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(1994). "Agencies take on park overflights." National Parks 68(5/6): 9.
Reports on the plan of President Bill Clinton's administration to devise regulations to reduce aircraft noise and visual intrusion in national parks. Companies' offer of air tours; Exacerbation of problems of noise and visual intrusion by growth of helicopter tours; Situations at Halekala and Hawaii Volcanoes and national parks in Hawaii.

(2002). "Big noise over the Grand Canyon." Noise Notes 1(2): 9-10.
The fate of the Grand Canyon National Park (GCNP), where increasing noise to what was operations over the GCNP. A Tourist attractions may become too popular. This is over-flights for "armchair" tourists are bringing once a place with only natural sounds. In an effort to bring the noise under control, the National Park Service has initiated a study to derive an evaluation methodology for air tour two zone system is being considered for impact assessment, leading to substantial restoration of natural quiet. [ABSTRACT FROM AUTHOR]

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(2004). "Muffling the Noise." Parks & Recreation 39(11): 37-37.
Reports that muffler manufacturer SuperTrapp Industries has donated samples of its exhaust mufflers for Off-Road Recreation Vehicles to Silver Lake State Park in Michigan, to be used to educate riders and park rangers about sound level restrictions within the park. Information on the Off-Road Recreation Vehicles Act.

(2009). Q&A Can You Still Find Peace and Quiet in our National Parks?, Wilderness Society: 18-19.
The article interviews Karen Trevino, manager of natural sounds program and acoustic expert Kurt Fristrup. When asked about the natural sounds that can be heard in National Parks, they says that the call of the coyote, howling of wolf, and bird sounds can be heard in the parks. They states that they are receiving complaints about the sounds of motor vehicles which harms the natural environment. They believe that the noise can change and effect a person's experience of visit to a national park.

Aguilar Soto, N., et al. (2006). "Does Intense Ship Noise Disrupt Foraging In Deep-Diving Cuvier's Beaked Whales (Ziphius Cavirostris)?" Marine Mammal Science 22(3): 690-699.

Amoser, S., et al. (2004). "Noise emission during the first powerboat race in an Alpine lake and potential impact on fish communities." The Journal of the Acoustical Society of America 116(6): 3789-3797.
In order to assess the effects of high-speed boating on fish communities, noise levels were measured during

The first Class 1 powerboat race on the Austrian Lake Traunsee. The noise spectra were compared to natural ambient noise and hearing abilities of four native fish species. Sound pressure levels (SPLs) were significantly elevated during the training heats and the race compared with natural levels, reaching up to 128 dB re 1 µPa (instantaneous SPL) at a distance of 300 m to the powerboats. Continuous equivalent SPLs were significantly lower during training and the pole position race compared to the race itself because fewer boats were simultaneously on the lake. The hearing abilities of the native hearing specialists and generalists were investigated. While carp and roach (two cyprinids) showed enhanced auditory sensitivity typical for hearing specialists, perch and whitefish were much less sensitive to sounds. Comparisons between power boat noise spectra and audiograms showed that the cyprinids can detect the boats up to several hundred meters distance because the main noise energy is well within the most sensitive hearing range. The hearing generalists, however, probably only perceive the first harmonic of the boat noise at close distances.

Anderson, M. A. (2008). "Revisited and Remembered." Taproot Journal 18(2): 17-20.
The article offers the author's insights regarding natural landscapes and soundscapes and his trip in the Colorado Plateau. He mentions that natural landscape provides him an opportunity to quite his mind and space for contemplation wherein one of the most comforting feelings was returning to sound of river, blupes, and swees. He notes that natural soundscapes are necessary for his ecological understanding.

Anderson, P. A., et al. (2011). "Sound, stress, and seahorses: the consequences of a noisy environment to animal health." Aquaculture 311(1): 129-138.
We examined stress responses to chronic noise exposure in a popular aquarium fish, the lined seahorse (Hippocampus erectus). Thirty-two animals were housed individually in either loud (123.3 ± 1.0 dB re: 1 µPa total RMS power at mid-water, 137.3 ± 0.7 dB at bottom) or quiet (110.6 ± 0.58 dB at mid-water, and 119.8 ± 0.4 dB at bottom) tanks for one month. Weekly behavioral observations were scored and compared between treatment means, as well as treatment variances, because stressed populations often exhibit increased variance in measures. At the end of each trial, animals were euthanized, assessed, and means and variances of the following measures were compared between treatments: weight change (ΔWt), change in Fulton condition factor (ΔK), hepatosomatic index, gonadosomatic index, leukocyte count and differential, packed cell volume, heterophil to lymphocyte (H:L) ratio, blood glucose concentration, plasma cortisol concentration, parasite presence/absence and number of organs infected, and presence/absence of bacterial infection.

Among behavioral results, tail adjustments and reduced or variable percentage of time spent stationary were interpreted as irritation behaviors. Animals in loud tanks were more variable in the number of tail adjustments made; this difference was especially significant in week one, when loud tank animals also made significantly more adjustments. Animals in loud tanks also demonstrated greater variation in the percentage of time spent stationary in the first week. Variability in these measures subsided after the first week, presumably due to habituation. Piping and clicking were considered pathological and distress behaviors (respectively). Animals piped and clicked more variably in loud tanks; this variability was especially pronounced in week 4. Other behaviors were unremarkable.

Among physiological results, animals in loud tanks declined in morphological indices more precipitously; these differences were significant in ΔWt and ΔK. Animals in loud tanks demonstrated significant and variable heterophilia and significantly higher and more variable H:L ratios. Plasma cortisol concentrations were higher among animals in loud tanks. Kidneys were significantly more affected by parasites in loud tanks. Other physiological measures were unremarkable.

Seahorses exposed to loud ambient noise in aquaria exhibit primary, secondary, and tertiary stress responses at behavioral and physiological levels, necessitating allostasis at costs to growth, condition, and immune status. Aquarists and aquaculturists are thus advised to incorporate soundproofing modifications during design and set-up of facilities to improve fish health, and growth in culture.

André, M., et al. (2011). "Low-frequency sounds induce acoustic trauma in cephalopods." Frontiers in Ecology and the Environment 9(9): 489-493.
There is currently relatively little information on how marine organisms process and analyze sound, making assessments about the impacts of artificial sound sources in the marine environment difficult. However, such assessments have become a priority because noise is now considered as a source of pollution that increasingly affects the natural balance of marine ecosystems. We present the first morphological and ultrastructural evidence of massive acoustic trauma, not compatible with life, in four cephalopod species subjected to low-frequency controlled-exposure experiments. Exposure to low-frequency sounds resulted in permanent and substantial alterations of the sensory hair cells of the statocysts, the structures responsible for the animals' sense of balance and position. These results indicate a need for further environmental regulation of human activities that introduce high-intensity, low-frequency sounds in the world's oceans.

Andringa, T. C., et al. (2013). "Positioning soundscape research and management." Journal of the Acoustical Society of America 134(4): 2739-2747.
This paper is an outcome of a workshop that addressed the question how soundscape research can improve its impact on the local level. It addresses a number of topics by complementing existing approaches and practices with possible future approaches and practices. The paper starts with an analysis of the role of sound annoyance and suboptimal soundscapes on the lives of individuals and concludes that a good soundscape, or more generally a good sensescape, is at the same time pleasant as well as conducive for the adoption of healthy habits. To maintain or improve sensescape quality, urban planning needs improved design tools that allow for a more holistic optimization and an active role of the local stakeholders. Associated with this is a gradual development from government to governance in which optimization of the soundscape at a local (administrative or geographic) level is directly influenced by the users of spaces. The paper concludes that soundscape research can have a greater impact by helping urban planners design for health and pleasant experiences as well as developing tools for improved citizen involvement in local optimization. [ABSTRACT FROM AUTHOR]

Arch, V. S. and P. M. Narins (2008). ""Silent" signals: Selective forces acting on ultrasonic communication systems in terrestrial vertebrates." Animal Behavior 76(4): 1423.

Arévalo, J. E. and K. Newhard (2011). "Traffic noise affects forest bird species in a protected tropical forest." Revista de biologia tropical 59(2): 969-980.

The construction of roads near protected forest areas alters ecosystem function by creating habitat fragmentation and through several direct and indirect negative effects such as increased pollution, animal mortality through collisions, disturbance caused by excessive noise and wind turbulence. Noise in particular may have strong negative effects on animal groups such as frogs and birds, that rely on sound for communication as it can negatively interfere with vocalizations used for territorial defense or courtship. Thus, birds are expected to be less abundant close to the road where noise levels are high. In this study, we examined the effects of road traffic noise levels on forest bird species in a protected tropical forest in Costa Rica. Data collection was conducted in a forest segment of the Carara National Park adjacent to the Coastal Highway. We carried out 120 ten minute bird surveys and measured road noise levels 192 times from the 19th to the 23rd of April and from the 21st to the 28th of November, 2008. To maximize bird detection for the species richness estimates we operated six 12m standard mist nets simultaneously with the surveys. The overall mist-netting effort was 240net/h. In addition, we estimated traffic volumes by tallying the number of vehicles passing by the edge of the park using 24 one hour counts throughout the study. We found that the relative abundance of birds and bird species richness decreased significantly with the increasing traffic noise in the dry and wet season. Noise decreased significantly and in a logarithmic way with distance from the road in both seasons. However, noise levels at any given distance were significantly higher in the dry compared to the wet season. Our results suggest that noise might be an important factor influencing road bird avoidance as measured by species richness and relative abundance. Since the protected forest in question is located in a national park subjected to tourist visitation, these results have conservation as well as management implications. A decrease in bird species richness and bird abundance due to intrusive road noise could negatively affect the use of trails by visitors. Alternatives for noise attenuation in the affected forest area include the enforcement of speed limits and the planting of live barriers. Rev. Biol. Trop. 59 (2): 969-980. Epub 2011 June 01.

Arroyo-Solís, A., et al. (2013). "Experimental evidence for an impact of anthropogenic noise on dawn chorus timing in urban birds." Journal of Avian Biology 44(3): 288-296.

Many animal species are living in urban areas, where they encounter human-altered environmental conditions. Artificial light and traffic noise are two of the most prominent anthropogenic factors, both of which potentially affect animal life. Here we studied the changes in traffic noise conditions over the morning in the urban bird habitat of the city of Seville, Spain. We tested experimentally whether noise from human activities can cause a shift in the timing of birdsong activity. Our data revealed that noise conditions vary

markedly among our replicate set of twelve streets. Relatively quiet streets show low base-line amplitude levels early in the morning, with frequent events of brief noise bursts, followed by a strong rise in noise levels. Relatively noisy streets have high base-line amplitude levels from a much earlier start in the morning. Experimental exposure data revealed a noise-related earlier start of dawn singing for two out of six species: the spotless starling Sturnus unicolor and the house sparrow Passer domesticus. Our experiment did not cover earlier singing species and revealed no impact for species with more-variable starting times of the dawn singing. Our study provides more insight into the intertwinings of bird and human behavior and confirms the potential for experimental approaches to successfully tackle questions related to the impact of anthropogenic factors on animal life in cities.

Aubin, T. and P. Jouventin (2002). "How to vocally identify kin in a crowd: the penguin model." Advances in the Study of Behavior 31: 243-277.

On penguins, individual recognition is observed between mates and between parents and chick(s). During the past five years, their particular strategies of coding—decoding have been tested by playing back modified display calls to six species, in Australia (little penguin, Eudyptula minor), in Antarctica (Adélie penguin, Pygoscelis adeliae; emperor penguin, Aptenodytes forsteri), and in subantarctic islands (king penguin, Aptenodytes patagonicus; macaroni penguin, Eudyptes chrysolophus; gentoo penguin, Pygoscelis papua). All species use only vocal cues to identify their partner, but in territorial species the nest is used as a meeting point. In large species, such as the king and the emperor penguins, which do not have a nest, the brooder carries the egg or the small chick on the feet, while the mate, and then the chick, has to be located in the noisy colony without any topographical cue.

According to theory, to extract a signal from background calls, animals analyze either frequency bands or modulations (amplitude and frequency modulations) of the partner's call. The first coding-decoding system, used by nesting penguins, is easy to produce but costly in terms of analysis time. The second one, used by non-nesting penguins, is a vocal signature which is fast to analyze but costly to produce. This acoustic signal is particularly efficient as a means to locate immediately the partner on the move in a noisy crowd. Briefly, frequency analysis is enough to solve the relatively easy problem of individual recognition in nesting birds, while the complex temporal analysis of modulations of the two non-nesting penguins is an adaptation to extreme acoustic and breeding conditions.

The macaroni penguin, which we have begun to test, seems to use both a frequency code similar to that of the other nesting species and a temporal code close to the one of a non-nesting penguin species, but much simpler.

Baker, P. J., et al. (2007). "Activity patterns of urban red foxes (Vulpes vulpes) reduce the risk of traffic-induced mortality." Behavioral Ecology 18(4): 716-724.

Traffic collisions can be a major source of mortality in wild populations, and animals may be expected to exhibit behavioral mechanisms that reduce the risk associated with crossing roads. Animals living in urban areas in particular have to negotiate very dense road networks, often with high levels of traffic flow. We

examined traffic-related mortality of red foxes (Vulpes vulpes) in the city of Bristol, UK, and the extent to which roads affected fox activity by comparing real and randomly generated patterns of movement. There were significant seasonal differences in the number of traffic-related fox deaths for different age and sex classes; peaks were associated with periods when individuals were likely to be moving through unfamiliar terrain and would have had to cross major roads. Mortality rates per unit road length increased with road magnitude. The number of roads crossed by foxes and the rate at which roads were crossed per hour of activity increased after midnight when traffic flow was lower. Adults and juveniles crossed 17% and 30% fewer roads, respectively, than expected from randomly generated movement. This highly mobile species appeared to reduce the mortality risk of minor category roads by changing its activity patterns, but it remained vulnerable to the effects of larger roads with higher traffic flows during periods associated with extraterritorial movements.

Baldwin, A. L., et al. (2006). "Effect of noise on the morphology of the intestinal mucosa in laboratory rats." Journal of the American Association for Laboratory Animal Science 45(1): 74-82.
To determine whether noise-induced stress disrupts the intestinal mucosa of laboratory rats, one group of 8 rats ('noise' rats) was subjected to 15 min of white noise (90 dB) daily for 3 wk. Another group ('quiet' rats) was housed for 3 wk in an acoustically similar room but with no additional noise. A 3rd group ('recovery' rats) was housed in the noise room for 3 wk and then in the quiet room for a further 3 wk. The ilea were fixed for microscopy. Villi adjacent to Peyer patches showed significantly more degranulated mast cells (mean ± standard error of the mean, 3.95 ± 0.80 versus 0.35 ± 0.29, respectively) and eosinophils (mean ± standard error of the mean, 9.46 ± 0.44 versus 4.58 ± 0.38) per villus section in noise rats than in quiet rats. Similar results were obtained with rooms reversed, to account for any differences in room characteristics. The mean width of villus laminar propria was significantly greater in noise rats than quiet rats, suggesting edema. In addition, mucosal epithelial cells of noise rats were often separated, sometimes detaching from the basement membrane, whereas those of quiet rats were intact. Behaviorally, noise rats exhibited significantly more grooming and rearing than quiet rats. Compared with noise rats, recovery rats showed no reduction in mast cell degranulation or mean width of villus lamina propria, but there were increased numbers of secreting goblet cells in villi adjacent to Peyer patches and some recovery of epithelial integrity.

Barber, J., et al. (2003). "Can two streams of auditory information be processed simultaneously? Evidence from the gleaning bat Antrozous pallidus." Journal of Comparative Physiology A 189(11): 843-855.
A tenet of auditory scene analysis is that we can fully process only one stream of auditory information at a time. We tested this assumption in a gleaning bat, the pallid bat (Antrozous pallidus) because this bat uses echolocation for general orientation, and relies heavily on prey-generated sounds to detect and locate its prey. It may therefore encounter situations in which the echolocation and passive listening streams temporally overlap. Pallid bats were trained to a dual task in which they had to negotiate a wire array, using echolocation, and land on one of 15 speakers emitting a brief noise burst in order to obtain a food reward. They were forced to process both streams within a narrow 300 to 500 ms time window by having the noise burst triggered by the bats' initial echolocation pulses as it approached the wire array. Relative to single task

controls, echolocation and passive sound localization performance was slightly, but significantly, degraded. The bats also increased echolocation interpulse intervals during the dual task, as though attempting to reduce temporal overlap between the signals. These results suggest that the bats, like humans, have difficulty in processing more than one stream of information at a time.

Barber, J. R., et al. (2011). "Anthropogenic noise exposure in protected natural areas: Estimating the scale of ecological consequences." Landscape Ecology 26(9): 1281-1295.

The extensive literature documenting the ecological effects of roads has repeatedly implicated noise as one of the causal factors. Recent studies of wildlife responses to noise have decisively identified changes in animal behaviors and spatial distributions that are caused by noise. Collectively, this research suggests that spatial extent and intensity of potential noise impacts to wildlife can be studied by mapping noise sources and modeling the propagation of noise across landscapes. Here we present models of energy extraction, aircraft overflight and roadway noise as examples of spatially extensive sources and to present tools available for landscape scale investigations. We focus these efforts in US National Parks (Mesa Verde, Grand Teton and Glacier) to highlight that ecological noise pollution is not a threat restricted to developed areas and that many protected natural areas experience significant noise loads. As a heuristic tool for understanding past and future noise pollution we forecast community noise utilizing a spatially-explicit land use change model that depicts the intensity of human development at sub-county resolution. For road noise, we transform effect distances from two studies into sound levels to begin a discussion of noise thresholds for wildlife. The spatial scale of noise exposure is far larger than any protected area, and no site in the continental US is free form noise. The design of observational and experimental studies of noise effects should be informed by knowledge of regional noise exposure patterns. 2011 Springer Science+Business Media B.V.

Barber, J. R., et al. (2010). "The costs of chronic noise exposure for terrestrial organisms." Trends in Ecology & Evolution 25(3): 180-189.

Growth in transportation networks, resource extraction, motorized recreation and urban development is responsible for chronic noise exposure in most terrestrial areas, including remote wilderness sites. Increased noise levels reduce the distance and area over which acoustic signals can be perceived by animals. Here, we review a broad range of findings that indicate the potential severity of this threat to diverse taxa, and recent studies that document substantial changes in foraging and anti-predator behavior, reproductive success, density and community structure in response to noise. Effective management of protected areas must include noise assessment, and research is needed to further quantify the ecological consequences of chronic noise exposure in terrestrial environments. [Copyright &y& Elsevier]

Barber, J. R., et al. (2009). "Conserving the wild life therein—protecting park fauna from anthropogenic noise." Park Science 26(3): 26-31.
Anthropogenic noise is a burgeoning issue for national parks. Acoustical monitoring has revealed chronic noise exposure even in remote wilderness sites. Increased noise levels significantly reduce the distance and area over which acoustic signals can be sensed by an animal receiver. A broad range of research findings indicates the potential severity of this threat to diverse taxa, and recent studies document substantial changes in behavior, breeding success, density, and community structure in response to noise. Analysis of these data make a compelling case for systematic efforts to preserve acoustic environments throughout the National Park System.

Barton, D. C. and A. L. Holmes (2007). "Off-highway vehicle trail impacts on breeding songbirds in northeastern California." Journal of Wildlife Management 71(5): 1617-1620.
Rapid growth in off-highway vehicle (OHV) use in North America leads to concerns about potential impacts on wildlife populations. We studied the relationship between distance to active OHV trail and songbird nesting success and abundance in northeastern California, USA, from 2002 to 2004. We found evidence of greater nest desertion and abandonment and reduced predation on shrub nests <100 m from OHV trails than at nests >100 m from OHV trails. Two of 18 species studied were less abundant at sites on trails than at sites 250 m from trails, and no species were more abundant on trails. Management of OHV trail development should consider possible negative impacts on nesting success and abundance of breeding birds.

Bayne, E. M., et al. (2008). "Impacts of chronic anthropogenic noise from energy-sector activity on abundance of songbirds in the boreal forest." Conservation Biology 22(5): 1186-1193.
The effects of human activities in forests are often examined in the context of habitat conversion. Changes in habitat structure and composition are also associated with increases in the activity of people with vehicles and equipment, which results in increases in anthropogenic noise. Anthropogenic noise may reduce habitat quality for many species, particularly those that rely on acoustic signals for communication. We compared the density and occupancy rate of forest passerines close to versus far from noise-generating compressor stations and noiseless well pads in the boreal forest of Alberta, Canada. Using distance-based sampling, we found that areas near noiseless energy facilities had a total passerine density 1.5 times higher than areas near noise-producing energy sites. The White-throated Sparrow (Zonotrichia albicollis), Yellow-rumped Warbler (Dendroica coronata), and Red-eyed Vireo (Vireo olivaceus) were less dense in noisy areas. We used repeat sampling to estimate occupancy rate for 23 additional species. Seven had lower conditional or unconditional occupancy rates near noise-generating facilities. One-third of the species examined showed patterns that supported the hypothesis that abundance is influenced by anthropogenic noise. An additional 4 species responded negatively to edge effects. To mitigate existing noise impacts on birds would require approximately $175 million. The merits of such an effort relative to other reclamation actions are discussed. Nevertheless, given the $100 billion energy-sector investment planned for the boreal forest in the next 10 years, including noise suppression technology at the outset of construction, makes noise mitigation a cost effective best-management practice that might help conserve high-quality habitat for boreal birds.

Becker, A., et al. (2013). "Does boat traffic cause displacement of fish in estuaries?" Marine Pollution Bulletin 75(1): 168-173.

Estuaries are increasingly under threat from a variety of human impacts. Recreational and commercial boat traffic in urban areas may represent a significant disturbance to fish populations and have particularly adverse effects in spatially restricted systems such as estuaries. We examined the effects of passing boats on the abundance of different sized fish within the main navigation channel of an estuary using high resolution sonar (DIDSON). Both the smallest (100–300 mm) and largest (>501 mm) size classes had no change in their abundance following the passage of boats. However, a decrease in abundance of mid-sized fish (301–500 mm) occurred following the passage of boats. This displacement may be attributed to a number of factors including noise, bubbles and the rapidly approaching object of the boat itself. In highly urbanised estuarine systems, regular displacement by boat traffic has the potential to have major negative population level effects on fish assemblages.

Bee, M. A. and E. M. Swanson (2007). "Auditory masking of anuran advertisement calls by road traffic noise." Animal Behavior 74(6): 1765-1776.

There is growing concern that anthropogenic noise could interfere with animal behaviors by masking the perception of acoustic communication signals. To date, however, few experimental studies have tested this general hypothesis. One common source of anthropogenic noise is the sound of roadway traffic. We tested the hypothesis that road traffic noise can mask a female's perception of male signals in the grey treefrog, Hyla chrysoscelis, by comparing the effects of traffic noise and the background noise of a breeding chorus on female responses to advertisement calls. In this species, advertisement calls are necessary and sufficient to attract females for breeding. Using a phonotaxis assay, we presented females with an advertisement call broadcast at one of nine signal levels (37–85 dB, 6-dB steps) in one of three masking conditions: (1) no masking noise, (2) a noise simulating a moderately dense breeding chorus, or (3) a noise modelled after road traffic noise recorded in two wetlands near major roads. Females showed similar increases in response latency and decreases in orientation towards the target signal in the presence of both the chorus noise and the traffic noise maskers. Moreover, response thresholds were elevated by about 20–25 dB in the presence of both noise maskers compared to the unmasked condition. Our results suggest that realistic levels of traffic noise could place constraints on the active space of the acoustic signals of some animals.

Bell, P. A., et al. (2009). "Aircraft overflights in national parks: Conflict and its potential resolution." Park Science 26(3): 65-67.

Benfield, J. A., et al. (2010). "Does Anthropogenic Noise in National Parks Impair Memory?" Environment & Behavior 42(5): 693-706.

Research on noise shows that a variety of effects including stress, annoyance, and performance decrements exist for certain types of sounds. Noise interferes with cognitive ability by overloading the attentional system or simply distracting from efficient encoding or rehearsal, but very little research has extended those findings to recreation or natural environments such as those found in national parks. By exposing participants to one of four soundscape conditions-control, natural, natural with voices, and natural with

ground traffic-the current project tested the effect of sound conditions on the recognition and recall of factual information presented whereas viewing scenes of national parks. Both the natural with voices and natural with ground traffic conditions caused significant decreases in memory scores while the natural condition showed no differences from the control condition. Implications for sound management strategies are discussed in the context of current legislation and recent field research. Avenues for future research to clarify the mode of memory interference are discussed. [ABSTRACT FROM AUTHOR]

Benfield, J. A., et al. (2010). "Aesthetic and affective effects of vocal and traffic noise on natural landscape assessment." Journal of Environmental Psychology 30(1): 103-111.

National parks have mandates both to preserve and protect natural settings and to assist visitors in viewing and interacting with those settings. Considerable scholarship has examined the trade-offs between preservation and recreation goals, such as protection of a natural setting when some visitors want to experience it from noisy aircraft or ground vehicles. The current project expands on previous noise research that showed the presence of aircraft noise to be detrimental to aesthetic and affective environmental assessments. Participants rated 25 scenes under quiet conditions or while hearing 45 dB(A) or 60 dB(A) of either natural sounds (bird calls, breeze through foliage), natural sounds with aircraft sounds, natural Sounds with ground traffic sounds, or natural Sounds with human voices. Results indicated that the presence of any anthropogenic noise-air traffic, ground traffic, or voices-negatively impacted environmental assessments, and more so at louder levels, while the natural soundscape had little to no effect on assessments. Additionally, the presence of air traffic, ground traffic, and human voices significantly decreased participant ratings of serenity while also increasing ratings of hostility, These effects were strongest for scenes that were high in scenic beauty. Results are discussed in the context of sound quality management in national parks and other settings. (C) 2009 Elsevier Ltd. All rights reserved.

Bermúdez-Cuamatzin, E., et al. (2009). "Strategies of song adaptation to urban noise in the house finch: syllable pitch plasticity or differential syllable use?" Behavior 146(9): 1269-1286.

The influence of ambient noise in shaping birdsong attributes has received much attention lately. Recent work shows that some birds sing higher-pitched songs in noisy areas, which may allow them to avoid acoustic interference; yet it is not clear how this is achieved. Higher-pitched songs may be produced either by using the same syllable types in quiet and noisy areas, but singing them at a higher frequency in the latter (syllable pitch plasticity), or by using different syllable types in silent and in noisy circumstances (differential syllable use). Here we explored both strategies in the Mexico City population of house finch (Carpodacus mexicanus), a species known to possess a repertoire of several hundreds of syllable types. Birds produced songs with higher minimum frequencies in noisy than in quiet areas. This was mostly due to the minimum

frequency of some syllable types being higher in noisy areas than in quiet locations. Also, males modulated the minimum frequency of the same syllable type during momentary increases of noise. Our results can help explain the high success of house finches at colonizing urban areas, while providing evidence of syllable pitch plasticity.

Bermúdez-Cuamatzin, E., et al. (2010). "Experimental evidence for real-time song frequency shift in response to urban noise in a passerine bird." Biology Letters: rsbl20100437.
Research has shown that bird songs are modified in different ways to deal with urban noise and promote signal transmission through noisy environments. Urban noise is composed of low frequencies, thus the observation that songs have a higher minimum frequency in noisy places suggests this is a way of avoiding noise masking. Most studies are correlative and there is as yet little experimental evidence that this is a short-term mechanism owing to individual plasticity. Here we experimentally test if house finches (Carpodacus mexicanus) can modulate the minimum frequency of their songs in response to different noise levels. We exposed singing males to three continuous treatments: low–high–low noise levels. We found a significant increase in minimum frequency from low to high and a decrement from high to low treatments. We also found that this was mostly achieved by modifying the frequency of the same low-frequency syllable types used in the different treatments. When different low-frequency syllables were used, those sung during the noisy condition were longer than the ones sang during the quiet condition. We conclude that house finches modify their songs in several ways in response to urban noise, thus providing evidence of a shortterm acoustic adaptation.

Bernal, X. E., et al. (2007). "Sexual differences in the behavioral response of túngara frogs, Physalaemus pustulosus, to cues associated with increased predation risk." Ethology 113(8): 755-763.
Engaging in mating behaviors usually increases exposure to predators for both males and females. Antipredator strategies during reproduction may have important fitness consequences for prey. Previous studies have shown that individuals of several species adjust their reproductive behavior according to their assessment of predation risk, but few studies have explored potential sexual differences in these strategies. In this study, we investigate whether the acoustic cues associated with predatory attacks or those associated with predators themselves affect the mating behavior of female and male túngara frogs, Physalaemus pustulosus. We compared the responses of females approaching a mate and those of calling males when exposed to mating calls associated with sounds representing increased hazard. When presented with mating calls that differed only in whether or not they were followed by a predation-related sound, females preferentially approached the call without predation-related sounds. In contrast to females, calling males showed greater vocal response to calls associated with increased risk than to a call by itself. We found significant differences in the responses of females and males to several sounds associated with increased hazard. Females behaved more cautiously than males, suggesting that the sexes balance the risk of predation and the cost of cautious mating strategies differently.

Bernat, S. (2013). "Awareness of Noise Hazards and the Value of Soundscapes in Polish National Parks." Archives of Acoustics 38(4): 479-487.

The goal of the studies undertaken in Polish national parks was to determine noise threats, examine the resources, assess the quality of soundscapes and identify the possibilities of their protection. The questionnaire method used in the studies made it possible to identify the awareness of noise threats and the value of soundscapes according to the park service staff. In addition, the semantic differential and description methods were used to learn how students assessed the soundscape quality of Polish national parks. Finally, avenues of further research on soundscape in environmentally valuable areas were indicated. The research findings indicate that each national park in Poland is characterized by diverse and unique soundscapes and is subject to the pressure of road traffic and tourism resulting in noise hazards. The conservation of the acoustic values of parks is necessary and possible.

Birke, L. (2002). "Effects of browse, human visitors and noise on the behavior of captive orangutans." Animal Welfare-Potters Bar 11(2): 189-202.

This paper reports a study of the behavior of captive orangutans (pongo pygmaeus) at Chester Zoo, UK. The study addressed two questions: what is the effect of the presence of fresh browse on the animals' behavior; and what is the effect of the presence of visitors? The first part of the study analyzed the animals' time budgets. The results indicated that the provision of fresh browse led to a decrease in the time spent sitting inactive by both adults and infants; it also led to an increase in the time spent by adults foraging for small food items in the wood chip floor-covering beneath the branches of browse. The time-budget data also showed differences in the animals' behavior between periods when large groups of visitors arrived and other periods on the same days when visitors were fewer. Specifically, adults used available paper sacks to cover their heads more during periods of high visitor density, and infants held onto adults more. The second part of the study comprised an experiment in which visitor behavior was manipulated. Visitor groups of similar sizes were asked to behave either quietly or noisily (making vocal noise), in order to determine whether the observed effects of visitors were attributable to group size or to the fact that larger groups tend to be noisier. The experiment indicated that the animals responded particularly to noise: when confronted with noisy groups, all animals looked more at the visitors, and infants approached and held onto adults more. The findings suggest that zoo managers may need to take visitor behavior into account in order to promote orangutan welfare.

Blickley, J. L., et al. (2012). "Experimental evidence for the effects of chronic anthropogenic noise on abundance of greater sage-grouse at leks." Conservation Biology 26(3): 461-471.

Increasing evidence suggests that chronic noise from human activities negatively affects wild animals, but most studies have failed to separate the effects of chronic noise from confounding factors, such as habitat fragmentation. We played back recorded continuous and intermittent anthropogenic sounds associated with natural gas drilling and roads at leks of Greater Sage-Grouse (Centrocercus urophasianus). For 3 breeding seasons, we monitored sage grouse abundance at leks with and without noise. Peak male attendance (i.e., abundance) at leks experimentally treated with noise from natural gas drilling and roads decreased 29% and 73%, respectively, relative to paired controls. Decreases in abundance at leks treated with noise occurred in the first year of the study and continued throughout the experiment. Noise playback did not have a cumulative effect over time on peak male attendance. There was limited evidence for an effect of

noise playback on peak female attendance at leks or male attendance the year after the experiment ended. Our results suggest that sage-grouse avoid leks with anthropogenic noise and that intermittent noise has a greater effect on attendance than continuous noise. Our results highlight the threat of anthropogenic noise to population viability for this and other sensitive species.

Blickley, J. L. and G. L. Patricelli (2012). "Potential acoustic masking of greater sage-grouse (Centrocercus urophasianus) display components by chronic industrial noise." Ornithological Monographs 2012(74): 23-35.

Anthropogenic noise can limit the ability of birds to communicate by masking their acoustic signals. Masking, which reduces the distance over which the signal can be perceived by a receiver, is frequency dependent, so the different notes of a single song may be masked to different degrees. We analyzed the individual notes of mating vocalizations produced by Greater Sage-Grouse (Centrocercus urophasianus) and noise from natural gas infrastructure to quantify the potential for such noise to mask Greater Sage-Grouse vocalizations over both long and short distances. We found that noise produced by natural gas infrastructure was dominated by low frequencies, with substantial overlap in frequency with Greater Sage-Grouse acoustic displays. Such overlap predicted substantial masking, reducing the active space of detection and discrimination of all vocalization components, and particularly affecting low-frequency and low-amplitude notes. Such masking could increase the difficulty of mate assessment for lekking Greater Sage-Grouse. We discuss these results in relation to current stipulations that limit the proximity of natural gas infrastructure to leks of this species on some federal lands in the United States. Significant impacts to Greater Sage-Grouse populations have been measured at noise levels that predict little or no masking. Thus, masking is not likely to be the only mechanism of noise impact on this species, and masking analyses should therefore be used in combination with other methods to evaluate stipulations and predict the effects of noise exposure.

Bomer, A. S. and R. D. Bruce (1992). "Long-Term Ambient Sound Monitoring in National Parks." Sound & Vibration 26(2): 16.

The increased emphasis on maintaining acceptable levels of noise pollution in the human environment has created a need for a baseline figure for ambient sound. The techniques used to establish these baseline figures are detailed. Measurements of low-level ambient sound were taken from sites located in Dinosaur Natl Monument, in Colorado and Utah, and the Glen Canyon Natl Recreation Area, in Arizona. Because there are daily and seasonal variations in ambient sound at these locations, the sound levels were monitored continually for a full year. The sound data collected at each site included hourly A-weighted sound levels, octave-band sound-pressure levels, and sound and video recordings for each of the sites.

Boncoraglio, G. and N. Saino (2007). "Habitat structure and the evolution of bird song: a meta-analysis of the evidence for the acoustic adaptation hypothesis." Functional Ecology 21(1): 134-142.

1. Habitat structure has been considered as a main factor shaping the evolution of bird song acoustics.
2. Based on expected differential patterns of sound degradation in different habitats, the acoustic adaptation hypothesis (AAH) proposes that songs with lower frequencies, narrower frequency ranges and longer inter-element intervals should occur more frequently in densely vegetated compared with herbaceous habitats.

3. Empirical tests of the AAH have provided mixed results. Here, we review for the first time the literature on this topic using a meta-analytical, quantitative approach.
4. Maximum, minimum, peak frequency and frequency range were found to be significantly lower in closed compared with open habitats, but the mean size of the effect of habitat was small. Inter-element intervals were not affected by habitat structure.
5. The AAH implicitly assumes that birds are selected to maximize song broadcast range and minimize degradation, while it neglects the potential role of energetic costs of singing and selection by eavesdroppers (e.g. predators and parasites).
6. Our meta-analysis supports the AAH, but habitat structure only weakly predicts the acoustical properties of bird songs. Thus, other potentially relevant factors should be included in realistic models of the evolution of bird song acoustics.

Bonier, F., et al. (2009). "The relationship between fitness and baseline glucocorticoids in a passerine bird." General and Comparative Endocrinology 163(1): 208-213.

Glucocorticoid (cort) hormones are increasingly applied in studies of free-ranging animals, with elevated baseline cort levels generally assumed to indicate individuals or populations in worse condition and with lower fitness (the Cort-Fitness Hypothesis). The relationship between cort and fitness is rarely validated and studies investigating the cort-fitness relationship often find results inconsistent with the Cort-Fitness Hypothesis. The inconsistency of these studies may result in part from variation in the cort-fitness relationship across life history stages. Here we address the following questions in a two-year study in free-ranging tree swallows (Tachycineta bicolor):

1. Do baseline cort levels correlate with fitness within a life history stage?
2. Does the cort-fitness relationship vary across different life history stages?
3. Does the cort-fitness relationship vary across life history stages within an individual?
4. Does reproductive effort influence cort levels, and do cort levels influence reproductive effort?

We measured baseline cort and fitness components in female birds of known breeding stages. We find correlations between baseline cort levels and fitness within some life history stages, but the relationship shifts from negative during early breeding to positive during late breeding, even within the same individuals. A positive relationship between baseline cort and fitness components during the nestling period suggests that reproductive investment may elicit higher cort levels that feedback to reallocate more effort to reproduction during critical periods of nestling provisioning. Our findings provide reason to question the Cort-Fitness Hypothesis, and have implications for the application of cort measures in monitoring the condition of populations of conservation concern.

Borkowski, J. J., et al. (2006). "Behavioral responses of bison and elk in Yellowstone to snowmobiles and snow coaches." Ecological Applications 16(5): 1911-1925.

Managers of public lands are charged with protecting some of our most important natural resources and ecosystems, while providing for their use and enjoyment by visitors. Almost one million visitors entered Yellowstone National Park by motorized means on snowmobiles (87%) or snow coaches (13%) during 1992–2003. Most vehicles toured the central portion of the park where bison (Bison bison) and elk (Cervus

elaphus) concentrate in geothermal areas. We sampled >6500 interactions between groups of these species and groups of snowmobiles and snow coaches (collectively, OSV, over-snow vehicles) during five winters (1999–2000, 2002–2004). Multinomial logits models were used to identify conditions leading to behavioral responses. Elk responded three times as often (52%) as bison (19%) during interactions with groups of snowmobiles and snow coaches due to increased vigilance responses (elk, 44%; bison, 10%). However, the frequency of higher-intensity movement responses by bison and elk were similar (6–7% travel, 1–2% flight, <1% defense) and relatively low compared to other studies of ungulates and snowmobile disturbance. The likelihood of active responses by bison and elk increased significantly if animals were on or near roads, groups were smaller, or humans approached. The likelihood of an active response by bison decreased within winters having the largest visitation, suggesting some habituation to snowmobiles and snow coaches. There was no evidence that snowmobile use during the past 35 years affected the population dynamics or demography of bison or elk. Thus, we suggest that regulations restricting levels and travel routes of over snow vehicles (OSVs) were effective at reducing disturbances to bison and elk below a level that would cause measurable fitness effects. We recommend park managers consider maintaining OSV traffic levels at or below those observed during our study. Regardless, differing interpretations of the behavioral and physiological response data will continue to exist because of the diverse values and beliefs of the many constituencies of Yellowstone.

Bowlby, W. (1981). "Transit vehicle noise emission levels in Yosemite National Park." (FHWA-DP-46-6): 54pp.

The Federal Highway Administration (FHWA) has been asked by the National Park Service (NPS) to conduct a study of alternatives to permitting automobiles within the Yosemite Valley in Yosemite National Park. The FHWA Demonstration Projects Division was called upon to assist in studying the noise impact of the different strategies. This report documents the results of noise emission level tests conducted by the Demonstration Projects Division on different types of transit vehicles. This data will form the base for predictions of the time-averaged levels expected in the Park from each strategy. This report also presents the results of ambient noise measurements in several areas in the valley.

Bowles, A. and B. Schulte-Fortkamp (2008). "Noise as an indicator of quality of life: advances in measurement of noise and noise effects on humans and animals in the environment." Acoustics Today 4(2): 35-39.

Bowles, A. E. (1995). "Responses of wildlife to noise." Wildlife and Recreationists: Coexistence through Management and Research. Island Press, Washington, DC: 109-156.

Bowles, A. E., et al. (1994). "Relative abundance and behavior of marine mammals exposed to transmissions from the Heard Island Feasibility Test." The Journal of the Acoustical Society of America 96(4): 2469-2484.

The Heard Island Feasibility Test source transmitted a hum at 209–220 dB re: 1 μPa at 175-m depth, centered on 57 Hz with a maximum bandwidth of 30 Hz for 1 h of every 3. Experienced marine mammal

observers conducted line-transect surveys and monitored marine mammal behavior visually and acoustically in a 70×70 km square centered on the transmission site. Thirty-nine groups of cetaceans and 19 of pinnipeds were sighted from both vessels before the start of transmissions. Thirty-nine groups of cetaceans and 23 of pinnipeds were sighted during transmissions. Blue (Balaenoptera musculus), fin (B. physalus), and sperm (Physeter macrocephalus) whales were sighted during the base line period; blue, sperm, and possibly sei (B. borealis) whales were sighted during the transmission period. More schools of hourglass dolphins (Lagenorhynchus cruciger) were sighted during transmissions, but fewer groups of pilot whales (Globicephala melas), southern bottlenose whales (Hyperoodon planifrons), and minke whales (B. acutorostrata). The density of all cetaceans was 0.0157 groups/km2 before the transmissions and 0.0166 groups/km2 during. Antarctic fur seals (Arctocephalus gazella) and southern elephant seals (Mirounga leonina) were seen, but not in sufficient numbers to estimate abundance. One blue whale tracked before, during and after a transmission changed respiration and reorientation rates, but did not avoid the source detectably. Sperm whales and pilot whales were heard in 23% of 1181 min of baseline acoustic surveys; but in none of 1939 min during the transmission period. Both species were heard within 48 h after the end of the test.

Bracciali, C., et al. (2012). "Effects of nautical traffic and noise on foraging patterns of Mediterranean damselfish (Chromis chromis)." PLoS ONE 7(7): e40582.

