable due to many potential confounding factors, such as the use of simulated sound sources, the elimination of natural influences (depredation, foraging requirements, etc.), and the inability to test for variation in reproductive fitness parameters.

3 Technical Approach

Prioritization Factors

Ten primary factors were used to develop a prioritized list of TES for future sound research on U.S. Army installations (Table C1). These factors included:

1. Number of installations with verified occurrences of AERTA-listed TES;
2. Level and type of military-based restrictions and their effect on installation-wide training capability. Both temporal (e.g., land-use restrictions during the breeding season) and spatial (e.g., back off distances from known TES use areas with restricted activity zones) restrictions were taken into account in rating overall training level restrictions for each installation(s) where specific species occurred.
3. Relative importance of the above installation(s) to the overall training capability of the Army. Some installations represent unique training opportunities (e.g., force-on-force training at the National Training Center at Fort Irwin) for the Army and therefore rated higher than other installations;
4. Level and quality of previous sound research for each of the 13 AERTA-listed species selected (Table C1);
5. Amount and quality of hearing sensitivity data;
6. Acres of Army land off-limits to training due to each species of concern;
7. Acres of Army land with some level of training restrictions;
8. Degree of overlap between animal hearing sensitivity and acoustic emissions for military sound source data (i.e., whether the animal perceives military sound sources);
9. Applicability to the other listed TES in the AERTA document;
10. Immediacy of Army need for sound mitigation research.

Species Profiles

Descriptions follow for 13 TES listed in the AERTA document. Information for evaluating the 10 priority factors for each species is broken into 4 categories:

1. Status and breeding range – presents state and Federal status and breeding range for each species. Distribution maps for Gray Bats, Gopher Tortoises, Red-cockaded Woodpeckers, and Wood Storks are from the Nature Serve website and are based on National Heritage Status rankings. Maps should only be used for distribution purposes and not to indicate breeding range.

2. Impacts on training capability – categorizes training restrictions for Army installations by species based on impact rating criteria developed by Schreiber et al. (1997a, b) and Shaw et al. (1997a, b): "Green (low) = species has no impact on a unit's ability to train/test to standard nor does it impact the training readiness of units or testing mission accomplishments; Amber (moderate) = species has an impact on unit's ability to train/test to standard but does not impact training readiness of units or testing mission accomplishments; Red (high) = species has an impact on unit's ability to train/test to standard and units have a difficult time meeting training readiness of units or testing mission accomplishments."
3. Threats to species survival – summarizes human-based and natural impacts that negatively affect TES viability.
4. Hearing sensitivity – presents available research on hearing sensitivity for each specific species or surrogate species, if applicable.

Desert Tortoise

Figure 1. Adult Desert Tortoise (photo by Andrew Walde).

Status and breeding range – The Mojave population of the Desert Tortoise (*Gopherus agassizii*; Figure 1; tortoises living north and west of the Colorado River) was federally listed as threatened on 2 April 1990, with critical habitat being designated on 8 February 1994 in California, Nevada, Arizona, and Utah (59 *Federal Register* [FR] 5820-5866; USFWS 1994). Desert Tortoises range from the Mojave and Sonoran Deserts in southern California, southern Nevada and Arizona, the southwestern tip of Utah to Sonora and northern Sinaloa, Mexico (Figure B1).

Impact on training capability – The Mojave population of Desert Tortoises have been documented on two Army installations in the southwestern United States (Schreiber et al. 1997a; Table C2). The presence of these threatened tortoises has caused high levels (red) of training and land use restrictions for the Army (Schreiber et al. 1997b; AERTA 1999; Table C1). Over 20,000 acres of critical habitat have been designated for the Desert Tortoise on Fort Irwin (south of UTM* 90 grid line, Figure 2). This area is restricted to all training and testing, except for land navigation on foot, which effectively eliminates one training corridor for tracked vehicles. On the Clark County Training Site, vehicles are restricted to existing roads (Schreiber et al. 1997a; AERTA 1999), which impacts training capability and readiness.

Fort Irwin expansion proposal – Fort Irwin is in the process of acquiring approximately 110,000 acres for expansion of the National Training Center (NTC; Figure 2). Parcel 1 (Superior Valley) encompasses 63,673 acres of land that are located southwest of the NTC and are contiguous with the southwest edge of the installation. This parcel is bound on the north by the Mojave B Range of the Naval Air Weapons Station, China Lake, and on the south by the Paradise Range and Lane Mountain. The western edge of this parcel of land is in the area of the Superior Dry Lakes. Parcel 2 (East Gate) contains 46,438 acres of land directly east of and contiguous to the NTC. This parcel is bound on the north by the Avawatz Mountains and on the east by State Highway 127. The installation has also requested the use of 22,139 acres of recently designated critical tortoise habitat in the southern portion of the installation (south of UTM 90 grid line).

The Army requests these additional lands due to current land-use requirements, development of Force XXI, equipment advances, and doctrine changes. The Army cites current land-use restrictions due to environmental off-limit areas (i.e., critical habitat), Goldstone NASA, Leach Lake Training Range, and live-fire ranges. Activities in the proposed area would include only instrumented training areas suitable for force-on-force and live-fire training of heavy brigade-sized military forces. NTC presently has one maneuver corridor suitable for brigade-sized maneuvers located between the Granite and Tiffort Mountains in the central portion of the installation (Figure 2). The Superior Valley parcel and area south of the UTM 90 line would be used as a second maneuver corridor for these brigade sized force-on-force maneuvers. Such training involves the rapid movements of large numbers of tracked and wheeled vehicles over extensive areas. The East Gate Parcel would be used as a staging area to prepare for maneuvers, but would not be used for training.

* Universal Transverse Mercator.

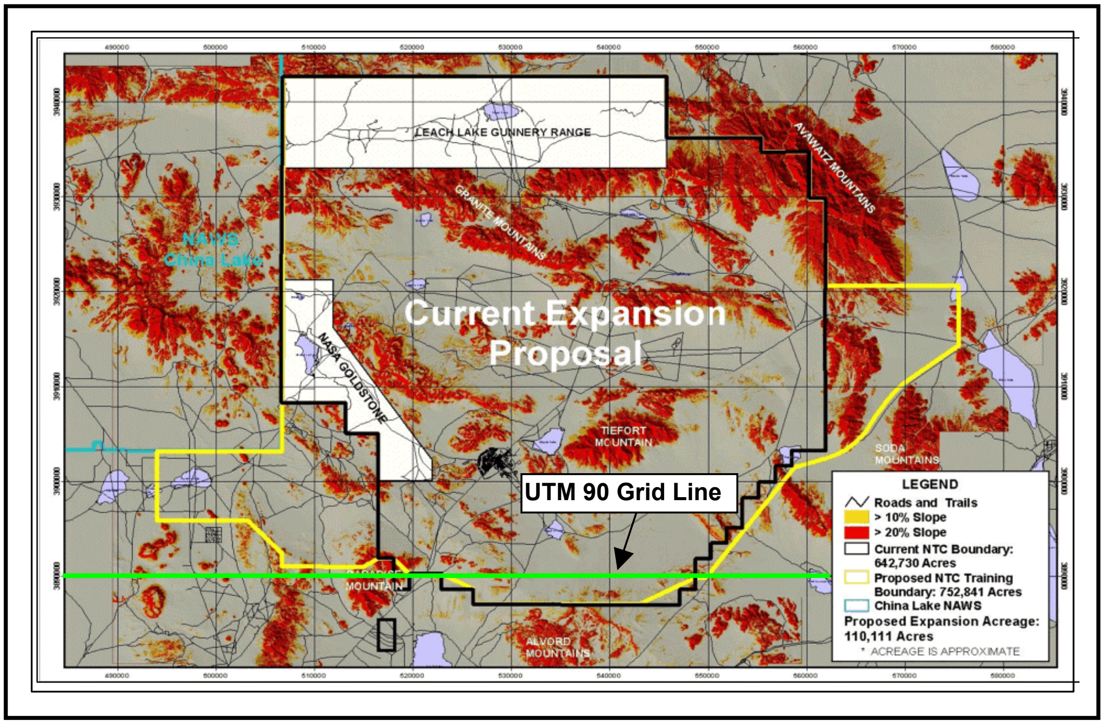

Figure 2. Map of the Fort Irwin expansion area (map developed by ITAM Office, Fort Irwin, 2000).

Threats to Desert Tortoise survival – Many types of human-based activities are believed to have contributed to tortoise declines in the Mojave Desert region (Berry 1984; USFWS 1994). These factors can range from large-scale impacts (urbanization, agricultural development, recreational use, military training, and grazing) to more individual-based impacts (collisions with vehicles, human collection for pets or food, increased depredation pressures due to urbanization and fragmentation or vandalism; USFWS 1994). While human activities can have direct and immediate impacts on tortoise populations (mortality from vehicle collisions, collection, and vandalism), indirect effects (increased depredation rates due to habitat fragmentation, soil compaction and its effects on plants, soil loss due to erosion or water pollution) can be more subtle, but potentially just as detrimental to long-term tortoise population viability.

Hearing sensitivity – Only one study has addressed Desert Tortoise audition (Bowles et al. 1999). The authors found that tortoises hear best in the 200-800 Hertz (Hz) range, with their greatest aural sensitivity at 250 Hz (Figure D1). Bowles et al. (1999) tested tortoise sensitivity to ground-borne vibrations below 200 Hz and found that tortoises could still perceive vibrations down to 50 Hz. These data imply that tortoises can perceive a large portion of sound energy from military sound sources, especially in the lower portion of the frequency range. When the sound spectra for various military sound sources (Figures D2–D5) are overlayed with tortoise hearing sensitivity data (Figure D1), a strong overlap is seen. It is predicted that Desert Tortoises are able to perceive a wide variety of military sound sources, and would be more sensitive to lower frequency sounds and vibrations.

Indiana Bat

Figure 3. Indiana Bat (photo by Joyce Hofman, Illinois Natural History Survey).

Status and breeding range – The Indiana Bat (*Myotis sodalis*; Figure 3) was federally listed as endangered throughout its range on 11 March 1967 (32 FR 4001). This bat is currently distributed in 22 states (Figure B2) that range from the western edge of the Ozark Plateau in Oklahoma, north to Iowa and southwestern Wisconsin, east to New Hampshire, and south to northern Alabama, with disjunct records in northwestern Florida (USFWS 1983). Critical habitat has been established for this species in Tennessee and Kentucky (USFWS 1983), with no critical habitat designations on military lands (Schreiber et al. 1997a, b; Shaw et al. 1997a, b). The Indiana Bat hibernates in limestone caves in the winter and roosts primarily in riparian upland woodlands in the summer (USFWS 1983). The main breeding and hibernating areas for Indiana Bats occur in nine cavernous limestone areas in Indiana, Kentucky, and Missouri (Humphrey 1982; USFWS 1983).

Impacts on training capability – Indiana Bats have been documented on 7 Army installations in the United States, though there is the potential that these bats occur on an additional 19 Army sites (Schreiber et al. 1997a, b; Shaw et al. 1997a, b; Table B1). The presence of these endangered bats has caused moderate levels (amber) of training and land-use restrictions for the Army (Table B2). Training restrictions could increase as more demographic information becomes available for Indiana Bats at summer breeding locations. Buffer zones have been established around caves to restrict military training activities on some Army lands. Fort Leonard Wood, MO, has established 162-m radius “Endangered Bat Areas” outside of Indiana Bat caves that are limited to only foot maneuvers outside of the caves, with no military activity inside the caves. In Bat Management Zone 1 (162-457 m from the cave), smoke and obscurant use and sound production are prohibited during certain portions of the year when Indiana Bats are using the caves. Bat Management Zone 2 extends to a 1,932-m radius and has sound production and habitat alteration limitations (Harland Bartholomew and Associates 1994).

Threats to Indiana Bat survival – Habitat loss and fragmentation, through urban and agriculture development (Garner 1991; Garner and Gardner 1992), human presence (Humphrey 1978; Thomas 1995), fire suppression (USFWS 1983), and chemical contamination (Geluso et al. 1976; Clark 1981) are all factors that have been implicated in causing bat population declines in North America (USFWS 1983). Human disturbance of hibernating bats has been a major factor in the long-term decline of Indiana Bats throughout its range (Evans et al. 1998). Human activities can arouse bats during hibernation (Hardin and Hassell 1970; Humphrey 1978; Thomas 1995), which can lead to substantial reductions in fat reserves that could ultimately impact individual survivorship (Thomas et al. 1990). The effects of human disturbance at summer Indiana Bat maternity colonies has not been well studied (USFWS 1983).

Few researchers have studied the effects of sound on Indiana Bats. Of the work that has been done, most has concentrated on documenting the response of hibernating Indiana Bats to sound and have not addressed bat response at summer roost locations. Of these studies, two investigated the effects of sound and vibration from construction projects on hibernating Indiana Bats (Myers 1975; Besha 1984), while one investigated the effects of military training sound (3D/Environmental 1996a, b). Data on Indiana Bat response to military sound was limited in the 3D/Environmental (1996a) study due to the mortality of all Indiana Bat subjects. Most of their data came from Little Brown Bats (*Myotis lucifugus*). The authors found that hibernating Indiana Bats and Little Brown Bats did not appear to respond to intense sound simulations (recordings of actual military activities played over a loudspeaker system). The authors also attempted to determine if the foraging patterns of Indiana Bats were impacted by nearby military sound. They were only able to record the foraging behavior of five Indiana Bats and only one of those locations was found near an active military range. The authors could not, therefore, adequately test for the effects of military training activities on Indiana Bat foraging. Besha (1984) found that quarrying activities generated ground-borne vibration peak particle velocities (PPV) of 0.25 inches per second (ips) and suggested limiting seismic vibration to 0.10 ips would be a safe threshold to avoid disturbed hibernating bats. Myers (1975) concluded that Indiana Bats were not impacted by construction activity and suggested that PPV of 0.02 ips would not be detrimental to hibernating Indiana Bats. Data on the effects of sound on Indiana Bats are limited. Data from the above studies should be used with caution due to their small sample size and lack of controls. Further research is needed to determine the potential effects of military training activities on Indiana Bats.

