4. Impact of Sound

4.1. Measurement of Sound

The unit to measure the loudness of sound is the A-weighted decibel scale or "dBA.[6]" The decibel scale is a logarithmic scale of sound power or intensity. An increase of 10dBA means an increase in sound intensity by a factor of two. An increase of 20 dBA means an increase in sound intensity by a factor of 4. Conversely, a reduction of 10 dBA corresponds to a reduction in sound intensity by 1/2, and so forth.

The smallest change in sound level that a human ear can perceive is about 3 dBA, and an increase of 5 dBA is usually noticeable. Normal conversation ranges between 44 and 65 dBA when the speakers are 3 to 6 feet apart. (FGMI, 2000)

Often, transportation sounds are used to describe sound levels because people can commonly relate to them. However, the sound intensity can vary significantly depending on the situation and machinery. According to the 2004 Forest Service Final EIS on Commercially Guided Helicopter Skiing on the Kenai Peninsula (page 3-3 and 3-4):

> *For example, estimates of "highway traffic sound include between 70 dB for passing automobiles and 80 dB for heavy traffic as heard from a sidewalk. Another source estimated light automobile traffic at about 50 dB. Further since frequency (volume of traffic) also enters into the sound equation, as does the relative composition or proportion of commercial and noncommercial vehicles, average speed, stop-and-go traffic, and time of day, estimates of typical noise are endlessly dynamic.*
>
> *Snowmobiles are reported to routinely produce sound levels exceeding 80 dB and some have been reported to exceed 100 dB.*
>
> *Railroad sound levels may reach 110 dB from horns at a distance of 100 feet and the trail itself passing at 80 dB. . . .*
>
> *The Federal Aviation Administration has published some detailed noise outputs of light aircraft and helicopters. For example common models such as the Cessna 206 generate 70 dB and the Piper PA-18 Super Cub generates 60 dB on take-off. In level flight at 500 feet elevation, an A-Star 350 helicopter used by [Chugach Powder Guides] produces 75 dB, at 1,000 feet produces approximately 70 dB. During power ascent and landing approaches sound are the loudest, 87.1 to 94.5 dB.*

[6] The difference between the decibel scale (dB) and A-weighting decibel (dBA) scale is that some of the A-weighted scale emphasizes the frequencies that human ear can hear. Specifically, the dBA scale de-emphasizes the high (6.3 kHz and above) and low (below 1 KHz) frequencies, and emphasizes the frequencies between 1 kHz and 6.3 kHz, in an effort to simulate the relative response of human hearing.

4.1.1. Effect of Distance on Sound Intensity

Sound level (noise) dissipates predictably as a function of distance from source and receptor (i.e., humans). In the simplest situation, a stationary point source, noise dissipates inversely as the square of the distance from the source — assuming no barriers or interference — such that sound level decreases approximately 6 dB for every doubling of distance. For a simple example, an automobile might produce 80 decibels at a distance of 25 feet. At a distance of 50, the noise level will be 74 dB; at a distance of 100 feet, the noise level will be 68 dB; and at a distance of 200 feet, the noise level will be 62 dB.

However, sound transmission also is dependent on terrain, vegetation, and temperature. Sound dissipates less in cold, dense air. Vegetation typically absorbs sound, although snow may mask the some of the vegetation's absorptive capacity. Sound may reflect in certain terrains such as canyons and valleys; intervening ridges may successfully block the sound.

4.1.2. Typical Sound Levels

In Table 4-1, below, measures of sound levels for typical noise sources found indoors and outdoors are shown.

Table 4-1. Sound Levels and Relative Loudness of Typical Noise Sources Found in Indoor and Outdoor Environments

Noise Source or Activity	Sound Level (dBA)	Subjective Impression	Relative Loudness (human judgment of different sound levels)
Jet aircraft takeoff from carrier (50 feet)	140	Threshold of pain	64 times as loud
50-hp siren (100 feet)	130		32 times as loud
Loud rock concert near stage; Jet takeoff (200 ft)	120	Uncomfortably loud	16 times as loud
Float plane takeoff (100 feet)	110		8 times as loud
Jet takeoff (2,000 ft)	100	Very loud	4 times as loud
Heavy truck or motorcycle (25 ft)	90		2 times as loud
Garbage disposal, food blender (2 feet); Pneumatic drill (50 feet)	80	Moderately loud	Reference loudness
Vacuum cleaner (10 feet); Passenger car at 65 MPH (25 feet)	70		1/2 as loud
Large store air conditioning unit (20 feet)	60		1/4 as loud
Light auto traffic (100 feet)	50	Quiet	1/8 as loud
Bedroom or quiet living room; bird calls	40		1/16 as loud
Quiet library, soft whisper (15 feet)	30	Very quiet	
High quality recording studio	20		
Acoustic Test Chamber	10	Just audible	
	0	Threshold of hearing	