Chromis chromis is a key species in the Mediterranean marine coastal ecosystems where, in summer, recreational boating and its associated noise overlap. Anthropogenic noise could induce behavioral modifications in marine organisms, thereby affecting population dynamics. In the case of an important species for the ecosystem like C. chromis, this could rebound on the community structure. Here, we measured nautical traffic during the summer of 2007 in a Southern Mediterranean Marine Protected Area (MPA) and simultaneously the feeding behavior of C. chromis was video-recorded, within both the no-take A-zone and the B-zone where recreational use is allowed. Feeding frequencies, escape reaction and school density were analyzed. C. chromis specimens were also collected from 2007 to 2008 to evaluate their physiological state using the Body Condition Index as a proxy of feeding efficiency. The MPA was more exploited by nautical tourism during holidays than on weekdays, particularly in the middle of the day. Greater traffic volume corresponded with lower feeding frequencies. The escape reaction was longer in duration (>1 min) when boat passed nearby, while moored boats did not induce an escape response. We found no differences in density between schools in the A- and B-zones and worse body conditions among those individuals inhabiting the B-zone in one area only. Overall, our findings revealed a significant modification of the daily foraging habits of C. chromis due to boat noise, which was slightly buffered by no-take zones established within the MPA.

Brandt, M. J., et al. (2011). "Responses of harbour porpoises to pile driving at the Horns Rev II offshore wind farm in the Danish North Sea." Marine Ecology Progress Series 421: 205-216.

Pile driving during offshore windfarm construction goes along with considerable noise emissions that potentially harm marine mammals in the vicinity and may cause large scale disturbances. Information on the scale of such disturbances is limited. Therefore, assessment and evaluation of the effects of offshore construction on marine mammals is difficult. During summer 2008, 91 monopile foundations were driven

into the seabed during construction of the offshore wind farm Horns Rev II in the Danish North Sea. We investigated the spatial and temporal scale of behavioral responses of harbour porpoises Phocoena phocoena to construction noise using passive acoustic monitoring devices (T-PODs) deployed in a gradient sampling design. Porpoise acoustic activity was reduced by 100% during 1 h after pile driving and stayed below normal levels for 24 to 72 h at a distance of 2.6 km from the construction site. This period gradually decreased with increasing distance. A negative effect was detectable out to a mean distance of 17.8 km. At 22 km it was no longer apparent, instead, porpoise activity temporarily increased. Out to a distance of 4.7 km, the recovery time was longer than most pauses between pile driving events. Consequently, porpoise activity and possibly abundance were reduced over the entire 5 mo construction period. The behavioral response of harbour porpoises to pile driving lasted much longer than previously reported. This information should be considered when planning future wind farm construction.

Branstetter, B. K., et al. (2013). "Auditory masking patterns in bottlenose dolphins (Tursiops truncatus) with natural, anthropogenic, and synthesized noise." The Journal of the Acoustical Society of America 133(3): 1811-1818.

Auditory masking occurs when one sound (usually called noise) interferes with the detection, discrimination, or recognition of another sound (usually called the signal). This interference can lead to detriments in a listener's ability to communicate, forage, and navigate. Most studies of auditory masking in marine mammals have been limited to detection thresholds of pure tones in Gaussian noise. Environmental noise marine mammals encounter is often more complex. In the current study, detection thresholds were estimated for bottlenose dolphins with a 10 kHz signal masked by natural, anthropogenic, and synthesized noise. Using a band-widening paradigm, detection thresholds exhibited a pattern where signal thresholds increased proportionally to bandwidth for narrow band noise. However, when noise bandwidth was greater than a critical band, masking patterns diverged. Subsequent experiments demonstrated that the auditory mechanisms responsible for the divergent masking patterns were related to across-channel comparison and within-valley listening.

Breeden, J. B., et al. (2008). "Effects of traffic noise on auditory surveys of urban White-winged Doves." The Wilson Journal of Ornithology 120(2): 384-389.

We investigated the effects of urban noise on auditory surveys of White-winged Doves (Zenaida asiatica) in two major cities in Texas. We conducted auditory point counts throughout the morning in San Antonio (n = 6) and Austin (n = 10) during week days (when traffic noise is higher) and weekends. We categorized survey points as near or far from roads (<0.8 and >0.8 km, respectively) for comparison. We documented no difference in density estimates in Austin between week days (46 ± 10 pairs/ha) and weekends (52 ± 10 pairs/ha; P = 0.23); however, weekend estimates were consistently higher throughout the morning. Weekend density estimates in San Antonio were higher after 0620 hrs (P < 0.04), the time coinciding with beginning of the morning commute during week days in this city. We documented that weekend estimates (45 ± 5 pairs/ha) were higher than week day estimates (33 ± 5 pairs/ha) for points near roads (within 0.8 km; P = 0.02) but not for points far from roads (P = 0.16). Our results indicate that traffic noise can bias auditory surveys. Survey methods that account for probability of detection should be used to correct for potential noise bias.

Brown, A. (1990). "Measuring the effect of aircraft noise on sea birds." Environment international

16(4-6): 587-592.

This paper reports on a procedure which exposes sea birds to acoustic stimuli simulating aircraft overflights, and is one of the first experiments to attempt to quantify the responses of birds in the wild to noise. The experiment, conducted on Australia's Great Barrier Reef, involved presentation of pre-recorded aircraft noise, with peak overflight levels of 65 dB9A) to 95 dB(A), to nesting sea bird colonies. Sea bird responses were videotaped and these tapes were subsequently analyzed by scoring the behavioral response of each bird in the colony. Results of a trial of this experimental procedure for one species, the Crested Tern (Sterna bergii), indicate that the maximum responses observed, preparing to fly or flying off, were restricted to exposures greater than 85 dB(A). A scanning behavior involving head-turning was the minimum response, and this, or a more intense response, was observed in nearly all birds at all levels of exposure. However an intermediate response, an alert behavior, demonstrated a strong positive relationship with increasing exposure. While the experiment has provided good control on simulated aircraft noise levels, preliminary observations of response of the colonies to balloon overflights suggests that visual stimulus is likely to be an important component of aircraft noise disturbance.

Brown, A. L. (2012). "A Review of Progress in Soundscapes and an Approach to Soundscape Planning." International Journal of Acoustics and Vibration 17(2): 73-81.

The soundscape approach considers the acoustic environment as a resource, focusing on sounds people want or prefer. Quiet is not a core requirement for such acoustic preference in the outdoor acoustic environment. Core requirements include congruent soundscape and landscape, and dominant wanted sounds in a place over, and not masked by, unwanted sounds. Acceptance, and further development, of the soundscape approach is facilitated by distinguishing it, both conceptually and in measurement and management approaches, from environmental noise management. Soundscape design, planning, and management, based on soundscape concepts, augment environmental noise management approaches, expanding the scope of application of the tools of acoustic specialists.

Brown, A. L., et al. (2011). "Towards standardization in soundscape preference assessment." Applied Acoustics 72(6): 387-392.

Abstract: The study of soundscapes involves diverse fields of practice, diverse approaches and diverse disciplinary interests. The field overlaps with the much larger and established field of environmental noise management, and also intersects, to various degrees, with other areas of acoustics such as sound quality, human acoustic comfort in buildings, and music—and also with non-acoustic fields such as wilderness and recreation management, urban and housing design, and landscape planning and management. Working Group 54 of ISO/TC 43/SC 1 has been formed with a remit of standardization for perceptual assessment of human sound preference (in outdoor space) using questionnaires. The working group began its work in 2009, with considerable and wide-ranging discussion amongst its members. This paper makes a range of observations, and sometimes suggestions, on matters pertinent to eventual definition of the soundscape; on outcomes of interest arising from experience of a soundscape; on the role of context in assessment; on sound sources in different places; and on relevant lessons for soundscape assessment from experience of questionnaire measurement of noise annoyance. It represents a personal view, though informed by a range

of opinions from the Working Group meeting and from literature. [Copyright &y& Elsevier]

Brown, A. L. and A. Muhar (2004). "An Approach to the Acoustic Design of Outdoor Space." Journal of Environmental Planning & Management 47(6): 827-842.

This paper focuses on soundscape planning, or acoustic design, in the planning and management of open space in both urban and non-urban areas. It is based on notions, promoted over several decades, that the acoustic aspects of open space can, and should be, subject to design in the same way as are the visual dimensions. The current paradigm for the management of the outdoor acoustic environment is noise control and soundscape planning needs to adopt quite different practices from noise control with respect to acoustic criteria and measurement. The paper explores the specification of acoustic objectives for outdoor soundscapes and the translation of these objectives into acoustic criteria that are amenable to measurement and prediction as part of the design process. Such objectives, termed Proposed Acoustic Environments, focus on the information content in sounds in a particular space and, only indirectly, on characteristics such as level or loudness. Outdoor acoustic design is mostly concerned with avoiding, or achieving, the masking of one set of information in the acoustic signal with other sets of information in the same signal. These are critical methodological issues if soundscape planning is to move from being a good idea to common practice. The paper sets out the elements of a process for the acoustic design or management of outdoor space. [ABSTRACT FROM AUTHOR]

Brown, C., et al. (2013). "Detection and Classification of Motor Vehicle Noise in a Forested Landscape." Environmental Management 52(5): 1262-1270.

Noise emanating from human activity has become a common addition to natural soundscapes and has the potential to harm wildlife and erode human enjoyment of nature. In particular, motor vehicles traveling along roads and trails produce high levels of both chronic and intermittent noise, eliciting varied responses from a wide range of animal species. Anthropogenic noise is especially conspicuous in natural areas where ambient background sound levels are low. In this article, we present an acoustic method to detect and analyze motor vehicle noise. Our approach uses inexpensive consumer products to record sound, sound analysis software to automatically detect sound events within continuous recordings and measure their

acoustic properties, and statistical classification methods to categorize sound events. We describe an application of this approach to detect motor vehicle noise on paved, gravel, and natural-surface roads, and off-road vehicle trails in 36 sites distributed throughout a national forest in the Sierra Nevada, CA, USA. These low-cost, unobtrusive methods can be used by scientists and managers to detect anthropogenic noise events for many potential applications, including ecological research, transportation and recreation planning, and natural resource management. [ABSTRACT FROM AUTHOR]

Brown, C. L., et al. (2012). "The Effect of Human Activities and Their Associated Noise on Ungulate Behavior." PLoS ONE 7(7): 1-9.

Background: The effect of anthropogenic noise on terrestrial wildlife is a relatively new area of study with broad ranging management implications. Noise has been identified as a disturbance that has the potential to induce behavioral responses in animals similar to those associated with predation risk. This study investigated potential impacts of a variety of human activities and their associated noise on the behavior of elk (Cervus elaphus) and pronghorn (Antilocapra americana) along a transportation corridor in Grand Teton National Park. Methodology/Principal Findings: We conducted roadside scan surveys and focal observations of ungulate behavior while concurrently recording human activity and anthropogenic noise. Although we expected ungulates to be more responsive with greater human activity and noise, as predicted by the risk disturbance hypothesis, they were actually less responsive (less likely to perform vigilant, flight, traveling and defensive behaviors) with increasing levels of vehicle traffic, the human activity most closely associated with noise. Noise levels themselves had relatively little effect on ungulate behavior, although there was a weak negative relationship between noise and responsiveness in our scan samples. In contrast, ungulates did increase their responsiveness with other forms of anthropogenic disturbance; they reacted to the presence of pedestrians (in our scan samples) and to passing motorcycles (in our focal observations). Conclusions: These findings suggest that ungulates did not consistently associate noise and human activity with an increase in predation risk or that they could not afford to maintain responsiveness to the most frequent human stimuli. Although reduced responsiveness to certain disturbances may allow for greater investment in fitness-enhancing activities, it may also decrease detections of predators and other environmental cues and increase conflict with humans. [ABSTRACT FROM AUTHOR]

Brown, J. S. (1999). "Vigilance, patch use and habitat selection: foraging under predation risk." Evolutionary Ecology Research 1(1): 49-71.

To balance conflicting demands for food and safety from predation, feeding animals have two useful tools. First, they can vary the amount of time they devote to harvesting patches that vary in predation risk and feeding rates. Second, they can use vigilance to trade-off food and safety while feeding from a food patch. I present a model for predicting how an optimal forager should jointly use these two tools. Factors influencing the use of these tools include encounter rate with predators, predator lethality in the absence of vigilance, effectiveness of vigilance in reducing predator lethality, the marginal value of energy to the forager and the forager's survivor's fitness. Patch-use behaviors influenced by these factors include vigilance level, quitting harvest rate and giving-up density (GUD). All three of these patch-use behaviors should increase in response to an increase in encounter rate with predators, predator lethality and the forager's survivor's fitness, and decrease with an increase in the marginal value of energy. In response to increasing the effectiveness of vigilance, vigilance should increase and the GUD and quitting harvest rate should decline. The amount of food left by a forager in a depletable food patch, the GUD, provides an empirical link for testing the model's predictions. Giving-up densities should increase with increasing predation risk, and GUDs should increase with declining food-density-specific harvest rates. Differences in GUDs among food patches attributable to differences in quitting harvest rates measure the contribution of time allocation to managing differences in predation risk. Differences in GUDs attributable to differences in food-density specific harvest rates measure the contribution of vigilance to managing predation risk.

Brownridge, D. (1986). "Filling the Parks with Noise." Sierra 71(4): 59.

Aircraft are considered the number-one problem in the vast Grand Canyon Nat'l Park, long revered for its all encompassing quiet. An estimated 100,000 tourist planes, helicopters, and military aircraft now fly in and over the Canyon annually. In the back country, the noise is audible as much as 95% of the time during the day. This proliferation of aircraft, the noisiest motor vehicles of all, intrude on the Peace and quiet that have always been considered inseparable from nature and the wilderness experience. Wildlife refuges in the West are also plagued by such noise pollution. Proposals to mitigate the intrusive impacts of park flights are coming from several sources, including a newly introduced congressional Bill calling for a study that would recommend appropriate altitudes for aircraft over all NPS units.

Bruintjes, R. and A. N. Radford (2013). "Context-dependent impacts of anthropogenic noise on individual and social behavior in a cooperatively breeding fish." Animal Behavior 85(6): 1343-1349.

Anthropogenic (man-made) noise is a global problem and present in virtually all terrestrial and aquatic environments. To date, most studies investigating the potential impact of this pollutant have focused on individual behavioral responses and simply considered whether noise has an effect. However, most animals engage in social interactions, which may be vulnerable to the adverse effects of noise, and work in other fields suggests that individuals might react differentially to comparable noise stimuli depending on their own characteristics and the current situation. We used controlled experiments and standardized tests to investigate the impacts of playback of the noise of a passing boat, a dominant acoustic stressor in the aquatic environment, on nest-digging behavior, anti-predator defense and social interactions in small

groups of Neolamprologus pulcher, a territorial and cooperatively breeding cichlid fish. Our results show that, in comparison to ambient noise, playback of boat noise: (1) reduced digging behavior, which is vital to maintain hiding and breeding shelters; (2) decreased defense against predators of eggs and fry, with direct consequences for fitness; and (3) increased the amount of aggression received and submission shown by subordinates. Moreover, the context (presence or absence of eggs) affected individual and social behaviors in response to the same noise source. Our results demonstrate the need to consider whole behavioral repertoires for a full understanding of the impact of anthropogenic noise, and indicate that the effects of this global pollutant are likely to be context dependent.

Brumm, H. (2004). "The impact of environmental noise on song amplitude in a territorial bird." Journal of Animal Ecology 73(3): 434-440.

1. The impact of environmental background noise on the performance of territorial songs was examined in free-ranging nightingales (Luscinia megarhynchos Brehm). An analysis of sound pressure levels revealed that males at noisier locations sang with higher sound levels than birds in territories less affected by background sounds.
2. This is the first evidence of a noise-dependent vocal amplitude regulation in the natural environment of an animal.
3. The results yielded demonstrate that the birds tried to mitigate the impairments on their communication caused by masking noise. This behavior may help to maintain a given transmission distance of songs, which are used in territory defense and mate attraction. At the same time, birds forced to sing with higher amplitudes have to bear the increased costs of singing.
4. This suggests that in songbirds the level of environmental noise in a territory will contribute to its quality and thus considerably affect the behavioral ecology of singing males.

Buckstaff, K. C. (2004). "Effects of watercraft noise on the acoustic behavior of bottlenose dolphins, Tursiops truncatus, in Sarasota Bay, Florida." Marine Mammal Science 20(4): 709-725.

Watercraft may provide the greatest source of anthropogenic noise for bottlenose dolphins living in coastal waters. A resident community of about 140 individuals near Sarasota, Florida, are exposed to a vessel passing within 100 m approximately every six minutes during daylight hours. I investigated the circumstances under which watercraft traffic may impact the acoustic behavior of this community, specifically looking for short-term changes in whistle frequency range, duration, and rate of production. To analyze whistles and received watercraft noise levels, acoustic recordings were made using two hydrophones towed from an observation vessel during focal animal follows of 14 individual dolphins. The duration and frequency range of signature whistles did not change significantly relative to vessel approaches. However, dolphins whistled significantly more often at the onset of approaches compared to during and after vessel approaches. Whistle rate was also significantly greater at the onset of a vessel approach than when no vessels were present. Increased whistle repetition as watercraft approach may simply reflect heightened arousal, an increased motivation for animals to come closer together, with whistles functioning to promote reunions. It may also be an effective way to compensate for signal masking, maintaining communication in a noisy environment.

Byrnes, P., et al. (2012). "Are less vocal rainforest mammals susceptible to impacts from traffic noise?" Wildlife Research 39(4): 355-365.

Context: Traffic noise is believed to cause road avoidance and other barrier effects in a variety of wildlife species, and to force changes to call pitch or loudness in others; however, this has never been tested in the absence of other road impacts. Noise impacts on species that do not frequently vocalize are also poorly understood. We investigated traffic-noise impacts on the following three rainforest mammals that do not often vocalize: Hypsiprymnodon moschatus, Uromys caudimaculatus and Perameles nasuta. These species have previously been observed to exhibit varying levels of road avoidance.

Aims: To determine whether traffic noise affects movement and behavior of medium-sized, ground-dwelling rainforest mammals in the absence of other road-associated variables and potential impacts. We hypothesized that noise impacts would be greatest for species previously shown to avoid roads. Noise impacts on these less vocal species compared with more vocal species is also discussed.

Methods: In north-eastern Queensland, Australia, mammals captured at least 500 m from any road were tracked after fitting with spool-and-line equipment. On noisy nights, traffic noise at levels similar to a busy highway was played continuously throughout the night from a line of 12 speakers mounted on trees. Speakers were silent on quiet nights.

Key results: Traffic noise caused no increase in avoidance of the speaker line and was not a barrier to movements across the line. Overall, movement paths on noisy nights appeared similar in pattern (tortuosity) to those of quiet nights. At a finer scale, movements of H. moschatus and P. nasuta became more tortuous later in the track, suggesting a return to normal foraging behavior and possible habituation to the noise.

Conclusions: These three species with varying levels of previously recorded road avoidance, did not respond negatively to traffic noise. There was, however, a suggestion of habituation by H. moschatus and P. nasuta in response to the noise.

Implications: The demonstrated lack of response to traffic noise in these less vocal species means that traffic noise is unlikely to cause road avoidance or barrier effects. Instead, lack of response and possible habituation to traffic noise may increase vulnerability to road mortality.

Cahn, R. (1980). "The state of the parks." Sierra Club Bulletin 65(3): 10-14.

The article reviews some of the findings of a recent report by the US National Park Service. The report lists threats, both inside and adjacent to park areas; the effects of air, water, noise pollution; aesthetic degradation, logging, mineral exploration, grazing and land development; and effects of visitor use.

Canaday, C. and J. Rivadeneyra (2001). "Initial effects of a petroleum operation on Amazonian birds: terrestrial insectivores retreat." Biodiversity & Conservation 10(4): 567-595.

Impacts of petroleum activities on birds in the Amazonian forest of Yasuní National Park and the Huaorani

Territory, Ecuador, were evaluated using data from 32 standardized 1-day surveys of twenty one ~2-ha sites, spread out over 90 km, located at four different distances (0, 0.5, 1.5, and ~4.5 km) into floristically diverse, primary, terra firme forest (240–320 m elev.), except one that was in 6-year-old secondary forest. Width of deforestation for roads was ≤25 m. The 263 species, identified via sight, sound, and mist-netting (4 nets) between 5:45 and 13:30 on days without heavy or constant rain, were grouped into 14 foraging guilds. Discriminant Function Analysis achieved complete separation of the 10 surveys adjacent to roads from the 22 surveys > 0.3 km into the forest, based on species richness per guild. Terrestrial insectivores contributed by far the most (76%) to this separation, and were the only guild to show a significant difference in the average number of species registered between the 6-edge sites and the 15 interior sites (Mann–Whitney U = 4, P = 0.001). Machinery noise seems to particularly affect this guild.

Carles, J. L., et al. (1999). "Sound influence on landscape values." Landscape and Urban Planning 43(4): 191-200.

In order to study the influence of the interaction between visual and acoustic stimuli on perception of the environment, 36 sound and image combinations were presented to 75 subjects. The sounds and images used were of natural and semi-natural settings and urban green space. Affective response was measured in terms of pleasure. The results show a rank of preferences running from natural to man-made sounds, with the nuance of a potential alert or alarm-raising component of the sound. The potential for alert or alarm raising may be related, over and above the information content or meaning, to the characteristics of the sound frequency spectrum, specifically to the existence of frequency bands whose sound levels impose themselves on the acoustic background. The congruence or coherence between sound and image influences preferences. Coherent combinations are rated higher than the mean of the component stimuli. Results suggest that there is a need to identify places or settings where the conservation of the sound environment is essential, because of its salient informational content or due to the drastic impact of the loss of sound quality on observer appreciation, for example, in urban green spaces, natural spaces and cultural landscapes.

Caro, T. (2005). Antipredator Defenses in Birds and Mammals, University of Chicago Press.

Casper, B. M., et al. (2013). "Effects of exposure to pile driving sounds on fish inner ear tissues." Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology 166(2): 352-360.

Impulsive pile driving sound can cause injury to fishes, but no studies to date have examined whether such injuries include damage to sensory hair cells in the ear. Possible effects on hair cells were tested using a specially designed wave tube to expose two species, hybrid striped bass (white bass Morone chrysops × striped bass Morone saxatilis) and Mozambique tilapia (Oreochromis mossambicus), to pile driving sounds. Fish were exposed to 960 pile driving strikes at one of three treatment levels: 216, 213, or 210 dB re 1 μPa2·s cumulative Sound Exposure Level. Both hybrid striped bass and tilapia exhibited barotraumas such as swim bladder ruptures, herniations, and hematomas to several organs. Hybrid striped bass exposed to the highest sound level had significant numbers of damaged hair cells, while no damage was found when fish were exposed at lower sound levels. Considerable hair cell damage was found in only one out of 11 tilapia specimens exposed at the highest sound level. Results suggest that impulsive sounds such as from pile

driving may have a more significant effect on the swim bladders and surrounding organs than on the inner ears of fishes, at least at the sound exposure levels used in this study.

Castellote, M., et al. (2012). "Acoustic and behavioral changes by fin whales (Balaenoptera physalus) in response to shipping and air gun noise." Biological Conservation 147(1): 115-122.
Non-lethal behavioral effects of underwater noise in marine mammals are difficult to measure. Here we report acoustic and behavioral changes by fin whales in response to two different types of anthropogenic noise: shipping and air gun noise. Acoustic features of fin whale 20-Hz song notes recorded in the Mediterranean Sea and Northeast Atlantic Ocean were compared for areas with different shipping noise levels, different traffic intensities in the Strait of Gibraltar and during a seismic air gun array survey. In high noise conditions 20-Hz note duration shortened, bandwidth decreased, center frequency decreased and peak frequency decreased. Similar results were obtained in 20-Hz song notes recorded during a 10-day seismic survey. During the first 72 h of the survey, a steady decrease in song received levels and bearings to singers indicated that whales moved away from the air gun array source and out of our detection area, and this displacement persisted for a time period well beyond the 10-day duration of seismic air gun activity. This study provides evidence that male fin whales from two different subpopulations modify song characteristics under increased background noise conditions, and that under seismic air gun activity conditions they leave an area for an extended period. We hypothesize that fin whale acoustic communication is modified to compensate for increased background noise and that a sensitization process may play a role in the observed temporary displacement. The observed acoustic and behavioral changes of this endangered species are discussed in the context of reproduction success and population survival.

Chan, A. A. Y.-H., et al. (2010). "Increased amplitude and duration of acoustic stimuli enhance distraction." Animal Behavior 80(6): 1075-1079.
Extraneous sounds have a variety of effects on animals; they may interfere with communication, cause physical harm, increase wariness, influence settlement decisions, or they may cause distractions in ways that increase vulnerability to predation. We designed a study to investigate the effects of changing both the amplitude and duration of an acoustic stimulus on distraction in a terrestrial hermit crab (Coenobita clypeatus). In experiment 1, we replicated the key findings from a field result: crabs hid more slowly in response to a silent visual stimulus when we simultaneously broadcast a white noise than they did when in a silent condition. In experiment 2, we altered the noise duration and found that a long noise generated greater latencies to hide than a short noise. In experiment 3, we increased the noise amplitude and found that hide latency increased with higher-intensity auditory stimuli. These experiments demonstrate a variety of stimulus factors that influence distraction. Our results suggest that prey animals could be in greater danger from predators when in an environment with auditory distractions.

Chapman, D. M. and D. D. Ellis (1998). "Elusive decibel: Thoughts on sonars and marine mammals." Canadian Acoustics 26(2): 29-31.
Sonar engineers, marine biologists and environmentally-conscious citizens continue to discuss the issues of using the same acoustical units to avoid confusion and misinterpretation, which can be traced back to the

multiple use of the term `decibel'. But the real focus of concern is to determine what underwater sound levels are harmful to marine life. Hence, mitigation measures must be developed to allow underwater acoustic systems to be operated while ensuring the protection of the marine environment.

Chuck, R. and T. Usa Park's noise plan causes uproar. Coates, P. A. (2005). "The Strange Stillness of the Past: Toward an Environmental History of Sound and Noise." Environmental History 10(4): 636-665.

Codarin, A., et al. (2009). "Effects of ambient and boat noise on hearing and communication in three fish species living in a marine protected area (Miramare, Italy)." Marine Pollution Bulletin 58(12): 1880-1887.

The WWF-Natural Marine Reserve of Miramare (Trieste, Italy) is located in a major industrial and vacation area in the Adriatic Sea. Consequently, noise emanating from boating and shipping is an inevitable factor for local fishes. This study investigates the effects of ambient and ship noise on representatives of three vocal fish families with different hearing abilities. Ambient and ship noise were recorded, their sound pressure levels measured and played back in the lab. Auditory sensitivity was determined in Chromis chromis, Sciaena umbra and Gobius cruentatus, utilizing the auditory evoked potential recording technique. Compared to lab conditions, hearing thresholds determined during ambient noise playbacks were barely masked. Contrary, the noise emanating from a cabin-cruiser substantially reduced auditory sensitivity relative to thresholds in ambient noise. This masking effect was most pronounced in the frequency range where acoustic communication takes place. Boat noise potentially affects acoustic communication in fishes inhabiting the reserve.

Conomy, J. T., et al. (1998). "Do black ducks and wood ducks habituate to aircraft disturbance?" The Journal of Wildlife Management: 1135-1142.

Requests to increase military aircraft activity in some training facilities in the United States have raised the need to determine if waterfowl and other wildlife are adversely affected by aircraft disturbance. We hypothesized that habituation was a possible proximate factor influencing the low proportion of free-ranging ducks reacting to military aircraft activities in a training range in coastal North Carolina during winters 1991 and 1992. To test this hypothesis, we subjected captive, wild-strain American black ducks (Anas rubripes) and wood ducks (Aix sponsa) to actual and simulated activities of jet aircraft. In the first experiment, we placed black ducks in an enclosure near the center of aircraft activities on Piney Island, a military aircraft target range in coastal North Carolina. The proportion of times black ducks reacted (e.g., alert posture, fleeing response) to visual and auditory aircraft activity decreased from 38 to 6% during the first 17 days of confinement. Response rates remained stable at 5.8% thereafter. In the second experiment, black ducks and wood ducks were exposed to 6 different recordings of jet noise. The proportion of times black ducks reacted to noise decreased ($P < 0.05$) from first day of exposure (25%) to last (i.e., day 4; 8%). Except for a 2% difference in comfort, we detected no differences ($P > 0.05$) in time-activity budgets of black ducks between pre-exposure to noise and 24 hr after first exposure. Unlike black ducks, wood duck responses to jet noise did riot decrease uniformly among experimental groups following initial exposure to noise ($P = 0.01$). We conclude that initial exposure to aircraft noise elicits behavioral responses from black ducks and wood ducks. With continued exposure of aircraft noise, black ducks may become habituated. However, wood

ducks did not exhibit the same pattern of response, suggesting that the ability of waterfowl to habituate to aircraft noise.

Crino, O. L., et al. (2013). "Effects of experimentally elevated traffic noise on nestling white-crowned sparrow stress physiology, immune function and life history." Journal of Experimental Biology 216(11): 2055-2062.

Roads have been associated with behavioral and physiological changes in wildlife. In birds, roads decrease reproductive success and biodiversity and increase physiological stress. Although the consequences of roads on individuals and communities have been well described, the mechanisms through which roads affect birds remain largely unexplored. Here, we examine one mechanism through which roads could affect birds: traffic noise. We exposed nestling mountain white-crowned sparrows (Zonotrichia leucophrys oriantha) to experimentally elevated traffic noise for 5 days during the nestling period. Following exposure to traffic noise we measured nestling stress physiology, immune function, body size, condition and survival. Based on prior studies, we expected the traffic noise treatment to result in elevated stress hormones (glucocorticoids), and declines in immune function, body size, condition and survival. Surprisingly, nestlings exposed to traffic noise had lower glucocorticoid levels and improved condition relative to control nests. These results indicate that traffic noise does affect physiology and development in white-crowned sparrows, but not at all as predicted. Therefore, when evaluating the mechanisms through which roads affect avian populations, other factors (e.g. edge effects, pollution and mechanical vibration) may be more important than traffic noise in explaining elevated nestling stress responses in this species.

Croll, D. A., et al. (2001). "Effect of anthropogenic low-frequency noise on the foraging ecology of Balaenoptera whales." Animal Conservation 4(1): 13-27.

The human contribution to ambient noise in the ocean has increased over the past 50 years, and is dominated by low-frequency (LF) sound (frequencies <1000 Hz) from shipping, oil and gas development, defense-related and research activities. Mysticete whales, including six endangered species, may be at risk from this noise pollution because all species produce and probably perceive low-frequency sound. We conducted a manipulative field experiment to test the effects of loud, LF noise on foraging fin blue (B. musculus) and (Balaenoptera physalus) whales off San Nicolas Island, California. Naive observers used a combination of attached tracking devices, ship-based surveys, aerial surveys, photo-identification and passive monitoring of vocal behavior to examine the behavior and distribution of whales when a loud LF source (US Navy SURTASS LFA) was and was not transmitting. During transmission, 12-30% of the estimated received levels of LFA of whales in the study area exceeded 140 dB re 1 μPa. However, whales continued to be seen foraging in the region. Overall, whale encounter rates and diving behavior appeared to be more strongly linked to changes in prey abundance associated with oceanographic parameters than to LF sound transmissions. In some cases, whale vocal behavior was significantly different between experimental and non-experimental periods. However, these differences were not consistent and did not appear to be related to LF sound transmissions. At the spatial and temporal scales examined, we found no obvious responses of whales to a loud, anthropogenic, LF sound. We suggest that the cumulative effects of anthropogenic LF noise over larger temporal and spatial scales than examined here may be a more important consideration for management agencies.

Culik, B. M., et al. (2001). "Reactions of harbor porpoises Phocoena phocoena and herring Clupea harengus to acoustic alarms." Marine Ecology Progress Series 211: 255-260.

Small cetaceans are susceptible to incidental mortality in the various forms of gillnet fisheries throughout their range. Research conducted since 1994 has shown that acoustic alarms (pingers) emitting high frequency pulsed sounds effectively reduce the number of harbor porpoise Phocoena phocoena casualties in sink gillnets. However, the mechanisms behind the effects of pingers were still not understood. Until now, advantages and risks associated with their widespread use could not be evaluated. Here we present the results of 2 field experiments: (1) theodolite-tracking of harbor porpoises exposed to a single PICE-pinger in Clayoquot Sound, Vancouver Island, Canada and (2) herring Clupea harengus capture rates in surface gillnets equipped with and without acoustic alarms (Dukane Netmark 1000, Lien, PICE) in the Baltic Sea herring fishery at Rügen Island, Germany. Our results show that harbor porpoises do not seem to react to an experimental net in their foraging area (n = 172 groups, median group size = 2 porpoises). Porpoise distance from the mid-point of the net was distributed around a median of only 150 m (range 4 to 987 m). A net equipped with an acoustic alarm, however, was avoided (n = 44 groups) within audible range (distance distribution median = 530 m, range 130 to 1140 m). The porpoises were thus effectively excluded from the personified area. Herring, one of the main prey species of harbor porpoises, were not affected by the acoustic alarms tested (n = 25407 fish captured). The advantages and risks of using acoustic alarms to mitigate by-catch are discussed.

Cunnington, G. M. and L. Fahrig (2010). "Plasticity in the vocalizations of anurans in response to traffic noise." Acta Oecologica 36(5): 463-470.

Many species use acoustic signals to attract mates, and such signals can be degraded by anthropogenic noise. Anuran abundance has been shown to be negatively correlated with road traffic which could be due in part to the interruption of mate attraction by traffic noise. However, this impact could be small if anurans can alter their vocalization characteristics to avoid masking of their calls by traffic noise. We predicted that: (i) anuran vocalization characteristics (dominant frequency, mean amplitude and call rate) should be different in areas with different traffic noise levels; (ii) increases in traffic noise can cause immediate changes in amphibian vocalization characteristics; (iii) these altered vocalizations are similar to those at high traffic sites. To test the first prediction we compared vocalizations of four species of anuran at breeding sites in locations with low traffic noise vs. sites with high traffic noise. For the second prediction we broadcast traffic noise at low traffic (quiet) sites, and compared the anuran vocalizations before vs. during the broadcast traffic noise. For the third prediction we compared vocalizations at high traffic sites to those produced at low traffic sites while broadcasting traffic noise. Three species of anurans found at locations with low traffic noise produced vocalizations with different characteristics than individuals of the same species found in locations with high traffic noise. Broadcast traffic noise immediately altered amphibian vocalization characteristics such that they became similar to those of the same species found in locations with high traffic noise. We conclude that plasticity in the vocalizations of anurans allows for the maintenance of acoustic communication in the presence of traffic noise.

Dähne, M., et al. (2013). "Effects of pile-driving on harbour porpoises (Phocoena phocoena) at the first offshore wind farm in Germany." Environmental Research Letters 8(2): 025002.

The first offshore wind farm 'alpha ventus' in the German North Sea was constructed north east of Borkum Reef Ground approximately 45 km north off the German coast in 2008 and 2009 using percussive piling for the foundations of 12 wind turbines. Visual monitoring of harbour porpoises was conducted prior to as well as during construction and operation by means of 15 aerial line transect distance sampling surveys, from 2008 to 2010. Static acoustic monitoring (SAM) with echolocation click loggers at 12 positions was performed additionally from 2008 to 2011. SAM devices were deployed between 1 and 50 km from the center of the wind farm. During aerial surveys, 18 600 km of transect lines were covered in two survey areas (10 934 and 11 824 km2) and 1392 harbour porpoise sightings were recorded. Lowest densities were documented during the construction period in 2009. The spatial distribution pattern recorded on two aerial surveys three weeks before and exactly during pile-driving points towards a strong avoidance response within 20 km distance of the noise source. Generalized additive modeling of SAM data showed a negative impact of pile-driving on relative porpoise detection rates at eight positions at distances less than 10.8 km. Increased detection rates were found at two positions at 25 and 50 km distance suggesting that porpoises were displaced towards these positions. A pile-driving related behavioral reaction could thus be detected using SAM at a much larger distance than a pure avoidance radius would suggest. The first waiting time (interval between porpoise detections of at least 10 min), after piling started, increased with longer piling durations. A gradient in avoidance, a gradual fading of the avoidance reaction with increasing distance from the piling site, is hence most probably a product of an incomplete displacement during shorter piling events.

David, J. (2006). "Likely sensitivity of bottlenose dolphins to pile-driving noise." Water and Environment Journal 20(1): 48-54.

Pile driver-generated noise has the potential to affect dolphin populations adversely as it is detectable up to 40 km from the source. At 9 kHz, this noise is capable of masking strong vocalizations within 10–15 km and weak vocalizations up to approximately 40 km. The masking radius reduces as the frequency increases: 6 km at 50 kHz and 1.2 km at 115 kHz. The impacts of masking are expected to be limited by the intermittent nature of pile driver noise, the dolphin's directional hearing, their ability to adjust vocalization amplitude and frequency, and the structured content of their signals. Behavioral modifications have been observed in response to underwater sounds, including those produced by pile drivers, although in the latter case this may have been due to redistribution of prey species. A range of mitigation measures are proposed that are aimed at reducing the impact of pile driver noise on dolphin populations.

Dawe, N. and P. Murphy (2013). "The Gros Morne Challenge." Landscapes/Paysages 15(1): 27-27.

The article discusses the emerging light pollution at the Gros Morne National Park in Newfoundland, Canada amid the increase in the use of lighting technology. The International Dark Sky Association classifies luminous pollution as clutter, glare, light, trespass, and urban sky glow. The non-profit organization seeks to preserve the night by limiting the luminous flux per acre.

De Canto, A. D. L. F., et al. (2010). "Increase in song frequency in response to urban noise in the great tit Parus major as shown by data from the Madrid (Spain) city noise map." Ardeola 57(1): 3-11.

De Robertis, A., et al. (2008). "Silent ships do not always encounter more fish: comparison of acoustic backscatter recorded by a noise-reduced and a conventional research vessel." ICES Journal of Marine Science: Journal du Conseil 65(4): 623-635.

The extent to which fish avoid approaching research vessels is an important source of uncertainty in fisheries surveys. Vessels radiate noise at the frequencies where fish hearing is most sensitive, and noise is thus thought to be the primary stimulus for vessel avoidance. In an effort to minimize vessel avoidance, international standards for noise emission by research vessels have been established. Although vessels meeting these criteria are now in service, the effectiveness of noise quietening on vessel avoidance remains poorly understood. The new, noise-reduced, RV "Oscar Dyson" (OD) will augment the conventionally constructed research vessel, "Miller Freeman" (MF) and serve as the primary platform in conducting acoustic surveys of walleye pollock (Theragra chalcogramma) in Alaska. To investigate whether noise reduction measures result in differential avoidance, which would bias the pollock abundance time-series, we conducted an inter-vessel comparison of acoustic backscatter recorded by OD and MF during a survey of walleye pollock in 2006 in the eastern Bering Sea. Overall, we found no evidence for differences in vessel avoidance that would impact the echo integration results of adult pollock. Analysis of pollock depth distributions from both vessels suggests that there is a comparatively greater diving response to OD, with the reaction taking place primarily after the vessel has passed and for fish shallower than 90 m. Given that the change in vertical distribution is after the fish have been detected by the echo sounder, this reaction should not influence echo-integration measurements. The results indicate that use of the OD rather than the MF is unlikely to bias the Bering Sea survey time-series through changes in vessel avoidance by adult walleye pollock.

De Soto, N. A., et al. (2013). "Anthropogenic noise causes body malformations and delays development in marine larvae." Scientific Reports 3: 2831.

Understanding the impact of noise on marine fauna at the population level requires knowledge about the vulnerability of different life-stages. Here we provide the first evidence that noise exposure during larval development produces body malformations in marine invertebrates. Scallop larvae exposed to playbacks of seismic pulses showed significant developmental delays and 46% developed body abnormalities. Similar effects were observed in all independent samples exposed to noise while no malformations were found in the control groups (4881 larvae examined). Malformations appeared in the D-veliger larval phase, perhaps due to the cumulative exposure attained by this stage or to a greater vulnerability of D-veliger to sound mediated physiological or mechanical stress. Such strong impacts suggest that abnormalities and growth delays may also result from lower sound levels or discrete exposures during the D-stage, increasing the potential for routinely-occurring anthropogenic noise sources to affect recruitment of wild scallop larvae in natural stocks.

Delaney, D. K., et al. (1999). "Effects of helicopter noise on Mexican spotted owls." The Journal of Wildlife Management: 60-76.

Military helicopter training over the Lincoln National Forest (LNF) in south central New Mexico has been severely limited to protect nesting Mexican spotted owls (Strix occidentalis lucida). To evaluate nesting and non-nesting spotted owl responses to helicopter noise, we measured flush frequency, flush distance,

alert behavior, response duration, prey delivery rates, female trips from the nest, and nest attentiveness during manipulated and non-manipulated periods, 1995-96. Chain saws were included in our manipulations to increase experimental options and to facilitate comparative results. We analyzed stimulus events by measuring noise levels as unweighted one-third-octave band levels, applying frequency weighting to the resultant spectra, and calculating the sound exposure level for total sound energy (SEL) and the 0.5-sec equivalent maximum energy level (LEQ max 0.5-sec) for helicopters, and the 10-sec equivalent average energy level (LEQ avg. 10-se) for chain saws. An owl-weighting (dBO) curve was estimated to emphasize the middle frequency range where strigiform owls have the highest hearing sensitivity. Manipulated and non-manipulated nest sites did not differ in reproductive success (P = 0.59) or the number of young fledged (P = 0.12). As stimulus distance decreased, spotted owl flush frequency increased, regardless of stimulus type or season. We recorded no spotted owl flushes when noise stimuli were >105 m away. Spotted owls returned to predisturbance behavior within 10-15 min after a stimulus event. All adult flushes during the nesting season occurred after juveniles had left the nest. Spotted owl flush rates in response to helicopters did not differ between non-nesting (13.3%) and nesting seasons (13.6%; P = 0.34). Spotted owls did not flush when the SEL noise level for helicopters was <102 dBO (92 dBA) and the LEQ level for chain saws was -59 dBO (46 dBA). Chain saws were more disturbing to spotted owls than helicopter flights at comparable distances. Our data indicate a 105-m buffer zone for helicopter overflights on the LNF would minimize spotted owl flush response and any potential effects on nesting activity.