The high intensity sound generated by military training activities and its potential damage to bats' hearing if they are in very close proximity to military sound sources have also been studied. Weaver and Vernon (1961, as cited in 3D/Environmental 1996a) postulated that the external auditory meatus (ear canal) for bats could function as a valve to close the meatus in response to intense sounds. The authors found that sound intensity could be reduced by 70 decibels (dB). Bat echolocation calls are high intensity sounds that can interfere with the detection of short-range echoes. To compensate for this, bats possess mechanical and neural means of attenuating their calls. Mechanical attenuation is achieved by contracting muscles of the middle ear (Henson 1965). It has been suggested that bats might use similar mechanisms to protect their auditory systems from intense environmental sounds (3D/Environmental 1996a).

Hearing sensitivity – No studies have specifically addressed the hearing sensitivity of Indiana Bats, presumably due to its endangered status. Information is usually inferred from surrogate species or from echolocation studies. Hearing sensitivity data are available for Little Brown Bats (Dalland 1965; Figure D6), which have been used as surrogates for investigating sound effects on Indiana Bats (3D/Environmental 1996a, b). It has been suggested that Little Brown Bats should be used with caution as surrogates for microchiroptean behavior and physiology (Henshaw 1965). While Indiana and Little Brown Bats use similar hibernacula and are morphologically similar, there are potential differences in hibernating behavior and physiology. Brenner (1974) reported that Indiana Bats moved at lower temperatures during hibernation than Little Brown Bats. Henshaw (1965) and Henshaw and Folk (1966) observed that Little Brown Bats showed deeper signs of hibernation than Indiana Bats. These data suggest that Little Brown Bats may be more difficult to arouse than Indiana Bats and may therefore underestimate Indiana Bat response to natural and human-based perturbations.

Bat hearing is reported to be most sensitive in the peak frequency range of its echolocation call (Suthers 1970). Fenton and Bell (1981) found that the peak frequency of Indiana Bat echolocation calls was 50 kHz with a range of 41–75 kHz, while Little Brown Bats produce a peak frequency of 45 kHz with a range of 38–78 kHz. Dalland (1965) corroborated these data by showing that Little Brown Bats had their peak hearing sensitivity at 40 kHz. Research also suggests that bats may be sensitive to frequencies below their typical range of echolocation use (Dalland 1965; Buchler and Childs 1981; Poussin and Simmons 1982; Hamr and Bailey 1984). Multiple authors have shown that Big Brown Bats (*Eptesicus fuscus*) detect sounds well below typical echolocation range. Buchler and Childs (1981) showed that Big Brown Bats oriented to distant "low" frequency (3–12 kHz), low intensity sounds. Poussin and Simmons (1982; Figure D6) and Hamr and Bailey (1984) reported even lower frequency sensitivity levels. Both studies found that Big Brown Bats detected signals down to 1 kHz and suggested that such sensitivity could be for passive prey detection. It is also possible that communication with conspecifics could occur at these frequencies.

Gray Bat

Figure 4. Gray Bat (photo by Merlin Tuttle, Bat Conservation International).

Status and breeding range – The Gray Bat (*Myotis grisescens*; Figure 4) was federally listed as endangered throughout its range on 28 April 1976 (41 FR 17740). This bat is currently distributed in 14 states (Figure B3) and ranges from southeastern Kansas and central Oklahoma east to western Virginia and western South Carolina, and from Missouri, Illinois, and Indiana south to southern Alabama, Georgia, and northwestern Florida (USFWS 1982; Decher and Choate 1995). Critical habitat has not been established for this species on military lands (Schreiber et al. 1997a, b; Shaw et al. 1997a, b). The Gray Bat roosts and hibernates year round in limestone caves throughout its range. The main breeding and hibernating areas for Gray Bats occur in Alabama, Arkansas, Kentucky, Missouri, and Tennessee (USFWS 1982).

Impacts on training capability – Gray Bats have been documented on seven Army installations in the United States (Schreiber et al. 1997a, b; Shaw et al. 1997a, b; Table C2). The presence of these endangered bats have caused moderate levels (amber) of training and land use restrictions for the Army (Table C1). The level of training restrictions could change as more demographic information becomes available for Gray Bats. Buffer zones have been established around caves to restrict military training activities on some Army lands. Fort Leonard Wood has established 162-m radius "Endangered Bat Areas" outside of Gray Bat caves that are limited to only foot maneuvers outside of the cave, with no military activity inside the cave. In Bat Management Zone 1 (162–457 m from the cave), smoke and obscurant use and sound production in this zone are prohibited during certain portions of the year when Gray Bats are using the caves. Bat Management Zone 2 extends to a 1,932-m radius and has sound production and habitat alteration limitations (Harland Bartholomew and Associates 1994).

Threats to Gray Bat survival – Human disturbance is the main reason for the decline of Gray Bats (USFWS 1982). Tuttle (1979) reported a direct correlation between frequency of human disturbance and population reductions in summer colonies in Alabama and Tennessee. Bats may abandon summer caves due to human visitation (Barbour and Davis 1969). Human activities, such as cave exploration (Barbour and Davis 1969; Harvey 1975), vandalism (Tuttle 1979), and cave commercialization (Tuttle 1979; USFWS 1982) have caused some of the greatest impacts on Gray Bat populations. Other factors, such as environmental contamination (i.e., pesticides, chemical pollution; Geluso et al. 1976; Clark et al. 1978), deforestation (Tuttle 1976; 1979), waterway impoundment (USFWS 1982), and natural disturbances (i.e., cave flooding; Tuttle 1979) can also seriously impact Gray Bat population viability.

Human activities can arouse bats during hibernation (Hardin and Hassell 1970; Humphrey 1978; Thomas 1995), which can lead to substantial reductions in fat reserves that could ultimately impact individual survivorship (Thomas et al. 1990). It is possible that military training activities in close proximity to Gray Bat caves could cause bats to abandon the cave (Mitchell 1998). Only one study has attempted to assess the effects of military activities on Gray Bats (3D/Environmental 1996a, b). The authors attempted to monitor Gray Bat response to sound and seismic vibrations from military activities through video cameras, but were not successful because the bats roosted outside their field of view. Other researchers have investigated the effects of sound and vibration from construction projects on hibernating bats (Myers 1975; Besha 1984). Besha (1984) found that quarrying activities generated ground-borne vibration PPV of 0.25 ips and suggested that limiting seismic vibration to 0.10 ips would be a safe threshold to avoid disturbing hibernating bats. Myers (1975) concluded that Indiana Bats were not impacted by construction activity and suggested that PPV of 0.02 ips would not be detrimental to hibernating Indiana Bats. Data on the effects of sound on Gray Bats are limited. Data from the above studies should be used with caution due to their small sample size and lack of controls. Further research would be needed to determine the potential effects of military training activities on Gray Bats.

The high intensity sound generated by military training activities could potentially damage bat hearing if bats are in very close proximity to military sound sources. Weaver and Vernon (1961, as cited in 3D/Environmental 1996a) postulated that the external auditory meatus (i.e., ear canal) for bats could function as a valve to close the meatus in response to intense sounds. The authors found that sound intensity could be reduced by 70 dB. Bat echolocation calls are high intensity sounds that can interfere with the detection of short-range echoes. To compensate for this, bats possess mechanical and neural means of attenuating their calls. Mechanical attenuation is achieved by contracting muscles of the middle ear (Henson 1965). It has been suggested that bats might use similar mechanisms to protect their auditory systems from intense environmental sounds (3D/Environmental 1996a).

Hearing sensitivity – No studies have specifically addressed the hearing sensitivity of Gray Bats, presumably due to its endangered status. Information is usually inferred from surrogate species or from echolocation studies. Hearing sensitivity data are available for Little Brown Bats (*Myotis lucifugus*; Dalland 1965), which have been used as surrogates for investigating sound effects on other endangered bats (i.e., Indiana Bats; 3D/ Environmental 1996a, b). Shimozawa et al. (1974) did not find any differences in the orientation sounds and audiograms of Little Brown Bats and Gray Bats. It appears as if the auditory systems in terms of echolocation are similar between these species. It has been suggested that Little Brown Bats should be used with caution as surrogates for microchiroptean behavior and physiology (Henshaw 1965).

Bat hearing has been reported to be most sensitive in the peak frequency range of its echolocation call (Suthers 1970). Fenton and Bell (1981) found that the peak frequency of Indiana Bat echolocation calls was 50 kHz with a range of 41–75 kHz, while Little Brown Bats produce a peak frequency of 45 kHz with a range of 38–78 kHz. Dalland (1965) corroborated these data by showing that Little Brown Bats had their peak hearing sensitivity at 40 kHz. Research also suggests that bats may be sensitive to frequencies below their typical range of echolocation use (Dalland 1965; Buchler and Childs 1981; Poussin and Simmons 1982; Hamr and Bailey 1984). Multiple authors have shown that Big Brown Bats (*Eptesicus fuscus*) detect sounds well below typical echolocation range. Buchler and Childs (1981) showed that Big Brown Bats oriented to distant “low” frequency (3-12 kHz), low intensity sounds. Poussin and Simmons (1982) and Hamr and Bailey (1984) reported even lower frequency sensitivity levels. Both studies found that Big Brown Bats detected signals down to 1 kHz and suggested that such sensitivity could be for passive prey detection. It is also possible that communication with conspecifics could occur at these frequencies.

Gopher Tortoise

Figure 5. Gopher Tortoise (photo from Solon Dixon Forestry Education Center, Auburn University).

Status and breeding range – Gopher Tortoises (*Gopherus Polyphemus*; Figure 5) are under different levels of legal protection throughout their range. The western population of the Gopher Tortoise, which includes areas west of the Tombigbee and Mobile Rivers in Alabama, Mississippi, and Louisiana, was federally listed as Threatened on 7 July 1987 (USFWS 1987; Figure B4). The Gopher Tortoise is state-listed as a protected nongame species in Alabama, state-listed as a species of special concern in Florida, state-listed as threatened in Georgia and Louisiana, and state-listed as endangered in South Carolina and Mississippi (USFWS 1987). The Gopher Tortoise is one of four extant species of tortoises in North America, but is the only member of the genus *Gopherus* indigenous to the southeastern United States (Germano 1994).

Impact on training capability – Gopher Tortoises have been documented on seven Army installations in the southeastern United States (Schreiber et al. 1997a, b; Wilson et al. 1997; Table C2). Camp Shelby, MS, is the only installation currently under training restrictions due to the threatened status of western Gopher Tortoise population (USFWS 1987). There are more than 16,000 acres of Army land with training restrictions, with an additional 883 acres that are off limits to training. Training restrictions include no vehicle movement within tortoise colony sites, except at artillery firing points. The presence of Gopher Tortoises on Army installations has caused moderate to high levels of training restrictions (Table C1). These ratings are based on the number of installations affected, number of acres off-limits and receiving restrictions, and on the importance of that installation(s) to the overall training capability of the Army.

Threats to Gopher Tortoise survival – There are a number of factors, mostly human-based, that are detrimental to Gopher Tortoise populations in the southeast (USFWS 1990a). Habitat loss and degradation (e.g., urbanization, agricultural development, fire suppression, mining) and habitat fragmentation (e.g., road construction) are major factors that have lead to the decline of Gopher Tortoises throughout its range (Wilson et al. 1997). Depredation on eggs and young has also contributed to this decline.

Hearing sensitivity – No studies to date have directly investigated the hearing sensitivity of Gopher Tortoises, though some work has been done on Desert Tortoise audition (Bowles et al. 1999). The authors found that Desert Tortoises have a hearing range of approximately 200-800 Hz, with their greatest sensitivity in the 250 Hz range (Figure D1). Bowles et al. (1999) tested the sensitivity of tortoises to military training vibrations below 200 Hz. Tortoise sensitivity dropped off fairly dramatically above and below 250 Hz, but tortoises were still fairly sensitive down to 50 Hz. This has important consequences when considering that most sound energy from military sound sources are in the lower portion of the frequency range (Figures D2–D4).

Golden-cheeked Warbler

Figure 6. Adult male Golden-cheeked Warbler (©1988 Greg W. Lasley).

Status and breeding range – The Golden-cheeked Warbler (*Dendroica chrysoparia*; Figure 6) was federally listed as endangered throughout its range on 27 December 1990 (55 FR 53153). This species was state-listed as endangered on 19 February 1991 (Executive Order No. 91-001). Golden-cheeked Warblers within the United States are only known to breed on the Edward's Plateau in central Texas (USFWS 1992; Figure B5).

Impact on training capability – This species has been found breeding on two Army installations (Table C2). The presence of Golden-cheeked Warblers on Army installations has created a high level (red) of training and land-use restrictions, which has reduced the Army's ability to train to standard (Tazik et al. 1992; AERTA 1999). There are more than 42,000 acres of Army land that have training restrictions (Table C1). Two Major Army Commands (MACOMs) — Forces Command (FORSCOM) and Medical Command (MEDCOM) — have been impacted by the presence of Golden-cheeked Warblers (Table C2). FORSCOM maneuver training is limited by the following restrictions: (1) only existing fighting positions are allowed; no digging of new positions authorized, (2) no clearing of habitat that obscures target lines, (3) units not authorized to travel more than 2 hours per 24-h period through warbler territories, (4) units not authorized to train in warbler territories, and (5) no use of obscurant smokes, chemical grenades/devices within 30 m of warbler habitat. MEDCOM is limited from conducting any high intensity training in habitat areas during the breeding season (AERTA 1999).

Threats to Golden-cheeked Warbler survival – Habitat degradation, fragmentation and loss are the primary factors causing the decline in Golden-cheeked Warbler populations (Benson 1990; Wahl et al. 1990; USFWS 1992). Habitat loss is mainly due to Ashe Juniper (*Juniperus ashei*) eradication programs, continuing urbanization, and agricultural development (Pulich 1976). Interspecific nest parasitism by Brown-headed Cowbirds (*Molthrus ater*) is another important threat to Golden-cheeked Warbler population viability that may be caused by increased habitat fragmentation (Brittingham and Temple 1983; Thompson 1994). During nonbreeding periods, warblers appear to be somewhat tolerant to moderate levels of timber harvesting and grazing. More severe forms of timber management such as clear-cutting and understory reduction by burning and livestock grazing may reduce habitat suitability even more for Golden-cheeked Warblers (Tazik et al. 1992).