Source: FGMI 2000. p.4:261

4.1.3. Measurement Metrics

There are a variety of measures that agencies and scientists use to measure instantaneous, average, maximum, and minimum sound. The vocabulary is useful to understand publications, ordinances, and stipulations. A few of the commonly used measures are explained below.

L_{eq}. (Equivalent Sound Level – a type of average sound level)

L_{eq} is the logarithmic average within a specified time period. Put another way, it is the summation of the total sound energy measured, then averaged over the entire sound period. It essentially provides an observer the average energy over that time period, given in decibels. Because it is a logarithmic average, L_{eq} is generally higher than the arithmetic average and is heavily influenced by occasional loud sounds.

L_{dn} (Day-night Level). L_{dn} is a 24-hour sound level, but with the nighttime hours penalized by adding 10 decibels to the actual noise level prior to averaging. The penalty helps account for added sensitivity to noise during nighttime hours.

L_X (Sound Level exceeded x% of the time); L_X is the sound level exceeded X% of the time over a specific period of time (such as an hour, or a 24-hour period). For example, L_{50} is the sound level exceeded 50% of the time; it is a type of "average" sound level that is easily explained to the common person. Statistically, it is the median sound level. In other words, L_{90} is the sound level exceeded 90% of the time during the time period; L_{10} is the sound level exceeded 10% of that time period. Some municipal noise ordinances are written specifying sound levels that cannot be exceeded 50% of the time, or 10% of the time, etc.

L_1 is the sound level exceeded 1% of the time. For typical sound emitters with a reasonably gradual profile — such as a helicopter or truck — the L_1 limit is effectively the upper limit of sound. For noise emitters that have a very sharp profile, such as a sonic boom, L_1 does not measure the effective upper sound limit. In fact, for sharp-profile sounds, like sonic booms, L_X does not would work very well. Sonic booms occur in a few seconds and this measure would miss the real effect of a few sonic booms per hour.

L_{max} & L_{min} (Maximum and Minimum). L_{max} & L_{min} are the maximum and minimum sound pressures for a given period given in dBA or dB.

4.2. Helicopter Sounds

There is some evidence that people notice helicopter sounds more than other aircraft sounds or, more accurately, that they believe helicopters are more annoying than other aircraft sounds.

In 2004, the FAA investigated this issue in response to a directive from Congress concerning helicopter noise effects in urban areas. (FAA 2004b). The FAA report summarizes the potential physiological effects of excessive noise on people. In general, significant sustained physiological effects require sustained exposure to high levels of sound, which is rarely the issue with respect to helicopter-supported recreation. The study also summarized the differences between the level of annoyance from helicopter sounds as compared to other sounds.

Helicopters cause a "Blade-Slap" phenomenon sometimes called Blade Vortex Interaction (BVI). This phenomenon occurs during descent conditions for landing, which "is the result of interaction by a rotor blade with previously shed tip vortices. These interactions generate a complex unsteady pressure field that propagates below the rotor as high impulsive noise." (FAA 2004b).

Blade-Slap did not adequately capture the unique annoyance of helicopter sound, as evidenced by other work referenced by the FAA. Low-frequency energy generated by

helicopter blades contributed to a higher-than-expected level of annoyance. Still other studies were unable to find a physical explanation for the increased annoyance, but still concluded that there is heightened reaction to helicopter sounds, as compared to those from fixed-wing aircraft. One portion of the report referenced two studies in England, and one community's response in particular:

> *The contribution of fixed-and rotary-wing aircraft to the overall noise exposure was about equal. However, the percentages of people who considered helicopters more disturbing than fixed-wing aircraft were 2 to 2.5 times as large as the percentages that considered helicopters less disturbing. In the communities of Esher and Epson,* [in the United Kingdom] *where the numbers of helicopters and fixed-wing aircraft were about equal, the disturbance due to helicopter noise was 2.5 times as large as that due to fixed-wing aircraft noise. People were more annoyed by helicopters even though on average, the fixed-wing aircraft were 5.0 dB louder*. (FAA, 2004b)

The FAA provides a number of possible explanations for this heightened community response. They note that the explanations are not mutually exclusive (FAA, 2004b):

- "A subsection of the population may be more sensitive to the low-frequency helicopter noise than is the majority of the population." While the size of the subset is not known, this group may be very sensitive to low-frequency sound and "is quite bothered and disturbed by this noise almost as soon as it crosses the threshold of audibility."