Delaney, D. K., et al. (2011). "Response of red-cockaded woodpeckers to military training operations." Wildlife Monographs 177(1): 1-38.

Military lands are a valuable resource in recovery of threatened, endangered, and at-risk species worldwide and have the highest density of threatened and endangered species of all major land management agencies in the United States. Many red-cockaded woodpeckers (Picoides borealis) that reside on federal lands occur on 15 military installations in the southeastern United States. This close association has increased concern over potential conflicts between conservation requirements of endangered species and the military's mission of combat readiness. Our objectives were to 1) determine if military training operations affect behavior, reproductive success, and productivity of red-cockaded woodpeckers; 2) develop a frequency-weighting function to assess woodpecker hearing sensitivity; 3) identify factors that affect woodpecker responses to military training operations; 4) develop distance and dose-response thresholds for quantifying woodpecker responses to noise levels and stimulus distances; 5) characterize military training operations through quantification of sound levels, source identification, distance from active woodpecker nests, frequency spectra, duration, and frequency of occurrence; and 6) document baseline woodpecker nesting behavior. We conducted our study on the Fort Stewart Military Installation located in southeast Georgia, USA.

Downy woodpeckers, as surrogates for red-cockaded woodpeckers, had their best hearing sensitivity within the peak range of the power spectrum of both downy and red-cockaded woodpecker vocalizations, which is at a higher frequency than that of a typical passerine. Overall, woodpeckers had a reduced auditory sensitivity relative to human hearing sensitivity and other species of small birds, especially in the frequency range >4 kHz. Woodpeckers were most sensitive in the 1.5- to 4.0-kHz range. Sensitivity appeared to drop

off quickly at frequencies <1.0 kHz and >4.0 kHz. Overall, we did not find that the woodpecker-frequency-weighting function we developed provided a better predictor of woodpecker flush response compared with A-weighting. More research is needed to better understand the relationship between frequency-weighting functions and woodpecker response behavior.

Potential breeding groups of woodpeckers across the population increased from 158 in 1997 to 181 in 2000, whereas nesting groups increased from 141 in 1998 to 170 in 2000, for overall increases of 14.6% and 20.6%, respectively, over the 3 years of this project. Fledging success rates for individual nests within the overall population remained consistent from 1998 to 2000, averaging 84.4%. Mean clutch sizes for woodpecker groups for 1998 to 2000 ranged from 2.75 to 3.01 eggs/nest, brood size ranged from 2.01 to 2.22 nestlings/nest, whereas the average number of young fledged ranged from 1.57 to 1.76 young/occupied nest. We observed no difference in reproductive success or productivity between experimental and control-tested red-cockaded woodpecker groups. Overall, experimental test groups produced an average of 2.98 eggs/nest, 1.89 nestlings/nest, and 1.54 young/occupied nest from 1999 to 2000, compared with 2.73 eggs/nest, 1.91 nestlings/nest, and 1.57 young/occupied nest at control groups.

We measured behavioral responses (nest attendance and arrivals and departures from the nest) of red-cockaded woodpeckers to military training events through direct and indirect (i.e., video surveillance) observation of 464.5 hours of woodpecker nesting behavior before and after controlled experimental events while recording and characterizing military-generated sound events using sound-recording equipment. We presented woodpeckers with actual 0.50-caliber blank machine gun fire and artillery simulators from controlled distances to develop distance and sound thresholds. We used video surveillance to document potential behavioral responses of woodpeckers primarily during non-experimental military training operations in areas that could not be safely monitored and to determine baseline woodpecker nesting behaviors. We recorded 2,846 non-experimental military noise events in 157 data sessions at 50 red-cockaded woodpecker groups from 1998 to 2000. We also recorded 206 experimental tests at 58 woodpecker groups during 1999 and 2000.

Life-table analyses of flush response time showed that at short ranges (15–30 m) the flush response was stronger for artillery simulator blasts than for blank fire in both the incubation and the nestling phases. In contrast, at medium distances (45–60 m) blank fire tended to produce more flush responses than artillery fire in both incubation and nestling phases. At longer distances (>60 m), blank fire and artillery produced similar flush responses in the incubation phase, whereas flush response was stronger for blank fire than for artillery in the nestling phase. In general, most animals that responded to military activity flushed within 5 seconds of the stimulus event. Woodpeckers returned to nests within an average of 4.4 minutes after being flushed by artillery simulators and 6.3 minutes after 0.50-caliber blank-fire tests. Woodpecker flush response rates increased as stimulus distance decreased and sound levels increased, regardless of stimulus type or year. Woodpeckers did not flush from nests when 0.50-caliber blank machine gun fire and artillery simulators were >152 m away and sound-exposure levels (decibels [dB]) were <68 dBW (woodpecker-based frequency weighting curve) and <65 dBW, respectively.

We found that blast treatments reduced arrival rates of adults at the nest, with the amount of reduction dependent on the type of blast stimulus and number of helpers at the nest. On the other hand, blast treatments had no detectable effects on nest attendance. The effect of blank fire on incubation-phase arrivals over a 30-minute interval (about 40% reduction) was nearly twice that of artillery simulator fire (about a 20% reduction). There was no evidence supporting any effect of stimulus type on arrivals during the nestling phase. Blast stimuli during incubation reduced arrivals by 40% when no helpers were present, but the strength of this effect decreased to 28% when one helper was present, and was only 6% for nests with ≥2 helpers. Distance of the blast from the nest did not affect the response of arrival rates to blast treatments.

Infrequent, short-duration military training exercises, as measured, did not appear to substantially impact red-cockaded woodpecker reproductive success and productivity on the Fort Stewart Military Installation. Our results may be applicable to other military installations where similar training activities and intensity levels occur. Additional research is needed to address possible habituation or sensitization of red-cockaded woodpeckers to human activities in proximity to active nest sites. Although we attempted to monitor woodpecker response to a number of military training activities, other types of military training operations or human-based activities with louder noise, longer duration, increased human presence, and greater frequency of occurrence could more negatively influence woodpecker nesting behavior and need to be investigated. Our results do not support the hypothesis that military maneuver training operations are limiting factors in the recovery of red-cockaded woodpeckers on military installations, based on our level and type of testing. Natural resource management policies on military installations have had a positive influence on the recovery of red-cockaded woodpeckers and probably outweigh the negative effects of typical military training. © The Wildlife Society, 2011

DeRuiter, S. L., et al. (2013). "Delphinid whistle production and call matching during playback of simulated military sonar." Marine Mammal Science 29(2): E46-E59.

In 2007 and 2008, controlled exposure experiments were performed in the Bahamas to study behavioral responses to simulated mid-frequency active sonar (MFA) by three groups of odontocetes: false killer whales, Pseudorca crassidens; short-finned pilot whales, Globicephala macrorhynchus; and melon-headed whales, Peponocephala electra. An individual in each group was tagged with a Dtag to record acoustic and movement data. During exposures, some individuals produced whistles that seemed similar to the experimental MFA stimulus. Statistical tests were thus applied to investigate whistle-MFA similarity and the relationship between whistle production rate and MFA reception time. For the false killer whale group, overall whistle rate and production rate of the most MFA-like whistles decreased with time since last MFA reception. Despite quite low whistle rates overall by the melon headed whales, statistical results indicated minor transient silencing after each signal reception. There were no apparent relationships between pilot whale whistle rates and MFA sounds within the exposure period. This variability of responses suggests that changes in whistle production in response to acoustic stimuli depend not only on species and sound source, but also on the social, behavioral, or environmental contexts of exposure.

DeRuiter, S. L., et al. (2013). "First direct measurements of behavioural responses by Cuvier's beaked whales to mid-frequency active sonar." Biology Letters 9(4): 20130223.

Most marine mammal strandings coincident with naval sonar exercises have involved Cuvier's beaked whales (Ziphius cavirostris). We recorded animal movement and acoustic data on two tagged Ziphius and obtained the first direct measurements of behavioural responses of this species to mid-frequency active (MFA) sonar signals. Each recording included a 30-min playback (one 1.6-s simulated MFA sonar signal repeated every 25 s); one whale was also incidentally exposed to MFA sonar from distant naval exercises. Whales responded strongly to playbacks at low received levels (RLs; 89–127 dB re 1 μPa): after ceasing normal fluking and echolocation, they swam rapidly, silently away, extending both dive duration and subsequent non-foraging interval. Distant sonar exercises (78–106 dB re 1 μPa) did not elicit such responses, suggesting that context may moderate reactions. The observed responses to playback occurred at RLs well below current regulatory thresholds; equivalent responses to operational sonars could elevate stranding risk and reduce foraging efficiency.

Di Iorio, L. and C. W. Clark (2010). "Exposure to seismic survey alters blue whale acoustic communication." Biology Letters 6(1): 51-54.

The ability to perceive biologically important sounds is critical to marine mammals, and acoustic disturbance through human-generated noise can interfere with their natural functions. Sounds from seismic surveys are intense and have peak frequency bands overlapping those used by baleen whales, but evidence of interference with baleen whale acoustic communication is sparse. Here we investigated whether blue whales (Balaenoptera musculus) changed their vocal behavior during a seismic survey that deployed a low-medium power technology (sparker). We found that blue whales called consistently more on seismic exploration days than on non-exploration days as well as during periods within a seismic survey day when the sparker was operating. This increase was observed for the discrete, audible calls that are emitted during social encounters and feeding. This response presumably represents a compensatory behavior to the elevated ambient noise from seismic survey operations.

Dingemanse, N. J., et al. (2002). "Repeatability and heritability of exploratory behavior in great tits from the wild." Animal Behavior 64(6): 929-938.

We investigated whether individual great tits, Parus major, vary consistently in their exploratory behavior in a novel environment and measured the repeatability and heritability of this trait. Wild birds were caught in their natural habitat, tested in the laboratory in an open field test on the following morning, then released at the capture site. We measured individual consistency of exploratory behavior for recaptured individuals (repeatability) and estimated the heritability with parent–offspring regressions and sibling analyses. Measures of exploratory behavior of individuals at repeated captures were consistent in both sexes and study areas (repeatability ranged from 0.27 to 0.48). Exploration scores did not differ between the sexes, and were unrelated to age, condition at fledging or condition during measurement. Heritability estimates were 0.22–0.41 (parent–offspring regressions) and 0.37–0.40 (sibling analyses). We conclude that (1) consistent individual variation in open field behavior exists in individuals from the wild, and (2) this behavioural variation is heritable. This is one of the first studies showing heritable variation in a behavioural trait in animals from the wild, and poses the question of how this variation is maintained under natural conditions.

Doksæter, L., et al. (2012). "Behavior of captive herring exposed to naval sonar transmissions (1.0–1.6 kHz) throughout a yearly cycle." The Journal of the Acoustical Society of America 131(2): 1632-1642.
Atlantic herring, Clupea harengus, is a hearing specialist, and several studies have demonstrated strong responses to man-made noise, for example, from an approaching vessel. To avoid negative impacts from naval sonar operations, a set of studies of reaction patters of herring to low-frequency (1.0–1.5 kHz) naval sonar signals has been undertaken. This paper presents herring reactions to sonar signals and other stimuli when kept in captivity under detailed acoustic and video monitoring. Throughout the experiment, spanning three seasons of a year, the fish did not react significantly to sonar signals from a passing frigate, at received root-mean-square sound-pressure level (SPL) up to 168 dB re 1μPa. In contrast, the fish did exhibit a significant diving reaction when exposed to other sounds, with a much lower SPL, e.g., from a two-stroke engine. This shows that the experimental setup is sensitive to herring reactions when occurring. The lack of herring reaction to sonar signals is consistent with earlier in situ behavioral studies. The complexity of the behavioral reactions in captivity underline the need for better understanding of the causal relationship between stimuli and reaction patterns of fish.

Dooling, R. J. and A. N. Popper (2007). "The effects of highway noise on birds." Sacramento, CA: The California Department of Transportation Division of Environmental Analysis 74.
There is a long standing, but difficult to resolve, concern that noise produced during the construction and operation of highways (together referred to as highway noise 2) may have an impact on bird behavior and physiology. The Endangered Species Act provides additional, compelling, motivation for understanding the effects of highway noise on federally listed species. Effects of highway noise may be insignificant under certain circumstances, or may include (but are not limited to): producing significant changes in behavior (e.g., the bird having to go further from its nesting site to find food); masking signals birds use to communicate between con specifics or recognize biological signals; impairing detection of sounds of predators and/or prey by masking; decreasing hearing sensitivity temporarily or permanently; and/or increasing stress and altering reproductive and other hormone levels. And there may even be more substantial and enduring impacts that potentially include interference with breeding by individuals and populations, thereby threatening the survival of individuals or species.

Doresky, J., et al. (2001). "Effects of military activity on reproductive success of red-cockaded woodpeckers." Journal of Field Ornithology 72(2): 305-311.
Although significant numbers of the federally endangered Red-cockaded Woodpecker (Picoides borealis) occur at military installations, little research has been initiated to determine what effects military activities have on the birds. From 1994–1996 we collected data at Ft. Benning Military Installation, Georgia, to assess the effects of selected military activities on reproductive success of the birds. Noise and vibration levels were recorded at or directly adjacent to active woodpecker clusters that received significant use by the military on a regular basis (i.e., firing of small arms and artillery). Identical data were collected at active clusters that were not normally used by military personnel and that we perceived to be relatively free of such disturbances. Surprisingly, we found no significant differences in noise or vibration levels between treatments and controls. There also were no significant differences between treatment and control sites with

regard to the numbers of eggs, nestlings, adults, return rates of adults feeding young, or masses of nestlings and adults. Habitat assessments revealed no differences in basal area or mid story density; however, under story was significantly more pronounced at treatment sites.

Dowling, J., et al. (2012). "Comparative effects of urban development and anthropogenic noise on bird songs." Behavioral Ecology 23(1): 201-209.

Many avian species live, breed, and communicate in urban areas. To survive and reproduce in these areas, birds must transmit their signals to intended receivers. As an arena for acoustic communication, 2 salient features of the urban environment are an abundance of reflective surfaces and a high level of low-frequency anthropogenic noise. Each presents unique communication challenges, with hard surfaces reflecting and distorting high frequencies and noise masking low-frequency song components. Based on this, we predicted that noise level would affect minimum song frequency and urban development (percentage of impervious surface) would affect maximum frequency and frequency range. We compared the effects of urban development and noise on songs of 6 bird species at 28 sites along an urban to rural gradient, across a broad range of noise levels. We found that minimum song frequency increased as noise level increased for 2 of 6 species, with 5 of 6 species showing a strong trend in the predicted direction. Species with lower frequency songs were more affected by noise. Maximum frequency and frequency range decreased for 2 of 6 species as urban development increased, and this effect was stronger for species with higher frequency songs. For some species, minimum frequency only increased with noise at less urban sites and similarly, maximum frequency and frequency range only decreased with urbanization at quiet sites, suggesting a trade-off between different vocal adjustments. Ours is the first study to investigate how noise and urban development affect song frequency characteristics of multiple bird species.

Downing, J. M. and C. M. Hobbs (2005). Challenges of Characterizing Natural Soundscapes. 34th International Congress on Noise Control Engineering 2005, INTERNOISE 2005, August 7, 2005 - August 10, 2005, Rio de Janeiro, Brazil, Institute of Noise Control Engineering of the USA.

There are many resources and values intrinsic to natural and wilderness areas, and the natural soundscape is one of those resources. The natural soundscape is an important aspect of one's experience of the scenery and solitude. Moreover, noise intrusions can lessen one's enjoyment of the experience. For researchers, characterizing natural soundscapes presents several challenges. First, measurement strategies must include the effects of temporal and spatial variations. Second, acoustical instrumentation must be portable and rugged, measure continuous one-third octave band spectra, and have low noise floors. Third, analysis of sound data must distill the information into meaningful measures while retaining the complexity of the soundscape. Once the natural soundscape is characterized, then assessment of current or potential noise intrusions can be evaluated. This presentation will highlight these aspects with examples from soundscape measurements made at Zion National Park. [This work partially sponsored by the US National Park Service].

Downing, M., et al. (2000). Measurement of the natural soundscapes in South Florida National Parks.

Duarte, M. H., et al. (2011). "Noisy human neighbors affect where urban monkeys live." Biology Letters 7(6): 840-842.

Urban areas and many natural habitats are being dominated by a new selection pressure: anthropogenic noise. The ongoing expansion of urban areas, roads and airports throughout the world makes the noise almost omnipresent. Urbanization and the increase of noise levels form a major threat to living conditions in and around cities. Insight into the behavioral strategies of urban survivors may explain the sensitivity of other species to urban selection pressures. Here, we show that urban black-tufted marmosets (Callithrix penicillata) living in noisy urban areas may select their home-range based primarily on ambient noise level. We have tested the hypothesis that the noise from vehicular traffic and visitors in an urban park in Brazil influences the use of home-range (space) by urban marmosets. Marmosets even avoided noisy areas with high food availability. In addition, they systematically preferred the quieter areas even with dynamic changes in the acoustic landscape of the park between weekdays and Sundays (no observations were made on Saturdays). These data provide evidence that the use of home-range by wild animals can be affected by a potential aversive stimulus such as noise pollution.

Dumyahn, S. L. and B. C. Pijanowski (2011). "Beyond noise mitigation: managing soundscapes as common-pool resources [electronic resource]." Landscape Ecology 26(9): 1311-1326.

The extent of noise and its impacts continues to grow globally indicating a different approach from regulating individual noise sources is needed. We pose the argument that soundscapes, or the acoustic environment, should be managed as a common-pool resource (CPR). Using CPR theory, we argue that soundscapes possess key features of CPRs: (1) multiple soundscape users, (2) difficulty of exclusion, and (3) subtractability and degradation. Using Ostrom's Social-Ecological Systems (SES) framework, we describe the main elements of soundscapes to consider for their sustainable management. In order to assess noise issues and challenges in managing national park soundscapes, we conducted interviews with U.S. National Park Service managers at parks identified as having air tour overflight impacts. While most managers indicated that aircraft overflights posed the most serious impacts to park resources and visitor experiences, the park units also experienced several other types of noise impacts including traffic on park roads, park maintenance operations, and different types of motorized recreational vehicles. Addressing single sources of noise is necessary, as is the case with air tour overflights, but we argue that a more comprehensive approach is needed to protect park soundscapes. From this study several SES framework variables emerged that need to be addressed for sustainable management, such as the lack of clear soundscape boundaries, availability of acoustic monitoring and data, and the number and types of soundscape users. Based on CPR theory and using the SES framework, the challenges and a potential new approach for sustainable management are discussed.

Eigenbrod, F., et al. (2008). "The relative effects of road traffic and forest cover on anuran populations." Biological Conservation 141(1): 35-46.

Road traffic and the loss of forests are both known to have negative effects on anurans. However, the relative importance of these two predictors is poorly understood because forest cover in the landscape is usually negatively correlated with the density of roads and traffic. To evaluate the independent effects of

traffic and forest cover, we selected 36 ponds near Ottawa, Canada, at the center of four landscape types: low forest/low traffic; low forest/high traffic; high forest/low traffic; and high forest/high traffic, where traffic and forest cover were measured within 100–2000 m of the edge of each pond. We surveyed all ponds in 2005 and re-surveyed a 23-pond subset in 2006. The negative association between species richness and traffic density was stronger (partial R2 = 0.34; P < .001) than the positive association of species richness with forest cover (partial R2 = 0.10; P > .05) in the landscape. Three of six common species showed stronger associations with traffic density than with forest cover –Bufo americanus, Rana pipiens, and Hyla versicolor; two species –Pseudacris crucifer and Rana sylvatica – showed stronger associations with forest cover than with traffic; while Rana clamitans showed similar associations with traffic and forest cover. Our results show that the overall negative effect of traffic on anuran populations in northeastern North America is at least as great as the negative effect of deforestation, and also that the relative effects of these two predictors on anuran abundance vary between species.

Ellis, D. H., et al. (1991). "Raptor responses to low-level jet aircraft and sonic booms." Environmental Pollution 74(1): 53-83.

We estimated effects of low-level military jet aircraft and mid- to high-altitude sonic booms (actual and simulated) on nesting peregrine falcons (Falco peregrinus) and seven other raptors by observing their responses to test stimuli, determining nesting success for the test year, and evaluating site reoccupancy rates for the year following the tests. Frequent and nearby jet aircraft passes: (1) sometimes noticeably alarmed birds, (2) occasionally caused birds to fly from perches or eyries, (3) most often evoked only minimal responses, and (4) were never associated with reproductive failure. Similarly, responses to real and simulated mid- to high-altitude sonic booms were often minimal and never appeared productivity limiting. Eighteen (95%) of 19 nest sites subjected to low-level jet flights and/or simulated sonic booms in 1980 fledged young during that year. Eighteen (95%) of 19 sites disturbed in 1980 were reoccupied by pairs or lone birds of the same species in 1981. We subjected four pairs of prairie falcons (Falco mexicanus) to low-level aircraft at ad libitum levels during the courtship and incubation phases when adults were most likely to abandon: all four eyries fledged young. From heart rate (HR) data taken via a telemetering egg at another prairie falcon eyrie, we determined that stimulus-induced HR alterations were comparable to rate changes for birds settling to incubate following flight. While encouraging, our findings cannot be taken as conclusive evidence that jet flights and/or sonic booms will have no long-term negative effects for other raptor species or for other areas. In addition, we did not experiment with totally naive wild adults, rotary-winged aircraft, or low-level sonic booms.

Ellison, W., et al. (2012). "A new context-based approach to assess marine mammal behavioral responses to anthropogenic sounds." Conservation Biology 26(1): 21-28.

Acute effects of anthropogenic sounds on marine mammals, such as from military sonars, energy development, and offshore construction, have received considerable international attention from scientists, regulators, and industry. Moreover, there has been increasing recognition and concern about the potential chronic effects of human activities (e.g., shipping). It has been demonstrated that increases in human activity and background noise can alter habitats of marine animals and potentially mask communications

for species that rely on sound to mate, feed, avoid predators, and navigate. Without exception, regulatory agencies required to assess and manage the effects of noise on marine mammals have addressed only the acute effects of noise on hearing and behavior. Furthermore, they have relied on a single exposure metric to assess acute effects: the absolute sound level received by the animal. There is compelling evidence that factors other than received sound level, including the activity state of animals exposed to different sounds, the nature and novelty of a sound, and spatial relations between sound source and receiving animals (i.e., the exposure context) strongly affect the probability of a behavioral response. A more comprehensive assessment method is needed that accounts for the fact that multiple contextual factors can affect how animals respond to both acute and chronic noise. We propose a three-part approach. The first includes measurement and evaluation of context-based behavioral responses of marine mammals exposed to various sounds. The second includes new assessment metrics that emphasize relative sound levels (i.e., ratio of signal to background noise and level above hearing threshold). The third considers the effects of chronic and acute noise exposure. All three aspects of sound exposure (context, relative sound level, and chronic noise) mediate behavioral response, and we suggest they be integrated into ecosystem-level management and the spatial planning of human offshore activities.

Engås, A., et al. (1996). "Effects of seismic shooting on local abundance and catch rates of cod ((Gadus morhua) and haddock)(Melanogrammus aeglefinus)." Canadian Journal of Fisheries and Aquatic Sciences 53(10): 2238-2249.

To determine whether seismic exploration affected abundance or catch rates of cod (Gadus morhua) and haddock (Melanogrammus aeglefinus), acoustic mapping and fishing trials with trawls and longlines were conducted in the central Barents Sea 7 days before, 5 days during, and 5 days after seismic shooting with air guns. Seismic shooting severely affected fish distribution, local abundance, and catch rates in the entire investigation area of 40 × 40 nautical miles. Trawl catches of cod and haddock and longline catches of haddock declined on average by about 50% (by mass) after shooting started, which agreed with the acoustic abundance estimates; longline catches of cod were reduced by 21%. Reductions in catch rates were observed 18 nautical miles from the seismic shooting area (3 × 10 nautical miles), but the most pronounced reduction occurred within the shooting area, where trawl catches of both species and longline catches of haddock were reduced by about 70% and the longline catches of cod by 45%; a relatively greater reduction was found (in catches and acoustic estimates) for large (>60 cm) than for small fish. Abundance and catch rates did not return to pre-shooting levels during the 5-day period after seismic shooting ended.

Ernenwein, R., et al. (1999). "Educating national park users on preserving natural soundscapes." The Journal of the Acoustical Society of America 106(4): 2202-2202.

The National Park Service (NPS) is the custodian of both some of the sites tied intimately to the history of powered flight and some of the quietest places in this country. Recognizing the need to both educate its personnel and the public about the sounds of nature and to properly deal with visitor opportunities like air tours that generate noise that masks the sounds of nature, the NPS has put together an educational package. This presentation will use many of those materials to show how the NPS is dealing with the protection of the sounds of nature, the natural soundscape of the parks.

Fewtrell, J. and R. McCauley (2012). "Impact of air gun noise on the behavior of marine fish and squid." Marine Pollution Bulletin 64(5): 984-993.
In this study various species of captive marine fish and one species of squid were exposed to the noise from a single air gun. Six trials were conducted off the coast of Western Australia with each trial using a different noise exposure regime. Noise levels received by the animals ranged between 120 and 184 dB re 1 µPa2.s (SEL).

Behavioral observations of the fish and squid were made before, during and after air gun noise exposure. Results indicate that as air gun noise levels increase, fish respond by moving to the bottom of the water column and swimming faster in more tightly cohesive groups. Significant increases in alarm responses were observed in fish and squid to air gun noise exceeding 147–151 dB re 1 µPa SEL. An increase in the occurrence of alarm responses was also observed as noise level increased.

Fidell, S., et al. (1996). "Effects of aircraft overflights on wilderness recreationists." The Journal of the Acoustical Society of America 100(5): 2909-2918.
On-site and telephone opinion surveys were conducted to assess outdoor recreationists' annoyance with aircraft overflights of wilderness areas. Although current technology for measuring noise exposure does not yet permit accurate and cost-effective estimates of dosage-response relationships in outdoor recreational settings, it was nonetheless possible to construct a rough relationship between estimated aircraft noise exposure and annoyance from the data of the on-site study. In the second survey, telephone interviews were administered to another sample of outdoor recreationists within 2 weeks of their return from visits to 12 wilderness areas. The prevalence of aircraft noise-induced annoyance (in any degree) among respondents in all wilderness areas ranged from 5% to 32%. The prevalence of a consequential degree of aircraft noise induced annoyance among respondents was less than 5% in all wilderness areas combined. Noise-induced annoyance proved to be a more direct measure of the effects of aircraft overflights on recreationists than more global measures such as visit satisfaction or intent to revisit.

Filiciotto, F., et al. (2013). "Effect of acoustic environment on gilthead sea bream (Sparus aurata): sea and onshore aquaculture background noise." Aquaculture 414: 36-45.
The present study evaluated the impact of sea background noise (the acoustic environment of the offshore aquaculture system) and onshore aquaculture system's ambient noise on the welfare of gilthead sea bream juveniles (Sparus aurata) through primary, secondary (biochemical and haematological indexes) and tertiary (growth performances) stress responses. The experiment lasted 120 days during which two different playlists of acoustic stimuli were projected inside six experimental tanks (each condition was replicated in three tanks). Offshore aquaculture noise conditions were recreated as the typical acoustic field in proximity of an offshore sea cage for fish farming using a random sequence of quiet sea background and boat noises. The acoustic field inside an onshore open concrete tank for fish farming represented the onshore aquaculture noise conditions. The other three tanks were used as a control condition without acoustic projection. The weights and lengths of fish exposed to offshore aquaculture noise were higher than the specimens in the control and onshore aquaculture groups. Moreover, higher levels of serum cortisol, glucose, red blood cell count, haematocrit value and haemoglobin content and lower levels of white blood cells were recorded in

fish groups from the control and onshore treatments. These results allow us to hypothesize that offshore aquaculture noise and the sea soundscape in particular positively influence growth performance and could reduce stress and improve the welfare of the sea bream.

Finneran, J. J., et al. (2000). "Auditory and behavioral responses of bottlenose dolphins (Tursiops truncatus) and a beluga whale (Delphinapterus leucas) to impulsive sounds resembling distant signatures of underwater explosions." The Journal of the Acoustical Society of America 108(1): 417-431.
A behavioral response paradigm was used to measure masked underwater hearing thresholds in two bottlenose dolphins and one beluga whale before and after exposure to impulsive underwater sounds with waveforms resembling distant signatures of underwater explosions. An array of piezoelectric transducers was used to generate impulsive sounds with waveforms approximating those predicted from 5 or 500 kg HBX-1 charges at ranges from 1.5 to 55.6 km. At the conclusion of the study, no temporary shifts in masked hearing thresholds (MTTSs), defined as a 6-dB or larger increase in threshold over pre-exposure levels, had been observed at the highest impulse level generated (500 kg at 1.7 km, peak pressure 70 kPa); however, disruptions of the animals' trained behaviors began to occur at exposures corresponding to 5 kg at 9.3 km and 5 kg at 1.5 km for the dolphins and 500 kg at 1.9 km for the beluga whale. These data are the first direct information regarding the effects of distant underwater explosion signatures on the hearing abilities of odontocetes.

Finneran, J. J., et al. (2002). "Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun." The Journal of the Acoustical Society of America 111(6): 2929-2940.
A behavioral response paradigm was used to measure masked underwater hearing thresholds in a bottlenose dolphin (Tursiops truncatus) and a white whale (Delphinapterus leucas) before and after exposure to single underwater impulsive sounds produced from a seismic watergun. Pre- and post-exposure thresholds were compared to determine if a temporary shift in masked hearing thresholds (MTTS), defined as a 6-dB or larger increase in post-exposure thresholds, occurred. Hearing thresholds were measured at 0.4, 4, and 30 kHz. MTTSs of 7 and 6 dB were observed in the white whale at 0.4 and 30 kHz, respectively, approximately 2 min following exposure to single impulses with peak pressures of 160 kPa, peak-to-peak pressures of 226 dB re 1 µPa, and total energy fluxes of 186 dB re 1 µPa2·s. Thresholds returned to within 2 dB of the pre-exposure value approximately 4 min after exposure. No MTTS was observed in the dolphin at the highest exposure conditions: 207 kPa peak pressure, 228 dB re 1 µPa peak-to-peak pressure, and 188 dB re 1 µPa2·s total energy flux.

Foch, J. D. (1992). "Bryce Canyon National Park and the Protection of Natural Quiet." Sound & Vibration 26(2): 20.
The impacts of anthropogenic sounds on the overall environment at Bryce Canyon Natl Park, UT, are described. The initial investigation at Bryce Canyon was instigated by a series of citizens' complaints regarding blasting near the location. A series of worst-case blasting tests to measure the impact of blast sounds on the environment were found to be close to the norm for coal mining operations. To effectively

predict the effects of a mine on ambient noise in the park, several additional factors had to be considered, such as meteorological and terrain effects. The results of the tests were used to formulate a policy forbidding surface mining in certain areas adjacent to the park.

Fontana, C. S., et al. (2011). "Bird diversity in a subtropical South-American City: effects of noise levels, arborisation and human population density." Urban Ecosystems 14(3): 341-360.

Cities are highly modified environments in which the only areas that resemble natural landscapes are urban parks with low human population density. Attempts are frequently made to maintain high bird diversity in cities for aesthetic or educational reasons. However, it remains unclear whether local site characteristics are important in determining bird assemblage composition or whether simplification of the assemblage is an inevitable consequence of the changes associated with human population density. From May 1998 to December 1999, we undertook bird counts at 521 points in Porto Alegre, Rio Grande do Sul, southern Brazil. Our main goal was to understand the pattern of distribution of the bird species richness and density within the city and determine which variables most affect species assemblages. We recorded 132 species belonging to 43 families that are common in Rio Grande do Sul and obtained quantitative data on 121 species in survey sites. The two most abundant species (House Sparrow, Passer domesticus and Rock dove, Columba livia) were exotics. Analysis based on a reduced subset of 134 points surveyed in spring/ early summer suggested that there was a North–south gradient in assemblage structure. Variation in assemblage structure was also affected by the number of trees, urban noise and human population density. However, human population density had a much smaller effect on richness and assemblage structure than variables subject to management, such as tree density and noise levels. These results suggest that complex communities may be maintained in densely populated urban areas of sub-tropical South-America given adequate urban planning.

Foote, A. D., et al. (2004). "Environment: whale-call response to masking boat noise." Nature 428(6986): 910-910.

Background noise can interfere with the detection and discrimination of crucial signals among members of a species. Here we investigate the vocal behavior in the presence and absence of whale-watcher boat traffic of three social groups (pods) of killer whales (Orcinus orca) living in the near shore waters of Washington state. We find longer call durations in the presence of boats for all three pods, but only in recent recordings made following a period of increasing boat traffic. This result indicates that these whales adjust their behavior to compensate for anthropogenic noise once it reaches a threshold level.

Forman, R. T. and L. E. Alexander (1998). "Roads and their major ecological effects." Annual Review of Ecology and Systematics 29(1): 207-231.

A huge road network with vehicles ramifies across the land, representing a surprising frontier of ecology. Species-rich roadsides are conduits for few species. Roadkills are a premier mortality source, yet except for local spots, rates rarely limit population size. Road avoidance, especially due to traffic noise, has a greater ecological impact. The still-more-important barrier effect subdivides populations, with demographic and probably genetic consequences. Road networks crossing landscapes cause local hydrologic and erosion effects, whereas stream networks and distant valleys receive major peak-flow and sediment impacts. Chemical effects

mainly occur near roads. Road networks interrupt horizontal ecological flows, alter landscape spatial pattern, and therefore inhibit important interior species. Thus, road density and network structure are informative landscape ecology assays. Australia has huge road-reserve networks of native vegetation, whereas the Dutch have tunnels and overpasses perforating road barriers to enhance ecological flows. Based on road-effect zones, an estimated 15–20% of the United States is ecologically impacted by roads.

Francis, C. D. and J. R. Barber (2013). "A framework for understanding noise impacts on wildlife: an urgent conservation priority." Frontiers in Ecology and the Environment 11(6): 305-313.
Anthropogenic noise is an important environmental stressor that is rapidly gaining attention among biologists, resource managers, and policy makers. Here we review a substantial literature detailing the impacts of noise on wildlife and provide a conceptual framework to guide future research. We discuss how several likely impacts of noise exposure have yet to be rigorously studied and outline how behavioral responses to noise are linked to the nature of the noise stimulus. Chronic and frequent noise interferes with animals' abilities to detect important sounds, whereas intermittent and unpredictable noise is often perceived as a threat. Importantly, these effects can lead to fitness costs, either directly or indirectly. Future research should consider the range of behavioral and physiological responses to this burgeoning pollutant and pair measured responses with metrics that appropriately characterize noise stimuli. This will provide a greater understanding of the mechanisms that govern wildlife responses to noise and help in identifying practical noise limits to inform policy and regulation.

Francis, C. D., et al. (2012). Noise Pollution Alters Ecological Services: Enhanced Pollination and Disrupted Seed Dispersal. Proc. R. Soc. B, The Royal Society.
Noise pollution is a novel, widespread environmental force that has recently been shown to alter the behavior and distribution of birds and other vertebrates, yet whether noise has cumulative, community-level consequences by changing critical ecological services is unknown. Herein, we examined the effects of noise pollution on pollination and seed dispersal and seedling establishment within a study system that isolated the effects of noise from confounding stimuli common to human-altered landscapes. Using observations, vegetation surveys and pollen transfer and seed removal experiments, we found that effects of noise pollution can reverberate through communities by disrupting or enhancing these ecological services. Specifically, noise pollution indirectly increased artificial flower pollination by hummingbirds, but altered the community of animals that prey upon and disperse Pinus edulis seeds, potentially explaining reduced P. edulis seedling recruitment in noisy areas. Despite evidence that some ecological services, such as pollination, may benefit indirectly owing to noise, declines in seedling recruitment for key-dominant species such as P. edulis may have dramatic long-term effects on ecosystem structure and diversity. Because the extent of noise pollution is growing, this study emphasizes that investigators should evaluate the ecological consequences of noise alongside other human-induced environmental changes that are reshaping human altered landscapes worldwide.

Francis, C. D., et al. (2009). "Noise pollution changes avian communities and species interactions." Current Biology 19(16): 1415-1419.

Humans have drastically changed much of the world's acoustic background with anthropogenic sounds that are markedly different in pitch and amplitude than sounds in most natural habitats 1; 2; 3 ; 4. This novel acoustic background may be detrimental for many species, particularly birds [1]. We evaluated conservation concerns that noise limits bird distributions and reduces nesting success via a natural experiment to isolate the effects of noise from confounding stimuli and to control for the effect of noise on observer detection biases [5]. We show that noise alone reduces nesting species richness and leads to different avian communities. Contrary to expectations, noise indirectly facilitates reproductive success of individuals nesting in noisy areas as a result of the disruption of predator-prey interactions. The higher reproductive success for birds within noisy habitats may be a previously unrecognized factor contributing to the success of urbanadapted species and the loss of birds less tolerant of noise. Additionally, our findings suggest that noise can have cascading consequences for communities through altered species interactions. Given that noise pollution is becoming ubiquitous throughout much of the world, knowledge of species-specific responses to noise and the cumulative effects of these novel acoustics may be crucial to understanding and managing human-altered landscapes.

Francis, C. D., et al. (2010). "Vocal frequency change reflects different responses to anthropogenic noise in two suboscine tyrant flycatchers." Proceedings of the Royal Society of London B: Biological Sciences: rspb20101847.

Anthropogenic noise is prevalent across the globe and can exclude birds from otherwise suitable habitat and negatively influence fitness; however, the mechanisms responsible for species' responses to noise are not always clear. One effect of noise is a reduction in effective acoustic communication through acoustic masking, yet some urban songbirds may compensate for masking by noise through altering their songs. Whether this vocal flexibility accounts for species persistence in noisy areas is unknown. Here, we investigated the influence of noise on habitat use and vocal frequency in two suboscine flycatchers using a natural experiment that isolated effects of noise from confounding stimuli common to urban habitats. With increased noise exposure, gray flycatcher (Empidonax wrightii) occupancy declined, but vocal frequency did not change. By contrast, ash-throated flycatcher (Myiarchus cinerascens) occupancy was uninfluenced by noise, but individuals in areas with greater noise amplitudes vocalized at a higher frequency, although the increase (≈200 kHz) may only marginally improve communication and may represent a secondary effect from increased vocal amplitude. Even so, the different flycatcher behavioral responses suggest that signal change may help some species persist in noisy areas and prompt important questions regarding which species will cope with an increasingly noisy world.

Francis, C. D., et al. (2011). "Noise pollution filters bird communities based on vocal frequency." PLoS ONE 6(11): e27052.

Human-generated noise pollution now permeates natural habitats worldwide, presenting evolutionarily novel acoustic conditions unprecedented to most landscapes. These acoustics not only harm humans, but threaten wildlife, and especially birds, via changes to species densities, foraging behavior, reproductive success, and predator-prey interactions. Explanations for negative effects of noise on birds include disruption of acoustic communication through energetic masking, potentially forcing species that rely upon

acoustic communication to abandon otherwise suitable areas. However, this hypothesis has not been adequately tested because confounding stimuli often co-vary with noise and are difficult to separate from noise exposure.

Francis, C. D., et al. (2011). "Landscape patterns of avian habitat use and nest success are affected by chronic gas well compressor noise." Landscape Ecology 26(9): 1269-1280.
Anthropogenic noise is becoming a dominant component of soundscapes across the world and these altered acoustic conditions may have severe consequences for natural communities. We modeled noise amplitudes from gas well compressors across a 16 km2 study area to estimate the influence of noise on avian habitat use and nest success. Using species with noise responses representative of other avian community members, across the study area we estimated gray flycatcher (Empidonax wrightii) and western scrub-jay (Aphelocoma californica) occupancy, and gray flycatcher nest success, which is highly dependent on predation by western scrub-jays. We also explore how alternative noise management and mitigation scenarios may reduce area impacted by noise. Compressor noise affected 84.5% of our study area and occupancy of each species was approximately 5% lower than would be expected without compressor noise. In contrast, flycatcher nest success was 7% higher, reflecting a decreased rate of predation in noisy areas. Not all alternative management and mitigation scenarios reduced the proportion of area affected by noise; however, use of sound barrier walls around compressors could reduce the area affected by noise by 70% and maintain occupancy and nest success rates at levels close to those expected in a landscape without compressor noise. These results suggest that noise from compressors could be effectively managed and, because habitat use and nest success are only two of many ecological processes that may change with noise exposure, minimizing the anthropogenic component of soundscapes should be a conservation priority.

Freimund, W. and N. Nicholas (2009). "Managing the natural soundscape: The National Park Service as a learning organization." Park Science 26(3): 68-70.

Frid, A. and L. Dill (2002). "Human-caused disturbance stimuli as a form of predation risk." Conservation Ecology 6(1).
A growing number of studies quantify the impact of nonlethal human disturbance on the behavior and reproductive success of animals. Although many are well designed and analytically sophisticated, most lack a theoretical framework for making predictions and for understanding why particular responses occur. Behavioral ecologists have recently begun to fill this theoretical vacuum by applying economic models of anti-predator behavior to disturbance studies. In this emerging paradigm, predation and nonlethal disturbance stimuli create similar trade-offs between avoiding perceived risk and other fitness-enhancing activities, such as feeding, parental care, or mating. A vast literature supports the hypothesis that anti-predator behavior has a cost to other activities, and that this trade-off is optimized when investment in anti-predator behavior tracks short-term changes in predation risk. Prey have evolved anti-predator responses to generalized threatening stimuli, such as loud noises and rapidly approaching objects. Thus, when encountering disturbance stimuli ranging from the dramatic, low-flying helicopter to the quiet wildlife photographer, animal responses are likely to follow the same economic principles used by prey encountering predators. Some authors have argued

that, similar to predation risk, disturbance stimuli can indirectly affect fitness and population dynamics via the energetic and lost opportunity costs of risk avoidance. We elaborate on this argument by discussing why, from an evolutionary perspective, disturbance stimuli should be analogous to predation risk. We then consider disturbance effects on the behavior of individuals—vigilance, fleeing, habitat selection, mating displays, and parental investment—as well as indirect effects on populations and communities. A wider application of predation risk theory to disturbance studies should increase the generality of predictions and make mitigation more effective without over-regulating human activities.