The two projects that have studied the effects of human activities on Golden-cheeked Warblers (Tazik et al. 1992; Benson 1995) are both passive in nature (i.e., researchers did not have any experimental control over the sound level or distance of stimuli). Benson (1995) studied the effects of roadway traffic sound on territory selection by Golden-cheeked Warblers. The author did not find a significant correlation between sound exposure and warbler occurrence based on the range of exposure levels examined. Tazik et al. (1992) provided some anecdotal information on the effects of military-associated activities on Golden-cheeked Warblers, but the authors did not provide any specific behavioral documentation relative to military activities. The authors suggested that only 1 percent of warblers on Fort Hood received significant levels of military training activities and that any impacts were minimized due to beneficial habitat management activities on the installation. Only a small percentage of the installation's warbler population is reported to be affected by military training activities due to the inability of tanks and other tactical vehicles to maneuver within high tree densities on steep slopes of warbler habitat (Tazik et al. 1992). The effects of military munitions sound on Golden-cheeked Warbler behavior and habitat use is unknown (Tazik et al. 1992). Ongoing research, funded by the Strategic Environmental Research and Development Program (SERDP) (Pater et al. 1999; Delaney et al. 2001), show that military sound can influence animal behavior and that sound level and distance are important variables to consider when documenting animal response to military training activities.

Hearing sensitivity – No hearing sensitivity information is available for Golden-cheeked Warblers; therefore, direct comparison of sound source level and frequency spectra of military sound sources with warbler hearing sensitivity data was not possible. Based on Dooling's work (1980, 1982, 1992) in developing "average bird" audiogram (Figure D7), it is highly likely that Golden-cheeked Warblers hear certain portions of the frequency spectra for various military training activities. Tazik et al. (1992) and Tazik (1991) showed that Golden-cheeked Warblers respond behaviorally to military training that strongly implies that the animals perceive military sound sources.

Black-capped Vireo

Figure 7. Adult male Black-capped Vireo (©1996 Greg W. Lasley).

Status and breeding range – The Black-capped Vireo (*Vireo atricapillus*; Figure 7) was federally listed as endangered on 6 October 1987 (52 FR 37420-37423), though the Federal status did not become effective until 5 November 1987. Historically, Black-capped Vireos bred from south-central Kansas through central Oklahoma to the Edward's Plateau in Texas and south and west to Big Bend National Park and into central Coahuila, Mexico (Graber 1957; American Ornithologist's Union 1983). The current breeding range is restricted to Oklahoma, Texas, and Mexico (USFWS 1991; Figure B6).

Impact on training capability – This species has been found breeding on six Army installations (Table C2). The presence of Black-capped Vireos on Army installations has created a high level (red) of training and land-use restrictions, which has reduced the Army's ability to train to standard (Tazik et al. 1992; AERTA 1999; Table C1). Four MACOMs — FORSCOM, MEDCOM, Army National Guard (ARNG), and Training and Doctrine Command (TRADOC) — have been impacted by Black-capped Vireo presence on Army lands. FORSCOM maneuver training is limited by the following restrictions: (1) only existing fighting positions are allowed, no digging of new positions authorized, (2) no clearing of habitat that obscures target lines, (3) no off trail driving, (4) no brush or tree cutting, camouflage, or road blockades, (5) units not authorized to travel more than 2 hours per 24-h period through vireo territories, (6) units not authorized to train in vireo territories, and (7) no use of obscurant smokes, chemical grenades/devices within 30 m of vireo habitat. MEDCOM is limited from conducting any high intensity training in habitat areas during the breeding season. ARNG is restricted from using approximately 80 acres of land during the vireo's breeding season, while TRADOC is prohibited from vehicular training in close proximity to the nesting area (AERTA 1999).

Threats to Black-capped Vireo survival – Numerous natural and human-based activities and land uses affect Black-capped Vireo populations and their habitats (Hayden et al. 2001; Weinburg et al. 1998). Direct habitat impacts, such as the conversion of potential vireo habitat to urban or agricultural areas, habitat degradation through suppression of the natural fire regime and livestock grazing, can substantially reduce the amount of suitable nesting habitat for vireos (Grzybowski et al. 1995; USFWS 1991). Human alteration of landscapes can also cause indirect impacts on vireo populations by increasing suitable habitat for predators. Human development has been linked with increases in cowbird populations within the vireo's range (USFWS 1991). The Black-capped Vireo is one of many bird species that suffers heavy nest depredation pressure from cowbirds and other species (Graber 1961; 52 FR 37420-37423; Weinburg et al. 1998). Historically, fire was the primary means by which Black-capped Vireo habitat was created (Graber 1961; Marshall et al. 1985). Prescribed burning was not found to negatively impact Black-capped Vireo fitness (O'Neal et al. 1996), though it is important to note that the effects of wildfire on vireos has not been well researched. Drought is another factor that can adversely affect bird abundance (Blake et al. 1992; Rotenberry et al. 1995). Drought conditions may limit food availability (Weinburg et al. 1998) to which insectivores have been shown to be particularly sensitive (Rotenberry et al. 1995).

No research to date has addressed the effects of military sound on Black-capped Vireos. Tazik et al. (1992) is the only study to assess the effects of military training activities on Black-capped Vireos. The authors suggested that regulating troop movements in known vireo habitat could minimize military training activity effects.

Tazik et al. (1992) suggested that military training activities could influence vireo habitat directly as well as their habitat use through vegetation trampling, bivouacking, obscurant smokes, habitat fragmentation through road construction, and road maintenance activities. Tazik (1991) concluded that, based on 1989 data, only 1 percent of all nests were expected to be negatively impacted by military activity. He suggested that potential impacts were outweighed by beneficial management practices on Fort Hood.

Hearing sensitivity – No hearing sensitivity information is available for Black-capped Vireos; therefore, direct comparison of sound source level and frequency spectra of military sound sources with warbler hearing sensitivity data was not possible. Based on Dooling's work (1980, 1982, 1992) in developing "average bird" audiogram (Figure D7), it is highly likely that Black-capped Vireos would hear certain portions of the frequency spectra for various military training activities. Tazik et al. (1992) and Tazik (1991) showed that vireos respond behaviorally to military training that strongly implies that the animals perceive military sound sources.

Lesser Long-nosed Bat

Figure 8. Lesser Long-nosed Bat (photo by Merlin Tuttle, Bat Conservation International).

Status and breeding range – The Lesser Long-nosed Bat *(Leptonycteris curasoae yerbabuenae*; Figure 8) was federally listed as endangered throughout its range on 30 September 1988 (53 FR 38460). This bat ranges from southern Arizona to southwestern New Mexico, and south into central Mexico (including Baja California) and Central America. No critical habitat has been proposed or designated for this species (USFWS 1995).

Impact on training capability – Lesser Long-nosed Bats have only been documented on two Army installations (Fort Huachuca, AZ, and Florence Military Reserve, AZ) in the southwestern United States (Schreiber et al. 1997a, b; Tables C1 and C2). The presence of these endangered bats has caused moderate levels (amber) of training and land-use restrictions (Table C1). Currently, soldiers are restricted from disturbing dense stands of Agave plants (e.g., *Agave palmeri, A. deserti,* and *A. parryi*, etc.) and from conducting fire producing training activities that may damage important foraging areas for the bats. Night training is also restricted in areas when the bats are present (AERTA 1999).

Threats to Lesser Long-nosed Bat survival – Habitat destruction of desert vegetation and over harvesting of Agave are thought to be contributing factors leading to the decline of Lesser Long-nosed Bats in the southwest (Howell and Roth 1981). Human disturbance of maternity roost caves may also represent an important threat (Cockrum and Petryszyn 1991; USFWS 1995), but has not been well studied. Only one study has attempted to determine the effects of military sound on Lesser Long-nosed Bats (Dalton and Dalton 1993). The authors did not document any overt behavioral responses relative to jet overflight sound. It is important to note that the study was limited in scope due to its passive nature, which prevented the establishment of any dose-response threshold relationships. Such thresholds are needed to better assess human disturbance impacts (USFWS 1995). Fire is another potential threat that can impact foraging resources for the Lesser Long-nosed Bats. Army installations are currently restricted from conducted fire producing training activities in dense stands of agave as a way to reduce any military impacts on the species (AERTA 1999).

Hearing sensitivity – No studies have specifically addressed the hearing sensitivity of Lesser Long-nosed Bats. Some work has been done on other flower and fruit feeding bats (Suthers and Summers 1980; Hartley and Suthers 1987). Plant feeding bats use short, broadband, low-intensity echolocation calls (Hartley and Suthers 1987), which are assumed to be an adaptation for orientation in cluttered environments (Simmons and Stein 1980; Pye 1980). Echlocation behavior may reflect a bat's dependence on different food material. Suthers and Summers (1980) found that *Rousettus aegyptiacus* (Egyptian fruit eating bat) had its greatest hearing sensitivity in the 10-kHz range, with hearing acuity dropping off dramatically above 20 kHz and below 4 kHz. It appears as if plant foraging bats are not as acoustically sensitive as insect foraging bats. As an example, Little Brown Bats and Big Brown Bats are sensitive to sounds down to 10–15 dB Sound Pressure Level (SPL) in the 20-kHz range (Dalland 1965; Poussin and Simmons 1982), while *Rousettus* is only sensitive to sounds produced at approximately 50 dB (SPL; Suthers and Summers 1980). There is no clear indication what role echolocation plays in flower and fruit feeding bats. It is assumed that reductions in echolocating acuity in plant foraging bats reflects the shift from insects to pollen as a source of protein, presumably reflecting a decreased role for echolocation in finding and assessing food.

Red-cockaded Woodpecker

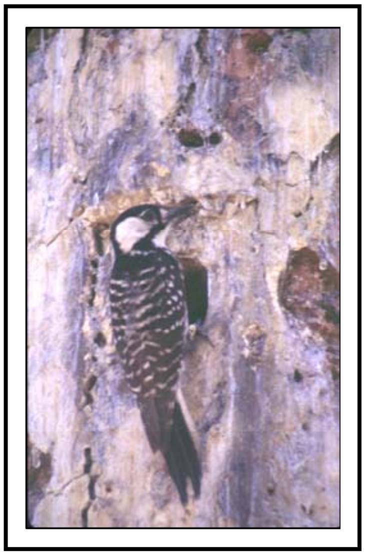

Figure 9. Red-cockaded Woodpecker (photo by David Delaney).

Status and breeding range – The Red-cockaded Woodpecker (RCW; *Picoides borealis*; Figure 9) was listed as endangered throughout its range on 13 October 1970 (35 FR 16047) and received Federal protection with the passage of the ESA in 1973. Historically, RCW populations were widely distributed throughout the south from eastern Texas to the Atlantic coast, and north to New Jersey (Jackson 1987). The distribution has been reduced with the extirpation of RCWs from New Jersey (Lawrence 1867), Missouri (Cunningham 1946), and most recently Maryland (Devlin et al. 1980). The majority of RCWs are restricted to public lands, namely national forests and military installations (Jackson 1978; Lennartz et al. 1983). It has been estimated that nearly a quarter of the remaining RCW population is located on 16 military installations in the southeast (Costa 1992; USFWS 2000; Figure B7).

Impact on training capability – RCW have been documented on at least 11 Army installations in the southeastern United States (Schreiber et al. 1997a, b; Shaw et al. 1997a, b; Tables C1 and C2). The presence of RCW on Army installations has created a high level (red) of training and land-use restrictions, which has reduced the Army's ability to train to standard (Hayden 1997). Four MACOMs — FORSCOM, TRADOC, ARNG, and Military Traffic Management Command (MTMC) — have been impacted by RCW presence on Army lands (Table C2). The Army is currently restricted from conducting the following training activities within 50 ft of RCW nest cavities: (1) military vehicle and personnel travel, including armor, (2) .50-caliber machine gun blank fire, 7.62-mm blank fire, and below, (3) artillery/hand grenade simulators and Hoffman type devices, (4) hand digging of hasty individual fighting positions, (5) use of smoke grenades and star cluster/ parachute flares, (6) smoke and haze operation, (7) no felling of trees within 800 m of RCW cavity trees without permission, and (8) training is limited during certain months within the RCW breeding season (see Hayden [1997] and Carter and Hayden [1994] for a more detailed description of past and current Army guidelines for RCWs). These current restrictions prohibit tactical training to doctrinal standards (AERTA 1999).

Threats to Red-cockaded Woodpecker survival – Habitat loss has been the single most important factor that has lead to the decline of RCWs throughout its range (USFWS 2000). Intensive logging for lumber and clearing of forests for agriculture were the leading causes for initial habitat losses (Frost 1993; Martin and Boyce 1993). Grazing by free-ranging hogs (*Sus scrofa*) and pine resin exploitation were two additional factors that contributed to pine tree habitat loss in the 1800s (Wahlenburg 1946; Frost 1993). Landers et al. (1995) and others have reported that human-based activities, such as fire suppression and clear cutting, further impacted longleaf pine ecosystems and associated RCW populations. Consequently, RCWs are experiencing severe limitations in the number of available cavity trees (Costa and Escano 1989; Rudolph et al. 1990; Conner et al. 1991, Walters et al. 1992) and are suffering from a fragmented distribution (USFWS 2000).

Until recently, researchers did not consider the possible effects of sound on RCWs, even though a large proportion of the population resides on military installations (Costa 1992). Jackson (1983) was first to comment on the potential impacts of sound on RCWs. His comments were limited in scope due to the use of anecdotal accounts from passive sound sources. The effect of military training sound on RCWs has only been studied in the last few years (Pater et al. 1999; Delaney et al. 2000, 2001; Doresky et al. 2001). Doresky et al. (2001) compared the reproductive success between passively disturbed and undisturbed RCW groups on Fort Benning from 1994-1996. The authors found no significant differences in the number of eggs, nestlings, adults, adult feeding rates, or mass of nestlings or adults between treatment and control RCW groups. Only one study has experimentally assessed the effects of military training sound on RCWs. Delaney et al. (2000, 2001) experimentally tested the effects of military maneuver sound (i.e., .50-caliber blank fire and artillery simulators) on the reproductive fitness of RCWs. Based on their level of testing, the authors did not find a significant reduction in the reproductive success or productivity of control versus experimental RCW groups. RCWs were observed flushing in response to military sound sources, but returned relatively quickly to attend nests. The authors also found that flush frequency increased and sound levels increased as stimulus distance decreased. Overall, Delaney et al. (2000, 2001) found that RCWs did not flush when artillery simulators were ≥ 152 m away and Sound Exposure Levels (SELs) were < 65 dBW, Woodpecker weighted (73 dBF, unweighted). They found that RCWs did not flush when .50-caliber blank fire was ≥ 152 m away and SEL were < 69 dBW, Woodpecker weighted (83 dBF, unweighted).