- "A-weighting is possibly not the most appropriate metric with which to assess helicopter noise because the A-weighting attenuates the low-frequency noise component." It may be that the A-weighting scale (dBA) understates the effect of low-frequency sound that is characteristic of helicopters

- "Noise-inducing building vibration and rattle has been shown to significantly increase noise annoyance and helicopter sound is rich in low-frequency content."

- As described above, "there is some evidence that suggests helicopter noise is slightly more annoying than fixed-wing aircraft noise at the same sound exposure level."

- Helicopter noise may be more noticeable because of the impulsive blade-slap sound. That is, it may be that helicopters, whether or not they are more annoying, are just more noticeable because of their distinctive sound.

- "There is the possible phenomena of 'virtual noise' in which a set of non-acoustical factors, such as bias (a personal judgment that the helicopter does not need to fly here) and the fear (of crashes/injury/death), greatly enhances people's negative attitudes." The FAA reports the perception to some people that "helicopters used for transportation of corporate executives, flightseeing, or ENG [electronic news gathering] are unimportant . . . There is the perception that helicopters could fly higher than they do and over less noise-sensitive areas." The report goes on to suggest that some people feel "that the

helicopter is 'a rich man's toy'." While helicopter-supported recreation was outside the scope of the FAA report, it is very possible that people's attitudes about helicopter-recreation affect their perception of annoyance.

- The way helicopters are operated can influence reactions. A fixed-wing aircraft just cannot stay in the area that long. It must move on. Helicopters have the capacity to hover and can operate close to the ground and on much smaller or remote land sites.

In summary, the FAA concluded that there appears to be some distinct characteristics of helicopter sound that make the equivalent sound level form a helicopter more disturbing — to some or many people — than similar sound levels from fixed-wing aircraft. For that reason, the report recommended that new models be developed that characterize human response to helicopter noise. Presumably, this may replace the A-weighted decibel scale (dBA). The specific recommendation is below:

> *Additional development of models for characterizing the human response to helicopter noise should be pursued. Civil helicopter annoyance assessments utilize the same acoustic methodology adopted for airplanes with no distinction for a helicopter's unique noise character. As a result, the annoyance of unaccustomed, "impulsive" helicopter noise has not been fully substantiated by a well-correlated metric. Comments from both the helicopter industry and the public strongly recommended that further socio-acoustic investigations be pursued. Additional civil helicopter annoyance studies may help review current noise measurement analysis methodology that would lead to improved noise mitigation effectiveness . . . In the mean time, the FAA will continue to rely upon the widely accepted Day-Night Sound Level (DNL) as its primary noise descriptor for airport and heliport land use planning. The FAA will also continue the use of supplemental noise descriptors for evaluation of helicopter noise issues.* (FAA, 2004b)

4.3. Example Noise Control Ordinances

The information below contains extracts from some representative noise control ordinances. However, the ordinances are complicated and not repeated in their entirety. They typically contain numerous definitions and exceptions. Only the most relevant parts of the ordinances are discussed below.

4.3.1. Municipality of Anchorage

Anchorage has a 12-page noise control ordinance. It has separate standards for airports, construction, power tools, motor vehicles, etc. One portion of the ordinance provides that on a person's private property he or she may not create sounds that cross into a property boundary of another person to exceed the limits shown in Table 4-2 below.

Table 4-2. Municipality of Anchorage Noise Ordinance

Receiving Land Use Category	Time	Sound Level (dBA)
Residential Area	7 AM - 10 PM	60
	10 PM - 7 AM	50
Commercial Area	7 AM - 10 PM	70
	10 PM - 7 AM	60
Industrial Area	All Times	80

Source: Anchorage Municipal Code 15.70.080(A)

Note that louder sound levels are allowed for motor vehicles being operated on a public right-of-way and from airports.