Fristrup, K., et al. (2009). "Measuring and monitoring soundscapes in the national parks." Park Science 26(3): 1-8.

The article presents an analysis of the acoustic management in natural parks which is significant in noise management. It suggests methods in measuring and monitoring soundscapes that are essential in documenting wildlife activity patterns. It features the logging software developed by the National Park Service and the Sound Pressure Level Annotation Tool (SPLAT), a visual analysis tool developed by Natural Sounds Program used for logging and calculating metrics based on the event frequency.

Fristrup, K. M. (2009). "A soundscape pons asinorum: Interim adaptation of A-weighted measurement practices to foster more accurate assessments of noise impacts in protected natural areas." Journal of the Acoustical Society of America 126(4): 2307-2307.

A-weighted measurements of environmental sound levels in functional ecosystems are often elevated by natural sources of sound energy above 1 kHz. It is aesthetically and biologically questionable to assert that a rich chorus of bird, frog, and insect sounds renders an environment less vulnerable to the effects of noise confined to lower frequencies. Accordingly, it seems worthwhile to explore alternative approaches to computing A-weighted sound levels that would reduce or eliminate this source of inflated measurements in park and wilderness settings. A systematic evaluation of acoustical measurements in units of the U.S. National Park Service reveals the extent to which A-weighted values are influenced by environmental sounds in each 1/3 octave band. This analysis can help motivate and inform the development of revised standards for A-weighted noise measurement and evaluation in protected natural areas. This seems a plausible first step toward a more biologically rigorous framework for assessing the impacts of noise to wildlife and visitors in National Parks. [ABSTRACT FROM AUTHOR]

Fuller, R. A., et al. (2007). "Daytime noise predicts nocturnal singing in urban robins." Biology Letters 3(4): 368-370.

Ambient noise interferes with the propagation of acoustic signals through the environment from sender

to receiver. Over the past few centuries, urbanization and the development of busy transport networks have led to dramatic increases in the levels of ambient noise with which animal acoustic communications must compete. Here we show that urban European robins Erithacus rubecula, highly territorial birds reliant on vocal communication, reduce acoustic interference by singing during the night in areas that are noisy during the day. The effect of ambient light pollution, to which nocturnal singing in urban birds is frequently attributed, is much weaker than that of daytime noise.

Fuzessery, Z. M., et al. (1993). "Passive sound localization of prey by the pallid bat (Antrozous p. pallidus)." Journal of Comparative Physiology A: Neuroethology, Sensory, Neural, and Behavioral Physiology 171(6): 767-777.

The pallid bat (Antrozous p. pallidus) uses passive sound localization to capture terrestrial prey. This study of captive pallid bats examined the roles of echolocation and passive sound localization in prey capture, and focused on their spectral requirements for accurate passive sound localization. Crickets were used as prey throughout these studies. All tests were conducted in dim, red light in an effort to preclude the use of vision. Hunting performance did not differ significantly in red light and total darkness, nor did it differ when visual contrast between the terrestrial prey and the substrate was varied, demonstrating that the bats did not use vision to locate prey. Our bats apparently used echolocation for general orientation, but not to locate prey. They did not increase their pulse emission rate prior to prey capture, suggesting that they were not actively scanning prey. Instead, they required prey-generated sounds for localization. The bats attended to the sound of walking crickets for localization, and also attacked small, inanimate objects dragged across the floor. Stationary and/or anesthetized crickets were ignored, as were crickets walking on substrates that greatly attenuated walking sounds. Cricket communication sounds were not used in prey localization; the bats never captured stationary, calling crickets. The accuracy of their passive sound localization was tested with an open-loop passive sound localization task that required them to land upon an anesthetized cricket tossed on the floor. The impact of a cricket produced a single 10–20 ms duration sound, yet with this information, the bats were able to land within 7.6 cm of the cricket from a maximum distance of 4.9 m. This performance suggests a sound localization accuracy of approximately ±1° in the horizontal and vertical dimensions of auditory space. The lower frequency limit for accurate sound localization was between 3–8 kHz. A physiological survey of frequency representation in the pallid bat inferior colliculus suggests that this lower frequency limit is around 5 kHz.

Goerlitz, H. and B. M. Siemers (2007). "Sensory ecology of prey rustling sounds: acoustical features and their classification by wild gray mouse lemurs." Functional Ecology 21(1): 143-153.

1. Predatory mammals and birds from several phylogenetic lineages use prey rustling sounds to detect and locate prey. However, it is not known whether these rustling sounds convey information about the prey, such as its size or profitability, and whether predators use them to classify prey accordingly.
2. We recorded rustling sounds of insects in Madagascar walking on natural substrate and show a clear correlation between insect mass and several acoustic parameters.
3. In subsequent behavioral experiments in the field, we determined whether nocturnal animals, when foraging for insects, evaluate these parameters to classify their prey. We used field-experienced Grey

Mouse Lemurs Microcebus murinus in short-term captivity. Mouse Lemurs are generally regarded as a good model for the most ancestral primate condition. They use multimodal sensorial information to find food (mainly fruit, gum, insect secretions and arthropods) in nightly forest. Acoustic cues play a role in detection of insect prey.

4. When presented with two simultaneous playbacks of rustling sounds, lemurs spontaneously chose the one higher above their hearing threshold, i.e. they used the rustling sound's amplitude for classification. We were not able, despite attempts in a reinforced paradigm, to persuade lemurs to use cues other than amplitude, e.g. frequency cues, for prey discrimination.
5. Our data suggests that Mouse Lemurs, when foraging for insects, use the mass–amplitude correlation of prey generated rustling sounds to evaluate the average mass of insects and to guide their foraging decisions.

Goerlitz, H. R., et al. (2008). "Cues for acoustic detection of prey: insect rustling sounds and the influence of walking substrate." Journal of Experimental Biology 211(17): 2799-2806.

When insects walk, they generally produce sounds. These can reveal the walkers' presence and location to potential predators such as owls, bats and nocturnal primates. Additionally, predators might extract information on taxon, palatability, size or profitability from the rustling sounds. In contrast to ear morphology, hearing physiology and psychoacoustics of acoustically oriented predators, little attention has hitherto been paid to the acoustic structure and information content of prey sounds. An important element in the ecology of acoustic prey detection remained virtually unexplored: the influence of the substrate type on rustling sounds. In this study, we analyzed amplitude and frequency parameters from insects walking on various natural substrates, in both Germany (Carabus beetles) and Madagascar (various beetles and cockroaches). The data show that rustling sound amplitude and frequency content depend on substrate type. On moist substrates arthropods produced less intense and less broadband rustling sounds than on dry substrates. Sound pressure level was reduced by about 6 dB, halving the detection range for the predator. For a given insect, rustling sound amplitude increased with walking speed. Finally, we found that the previously established correlation of arthropod size and rustling amplitude holds across multiple substrates. Based on these data, we provide for the first time estimates of realistic detection distances in the field. These distances range from below 1 m to over 13 m, depending on the substrate, insect mass, walking speed and background noise level. These estimates are crucial for an understanding of the foraging ecology, foraging efficiency and sensory ecology of acoustic predators.

Goines, L. and L. Hagler (2007). "Noise Pollution: A Modem Plague." Southern Medical Journal 100(3): 287-294.

Noise is defined as unwanted sound. Environmental noise consists of all the unwanted sounds in our communities except that which originates in the workplace. Environmental noise pollution, a form of air pollution, is a threat to health and well-being. It is more severe and widespread than ever before, and it will continue to increase in magnitude and severity because of population growth, urbanization, and the associated growth in the use of increasingly powerful, varied, and highly mobile sources of noise. It will also continue to grow because of sustained growth in highway, rail, and air traffic, which remain major sources of environmental noise. The potential health effects of noise pollution are numerous, pervasive, persistent, and

medically and socially significant. Noise produces direct and cumulative adverse effects that impair health and that degrade residential, social, working, and learning environments with corresponding real (economic) and intangible (well-being) losses. It interferes with sleep, concentration, communication, and recreation. The aim of enlightened governmental controls should be to protect citizens from the adverse effects of airborne pollution, including those produced by noise. People have the right to choose the nature of their acoustical environment; it should not be imposed by others. [ABSTRACT FROM AUTHOR]

Goldbogen, J. A., et al. (2013). "Blue whales respond to simulated mid-frequency military sonar." Proceedings: Biological Sciences 280(1765): 1-8.

Mid-frequency military (1–10 kHz) sonars have been associated with lethal mass strandings of deep-diving toothed whales, but the effects on endangered baleen whale species are virtually unknown. Here, we used controlled exposure experiments with simulated military sonar and other mid-frequency sounds to measure behavioral responses of tagged blue whales (Balaenoptera musculus) in feeding areas within the Southern California Bight. Despite using source levels orders of magnitude below some operational military systems, our results demonstrate that mid-frequency sound can significantly affect blue whale behavior, especially during deep feeding modes. When a response occurred, behavioral changes varied widely from cessation of deep feeding to increased swimming speed and directed travel away from the sound source. The variability of these behavioral responses was largely influenced by a complex interaction of behavioral state, the type of mid-frequency sound and received sound level. Sonar-induced disruption of feeding and displacement from high-quality prey patches could have significant and previously undocumented impacts on baleen whale foraging ecology, individual fitness and population health.

Goldstein, M. I., et al. (2005). "Mountain goat response to helicopter overflights in Alaska." Wildlife Society Bulletin 33(2): 688-699.

The number of helicopter flights used to gain access to backcountry has increased in recent years. Biologists, land managers, and the public have expressed concern about disturbance impacts to mountain goats (Oreamnos americanus) resulting from helicopter activity. We recorded behavioral responses of 122 groups of mountain goats from 347 helicopter overflights at 4 geographic areas in Alaska and analyzed responses in relation to distance and angle from helicopters to mountain goats, reproductive class, season, and area of study. We used multinomial logistic regression modeling combined with a bootstrap randomization procedure to identify factors associated with increased probability of mountain goats being in 1 of the 4 behavioral response categories during helicopter overflights. The probability of a goat group being disturbed was inversely related to distance of the helicopter from the group. Odds of disturbance increased by a factor of 1.25 for every 100-m reduction in approach distance. Approach distances resulting in >90% probability of maintenance were

significantly larger where mountain goats had received less prior exposure to helicopters. When mountain goats were disturbed during overflights, a second analysis (i.e., gamma regression model with inverse link function) estimated elapsed time until mountain goats returned to maintenance behavior. The length of time that a goat remained in a disturbed state following overflight did not depend upon any of the covariates; mountain goats remained in a disturbed state for an average of 30.7 seconds (95% CI, 25.7–35.9 seconds). The results offer land managers an opportunity to evaluate risk for permitting helicopter activity.

Goodwin, S. E. and W. G. Shriver (2011). "Effects of Traffic Noise on Occupancy Patterns of Forest Birds." Conservation Biology 25(2): 406-411.

Noise may drive changes in the composition and abundance of animals that communicate vocally. Traffic produces low-frequency noise (<3 kHz) that can mask acoustic signals broadcast within the same frequency range. We evaluated whether birds that sing within the frequency range of traffic noise are affected by acoustic masking (i.e., increased background noise levels at the same frequency of vocalizations reduce detection of vocalization) and are less abundant in areas where traffic noise is loud (44-57 dB). We estimated occupancy, the expected probability that a given site is occupied by a species, and detection probabilities of eight forest-breeding birds in areas with and without traffic noise as a function of noise and three measures of habitat quality: percent forest cover, distance from plot center to the edge of forest, and the number of standing dead trees or snags. For the two species that vocalize at the lowest peak frequency (the frequency with the most energy) and the lowest overall frequency (Yellow-billed Cuckoo [Coccyzus americanus] and White-breasted Nuthatch [Sitta carolinensis]), the presence of traffic noise explained the greatest proportion of variance in occupancy, and these species were 10 times less likely to be found in noisy than in quiet plots. For species that had only portions of their vocalizations overlapped by traffic noise, either forest cover or distance to forest edge explained more variation in occupancy than noise or no single variable explained occupancy. Our results suggest that the effects of traffic noise may be especially pronounced for species that vocalize at low frequencies. El ruido puede producir cambios en la composición y abundancia de animales que se comunican vocalmente. El tráfico produce ruido de baja frecuencia (<3 kHz) que puede enmascarar la transmisión de señales acústicas en el mismo rango de frecuencia. Evaluamos sí las aves que cantan en el rango de frecuencia del ruido de tráfico son afectadas por el enmascaramiento acústico (i.e., el incremento en los niveles de ruido de fondo con la misma frecuencia de las vocalizaciones reduce la detección de vocalización) y son menos abundantes en áreas donde el ruido de tráfico es alto (44-57 dB). Estimamos la ocupación, la probabilidad esperada de que un sitio determinado sea ocupado por una especie, y las probabilidades de detección de 8 especies de aves de bosque en áreas con y sin ruido de tráfico como una función del ruido y 3 medidas de calidad de hábitat: porcentaje de cobertura forestal, distancia del centro de la parcela al borde del bosque y el número de árboles muertos en pie. Para las especies que vocalizan en el pico menor de frecuencia (la frecuencia con mayor energía) y en la menor frecuencia total (Coccyzus americanus y Sitta carolinensis), la presencia de ruido de tráfico explicó la mayor proporción de varianza en la ocupación, y fue 10 veces menos probable encontrar estas especies en parcelas ruidosas que en parcelas silenciosas. Para especies cuyas vocalizaciones se traslaparon parcialmente con el ruido de tráfico, la variación en la ocupación fue explicada más

por la cobertura vegetal o la distancia al borde del bosque que por el ruido o ninguna variable individual explicó la ocupación. Nuestros resultados sugieren que los efectos del ruido de tráfico pueden ser especialmente pronunciados para especies que vocalizan en frecuencias bajas.

Goudie, R. I. (2006). "Multivariate behavioral response of harlequin ducks to aircraft disturbance in Labrador." Environmental Conservation 33(01): 28-35.

The effects of low-level aircraft over-flights on behavior of harlequin ducks (Histrionicus histrionicus) breeding in central Labrador were quantified during 2000–2002. The Canadian Department of National Defense supports a low-level training program in the 130 000 km2 Military Training Area of Labrador involving military jets. The Institute for Environmental Monitoring and Research (IEMR) undertakes scientific research into environmental impacts of low-level military jet over-flights. A suite of 17 behavioral categories of paired male and female harlequin ducks was modeled, and a canonical variable representing alert behavior, inactivity on the water and decreased inactivity out of water in response to over-flights represented 73.1% of the variance in the data cluster and provided marked separation of disturbed and undisturbed groups. Behavioral responses of harlequin ducks to military jets were 23 times stronger than their responses to float planes, helicopters and military cargo planes, and the significant interaction of aircraft type and noise indicated that noise may be the primary stressor affecting behavior. A quadratic response of the canonical variable to noise generated from aircraft during standardized 30-minute observation periods was defined. The multivariate analyses were more robust because they indicated covariance in behavioral categories associated with disturbance that was not originally detected in univariate analyses, suggesting the importance of integrating behaviors other than overt responses. The significant effects of military jet over-flights on harlequin duck behavior emphasize the need to evaluate potential population consequences of aircraft disturbance.

Grafe, T. U., et al. (2002). "Frogs flee from the sound of fire." Proceedings of the Royal Society of London B: Biological Sciences 269(1495): 999-1003.

Fire has an important role in the sensory ecology of many animals. Using acoustic cues to detect approaching fires may give slow-moving animals a head start when fleeing from fires. We report that aestivating juvenile reed frogs (Hyperolius nitidulus) respond to playbacks of the sound of fire by fleeing in the direction of protective cover, where they are safe. This is a novel response to fire not known to occur in other animals. Moreover, we identify the rapid rise-time of the crackling sound of fire as the probable cue used. These results suggest that amphibian hearing not only has evolved through sexual selection, but also must be viewed in a broader context.

Grubb, T. G., et al. (2013). "Response of Nesting Northern Goshawks to Logging Truck Noise in Northern Arizona." The Journal of Wildlife Management 77(8): 1618-1625.

We recorded 94 sound-response events at 3 adult-occupied northern goshawk (Accipiter gentilis) nests 78 m, 143 m, and 167 m from the nearest United States Forest Service maintenance level 3, improved gravel road on the Kaibab Plateau in northern Arizona. During 4 test sessions on 7, 8, 10, and 11 June 2010, we recorded 60 experimentally controlled logging trucks; 30 non-experimental, civilian, fixed-winged aircraft;

3 non-experimental, passing cars; and 1 all-terrain vehicle (ATV). Logging truck sound, principally engine and exhaust, was concentrated in the 63 Hz and 80 Hz, 1/3-octave frequency bands. Aircraft sound was concentrated in the 100 Hz and 125 Hz, 1/3-octave frequency bands. Logging truck noise levels varied among nest sites and with distance from roads. At 167 m from the closest road, the logging truck averaged approximately 8 decibels (dB, all decibel levels C-weighted, adjusted, 1 s, equivalent sound level, CLEQ) quieter than aircraft. At 143 m, the logging truck was approximately 3 dB quieter than passing aircraft. Only at 78 m was logging truck noise louder on average than aircraft, by approximately 6 dB. Average aircraft noise levels for each day of testing ranged between 45.6 dB and 67.9 dB and when averaged across the entire study period, varied little among the 3 test sites, 60.1–65.6 dB. On average, our test logging truck (61.9 dB) was no louder than passing aircraft (62.3 dB), which goshawks generally ignored. The logging truck resulted in 27% no response and 73% alert (head turning) response, passing aircraft resulted in 90% no response and only 10% alert response, and the cars and ATV combined resulted in 50% each for no response and alert response. Goshawk alert response rates were inversely proportional to nest distance from the nearest road, decreasing from 91% to 57% alert between 78 m and 167 m. No movements or flushes were associated with either our experimental testing or passive recording of other vehicular noise stimuli. All tested pairs of goshawks successfully fledged young. Because logging truck noise had no effect on northern goshawks nesting along level 3, improved gravel roads on the Kaibab Plateau, restriction of log hauling and other road-based travel activities on similar roads within post-fledging family areas (PFAs) appears unnecessary based on the type and extent of our testing.

Gutschalk, A., et al. (2008). "Neural correlates of auditory perceptual awareness under informational masking." PLoS Biol 6(6): e138.

Our ability to detect target sounds in complex acoustic backgrounds is often limited not by the ear's resolution, but by the brain's information-processing capacity. The neural mechanisms and loci of this "informational masking" are unknown. We combined magnetoencephalography with simultaneous behavioral measures in humans to investigate neural correlates of informational masking and auditory perceptual awareness in the auditory cortex. Cortical responses were sorted according to whether or not target sounds were detected by the listener in a complex, randomly varying multi-tone background known to produce informational masking. Detected target sounds elicited a prominent, long-latency response (50–250 ms), whereas undetected targets did not. In contrast, both detected and undetected targets produced equally robust auditory middle-latency, steady-state responses, presumably from the primary auditory cortex. These findings indicate that neural correlates of auditory awareness in informational masking emerge between early and late stages of processing within the auditory cortex.

Habib, L., et al. (2007). "Chronic industrial noise affects pairing success and age structure of ovenbirds Seiurus aurocapilla." Journal of Applied Ecology 44(1): 176-184.

1. Anthropogenic noise is rapidly increasing in wilderness areas as a result of industrial expansion. While many road studies have attempted to assess the effects of industrial noise on birds, conflicting factors such as edge effects often inhibit the ability to draw strong conclusions.
2. We assessed pairing success and age distribution of male ovenbirds Seiurus aurocapilla in the boreal

forest of Alberta, Canada, in areas around noise-generating compressor stations compared with areas around habitat-disturbed, but noiseless, wellpads. This allowed us to control for edge effects, human visitation and other factors that are not controlled for in studies of noise generated by roads. Generalized estimating equations (GEE) were used to assess the impacts of noise on ovenbird pairing success, age structure and body morphology.

3. We found a significant reduction in ovenbird pairing success at compressor sites (77%) compared with noiseless wellpads (92%). These differences were apparent regardless of territory quality or individual male quality. Significantly more inexperienced birds breeding for the first time were found near noise-generating compressor stations than noiseless wellpads (48% vs. 30%).
4. While there are multiple proximate explanations for these results, the ultimate cause of the changes seems to be noise pollution. We hypothesize that noise interferes with a male's song, such that females may not hear the male's song at greater distances and/or females may perceive males to be of lower quality because of distortion of song characteristics.
5. Synthesis and applications. This work demonstrates that chronic background noise could be an important factor affecting bird populations. It can impact upon pairing success and age structure of passerines; in boreal Alberta this could pose a problem for certain species as energy development expands rapidly.

Hage, S. R., et al. (2013). "Ambient noise induces independent shifts in call frequency and amplitude within the Lombard effect in echolocating bats." Proceedings of the National Academy of Sciences of the United States of America 110(10): 4063-4068.

The Lombard effect an involuntary rise in call amplitude in response to masking ambient noise, represents one of the most efficient mechanisms to optimize signal-to-noise ratio. The Lombard effect occurs in birds and mammals, including humans, and is often associated with several other vocal changes, such as call frequency and duration. Most studies, however, have focused on noise dependent changes in call amplitude. It is therefore still largely unknown how the adaptive changes in call amplitude relate to associated vocal changes such as frequency shifts, how the underlying mechanisms are linked, and if auditory feedback from the changing vocal output is needed. Here, we examined the Lombard effect and the associated changes in call frequency in a highly vocal mammal, echolocating horseshoe bats. We analyzed how bandpass filtered noise (BFN; bandwidth 20 kHz) affected their echolocation behavior when BFN was centered on different frequencies within their hearing range. Call amplitudes increased only when BFN was centered on the dominant frequency component of the bats' calls. In contrast, call frequencies increased for all but one BFN center frequency tested. Both amplitude and frequency rises were extremely fast and occurred in the first call uttered after noise onset, suggesting that no auditory feedback was required. The different effects that varying the BFN center frequency had on amplitude and frequency rises indicate different neural circuits and/or mechanisms underlying these changes.

Halfwerk, W., et al. (2011). "Low-frequency songs lose their potency in noisy urban conditions." Proceedings of the National Academy of Sciences 108(35): 14549-14554.

Many animal species communicate with their mates through acoustic signals, but this communication seems to become a struggle in urbanized areas because of increasing anthropogenic noise levels. Several bird

species have been reported to increase song frequency by which they reduce the masking impact of spectrally overlapping noise. However, it remains unclear whether such behavioral flexibility provides a sufficient solution to noisy urban conditions or whether there are hidden costs. Species may rely on low frequencies to attract and impress females, and the use of high frequencies may, therefore, come at the cost of reduced attractiveness. We studied the potential trade off between signal strength and signal detection in a successful urban bird species, the great tit (Parus major). We show that the use of low-frequency songs by males is related to female fertility as well as sexual fidelity. We experimentally show that urban noise conditions impair male–female communication and that signal efficiency depends on song frequency in the presence of noise. Our data reveal a response advantage for high-frequency songs during sexual signaling in noisy conditions, whereas low-frequency songs are likely to be preferred. These data are critical for our understanding of the impact of anthropogenic noise on wild-ranging birds, because they provide evidence for low-frequency songs being linked to reproductive success and to be affected by noise-dependent signal efficiency.

Halfwerk, W., et al. (2011). "Negative impact of traffic noise on avian reproductive success." Journal of Applied Ecology 48(1): 210-219.

1. Traffic affects large areas of natural habitat worldwide. As a result, the acoustic signals used by birds and other animals are increasingly masked by traffic noise. Masking of signals important to territory defense and mate attraction may have a negative impact on reproductive success. Depending on the overlap in space, time and frequency between noise and vocalizations, such impact may ultimately exclude species from suitable breeding habitat. However a direct impact of traffic noise on reproductive success has not previously been reported.
2. We monitored traffic noise and avian vocal activity during the breeding season alongside a busy Dutch motorway. We measured variation in space, time and spectrum of noise and tested for negative effects on avian reproductive success using long-term breeding data on great tits Parus major.
3. Noise levels decreased with distance from the motorway, but we also found substantial spatial variation independent of distance. Noise also varied temporally with March being noisier than April, and the daytime being noisier than night-time. Furthermore, weekdays were clearly noisier than weekends. Importantly, traffic noise overlapped in time as well as acoustic frequency with avian vocalization behavior over a large area.
4. Traffic noise had a negative effect on reproductive success with females laying smaller clutches in noisier areas. Variation in traffic noise in the frequency band that overlaps most with the lower frequency part of great tit song best explained the observed variation.
5. Additionally, noise levels recorded in April had a negative effect on the number of fledglings, independent of clutch size, and explained the observed variation better than noise levels recorded in March.
6. Synthesis and applications. We found that breeding under noisy conditions can carry a cost, even for species common in urban areas. Such costs should be taken into account when protecting threatened species, and we argue that knowledge of the spatial, temporal and spectral overlap between noise and species-specific acoustic behavior will be important for effective noise management. We provide some cost-effective mitigation measures such as traffic speed reduction or closing of roads during the breeding season.

Hamr, J. and E. Bailey (1985). "Detection and discrimination of insect flight sounds by big brown bats (Eptesicus fuscus)." Biology of Behavior 10(2): 105-121.

Hatch, L. T. and K. M. Fristrup (2009). "No barrier at the boundaries: implementing regional frameworks for noise management in protected natural areas." Marine Ecology Progress Series 395: 223-244.

The article presents a study on the condition of the ecosystem framework to manage underwater and airborne noise sources in parks and sanctuaries in the U.S. The study reviewed the policy regarding regional noise management and the results gathered from two case studies on noise management at spatially expressed contents such as the Grand Canyon National Park and the Gerry E. Studds Stellwagen Bank National Marine Sanctuary were analyzed. The study suggests that the noise obtained through transportation networks should be handled in order to conserve the local resources for both case studies. It also discusses the four approaches to manage noise in the protected areas based on the study.

Hayward, L. S., et al. (2011). "Impacts of acute and long-term vehicle exposure on physiology and reproductive success of the northern spotted owl." Ecosphere 2(6): 1-20.

Stress physiologists posit that multiple simultaneous demands faced by an organism may have non-additive effects on the magnitude of their response to disturbance. The environmental assessment literature emphasizes a similar phenomenon at the population level, arguing that populations can compensate for perturbations up to a threshold, beyond which disturbance impacts may be greatly magnified—and even cause system collapse. We integrated these two approaches to examine the roles of environment, life history stage, prior disturbance experience, and their interactions on vulnerability to disturbance in a free living species. Specifically, we examined the effects of off-highway vehicle use on the federally threatened northern spotted owl (NSO), Strix occidentalis caurina, by measuring fecal glucocorticoid metabolites (fGCs), which reflect disturbance; fecal thyroid hormone metabolites (fT3), which reflect nutrition; and the number of offspring fledged within a season. We experimentally applied one hour of motorcycle exposure to NSOs during periods of incubation (May) and fledging (July), comparing fGC levels of treated NSO with those of non-exposed controls. Acute vehicle exposure generally increased fGCs in the short term. Males showed the highest glucocorticoid response to vehicle disturbance in May when they were typically solely responsible for feeding themselves, their mates and their nestlings. By contrast, response to motorcycle exposure among females depended on their level of fT3 and their number of young. Levels of fGCs were highest post treatment among females that lacked young and had high fT3 (good nutrition); fGC levels were lower in treated females compared to controls among females with two young and low fT3 (compromised nutrition), possibly reflecting allostatic overload. The correlational approach showed that NSO close to roads had higher levels of fT3, suggesting better nutrition. Surprisingly, fGC levels were unrelated to proximity of roads, irrespective of noise. Presumably, the tendency for traffic exposure to increase fGCs over the longterm was offset by nutritional gains (i.e., reduced fGCs and high fT3) associated with proximity to roads. Sound level meters enabled us to quantify road noise on a subset of NSO territories. NSO close to noisy roads fledged significantly fewer young than NSO near quiet roads, indicating that routine traffic exposure may decrease NSO reproductive success over time.

Hinam, H. L. and C. C. S. Clair (2008). "High levels of habitat loss and fragmentation limit reproductive success by reducing home range size and provisioning rates of Northern saw-whet owls." Biological Conservation 141(2): 524-535.

Studies of the effects of habitat fragmentation have been heavily biased toward population and community questions, with less attention on the effects of habitat loss and fragmentation on individual behavior and reproduction. We studied the effects of habitat amount and configuration on the foraging behavior, provisioning rates and physiological condition of breeding male northern saw-whet owls (Aegolius acadicus) nesting in the fragmented aspen parkland of central Alberta, Canada. We then examined the relationship between provisioning behavior and both reproductive success, and juvenile physiological condition. Males nesting in areas with little forest cover and large inter-patch distances spent more time perching, maintained smaller home ranges, and provisioned their nests less frequently. However, home range size and provisioning rates leveled off in landscapes with moderate to high forest cover. Male owls breeding in areas with low forest cover, and those raising large broods, also exhibited higher levels of chronic stress, as measured by heterophil/lymphocyte (H/L) ratios. Predictably, males that provisioned the nest less often fledged fewer young, which, in turn, exhibited higher variation in physiological condition. These results suggest that low levels of habitat loss and fragmentation may be beneficial to saw-whet owls, potentially by increasing prey abundance. However, high levels of habitat loss and fragmentation appeared to reduce the foraging efficiency of male saw-whet owls, increase their levels of physiological stress, and reduce their reproductive success. Increasing habitat loss and fragmentation may ultimately decrease population sizes of saw whet owls in this area and other species that are similarly affected by changes to in habitat composition or configuration.

Hingson, D. J. (2009). Grand Canyon vs. The Soundscape from Nowhere. 38th International Congress and Exposition on Noise Control Engineering 2009, INTER-NOISE 2009, August 23, 2009 - August 26, 2009, Ottawa, ON, Canada, Noise Control Foundation.

Twenty two years have elapsed since the U.S. National Parks Overflights Act mandated the prompt, "substantial restoration" of the natural quiet of the aircraft-noise imperiled soundscape of the Grand Canyon National Park. Long-anticipated deadlines for compliance expired in 2008, without satisfactorily implemented final plan or new date certain. Previous Administrations have not conformed to specifications/standards or planning deadlines required by Congress, immediate past Administrations, or by the Park Service under its legal mandates. However, every battle has its turning point. Will 2009 be the turning point to a quiet Canyon? Success will require immediate NPS application of long-established restoration standards (based on "audibility"), Park zoning, and buttressed with emerging supplemental noise indicators addressing loudness and/or persistent impulsiveness. Effectiveness of imminently anticipated management actions in the form of a 2009 Environmental Impact Statement and stepped up political oversight will be examined. These could restore a more truly authentic Grand Canyon wilderness natural quiet, compared with the current, unsavory "Soundscape of Nowhere. " The protracted planning imbroglio here illuminates similarly unmet, pressing restoration concerns at other U.S. national parks, and need for increased executive/ congressional oversight.

Hu, Y. and G. C. Cardoso (2010). "Which birds adjust the frequency of vocalizations in urban noise?" Animal Behavior 79(4): 863-867.

Urban environments present an opportunity to study the evolution of animal communication in acoustically novel habitats. Several species of birds raise the minimum frequency of vocalizations in urban noise, which is louder at lower frequencies. We recorded 12 species of birds in urban and non-urban environments, and tested whether the extent to which different species raise their minimum frequency is related to the frequency range they use. We found that raising the minimum frequency is common in urban birds and is not restricted to passerine song, but also occurs in other vocalizations of passerines and parrots. There was a strong curvilinear relation between the extent to which urban birds raise the minimum frequency and the typical minimum frequency of the species: species with intermediate minimum frequencies (around 1–1.5 kHz) raised the frequency more than species with either higher or lower minimum frequency. This suggests that high-frequency species, which are less affected by urban noise, do not need to adjust the frequency of vocalizations as much. It also suggests that for species with very low frequencies, in a frequency range where urban noise augments exponentially, increasing frequency may not overcome masking by noise efficiently, and these species may use different adaptations. This indicates that frequency differences between species influence the way in which they respond to the same communication problem (masking by low-frequency noise), and possibly also the subsequent evolution of acoustic signals.

Hunt, M. (1999). "Management of the environmental noise effects associated with sightseeing aircraft in the Milford Sound area, New Zealand." Noise Control Engineering Journal 47(4): 133-141.

Visitors to National Parks in New Zealand have strong expectations about their rights to enjoy recreational opportunities in natural areas free from perceived adverse effects of aircraft overflying and aircraft related sound. These factors influence their responses to surveys of annoyance and level of satisfaction with the outdoor experience. This paper considers the methods available for managing conflicts between users of the natural environment and the air-tourism industry. The two issues described in the paper are: 1) controlling total noise emitted from an aerodrome in Fiordland National Park, based on the method recommended by NZ Standard (NZS6805: 1992), and 2) a model for investigating aircraft overflying noise impacts over the main walking tracks in the hilly terrain of the Milford Track located in Fiordland National Park.

Iglesias, C., et al. (2012). "The Influence of Traffic Noise on Vertebrate Road Crossing Through Underpasses." Ambio 41(2): 193-201.

Noise produces multiple effects on ecosystems and it influences habitat use by vertebrates near roads. Thus, it may reduce the effectiveness of mitigation measures installed on roads to alleviate population fragmentation. This study analyses the effects of noise on the use by vertebrates of 19 underpasses at a motorway. It employs generalized linear models to test the effect of three noise indicators at the underpasses and in their vicinity on the crossing frequency of eight animal species. The results show that the road crossings are subjected to high and variable noise levels. Nevertheless, there is no consistent response to noise by vertebrates. This suggests that wildlife use of underpasses is determined more by habitat characteristics than by the levels of noise tolerated. The conclusion is that noise abatement measures on roads in areas of faunal sensitivity should focus on general noise reduction rather than on making individual crossing places quieter.

Iglesias Merchan, C. and L. Diaz-Balteiro (2013). "Noise pollution mapping approach and accuracy on landscape scales." Science of the Total Environment 449: 115-125.

Noise mapping allows the characterization of environmental variables, such as noise pollution or soundscape, depending on the task. Strategic noise mapping (as per Directive 2002/49/EC, 2002) is a tool intended for the assessment of noise pollution at the European level every five years. These maps are based on common methods and procedures intended for human exposure assessment in the European Union that could be also be adapted for assessing environmental noise pollution in natural parks. However, given the size of such areas, there could be an alternative approach to soundscape characterization rather than using human noise exposure procedures. It is possible to optimize the size of the mapping grid used for such work by taking into account the attributes of the area to be studied and the desired outcome. This would then optimize the mapping time and the cost. This type of optimization is important in noise assessment as well as in the study of other environmental variables. This study compares 15 models, using different grid sizes, to assess the accuracy of the noise mapping of the road traffic noise at a landscape scale, with respect to noise and landscape indicators. In a study area located in the Manzanares High River Basin Regional Park in Spain, different accuracy levels (Kappa index values from 0.725 to 0.987) were obtained depending on the terrain and noise source properties. The time taken for the calculations and the noise mapping accuracy results reveal the potential for setting the map resolution in line with decision makers' criteria and budget considerations.

Iglesias Merchan, C., et al. (2014). "Noise pollution in national parks: Soundscape and economic valuation." Landscape & Urban Planning 123: 1-9.

Highlights: [•] Soundscape-assessment methods and economic valuation were merged in a national park. [•] Outdoor anthropogenic noises degrade the park soundscapes. [•] Visitors refer to annoyance by human made noises. [•] Visitors are willing to pay for the noise reduction. [ABSTRACT FROM AUTHOR]

Jung, C. A. and S. E. Swearer (2011). "Reactions of temperate reef fish larvae to boat sound." Aquatic Conservation: Marine and Freshwater Ecosystems 21(4): 389-396.

Anthropogenic sound as a stressor in aquatic systems is of increasing concern. The present study evaluated whether boat sound either deters larval fish or interferes with their ability to use biological sounds for navigating.

Pre-metamorphic larval fishes were caught in a pair of light traps deployed off a shallow rocky reef in Port Phillip Bay, Australia, with one trap randomly assigned one of two boat sound treatments, at sound pressure levels experienced in situ, and the other without any sound treatment. The boat sound treatment included either (1) boat engine sound without any other sound, or (2) boat engine sound with biological and physical sound from a pier, a positive but weak cue indicative of much of the available benthic habitat in the vicinity.

Total larval abundance and species composition of the assemblage were compared between the sound-exposed trap and the control trap. When only boat sound was broadcast, no significant differences between sound exposed and control traps was observed. When boat sound was broadcast together with pier sound, significantly more fishes were caught in the sound-exposed trap (~300% of 'control' traps). The results of this study suggest that a) common boat sound is not readily avoided by larval fishes, and that b) larval fishes are attracted to biological sound in spite of the presence of boat sound. Together the results suggest that boat sound at levels experienced in situ might not have deleterious effects on recruitment of larval fishes, i.e. the capacity to alter recruitment patterns.

Kaiser, K., et al. (2011). "When sounds collide: the effect of anthropogenic noise on a breeding assemblage of frogs in Belize, Central America." Behavior 148(2): 215-232.

Many organisms depend on acoustic communication for myriad functions, and have evolved behaviors to minimize effects of naturally occurring acoustic interference. However, as habitats are subject to increased alteration, anthropogenic noise becomes unavoidable, and how animals overcome such interference is not well understood. In most ecosystems, only a subset of frog species is associated with disturbed habitats; the ability of these species to overcome exogenous noise suggests that habitat associations may be related to species' response to noise. We tested the hypothesis that frogs associated with largely undisturbed forest habitat would be less likely to increase call output in response to exogenous noise than would those associated with disturbed or open habitat. While this relationship was not significant, we found a slight trend supporting the hypothesis. We then asked whether anthropogenic noise affects chorus tenure at individual or at chorus-levels. Male frogs exposed to anthropogenic noise decreased both the number of days present at the chorus and the nightly chorus duration relative to controls. Because females generally join choruses late at night to breed, the effects of noise shown here are likely to substantially decrease frog reproductive success; thus, the acoustic environment may play an important role in shaping population dynamics and in amphibian declines.

Kane, A., et al. (2010). "Exposure of fish to high-intensity sonar does not induce acute pathology." Journal of Fish Biology 76(7): 1825-1840.

This study investigated immediate effects of intense sound exposure associated with low-frequency (170–320 Hz) or with mid-frequency (2·8–3·8 kHz) sonars on caged rainbow trout Oncorhynchus mykiss, channel catfish Ictalurus punctatus and hybrid sunfish Lepomis sp. in Seneca Lake, New York, U.S.A. This study focused on potential effects on inner ear tissues using scanning electron microscopy and on non-auditory tissues using gross and histopathology. Fishes were exposed to low-frequency sounds for 324 or 628 s with a received peak signal level of 193 dB re 1 μPa (root mean square, rms) or to mid-frequency sounds for 15 s with a received peak signal level of 210 dB re 1 μPa (rms). Although a variety of clinical observations from various tissues and organ systems were described, no exposure-related pathologies were observed. This study represents the first investigation of the effects of high-intensity sonar on fish tissues in vivo. Data from this study indicate that exposure to low and mid-frequency sonars, as described in this report, might not have acute effects on fish tissues.

Kaplan, M. B. and T. A. Mooney (2015). "Ambient noise and temporal patterns of boat activity in the US Virgin Islands National Park." Marine Pollution Bulletin 98(1/2): 221-228.
Human activity is contributing increasing noise to marine ecosystems. Recent studies have examined the effects of boat noise on marine fishes, but there is limited understanding of the prevalence of this type of sound source. This investigation tracks vessel noise on three reefs in the US Virgin Islands National Park over four months in 2013. Ambient noise levels ranged from 106 to 129 dB rms re 1 μPa (100 Hz–20 kHz). Boat noise occurred in 6–12% of samples. In the presence of boat noise, ambient noise in a low-frequency band (100–1000 Hz) increased by >7 dB above baseline levels and sound levels were significantly higher. The frequency with the most acoustic energy shifted to a significantly lower frequency when boat noise was present during the day. These results indicate the abundance of boat noise and its overlap with reef organism sound production, raising concern for the communication abilities of these animals. [ABSTRACT FROM AUTHOR]

Kariel, H. G. (1990). "Factors affecting response to noise in outdoor recreational environments." Canadian Geographer / Le Géographe Canadien 34(2): 142-149.
As the world gets more and more crowded, silence becomes a rarer and rarer natural resource. (Rennicke 1987, 27)

Karp, D. S. and R. Guevara (2011). "Conversational Noise Reduction as a Win-Win for Ecotourists and Rain Forest Birds in Peru." Biotropica 43(1): 122-130.
For all its positive attributes, the recent expansion of ecotourism has resulted in greater influxes of people into natural areas, causing a range of impacts including behavioral disruptions among wildlife. How animals respond to conversation is poorly understood, but noise reduction may reduce the impact of ecotourists while simultaneously enhancing their experience with higher wildlife encounter rates. We tested the response of a rain forest bird community to noise by playing a recorded conversation while conducting point censuses in a terra firme forest in Tambopata, Peru. Fifty decibel conversation (approximately library speaking volume) caused declines of 35 percent in total detections and 33 percent in detected species richness. Birds reacted similarly to 60 dB (approximately the volume of an excited child): average detections declined by 39 percent and detected species richness by 37 percent. Specifically, noise-induced detection declines were manifest both in decreased vocalizations (37% decline) and decreased physical sightings (44% decline). Lowered detection frequencies indicate behavioral shifts. As vocalization is involved in territory defense, breeding behavior, and predator detection, strong noise responsiveness indicates potential harm for birds. Insectivores were the most affected bird guild, raising conservation concerns, as insectivorous birds are sensitive to habitat modification. Birds reacted strongly to noise both near an established

ecotourist lodge and in an intact reserve, indicating an absence of habituation. Thus, as a method for reducing ecotourism's footprint on native fauna and improving tourist satisfaction with increased wildlife sightings, noise reduction seems promising, even for well-established ecotourist lodges.