Hearing sensitivity – No studies have specifically addressed the hearing sensitivity of RCW. One project has studied the hearing sensitivity of the Downy Woodpecker (*Picoides pubescens*) as a surrogate to the RCW (Delaney et al. 2002). The authors determined that RCWs are most sensitive in the 1,500-2,000 Hz range. Sensitivity appears to drop off quickly at frequencies below 1,000 Hz and above 4,000 Hz (Figure D7). More research is needed to further test woodpecker hearing sensitivity at frequencies below 500 Hz.

Mexican Spotted Owl

Figure 10. Mexican Spotted Owl (photo by David Delaney).

Status and breeding range – The Mexican Spotted Owl (*Strix occidentalis lucida*; Figure 10) was federally listed as threatened throughout its range on 16 March 1993 (58 FR 14248). Its current distribution encompasses Utah, Colorado, Arizona, New Mexico, Texas, and central Mexico (Ward et al. 1995; Figure B8). Critical habitat has been designated on Federal lands (4.6 million acres) for this subspecies in all states listed above except Texas (66 FR 8530-8553).

Impact on training capability – The presence of Mexican Spotted Owls on Army installations has created a low-moderate level (green-amber) of land use restrictions for training (AERTA 1999). Of the four installations where these owls reside, two installations (Camp Navajo, NM, and Fort Huachuca) have training restrictions due to the establishment of critical habitat for the owls (Schreiber et al. 1997a b; Tables C1 and C2). Two MACOMs (TRADOC and ARNG) have been impacted by Mexican Spotted Owl presence on Army lands. TRADOC forces are prohibited from training in critical habitat where spotted owls forage and nest. ARNG forces are restricted from training in areas within 183 m (600 ft) of protected activity areas. Such restrictions do not prevent ARNG forces from training to standard (AERTA 1999).

Threats to Mexican Spotted Owl survival – Habitat loss is believed to be the primary factor impacting Mexican Spotted Owls survivability (USFWS 1995). The Forest Service's practice of managing timber primarily under a shelterwood harvest regime has produced even-aged forest stands compared with uneven-aged, multilayered stands that spotted owls use most often for nesting and roosting. Other important threats to spotted owls include: (1) stand-replacement fires, (2) fuelwood harvest, (3) livestock grazing, (4) urban or agriculture development, and (5) forest insects and disease. Factors such as military operations, road construction, mining, and recreation are considered minor threats to spotted owls (USFWS 1995).

Researchers have been aware that human activities might impact spotted owl life history parameters (reproductive fitness, nesting behavior; Moir et al. 1995), but have not studied them directly until recently (Delaney et al. 1999; Swarthout and Steidl 2001). Delaney et al. (1999) is the only study to experimentally tested spotted owl response to sound stimuli (i.e., military helicopters and chainsaw activity). The authors compared direct (flush response, etc.) and indirect (nest attentiveness, prey delivery rate, trip duration and length, etc.) nesting behaviors between experimental and control owl nest sites. Based on their level of testing, the authors did not find a significant reduction in the reproductive success or productivity for control versus experimental spotted owl nest sites. Spotted owls flew from roost locations in response to helicopter and chain saw sound during non- and post-nesting seasons, but did not flush in response to tests during in the nesting season. The authors also found that flush frequency increased and sound level increased as stimulus distance from owls decreased. Delaney et al. (1999) found that owls did not flush when sound stimuli were > 105 m away and SELs for helicopters were ≤ 102 dBO (Owl-weighted; 92 dBA, A-weighted), and Equivalent Average Energy Levels (LEQs) for chainsaws were ≤ 59 dBO (46 dBA).

Hearing sensitivity – No studies have specifically tested the hearing sensitivity of Mexican Spotted Owls (Delaney et al. 1999). Available information indicates that owl hearing is quite similar among members of the same taxonomic order. Within the order Strigiformes, Delaney et al. (1999) found audiograms for two species (Great-horned Owl [*Bubo virginianus*] and Barn Owl [*Tyto alba*]) within the same Suborder (Strigi) as spotted owls. The authors used these audiograms to approximate frequency-weighting sound levels for owls. This owl weighting emphasized the middle frequency range where owls had the greatest hearing sensitivity (Trainer 1946; Konishi 1973). Based on research by Delaney et al. (1999), there appears to be a substantial overlap between owl hearing sensitivity and military-based sound spectral data (Figures D2–D4). Spotted owls would be expected to be most sensitive to sounds within the middle frequency range and less sensitive to sounds in the upper and lower portion of the frequency spectrum (Delaney et al. 1999).

Northern Spotted Owl

Figure 11. Northern Spotted Owl (photo by J&K Hollingsworth, U.S. Fish and Wildlife Service).

Status and breeding range – The Northern Spotted Owl (*Strix occidentalis caurina*; Figure 11) was federally listed as threatened throughout its range on 26 June 1990 (55 FR 26114-216192). Its current distribution encompasses northwestern California, western Oregon, Washington, and southwestern portions of British Columbia in Canada (Forsman et al. 1984; Figure B8). Critical habitat was designated for this subspecies on 14 February 1992 (57 FR 1796).

Impact on training capability – Northern Spotted Owls do not currently reside on any Army installations, though critical habitat designations on military lands in Washington State (58,000 acres; 57 FR 1796) have caused some training restrictions at Fort Lewis (Schreiber et al. 1997a, b; Table C1).

Threats to Northern Spotted Owl survival – Habitat loss is the primary factor impacting Northern Spotted Owl survivability (Forsman et al. 1984). The Forest Service's practice of managing timber primarily under a shelterwood harvest regime has produced even-aged forest stands compared with uneven-aged, multi-layered stands that spotted owls use most often for nesting and roosting. Other important threats to spotted owls include: stand-replacement fires, fuelwood harvest, livestock grazing, urban or agriculture development, forest insects, and disease. Factors such as military operations, road construction, mining, and recreation are thought to be minor threats to spotted owls (USFWS 1995).

Researchers have been aware that human activities might impact spotted owl life history parameters (reproductive fitness, nesting behavior; Moir et al. 1995), but have not studied them directly until recently (Delaney et al. 1999; Swarthout and Steidl 2001). Delaney et al. (1999) is the only study to experimentally test spotted owl response to sound stimuli (i.e., military helicopters and chainsaw activity). Direct (flush response, etc.) and indirect (nest attentiveness, prey delivery rate, trip duration and length, etc.) nesting behaviors were compared between experimental and control owl nest sites. Based on their level of testing, the authors did not find a significant reduction in the reproductive success or productivity for control versus experimental spotted owl nest sites. Spotted owls flew from roost locations in response to helicopter and chain saw sound during non- and post-nesting seasons, but did not flush in response to tests during in the nesting season. The authors also found that both flush frequency and sound level increased as stimulus distance from owls decreased. Delaney et al. (1999) found that owls did not flush when sound stimuli were > 105 m away and SELs for helicopters were ≤ 102 dBO (Owl-weighted; 92 dBA, A-weighted), and LEQs for chainsaws were ≤ 59 dBO (46 dBA).

Hearing sensitivity – No studies have specifically tested the hearing sensitivity of spotted owls (Delaney et al. 1999). Available information indicates that owl hearing is quite similar among members of the same taxonomic order. Within the order Strigiformes, Delaney et al. (1999) found audiograms for two species (Great-horned Owl [*Bubo virginianus*] and Barn Owl [*Tyto alba*]) within the same Suborder (Strigi) as spotted owls. These audiograms were used to approximate frequency-weighting sound levels for owls. This owl weighting emphasized the middle frequency range where owls had the greatest hearing sensitivity (Trainer 1946; Konishi 1973). Based on research by Delaney et al. (1999), there appears to be a substantial overlap between owl hearing sensitivity and military-based sound spectral data (Figures D2–D4). Spotted owls would be expected to be most sensitive to sounds within the middle frequency range and less sensitive to sounds in the upper and lower portion of the frequency spectrum (Delaney et al. 1999).

Northern Aplomado Falcon

Figure 12. Northern Aplomado Falcon (photo by Glen Mills, Texas Parks and Wildlife Div.).

Status and breeding range – The Northern Aplomado Falcon (*Falco femoralis septentrionalis*; Figure 12) was federally listed as endangered on 26 February 1986 (51 FR 6690). Historically, this subspecies ranged from southeastern Arizona, southern New Mexico, southwestern to south-central Texas, south into Mexico, and to Central America north of Nicaragua (Howell 1972). Northern Aplomado Falcons have not been documented nesting in the United States since 1952 (USFWS 1990b). Critical habitat has not been designated for this species.

Impact on training capability – Northern Aplomado Falcons have only been documented at one Army installation in the United States (i.e., White Sands Missile Range; Table C2). This subspecies is not presently causing any training restrictions for the Army, but there is potential for future conflicts due to the reintroduction of these falcons through Safe Harbor Agreements between the U.S. Fish and Wildlife Service, The Peregrine

Fund, and private landowners. Attempts to reintroduce the Northern Aplomado Falcon began in south Texas in 1977 (Cade et al. 1991).

Threats to Northern Aplomado Falcon survival – Habitat loss and degradation through agricultural development, brush encroachment (Hector 1987), fire suppression, stream channelization (Hastings and Turner 1964) and overgrazing by livestock are factors that are believed to have led to declines in the Northern Aplomado Falcon in the United States (USFWS 1990b). Mora et al. (1997) suggested that environmental contaminants in the prey base of the Aplomado Falcon could have a negative effect on falcon reproduction and survival that could hinder the recovery of the species. Due to the lack of overlap between falcons and military activities, it is believed that there are currently no military impacts on Northern Aplomado Falcons.

Hearing sensitivity – The hearing sensitivity of Northern Aplomado Falcons has not been studied directly, but it does appear that other species within the same genera do perceive sound from military sources. Studies have investigated the effects of military activities on Peregrine Falcons (*Falco peregrinus*; Windsor 1977), Prairie Falcons *(F. mexicanus*; Ellis 1981), and Gyrfalcons (*F. rusticolus*; Platt 1977) and have documented behavioral responses to other sound sources, such as the effects of construction activity on Prairie Falcons (Holthuijzen et al. 1990). We anticipate that Northern Aplomado Falcons would perceive some portion of the sound spectrum from military sound sources. Additional research would be needed to determine how much overlap exists between the hearing sensitivity of these falcons and weapon source data.

Least Bell's Vireo

Figure 13. Least Bell's Vireo (photo by Orange County Water Board).

Distribution and status – The Least Bell's Vireo (*Vireo bellii pusillus*; Figure 13) was federally listed as endangered on 2 May 1986 (59 FR 4845-4867), followed by the designation of critical habitat on 2 February 1994 in the Los Padres National Forest. Historically, this species occurred from northern California, along the Salinas River in Monterey County, to northwestern Baja California, Mexico. Currently, the northern breeding limit for this species is the Santa Ynez River in Santa Barbara County. The breeding distribution for Least Bell's Vireo is restricted to only seven counties in California (Imperial, Kern, Los Angeles, Riverside, Santa Barbara, San Bernardino, and Ventura; USFWS 1998).

Impacts on training capability – The Army does not have any training or land-use restrictions based on Least Bell's Vireo (Schreiber et al. 1997a, b). The Least Bell's Vireo has not been recently documented on military lands, but these birds are found on lands contiguous to three Army installations in California (Camp San Luis Obispo, Camp Roberts, and Fort Hunter Liggett; Table C2).

Threats to Least Bell's Vireo survival – Habitat loss and degradation are the primary factors that have led to the decline of the Least Bell's Vireo (Gray and Greaves 1984). Nest parasitism is another factor, that is thought to be symptomatic of fragmentation effects (Robinson et al. 1995), that has severely reduced population numbers for many passerines, including endangered or threatened species (Mayfield 1977). Few studies have addressed the effects of sound on the Least Bell's Vireo (e.g., Hunsaker and Kern 2001). Hunsaker and Kern are developing a model to predict the effects of sound on reproductive fitness parameters for the species. Other sound work has been done on other neotropical birds in California (Awbrey 1993), but is not necessarily applicable to vireos.

Hearing sensitivity – The hearing sensitivity of the Least Bell's Vireo has not been tested directly. Based on Dooling's (1980, 1982) "average bird" audiogram, it is believed that Least Bell's Vireo would perceive some aspects of military training activities (Figure D8). More research would be needed to assess the effects of sound on Least Bell's Vireo.

Wood Stork

Figure 14. Wood Stork (© 2002 Don Roberson www.montereybay.com/creagrus).

Distribution and status – The Wood Stork (*Mycteria americana*; Figure 14) was federally listed as endangered on 28 February 1984 (49 FR 4772-7335), and is state-listed as endangered in Alabama, Florida, Georgia, North Carolina, and South Carolina. The current U.S. breeding range of the Wood Stork includes Florida, Georgia, and South Carolina (USFWS 1996; Figure B9).

Impacts on training capability – Wood Storks have been documented on four Army installations (Tables C1 and C2), though no breeding pairs have been located (Schreiber et al. 1997a, b; Mitchell 1999). The Army does not currently have any training restrictions based on Wood Stork presence (Schreiber et al. 1997a, b; AERTA 1999; Table C1).

Threats to Wood Stork survival – Habitat alteration through water level manipulation (Kushlan et al. 1975) and loss of feeding habitat (Ogden and Nesbitt 1979; Ogden and Patty 1981) are two of the greatest factors impacting Wood Stork productivity (USFWS 1996). A change in water level also facilitates mammalian depredation (Rodgers et al. 1988). Human activity has been shown to elicit flush responses by Wood Storks. Rodgers and Smith (1995) recommended a 63–65-m buffer zone around Wood Stork nests to mitigate for various human activities.

Hearing sensitivity – The hearing sensitivity of the Wood Stork has not been tested directly. Based on Dooling's (1980, 1982) "average bird" audiogram (Figure D7), it is believed that Wood Storks would perceive some aspect of military training activities. More research would be needed to assess the effects of sound on Wood Storks.