4.3.2. Noise ordinances that include an increase above background

Some municipal ordinances combine average noise levels, like those described in the Anchorage ordinance, with maximum temporary increases. For example, Sacramento County includes the sound limits in Table 4-3 below.

Table 4-3. Sacramento County Noise Ordinance

	Allowable Increase Above Average	Decibel Limit (dBA)	
		Day	Night
Average Maximum Level	--	55	50
≤ 30 minutes/hour	0	55	50
≤ 15 minutes/hour	+5	60	55
≤ 5 minutes/hour	+10	65	60
≤ 1 minute per hour	+15	70	65
Not to be exceeded at any time	+20	75	60

Note that the time duration for an increase does not have to be consecutive. For example, the ordinance allows up to 15 minutes during any daytime hour at 50 dBA, but the 15-minutes do not have to be all during the same 15 minutes. It can be at anytime during that hour, but which cumulatively do not add to more than 15 minutes.

Also, the Sacramento County ordinance is five pages long with a number of definitions and exceptions.

4.3.3. Ordinance for Quiet Areas

The State of Oregon has a 24-page noise control ordinance with specific limits for front-engine cars, rear-engine cars, trucks, school buses, snowmobiles, airports, off-road vehicles, snowmobiles, and many other sound sources. The ordinance includes limitation for industrial and commercial noise sources for "quiet areas."

Table 4-4. Oregon State Standards for Commercial Industrial Sources in Quiet Areas

	Decibel Limit (dBA)	
	Day	Night
L_{50}	50	45
L_{10}	55	50
L_1	60	55

This standard has some advantages – it is easily understood by the common person. Using the day-time standards for example: During each hour, a sound source must be quieter than 50 dBA for half the time and may be louder than 50 dBA for 50% of the time. However, they may be louder than 55 dBA for only 10% of the time each hour (six minutes) and for 1% of the time during each day-time hour — 36 seconds, the noise may be louder than 60 dBA. Thus, the L_1 limit is effectively the upper limit for most types of sound.

4.3.4. DNR Limits Used at True North Gold Mine

For one specific permit issue, DNR adopted noise control stipulations that are very close to the Oregon noise control standard described above. They did so to regulate sound impacts from True North Gold Mine haul trucks on nearby residences on Cleary Summit outside of Fairbanks. The sound limits that DNR imposed on True North trucking operations are those in Table 4-5 below:

Table 4-5. DNR Noise Control Limits for True North Gold Mine Road Right-of-Way

	Decibel Limit (dBA)	
	Day	Night
L_{50}	55	45
L_{10}	60	50
L_{1}	75	55

4.3.5. Federal Highway Administration Noise Criteria

The Federal Highway Administration has traffic noise impact criteria for federally funded road and high projects. (See Title 23 of the Code of Federal Regulations (CFR) Part 772, Procedures for abatement of Highway Traffic Noise and Construction Noise.) The criteria are applicable for residences, churches, schools, recreational uses, or commercial and industrial areas using hour equivalent sound level (L_{eq}). A summary is contained in Table 4-6.

Table 4-6. FHWHA Roadway Noise Abatement Criteria

Land Use Category		Hourly L_{eq} (dBA)
Type A	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose	57 (exterior)
Type B	Picnic areas, recreation areas, playgrounds, active sports areas, parks, residences (exterior) motels, hotels, schools, churches, libraries and hospitals	67 (exterior)
Type C	Developed lands, properties or activities not included in the above categories	72 (exterior)
Type D	Undeveloped land	--
Type E	Residences, motels, hotels, public meeting rooms, schools churches, libraries, hospitals and auditoriums	52 (interior)

4.3.6. Predictors of Community Reaction Matrices

There are some criteria that may not be useable as noise control ordinances, but are able to predict community reaction for intrusive noise sources. (Von Bierke, 1993). The matrix in Table 4-7 uses the day-night sound level (L_{dn}) which assesses noise for the entire day, and has a penalty for nighttime noise to account for the increased sensitivity to noise at night and generally lower nighttime ambient sound levels.