Kaseloo, P. A. (2005). "Synthesis of noise effects on wildlife populations." Road Ecology Center.
This report contains a partial summary of a literature review dealing with the effect of noise on wildlife emphasizing the effects on birds. Beginning with studies in the Netherlands and, later, in the United States, a series of studies have indicated that road noise has a negative effect on bird populations (particularly during breeding) in a variety of species. These effects can be significant with 'effect distances' (i.e., those within which the density of birds is reduced) of two to three thousand meters from the road. In these reports, the effect distances increase with the density of traffic on the road being greatest near large, multi-lane highways with high densities. A similar effect has been reported for both grassland and woodland species. It is important to note that 1) not all species have shown this effect and 2) some species show the opposite response,increasing in numbers near roads or utilizing rights-of-way. It is important to determine the cause of this effect and to utilize additional or alternative methods beyond population densities as the sole measure of effect distance, because the latter is susceptible to variation due to changes in overall population density. Recommendations for further study are given, including alternative measures of disturbance in birds

Kastak, D., et al. (1999). "Underwater temporary threshold shift induced by octave-band noise in three species of pinniped." The Journal of the Acoustical Society of America 106(2): 1142-1148.
Pure-tone sound detection thresholds were obtained in water for one harbor seal (Phoca vitulina), two California sea lions (Zalophus californianus), and one northern elephant seal (Mirounga angustirostris) before and immediately following exposure to octave-band noise. Additional thresholds were obtained following a 24-h recovery period. Test frequencies ranged from 100 Hz to 2000 Hz and octave-band exposure levels were approximately 60–75 dB SL (sensation level at center frequency). Each subject was trained to dive into a noise field and remain stationed underwater during a noise-exposure period that lasted a total of 20–22 min. Following exposure, three of the subjects showed threshold shifts averaging 4.8 dB (Phoca), 4.9 dB (Zalophus), and 4.6 dB (Mirounga). Recovery to baseline threshold levels was observed in test sessions conducted within 24 h of noise exposure. Control sessions in which the subjects completed a simulated noise exposure produced shifts that were significantly smaller than those observed following noise exposure. These results indicate that noise of moderate intensity and duration is sufficient to induce TTS under water in these pinniped species.

Kastelein, R., et al. (2001). "The influence of three acoustic alarms on the behavior of harbour porpoises (Phocoena phocoena) in a floating pen." Marine Environmental Research 52(4): 351-371.
Harbour porpoise by-catch may be reduced by deterring porpoises from nets acoustically. In this study, two harbour porpoises were subjected to three acoustic alarms. The effect of each alarm was judged by comparing the animals' position and respiration rate during a test period with that during a baseline period. The XP-10 alarm produced 0.3 s tonal signals randomly selected from a set of 16 with fundamental frequencies between 9 and 15 kHz, with a constant pulse interval of 4.8 s (duty cycle 6%). The 2MP alarm

produced 0.3 s tonal signals randomly selected from a set of 16 with similar fundamental frequencies but with random pulse intervals of between 2 and 5 s (duty cycle 8%). The frequency spectra and source levels of the 2MP and XP-10 alarms varied depending on the signal selected. The HS20-80 alarm produced a constant, but asymmetrical frequency modulated sine wave between 20 and 80 kHz with total pulse duration of 0.3 s, with random pulse intervals of between 2 and 5 s (duty cycle 4.6%). The porpoises reacted to all three alarms by swimming away from them and by increasing their respiration rate. The XP-10, which on average had the highest source level, had the strongest effect.

Kastelein, R., et al. (2005). "The influence of acoustic emissions for underwater data transmission on the behavior of harbour porpoises (Phocoena phocoena) in a floating pen." Marine Environmental Research 59(4): 287-307.

To prevent grounding of ships and collisions between ships in shallow coastal waters, an underwater data collection and communication network is currently under development: Acoustic Communication network for Monitoring of underwater Environment in coastal areas (ACME). Marine mammals might be affected by ACME sounds since they use sounds of similar frequencies (around 12 kHz) for communication, orientation, and prey location. If marine mammals tend to avoid the vicinity of the transmitters, they may be kept away from ecologically important areas by ACME sounds. One marine mammal species that may be affected in the North Sea is the harbour porpoise. Therefore, as part of an environmental impact assessment program, two captive harbour porpoises were subjected to four sounds, three of which may be used in the underwater acoustic data communication network. The effect of each sound was judged by comparing the animals' positions and respiration rates during a test period with those during a baseline period. Each of the four sounds could be made a deterrent by increasing the amplitude of the sound. The porpoises reacted by swimming away from the sounds and by slightly, but significantly, increasing their respiration rate. From the sound pressure level distribution in the pen, and the distribution of the animals during test sessions, discomfort sound level thresholds were determined for each sound. In combination with information on sound propagation in the areas where the communication system may be deployed, the extent of the `discomfort zone' can be estimated for several source levels (SLs). The discomfort zone is defined as the area around a sound source that harbour porpoises are expected to avoid. Based on these results, SLs can be selected that have an acceptable effect on harbour porpoises in particular areas. The discomfort zone of a communication sound depends on the selected sound, the selected SL, and the propagation characteristics of the area in which the sound system is operational. In shallow, winding coastal water courses, with sandbanks, etc., the type of habitat in which the ACME sounds will be produced, propagation loss cannot be accurately estimated by using a simple propagation model, but should be measured on site. The SL of the communication system should be adapted to each area (taking into account bounding conditions created by narrow channels, sound propagation variability due to environmental factors, and the importance of an area to the affected species). The discomfort zone should not prevent harbour porpoises from spending sufficient time in ecologically important areas (for instance feeding areas), or routes towards these areas.

Kastelein, R. A., et al. (2011). "Hearing thresholds of a harbor porpoise (Phocoena phocoena) for

helicopter dipping sonar signals (1.43–1.33 kHz)(L)." The Journal of the Acoustical Society of America 130(2): 679-682.

Helicopter long range active sonar (HELRAS), a "dipping" sonar system used by lowering transducer and receiver arrays into water from helicopters, produces signals within the functional hearing range of many marine animals, including the harbor porpoise. The distance at which the signals can be heard is unknown, and depends, among other factors, on the hearing sensitivity of the species to these particular signals. Therefore, the hearing thresholds of a harbor porpoise for HELRAS signals were quantified by means of a psychophysical technique. Detection thresholds were obtained for five 1.25 s simulated HELRAS signals, varying in their harmonic content and amplitude envelopes. The 50% hearing thresholds for the different signals were similar: 76 dB re 1 µPa (broadband sound pressure level, averaged over the signal duration). The detection thresholds were similar to those found in the same porpoise for tonal signals in the 1–2 kHz range measured in a previous study. Harmonic distortion, which occurred in three of the five signals, had little influence on their audibility. The results of this study, combined with information on the source level of the signal, the propagation conditions and ambient noise levels, allow the calculation of accurate estimates of the distances at which porpoises can detect HELRAS signals.

Kastelein, R. A., et al. (2007). "Effects of acoustic alarms, designed to reduce small cetacean by-catch in gillnet fisheries, on the behavior of North Sea fish species in a large tank." Marine Environmental Research 64(2): 160-180.

World-wide many cetaceans drown incidentally in fishing nets. To reduce the unwanted by-catch in gill nets, pingers (acoustic alarms) have been developed that are attached to the nets. In the European Union, pingers will be made compulsory in some areas in 2005 and in others in 2007. However, pingers may effect non-target marine fauna such as fish. Therefore in this study, the effects of seven commercially-available pingers on the behavior of five North Sea fish species in a large tank were quantified. The species tested were: sea bass (Dicentrarchus labrax), pout (Trisopterus luscus), thicklip mullet (Chelon labrosus), herring (Clupea harengus), and cod (Gadus morhua). The fish were housed as single-species schools of 9–13 individuals in a tank. The behavior of fish in quiet periods was compared with their behavior during periods with active pingers. The results varied both between pingers and between fish species. Sea bass decreased their speed in response to one pinger and swam closer to the surface in response to another. Thick lip mullet swam closer to the bottom in response to two pingers and increased their swimming speed in response to one pinger. Herring swam faster in response to one pinger, and pout and cod (close relatives) showed no behavioral responses to any of the pingers. Of the seven pingers tested, four elicited responses in at least one fish species, and three elicited no responses. Whether similar responses would be elicited in these fish species in the wild, and if so, whether such responses would influence the catch rate of fisheries, cannot be derived from the results of this study. However, the results indicate the need for field studies with pingers and fish. Based on the small number of fish species tested, the present study suggests that the higher the frequency of a pinger, the less likely it is to affect the behavior of marine fish.

Kastelein, R. A., et al. (2008). "Startle response of captive North Sea fish species to underwater tones between 0.1 and 64kHz." Marine Environmental Research 65(5): 369-377.

World-wide, underwater background noise levels are increasing due to anthropogenic activities. Little is known about the effects of anthropogenic noise on marine fish, and information is needed to predict any negative effects. Behavioral startle response thresholds were determined for eight marine fish species, held in a large tank, to tones of 0.1–64 kHz. Response threshold levels varied per frequency within and between species. For sea bass, the 50% reaction threshold occurred for signals of 0.1–0.7 kHz, for thick lip mullet 0.4–0.7 kHz, for pout 0.1–0.25 kHz, for horse mackerel 0.1–2 kHz and for Atlantic herring 4 kHz. For cod, pollack and eel, no 50% reaction thresholds were reached. Reaction threshold levels increased from ~100 dB (re 1 µPa, rms) at 0.1 kHz to ~160 dB at 0.7 kHz. The 50% reaction thresholds did not run parallel to the hearing curves. This shows that fish species react very differently to sound, and that generalizations about the effects of sound on fish should be made with care. As well as on the spectrum and level of anthropogenic sounds, the reactions of fish probably depend on the context (e.g. location, temperature, physiological state, age, body size, and school size).

Kastelein, R. A., et al. (2006). "The influence of underwater data transmission sounds on the displacement behavior of captive harbour seals (Phoca vitulina)." Marine Environmental Research 61(1): 19-39.

To prevent grounding of ships and collisions between ships in shallow coastal waters, an underwater data collection and communication network (ACME) using underwater sounds to encode and transmit data is currently under development. Marine mammals might be affected by ACME sounds since they may use sound of a similar frequency (around 12 kHz) for communication, orientation, and prey location. If marine mammals tend to avoid the vicinity of the acoustic transmitters, they may be kept away from ecologically important areas by ACME sounds. One marine mammal species that may be affected in the North Sea is the harbour seal (Phoca vitulina). No information is available on the effects of ACME-like sounds on harbour seals, so this study was carried out as part of an environmental impact assessment program. Nine captive harbour seals were subjected to four sound types, three of which may be used in the underwater acoustic data communication network. The effect of each sound was judged by comparing the animals' location in a pool during test periods to that during baseline periods, during which no sound was produced. Each of the four sounds could be made into a deterrent by increasing its amplitude. The seals reacted by swimming away from the sound source. The sound pressure level (SPL) at the acoustic discomfort threshold was established for each of the four sounds. The acoustic discomfort threshold is defined as the boundary between the areas that the animals generally occupied during the transmission of the sounds and the areas that they generally did not enter during transmission. The SPLs at the acoustic discomfort thresholds were similar for each of the sounds (107 dB re 1 µPa). Based on this discomfort threshold SPL, discomfort zones at sea for several source levels (130–180 dB re 1 µPa) of the sounds were calculated, using a guideline sound propagation model for shallow water. The discomfort zone is defined as the area around a sound source that harbour seals are expected to avoid. The definition of the discomfort zone is based on behavioral discomfort, and does not necessarily coincide with the physical discomfort zone. Based on these results, source levels can be selected that have an acceptable effect on harbour seals in particular areas. The discomfort zone of a communication sound depends on the sound, the source level, and the propagation characteristics of the area in which the sound system is operational. The source level of the

communication system should be adapted to each area (taking into account the width of a sea arm, the local sound propagation, and the importance of an area to the affected species). The discomfort zone should not coincide with ecologically important areas (for instance resting, breeding, suckling, and feeding areas), or routes between these areas.

Kerth, G. and M. Melber (2009). "Species-specific barrier effects of a motorway on the habitat use of two threatened forest-living bat species." Biological Conservation 142(2): 270-279.
It is generally recognized that roads can adversely affect local animal populations but little is known how roads affect bats. In particular, no study compared the response of bats that differ in foraging ecology to motorways that cut through the breeding habitat. As bats are key species in conservation, such data are urgently needed for designing management plans. Using radio-telemetry, mist netting, and mark-recapture data we investigated the effects of a motorway with heavy traffic on the habitat use of two threatened forest living bats. We compared barbastelle bats (Barbastella barbastellus), which forage in open space, to Bechstein's bats (Myotis bechsteinii), which glean prey from the vegetation. Five of six radio-tracked barbastelle bats crossed the motorway during foraging and roost switching, flying through underpasses and directly over the motorway. In contrast, only three of 34 radio-tracked Bechstein's bats crossed the motorway during foraging, all three using an underpass. Bechstein's bats, unlike barbastelle bats, never crossed the motorway during roost switching. Moreover, only in Bechstein's bats individuals foraging close to the motorway had smaller foraging areas than individuals foraging further away, whereas other forest edges had no such effect. Our data show that motorways can restrict habitat accessibility for bats but the effect seems to depend on the species' foraging ecology and wing morphology. We suggest that motorways have stronger barrier effects on bats that forage close to surfaces than on bats that forage in open space, and discuss the implications of our findings for bat conservation during road construction.

Kight, C. R., et al. (2012). "Anthropogenic noise is associated with reductions in the productivity of breeding Eastern Bluebirds (Sialia sialis)." Ecological Applications 22(7): 1989-1996.
Although previous studies have related variations in environmental noise levels with alterations in communication behaviors of birds, little work has investigated the potential long-term implications of living or breeding in noisy habitats. However, noise has the potential to reduce fitness, both directly (because it is a physiological Stressor) and indirectly (by masking important vocalizations and/or leading to behavioral changes). Here, we quantified acoustic conditions in active breeding territories of male Eastern Bluebirds (Sialia sialis). Simultaneously, we measured four fitness indicators: cuckoldry rates, brood growth rate and condition, and number of fledglings produced (i.e., productivity). Increases in environmental noise tended to be associated with smaller brood sizes and were more strongly related to reductions in productivity. Although the mechanism responsible for these patterns is not yet clear, the breeding depression experienced by this otherwise disturbance-tolerant species indicates that anthropogenic noise may have damaging effects on individual fitness and, by extraction, the persistence of populations in noisy habitats. We suggest that managers might protect avian residents from potentially harmful noise by keeping acoustically dominant anthropogenic habitat features as far as possible from favored songbird breeding habitats, limiting noisy human activities, and/or altering habitat structure in order to minimize the propagation of noise pollution.

Kight, C. R. and J. P. Swaddle (2011). "How and why environmental noise impacts animals: an integrative, mechanistic review." Ecology Letters 14(10): 1052-1061.

The scope and magnitude of anthropogenic noise pollution are often much greater than those of natural noise and are predicted to have an array of deleterious effects on wildlife. Recent work on this topic has focused mainly on behavioral responses of animals exposed to noise. Here, by outlining the effects of acoustic stimuli on animal physiology, development, neural function and genetic effects, we advocate the use of a more mechanistic approach in anthropogenic environments. Specifically, we summarize evidence and hypotheses from research on laboratory, domestic and free-living animals exposed to biotic and abiotic stimuli, studied both observationally and experimentally. We hope that this molecular- and cellular-focused literature, which examines the effects of noise on the neuroendocrine system, reproduction and development, metabolism, cardiovascular health, cognition and sleep, audition, the immune system, and DNA integrity and gene expression, will help researchers better understand results of previous work, as well as identify new avenues of future research in anthropogenic environments. Furthermore, given the interconnectedness of these physiological, cellular and genetic processes, and their effects on behavior and fitness, we suggest that much can be learned from a more integrative framework of how and why animals are affected by environmental noise.

Klinck, H., et al. (2012). "Seasonal presence of cetaceans and ambient noise levels in polar waters of the North Atlantic." The Journal of the Acoustical Society of America 132(3): EL176-EL181.

In 2009 two calibrated acoustic recorders were deployed in polar waters of the North Atlantic to study the seasonal occurrence of blue, fin, and sperm whales and to assess current ambient noise levels. Sounds from these cetaceans were recorded at both locations in most months of the year. During the summer months, seismic airguns associated with oil and gas exploration were audible for weeks at a time and dominated low frequency noise levels. Noise levels might further increase in the future as the receding sea ice enables extended human use of the area.

Knudsen, E. I. and M. Konishi (1979). "Mechanisms of sound localization in the barn owl (Tyto alba)." Journal of Comparative Physiology 133(1): 13-21.

1. We investigated the mechanisms by which the barn owl (Tyto alba) determines the azimuth and elevation of a sound source. Our measure of localizing ability was the accuracy with which the owl oriented its head to a sound source.
2. When localizing tonal signals, the owl committed the smallest errors at frequencies between 4 and 8 kHz. The azimuthal component of these errors was frequency independent from 1 to 8 kHz, but the elevational component increased dramatically for frequencies below 4 kHz.
3. The owl's mean error when localizing wide band noise was nearly three times less than its mean error when localizing the optimal frequency for tonal localization (6 kHz).
4. Occluding the right ear caused the owl to orient below and to the left of the sound source; occluding the left ear caused it to orient above and to the right of the sound source.
5. With ruff feathers (facial ruff) removed, the owl continued to localize sounds accurately in azimuth, but failed to localize sounds in elevation.

6. We conclude from these results that the barn owl uses interaural comparisons of sound spectrum to determine the elevation of a sound source. Both interaural onset time and interaural spectrum are used to identify the azimuth of the sound source. If onset time is not available (as in a continuous sound), the owl can derive the azimuth of the source from interaural spectrum alone, but its spatial resolution is poorer.

Koschinski, S., et al. (2003). "Behavioral reactions of free-ranging porpoises and seals to the noise of a simulated 2 MW windpower generator." Marine Ecology Progress Series 265: 263-273.
Operational underwater noise emitted at 8 m s-1 by a 550 kW Wind World wind-turbine was recorded from the sea and modified to simulate a 2 MW wind-turbine. The sound was replayed from an audio CD through a car CD-player and a J-13 transducer. The maximum sound energy was emitted between 30 and 800 Hz with peak source levels of 128 dB (re 1 µPa2 Hz-1 at 1 m) at 80 and 160 Hz (1/3-octave center frequencies). This simulated 2 MW wind-turbine noise was played back on calm days (<1 Beaufort) to free-ranging harbour porpoises Phocoena phocoena and harbour seals Phoca vitulina in Fortune Channel, Vancouver Island, Canada. Swimming tracks of porpoises and surfacing of seals were recorded with an electronic theodolite situated on a clifftop 14 m above sea level. Echolocation activity of harbour porpoises close to the sound source was recorded simultaneously via an electronic click detector placed below the transducer. In total we tracked 375 porpoise groups and 157 seals during play-back experiments, and 380 porpoise groups and 141 surfacing seals during controls. Both species showed a distinct reaction to wind-turbine noise. Surfacing in harbour seals were recorded at larger distances from the sound source (median = 284 vs 239 m during controls; p = 0.008, Kolmogorov-Smirnov test) and closest approaches increased from a median of 120 to 182 m (p < 0.001) in harbour porpoises. Furthermore, the number of time intervals during which porpoise echolocation clicks were detected increased by a factor of 2 when the sound source was active (19.6% of all 1 min intervals as opposed to 8.4% of all intervals during controls; p < 0.001).These results show that harbour porpoises and harbour seals are able to detect the low-frequency sound generated by offshore wind-turbines. Controlled exposure experiments such as the one described here are a first step to assess the impact on marine mammals of the new offshore wind-turbine industry.

Krause, B., et al. (2011). "Measuring and interpreting the temporal variability in the soundscape at four places in Sequoia National Park [electronic resource]." Landscape Ecology 26(9): 1247-1256.
The soundscape was recorded in four selected places in Sequoia National Park CA, to quantify and assess the diurnal and seasonal character of the park's soundscape. The recording sites were selected to represent a combination of elevation and vegetation diversity. Hour-long sound recordings were made by four individuals at each place during fall, spring, summer and winter at dawn, midday, dusk, and midnight with identical recording instrumentation. The recordings of the soundscape were made in an old growth forest (Crescent Meadow), in a foothill oak savanna (Sycamore Spring), in an upland savanna chaparral (Shepherd Saddle) and in a foothill riparian location adjacent to the Kiawah River (Buckeye Flat). Sound recordings were analyzed using a normalized Power Spectral Density (PSD) algorithm and partitioned into 1℗ kHz intervals based on 12 subsamples from each of the 64℗ h-long sound recordings. Biological signals (biophony) were based on the highest PSD value within the range of 2–8℗ kHz. A multilevel analysis (MLA) was used to examine temporal patterns of biophony at four locations in Sequoia National Park. Unsupervised Landsat Thematic Mapper

Satellite Imagery identified 25 vegetation regimes in Sequoia National Park. Satellite signatures of the habitat where recordings were made were extracted from the imagery to scale to the region.

Krausman, P. R., et al. (2004). "Effects of military operations on behavior and hearing of endangered Sonoran pronghorn." Wildlife Monographs 157(1): 1-41.

Our objectives in this study were to determine whether military activities (e.g., overflight noise, noise from ordnance delivery, ground-based human activity) on the Barry M. Goldwater Range (BMGR) affect the behavior and hearing of Sonoran pronghorn (Antilocapra americana sonoriensis). We contrasted the behavior of pronghorn on BMGR with the closest population of pronghorn in the United States that was not subjected to routine military activity (i.e., on the Buenos Aires National Wildlife Refuge [BANWR], Arizona). Forty percent of the landscape used by the endangered Sonoran pronghorn in the United States is within the 5,739 km2 BMGR, a bombing and gunnery facility in southwestern Arizona. The range of Sonoran pronghorn covers about 88% of BMGR. The 179 Sonoran pronghorn that lived in the United States in December 1992 declined to 99 by December 2000. The Sonoran pronghorn has been listed as endangered for >30 years, but population limiting factors are unknown. Because Sonoran pronghorn use BMGR, land and wildlife managers raised concerns about the potential effects of military activities on the population. Possible indirect effects of military activities on Sonoran pronghorn, aside from direct mortality or injury, from ordnance delivery, chaff, flares, live ammunition, aircraft mishaps, interference from ground vehicles and personnel, include alteration of behavior or physiology. We conducted the study on the North and South Tactical Ranges (NTAC and STAC), BMGR, from February 1998 to June 2000. Hearing exams were conducted in Camp Verde, Arizona, the University of Arizona, and on the East Tactical Range (ETAC), BMGR. Interactions between pronghorn and military activity were restricted to 4 observation points that provided viewing areas from which pronghorn and military activity could be observed from ≤ 10 km. We systematically located pronghorn with spotting scopes and telemetry. When located, we described their behavior and military activity using scan sampling. We tested hearing using auditory brainstem responses (ABR). We could not test the hearing of Sonoran pronghorn because of their endangered status, so we contrasted hearing of pronghorn near Camp Verde, Arizona, and desert mule deer (Odocoileus hemionus eremicus) that were and were not exposed to sound pressure levels from military activity. We recorded behavior observations of Sonoran pronghorn on 172 days (44,375 observation events [i.e., 1 observation/30 second]) over 373 hours. These data were compared with 93 days of behavioral data (24,297 observation events) over 202 hours for pronghorn not regularly influenced by military aircraft. Overall, we did not detect behavioral differences (i.e., time spent bedding, standing, foraging, traveling) between males and females. Pronghorn exposed to military activity, and those that were not, bedded the same amount of time. Pronghorn at BMGR foraged less and stood and traveled more than pronghorn not exposed to military activity. These trends were the same with and without anthropogenic activity. Only 7.3% of behavioral events occurred with identifiable stimuli. Military overflights occurred 363 times (0.8%) and non-military overflights occurred 77 times (<0.2%). Pronghorn rarely responded to military aircraft, but often moved >10 m when ground stimuli were present.

Ambient noise levels ranged up to 123.1 decibels (dB). The average sound pressure level on days with military activity was 65.3 dB compared to 35.0 dB without military activity. Because we obtained hearing

tests from deer and pronghorn, we were able to develop an ungulate weighting filter on the noise generated from overflights of A-10 and F-16 aircraft. Desert ungulates do not hear sound pressure levels generated from these aircraft as well as humans do (i.e., 14–19 dB lower).The military activity we examined had only marginal influence on Sonoran pronghorn. Pronghorn used the ranges shared with the military throughout the year and behavioral patterns of pronghorn were similar with and without the presence of military stimuli. Furthermore, pronghorn behavior exposed to military activity was similar to behaviors of pronghorn not exposed to regular military activity. The auditory characteristics of pronghorn were similar for those that have and have not been exposed to military activity. The population of Sonoran pronghorn in the United States continues to decline and is in serious danger of extirpation. Clearly, additional work needs to be done, but military activity as measured herein is not a limiting factor.

Krausman, P. R., et al. (1998). "Effects of Jet Aircraft on Mountain Sheep." The Journal of Wildlife Management 62(4): 1246-1254.

Military-designated air spaces have been established above national parks and monuments, wildlife refuges, wilderness areas, and Department of Defense lands. Each of these landscapes is managed differently, which has led to questions of compatibility between military aircraft and wildlife. We determined the influence of F-16 aircraft overflights on mountain sheep (Ovis canadensis nelsoni) from January 1990 to May 1992 in the Desert National Wildlife Refuge, Nevada. We constructed a 320-ha enclosure and calibrated the area for sound pressure levels (i.e., noise) created by F-16 aircraft flying along the ridgeline of the mountains in the enclosure, approximately 125 m above ground level. In May 1990, we placed 12 mountain sheep from the surrounding area in the enclosure and monitored their behavior and use of habitats for 1 year to ensure they were familiar with the area before they were subjected to aircraft overflights. The habitat use and activity of the sheep in the enclosure were similar to free-ranging conspecifics. In May 1991, we instrumented 5 mountain sheep with heart-rate monitors and added them to the enclosure. During May 1991 to May 1992, F-16 aircraft flew over the enclosure 149 times during 3 1-month periods. We recorded heart rate and behavior of sheep 15 min pre-overflight, during the overflight, and post-overflight. Heart rate increased above preflight levels in 21 of 149 overflights but returned to preflight levels within 120 sec. When F-16 aircraft flew over the enclosure, the noise levels created did not alter behavior or use of habitat, or increase heart rates to the detriment of the sheep in the enclosure.

Krog, N. H. and B. Engdahl (2005). "Annoyance with aircraft noise in local recreational areas and the recreationists' noise situation at home." Journal of the Acoustical Society of America 117(1): 221-231.

Few socioacoustic studies have examined the effect of noise on outdoor recreationists. Most studies concentrate on one setting of the everyday life of a noise-exposed population, which mainly has been the residential setting. This article relates annoyance with aircraft noise in outdoor recreational areas to the recreationists' noise situation at home. In conjunction with the relocation of the main airport of Norway in 1998, field studies were conducted before and after the change in one area near the old airport (1930 survey respondents), and one area near the new airport (1001 survey respondents). Multivariate linear regression analyses of the relationship between annoyance and aircraft noise exposure (LAeq for the aircraft events) in the recreational areas were conducted, controlled for noise annoyance at home, or aircraft noise exposure

at home, the situation (before/after the change), context- and demographic variables. People more highly annoyed at home tended to be more annoyed than others while in the recreational areas. A significant effect of aircraft noise exposure at home on annoyance in the recreational setting was not found. More research is warranted regarding the relationship between noise exposure at home and outdoor recreational demands. © 2005 Acoustical Society of America. [ABSTRACT FROM AUTHOR]

Kuehne, L. M., et al. (2013). "The Soundscapes of Lakes across an Urbanization Gradient." PLoS ONE 8(2): 1-10.

Background/Methodology: A significant implication of increasing urbanization is anthropogenic noise pollution. Although noise is strongly associated with disruption of animal communication systems and negative health effects for humans, the study of these consequences at ecologically relevant spatial and temporal scales (termed soundscape ecology) is in early stages of application. In this study, we examined the above- and below-water soundscape of recreational and residential lakes in the region surrounding a large metropolitan area. Using univariate and multivariate approaches we test the importance of large- and local-scale landscape factors in driving acoustic characteristics across an urbanization gradient, and visualize changes in the soundscape over space and time. Principal Findings: Anthropogenic noise (anthrophony) was strongly predicted by a landcover-based metric of urbanization (within a 10 km radius), with presence of a public park as a secondary influence; this urbanization signal was apparent even in below-water recordings. The percent of hourly measurements exceeding noise thresholds associated with outdoor disturbance was 67%, 17%, and 0%, respectively, for lakes characterized as High, Medium, and Low urbanization. Decreased biophony (proportion of natural sounds) was associated with presence of a public park followed by increased urbanization; time of day was also a significant predictor of biophony. Local-scale (shoreline) residential development was not related to changes in anthrophony or biophony. The patterns we identify are illustrated with a multivariate approach which allows use of entire sound samples and facilitates interpretation of changes in a soundscape. Conclusions/Significance: As highly valued residential and recreation areas, lakes represent everyday soundscapes important to both humans and wildlife. Our findings that many of these areas, particularly those with public parks, routinely experience sound types and levels associated with disturbance, suggests that urban planners need to account for the effect of increasing development on soundscapes to avoid compromising goals for ecological and human health. [ABSTRACT FROM AUTHOR]

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Kuningas, S., et al. (2013). "Killer whale presence in relation to naval sonar activity and prey abundance in northern Norway." ICES Journal of Marine Science: Journal du Conseil 70(7): 1287-1293.
In this study, retrospective data on naval sonar activity and prey abundance were correlated with killer whale sightings within a fjord basin in northern Norway. In addition, passive acoustic and visual marine mammal surveys were conducted before, during, and after a specific navy exercise in 2006. Herring abundance was the main factor affecting killer whale presence. Naval sonar, either operational navy sonar exercises (Flotex) or experimental sonar activity (CEE) alone, did not explain killer whale occurrence. However, naval sonar activity during a period of low prey availability seemed to have had a negative effect on killer whale presence. We conclude that the level of reaction to sonar can be influenced by multiple factors, including availability of prey.

Kvadsheim, P. H., et al. (2010). "Behavioral and physiological responses of hooded seals (Cystophora cristata) to 1 to 7 kHz sonar signals." Aquatic Mammals 36(3): 239.
Controlled exposure experiments on captive hooded seals (Cystophora cristata) were made to examine behavioral and physiological effects of sonar signals. The animals were instrumented with data loggers recording heart rate, dive depth, and swimming activity, and then released into a 1,200 m^sup 3^ net-cage in the ocean. The exposure consisted of three different 1-s sonar signals covering the 1 to 7 kHz band transmitted either by using 10-s inter-ping intervals and gradually increasing source level from 134 to 194 dBRMS (re 1 µPa @1 m) within 6 min, or using the maximum source level of 194 dBRMS from the first ping but gradually decreasing the inter-ping intervals from 100 s to 10 s within 10 min (duty cycle increasing from 1 to 10%). Transmission loss from the source to the animal varied from 10 to 27 dB, depending on the exact location within the net-cage and the transmitted frequency. The animals responded to the initial (10% duty cycle) exposure with avoidance to signals above 160 to 170 dBRMS (re 1 µPa) received levels. This involved reduced diving activity, commencement of rapid exploratory swimming at surface, and eventually displacement to areas of least sound pressure level. However, already upon the second exposure, the initial rapid swimming activity was absent, while the reduction in diving activity became even more pronounced. No differences were found in behavioral response to different transmitted frequencies. Increased heart rate at the surface indicates emotional activation during sonar exposure, but lack of effect of sonar exposure on heart rate during diving indicates that physiological responses to diving remain intact.

L Quinn, J., et al. (2006). "Noise, predation risk compensation and vigilance in the chaffinch Fringilla coelebs." Journal of Avian Biology 37(6): 601-608.
Background noise should in theory hinder detection of auditory cues associated with approaching danger. We tested whether foraging chaffinches Fringilla coelebs responded to background noise by increasing vigilance, and examined whether this was explained by predation risk compensation or by a novel stimulus hypothesis. The former predicts that only inter-scan interval should be modified in the presence of background noise, not vigilance levels generally. This is because noise hampers auditory cue detection and increases perceived predation risk primarily when in the head-down position, and also because

previous tests have shown that only interscan interval is correlated with predator detection ability in this system. Chaffinches only modified interscan interval supporting this hypothesis. At the same time they made significantly fewer pecks when feeding during the background noise treatment and so the increased vigilance led to a reduction in intake rate, suggesting that compensating for the increased predation risk could indirectly lead to a fitness cost. Finally, the novel stimulus hypothesis predicts that chaffinches should habituate to the noise, which did not occur within a trial or over 5 subsequent trials. We conclude that auditory cues may be an important component of the trade-off between vigilance and feeding, and discuss possible implications for anti-predation theory and ecological processes.

La Manna, G., et al. (2013). "Behavioral strategy of common bottlenose dolphins (Tursiops truncatus) in response to different kinds of boats in the waters of Lampedusa Island (Italy)." Aquatic Conservation: Marine and Freshwater Ecosystems 23(5): 745-757.

Owing to the increase of boat-traffic in the ocean many studies have been conducted to determine the response of bottlenose dolphin (Tursiops truncatus) to this kind of disturbance. This species is affected by boats in various ways and the response depends on the behavioral state of the dolphin but also on the kind of vessel. This study aimed to determine the effect of motorboats and trawlers on dolphins' presence, permanence in the area and whistle parameters in Lampedusa waters (Italy). Sampling was carried out between May and December 2006 and between July and September 2009, using experimental passive acoustic monitoring systems (PAM); a total of 300 h of recordings and 3000 whistles were analyzed. The dolphins' behavioral strategies depend on the kind of boats: in the case of motorboats, dolphins preferred to leave the area as the disturbance became too heavy to be tolerated; in the case of trawlers, dolphins changed their acoustic behavior to compensate for the masking noise. The study highlighted the efficacy of PAM to detect the behavioral response of dolphins, suggesting a novel approach to assessing anthropogenic influences on marine mammal vocalizations in the absence of visual observations.

Ladich, F. and T. Schulz-Mirbach (2013). "Hearing in cichlid fishes under noise conditions." PLoS ONE 8(2): e57588.

Hearing thresholds of fishes are typically acquired under laboratory conditions. This does not reflect the situation in natural habitats, where ambient noise may mask their hearing sensitivities. In the current study we investigate hearing in terms of sound pressure (SPL) and particle acceleration levels (PAL) of two cichlid species within the naturally occurring range of noise levels. This enabled us to determine whether species with and without hearing specializations are differently affected by noise.

Lampe, U., et al. (2012). "Staying tuned: grasshoppers from noisy roadside habitats produce courtship signals with elevated frequency components." Functional Ecology 26(6): 1348-1354.

Anthropogenic noise is known to affect acoustic signal production in birds, frogs and mammals. These animals use different mechanisms to adjust their signals to elevated background noise levels (increase in signal amplitude, shift to higher frequencies, etc.). Previous studies have concentrated on behaviorally plastic changes in signal production as a result of elevated background noise levels. To our knowledge, long-term effects of anthropogenic noise on signal production have not yet been investigated. Moreover,

strategies of invertebrate species to ensure acoustic signal transmission under anthropogenic noise have not been examined, so far. We tested whether and how male Chorthippus biguttulus grasshoppers from noisy roadside habitats may adjust acoustic courtship signals to elevated background noise levels, compared with conspecifics from quiet control habitats. In this species, sexually selected male courtship signals serve to attract potential mating partners, which make the undisturbed transmission of signals in habitats with increased background noise levels crucial for male reproductive success. Compared to males from control populations, males from roadside habitats produced songs with a significantly higher local frequency maximum under standardized, quiet recording conditions. This local frequency maximum (in the range of c. 6–9 kHz) overlaps with low-frequent road noise that has the potential to degrade or mask this part of the signals' frequency spectrum. To our knowledge, this is the first evidence that insects from noisy habitats produce different acoustic signals than conspecifics from quiet habitats, possibly using a more permanent mechanism for signal adjustment than behavioral plasticity, which was found in different bird species adjusting to high background noise levels. Such an effect of anthropogenic noise has not been shown for any invertebrate species before, and our results suggest that similar strategies to avoid degradation or masking by noise (i.e. increase in carrier frequency) are used over a wide range of taxa, including both, vertebrates and invertebrates.

Laurance, W. F., et al. (2008). "Impacts of roads, hunting, and habitat alteration on nocturnal mammals in African rainforests." Conservation Biology 22(3): 721-732.

Nocturnal mammals are poorly studied in Central Africa, a region experiencing dramatic increases in logging, roads, and hunting activity. In the rainforests of southern Gabon, we used spotlighting surveys to estimate abundances of nocturnal mammal species and guilds at varying distances from forest roads and between hunted and unhunted treatments (comparing a 130-km2 oil concession that was nearly free of hunting, with nearby areas outside the concession that had moderate hunting pressure). At each of 12 study sites that were evenly divided between hunted and unhunted areas, we established standardized 1-km transects along road verges and at 50, 300, and 600 m from the road. We then repeatedly surveyed mammals at each site during 2006. Hunting had few apparent effects on this assemblage. Nevertheless, the species richness and often the abundance of nocturnal primates, smaller ungulates, and carnivores were significantly depressed within approximately 30 m of roads. Scansorial rodents increased in abundance in hunted forests, possibly in response to habitat changes caused by logging or nearby swidden farming. In multiple-regression models many species and guilds were significantly influenced by forest-canopy and understory cover, both of which are altered by logging and by certain abiotic variables. In general, nocturnal species, many of which are arboreal or relatively small in size (<10 kg), were less strongly influenced by hunting and more strongly affected by human-induced changes in forest structure than were larger mammal species in our study area.

Lavendel, B. (2002). "Preserving the Peace and Quiet." National Parks 76(5/6): 34.

Focuses on the preservation of the sound of nature. Impact of man-made sound in parks on visitors and wildlife; Correlation between the deterioration of natural soundscape and the decline of the ecosystem.

Leader, N., et al. (2005). "Acoustic properties of two urban song dialects in the orange-tufted sunbird (Nectarinia osea)." The Auk 122(1): 231-245.

Biologically important acoustic signals must be transmitted from a signaler to a receiver. Over distance, however, sounds may undergo modification through attenuation, degradation, and masking. Recent anthropogenic habitat modification occurring in many places—in urban habitats, in particular—has rapidly changed local topography and atmospheric conditions and generated new patterns of noise that are likely to interfere with communicative signals. As part of a study of microgeographic song dialects in an urban population of Orange-tufted Sunbirds (Nectarinia osea) in Israel, we examined the environmental influences on song transmission and reception in a rapidly developing human-altered environment. We examined the physical properties of the two dialect song types, which exhibit a large difference of 2–3 kHz in the maximum frequency of the trill, using sound transmission measurements to test how both song types propagate through a highly obstructed habitat of buildings and vegetation. Additionally, we examined how ambient noise—in particular, low-frequency noise arising mainly from automobile traffic— affects the transmission of both dialect songs. Finally, using song playback, we investigated the consequences of sound degradation on dialect recognition and discrimination by sunbirds. The dialect containing higher frequencies in the trill was found to undergo severe frequency-dependent attenuation, in which the maximum frequency of the trill notes drops by >2 kHz over a distance of 70–100 m (less than two territories away). Also, the possibility that the use of higher frequencies in that dialect group's song is intended to overcome masking by urban ambient noise, which is concentrated mainly in lower frequencies, was not supported by our findings. Males singing the high dialect responded differently to playbacks of an intact and an attenuated form of their dialect song. Taken together, our results suggest that the dialect containing higher frequencies in the trill may be unsuitable for effective long-range transmission through this particular sunbird habitat.

Leighton, T. G. (2012). "How can humans, in air, hear sound generated underwater (and can goldfish hear their owners talking)?" The Journal of the Acoustical Society of America 131(3): 2539-2542.

The air/water interface at the top of a body of water is often treated from below as a pressure release boundary, which it closely matches. The small discrepancy in that match, however, is enough to enable humans in air to hear sounds generated underwater, which would not be possible across a pressure release boundary. A discussion of this phenomenon, designed for teaching purposes and using no more acoustics than would be contained in a first-year undergraduate syllabus in acoustics, leads to a discussion of whether goldfish can hear their owners speaking. The analysis is then used to illustrate the care needed when comparing sound levels in air and water, a process which continues to lead to erroneous statements in the media and some academic articles.

Lengagne, T. (2008). "Traffic noise affects communication behavior in a breeding anuran, Hyla arborea." Biological Conservation 141(8): 2023-2031.

Modern human societies generate new patterns of noise that may affect acoustic communication in many animal species. Whilst animals have evolved several mechanisms to cope with natural background noise, the rapid increase of anthropogenic alteration of acoustic environment could challenge the potential for adjustments of communicative systems. Because acoustic communication is involved in crucial behaviors,

noise pollution can be particularly detrimental in affecting breeding success or survival. I investigated the impact of traffic noise on acoustic communication in a tree frog by way of an experimental approach using noise playback. Traffic noise triggered a decrease of the males' calling activity, with males being more affected when noise amplitude increased. Additionally, the males' social situation (calling in chorus versus alone) exerted a strong influence on sensitiveness to noise. Males were only weakly affected by noise pollution when calling in a chorus situation, probably because they were more stimulated and because traffic noise emergence was lower. Moreover results showed that in response to noise playback, males are not able to adjust their temporal or frequency call structures to increase efficiency of the information transfer. Understanding species' ability to adapt their communicative systems to cope with human-made noise constitutes an important contribution to wildlife conservation.

Leonard, M. L. and A. G. Horn (2008). "Does ambient noise affect growth and begging call structure in nestling birds?" Behavioral Ecology 19(3): 502-507.

Much of the research examining the effects of ambient noise on communication has focused on adult birds using acoustic signals in mate attraction and territory defense. Here, we examine the effects of noise exposure on young birds, which use acoustic signals to solicit food from parents. We found that nestling tree swallows (Tachycineta bicolor) exposed to playbacks of white noise, within natural amplitude levels, from days 3 to 15 post hatch had begging calls with higher minimum frequencies and narrower frequency ranges than control nestlings raised in nests without added noise. Differences in begging call structure also persisted in the absence of noise. Two days after the noise was removed, experimental nestlings produced calls that were narrower in frequency range and less complex than control nestlings. We found no difference in growth between experimental and control nestlings. Our results suggest that long-term noise exposure affects the structure of nestling begging calls. These effects persist in the absence of noise, suggesting that noise may affect how calls develop.