4 Findings and Discussion

Examination of the literature revealed that few studies experimentally tested the effects of human disturbance on animals. Most of these studies were anecdotal and failed to quantitatively measure either the stimulus or the behavioral response to the animal's fitness. Military training activity was found to be the sound source most frequently studied. The reason for this appears to be that most military activities produce high-level sound events and are located in remote locations where more animals reside. This has lead to conflicts between military training capability and TES conservation efforts. Without any scientific information available, regulatory agencies have been more conservative in their findings, which has lead to increased training and land-use restrictions for the Army.

Certain Army installations have greater training and land-use restrictions than others. This is due to a number of factors, namely, the pervasiveness of TES on Army lands, the legal status of that species, the overlap between training land use and species habitat use (e.g., fire producing training and its impact on the prime foraging habitat of the Lesser Long-nosed Bat), as well as the level of management on and off the installation. Realistically, installations will be placed under more stringent controls and have greater restrictions if a species is federally protected and occurs on many installations. It was found that the installations that had the greatest training and land-use restrictions had the greatest overlap in training land use and the habitat requirements of TES on the installation. It is important to note that the management of TES off an installation can often be as important as the level and quality of management on post. Case in point is the RCW. The lack of RCW management and habitat protection around military installations in the southeastern United States has transformed military installations into a type of refugia for wildlife. Because other Federal and private landowners have not managed their lands in a sustainable manner, more importance has been placed on the management of this species on military lands.

The effect that these restrictions have on the Army depends on the importance of that installation(s) to the overall training capability of the Army, the number of installations where a specific species resides, the number of acres that have training restrictions or are off limits to training, the types of training restrictions (i.e., do restrictions impact the Army's ability to train to standard), and the temporal (e.g., breeding season exclusions) and spatial (e.g., buffer zones) nature of the training restrictions. Based on findings from this project, the following priority list of TES is recommended for future sound studies on Army lands: (1) Desert Tortoise, (2) Indiana Bat, (3) Gray Bat, (4) Gopher Tortoise, (5) Black-capped Vireo, (6) Golden-cheeked Warbler, and (7) Lesser Long-nosed Bat.

The Desert Tortoise was chosen as the highest priority TES for future sound research on Army lands for a number of reasons:

1. Training on Fort Irwin has been impacted by the presence of Desert Tortoises through the establishment of critical habitat and offset areas. Such impacts are significant when the importance of Fort Irwin to the overall training capability of the Army is considered.
2. There is a high level of urgency for initiating a disturbance study due to the possible expansion of Fort Irwin. Such an expansion represents an ideal opportunity to assess the potential effects of military training on this species before, during, and after the expansion has occurred.
3. A large number of acres are restricted or off limits to training on Fort Irwin.
4. No field research has addressed the effects of military training sound on Desert Tortoises.
5. Research on this species would have a high level of applicability to other AERTA-listed TES, such as the Gopher Tortoise.

The Indiana and Gray Bat received the second and third priority designations due to: (1) the pervasiveness of these species on Army lands, (2) lack of distribution and abundance information for these species on Army lands, (3) lack of information on how military training sound impacts bats during hibernation and at summer roost sites, and (4) potential for high level of applicability of such research to other species of bats.

Gopher Tortoises were designated in the fourth position of priority, behind Desert Tortoises and Indiana and Gray Bats for the following reasons: (1) Gopher Tortoises are federally listed on only one Army installation (i.e., Camp Shelby), (2) Gopher Tortoises were placed above the vireos, warblers, and Lesser Long-nosed Bats due to the potential that, if the eastern population gain Federal protective status on the six additional Army installations, there could be potential impacts, (3) Gopher Tortoises cause significant levels of training and land use restrictions for the Army, and (4) sound disturbance research on Gopher Tortoises would have a high level of applicability to other species on the AERTA list (i.e., Desert Tortoises).

Black-capped Vireos and Golden-cheeked Warblers were designated fifth and sixth priority due to: (1) importance of Fort Hood and surrounding installations to the overall training capability of the Army, (2) high level of training and land-use restrictions on military lands, and (3) number of acres restricted from military training. It would be difficult to extrapolate findings from sound disturbance research on these species to other listed species due to the unique nature of their habitat requirements and individual species behaviors.

The Lesser Long-nosed Bat represents the last species that is recommended for future sound research and is in the seventh priority position for the following reasons: (1) Lesser Long-nosed Bats have moderately impacted training and land use on Army lands, (2) no experimental studies have been conducted on the potential effects of military training on Lesser Long-nosed Bats, and (3) only two installations are impacted by the presence of this species.

The Red-cockaded Woodpecker is recommended for removal from the list of candidate species for any future sound research because sound disturbance research has already been conducted on this species. It is further recommended that the Least Bell's Vireo, Mexican Spotted Owl, Northern Spotted Owl, Northern Aplomado Falcon, and Wood Stork be removed from consideration for future sound work based on the following: (1) these species have low population numbers on Army lands, (2) these species cause limited training and land-use restrictions for the Army, (3) low applicability of sound disturbance research to other TES on the AERTA list for most of these species, and (4) some of these species have already been involved in sound disturbance projects. It is believed that it would be difficult to extrapolate findings from sound disturbance research on these species to other listed species due to the unique nature of their habitat requirements and individual species behaviors.

5 Conclusions and Future Research

Conclusions

More research is needed to assess the effects of military training activities on TES on Army lands. Due to limitations in funding sources for sound assessment research, military training impact studies needed to be prioritized. Army installations with significant training and land-use restrictions should receive the highest priority for future sound research, as should species that reside on multiple installations and installations with significant training importance to the Army. Most of the available disturbance research to date is anecdotal and lacks specific information on direct animal response to sound disturbance events. Experimental studies are needed to directly test animal response to variations in military sound source distance, source type, and sound levels to develop dose-response thresholds for a variety of military sound sources.

Future Research

Based on findings during this project, study plans will be developed to research the effects of military training sound on AERTA-listed species as prioritized.

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Glossary

Equivalent Average Sound Level (LEQ) is the average sound level for a steady sound source over a stated period of time.

Frequency Weighting is an algorithm of frequency-dependent attenuation that simulates the hearing sensitivity and range of the study subjects. Frequency weighting discriminates against sound that, while easily measured, is not heard by the study subjects. Frequency weighting should be specific to the study subject. It is important to note that A-weighting based on human hearing sensitivity is not appropriate for animals. Various animal-weighted curves have been developed to more clearly address differences between human and animal hearing (i.e., Owl-weighted, Woodpecker-weighted).

Sound Exposure Level (SEL) represents the total sound energy over a stated period of time or event.

Sound Pressure Level (SPL) is the minimum pressure fluctuation detected by the ear. SPL measures the magnitude of the sound and is a relative quantity for the ratio between the actual sound pressure and a fixed reference pressure.

Appendix A: Project-Related Legal Requirements

Section 7 of the Endangered Species Act (ESA) requires Federal Agencies to carry out programs for the conservation of threatened and endangered (listed) species (TES). Agencies are also required, through consultation with the U.S. Fish and Wildlife Service (USFWS) or the National Marine Fisheries Service (NMFS), to ensure their actions do not jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat. To facilitate compliance with this requirement, the ESA requires the preparation of a Biological Assessment (BA) for major actions (Endangered Species Management Plans, Integrated Natural Resource Management Plans, and Installation's Ongoing Mission). The purpose of the BA is to help the agency determine the effect of the proposed action on listed species present within the action area. If the proposed action may affect a listed species the agency must consult with the USFWS or NMFS, as appropriate. The agency informally consults to determine if there are methods or modifications to the action to avoid adverse effects to listed species. If modifications are developed, consultation is completed and the action may proceed. If adverse impacts are unavoidable, formal consultation is initiated. The USFWS or the NMFS will evaluate the status of the species, the environmental baseline, the effects of the proposed action to determine if the project may jeopardize the continued existence or adversely modify critical habitat. As a result of the formal consultation, the USFWS or the NMFS will issue a Biological Opinion (BO). If the BO concludes the action will jeopardize the continued existence of the species or adversely modify critical habitat the BO will provide reasonable and prudent alternatives for the proposed action that are nondiscretionary for the action agency. If the BO concludes the action will not jeopardize the continued existence of a listed species or adversely modify critical habitat, the USFWS or NMFS may issue an Incidental Take Statement (ITS) that will provide reasonable and prudent measures with specific terms and conditions that will minimize take of the species (ESA take prohibitions are explained in the next paragraph). These measures and conditions are nondiscretionary. The ITS exempts the agency from violating the ESA for taking of a listed species. The implementation of these nondiscretionary alternative measures and conditions may place constraints on the execution of the military mission.

Section 9 of the ESA prohibits take of endangered species, where "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct. Within the definition of take, the term "harm" has been subject to significant judicial scrutiny. "Harm" is clearly an act that actually kills or injures wildlife, but it may also include actions that significantly impair essential behavioral patterns, including breeding, feeding, or sheltering.

The National Environmental Policy Act (NEPA) requires Federal agencies to assess the impact of planned activities on the environment and to make the assessment available to the general public. The decision-making procedures may be documented by either an Environmental Assessment (EA) or an Environmental Impact Statement (EIS). Sound and TES are often important issues in these documents, particularly as reviewers place a stronger emphasis on cumulative effects of activities.

Appendix B: Range Maps for AERTA-Listed TES of Concern

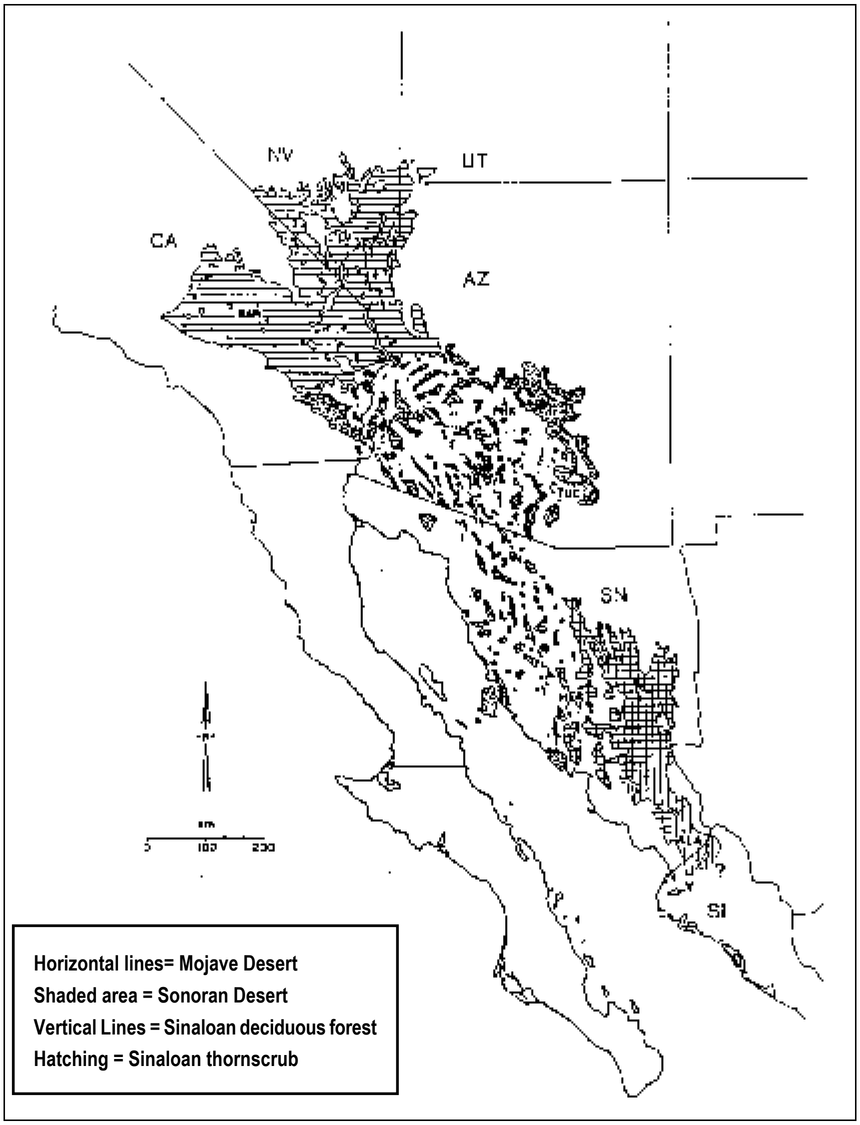

Figure B1. Desert Tortoise range map (Germano 1994).

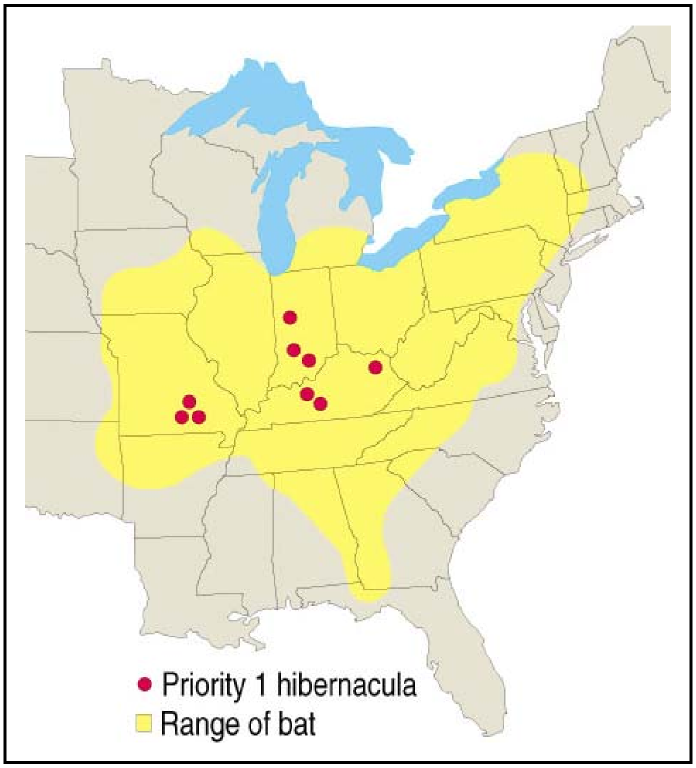

Figure B2. Indiana Bat range map (Drobney and Clawson, unpublished report).