The matrix predicts community reaction to new noise sources. Because it uses the day-night sound level (L_{dn}), the matrix includes a 10 dB penalty for night-time noise. The

matrix is helpful in determining the likely community reaction to a new, intrusive noise source such as introduction of helicopters sounds in an otherwise quiet area. It shows that it may not take a very large increase in sound levels (especially night-time sound levels) to provide significant community reaction.

While the matrix may be useful, we know of no agency or municipality that uses this matrix for its noise control ordinance. The reason may be, in part, because it is difficult for an agency to base the allowed level of noise on whether someone is likely to complain, whether those complaints are viewed as justified, or even actually occur. In addition, the 10 decibel night-time penalty that is imbedded in the metric may also be problematic. For a quiet area, where the average sound level has a decibel level between 40 and 50 dBA (between the sound level of a bedroom or quiet living room; bird calls and light auto traffic at 100 feet), the penalty may require that any new source be 10 dB less than that sound. A 30 dBA level is the sound level of a quiet library or soft whisper at 15 feet. This does not seem realistic. Alternatively, a sound emitter may be less than the allowed maximum during the day, but "save up" the margin for averaging during the night. This may also be confusing to those trying to eliminate noise during sensitive time periods. For these reasons, the matrix is probably not useful as an actual standard. It may be useful in considering community acceptance of a new sound source.

Table 4-7. Community Reaction Matrix

Community Average Reaction	**Relative L_{dn} in dB (normalized intruding minus background)**
None (Many residents probably do not notice the noise, but others may be somewhat disturbed)	-5
Sporadic Complaints (Some complaints, but generally not persistent)	0
Widespread Complaints (Some persistent complaints)	5
Threats of Legal Action (Large numbers of persistent complaints, organized efforts against those responsible for the noise)	14
Vigorous Action (Community reaction may be strong enough to force offenders to limit drastically or cease operations)	21

4.4. The Usefulness (or lack thereof) of Sound Measurement

The discussion in this section has treated sounds as if they were all alike differing only in their intensity (loudness). Common experience, however, shows that all sounds are not alike, despite the difficulty in capturing those differences in measurements. Three examples may illustrate the differences.

Most people have had the experience of sitting on an airplane near a family with a baby. When that baby is laughing, few people find it disturbing. But when the baby is crying, even if the decibel level is similar, many people find it disturbing, some very disturbing.

Other people may be able to sleep through a spouse's snoring, or the furnace cranking on and off, but are driven to anger by their neighbor's dog barking (especially if they don't particularly like the neighbor). This occurs even when the dog barking is not noticeably louder than the snoring or the furnace.

A resource issue near Fairbanks illustrates the point as well. DNR limited the sound level of True North Gold Mine haul trucks to nighttime average (median) level of 45 dBA. For up to 36 seconds an hour the sound level could extend up to 55 dBA. This is not particularly loud. 45 dBA is between "bedroom or quiet living room; bird calls" and "light auto traffic at 100 feet." 55 dBA is between that level and "large store air conditioning unit (20 feet)." Note that these sound levels are at the property boundary. Sound levels inside the house in the winter when windows are closed (when the noise was most disputed by residents) are much lower.

Despite the restrictive sound levels, DNR received complaints from nearby residents. A few individuals in particular were very persistent. DNR received a number of complaints from the owner and guests of a bed and breakfast that indicated that these low level sounds disrupted their sleep.

When DNR had a consulting firm monitor the background noise levels at night in the subdivision, it found that the loudest sound was a water truck delivering water in the middle of the night. The water truck was louder than the mine's haul trucks, yet no one complained. When a meeting was held at one of the facilities to discuss the sound levels, staff noticed that the sound of the furnace going on and off was louder than the sound of the trucks. Further, the individual who complained most frequently about the trucks was situated adjacent to a dog lot.

No one complained about the water truck, which had been delivering water at night (apparently loudly), for years. The residents did not even notice the furnace. No one complained about the dog lot, which had been there for years. Yet the trucks, which third-party monitoring showed to have a median sound level close to the sound level of bird calls, prompted many complaints.

The point of this illustration is not that the residents were unreasonable, or that trucks should be banned at night. (The area, after all, had an industrial zoning). Rather, it illustrates the limitations of thinking about sound only in decibels. If people can identify an unwanted sound, they may consider it a bothersome noise despite other, louder sounds that do not have the stigma.