Leonard, M. L. and A. G. Horn (2012). "Ambient noise increases missed detections in nestling birds." Biology Letters 8(4): 530-532.

Ambient noise can mask acoustic cues, making their detection and discrimination difficult for receivers. This can result in two types of error: missed detections, when receivers fail to respond to the appropriate cues, and false alarms, when they respond to inappropriate cues. Nestling birds are error-prone, sometimes failing to beg when parents arrive with food (committing missed detections) or begging in response to stimuli other than a parent's arrival (committing false alarms). Here, we ask whether the frequency of these errors by nestling tree swallows (Tachycineta bicolor) increases in the presence of noise. We found that nestlings exposed to noise had more missed detections than their unexposed counterparts. We also found that false alarms remained low overall and did not differ significantly between noise and quiet treatments. Our results suggest that nestlings living in noisy environments may be less responsive to their parents than nestlings in quieter environments.

Lesage, V., et al. (1999). "The effect of vessel noise on the vocal behavior of belugas in the St. Lawrence River estuary, Canada." Marine Mammal Science 15(1): 65-84.

During June-July 1991, we monitored the vocal behavior of belugas before, during, and after exposure to noise from a small motorboat and a ferry to determine if there were any consistent patterns in their vocal behavior when exposed to these two familiar, but different sources of potential disturbance. Vocal responses were observed in all trials and were more persistent when whales were exposed to the ferry than to the small boat. These included (1) a progressive reduction in calling rate from 3.4–10.5 calls/whale/min to 0.0 or <1.0 calls/whale/min while vessels were approaching; (2) brief increases in the emission of falling tonal calls and the three pulsed-tone call types; (3) at distances <1 km, an increase in the repetition of specific calls, and (4) a shift in frequency bands used by vocalizing animals from a mean frequency of 3.6 kHz prior to exposure to noise to frequencies of 5.2-8.8 kHz when vessels were close to the whales.

Levy, L. and S. Falzarano (2009). "Tools of the trade: An example of using spectrograms to count fixed-wing aircraft." Park Science 26(3): 48-49.

Levy, L. and S. Falzarano (2009). "Visually impaired students help collect acoustic data in Grand Canyon National Park." Park Science 26(3): 50-51.

Little, J. B. (2000). "Desperately Seeking Silence." Audubon 102(1): 70.
Profiles self-declared acoustic ecologist Gordon Hempton. His educational background; Information on his video `Vanishing Dawn Chorus'; How he launched his One Square Inch of Silence, a plan for saving the soundscape of America's national parks; Comments from Bill Schmidt, a natural resources representative for the National Park Service.

Liu, M., et al. (2013). "Ship noise-induced temporary hearing threshold shift in the Chinese sucker Myxocyprinus asiaticus (Bleeker, 1864)." Journal of Applied Ichthyology 29(6): 1416-1422.
Ship noise-induced temporary hearing threshold shift in the Chinese sucker Myxocyprinus asiaticus

Lohr, B., et al. (2003). "Detection and discrimination of natural calls in masking noise by birds: estimating the active space of a signal." Animal Behavior 65(4): 763-777.
We tested the ability of birds to detect and discriminate natural vocal signals in the presence of masking noise using operant conditioning. Masked thresholds were measured for budgerigars, Melopsittacus undulatus, and zebra finches, Taeniopygia guttata, on natural contact calls of budgerigars, zebra finches and canaries, Serinus canaria. Thresholds increased with increasing call bandwidth, the presence of amplitude modulation and high rates of frequency modulation in calls. As expected, detection thresholds increased monotonically with background noise level. Call detection thresholds varied with the spectral shape of noise. Vocal signals were masked predominantly by noise energy in the spectral region of the signals and not by energy at spectral regions remote from the signals. In all cases, thresholds for discrimination between calls of the same species were higher than thresholds for detection of those calls. Our data provide the first opportunity to estimate distances over which specific communication signals may be effective (i.e. their 'active space') using masked thresholds for the signals themselves. Our results suggest that measures of peak sound pressure level, combined with the spectrum level of noise within the frequency channel having

the greatest signal power relative to background noise, give the most similar results for estimating a signal's maximum communication distance across a variety of sounds. We provide a simple model for estimating likely detection and discrimination distances for the signals tested here. Copyright 2003 Published by Elsevier Science Ltd on behalf of The Association for the Study of Animal Behavior.

Love, E. K. and M. A. Bee (2010). "An experimental test of noise-dependent voice amplitude regulation in Cope's grey treefrog, Hyla chrysoscelis." Animal Behavior 80(3): 509-515.

One strategy for coping with the constraints on acoustic signal reception posed by ambient noise is to signal louder as noise levels increase. Termed the 'Lombard effect', this reflexive behavior is widespread among birds and mammals and occurs with a diversity of signal types, leading to the hypothesis that voice amplitude regulation represents a general vertebrate mechanism for coping with environmental noise. Support for this evolutionary hypothesis, however, remains limited due to a lack of studies in taxa other than birds and mammals. Here, we report the results of an experimental test of the hypothesis that male grey treefrogs increase the amplitude of their advertisement calls in response to increasing levels of chorus shaped noise. We recorded spontaneously produced calls in quiet and in the presence of noise broadcast at sound pressure levels ranging between 40 dB and 70 dB. While increasing noise levels induced predictable changes in call duration and rate, males did not regulate call amplitude. These results do not support the hypothesis that voice amplitude regulation is a generic vertebrate mechanism for coping with noise. We discuss the possibility that intense sexual selection and high levels of competition for mates in choruses place some frogs under strong selection to call consistently as loudly as possible.

Lowry, H., et al. (2011). "Tolerance of auditory disturbance by an avian urban adapter, the noisy miner." Ethology 117(6): 490-497.

Urbanization creates challenges for wildlife, most notably through changes in resource availability and the frequent occurrence of sensory disturbance. Some native species, however, have been able to exploit and thrive in urban environments. Research, in this regard, has mostly focused on the ecological conditions that have allowed such species to prosper. In contrast, less attention has been devoted to evaluating how they cope with human proximity and disturbance. In a field experiment on a successful Australian 'urban adapter', the Noisy miner, Manorina melanocephala, we compared tolerance of a loud, startling sound stimulus by urban and rural individuals. We found group size differences between birds occupying urban and rural sites: more urban birds came into the testing area in response to the initial alarm-call playback compared with rural birds. Urban and rural birds also differed significantly in their behavioral response profile to the test sound stimulus. Nearly half (47.5%) of the rural, but only 22.5% of the urban birds took flight and of those that did, only 1 of 9 urban individuals retreated >5 m, compared with 13 of 19 rural birds. About one-third of urban, but only 5% of rural individuals responded to the sound stimulus with aggressive displays. The most frequent response to the stimulus, irrespective of habitat type, was to remain near the sound source and engage in visual surveillance. The high frequency of this response in both urban and rural individuals suggested that most noisy miners were quite 'bold', a temperament trait that is likely to be important in successful urban colonization by birds.

Luther, D. and L. Baptista (2010). "Urban noise and the cultural evolution of bird songs." Proceedings of the Royal Society of London B: Biological Sciences 277(1680): 469-473.

In urban environments, anthropogenic noise can interfere with animal communication. Here we study the influence of urban noise on the cultural evolution of bird songs. We studied three adjacent dialects of white crowned sparrow songs over a 30-year time span. Urban noise, which is louder at low frequencies, increased during our study period and therefore should have created a selection pressure for songs with higher frequencies. We found that the minimum frequency of songs increased both within and between dialects during the 30-year time span. For example, the dialect with the highest minimum frequency is in the process of replacing another dialect that has lower frequency songs. Songs with the highest minimum frequency were favored in this environment and should have the most effective transmission properties. We suggest that one mechanism that influences how dialects, and cultural traits in general, are selected and transmitted from one generation to the next is the dialect's ability to be effectively communicated in the local environment.

Luther, D. and K. Gentry (2013). "Sources of background noise and their influence on vertebrate acoustic communication." Behavior 150(9-10): 1045-1068.

Many animals rely on long-range communication for species recognition, mate selection and territorial defense, but background noise from the environment can constrain their communication. Background noise from both biotic and abiotic sources is ubiquitous. In general, acoustic noise from abiotic sources, including anthropogenic noise, has energy mostly below 1 kHz. Arthropods tend to produce sounds in the 4–10 kHz range, while birds, amphibians and mammals generally have vocalizations with frequencies between 1 and 5 kHz. There are several ways that signalers could improve the efficiency of their acoustic signals to counteract the constraints of background noise. Signalers could make long-term and short-term signal adjustments to increase the detectability and discriminability of their signals. As predicted by signal detection theory adjustments can include increases in contrast between signals and noise, such as the intensity of the signal, the structure of the signal and an increase in signal redundancy. Our study reviews the sources of acoustic background noise, adjustments made by signalers to increase signal efficacy, and the influence of acoustic background noise on the evolution of acoustic communication in terrestrial vertebrate species.

Luther, D. A. (2008). "Signaller: receiver coordination and the timing of communication in Amazonian birds." Biology Letters 4(6): 651-654.

The efficacy of communication relies on the detection of signals against background noise. Some species are known to alter the timing of vocalizations to avoid acoustic interference from similar signals of other species, but nothing is known about the possibility of coordinated adjustments in the timing of receivers' attention. I examined the possibility that co-occurring species might respond as well as vocalize at different times in a diverse tropical avifauna by presenting playbacks of recordings to territorial birds at typical and atypical times for singing during the dawn chorus. The results show that co-occurring species of birds in a diverse avifauna partition the timing of both production and response in a way that would reduce acoustic interference between species.

Luther, D. A. and E. P. Derryberry (2012). "Birdsongs keep pace with city life: changes in song over time in an urban songbird affects communication." Animal Behavior 83(4): 1059-1066.

Animals in urban environments often must adjust their vocalizations to be heard over the din of anthropogenic ambient noise. Most studies of this process use current comparisons of environments that vary in ambient noise; here, we evaluate over time the effects of the urban environment on signal structure and salience. We show that white-crowned sparrow, Zonotrichia leucophrys, song increased in minimum frequency between 1969 and 2005 in San Francisco, California, U.S.A., coincident with rising levels of traffic noise. A higher minimum frequency is less likely to be masked by low-frequency ambient noise and thus is more likely to be effective as a communication signal. To test whether this change in song affects receiver response, we presented territorial males current (2005) and historical (1969) local songs. Males responded more strongly to current than to historical songs, suggesting that current songs communicate more effectively in the current local environment. The results suggest that behavioral adjustment to anthropogenic ambient noise over time can affect cultural evolution and communication.

Lynch, E., et al. (2011). "An assessment of noise audibility and sound levels in U.S. National Parks." Landscape Ecology 26(9): 1297-1309.

Throughout the United States, opportunities to experience noise-free intervals are disappearing. Rapidly increasing energy development, infrastructure expansion, and urbanization continue to fragment the acoustical landscape. Within this context, the National Park Service endeavors to protect acoustical resources because they are essential to park ecology and central to the visitor experience. The Park Service monitors acoustical resources in order to determine current conditions, and forecast the effects of potential management decisions. By community noise standards, background sound levels in parks are relatively low. By wilderness criteria, levels of noise audibility are remarkably high. A large percentage of the noise sources measured in national parks (such as highways or commercial jet traffic) originates outside park boundaries and beyond the management jurisdiction of NPS. Many parks have adopted noise mitigation plans, but the regional and national scales of most noise sources call for conservation and management efforts on similar scales. [ABSTRACT FROM AUTHOR]

Mace, B. L., et al. (1999). "Aesthetic, Affective, and Cognitive Effects of Noise on Natural Landscape Assessment." Society & Natural Resources 12(3): 225-242.

Research has shown that helicopter noise from tourist flights is very common in some national parks and wilderness areas . At Grand Canyon National Park , air craft noise has been found to be as high as 76 dB (A) with as many as 43 noise events in a 20-minute period . The present study examined the influence of 40 dB (A) or 80 dB (A) helicopter noise on assessment of a popular Grand Canyon vista in a laboratory simulation.

Participants (44 female and 36 male undergraduates) viewed 68 slides of scenic vistas and assessed them on naturalness, preference, and scenic beauty and evaluated dimensions of freedom, annoyance, solitude, and tranquility. Compared to a control condition of background natural sounds (e.g.,birds, brooks), noise conditions negatively impacted all dependent measures. Although the effects were most pronounced at the 80-dB level, even the 40-dB helicopter noise negatively impacted all dependent variables. Results suggest that helicopter noise interferes with the quality of the visitor experience and even affects the perceived aesthetic quality of landscapes. [ABSTRACT FROM AUTHOR]

Mace, B. L., et al. (2004). "Visibility and Natural Quiet in National Parks and Wilderness Areas." Environment & Behavior 36(1): 5-31.

For over a century, authorities have recognized cultural and psychological benefits of preserving national parks and wilderness areas. Yet, with increases in visitation and mechanized travel, air and noise pollution are intruding more and more into preserved natural areas. Psychological research shows that humans can detect very low levels of these pollutants in natural and laboratory settings, that air and noise pollution detract from the enjoyment of the visitor experience, and that people place a high value on naturally quiet, pollution-free settings. This article discusses how psychological research is essential for a more complete understanding of the value and the influence of both visibility and quiet surroundings with a focus on applied, field-based research in national parks and wilderness areas. The article concludes with recommendations for future directions in research in these areas and argues that implications of psychological research results should be addressed in the natural resource policy-making process. [ABSTRACT FROM AUTHOR]

Madsen, P. (2005). "Marine mammals and noise: Problems with root mean square sound pressure levels for transients." The Journal of the Acoustical Society of America 117(6): 3952-3957.

Current mitigation levels for noise transients impinging on marine mammals are specified by rms pressures. The rms measure critically relies upon choosing the size of averaging window for the squared pressures. Derivation of this window is not standardized, which can lead to 2–12 dB differences in rms sound pressure for the same wave forms. rms pressure does not represent the energy of the noise pulse and it does not

prevent exposure to high peak pressures. Safety levels for transients should therefore be given by received peak–peak sound pressure and energy flux density instead of rms sound pressure levels.

Madsen, P. and B. Møhl (2000). "Sperm whales (Physeter catodon L. 1758) do not react to sounds from detonators." The Journal of the Acoustical Society of America 107(1): 668-671.
A number of observations show that sperm whales (Physeter catodon L. 1758) react to various man-made pulses with moderate source levels. The behavioral responses are described to vary from silence to fear. Click rates of five submerged male sperm whales were measured during the discharge of eight detonators off Andenes, northern Norway. In addition, the behavioral response of a surfaced specimen was observed. Click rates of the submerged whales and the behavior of the surfaced specimen did not change during the discharges with received sound levels of some 180 dB re 1 μPa peRMS. The apparent lack of response to the discharges could be due to similarity between sperm whale clicks and detonations. Accordingly, it can be speculated that the discharges may have been perceived as isolated clicks from conspecifics.

Madsen, P., et al. (2002). "Male sperm whale behavior during exposures to distant seismic survey pulses." Aquatic Mammals 28(3): 231-240.
The behavior of adult, male sperm whales in polar waters (69$20%N, 15$40%E) during exposure to pulses from a remote (>20 km) seismic survey vessel and artificial codas is described and discussed. Five hours of recordings with a large aperture array contained both air gun pulses and sperm whale clicks. The seismic survey pulses received were smeared-out in time and high-pass filtered due to multipath propagation in shallow water. The pulses received had a "10 dB spectrum content in the frequency range of 210–260 Hz and a maximum "10 dB duration of 1400 ms. Estimated maximum sound pressure received at the whales were 146 dB re 1 "Pa (p-p) (124 dB re 1 "Pa2s in energy terms).The exposure to the seismic survey pulses did not elicit observable avoidance and the whales stayed in the area for at least 13 days of exposure. Nor did the whales fall silent or change their normal vocal patterns during feeding dives. It appears that foraging male sperm whales in this habitat and at these received levels are not more susceptible to air gun pulses than are cetaceans in general. During emissions of artificial codas, sound levels at the whales being unknown, the sperm whales did not cease clicking as reported from previous investigations, but two whales seemed to direct their high power, narrow-beam sonar towards the coda transmitter

Maes, J. and G. de Groot (2003). "Effects of noise on the performance of rats in an operant discrimination task." Behavioral Processes 61(1): 57-68.
Two experiments examined the effect of the presentation of an irregular, moderate intensity auditory stimulus ('noise') on the performance of rats in an operant discrimination task. In Experiment 1, rats first learned to press a lever in the presence of a visual stimulus but not in its absence. Discrimination performance was impaired during subsequent exposure to noise. In Experiment 2, different groups of rats learned the discrimination task under a noise or a no-noise condition. Thereafter, all rats were tested under each noise condition. Discrimination performance was best when the noise condition at test was identical to the noise condition at training. These results were discussed in the framework of arousal, distraction, generalization decrement, and contextual occasion setting. They point to the necessity of using

a 2×2 factorial design in human and animal research on noise effects, with noise condition at training (noise present or absent) and noise condition at test (noise present or absent) as factors.

Magrath, R. D., et al. (2007). "How to be fed but not eaten: nestling responses to parental food calls and the sound of a predator's footsteps." Animal Behavior 74(5): 1117-1129.
Nestling birds could minimize the risk of being overheard by predators by becoming silent after parental alarm calls, begging only when parents arrive with food, and independently assessing cues that a predator is nearby. Begging only to parents is challenging because young that respond quickly can be more likely to be fed, so there is a benefit of using subtle cues of parental arrival, potentially leading to erroneous begging. Parents might reduce the risk of error by giving food calls signaling that they have arrived with food, but there have been few studies contrasting begging to food calls compared with other parental vocalizations. Furthermore, it is unknown whether nestlings can use acoustic cues to independently detect predators. White-browed scrubwren, Sericornis frontalis, nestlings become silent after parental alarm calls, but it is unknown whether they respond specifically to parental food calls or directly to predator sounds. We conducted a field playback experiment, and found that young begged more vigorously to food calls than other parental vocalizations tested, and nearly as strongly to playback as during real feeding visits by parents. However, nestlings also mistakenly begged to playback of superb fairy-wren, Malurus cyaneus, song, possibly because of acoustic similarities to food calls. Finally, nestlings responded with silence to playback of the sound of their major predator (pied currawong, Strepera graculina) walking on leaf litter. Scrubwren nestlings can therefore be 'switched on' and 'switched off' by parental vocalizations, are prone to error, and may independently assess risk.

Maier, J. A., et al. (1998). "Responses of caribou to overflights by low-altitude jet aircraft." The Journal of Wildlife Management: 752-766.
Military training exercises have increased in Alaska in recent years, and the possible effects of low-altitude overflights on wildlife such as barren-ground caribou (Rangifer tarandus) have caused concern among northern residents and resource agencies. We evaluated the effects of overflights by low-altitude, subsonic jet aircraft by U.S. Air Force (USAF) A-10, F-15, and F-16 jets on daily activity and movements of free-ranging female caribou. This study was conducted on caribou of the Delta Caribou Herd in interior Alaska during each of 3 seasons in 1991: late winter, post-calving, and insect harassment. Noise levels experienced by caribou were measured with Animal Noise Monitors (ANMs) attached to radiocollars. Caribou subjected to overflights in late winter interrupted resting bouts and consequently engaged in a greater number of resting bouts than caribou not subjected to overflights (P = 0.05). Caribou subjected to overflights during post-calving were more active (P = 0.03) and moved farther (P = 0.01) than did caribou not subjected to overflights. Caribou subjected to overflights during the insect season responded by becoming more active (P = 0.01). Responses of caribou to aircraft were mild in late winter, intermediate in the insect season, and strongest during post-calving. We conclude that females with young exhibit the most sensitive response to aircraft disturbance. Accordingly, military training exercises should be curtailed in areas where caribou are concentrated during calving and post-calving.

Maleki, K. and S. M. Hosseini (2011). "Investigation of the effects of leaves, branches and canopies of trees on noise pollution reduction." Annals of Environmental Science 5: 13-21.
In order to determine the effects of tree branches, leaves and their canopies on noise pollution, different types of trees from the Chitgar forest park in Tehran were investigated and compared in the seasons of spring and fall. Noise values were taken with noise meter equipment at four points of measurement: (a) an open area as the control treatment (without trees), urban forests of pure stands of (b) Pinus eldarica, Robinia pseudoacasia, and (c) a mixed stand at 7 distances (10, 20, 30, 40, 50, 75 and 100 meters from the source of the noise which was located behind the tree stands). The experiment was repeated five times in the above mentioned seasons. The noise pollution of the region was also taken into account. The results indicated that in the studied area, the average noise level was more than the Iranian national noise standard. The largest noise reduction occurred in the mixed stand, which was about 19.07 dB(A) and the lowest amount of reduction was seen in the pure stand of Robinia pseudoacasia which was about 14.7 dB(A). The most significant noise reduction took place 75 meters away from the source of the noise. The differences between noise pollution abatement of the pure stand of Robinia pseudoacasia and the mixed stand in spring and fall were 5.01 and 6.05 dB(A), respectively. The results of this study suggest that in order to solve the issue of noise pollution of industries and road traffic, especially in big cities like Tehran, noise barriers need to be specified in city construction in specific zones that are covered with trees and vegetation with appropriate width.

Manning, R., et al. (2010). "A program of research to support management of visitor-caused noise at Muir Woods National Monument." Park Science 26(3): 54-58.

Marin, L. D., et al. (2011). "Motivation and Acceptability Norms of Human-Caused Sound in Muir Woods National Monument." Leisure Sciences 33(2): 147-161.
Acceptability of sound, natural or human-caused, was predicted to vary by an individual's motivation for quiet at Muir Woods National Monument. This study used a dose-response methodology where visitors (n = 157; response rate = 54%) listened to five audio recordings varying in the percentage of time that human-caused sound was louder than natural sound (percent time above). Visitors then rated the acceptability (pleasing to annoying) of each recording. Cluster analysis was used to segment individuals into three homogeneous groups based on their motivations (i.e., low, moderate, and high motivation for quiet) for visiting the park. Results indicated that as percent time above natural sound increased, visitor ratings of human-caused sound decreased. Reactions to human-caused sound also decreased as motivation for quiet increased. Consensus regarding the acceptability of sound was greatest when the percent time above natural sound was lowest (i.e., quietest sounds). Recommendations are offered for setting standards to meet soundscape objectives. [ABSTRACT FROM AUTHOR]

Marler, P. (2004). "Bird calls: a cornucopia for communication." Nature's music: The science of Birdsong: 132-176.

Marquis, A. L. (2006). "A Sound Resolution." National Parks 80(2): 14-16.
The article discusses the effort to curb noise pollution in United States parks. One such effort is the Natural Sounds Program established by the U.S. National Park Service in 2001 to monitor appropriate and obtrusive sounds, establish ambient baselines, and assess potential impacts in parks. Not all man-made sounds are considered inappropriate. Cannons and gunshots, for example, are part of the soundscape at Gettysburg National Military Park. But the increasing level of background noise poses problems to animals who are unable to hear as far out as they used to. Airplanes, snowmobiles and other motorized vehicles are among the more obvious culprits. But Park Services operations are also a common source of inappropriate sound.

McCauley, R. D., et al. (2003). "High intensity anthropogenic sound damages fish ears." The Journal of the Acoustical Society of America 113(1): 638-642.
Marine petroleum exploration involves the repetitive use of high-energy noise sources, air-guns, that produce a short, sharp, low-frequency sound. Despite reports of behavioral responses of fishes and marine mammals to such noise, it is not known whether exposure to air-guns has the potential to damage the ears of aquatic vertebrates. It is shown here that the ears of fish exposed to an operating air-gun sustained extensive damage to their sensory epithelia that was apparent as ablated hair cells. The damage was regionally severe, with no evidence of repair or replacement of damaged sensory cells up to 58 days after air-gun exposure.

McClure, C. J., et al. (2013). "An experimental investigation into the effects of traffic noise on distributions of birds: avoiding the phantom road." Proceedings of the Royal Society of London B: Biological Sciences 280(1773): 20132290.
Many authors have suggested that the negative effects of roads on animals are largely owing to traffic noise. Although suggestive, most past studies of the effects of road noise on wildlife were conducted in the presence of the other confounding effects of roads, such as visual disturbance, collisions and chemical pollution among others. We present, to our knowledge, the first study to experimentally apply traffic noise to a roadless area at a landscape scale—thus avoiding the other confounding aspects of roads present in past studies. We replicated the sound of a roadway at intervals—alternating 4 days of noise on with 4 days off—during the autumn migratory period using a 0.5 km array of speakers within an established stopover site in southern Idaho. We conducted daily bird surveys along our 'Phantom Road' and in a nearby control site. We document over a one-quarter decline in bird abundance and almost complete avoidance by some species between noise-on and noise-off periods along the phantom road and no such effects at control sites—suggesting that traffic noise is a major driver of effects of roads on populations of animals.

McCusker, V. and K. Cahill (2009). "Integrating soundscapes into National Park Service planning." Park Science 26(3): 1-7.
The article focuses on how soundscape management planning fits in the context of the planning network

for the National Park Service (NPS). It states that the resource stewardship strategy, a type of program plan in the NPS planning framework, should include indicators, target values, and management strategies for soundscapes or natural sounds. Furthermore, soundscape-related management objectives and actions that should be included in the implementation plans for the NPS are discussed.

McGregor, P. K., et al. (2013). Anthropogenic noise and conservation. Animal Communication and Noise, Springer: 409-444.

Anthropogenic noise is a common but evolutionarily recent influence on communicating animals and evidence is accumulating of its adverse impacts on human health, therefore it has potential relevance to conservation. However, demonstrating that this potential is realized is not straightforward. A particular issue is the difficulty of assessing likely impacts from the limited evidence on the main factors influencing impacts —from the hearing abilities of animals of conservation concern through to the characteristics of emitted sound fields in natural environments. Further issues include the likely underestimation of behavioral effects, and a lack of knowledge of how animals trade off costs and benefits. In this chapter, we aim to highlight the main themes emerging from the growing interest in the effects of anthropogenic noise on conservation. We predominantly consider the marine environment (with examples drawn mainly from marine mammals) and the terrestrial environment (with bird examples). An important consideration that emerges from the increasing levels of anthropogenic noise and difficulties in assessing specific impacts is the need to develop interim guidance, while more detailed information is gathered and assessed.

McGregor, R. L., et al. (2008). "Do small mammals avoid roads because of the traffic?" Journal of Applied Ecology 45(1): 117-123.

1. Roads can act as barriers to animal movement, which may reduce population persistence by reducing recolonization of empty habitats and limiting immigration. Appropriate mitigation of this barrier effect (e.g. seasonal road closures, location and design of wildlife over- or underpasses) depends upon whether the animals avoid the road itself or the traffic on the road. Empirical studies of road avoidance to date do not generally differentiate between these.
2. We conducted short- and long-distance translocations and trapping studies of white-footed mice (Peromyscus leucopus) and eastern chipmunks (Tamias striatus) near two-lane paved roads, which differed widely in traffic amount, from 47 to 15 433 vehicles per day.
3. In the trapping study (13 sites) only five animals moved across a road, in comparison to 36 animals that moved the same distance without an intervening road ($P < 0{\cdot}0001$). In the short-distance translocations (15 sites), 51% of the small mammals that were translocated across roads returned, in comparison to a return rate of 77% of animals that were translocated a similar distance with no intervening road ($P = 0{\cdot}009$).
4. In the long-distance translocation study (24 sites) we found that each intervening road reduced the probability of successful return by about 50%.
5. We found no significant effects of traffic amount on return rates in either the short-distance or the long-distance translocations studies.
6. Small mammal densities were not lower near roads and we found no evidence for a decrease in density near roads with increasing traffic amount.

7. Synthesis and applications. Our results suggest that small mammals avoid the road itself, and not emissions such as noise from the traffic on the roads. Our results imply that the barrier effect of roads on these species cannot be mitigated by measures aimed at reducing traffic amount; other measures such as wildlife passages would be needed.

McLaughlin, K. E. and H. P. Kunc (2013). "Experimentally increased noise levels change spatial and singing behavior." Biology Letters 9(1): 20120771.

The reasons why animal populations decline in response to anthropogenic noise are still poorly understood. To understand how populations are affected by noise, we must understand how individuals are affected by noise. By modifying the acoustic environment experimentally, we studied the potential relationship between noise levels and both spatial and singing behavior in the European robin (Erithacus rubecula). We found that with increasing noise levels, males were more likely to move away from the noise source and changed their singing behavior. Our results provide the first experimental evidence in a free ranging species, that not merely the presence of noise causes changes in behavior and distribution, but that the level of noise pollution plays a crucial role as well. Our results have important implications for estimating the impact of infrastructure which differs in the level of noise produced. Thus, governmental planning bodies should not only consider the physical effect on the landscape when assessing the impact of new infrastructure, but also the noise levels emitted, which may reduce the loss of suitable habitats available for animals.

Mei, Z. and K. Jian (2007). "Towards the evaluation, description, and creation of soundscapes in urban open spaces." Environment & Planning B: Planning & Design 34(1): 68-86.

Soundscape is about relationships between the ear, human beings, sound environments, and society. Soundscape research is interdisciplinary. On the basis of a series of case studies in Europe and China and an intensive literature review, the soundscape description, evaluation, and creation in urban open spaces are systematically examined, in terms of four basic elements: sound, space, people, and environment. Factors affecting soundscape evaluation in urban open spaces, including acoustic–psychological–social characteristics of various sounds, acoustic effects of space boundaries and elements, social–demographic characteristics of users, and general physical–environmental conditions, are identified, and, consequently, a system for soundscape description is established. Potentials of creating and designing soundscape in urban spaces are then discussed in terms of sound and space. [ABSTRACT FROM AUTHOR]

Melcon, M. L., et al. (2012). "Blue whales respond to anthropogenic noise." PLoS ONE 7(2): e32681.

Anthropogenic noise may significantly impact exposed marine mammals. This work studied the vocalization response of endangered blue whales to anthropogenic noise sources in the mid-frequency range using

passive acoustic monitoring in the Southern California Bight. Blue whales were less likely to produce calls when mid-frequency active sonar was present. This reduction was more pronounced when the sonar source was closer to the animal, at higher sound levels. The animals were equally likely to stop calling at any time of day, showing no diel pattern in their sensitivity to sonar. Conversely, the likelihood of whales emitting calls increased when ship sounds were nearby. Whales did not show a differential response to ship noise as a function of the time of the day either. These results demonstrate that anthropogenic noise, even at frequencies well above the blue whales' sound production range, has a strong probability of eliciting changes in vocal behavior. The long-term implications of disruption in call production to blue whale foraging and other behaviors are currently not well understood.

Mendes, S., et al. (2011). "Bird song variations along an urban gradient: The case of the European blackbird (Turdus merula)." Landscape and Urban Planning 99(1): 51-57.

Species that use vocal communication have difficulties in transmitting their messages in noisy habitats. The capacity to adapt songs to prevent them from being masked by noise could be a key factor for reproductive success in such environments. Previous research has demonstrated changes in several song parameters between rural and urban areas. In the present study we were prompted to check vocal adjustment along an urban gradient. The survey was carried out in the city of Salamanca (Spain), which owing to its small size has a strong physical gradient over a short distance. We recorded the songs of 27 common blackbirds (Turdus merula) and ambient noise at 13 sites. The choice of sites corresponds to different areas along this gradient: urban, periurban and rural zones. Anthropogenic noise increased from the rural to urban recording sites. Differences in vocalizations were found in both the maximum and minimum frequencies among the three areas. The blackbird can shift its entire vocalization to avoid masking by ambient noise, which occurs mainly at low frequencies. Song frequencies showed a graded response to ambient noise. Urban gradients in small cities are steep and strong, but the degree of isolation is low. In this context, vocal adjustment is more likely to be possible by means of behavioral plasticity although environmental pressure could lead to genetic changes in more isolated areas. Other changes along the urban gradient modify both ecology and population parameters of the blackbirds and could also be another possible explanation for song variation.

Mennitt, D. J. and K. M. Fristrup (2012). "Obtaining calibrated sound pressure levels from consumer digital audio recorders." Applied Acoustics 73(11): 1138-1145.

Abstract: Audio recording of environmental sound is an increasingly efficient method for autonomously sensing many ecological and anthropogenic processes. The increasing capabilities of consumer digital audio recorders (DARs), especially increases in storage capacity and reductions in power consumption, enable continuous audio recordings exceeding 1month in duration with packages that are relatively small and inexpensive. To augment the ability of these systems to document the range of sounds present at a location, this paper examines two methods for calibrating recorders to measure sound levels. Compressed audio recorded by a DAR can be processed to yield relatively consistent measures of one-third octave band Leq values within a limited frequency and dynamic range. This was evaluated by synchronizing data with a Type-1 sound level meter. The calibration is stable over a 23day deployment outdoors with wide variation in ambient temperature and humidity. When considering aggregate acoustic metrics over time or a wide

bandwidth such as an hourly A-weighted L 50, the results can be quite accurate (within 1dBA). [Copyright &y& Elsevier]

Merchant, N. D., et al. (2015). "Measuring acoustic habitats." Methods in Ecology & Evolution 6(3): 257-265.
Many organisms depend on sound for communication, predator/prey detection and navigation. The acoustic environment can therefore play an important role in ecosystem dynamics and evolution. A growing number of studies are documenting acoustic habitats and their influences on animal development, behavior, physiology and spatial ecology, which has led to increasing demand for passive acoustic monitoring (PAM) expertise in the life sciences. However, as yet, there has been no synthesis of data processing methods for acoustic habitat monitoring, which presents an unnecessary obstacle to would-be PAM analysts., Here, we review the signal processing techniques needed to produce calibrated measurements of terrestrial and aquatic acoustic habitats. We include a supplemental tutorial and template computer codes in matlab and r, which give detailed guidance on how to produce calibrated spectrograms and statistical analyses of sound levels. Key metrics and terminology for the characterisation of biotic, abiotic and anthropogenic sound are covered, and their application to relevant monitoring scenarios is illustrated through example data sets. To inform study design and hardware selection, we also include an up-to-date overview of terrestrial and aquatic PAM instruments., Monitoring of acoustic habitats at large spatiotemporal scales is becoming possible through recent advances in PAM technology. This will enhance our understanding of the role of sound in the spatial ecology of acoustically sensitive species and inform spatial planning to mitigate the rising influence of anthropogenic noise in these ecosystems. As we demonstrate in this work, progress in these areas will depend upon the application of consistent and appropriate PAM methodologies. [ABSTRACT FROM AUTHOR]

Merrill, S. B. and C. R. Erickson (2003). "A GPS-based method to examine wolf response to loud noise." Wildlife Society Bulletin: 769-773.
We used Global Positioning System (GPS) telemetry data to examine responses of a breeding male and 2 yearling wolves (Canis lupus) to military firing at Camp Ripley National Guard Training Site in Little Falls, Minnesota. Two of 3 wolves showed movements toward firing points more often than expected. Movements

toward firing points were more frequent when wolves were <5 km from the firing point before firing began. The breeding male moved toward firing points more often than the 2 yearlings. The method developed in this study could be useful for identifying tolerance thresholds in other wildlife species and for determining whether thresholds change when animals adjust to human activitie

Miksis-Olds, J. L., et al. (2007). "Noise level correlates with manatee use of foraging habitats." The Journal of the Acoustical Society of America 121(5): 3011-3020.

The introduction of anthropogenic sound to coastal waters is a negative side effect of population growth. As noise from boats, marine construction, and coastal dredging increases, environmental and behavioral monitoring is needed to directly assess the effect these phenomena have on marine animals. Acoustic recordings, providing information on ambient noise levels and transient noise sources, were made in two manatee habitats: grassbeds and dredged habitats. Recordings were made over two 6-month6-month periods from April to September in 2003 and 2004. Noise levels were calculated in one-third octave bands at nine center frequencies ranging from 250Hzto64kHz250Hzto64kHz. Manatee habitat usage, as a function of noise level, was examined during four time periods: morning, noon, afternoon, and night. Analysis of sightings data in a variety of grassbeds of equal species composition and density indicate that manatees select grassbeds with lower ambient noise for frequencies below 1kHz1kHz. Additionally, grassbed usage was negatively correlated with concentrated boat presence in the morning hours; no correlation was observed during noon and afternoon hours. This suggests that morning boat presence and its associated noise may affect the use of foraging habitat on a daily time scale.

Miksis-Olds, J. L., et al. (2007). "Simulated vessel approaches elicit differential responses from manatees." Marine Mammal Science 23(3): 629-649.

One of the most pressing concerns associated with conservation of the endangered Florida manatee is mortality and serious injury due to collisions with watercraft. Watercraft collisions are the leading identified cause of manatee mortality, averaging 25% and reaching 31% of deaths each year. The successful establishment and management of protected areas depend upon the acquisition of data assessing how manatees use different habitats, and identification of environmental characteristics influencing manatee behavior and habitat selection. Acoustic playback experiments were conducted to assess the behavioral responses of manatees to watercraft approaches. Playback stimuli made from prerecorded watercraft approaches were constructed to simulate a vessel approach to approximately 10 m in sea grass habitats. Stimulus categories were (1) silent control, (2) approach with outboard at idle speed, (3) vessel approach at planning speed, and (4) fast personal watercraft approach. Analyses of swim speed, changes in behavioral state, and respiration rate indicate that the animals responded differentially to the playback categories. The most pronounced responses, relative to the controls, were elicited by personal watercraft. Quantitative documentation of response during playbacks provides data that may be used as the basis for future models to predict the impact of specific human activities on manatees and other marine mammal populations.

Miksis-Olds, J. L. and T. Wagner (2011). "Behavioral response of manatees to variations in environmental sound levels." Marine Mammal Science 27(1): 130-148.

Florida manatees (Trichechus manatus latirostris) inhabit coastal regions because they feed on the aquatic vegetation that grows in shallow waters, which are the same areas where human activities are greatest. Noise produced from anthropogenic and natural sources has the potential to affect these animals by eliciting responses ranging from mild behavioral changes to extreme aversion. Sound levels were calculated from recordings made throughout behavioral observation periods. An information theoretic approach was used to investigate the relationship between behavior patterns and sound level. Results indicated that elevated sound levels affect manatee activity and are a function of behavioral state. The proportion of time manatees spent feeding and milling changed in response to sound level. When ambient sound levels were highest, more time was spent in the directed, goal-oriented behavior of feeding, whereas less time was spent engaged in undirected behavior such as milling. This work illustrates how shifts in activity of individual manatees may be useful parameters for identifying impacts of noise on manatees and might inform population level effects.

Miller, N. P. (2008). "US National Parks and management of park soundscapes: A review." Applied Acoustics 69(2): 77-92.

Abstract: For more than 17years the US National Park Service has been developing the methods, processes and skills required to effectively manage the soundscapes of the National Parks. The author and his company have had the honor of providing technical acoustics related assistance throughout much of this period. This article presents his reflections on the process, its technical and political complexities, and provides what are hoped to be useful syntheses derived both from his experiences and from past and recent discussions with many of the participants. Specifically, the article describes the fundamental questions that need to be answered for management of natural soundscapes, the types of noise issues that arise in parks, the need for quantitative data, approaches to identifying, measuring and collecting those data, and a suggested approach for developing criteria designed to effectively manage sounds in natural areas. [Copyright &y& Elsevier]

Miller, R. L. (1996). "Federal regulations and other activities in noise control." Noise Control Engineering Journal 44(3): 149-152.

Following the elimination of funding for the U.S. Environmental Protection Agency's Office of Noise Abatement and Control in the early 1980s, a coordinated Federal approach to noise control largely disappeared. Instead, governmental agencies were left to deal with their noise problems on their own, usually meaning that they responded only to specific legislation, political pressures, or litigation. Agency coordination, when it did occur, was effected by Executive Order. That is not all bad news. This paper briefly reviews Federal regulations controlling the world of transportation noise over the past 25 years, but focuses to a greater extent on the ongoing efforts of government to influence the noise environments of our

communities into the next century. The paper summarizes the actions of the Federal Aviation Administration, the National Aeronautics and Space Administration, and the Department of Defense as they confront issues of aircraft noise and airspace management; the National Park Service as it struggles to resolve conflicting mandates to preserve natural quiet and solitude while providing access to and public enjoyment of National Parks and Forests; the Federal Railroad Administration and the Federal Transit Administration in their endeavors to control noise from transit, high-speed rail, and mag-lev systems; and the Federal Highway Administration as it develops better tools to assess and control the noise impacts of traffic.

Miller, Z. D., et al. (2014). "Birding by Ear: A Study of Recreational Specialization and Soundscape Preference." Human Dimensions of Wildlife 19(6): 498-511.
Soundscapes have become recognized as an important natural resource. The traditional human-made versus natural soundscape comparison currently used in recreational resource management is challenged by borrowing soundscape components (i.e., biophony, anthmphony, geophony) from soundscape ecology. This article evaluated the soundscape preference of birders. A three-component model of recreational specialization was used to evaluate how recreationists differ in their preference for soundscape components. Data from in-person surveys collected at The Audubon Center and Sanctuary at Francis Beidler Forest in Harleyville, South Carolina were used in combination with surveys from online birding list servers to obtain a sample of 415 individuals with varying levels of specialization. The findings suggest soundscape preference exists as biophony, geophony, and anthrophony and that more specialized birders found geophony to be significantly more annoying than less specialized birders. Additionally, the skill and knowledge component of specialization best explained the difference in geophony preference among birders.
[ABSTRACT FROM AUTHOR]

Mockford, E. J. and R. C. Marshall (2009). "Effects of urban noise on song and response behavior in great tits." Proceedings of the Royal Society of London B: Biological Sciences 276(1669): 2979-2985.
Acoustic communication is fundamental in avian territory defence and mate attraction. In urban environments where sound transmissions are more likely to be masked by low-frequency anthropogenic noise, acoustic adaptations may be advantageous. However, minor modifications to a signal could affect its efficacy. While recent research has shown that there is divergence between songs from noisy and quiet areas, it is unknown whether these differences affect the response to the signal by its receivers. Here, we show that there is a difference in spectral aspects of rural and urban song in a common passerine, the great tit Parus major, at 20 sites across the UK. We also provide, to our knowledge, the first demonstration that such environmentally induced differences in song influence the response of male territory holders. Males from quiet territories exhibited a significantly stronger response when hearing song from another territory

holder with low background noise than from those with high background noise. The opposite distinction in response intensity to homotypic versus heterotypic song was observed in males from noisy territories. This behavioral difference may intensify further signal divergence between urban and rural populations and raises important questions concerning signal evolution.