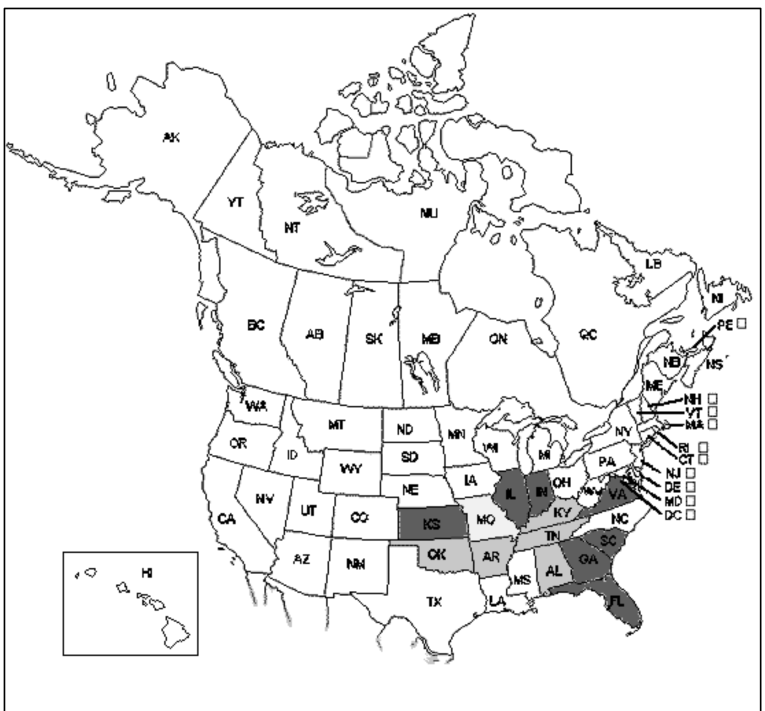

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Figure B3. Gray Bat range map.

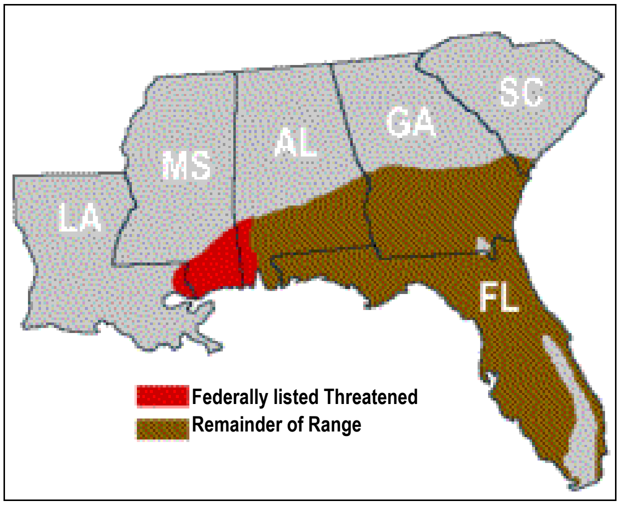

Figure B4. Gopher Tortoise range map (Gopher Tortoise Council).

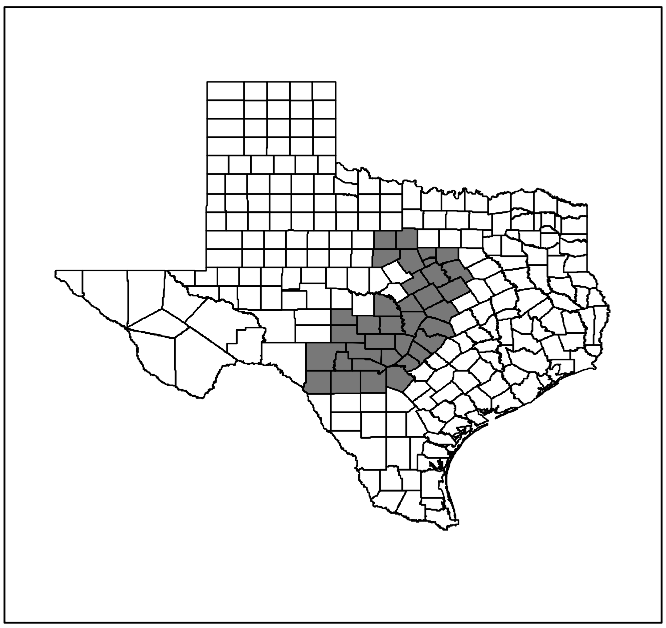

Figure B5. Historic breeding range of Golden-cheeked Warblers in Texas (Hayden et al. 2001).

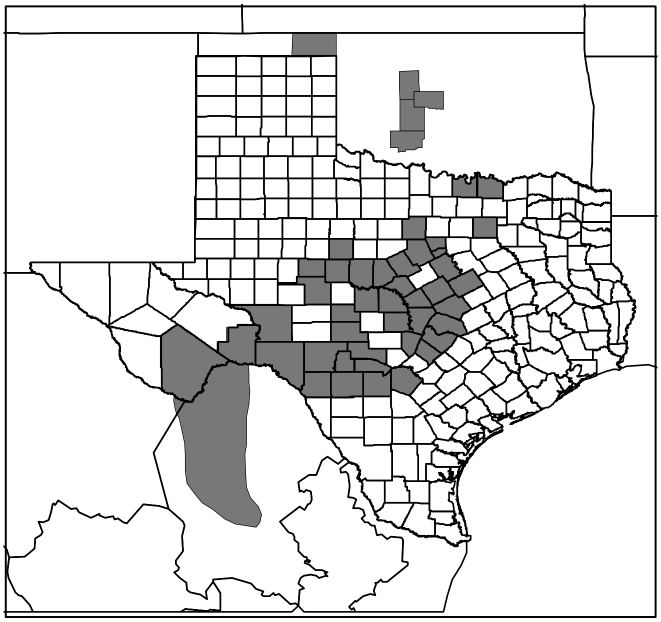

Figure B6. Historic breeding range of Black-capped Vireos in Texas, Oklahoma, and Mexico (Hayden et al. 2001.)

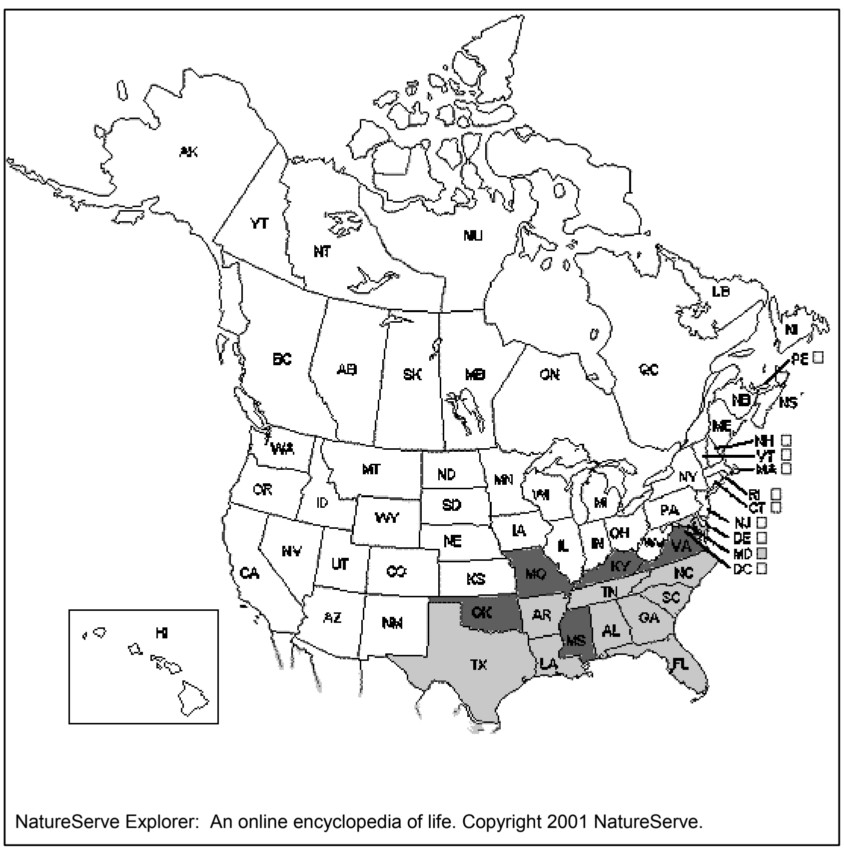

Figure B7. Red-cockaded Woodpecker range map. This species may be extirpated from Maryland and Tennessee.

Figure B8. Distribution map for Mexican and Northern Spotted Owls (map developed by Center for Biological Diversity).

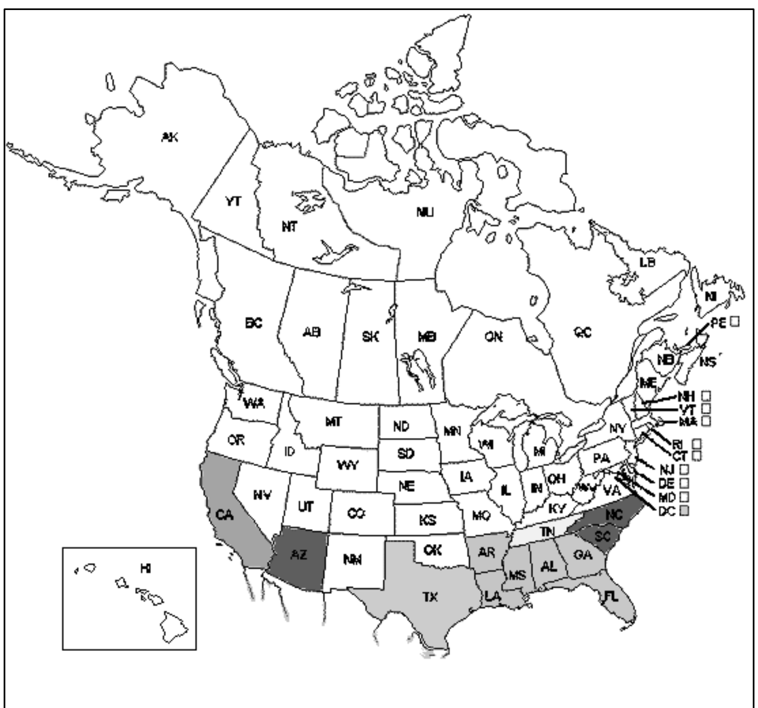

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Figure B9. Wood Stork range map. This species may be extirpated from Texas.

Note: The NatureServe Explorer migratory bird maps do not yet distinguish breeding vs. nonbreeding states of occurrence and the wood stork currently breeds in the United States only in Florida, Georgia, and South Carolina.

Appendix C: Summary Data Tables

Table C1. Factors used to prioritize 13 TES listed in the revised 1999 AERTA.

Common Name	No. Army Sites Occupied	Level of Installation Restrictions	Army-Wide Training Impacts	Previous Noise Research	Hearing Sensitivity Data	Acres Off limits	Acres Restricted	Audiogram/ Military Noise Overlap	AERTA/TES Applicability	Noise Research Need
Birds										
Black-capped Vireo	6	Amber-Red	Amber-Red	None	None	0	14,120	Probable	Low	Moderate
Golden-cheeked Warbler	2	Amber-Red	Amber-Red	2 Passive field studies (1 non DoD)	None	0	42,860	Probable	Low	Moderate
Least Bell's Vireo	0	Green	Green	None	None	0	0	Probable	Low	Low
Mexican Spotted Owl	4	Green-Amber	Green-Amber	Experimental field study	Surrogate	5,400	4,800	Yes	High	Low
Northern Aplomado Falcon	1	Green	Green	None	None	0	426,880	Probable	Low	Low
Northern Spotted Owl	0	Amber	Green	None	Surrogate	N/A	N/A	Yes	High	Low
Red-cockaded Woodpecker	11	Red	Red	Experimental field study; Passive field study	Surrogate	1,742	7,204	Yes	Low	None (Complete)
Wood Stork	4	Green	Green	None	None	0	0	Probable	Low	Low
Mammals										
Gray Bat	7	Amber	Amber	Passive field study (non-cave)	Surrogate	N/A	N/A	Yes	High	Moderate
Indiana Bat	7	Amber	Amber	3 Passive field studies; (non DoD, cave projects) Laboratory study	Surrogate	N/A	N/A	Yes	High	Moderate
Lesser Long-nosed Bat	2	Amber	Amber	Passive field study (cave)	None	5,000	5,000	Probable	Moderate	Low-Moderate
Reptiles										
Desert Tortoise	2 (+1 SOC)	Amber-Red	Red (unique)	Laboratory study	Yes	20,000	23,883	Yes	High	High
Gopher Tortoise	1 (+6 SOC)	Amber-Red	Amber-Red	None	Surrogate	883	16,081	Yes	High	Moderate-High

Table C2. Range of 13 TES listed in the 1999 revised AERTA requirements.