This discrimination between similar-intensity sounds is a real phenomena, but one with which government has a difficult time dealing. It is very difficult for government to

determine that one activity is allowed, but a different activity with the same or even lower sound level is not. While there may be some areas, such as parks that are managed particularly to allow people to enjoy a natural setting (including natural sounds), it is unusual in most situations for government to base regulation on some people's perception that an activity is unwanted, even if the physical impacts are low.

4.5. Impacts

Conducting helicopter operations is not without impact to wildlife, residents, or other users in the area. Most government land management agencies must, by law, consider those impacts when making land management decisions. They typically do so through Environmental Assessments, Environmental Impact Statements, or other decisional documents produced for specific actions and have detailed information about impacts to wildlife, recreationists, and the soundscape. Generally, authorizations require the avoidance of observed wildlife and horizontal or vertical separation from known breeding areas. See specific areas for wildlife mitigation measures in Area-Specific Helicopter-Supported Recreational Activities in Section 6. The following is a synopsis of those materials.

4.5.1. Impacts on Wildlife

Human-generated sound is known to affect animals in a variety of ways including annoyance, chronic stress, and hearing loss. Sound may directly affect reproductive physiology or energy consumption as individual animals spend energy, or lose mating or foraging opportunities by repeatedly reacting to or avoiding loud sound. Animals may be forced to retreat from favorable habitat to avoid human-generated sounds. Though direct effects of sound on wildlife may be the most obvious, it may also have indirect effects on populations as well through these mechanisms.

Wildlife biologists report that from extensive studies on wildlife reaction to helicopter sounds, that reaction to sound is species-specific and cannot be generalized (See Appendix J)

Regardless of whether a permit is issued, the threshold for wildlife management is federal and state laws that do not allow the harassment or disturbance of wildlife:

> *AS. 16.05.940(34) "take" means taking, pursuing, hunting, fishing, trapping, or in any manner disturbing, capturing, or killing or attempting to take, pursue, hunt, fish, trap, or in any manner capture or kill fish or game.*

Further, actions are also subject to the Endangered Species Act of 1973 (as reauthorized in 1988), the Marine Mammal Protection Act of 1972, and the Bald and Golden Eagle Protection Act of 1940 (as amended).

Under the Bald and Golden Eagle Protection Act, as amended, it is unlawful to import, export, ***take,*** sell, purchase, or barter any bald eagle or golden eagle, their parts, products, nests, or eggs. "Take" includes pursuing, shooting, poisoning, wounding, killing, capturing, trapping, collecting, molesting, or disturbing the eagles. (See 16 U.S.C. §§ 1531 – 1544.)

The Marine Mammal Protection Act, prohibits the ***take*** of all marine mammal species in U.S. waters. "Take" is defined as: "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." Harassment is defined as "any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild; or has the potential to disturb a marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering." (See 16 U.S.C. § 1362.)

4.5.1.1.Mountain Goats

For alpine skiing and helicopter tours of backcountry and glaciated areas, the species most likely to be affected are mountain goats. This is primarily due to the proximity of their habitat to flight routes and tour landing sites. Preferred winter habitat of mountain goats is often steep and rocky, south-facing slopes, that are exposed to sun and wind and are confining in terms of forage and movement. (Greater Yellowstone, 1999)

> *Mountain goats breed during the months of November and December, and billies may wander considerable distances in search of nannies. The nannies drop their kids during the months of early May through early June. During these vital life stages, mountain goats are particularly sensitive to disturbances. (McCracken, 2002)*

Because mountain goats are sensitive to loud noises (such as what a helicopter produces), their behavior may be affected based on duration and proximity. (Greater Yellowstone, 1999)

Members of the Northern Wild Sheep and Goat Council recommend a 1.5 km (roughly one mile) distance for known nursery or critical winter range habitat. In their 2004 position paper, the group stated that "mountain goat winter and kidding distribution and habitat selection should be known and mapped prior to issuance of annual or multi-year helicopter-recreation special use permits." The paper emphasizes that physiological responses can occur even in the absence of behavior responses and that assumptions of habituation can not be made. (NWSGC, 2004) Federal and state agencies in Alaska have not relied on this position paper as a basis for their authorizations, but have conducted their own research, relied on published research, or the recommendations of biologists on staff. Two of the published documents that the agencies appear to rely upon the most are summarized below.