Mockford, E. J., et al. (2011). "Degradation of rural and urban great tit song: testing transmission efficiency." PLoS ONE 6(12): e28242.

Acoustic signals play a fundamental role in avian territory defence and mate attraction. Several studies have now shown that spectral properties of bird song differ between urban and rural environments. Previously this has been attributed to competition for acoustic space as a result of low-frequency noise present in cities. However, the physical structure of urban areas may have a contributory effect. Here we investigate the sound degradation properties of woodland and city environments using both urban and rural great tit song. We show that although urban surroundings caused significantly less degradation to both songs, the transmission efficiency of rural song compared to urban song was significantly lower in the city. While differences between the two songs in woodland were generally minimal, some measures of the transmission efficiency of rural song were significantly lower than those of urban song, suggesting additional benefits to singing rural songs in this setting. In an attempt to create artificial urban song, we mimicked the increase in minimum frequency found several times previously in urban song. However, this did not replicate the same transmission properties as true urban song, suggesting changes in other song characteristics, such as temporal adjustments, are needed to further increase transmission of an avian signal in the city. We suggest that the structure of the acoustic environment, in addition to the background noise, plays an important role in signal adaptation.

Montague, M. J., et al. (2013). "Phenotypic plasticity affects the response of a sexually selected trait to anthropogenic noise." Behavioral Ecology 24(2): 343-348.

Sexually selected traits are shaped by an interaction between sexual selection and other natural selection pressures in the environment. However, there is little understanding of how recent anthropogenic environmental change affects the elaboration of sexually selected traits. Most sexually selected traits are complex displays comprising multiple components that interact in a functional way, thereby affecting overall trait expression. To understand how environmental change may shape the expression of sexually selected traits, we have to consider not only (i) the phenotypic plasticity of individual components of traits but also their (ii) phenotypic integration, that is, the correlations among trait components, as well as (iii) plasticity integration, that is, the correlations among the plasticities of trait components. Here, we show that background noise is a considerable pressure in shaping a sexually selected multicomponent acoustic signal, bird song. We compared singing behavior of European robins (Erithacus rubecula) in territories that differed in levels of anthropogenic noise and conducted noise-exposure experiments to test if behavioral plasticity caused immediate changes in song components, for example, minimum frequency, song complexity, and song length. We found that song components differed in their plasticity to background noise and that plasticity integration between components may further restrict the elaboration of song. Thus, the altered expression of song components under noise exposure leads to increased phenotypic integration, which

is linked with reduced song complexity. Our findings demonstrate that plasticity integration restricts the elaboration of a sexually selected trait, which raises the question of how changing environments may modify sexual selection.

Mooney, T. A., et al. (2009). "Sonar-induced temporary hearing loss in dolphins." Biology Letters: rsbl. 2009.0099.
There is increasing concern that human-produced ocean noise is adversely affecting marine mammals, as several recent cetacean mass strandings may have been caused by animals' interactions with naval 'midfrequency' sonar. However, it has yet to be empirically demonstrated how sonar could induce these strandings or cause physiological effects. In controlled experimental studies, we show that mid-frequency sonar can induce temporary hearing loss in a bottlenose dolphin (Tursiops truncatus). Mild-behavioural alterations were also associated with the exposures. The auditory effects were induced only by repeated exposures to intense sonar pings with total sound exposure levels of 214 dB re: 1 μPa2 s. Data support an increasing energy model to predict temporary noise-induced hearing loss and indicate that odontocete noise exposure effects bear trends similar to terrestrial mammals. Thus, sonar can induce physiological and behavioral effects in at least one species of odontocete; however, exposures must be of prolonged, high sound exposures levels to generate these effects.

Moore, S. E., et al. (2012). "A new framework for assessing the effects of anthropogenic sound on marine mammals in a rapidly changing Arctic." Bioscience 62(3): 289-295.
A new framework for assessing the effects of anthropogenic sound onmarinemammals in a rapidly changing arctic.

Morley, E. L., et al. (2014). The Importance of Invertebrates when Considering the Impacts of Anthropogenic Noise. Proc. R. Soc. B, The Royal Society.
Anthropogenic noise is now recognized as a major global pollutant. Rapidly burgeoning research has identified impacts on individual behavior and physiology through to community disruption. To date, however, there has been an almost exclusive focus on vertebrates. Not only does their central role in food webs and in fulfilling ecosystem services make imperative our understanding of how invertebrates are impacted by all aspects of environmental change, but also many of their inherent characteristics provide opportunities to overcome common issues with the current anthropogenic noise literature. Here, we begin by explaining why invertebrates are likely to be affected by anthropogenic noise, briefly reviewing their capacity for hearing and providing evidence that they are capable of evolutionary adaptation and behavioral plasticity in response to natural noise sources. We then discuss the importance of quantifying accurately and fully both auditory ability and noise content, emphasizing considerations of direct relevance to how invertebrates detect sounds. We showcase how studying invertebrates can help with the behavioral bias in the literature, the difficulties in drawing strong, ecologically valid conclusions and the need for studies on fitness impacts. Finally, we suggest avenues of future research using invertebrates that would advance our understanding of the impact of anthropogenic noise.

Morton, A. B. and H. K. Symonds (2002). "Displacement of Orcinus orca (L.) by high amplitude sound in British Columbia, Canada." ICES Journal of Marine Science: Journal du Conseil 59(1): 71-80.
Whale displacement by acoustic "pollution" has been difficult to document, even in cases where it is strongly suspected, because noise effects can rarely be separated from other stimuli. Two independent studies on the natural history of killer whales (Orcinus orca) monitored frequency of whale occurrence from January 1985 through December 2000 in two adjacent areas: Johnstone Strait and the Broughton Archipelago. Four high-amplitude, acoustic harassment devices (AHDs) were installed throughout 1993 on already existing salmon farms in the Broughton Archipelago, in attempts to deter predation on fish pens by harbour seals (Phoca vitulina Linnaeus). While whale occurrence was relatively stable in both areas until 1993, it then increased slightly in the Johnstone Strait area and declined significantly in the Broughton Archipelago while AHDs were in use. Both mammal-eating and fish-eating killer whales were similarly impacted. Acoustic harassment ended in the Broughton Archipelago in May 1999 and whale occurrence re-established to baseline levels. This study concludes that whale displacement resulted from the deliberate introduction of noise into their environment.

Mukhin, A., et al. (2008). "Acoustic information as a distant cue for habitat recognition by nocturnally migrating passerines during landfall." Behavioral Ecology 19(4): 716-723.
During migration, birds must fly over suboptimal habitats differing from those selected during breeding and wintering. Nocturnally migrating passerines need to assess the suitability of potential stopover habitats during landfall. Before actual landfall, distant cues may play a significant role in habitat selection. In this paper, we studied the possibility that migrant songbirds use acoustic information as distant cues for habitat selection when ceasing flight. We also investigated differences between habitat generalists and specialists in their use of acoustic cues by comparing the proportion of species killed at lighthouses with those captured in mist nets using song playback in both suitable habitats and suboptimal stopover habitats during spring and fall migratory seasons. Our observations showed that during twilight landfall, birds may respond to acoustic cues, especially when visual cues are reduced or absent. This was true for habitat specialists (Eurasian reed warblers and sedge warblers) whose songs are also more attractive to conspecifics and other birds of wetland habitats than to habitat generalists (pied flycatchers and redwings). Adult Eurasian reed warblers had a tendency to be more attracted by acoustic cues than juveniles. This finding suggests that previous experience may play a role in habitat recognition using acoustic stimuli.

Murphy, E. and E. A. King (2011). "Scenario analysis and noise action planning: Modelling the impact of mitigation measures on population exposure." Applied Acoustics 72(8): 487-494.
This paper reports on strategic noise mapping research conducted in Dublin, Ireland. Noise maps are constructed for the day–evening–night-time and night-time periods and levels of population exposure are estimated for the same periods. In methodological terms, the research uses the UK's calculation of road traffic noise (CRTN) method for calculating noise levels in the study area. This method has been adopted as the interim calculation method by the Irish authorities responsible for meeting the obligations set out in the EU Environmental Noise Directive (END). The research also investigates the usefulness of three noise mitigation measures for 'acoustical planning' purposes: traffic reductions, speed reductions and erection of

acoustical barriers. The results indicate that levels of population exposure during night-time are extremely high relative to guideline limits set down by the World Health Organisation. In addition, the results highlight the significant role that certain noise mitigation measures can play in good 'acoustical planning'.

Nachtigall, P. E., et al. (2004). "Temporary threshold shifts after noise exposure in the bottlenose dolphin (Tursiops truncatus) measured using evoked auditory potentials." Marine Mammal Science 20(4): 673-687.

The time course of recovery from temporary threshold shift (TTS) was measured in a bottlenose dolphin, Tursiops truncatus, using an evoked-potential procedure. The envelope-following response (EFR), which is a rhythmic train of auditory brainstem responses (ABR) to sinusoidally amplitude-modulated tones, was used as an indicator of the sound reception by the animal. Variation of the intensity of the stimulus allowed us to measure the animal's hearing via EFR thresholds. During each session, following an initial measure of threshold, the trained animal voluntary positioned itself within a hoop 1 m underwater while a 160 dB re 1 μPa noise of a 4–11 kHz bandwidth was presented for 30 min. After the noise exposure, thresholds were measured again at delays of 5, 10, 15, 25, 45, and 105 min. Measurements were made at test frequencies of 8, 11.2, 16, 22.5, and 32 kHz. The maximum TTS occurred 5 min after exposure and rapidly recovered with a rate of around 1.5 dB per doubling of time. TTS occurred at test frequencies from 8 to 16 kHz, with the maximum at 16 kHz. TTS was negligible at 22.5 kHz and absent at 32 kHz.

Naguib, M., et al. (2013). "Noise annoys: effects of noise on breeding great tits depend on personality but not on noise characteristics." Animal Behavior 85(5): 949-956.

Nemeth, E. and H. Brumm (2009). "Blackbirds sing higher-pitched songs in cities: adaptation to habitat acoustics or side-effect of urbanization?" Animal Behavior 78(3): 637-641.

When animals colonize cities they often have to adapt their physiology, life history and behavior to the novel environment. Songbirds rely on acoustic communication for reproduction, and recent studies indicate that songs vary between urban and nonurban habitats. In cities, birds sing louder or use higher frequencies compared to their conspecifics in forests. These habitat-specific differences in song have been interpreted as an adaptation of the city birds to mitigate acoustic masking by low-frequency traffic noise. We compared the songs of blackbirds, Turdus merula, from the city center of Vienna and the Vienna Woods and found that forest birds sang at lower frequencies and with longer intervals between songs. This difference in song pitch might reflect an adaptation to urban ambient noise. However, the song divergence could also be the result of more intense vocal interaction in the more densely populated city areas or a side-effect of physiological adaptation to urban habitats. We emphasize the need for experimental studies in blackbirds, but also in other species, to clarify a possible causal link between urban acoustics and song characteristics of city birds.

Nemeth, E. and H. Brumm (2010). "Birds and anthropogenic noise: are urban songs adaptive?" The American Naturalist 176(4): 465-475.

In cities with intense low-frequency traffic noise, birds have been observed to sing louder and at a higher pitch. Several studies argue that higher song pitch is an adaptation to reduce masking from noise, and

it has even been suggested that the song divergence between urban and nonurban songs might lead to reproductive isolation. Here we present models of signal transmission to compare the benefits of raised song amplitude and song pitch in terms of sound transmission. We chose two bird species that sing with higher pitch in urban areas, the great tit (Parus major) and the blackbird (Turdus merula). For both species, we calculated communication distances in response to different levels of urban noise and in their natural forest habitats. We found that an increase in vocal pitch increased communication distance only marginally. In contrast, vocal amplitude adjustments had a strong and significantly larger effect. Our results indicate that frequency changes of urban songs are not very effective in mitigating masking from traffic noise. Increased song pitch might not be an adaptation to reduce signal masking but a physiological side effect of singing at high amplitudes or an epiphenomenon of urbanization that is not related to signal transmission.

Nemeth, E., et al. (2013). Bird Song and Anthropogenic Noise: Vocal Constraints may Explain why Birds Sing Higher Frequency Songs in Cities. Proc. R. Soc. B, The Royal Society.
When animals live in cities, they have to adjust their behavior and life histories to novel environments. Noise pollution puts a severe constraint on vocal communication by interfering with the detection of acoustic signals. Recent studies show that city birds sing higher-frequency songs than their conspecifics in non-urban habitats. This has been interpreted as an adaptation to counteract masking by traffic noise. However, this notion is debated, for the observed frequency shifts seem to be less efficient at mitigating noise than singing louder, and it has been suggested that city birds might use particularly high-frequency song elements because they can be produced at higher amplitudes. Here, we present the first phonetogram for a songbird, which shows that frequency and amplitude are strongly positively correlated in the common blackbird (Turdus merula), a successful urban colonizer. Moreover, city blackbirds preferentially sang higher-frequency elements that can be produced at higher intensities and, at the same time, happen to be less masked in lowfrequency traffic noise.

Neuweiler, G. (1989). "Foraging ecology and audition in echolocating bats." Trends in Ecology & Evolution 4(6): 160-166.
The types of echolocation signal and the auditory capacities of echolocating bats are adapted to specific acoustical constraints of the foraging areas. Bats hunting insects above the canopy use low frequencies for echolocation; this is an adaptation to prey detection over long distances. Bats foraging close to and within foliage avoid masking of insect echoes by specializing on 'fluttering target' detection. 'Gleaning' bats are adapted to the auditory detection of very faint noises generated by ground-dwelling prey, and are capable of analysing fine changes in the echo spectrum, which may indicate a stationary prey changing its posture on a substrate. This review of recent research demonstrates that, in bats, foraging ecology and audition are intricately interrelated and interdependent.

Newman, P., et al. (2009). "From landscapes to soundscapes: Introduction to the special issue." Park Science 26(3): 1-5.
The article discusses various reports published within the issue including one by Fristrup on measuring and monitoring anthropogenic sound in the national parks, one by Robert Manning on identifying normative

standards for visitor-caused noise at Muir Woods National Monument, and one by McCusker and Cahill on how National Park Service addressing the soundscape-related issues in park management and planning.

Newman, P., et al. (2013). Monitoring and Managing Anthropogenic Noise in National Parks: Lessons Learned from Field and Laboratory Sstudies. 42nd International Congress and Exposition on Noise Control Engineering 2013: Noise Control for Quality of Life, INTER-NOISE 2013, September 15, 2013 - September 18, 2013, Innsbruck, Austria, OALOsterreichischer Arbeitsring fur Larmbekampfung.
For more than ten years, collaborative social science research initiatives between university researchers, environmental consulting planners, and federal agency programs have advanced understanding of soundscape management in parks. The results of these efforts have been integrated into management processes, enabling managers to monitor and manage acoustic resource and experiential conditions in protected areas. During this time, research methods have been developed and improved. These include measuring and evaluating sounds both in the field and laboratories, using messaging to alter perceptions and behaviors related to sounds, and using a vast array of technologies for measuring and demonstrating sound modeling, replication, presentation, and effects on human physiological response. Case studies demonstrating methodological developments for evaluating perceptions and effects of sounds and measuring and managing visitor soundscape experiences are discussed. Key research findings are presented, suggesting the continued importance of research and management strategies that promote protection of natural sounds and associated visitor experiences.

Noam, L., et al. (2005). "Acoustic Properties of Two Urban Song Dialects in the Orange-Tufted Sunbird (Nectarinia osea) (Propiedades Acústicas de Dos Dialectos del Canto Urbano de Nectarinia osea)." The Auk 122(1): 231-245.
Biologically important acoustic signals must be transmitted from a signaler to a receiver. Over distance, however, sounds may undergo modification through attenuation, degradation, and masking. Recent anthropogenic habitat modification occurring in many places-in urban habitats, in particular-has rapidly changed local topography and atmospheric conditions and generated new patterns of noise that are likely to interfere with communicative signals. As part of a study of microgeographic song dialects in an urban population of Orange-tufted Sunbirds (Nectarinia osea) in Israel, we examined the environmental influences on song transmission and reception in a rapidly developing human-altered environment. We examined the physical properties of the two dialect song types, which exhibit a large difference of 2-3 kHz in the maximum frequency of the trill, using sound transmission measurements to test how both song types propagate through a highly obstructed habitat of buildings and vegetation. Additionally, we examined how ambient noise-in particular, low-frequency noise arising mainly from automobile traffic-affects the transmission of both dialect songs. Finally, using song playback, we investigated the consequences of sound degradation on dialect recognition and discrimination by sunbirds. The dialect containing higher frequencies in the trill was found to undergo severe frequency-dependent attenuation, in which the maximum frequency of the trill notes drops by >2 kHz over a distance of 70-100 m (less than two territories away). Also, the possibility that the use of higher frequencies in that dialect group's song is intended to overcome masking by urban ambient noise, which is concentrated mainly in lower frequencies, was not supported by our findings. Males singing

the high dialect responded differently to playbacks of an intact and an attenuated form of their dialect song. Taken together, our results suggest that the dialect containing higher frequencies in the trill may be unsuitable for effective long-range transmission through this particular sunbird habitat.

Nowacek, D. P., et al. (2007). "Responses of cetaceans to anthropogenic noise." Mammal Review 37(2): 81-115.

Since the last thorough review of the effects of anthropogenic noise on cetaceans in 1995, a substantial number of research reports has been published and our ability to document response(s), or the lack thereof, has improved. While rigorous measurement of responses remains important, there is an increased need to interpret observed actions in the context of population-level consequences and acceptable exposure levels. There has been little change in the sources of noise, with the notable addition of noise from wind farms and novel acoustic deterrent and harassment devices (ADDs/AHDs). Overall, the noise sources of primary concern are ships, seismic exploration, sonars of all types and some AHDs. 2. Responses to noise fall into three main categories: behavioral, acoustic and physiological. We reviewed reports of the first two exhaustively, reviewing all peer-reviewed literature since 1995 with exceptions only for emerging subjects. Furthermore, we fully review only those studies for which received sound characteristics (amplitude and frequency) are reported, because interpreting what elicits responses or lack of responses is impossible without this exposure information. Behavioral responses include changes in surfacing, diving and heading patterns. Acoustic responses include changes in type or timing of vocalizations relative to the noise source. For physiological responses we address the issues of auditory threshold shifts and 'stress', albeit in a more limited capacity; a thorough review of physiological consequences is beyond the scope of this paper. 3. Overall, we found significant progress in the documentation of responses of cetaceans to various noise sources. However, we are concerned about the lack of investigation into the potential effects of prevalent noise sources such as commercial sonars, depth finders and fisheries acoustics gear. Furthermore, we were surprised at the number of experiments that failed to report any information about the sound exposure experienced by their experimental subjects. Conducting experiments with cetaceans is challenging and opportunities are limited, so use of the latter should be maximized and include rigorous measurements and or modelling of exposure.

Ortega, C. P. and C. D. Francis (2012). "Effects of gas-well-compressor noise on the ability to detect birds during surveys in northwest New Mexico." Ornithol. Monogr 74: 78-90.

We used three site types to address whether noise from gas well compressors interfered with our ability to detect birds in the Rattlesnake Canyon Habitat Management Area, San Juan County, New Mexico: (1) gas wells without compressors (control), (2) gas wells with compressors turned off only during surveys (T-off), and (3) gas wells with compressors running during the surveys (T-on). We conducted 571 bird surveys at 294 point-count locations, which were 50–150 m from gas well pads. We measured sound pressure levels (SPLs) at point locations: control mean = 38.6 ± 3.0 (SD) dB(A); T-off mean = 55.0 ± 5.2 dB(A), measured with compressors on; and T-on mean = 52.7 ± 4.5 dB(A). We observed significant differences in species richness, individual abundance, and bird diversity among site types; the differences existed between control and T-on sites and between T-off and T-on sites, but not between control and T-off sites. Species richness, individual

abundance, and species diversity were all significantly and negatively influenced by SPL values. A significantly higher proportion of birds were detected on T-off sites compared with T-on sites for 13 species; this compares with only one species that was detected more at T-on sites than at T-off sites. Our results strongly suggest that noise emitted from gas well compressors significantly impaired our ability to detect birds. We determined that the detection threshold is ~45 dB(A), beyond which noise impairs human ability to detect birds within 60 m. These results are relevant to bird surveys in areas where natural and anthropogenic noise may negatively bias detections.

Owen, M. A., et al. (2004). "Monitoring stress in captive giant pandas (Ailuropoda melanoleuca): behavioral and hormonal responses to ambient noise." Zoo Biology 23(2): 147-164.
Anthropogenic noise may impact captive breeding programs for endangered species. We recorded ambient noise and monitored potential behavioral and hormonal indices of stress in two captive giant pandas for 4 years. Statistical analyses were conducted for each individual separately, which allowed us to generalize only to these two animals. These preliminary findings indicate that ambient noise can have long-lasting effects on stress indices. Days characterized by louder levels of noise were associated with increased locomotion, restless manipulation of the exit door of the enclosure, increased scratching and vocalizations indicative of agitation, and/or increased glucocorticoids excreted in urine. These general effects were modulated by several factors: 1) Brief loud noise evoked behavioral distress, but not pituitary-adrenal activation. More chronic, moderate-amplitude noise was associated with higher levels of glucocorticoids. 2) Some responses were frequency-dependent, with loud low-frequency noise having the greatest impact. 3) Female reproductive condition interacted significantly with noise amplitude for all behavioral measures, with stronger effects for the loudest acute noises. The female appeared especially sensitive to noise during estrus and lactation, and less so during pregnancy/pseudopregnancy and nonreproductive periods. Despite these statistical effects, we found no compelling evidence that these adjustments indicate substantive detrimental effects on well-being or reproduction. Nonetheless, careful monitoring of giant pandas and other captive-held species is advisable, especially during reproductively sensitive periods such as implantation and birth.

Owens, J. L., et al. (2012). "The effects of extended exposure to traffic noise on parid social and risk-taking behavior." Behavioral Processes 91(1): 61-69.
Traffic noise is a prevalent and yet poorly understood anthropogenic disturbance associated with reduced avian diversity, population densities and pairing and mating success. How these systems are affected is not clear as a direct experimental link between noise and behavior underlying these patterns is missing. Here we provide the first empirical evidence of the effects of long-term exposure to simulated traffic noise on social and risk-taking behavior of Carolina chickadees (Poecile carolinensis) and tufted titmice (Baeolophus bicolor). In testing for these effects we compare two hypotheses regarding the effects of noise on behavior. We found that noise increases sociality by reducing nearest neighbor distances and increasing the number of close-perches within study flocks. These behavioral responses mimic those of species in high-risk situations, such as birds in the presence of a predator. These results provide support for the 'Increased Threat Hypothesis,' which argues that chronic traffic noise affects behavior by increasing the perceived level of threat. Although the adaptive value or function of these responses to noise is unknown, they may serve to mitigate any

negative effects of traffic noise. If true, species lacking behavioral plasticity may be more susceptible to effects of traffic noise and other similar acoustic disturbances.

Park, L., et al. (2009). "Modeling and mapping hikers' exposure to transportation noise in Rocky Mountain National Park." Park Science 26(3): 1-10.

Soundscape-related indicators that reflect continuous and spatially diverse measures of natural quiet and human-caused noise can be difficult and costly to measure directly. This research project integrated soundscape and hiker spatial modeling to provide detailed models of noise conditions as experienced by trail hikers around the Bear Lake Road corridor at Rocky Mountain National Park. GPS data were used to generate a spatial model of hiker travel, soundscape modeling software calibrated with field data was used to generate a spatial model of sound, and the models were integrated in a geographic information system to provide insights for a baseline management option scenario. The effects of potential management alternatives can be explored proactively before being deployed in a park or protected area. Specific indicators included percentage of groups' time spent in quiet, percentage of groups experiencing an arbitrary period of natural quiet, and distance/time required to reach natural quiet from any of the trailheads studied. [ABSTRACT FROM AUTHOR]

Parks, S. E., et al. (2007). "Short-and long-term changes in right whale calling behavior: the potential effects of noise on acoustic communication." The Journal of the Acoustical Society of America 122(6): 3725-3731.

The impact of anthropogenic noise on marine mammals has been an area of increasing concern over the past two decades. Most low-frequency anthropogenic noise in the ocean comes from commercial shipping which has contributed to an increase in ocean background noise over the past 150 years. The long-term impacts of these changes on marine mammals are not well understood. This paper describes both shortand long-term behavioral changes in calls produced by the endangered North Atlantic right whale (Eubalaena glacialis) and South Atlantic right whale (Eubalaena australis) in the presence of increased lowfrequency noise. Right whales produce calls with a higher average fundamental frequency and they call at a lower rate in high noise conditions, possibly in response to masking from low-frequency noise. The longterm changes have occurred within the known lifespan of individual whales, indicating that a behavioral change, rather than selective pressure, has resulted in the observed differences. This study provides evidence of a behavioral change in sound production of right whales that is correlated with increased noise levels and indicates that right whales may shift call frequency to compensate for increased band-limited background noise.

Parks, S. E., et al. (2011). "Individual right whales call louder in increased environmental noise." Biology Letters 7(1): 33-35.

The ability to modify vocalizations to compensate for environmental noise is critical for successful communication in a dynamic acoustic environment. Many marine species rely on sound for vital life functions including communication, navigation and feeding. The impacts of significant increases in ocean noise levels from human activities are a current area of concern for the conservation of marine mammals. Here, we document changes in calling behavior by individual endangered North Atlantic right whales (Eubalaena glacialis) in increased background noise. Right whales, like several bird and primate species, respond to periods of increased noise by increasing the amplitude of their calls. This behavior may help maintain the communication range with conspecifics during periods of increased noise. These call modifications have implications for conservation efforts for right whales, affecting both the way whales use sound to communicate and our ability to detect them with passive acoustic monitoring systems.

Parks, S. E., et al. (2009). "Variability in ambient noise levels and call parameters of North Atlantic right whales in three habitat areas." The Journal of the Acoustical Society of America 125(2): 1230-1239.

The North Atlantic right whale inhabits the coastal waters off the east coasts of the United States and Canada, areas characterized by high levels of shipping and fishing activities. Acoustic communication plays an important role in the social behavior of these whales and increases in low-frequency noise may be leading to changes in their calling behavior. This study characterizes the ambient noise levels, including both natural and anthropogenic sources, and right whale upcall parameters in three right whale habitat areas. Continuous recordings were made seasonally using autonomous bottom-mounted recorders in the Bay of Fundy, Canada (2004, 2005), Cape Cod Bay, (2005, 2006), and off the coast of Georgia (2004–2005, 2006–2007). Consistent interannual trends in noise parameters were found for each habitat area, with both the band level and spectrum level measurements higher in the Bay of Fundy than in the other areas. Measured call parameters varied between habitats and between years within the same habitat area, indicating that habitat area and noise levels alone are not sufficient to predict variability in call parameters. These results suggest that right whales may be responding to the peak frequency of noise, rather than the absolute noise level in their environment.

Parris, K. and A. Schneider (2009). "Impacts of traffic noise and traffic volume on birds of roadside habitats." Ecology and Society 14(1).

Roadside habitats are important for a range of taxa including plants, insects, mammals, and birds, particularly in developed countries in which large expanses of native vegetation have been cleared for agriculture or urban development. Although roadside vegetation may provide suitable habitat for many species, resident animals can be exposed to high levels of traffic noise, visual disturbance from passing vehicles, and the risk of collision with cars and trucks. Traffic noise can reduce the distance over which acoustic signals such as song can be detected, an effect known as acoustic interference or masking. Studies from the northern hemisphere show that the singing behavior of birds changes in the presence of traffic noise. We investigated the impact of traffic noise and traffic volume on two species of birds, the Grey Shrike-thrush (Colluricincla harmonica) and the Grey Fantail (Rhipidura fuliginosa), at 58 roadside sites on

the Mornington Peninsula, southeastern Australia. The lower singing Grey Shrike-thrush sang at a higher frequency in the presence of traffic noise, with a predicted increase in dominant frequency of 5.8 Hz/dB of traffic noise, and a total effect size of 209 Hz. In contrast, the higher singing Grey Fantail did not appear to change its song in traffic noise. The probability of detecting each species on a visit to a site declined substantially with increasing traffic noise and traffic volume, with several lines of evidence supporting a larger effect of traffic noise. Traffic noise could hamper detection of song by conspecifics, making it more difficult for birds to establish and maintain territories, attract mates and maintain pair bonds, and possibly leading to reduced breeding success in noisy roadside habitats. Closing key roads during the breeding season is a potential, but untested, management strategy to protect threatened bird species from traffic noise and collision with vehicles at the time of year when they are most vulnerable to their impacts. Other management options include reducing the speed and/or volume of traffic on such roads to an acceptably low level. Ours is the first study to investigate the effect of traffic noise on the singing behavior of birds in the southern hemisphere.

Parris, K., et al. (2009). "Frogs call at a higher pitch in traffic noise." Ecology and Society 14(1).
Male frogs call to attract females for mating and to defend territories from rival males. Female frogs of some species prefer lower-pitched calls, which indicate larger, more experienced males. Acoustic interference occurs when background noise reduces the active distance or the distance over which an acoustic signal can be detected. Birds are known to call at a higher pitch or frequency in urban noise, decreasing acoustic interference from low-frequency noise. Using Bayesian linear regression, we investigated the effect of traffic noise on the pitch of advertisement calls in two species of frogs, the southern brown tree frog (Litoria ewingii) and the common eastern froglet (Crinia signifera). We found evidence that L. ewingii calls at a higher pitch in traffic noise, with an average increase in dominant frequency of 4.1 Hz/dB of traffic noise, and a total effect size of 123 Hz. This frequency shift is smaller than that observed in birds, but is still large enough to be detected by conspecific frogs and confer a significant benefit to the caller. Mathematical modelling predicted a 24% increase in the active distance of a L. ewingii call in traffic noise with a frequency shift of this size. Crinia signifera may also call at a higher pitch in traffic noise, but more data are required to be confident of this effect. Because frog calls are innate rather than learned, the frequency shift demonstrated by L. ewingii may represent an evolutionary adaptation to noisy conditions. The phenomenon of frogs calling at a higher pitch in traffic noise could therefore constitute an intriguing trade-off between audibility and attractiveness to potential mates.

Parris, K. M. and M. A. McCarthy (2013). "Predicting the effect of urban noise on the active space of avian vocal signals." The American Naturalist 182(4): 452-464.
Urbanization changes the physical environment of nonhuman species but also markedly changes their acoustic environment. Urban noise interferes with acoustic communication in a range of animals, including birds, with potentially profound impacts on fitness. However, a mechanistic theory to predict which species of birds will be most affected by urban noise is lacking. We develop a mathematical model to predict the decrease in the active space of avian vocal signals after moving from quiet forest habitats to noisy urban habitats. We find that the magnitude of the decrease is largely a function of signal frequency. However, this

relationship is not monotonic. A metaregression of observed increases in the frequency of birdsong in urban noise supports the model's predictions for signals with frequencies between 1.5 and 4 kHz. Using results of the metaregression and the model described above, we show that the expected gain in active space following observed frequency shifts is up to 12% and greatest for birds with signals at the lower end of this frequency range. Our generally applicable model, along with three predictions regarding the behavioral and population-level responses of birds to urban noise, represents an important step toward a theory of acoustic communication in urban habitats.

Patenaude, N. J., et al. (2002). "Aircraft sound and disturbance to bowhead and beluga whales during spring migration in the Alaskan Beaufort Sea." Marine Mammal Science 18(2): 309-335.
Short-term behavioral responses of bowhead whales (Balaena mysticetus) and beluga whales (Delphinapterus leucas) to a Bell 212 helicopter and Twin Otter fixed-wing aircraft were observed opportunistically during four spring seasons (1989–1991 and 1994). Behaviors classified as reactions consisted of short surfacings, immediate dives or turns, changes in behavior state, vigorous swimming, and breaching.The helicopter elicited fewer detectable responses by bowheads (14% of 63 groups) than by belugas (38% of 40). Most observed reactions by bowheads (63%) and belugas (86%) occurred when the helicopter was at altitudes ≤150 m and lateral distances ≤250 m. Belugas reacted significantly more frequently during overflights at lateral distances ≤250 m than at longer lateral distances (P= 0.004). When the helicopter was on the ice with engines running, 7 of 14 groups of belugas reacted, up to 320 m away, sometimes with small-scale (≤100 m) diversion; only 1 of 8 groups of bowheads reacted. For the fixed-wing aircraft, few bowheads (2.2%) or belugas (3.2%) were observed to react to overflights at altitudes 60–460 m. Most observed reactions by bowheads (73%) and belugas (70%) occurred when the fixed-wing aircraft was at altitudes ≤182 m and lateral distances ≤250 m. However, the proportions reacting, especially to lowaltitude flights (e. g., ≤182 m), were underestimated for both species because observation opportunities were brief. Even so, reactions were more common when the aircraft was low (≤182 m): P= 0.009 for belugas, P= 0.06 for bowheads. There was little if any reaction by bowheads when the aircraft circled at altitude 460 m and radius 1 km.Aircraft sounds measured underwater at depths 3 m and 18 m showed that a Bell 212 helicopter was 7–17.5 dB noisier than a Twin Otter (10–500 Hz band). Bell 212 sound consisted mainly of main rotor tones ahead of the helicopter and tail rotor tones behind it. Twin Otter sound contained fewer prominent tones. Peak sound level as received underwater was inversely related to aircraft altitude, and received levels at 3 m depth averaged 2.5 dB higher than at 18 m depth. The dominant low-frequency components of aircraft sound are presumed to be readily audible to bowheads. For belugas, these components may be inaudible, or at most only weakly audible. Mid-frequency sound components, visual cues, or both, are probably important in eliciting beluga reactions to aircraft.

Pater, L. L., et al. (2009). "Recommendations for improved assessment of noise impacts on wildlife." Journal of Wildlife Management 73(5): 788-795.
Research to determine noise impacts on animals benefits from methodology that adequately describes the acoustical stimulus as well as the resulting biological responses. We present acoustical considerations and research techniques that we have found to be useful. These include acoustical definitions and noise

measurement techniques that conform to standardized acoustical practice and advice for controlled experimentation to supplement behavioral observation. Specific considerations include characteristics of noise stimulus, selection of noise metrics, use of frequency-weighting algorithms tailored to a specific animal species, selection and placement of noise measurement equipment, and methods for documenting animal responses. We also present arguments for measuring the noise stimulus at the location and time of each response observation. Our purpose is to recommend some baseline terminology, metrics, and techniques prerequisite to effective assessment of noise impacts on terrestrial wildlife whenever and wherever potential conflicts arise.

Patón, D., et al. (2012). "Tolerance to noise in 91 bird species from 27 urban gardens of Iberian Peninsula." Landscape and Urban Planning 104(1): 1-8.

Urban noise is one of the most important factors explaining the abundance of birds in urban areas. If urban planners have information on the effects of noise on diverse avian species, they can design better gardens that can be useful for the conservation of endangered species. In this sense, many studies have been realized in diverse urban areas across the world. However, information on the exact effects of noise on urban birds in SW Iberian Peninsula does not exist. In this paper, we show the first study on the effects of urban noise on 91 bird species in 27 parks in diverse cities and villages of Spain and Portugal. Our study includes from rural areas with noise levels below 40 dB, to parks inside big cities such as Madrid and Sevilla that surpass 70 dB. The range of noise conditions, studied parks and the seasonal and annual replication of this study permits extraction clears conclusions. In this sense, the ten species most affected by noise, in terms of percentage of explained variance, are: Regulus regulus with 34.62% variability associated with noise, Streptopelia turtur (24.24%), Dendrocopos minor (20.39%), Buteo buteo (15.15%), Hirundo daurica (13.15), Corvus corax (11.09%), Oriolus oriolus (10.23%), Cettia cetti (6.47%), Passer hispanoliensis (6.33%) and Sylvia melanocephala (5.82%). Our data demonstrates that many of these protected species could be attract to urban gardens if noise levels were reduced below 50 dB by using, for example, acoustic barriers.

Patricelli, G. L. and J. L. Blickley (2006). "Avian communication in urban noise: causes and consequences of vocal adjustment." The Auk 123(3): 639-649.

The "acoustic adaptation" hypothesis (Morton 1975, Wiley and Richards 1978, Richards and Wiley 1980, Ryan and Brenowitz 1985) laid the groundwork for the "sensory drive" concept (Endler 1992), which describes how environment affects the evolution of sensory systems and signals in all modalities. By allowing us to examine animal signals as adaptations shaped by selection, this framework has lead to a greater understanding of the bewildering diversity of animal signals. One of the environmental factors that exerts selection pressure on acoustic signals is ambient noise (Ryan and Brenowitz 1985). To elicit a response from a receiver, signals must be detectable in background noise; the detectability of a signal is determined by the signal-to-noise ratio (SNR) and the masked auditory detection threshold of the receiver (Marten and Marler 1977, Brenowitz 1982, Dooling 2004). Within a given frequency band, signals with an SNR below the detection threshold of the receiver are "masked." Background noise thus plays a fundamental role in determining which "receivers" can hear a vocalization and the fidelity of the signal received. Noise varies among locations, and there is evidence that many species have evolved signals that maximize the habitat-specifi c SNR (reviewed in Brumm

and Slabbekoorn 2005). For birds in and around urban areas and roads, the background noise is largely anthropogenic. Urban development thus provides a unique opportunity for a "natural" experiment studying how signals change in response to rapid change in the acoustic environment. This natural experiment can inform us about how sensory drive can change signals and about the mechanism by which these changes occur. Understanding this process also has important conservation implications, allowing us to predict how birds will adjust to urban development and potentially to mitigate the eff ects of this development on communicating birds. In this issue of The Auk, Wood and Yezerinac (2006) present evidence that Song Sparrows (Melospiza melodia) adjust their vocalizations to reduce masking by urban noise, and they propose and discuss several mechanisms by which these changes may arise. In a study of urban Song Sparrows in Portland, Oregon, Wood and Yezerinac found a positive relationship between the minimum frequency of male song and the amplitude of anthropogenic noise. They also found that males shied more energy into the higher frequencies (4–9 kHz) of their songs in noisy areas. Urban noise is loudest between 1–2 kHz, so both of these responses should serve to decrease masking by shiing the spectral energy of the vocalization away from the spectral energy of the noise (Lohr et al. 2003). These results suggest that Song Sparrows, like several other birds (Slabbekoorn and Peet 2003, Brumm 2004b, Fernández-Juricic et al. 2005), respond to changes in the acoustic environment by altering their songs; we refer to this process as "vocal adjustment." All known examples of avian vocal adjustment in response to urban noise have involved song, but other types of vocalizations—such as begging calls, alarm calls, and food calls—may also be adjusted (Warren et al. 2006). In this overview, we ask three questions: (1) what features of a bird's vocalization can be adjusted to reduce masking, (2) how do these adjustments come about, and (3) what are the consequences of these changes for individual fi tness and population persistence? The answers to these questions depend on the morphological, developmental, and behavioral underpinnings of the vocalization, and the context in which the vocalization is used. This is an area where knowledge of physiology, developmental neurobiology, animal behavior, and behavioral ecology all contribute to understanding how animals adjust (or fail to adjust) to anthropogenic change.

Penna, M. and C. Hamilton-West (2007). "Susceptibility of evoked vocal responses to noise exposure in a frog of the temperate austral forest." Animal Behavior 74(1): 45-56.

Animals that communicate by means of acoustic signals show diverse strategies in the presence of noise interference. Penna et al. (2005, Animal Behavior, 70, 639–651) found that the leptodactylid frog Eupsophus calcaratus from the temperate austral forest increases its vocal output in the presence of natural noises and a band-pass noise overlapping the main spectral components of its advertisement call. We subjected the sympatric species E. emiliopugini to similar experimental conditions to assess its response to noise exposure. Male E. emiliopugini showed no increase in vocal activity in the presence of moderate noise levels (67 dB RMS SPL, fast weighting) and decreased their vocal output in the presence of band-pass noise of increasing intensity (49–85 dB RMS SPL, fast weighting). However, E. emiliopugini, like E. calcaratus, increased the amplitude of their vocal responses in these circumstances. The vocal responses of males of E. emiliopugini under noise exposure and their contrast with the congeneric species unveil different strategies in confronting interference, whose origins and adaptive significance warrant further study.

Penna, M., et al. (2005). "Effect of natural and synthetic noise on evoked vocal responses in a frog of the temperate austral forest." Animal Behavior 70(3): 639-651.

Animals using sound communication have developed different strategies to overcome noise interference, but studies have rarely examined animals behaving in their natural environments. Males of the leptodactylid frog Eupsophus calcaratus exposed to natural noises of wind, rain, creek and sea surf and to a band-pass noise encompassing the main spectral components of the conspecific advertisement call increased their call rate in the presence of noises of moderate level, and this effect was particularly strong for the band-pass noise. Frogs exposed to band-pass noise of different intensities increased their call rate in response to exposures of 66–78 dB RMS sound pressure level. Call duration followed similar trends, but the effects of noise exposure on this measure of evoked vocal response were not as strong as those on call rate. The vocal responsiveness of males of this species in the presence of noise denotes adaptations to cope with high interference, in spite of the relatively simple acoustic environment of the austral temperate forest.

Perry, E. A., et al. (2002). "Effects of sonic booms on breeding gray seals and harbor seals on Sable Island, Canada." The Journal of the Acoustical Society of America 111(1): 599-609.