Scientific Name	Common Name	U.S. Range	Installation	State	MACOM	Federal Status	Occur	Critical Habitat	Impact
Birds									
Vireo atricapillus	Black-capped Vireo	LA, NE, OK, KS, TX	Addicks Reservoir	TX	ARNG	Endangered over entire range	Onsite	None	Yes
			Camp Barkeley	TX	ARNG		Both	None	Yes
			Fort Hood	TX	FORSCOM		Both	None	Yes
			Fort Sam Houston	TX	MEDCOM		Both	None	Yes
			Fort Sill	OK	TRADOC		Both	None	Yes
			STARC	TX	ARNG		Onsite	None	Yes
Dendroica chrysoparia	Golden-cheeked Warbler	TX	Fort Hood	TX	FORSCOM	Endangered over entire range	Both	None	Yes
			Fort Sam Houston	TX	MEDCOM		Both	None	Yes
Vireo bellii pusillus	Least Bell's Vireo	CA	Camp Roberts	CA	ARNG	Endangered over entire range	Contiguous	None	None
			Camp San Luis Obispo	CA	ARNG		Contiguous	None	None
			Fort Hunter Liggett	CA	USARC		Contiguous	None	None
Strix occiden-talis lucida	Mexican Spotted Owl	AZ, CO, NM, UT, TX	Camp Navajo	NM	ARNG	Threatened over entire range	Both	Yes	Yes
			Fort Bliss	TX	TRADOC		Both	No	None
			Fort Carson	CO	FORSCOM		Both	N/A	None
			Fort Huachuca	AZ	TRADOC		Both	Yes	Yes
			White Sands Missile Range	NM	AMC	Threatened	Contiguous	No	None
Falco femoralis septentrionalis	Northern Aplomado Falcon	AZ, NM, TX	Fort Bliss	TX	TRADOC	Endangered over entire range	Contiguous	None	None
			White Sands Missile Range	NM	AMC		Both	None	None
Strix occiden-talis caurina	Northern Spotted Owl	CA, OR, WA	Camp Adair	OR	ARNG	Threatened over entire range	Contiguous	None	None
			Camp Rilea	OR	ARNG		Contiguous	None	None
			Fort Lewis	WA	FORSCOM		Not present	Yes	Yes

Scientific Name	Common Name	U.S. Range	Installation	State	MACOM	Federal Status	Occur	Critical Habitat	Impact
Birds (cont.)									
Picoides borealis	Red-cockaded Woodpecker	AL, AR, FL, GA, KY, LA, MS, NC, OK, SC, TX, VA	Camp Beauregard	LA	ARNG	Endangered over entire range	Contiguous	None	None
			Camp Blanding	FL	ARNG		Both	None	None
			Camp Mackell	NC	FORSCOM		Onsite	None	None
			Camp Shelby	MS	ARNG		Contiguous	None	None
			Fort Benning	GA	TRADOC		Onsite	None	Yes
			Fort Bragg	NC	FORSCOM		Both	None	Yes
			Fort Gordon	GA	TRADOC		Onsite	None	Yes
			Fort Jackson	SC	TRADOC		Onsite	None	Yes
			Fort Polk	LA	FORSCOM		Both	None	Yes
			Fort Stewart	GA	FORSCOM		Onsite	None	Yes
			Leesburg TS	SC	ARNG		Onsite	None	Yes
			Peason Ridge	LA			Onsite	None	Yes
			Sunny Point	NC	MTMC		Both	None	Yes
Mycteria americana	Wood Stork	AL, GA, FL, SC	Camp Blanding	FL	ARNG	Endangered over entire range	Onsite	N/A	None
			Fort Benning	GA	TRADOC		Both	None	None
			Fort Gordon	GA	TRADOC		Onsite	None	None
			Fort Stewart	GA	FORSCOM		Both	None	None
			Sunny Point	NC	MTMC		Contiguous	None	None
Mammals									
Myotis grisescens	Gray Bat	AL, AR, FL, GA, IL, IN, KS, KY, MO, MS, NC, OK, TN, VA	Anniston Army Depot	AL	AMC	Endangered over entire range	Onsite	None	N/A
			Camp Crowder	MO	ARNG		Both	None	N/A
			Fort Campbell	KY	FORSCOM		Contiguous	None	N/A
			Fort Knox	TN	TRADOC		Onsite	None	N/A
			Fort Leonard Wood	MO	TRADOC		Both	None	N/A
			Fort McClellan	AL	TRADOC		Both	None	N/A
			Fort Rucker	AL	TRADOC		Contiguous	None	N/A
			Indiana AAP	IN	AMC		Contiguous	None	N/A

Scientific Name	Common Name	U.S. Range	Installation	State	MACOM	Federal Status	Occur	Critical Habitat	Impact
Mammals (cont.)			Redstone Arsenal	LA	AMC	Endangered over entire range	Both	None	N/A
			Skelton TS	MO	ARNG		Contiguous	None	N/A
			Tullahoma TS	TN	ARNG		Contiguous	None	N/A
			Truman TS	MO	ARNG		Contiguous	None	N/A
Myotis grisescens	Gray Bat		Wendall Ford Regional Training Center	KY	ARNG		Onsite	None	N/A
			West Kentucky TS	KY	ARNG		Both	None	N/A
Myotis sodalis	Indiana Bat	AL, AR, CT, IA, IL, IN, KY, MA, MD, MI, MO, NC, NJ, NY, OH, OK, PA, SC, TN, VA, VT, WV	ARDEC (Picatinny Arsenal)	NJ	AMC	Endangered over entire range	Both	None	N/A
			Camp Atterbury	IN	ARNG		Onsite	None	N/A
			Fort Campbell	KY	FORSCOM		Onsite	None	N/A
			Fort Knox	TN	TRADOC		Both	None	N/A
			Fort Leonard Wood	MO	TRADOC		Both	None	N/A
			Indiana AAP	IN	AMC		Contiguous	None	N/A
			Iowa AAP	IA	AMC		Onsite	None	N/A
			Macon TS	MO	ARNG		Contiguous	None	N/A
			Newport Chemical Depot	IN	AMC		Onsite	None	N/A
			Ravenna AAP	OH	AMC (BRAC)		Contiguous	None	N/A
			Redstone Arsenal	LA	AMC		Contiguous	None	N/A
			Jefferson Proving Ground	IN	AMC (BRAC)		Contiguous	None	N/A
			Tobyhanna AAP	PA	AMC		Contiguous	None	N/A
			Volunteer AAP	TN	AMC		Contiguous	None	N/A
			Charles M. Price Support Center	IL	AMC		Contiguous	None	N/A
			Watervliet	NY	AMC		Contiguous	None	N/A
			U.S. Military Academy	NY	USMA		Contiguous	None	N/A

Scientific Name	Common Name	U.S. Range	Installation	State	MACOM	Federal Status	Occur	Critical Habitat	Impact
Mammals (cont.)			Radford AAP	VA	AMC		Contiguous	None	N/A
			Letterkenny AD	PA	AMC		Contiguous	None	N/A
			Milan AAP	TN	AMC		Contiguous	None	N/A
			Crane AA Activity	IN	AMC		Contiguous	None	N/A
			Holston AAP	TN	AMC		Contiguous	None	N/A
			Ft. McClellan	AL	AMC (BRAC)		Contiguous	None	N/A
			Joliet AAP	IL	AMC		Contiguous	None	N/A
			Rock Island Arsenal	IL	AMC		Contiguous	None	N/A
Myotis sodalis	Indiana Bat		Savanna Army Depot	IL	AMC (BRAC)		Contiguous	None	N/A
Leptonycteris curasoae yerbabuenae	Lesser Long-nosed Bat	AZ, NM	Florence Military Reserve	AZ	ARNG	Endangered over entire range	N/A	None	N/A
			Fort Huachuca	AZ	TRADOC		Both	None	
Reptiles									
Gopherus agassizii	Desert Tortoise	AZ, CA, UT, NM, NV	Clark County TS	NV	ARNG	Threatened over entire range, except AZ south and east of Colorado River	Both	Yes	Yes
			Fort Irwin	CA	FORSCOM		Both	None	Yes
			Yuma Proving Ground	AZ	AMC	Species of Concern (SOC)	Both	None	N/A, no T&E status on YPG
Gopherus polyphemus	Gopher Tortoise	AL, FL, GA, LA, MS, SC	Camp Shelby	MS	ARNG	Threatened wherever found west of Mobile and Tombigbee Rivers in AL, MS, and LA.	Both	None	Yes
			Camp Blanding	FL	ARNG	SOC	Onsite	None	Yes
			Fort Stewart	GA	FORSCOM	SOC	Onsite	None	Yes
			Fort Gordon	GA	FORSCOM	SOC	Onsite	None	Yes
			Fort Benning	GA	FORSCOM	SOC	Onsite	None	Yes
			Georgia National Guard	GA	ARNG	SOC	Onsite	None	Yes
			Fort Rucker	AL	FORSCOM	SOC	Onsite	None	Yes

Appendix D: Hearing Sensitivity Data and Source Spectra Examples

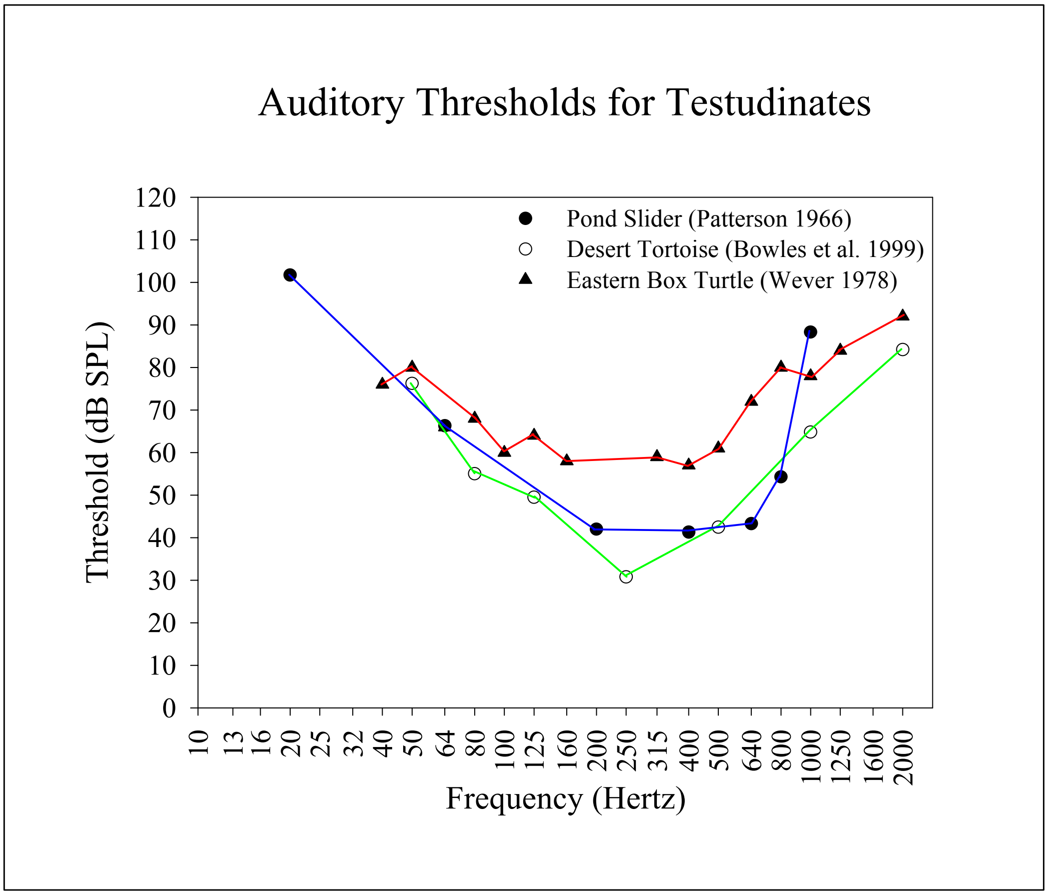

Figure D1. Hearing sensitivity data for tortoises and turtles. (Figure developed based on work by Patterson [1966], Wever [1978], and Bowles et al. [1999].)

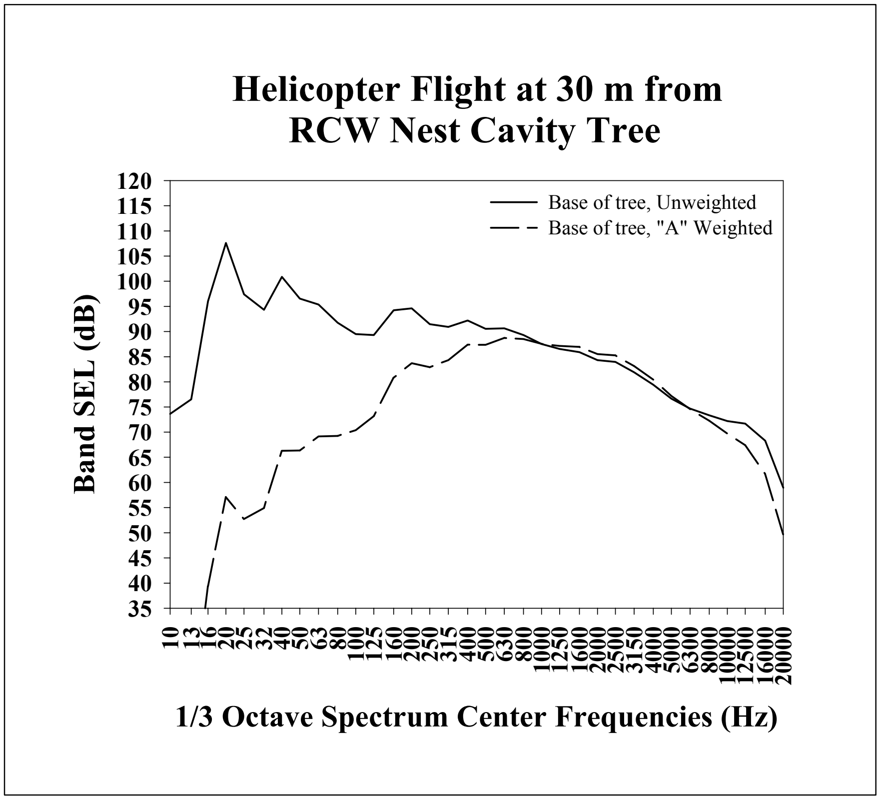

Figure D2. SEL weighting comparison for a helicopter overflight at 30 m.