Chapter 4 of the Juneau Icefield EIS includes some of the issues associated with helicopter disturbance as:

- Physiological responses, such as increased heart rate or stress hormone levels, but whether such responses lead to long-term harm is equivocal.
- If other events such as nursing young or harsh winters are combined, the impacts of physiological stress can be more severe.
- Breeding success, feeding and habitat use may be affected.

- Accidental injury can result from trampling, falling, and running into objects or off cliffs.
- Reproductive losses can occur when young are left unattended or abandoned.
- Panicked running results in increased energy use.
- Reduced food intake if the animal happened to be feeding.
- Habitat avoidance or abandonment.

Steeve Côté conducted a study in Alberta from June to August 1995 to determine the effects of helicopter use in geophysical exploration for oil and gas. Côté found that the distance between the helicopter and the goats was the most important factor affecting behavior. When the helicopter was less than 500 meters away, 85% of the mountain goats observed were greatly disturbed (fleeing and hiding reactions). When the distance was increased to greater than 1500 meters, only 9% were. Similar to other studies, Côté also found that whether there were one or more overflights, the goats behaved similarly – as if each flight was a new event. Thirty-two percent of the goats were greatly disturbed by the overflight, 26% were moderately disturbed, and 42% were lightly disturbed. Note that one marked difference between helicopter use for geophysical surveys and helicopter tours is the requirement for flying a straight course in the collection of data. Helicopter tour pilots should be able to easily avoid winter habitat and critical areas through avoidance of known habitats or vertical/horizontal buffers from observed animals.

In 2001 and 2002, Goldstein, et al, recorded behavioral responses of 122 groups of mountain goats from 347 helicopter overflights. These observances occurred in four geographic areas in southeastern and southcentral Alaska. Like Côté, Goldstein's group found that mountain goats fled and hid from helicopter overflights. However, they found that the response was "muted in comparison."

> *Topography may provide some explanation for the different magnitudes of response, due to terrain, noise levels, and proximity to escape cover. Mountain goats in open, undulating terrain in Alberta responded by running for long distances (>100 m) or remaining alert for extended periods of time (>10 min) (Côté 1996). On our study sites, steep terrain may have limited the ability of mountain goats to run long distances. Proximity to escape cover may have reduced the magnitude of the responses we detected.…In our study areas, goats with greater prior exposure to helicopters seemed to have the most tolerance for helicopter overflights. The length of time that a goat remained in a disturbed state following an overflight, however, was not different between areas. (Goldstein, 2005)*

The Goldstein report recommended no-fly zones for known mountain goat locations. Further, they listed specific approach distances for the four geographic areas, based on a measure of risk disturbance of less than 25%:

Kenai Peninsula-Turnagain Arm:	1,000 m.
Eastern Prince William Sound:	1,234 m.
Chilkat Mountain Range	771 m.

Juneau Icefield: 500 m.

4.5.1.2.Other wildlife

Impacts could occur to black bear, brown bear, wolverines, mountain goat, gray wolf, bald eagle, Steller sea lion, trumpeter swan, moose, or harbor seal.

Ronald Larkin, in a 1996 literature review of the effects of military noise (such as helicopters) on wildlife, showed that different species have widely different responses to helicopter presence and noise. Negative responses can include birds abandoning nests, decreased chick survival, decreased reproduction, interruptions in feeding, and metabolic stress responses.

Brown/grizzlies bears react moderately or strongly to helicopters than fixed-wing aircraft. Bears fled to cover 61 percent of the time in response to fixed-wing overflights, and 88 percent of the time in response to helicopters, during petroleum exploration activities in Northwest Territories (Harding and Nagy, 1976 as cited in Juneau Icefield EIS, Forest Service, 2002a). Mitigation strategies include minimizing traffic during the denning period (October to early May), scheduling flights between 1 hour after sunrise to 1 hour before sunset (April through October), and maintaining a minimum altitude of 300 meters (984 feet) (IGBC, 1987; Claar et al. 1999; MELP, 2001 as cited in Juneau Icefield EIS, Forest Service, 2002a).

Habituation varies among individual eagles, and generally was greatest at nest sites with the most frequent overflights. Grubb and Bowman (as cited in Juneau Icefield EIS, Forest Service, 2002a) recommended a 600-meter (1,969-foot) aircraft exclusion zone around nests.

4.5.1.3. Summary of Mitigation Measures

Table 0-4 in the Executive Summary summarizes mitigation measures most frequently used by regulators in managing the impacts of helicopter-supported recreation activities on wildlife.