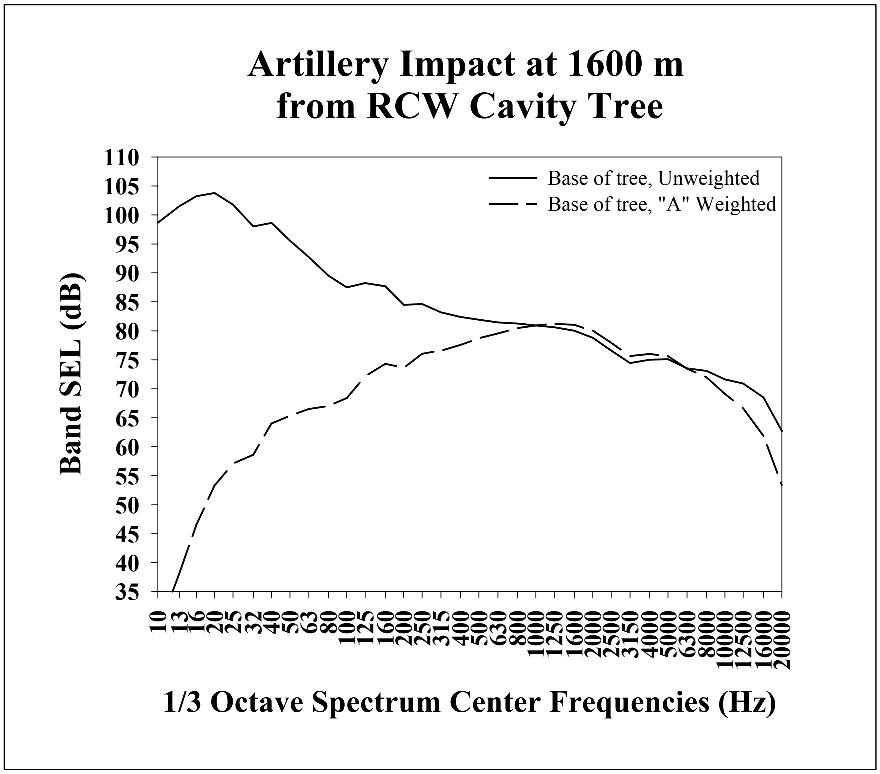

Figure D3. SEL weighting comparison of artillery impact noise at 1,600 m.

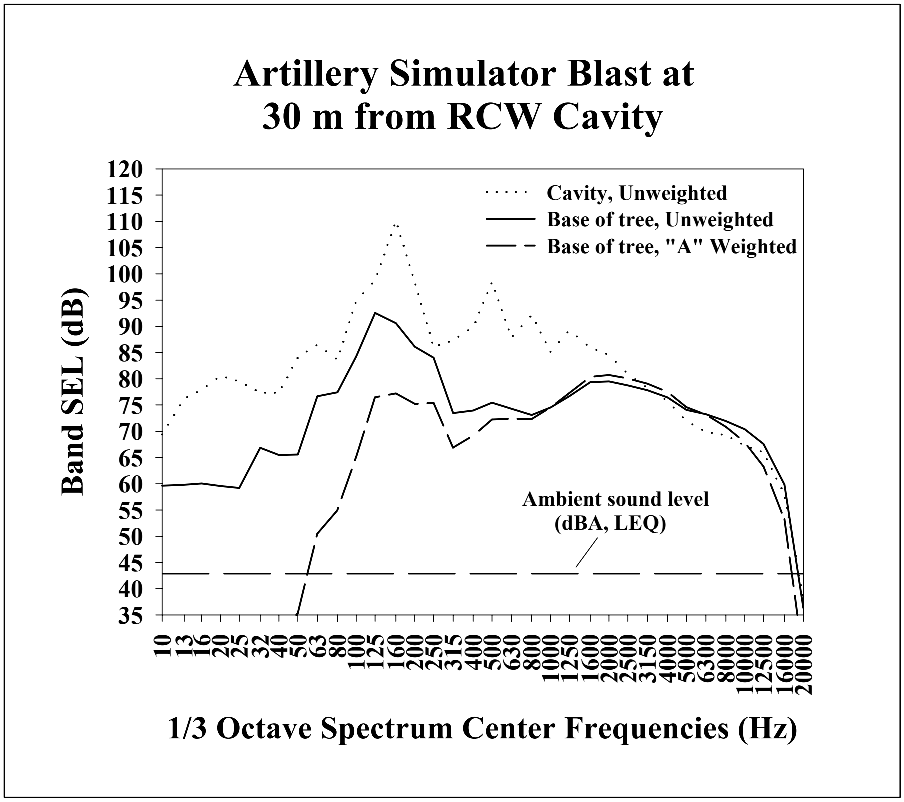

Figure D4. SEL weighting comparison of an artillery simulator blast at 30 m.

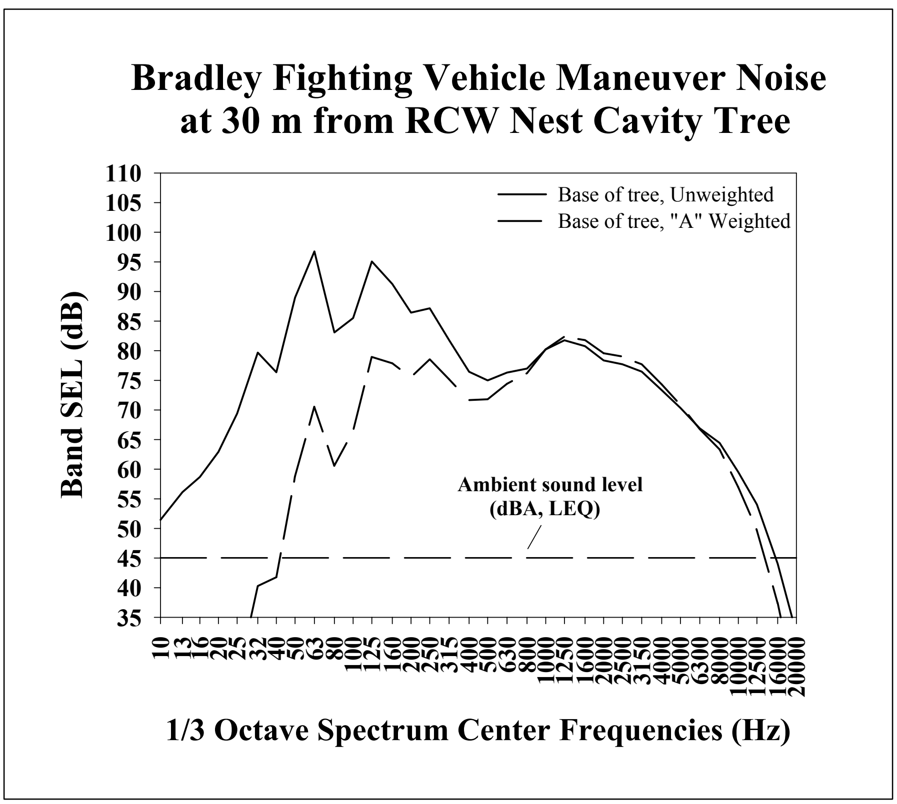

Figure D5. SEL weighting comparison for Bradley fighting vehicle maneuver noise at 30 m.

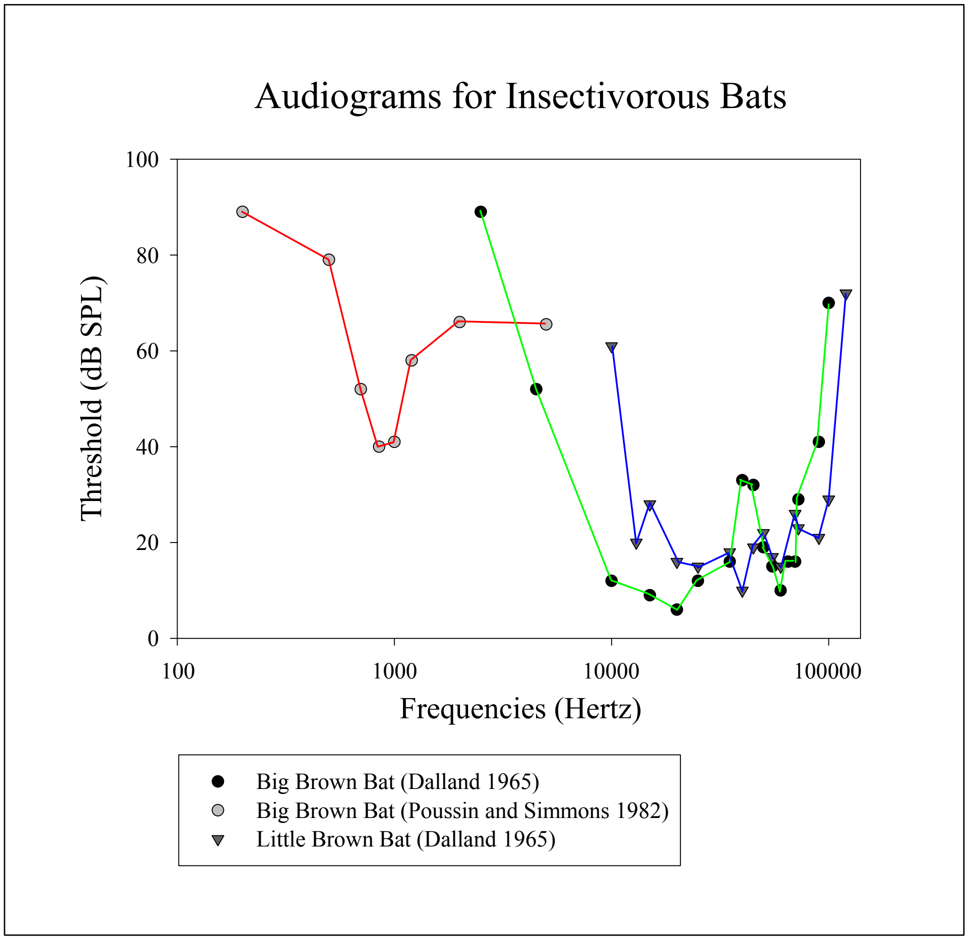

Figure D6. Hearing sensitivity data for insectivorous bats. (Figure developed based on work by Dalland [1965] and Poussin and Simmons [1982].)

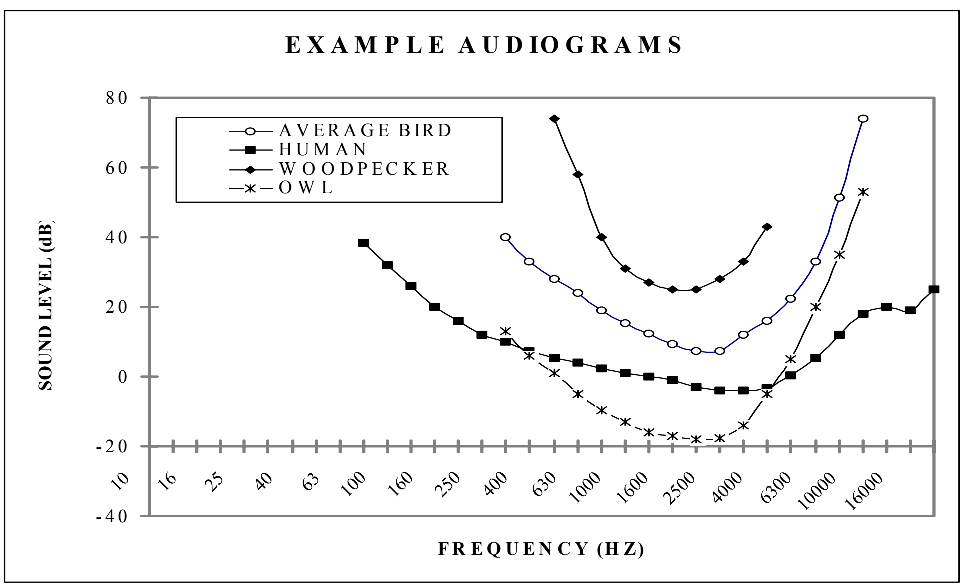

Figure D7. Examples of audiograms and frequency-weighting functions for humans and various bird species. (Figure developed based on work by Dooling [1982], Lohr et al. [1999], Trainer [1946], and Konishi [1973].)

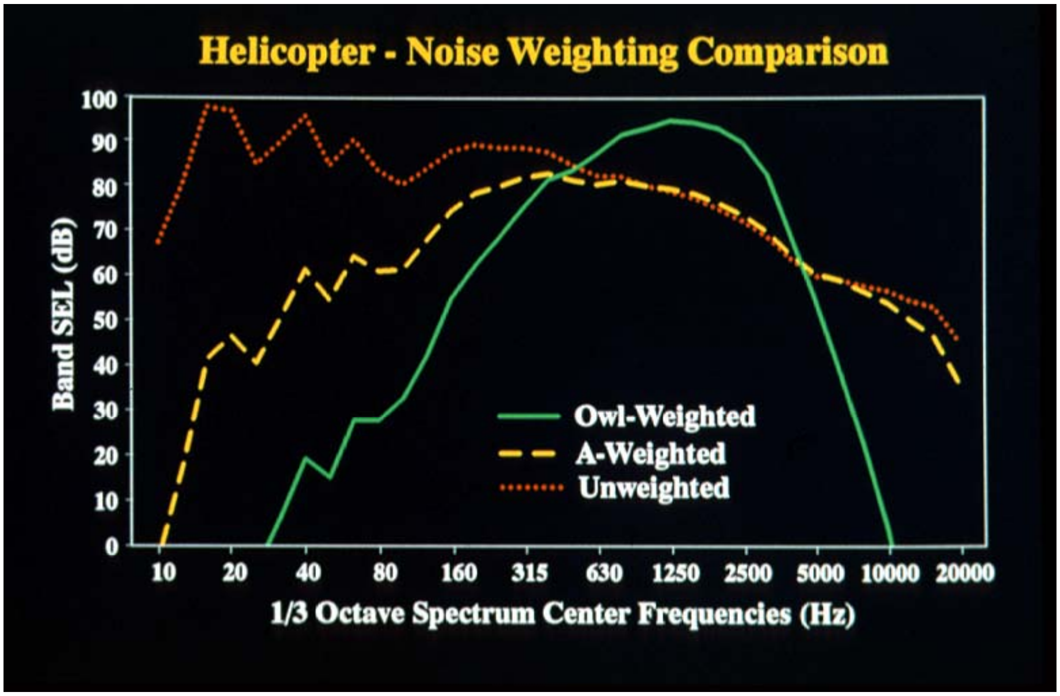

Figure D8. SEL comparison of owl-, A-, and unweighted helicopter noise at 60 m.

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14. ABSTRACT

This report represents the first year of a continuing study addressing the effects of military training noise on Threatened and Endangered Species (TES). The purpose of this study was to prioritize specific TES of concern from the U.S. Army Environmental Requirement and Technology Assessment species list and develop a prioritized list of TES for future noise research relative to military training noise effects. The primary research objective for future noise research is to determine the impact of certain types of military training noise on TES. A secondary objective is to develop and disseminate cost-effective techniques for documenting the effects of training noise on TES populations.

15. SUBJECT TERMS
threatened and endangered species (TES), military training, wildlife conservation, U.S. Army Environmental Requirement and Technology Assessment (AERTA), sound management, noise

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