4.5.2. Impacts on People

4.5.2.1.Impacts on Urban Communities

At some level of sound intensity and duration, people experience physiological and psychological effects. According to the 2002 USFS Juneau Icefield Final EIS (p 4-22), the "US Environmental Protection Agency has established 70 dB to by the *maximum* safe *average* amount of sound…(sleep loss and other adverse physiological and psychological response may occur at lower levels), and continuous exposures to sound levels of 85 dB and above may be physically hazardous to hearing." While sound levels from government-authorized helicopter-recreation should not occur at a level to cause a physiological impact, they may still cause significant community displeasure.

Individuals in Juneau or other urban communities are subject to a cacophony of sound. To the extent that helicopter-recreation causes a sudden increase in sound levels, or even a gradual long-term increase, there will be a significant impact on community residents. To the extent that the sound levels are within background sound levels within these communities, the impacts will be limited or may be non-existent.

4.5.2.2.Impacts on Recreational Cabins and Rural Areas.

A concentrated increase in helicopter sounds has the potential to change people's enjoyment of their recreational cabin or other rural areas. These areas usually lack the level of human-caused background sounds audible within a city. In fact, the relative quiet may be one of the characteristics that attract people to the area in the first place. If that quiet is affected or shattered frequently, it is likely to matter very much to those who live there.

From the 2002 USFS Juneau Icefield Final EIS (p 4-23),

> *How people perceive the loudness of any given sound depends on several measurable physical characteristics of the sound. These characteristics include: (1) intensity, (2) frequency of contact, (3) change in sound pressure, and (4) rate of increase of sound pressure levels. However, the loudness of the sound is not the (only) issue. It is the noise of the helicopter. Noise is usually regarded as unwanted sound — sound that disturbs routine activities and quiet, and perhaps causes a feeling of annoyance. Which sounds are noise is obvious to each listener and he or she has no need to measure it. It is there and it is bothersome. Annoyance response is remarkably complex, and considered on an individual basis, displays a wide variability for any given noise. These variables include (1) emotional variables such as feelings about the necessity or preventability of the noise, judgment of the importance value[7] which is produced by the noise, and activity at the time an individual hears a noise, and (2) physical variables such as the setting, time of day, season, predictability of noise, control over noise, and length of time an individual lie exposed to the noise.*

Like the examples explained in Section 4.4, helicopter noise that is obvious to individuals who value the relative quiet of an area will be disliked. Sometimes it will be intensely disliked and can affect the individual's enjoyment of a cabin or community. The extent of the impact will typically depend on the extent to which the helicopter noise is disruptive: how often it occurs and how clearly it can be heard above natural noises in the area.

Any more precise impact on the lifestyles of individuals in recreational cabins and rural areas would depend on the specifics of the situation.

[7] Importance value. In other words, if someone believes that the use is important, they are likely to be more tolerant of the sound it produces.

4.5.2.3.Impacts on Recreationists and Recreation Areas

The conflicts between helicopter-supported recreation and other primarily non-motorized uses in the area are well known. People who recreate in the backcountry say that the presence of a helicopter, primarily as a source of noise in an otherwise pristine or quiet area detracts from their experience. Some feel that the sudden presence of heli-skiers or tourists in areas that they have expended considerable effort to reach is unfair, especially when it involves terrain accessible for day tours. (Forest Service, 2004a)

Essentially, the impacts are two-fold. Those who use the backcountry may be displaced by the helicopter tours — either because those brought in by helicopter use the resources, or because the noise drives them away. Even if they are not displaced, their enjoyment and perception of an area may be significantly affected.

These issues received national attention at the Grand Canyon where the conflict between sounds caused by flightseeing aircraft and those enjoying the natural environment were the subject of legislation by Congress.

The National Parks Air Tour Management Act of 2000 requires FAA and NPS to jointly establish air tour management plans to "mitigate or prevent the significant adverse impacts, if any, of commercial air tour operations upon the natural and cultural resources, [and] visitor experiences." Alaska's national parks as well as the Grand Canyon, were exempted from this Act.

The issues are similar, though perhaps less intense, elsewhere. Nevertheless, helicopter-supported recreation has the potential to displace backcountry recreationists and to decrease the enjoyment of those who remain.