The Concorde produces audible sonic booms as it passes 15 km north of Sable Island, Nova Scotia, where gray and harbor seals occur year round. The purpose of this research was to assess how sonic booms affect these seals. The intensity of the booms was measured and three types of data (beach counts, frequency of behavior, and heart rate) were collected before and after booms during the breeding seasons of the two species. In addition to the data taken during breeding, beach counts were made before and after booms during the gray seal moult. The greatest range in overpressure within a single boom was 2.70 psf during gray seal breeding and 2.07 psf during harbor seal breeding. No significant differences were found in the behavior or beach counts of gray seals following sonic booms, regardless of the season. Beach counts and most behaviors of harbor seals also did not differ significantly following booms, however, harbor seals became more vigilant. The heart rates of four gray seal mothers and three pups showed no clear change as a result of booms, but six male harbor seals showed a nonsignificant tendency toward elevated heart rates during the 15-s interval of the boom. These results suggest sonic booms produced by the Concorde, in level flight at altitude and producing on average a sonic boom of 0.9 psf, do not substantially affect the breeding behavior of gray or harbor seals.

Pheasant, R. J., et al. (2010). "The importance of auditory-visual interaction in the construction of 'tranquil space'." Journal of Environmental Psychology 30(4): 501-509.

In a world of sensory overload it is becoming increasingly Important to provide environments that enable us to recover our sense of well being Such restorative (tranquil) environments need to comprise sufficient sensory stimulation to keep us engaged whilst at the same time providing opportunity for reflection and relaxation One essential aspect in safeguarding existing or developing new tranquil space is understanding the optimum relationship between the soundscape and the visual composition of a location This research represents a first step in understanding the effects of audio-visual interaction on the perception of tranquillity and identifies how the interpretation of acoustic information is an integral part of this process By using uni and bi-modal auditory-visual stimuli in a two stage experimental strategy it has been possible to measure the key components of the

tranquillity construct The findings of this work should be of particular interest to those charged with landscape management such as National Park Authorities Regional Councils and other agencies concerned with providing and maintaining public amenity (C) 2010 Elsevier Ltd All rights reserved

Picciulin, M., et al. (2010). "In situ behavioral responses to boat noise exposure of Gobius cruentatus (Gmelin, 1789; fam. Gobiidae) and Chromis chromis (Linnaeus, 1758; fam. Pomacentridae) living in a Marine Protected Area." Journal of Experimental Marine Biology and Ecology 386(1): 125-132.
The short-term behavioral effects of two types of boat noise were tested on Gobius cruentatus and Chromis chromis, i.e. one permanently and one temporarily benthic vocal fish species living inside the WWF-Natural Miramare Marine Reserve (Northern Adriatic Sea, Italy). The underwater noises produced by a 26-m tourist ferry and a 5-m fiberglass boat were recorded inside the core zone of the reserve. Each type of boat noise was subsequently played back in situ to 10 animals per species (C. chromis males caring their nests or G. cruentatus in their shelters). The 1/3 octave spectra of recorded sound pressure levels were compared to the underwater ambient noise level and to sound pressure level measured at the hearing threshold of the two species. The boat noise levels have been calculated in terms of particle acceleration for both field measurements and in situ playback projections and subsequently compared to the available measured values of particle acceleration at the hearing threshold.The animals were free to move in all directions during the whole experimental session. The behavior of each fish was videotaped by an underwater camera for a total of 10 min (5 min before and 5 min during the noise playback). No short-term behavioral reaction (aversion) was observed in any of the specimen of the two species during the playback of the recorded noises, therefore suggesting no impact. However a time-budget analysis revealed a significant change in the total time spent in caring their nests (C. chromis) or inside their shelters (G. cruentatus). This result highlighted how analyzing fish reaction on a short-term might underestimate the effects of noise disturbance and indicated that the overall fish behavior should be considered to assess noise impact.

Pieretti, N. and A. Farina (2013). "Application of a recently introduced index for acoustic complexity to an avian soundscape with traffic noise." The Journal of the Acoustical Society of America 134(1): 891-900.
An altered acoustic environment can have severe consequences for natural communities, especially for species that use acoustic signals to communicate and achieve breeding success. Numerous studies have focused on traffic noise disturbance, but the possible causes of road effects are inter-correlated and the literature on noise qua noise is sometimes contradictory. To provide further empirical data in this regard, the authors investigated the spatio-temporal variability of the singing dynamics of an avian community living in an acoustic context altered by traffic noise. Fieldwork was carried out in a wood of Turkey oaks (central Italy) bordered on one side by a main road. The soundscape was examined by positioning eight digital recorders, distributed in two transects perpendicular to the road, and recording between 6:30 and 8.30 a.m. for 12 continuous sessions. The acoustic complexity index was used to obtain a quantification of singing dynamics, which were positively correlated with traffic noise. This may indicate that birds try to propagate their signals with greater emphasis (e.g., amplified redundancy or loudness of the songs) to override the masking effect

of noise. Nevertheless, an ecotonal effect could have influenced the correlation results, with this enhanced dynamic possibly being due to a more densely populated environment.

Pijanowski, B. C., et al. (2011). "What is soundscape ecology? An introduction and overview of an emerging new science." Landscape Ecology 26(9): 1213-1232.

We summarize the foundational elements of a new area of research we call soundscape ecology. The study of sound in landscapes is based on an understanding of how sound, from various sources-biological, geophysical and anthropogenic-can be used to understand coupled natural-human dynamics across different spatial and temporal scales. Useful terms, such as soundscapes, biophony, geophony and anthrophony, are introduced and defined. The intellectual foundations of soundscape ecology are describedthose of spatial ecology, bioacoustics, urban environmental acoustics and acoustic ecology. We argue that soundscape ecology differs from the humanities driven focus of acoustic ecology although soundscape ecology will likely need its rich vocabulary and conservation ethic. An integrative framework is presented that describes how climate, land transformations, biodiversity patterns, timing of life history events and human activities create the dynamic soundscape. We also summarize what is currently known about factors that control temporal soundscape dynamics and variability across spatial gradients. Several different phonic interactions (e.g., how anthrophony affects biophony) are also described. Soundscape ecology tools that will be needed are also discussed along with the several ways in which soundscapes need to be managed. This summary article helps frame the other more application-oriented papers that appear in this special issue.

Pijanowski, B. C., et al. (2011). "Soundscape Ecology: The Science of Sound in the Landscape." Bioscience 61(3): 203-216.

This article presents a unifying theory of soundscape ecology, which brings the idea of the soundscape----the collection of sounds that emanate from landscapes----into a research and application focus. Our conceptual framework of soundscape ecology is based on the causes and consequences of biological (biophony), geophysical (geophony), and human-produced (anthrophony) sounds. We argue that soundscape ecology shares many parallels with landscape ecology, and it should therefore be considered a branch of this maturing field. We propose a research agenda for soundscape ecology that includes six areas: (1) measurement and analytical challenges, (2) spatial-temporal dynamics, (3) soundscape linkage to environmental covariates, (4) human impacts on the soundscape, (5) soundscape impacts on humans, and (6) soundscape impacts on ecosystems. We present case studies that illustrate different approaches to understanding soundscape dynamics. Because soundscapes are our auditory link to nature, we also argue for their protection, using the knowledge of how sounds are produced by the environment and humans.

Pine, M. K., et al. (2012). "Turbine sound may influence the metamorphosis behavior of estuarine crab megalopae." PLoS ONE 7(12): e51790.

It is now widely accepted that a shift towards renewable energy production is needed in order to avoid further anthropogenically induced climate change. The ocean provides a largely untapped source of renewable energy. As a result, harvesting electrical power from the wind and tides has sparked immense

government and commercial interest but with relatively little detailed understanding of the potential environmental impacts. This study investigated how the sound emitted from an underwater tidal turbine and an offshore wind turbine would influence the settlement and metamorphosis of the pelagic larvae of estuarine brachyuran crabs which are ubiquitous in most coastal habitats. In a laboratory experiment the median time to metamorphosis (TTM) for the megalopae of the crabs Austrohelice crassa and Hemigrapsus crenulatus was significantly increased by at least 18 h when exposed to either tidal turbine or sea-based wind turbine sound, compared to silent control treatments. Contrastingly, when either species were subjected to natural habitat sound, observed median TTM decreased by approximately 21–31% compared to silent control treatments, 38–47% compared to tidal turbine sound treatments, and 46–60% compared to wind turbine sound treatments. A lack of difference in median TTM in A. crassa between two different source levels of tidal turbine sound suggests the frequency composition of turbine sound is more relevant in explaining such responses rather than sound intensity. These results show that estuarine mudflat sound mediates natural metamorphosis behavior in two common species of estuarine crabs, and that exposure to continuous turbine sound interferes with this natural process. These results raise concerns about the potential ecological impacts of sound generated by renewable energy generation systems placed in the nearshore environment.

Pirotta, E., et al. (2012). "Vessel noise affects beaked whale behavior: results of a dedicated acoustic response study." PLoS ONE 7(8): e42535.

Some beaked whale species are susceptible to the detrimental effects of anthropogenic noise. Most studies have concentrated on the effects of military sonar, but other forms of acoustic disturbance (e.g. shipping noise) may disrupt behavior. An experiment involving the exposure of target whale groups to intense vesselgenerated noise tested how these exposures influenced the foraging behavior of Blainville's beaked whales (Mesoplodon densirostris) in the Tongue of the Ocean (Bahamas). A military array of bottom-mounted hydrophones was used to measure the response based upon changes in the spatial and temporal pattern of vocalizations. The archived acoustic data were used to compute metrics of the echolocation-based foraging behavior for 16 targeted groups, 10 groups further away on the range, and 26 non-exposed groups. The duration of foraging bouts was not significantly affected by the exposure. Changes in the hydrophone over which the group was most frequently detected occurred as the animals moved around within a foraging bout, and their number was significantly less the closer the whales were to the sound source. Non-exposed groups also had significantly more changes in the primary hydrophone than exposed groups irrespective of distance. Our results suggested that broadband ship noise caused a significant change in beaked whale behavior up to at least 5.2 kilometers away from the vessel. The observed change could potentially correspond to a restriction in the movement of groups, a period of more directional travel, a reduction in the number of individuals clicking within the group, or a response to changes in prey movement.

Pohl, N. U., et al. (2012). "Great tits in urban noise benefit from high frequencies in song detection and discrimination." Animal Behavior 83(3): 711-721.

Field studies in urban environments have shown that birds sing with higher frequencies in response to noise, but so far there are no perceptual data showing benefits of high-frequency songs over low-frequency

songs under typical urban noise conditions. In this study we investigated the potential effects of specific frequency use in different environments on the perceptual performance of trained great tits, Parus major, in the laboratory. Test signals consisted of song phrases shifted both up and down in frequency. The subjects had either to detect test songs or to discriminate between test songs in both urban and woodland noise conditions. In the detection experiment, auditory thresholds were on average 6 dB better for high- than lowfrequency song variants in urban noise, while in woodland noise there was no difference in detectability. In the discrimination experiment, the great tits showed different patterns of discrimination in urban compared to woodland noise conditions. Discrimination between low-frequency song variants in urban noise was less efficient than discriminating between other frequency variants, which was not the case in woodland noise. Our analysis revealed that features concerning the high-frequency elements of the songs were used in urban noise, while the birds used more features of the whole songs to solve the discrimination task in woodland noise. Our results on the perceptual abilities of birds under urban noise conditions provide rare and novel insights on the receiver side complementing many studies on noise-level-dependent frequency use on the sender side.

Pohl, N. U., et al. (2009). "Effects of signal features and environmental noise on signal detection in the great tit, Parus major." Animal Behavior 78(6): 1293-1300.
Environmental noise caused by human activities may hamper acoustic communication in animals. Field studies in urban environments suggest that birds may alter their communicative behavior in response to noise, but there is little experimental evidence for a detrimental effect of urban noise on perception. We investigated the masking effects of urban noise on signal detection using operant tests with great tits in the laboratory. We compared masking effects induced by urban noise, woodland noise and a typical dawn chorus, including a variety of singing birds. Maskers were presented at their natural sound pressure level and masking conditions were compared to a silent no-masker condition. The signals to be detected were composed of artificial sinusoids and noise bands mimicking signal features of natural great tit song elements. Both masker condition and signal feature significantly affected signal detection in the captive great tits. Deteriorated auditory thresholds in woodland and urban noise required the signal to be on average 12 dB and 18 dB louder than in the no-masker condition, respectively. The dawn chorus masker showed the most dramatic shift in auditory threshold of about 29 dB. Signals with the sound energy concentrated within a narrow frequency range were on average easier to detect than signals spread over a wide frequency range. Our perceptual results provide insight into how birds may counteract negative masking effects by singing song elements with specific features.

Popper, A. N., et al. (2007). "The effects of high-intensity, low-frequency active sonar on rainbow trout." The Journal of the Acoustical Society of America 122(1): 623-635.
This study investigated the effects on rainbow trout (Oncorhynchus mykiss) of exposure to high-intensity, low-frequency sonar using an element of the standard Surveillance Towed Array Sensor System Low Frequency Active (LFA) sonar source array. Effects of the LFA sonar on hearing were tested using auditory brainstem responses. Effects were also examined on inner ear morphology using scanning electron microscopy and on nonauditory tissues using general pathology and histopathology. Animals were exposed

to a maximum received rms sound pressure level of 193dB193dB re 1µPa21µPa2 for 324 or 648s648s, an exposure that is far in excess of any exposure a fish would normally encounter in the wild. The most significant effect was a 20-dB20-dB auditory threshold shift at 400Hz400Hz. However, the results varied with different groups of trout, suggesting developmental and/or genetic impacts on how sound exposure affects hearing. There was no fish mortality during or after exposure. Sensory tissue of the inner ears did not show morphological damage even several days post–sound exposure. Similarly, gross- and histopathology observations demonstrated no effects on nonauditory tissues.

Popper, A. N., et al. (2005). "Effects of exposure to seismic air gun use on hearing of three fish species." The Journal of the Acoustical Society of America 117(6): 3958-3971.
Seismic airguns produce considerable amounts of acoustic energy that have the potential to affect marine life. This study investigates the effects of exposure to a 730 in.3730 in.3 air gun array on hearing of three fish species in the Mackenzie River Delta, the northern pike (Esox lucius), broad whitefish (Coregonus nasus), and lake chub (Couesius plumbeus). Fish were placed in cages in the 1.9 m of water and exposed to five or 20 air gun shots, while controls were placed in the same cage but without air gun exposure. Hearing in both exposed and control fish were then tested using the auditory brainstem response (ABR). Threshold shifts were found for exposed fish as compared to controls in the northern pike and lake chub, with recovery within 24 hours of exposure, while there was no threshold shift in the broad whitefish. It is concluded that these three species are not likely to be substantially impacted by exposure to an air gun array used in a river seismic survey. Care must be taken, however, in extrapolation to other species and to fishes exposed to airguns in deeper water or where the animals are exposed to a larger number of air gun shots over a longer period of time.

Potvin, D. A. and R. A. Mulder (2013). "Immediate, independent adjustment of call pitch and amplitude in response to varying background noise by silvereyes (Zosterops lateralis)." Behavioral Ecology 24(6): 1363-1368.
Many birds raise the pitch of their vocalizations in urban environments, a shift generally attributed to avoidance of low frequencies vulnerable to masking by anthropogenic noise (acoustic adaptation hypothesis [AAH]). However, high frequencies could just be an incidental byproduct of singing more loudly (Lombard hypothesis). If birds cope with background noise by singing more loudly and increases in frequency are byproducts of increased amplitudes, they should respond with louder songs (and increased pitch) to either high- (HFN) or low-frequency noise (LFN) of similar amplitude. However, if birds adaptively adjust frequency to minimize interference, they should increase frequency in response to LFN but decrease it in response to HFN. We exposed silvereyes (Zosterops lateralis), which use higher songs and calls in urban areas, to highand low-frequency background noise of standardized amplitude. Silvereyes from both rural and urban areas exposed to HFN responded by lowering the minimum frequencies of their calls, and this shift was independent of call amplitude, which increased in all noise treatments. These findings support the AAH. Calls during HFN treatments were also longer than those made during quiet treatments. Our results suggest that silvereyes are capable of flexible adjustments of call frequency, amplitude, and duration to maximize signal-to-noise ratio in noisy environments.

Potvin, D. A., et al. (2011). "Geographically pervasive effects of urban noise on frequency and syllable rate of songs and calls in silvereyes (Zosterops lateralis)." Proceedings of the Royal Society of London B: Biological Sciences 278(1717): 2464-2469.

Recent studies in the Northern Hemisphere have shown that songbirds living in noisy urban environments sing at higher frequencies than their rural counterparts. However, several aspects of this phenomenon remain poorly understood. These include the geographical scale over which such patterns occur (most studies have compared local populations), and whether they involve phenotypic plasticity or microevolutionary change. We conducted a field study of silvereye (Zosterops lateralis) vocalizations over more than 1 million km2 of urban and rural south-eastern Australia, and compared possible effects of urban noise on songs (which are learned) and contact calls (which are innate). Across 14 paired urban and rural populations, silvereyes consistently sang both songs and contact calls at higher frequencies in urban environments. Syllable rate (syllables per second) decreased in urban environments, consistent with the hypothesis that reflective structures degrade song and encourage longer intervals between syllables. This comprehensive study is, to our knowledge, the first to demonstrate varied adaptations of urban bird vocalizations over a vast geographical area, and to provide insight into the mechanism responsible for these changes.

Powell, D. M., et al. (2006). "Effects of construction noise on behavior and cortisol levels in a pair of captive giant pandas (Ailuropoda melanoleuca)." Zoo Biology 25(5): 391-408.

Studies of the effects of ambient noise on animals have found variable results. A study was conducted at the Smithsonian's National Zoological Park to determine what effect short-term demolition work would have on the behavior and cortisol excretion of giant pandas. Behavioral and endocrine differences were examined during the presence and absence of demolition work being conducted on an adjacent exhibit complex. High frequency noise was significantly louder on work days compared to non-work days. Panda activity budgets differed significantly between work and post-work periods, although in different ways. The male's use of substrates and locations that might be associated with refuge or shelter changed during the study; the female did not show similar changes. He spent more time in the enclosure adjacent to the work site rather than a more distant enclosure during the demolition period whether work was occurring or not. The behavior of both animals was more often characterized as "restless" during, as opposed to before or after the work period. In general, cortisol excretion increased during the study in both animals but this was likely a seasonal effect in the male. In many cases, significant short-term increases in cortisol were temporally associated with certain kinds of construction noises or specific physiological events. Variability in cortisol secretion fluctuated during the study for both animals but in differing patterns. These results demonstrate that demolition noise was associated with behavioral and some physiological changes in giant pandas, and these changes were individual-specific. Zoo Biol 0:1–18, 2006. © 2006 Wiley-Liss, Inc.

Preisler, H. K., et al. (2006). "Statistical methods for analysing responses of wildlife to human disturbance." Journal of Applied Ecology 43(1): 164-172.

1. Off-road recreation is increasing rapidly in many areas of the world, and effects on wildlife can be highly detrimental. Consequently, we have developed methods for studying wildlife responses to off-road recreation with the use of new technologies that allow frequent and accurate monitoring of human–

wildlife interactions. To illustrate these methods, we studied the response of Rocky Mountain elk Cervus elaphus L. to all-terrain vehicles (ATVs), one of the most prominent forms of summer recreation in North America. We studied elk because the species is not only of keen economic and social interest across North America and Europe but also exemplifies species that can be sensitive to human disturbance.

2. The study was part of a controlled landscape experiment where global positioning system (GPS)-equipped recreationists traversed an established 32-km route inside a 1453-ha elk-proof enclosure. Elk locations before and during the human disturbances were monitored using an automated telemetry system. The unique data set and study objectives led to our development of statistical methods for analysing the response of wildlife to human disturbance.
3. We developed a statistical method, referred to as a probabilistic flight response, which accounted for daily circadian rhythms in movement behavior of elk, and related the probability of flight to distance to the disturbance and a number of environmental covariates. We also present methods for estimating spatially and temporally explicit movement vectors as a way of detecting and visualizing landscape-level movement patterns.
4. Using these methods, we observed that elk appeared to respond at relatively long distances (> 1000 m) to ATVs, and that the estimated probability of flight appeared to be higher when elk were closer to the ATV routes, even when the distance to an ATV was large.
5. Synthesis and applications. Our study quantifies the response of wildlife to human disturbance at a resolution well beyond previous work, and provides methods to improve our understanding of wildlife–human interactions related to management of wildlife and recreation. These methods may be used for any study involving accurate, frequent monitoring of animals and humans with the use of GPS or similar technologies now commonly available.

Proppe, D., et al. (2013). "Physical condition of Black-capped Chickadees (Poecile atricapillus) in relation to road disturbance." Canadian Journal of Zoology 91(11): 842-845.

Roads and their associated low-frequency noise have been linked with a reduction in abundance and density for many songbird species. However, a handful of species remain equally abundant in roadside habitats and nondisturbed areas. Abundance is a valuable baseline indicator of a species' ability to adapt to habitats altered by roads, but does not directly ascertain whether health is affected in these species. Here we examine whether Black-capped Chickadees (Poecile atricapillus (L., 1766)), a species that remains abundant near roads, exhibit higher levels of chronic stress or reduced physical condition when residing near roads. Neither hematological measures of chronic stress, nor any of our measures of physical condition, differed significantly between Black-capped Chickadees inhabiting areas near or far from roads. Our results suggest that health and physical condition, like abundance, are not significantly affected by roads in the Black-capped Chickadee. This species may be an ideal model for understanding how some songbird species adapt to roads and the noise that they produce.

Proppe, D. S., et al. (2012). "Black-capped chickadees Poecile atricapillus sing at higher pitches with elevated anthropogenic noise, but not with decreasing canopy cover." Journal of Avian Biology 43(4): 325-332.

Several songbird species sing at higher frequencies (i.e. higher pitch) when anthropogenic noise levels are elevated. Such frequency shifting is thought to be an adaptation to prevent masking of bird song by anthropogenic noise. However, no study of this phenomenon has examined how vegetative differences between noisy and quiet sites influence frequency shifting. Variation in vegetative structure is important because the acoustic adaptation hypothesis predicts that birds in more open areas should also sing at higher frequencies. Thus, vegetative structure may partially explain the observation of higher frequency songs in areas with high levels of anthropogenic noise. To distinguish between frequency shifting due to noise or vegetative structure we recorded the songs of black-capped chickadees Poecile atricapillus vocalizing in high and low noise sites with open and closed canopy forests. Consistent with the noise dependent frequency hypothesis, black-capped chickadees sang at higher frequencies in high noise sites than in low noise sites. In contrast, birds did not sing at higher frequencies in sites with more open canopies. These results suggest that frequency shifting in chickadees is more strongly related to ambient noise levels than to vegetative structure. A second frequency measure, inter-note ratio, was reduced at higher levels of canopy cover. We speculate that this may be due to a non-random distribution of dominant males. In sum, our results support the hypothesis that some birds sing at higher frequencies to avoid overlap with anthropogenic noise, but suggest that vegetative structure may play a role in the modification of other song traits.

Proppe, D. S., et al. (2013). "Anthropogenic noise decreases urban songbird diversity and may contribute to homogenization." Global Change Biology 19(4): 1075-1084.

More humans reside in urban areas than at any other time in history. Protected urban green spaces and transportation greenbelts support many species, but diversity in these areas is generally lower than in undeveloped landscapes. Habitat degradation and fragmentation contribute to lowered diversity and urban homogenization, but less is known about the role of anthropogenic noise. Songbirds are especially vulnerable to anthropogenic noise because they rely on acoustic signals for communication. Recent studies suggest that anthropogenic noise reduces the density and reproductive success of some bird species, but that species which vocalize at frequencies above those of anthropogenic noise are more likely to inhabit noisy areas. We hypothesize that anthropogenic noise is contributing to declines in urban diversity by reducing the abundance of select species in noisy areas, and that species with low-frequency songs are those most likely to be affected. To examine this relationship, we calculated the noise-associated change in overall species richness and in abundance for seven common songbird species. After accounting for variance due to vegetative differences, species richness and the abundance of three of seven species were reduced in noisier locations. Acoustic analysis revealed that minimum song frequency was highly predictive of a species' response to noise, with lower minimum song frequencies incurring greater noise-associated reduction in abundance. These results suggest that anthropogenic noise affects some species independently of vegetative conditions, exacerbating the exclusion of some songbird species in otherwise suitable habitat. Minimum song frequency may provide a useful metric to predict how particular species will be affected by noise. In sum, mitigation of noise may enhance habitat suitability for many songbird species, especially for species with songs that include low-frequency elements.

Purser, J. and A. N. Radford (2011). "Acoustic noise induces attention shifts and reduces foraging performance in three-spined sticklebacks (Gasterosteus aculeatus)." PLoS ONE 6(2): e17478.
Acoustic noise is known to have a variety of detrimental effects on many animals, including humans, but surprisingly little is known about its impacts on foraging behavior, despite the obvious potential consequences for survival and reproductive success. We therefore exposed captive three-spined sticklebacks (Gasterosteus aculeatus) to brief and prolonged noise to investigate how foraging performance is affected by the addition of acoustic noise to an otherwise quiet environment. The addition of noise induced only mild fear-related behaviors - there was an increase in startle responses, but no change in the time spent freezing or hiding compared to a silent control - and thus had no significant impact on the total amount of food eaten. However, there was strong evidence that the addition of noise increased food-handling errors and reduced discrimination between food and non-food items, results that are consistent with a shift in attention. Consequently, noise resulted in decreased foraging efficiency, with more attacks needed to consume the same number of prey items. Our results suggest that acoustic noise has the potential to influence a whole host of everyday activities through effects on attention, and that even very brief noise exposure can cause functionally significant impacts, emphasising the threat posed by ever-increasing levels of anthropogenic noise in the environment.

Rabat, A. (2007). "Extra-auditory effects of noise in laboratory animals: the relationship between noise and sleep." Journal of the American Association for Laboratory Animal Science 46(1): 35-41.
Noise has both auditory and extra-auditory effects. Some of the most deleterious extra-auditory effects of noise are those leading to sleep disturbances. These disturbances seem to be related to both endogenous (physical parameters) and exogenous (sex, age) factors of noise. Despite correlative relations between noise level and awakenings, the scientific community has not reached consensus regarding a specific action of these factors on the different sleep stages. In animal research, 2 complementary main fields of research exist. One is focused on the positive modulation of sleep by repeated tone stimulation. The other concerns noise-related sleep disturbances. The few studies that have investigated noise-related sleep disturbances suggest the following conclusions. First, sleep disturbances are greater upon exposure to environmental noise, whose frequency spectrum is characterized by high and ultrasonic sounds, than white noise. Second, unpredictability and pattern of noise events are responsible for extractions from both SWS and PS. Third, chronic exposure to noise permanently reduces and fragments sleep. Finally, in chronic noise exposure, an inter-individual variability in SWS deficits is observed and correlated to a psychobiological profile related to an incapability to face stressful situations. Based on results from other research, acute noise-related sleep perturbations could result from an imbalance in the sleep–wake cycle in favor of arousing ascending systems. Chronic noise-related sleep disturbances may arise due to imbalance of the sleep-wake cycle and malfunctioning of the hypothalamo-pituitary-adrenal axis which may both contribute to the development of pathology.

Rabin, L. A., et al. (2006). "The effects of wind turbines on antipredator behavior in California ground squirrels (Spermophilus beecheyi)." Biological Conservation 131(3): 410-420.
Electricity-generating wind turbines are an attractive energy source because they are renewable and produce no emissions. However, they have at least two potentially damaging ecological effects. Their rotating blades

are hazardous to raptors which occasionally fly into them. And wind turbines are very noisy when active, a feature that may interfere with the lives of animals beneath them. We studied California ground squirrels (Spermophilus beecheyi) in the Altamont Pass Wind Resource Area of Northern California. These squirrels emit vocalizations that alert others to the presence of a predator, and so may be forced to compensate for turbine noise by modifying antipredator behavior. We compared the antipredator behavior of squirrels at two sites, one close to and the other far from turbines, and under two conditions, during baseline and playback of conspecific alarm calls. We generated composite two variables using principle components analysis, one representing vigilance and one representing another cautionary antipredator tactic, for further statistical comparisons. Animals at the Turbine site exhibited elevated levels of vigilance and showed increased caution demonstrated in part, by returning to the area near their burrows during alarm calling. We conclude that this site difference is probably caused by the disparity in turbine noise, since predator abundance, group size, and vegetation type and density were similar for the two sites. Though population level impacts of these behavioral differences remain to be explored, our results indicate that behavioral impacts of turbines on wildlife should be considered during future turbine development.

Radford, A. N., et al. (2014). "Acoustic communication in a noisy world: can fish compete with anthropogenic noise?" Behavioral Ecology: aru029.
Anthropogenic (man-made) noise has changed the acoustic environment both on land and underwater and is now recognized as a pollutant of international concern. Increasing numbers of studies are assessing how noise pollution affects animals across a range of scales, from individuals to communities, but the topic receiving the most research attention has been acoustic communication. Although there is now an extensive literature on how signalers might avoid potential masking from anthropogenic noise, the vast majority of the work has been conducted on birds and marine mammals. Fish represent more than half of all vertebrate species, are a valuable and increasingly utilized model taxa for understanding behavior, and provide the primary source of protein for >1 billion people and the principal livelihoods for hunderds of millions. Assessing the impacts of noise on fish is therefore of clear biological, ecological, and societal importance. Here, we begin by indicating why acoustic communication in fish is likely to be impacted by anthropogenic noise. We then use studies from other taxa to outline 5 main ways in which animals can alter their acoustic signaling behavior when there is potential masking due to anthropogenic noise and assess evidence of evolutionary adaptation and behavioral plasticity in response to abiotic and biotic noise sources to consider whether such changes are feasible in fish. Finally, we suggest directions for future study of fish acoustic behavior in this context and highlight why such research may allow important advances in our general understanding of the impact of this global pollutant.

Rainbolt, G. N., et al. (2012). "The Influence of Anthropogenic Sound in Historical Parks: Implications for Park Management." Journal of Park & Recreation Administration 30(4): 53-65.
Executive Summary: Understanding the influence of anthropogenic sounds on national park visitors has been the subject of several recent studies. In general, most of this research has focused on the implications of anthropogenic sounds (i.e., car noise or human voices) on landscape evaluation and overall visitor satisfaction depending on sound type and volume level. These studies have revealed significant interactions

between visitor experience and sound in the nature-based national parks, but there has been little research investigating the role of the anthropogenic sounds on visitor experience in historical parks that are also part of the national park system. In particular, visitor expectations and experiences in national parks may vary depending on if a park is more focused on the natural environment or the historical heritage of the United States. The current study focuses on historical parks and how visitor outcomes based in both experiences (e.g., satisfaction) and benefits (e.g, learning) are influenced by the presence of anthropogenic sounds. Undergraduate college students were exposed to a simulated, laboratory-based tour of two historical parks (The National Mall, Gettysburg National Military Park) that included six tour stops per tour with narrative information provided at each stop. Both human voices and aircraft noise (i.e., anthropogenic sounds) were introduced in conjunction with narratives at historical tour stops. The percent time audible of these anthropogenic sounds varied within the sample with three sound interference conditions: no sound, low presence (16-33%), and high presence (66--100%). In other words, based on the experimental condition to which they were assigned, participants were exposed to varying levels of anthropogenic sounds during the tour stops. Questions related to the tour stops were asked at the end of each historical park tour. Results suggest that there is a relationship between the presence of sounds and certain visitor outcomes. Both experience- based visitor outcomes (e.g., satisfaction with tour stop) and benefits-based visitor outcomes (e.g., retention of information) varied depending on sound type and sound duration exposure. More specifically, human voices detracted from satisfaction ratings more so than no anthropogenic sound and aircraft conditions. Also, as interference level (duration of sound exposure) increased, appeal of the site and prescribed level of appropriateness related to the information in the tour narrative decreased. Benefits, in the form of retention of the themes related to both tours (Washington DC, Gettysburg), also decreased for the high sound interference group. These results have important implications for management at the park level to ensure a high quality visitor experience. [ABSTRACT FROM AUTHOR]

Rapoza, A., et al. (2015). "The relationship between aircraft noise exposure and day-use visitor survey responses in backcountry areas of national parks." The Journal of the Acoustical Society of America 138(4): 2090-2105.

Raskin, J. (2013). "The Sounds of Silence." Bay Nature 13(2): 22-27.
The article focuses on the work of acoustic ecologists including Bernie Krause who pioneered the field in the 1970s and published in 2012 "The Great Animal Orchestra," which sums up his soundscape exploration. Nature Sounds Society members Sharon Perry and Dan Dugan have recorded sounds in Muir Woods National Monument, one of the National Park Service's (NPS) pilot sites for its Natural Sounds Program. Works by park ranger Mia Monroe and bioacoustician Michael Stocker are also highlighted.

Rasmussen, S., et al. (2009). "Construction noise decreases reproductive efficiency in mice." Journal of the American Association for Laboratory Animal Science 48(4): 363-370.
Excessive noise is well known to impair rodent health. To better understand the effect of construction noise and to establish effective noise limits during a planned expansion of our vivarium, we analyzed the effects of construction noise on mouse gestation and neonatal growth. Our hypothesis was that high levels of construction noise would reduce the number of live births and retard neonatal growth. Female Swiss Webster mice were individually implanted with 15 B6CBAF1/J embryos and then exposed to 70- and 90-dBA concrete saw cutting noise samples at defined time points during gestation. In addition, groups of mice with litters were exposed to noise at 70, 80, or 90 dBA for 1 h daily during the first week after parturition. Litter size, birth weight, incidence of stillborn pups, and rate of neonatal weight gain were analyzed. Noise decreased reproductive efficiency by decreasing live birth rates and increasing the number of stillborn pups.

Redondo, P., et al. (2013). "Urban noise influences vocalization structure in the House Wren Troglodytes aedon." Ibis 155(3): 621-625.
Urban habitats are noisy and constrain acoustic communication in birds. We analyzed the effect of anthropogenic noise on the vocalization characteristics of House Wrens Troglodytes aedon at two sites with different noise levels (rural and urban). We measured in each song and song trill the frequency bandwidth, maximum amplitude, highest and minimum frequency, and trill rate. In noisy urban environments, there was a reduction in bandwidth and an increase in trill rate relative to quieter, rural environments. The whole song of birds from both populations increased in minimum frequency as noise increased, improving song transmission.

Reijnen, R. and R. Foppen (2006). Impact of road traffic on breeding bird populations. The Ecology of Transportation: Managing Mobility for the Environment, Springer: 255-274.

Rendell, L. and J. Gordon (1999). "Vocal response of long-finned pilot whales (Globicephala Melas) to military sonar in the Ligurian Sea." Marine Mammal Science 15(1): 198-204.

Rheindt, F. E. (2003). "The impact of roads on birds: does song frequency play a role in determining susceptibility to noise pollution?" Journal für Ornithologie 144(3): 295-306.
Traffic noise is known to have a negative impact on bird populations in general, but little is known about the mechanisms by which sound pollution affects bird communities. However, a knowledge of these mechanisms is imperative if we want to account for the differences in susceptibility to traffic noise that exist between species, and may thus be critical for conservation action. To address this issue, population assessments were carried out in a contiguous area of oak-beech forest at differing distances from a much frequented motorway to determine the road effect on the whole bird community. As expected, species richness and diversity decreased towards the motorway, and bird abundance was significantly lower along the motorway than in the control area. However, a few species defied the negative impact of the motorway. The songs of the more abundant passerines were analyzed with regard to three frequency parameters to determine whether or not a relationship exists between the song pitch of a species and its sensitivity to

noise pollution. A significant relationship was found between dominant frequency and decline in abundance towards the motorway, which indicates that having a higher-pitched song with frequencies well above those of traffic noise makes a bird less susceptible to noise pollution. These results suggest that acoustic masking is one of the mechanisms by which traffic noise negatively affects passerine density along roads.

Rice, W. R. (1982). "Acoustical location of prey by the marsh hawk: adaptation to concealed prey." The Auk: 403-413.

The ability of Marsh Hawks (Circus cyaneus) to locate prey acoustically was measured in both the laboratory and the field. Laboratory experiments indicated that the directional hearing of the Marsh Hawk was substantially better than that of a sample of typical diurnal raptors and similar to that of owls capable of capturing prey in total darkness. Angular resolution along the horizontal axis was 2? for the Marsh Hawks, 1-2? for the owls, and 8-12? for the sample of typical diurnal raptors. For the Marsh Hawks, angular resolution along the vertical axis was at least 2?. The maximum range at which prey could be detected by sound was estimated to be 3-4 m for the Marsh Hawk and 7 m for the Bam Owl (Tytoalba). Field experiments indicated that free-ranging Marsh Hawks could locate vole vocalizations (squeaks) accurately and attack prey successfully without the aid of visual or olfactory cues. Additional field experiments were conducted to determine how the Marsh Hawk integrates auditory and visual cues while capturing concealed prey. These experiments show that the Marsh Hawk does not require motion cues or auditory depth perception to determine the elevation of a sound source. Received 23 December 1980, accepted 5 October 1981

Ríos-Chelén, A. A., et al. (2013). "Dealing with urban noise: vermilion flycatchers sing longer songs in noisier territories." Behavioral Ecology and Sociobiology 67(1): 145-152.

In noisy conditions, several avian species modulate their songs in amplitude and in the temporal or frequency domains, presumably to improve communication. Most studies on how passerine birds perform such adjustments have been carried out in oscines, a group well known for the importance of learning in the development of their songs. On the other hand, suboscines, in which learning appears to have little influence on the development of their songs, have been largely neglected. We evaluated song adjustment to noise in the vermilion flycatcher (Pyrocephalus rubinus), a suboscine bird. We conducted song recordings and noise measurements at several territories within Mexico City during the length of the dawn chorus. Males living in noisier places sang long songs, while those males inhabiting quieter places sang both short and long songs. We also found evidence of individual song plasticity, as males sang less versatile songs (i.e., songs with more introductory elements) later in the morning when noise levels were higher. This individual shift in song seems to be more associated to time of the day rather than to the observed rise in noise. However, we cannot discard an effect of noise, which should be evaluated with an experiment. We discuss our results in the context of other studies with oscine passerines and other taxa and consider implications for signaling in intra- and intersexual contexts.

Ríos-Chelén, A. A., et al. (2012). "The learning advantage: bird species that learn their song show a tighter adjustment of song to noisy environments than those that do not learn." Journal of Evolutionary Biology 25(11): 2171-2180.

Song learning has evolved within several avian groups. Although its evolutionary advantage is not clear, it has been proposed that song learning may be advantageous in allowing birds to adapt their songs to the local acoustic environment. To test this hypothesis, we analyzed patterns of song adjustment to noisy environments and explored their possible link to song learning. Bird vocalizations can be masked by lowfrequency noise, and birds respond to this by singing higher-pitched songs. Most reports of this strategy involve oscines, a group of birds with learning-based song variability, and it is doubtful whether species that lack song learning (e.g. suboscines) can adjust their songs to noisy environments. We address this question by comparing the degree of song adjustment to noise in a large sample of oscines (17 populations, 14 species) and suboscines (11 populations, 7 species), recorded in Brazil (Manaus, Brasilia and Curitiba) and Mexico City. We found a significantly stronger association between minimum song frequency and noise levels (effect size) in oscines than in suboscines, suggesting a tighter match in oscines between song transmission capacity and ambient acoustics. Suboscines may be more vulnerable to acoustic pollution than oscines and thus less capable of colonizing cities or acoustically novel habitats. Additionally, we found that species whose song frequency was more divergent between populations showed tighter noise–song frequency associations. Our results suggest that song learning and/or song plasticity allows adaptation to new habitats and that this selective advantage may be linked to the evolution of song learning and plasticity.

Ripmeester, E. A., et al. (2010). "Habitat-related birdsong divergence: a multi-level study on the influence of territory density and ambient noise in European blackbirds." Behavioral Ecology and Sociobiology 64(3): 409-418.

Song plays an important role in avian communication and acoustic variation is important at both the individual and population level. Habitat-related variation between populations in particular can reflect adaptations to the environment accumulated over generations, but this may not always be the case. In this study, we test whether variation between individuals matches local conditions with respect to noise level and territory density to examine whether short-term flexibility could contribute to song divergence at the population level. We conducted a case study on an urban and forest population of the European blackbird and show divergence at the population level (i.e. across habitats) in blackbird song, anthropogenic noise level and territory density. Unlike in several other species, we found a lack of any correlation at the individual level (i.e. across individuals) between song features and ambient noise. This suggests species-specific causal explanations for noise-dependent song differentiation which are likely associated with variation in song-copying behavior or feedback constraints related to variable singing styles. On the other hand, we found that at the level of individual territories, temporal features, but not spectral ones, are correlated to territory density and seasonality. This suggests that short-term individual variation can indeed contribute to habitat-dependent divergence at the population level. As this may undermine the potential role for song as a population marker, we conclude that more investigations on individual song flexibility are required for a better understanding of the impact of population-level song divergence on hybridisation and speciation.

Risch, D., et al. (2012). "Changes in humpback whale song occurrence in response to an acoustic source 200 km away." PLoS ONE 7(1): e29741.

The effect of underwater anthropogenic sound on marine mammals is of increasing concern. Here we show

that humpback whale (Megaptera novaeangliae) song in the Stellwagen Bank National Marine Sanctuary (SBNMS) was reduced, concurrent with transmissions of an Ocean Acoustic Waveguide Remote Sensing (OAWRS) experiment approximately 200 km away. We detected the OAWRS experiment in SBNMS during an 11 day period in autumn 2006. We compared the occurrence of song for 11 days before, during and after the experiment with song over the same 33 calendar days in two later years. Using a quasi-Poisson generalized linear model (GLM), we demonstrate a significant difference in the number of minutes with detected song between periods and years. The lack of humpback whale song during the OAWRS experiment was the most substantial signal in the data. Our findings demonstrate the greatest published distance over which anthropogenic sound has been shown to affect vocalizing baleen whales, and the first time that active acoustic fisheries technology has been shown to have this effect. The suitability of Ocean Acoustic Waveguide Remote Sensing technology for in-situ, long term monitoring of marine ecosystems should be considered, bearing in mind its possible effects on non-target species, in particular protected species.

Rochat, J. L., et al. (2013). "Noise and Natural Sounds in America's National Parks." TR News (0738-6826)(288): 38-39.

The article discusses the efforts to reduce noise and natural sounds in national parks in the U.S. It mentions the research which focuses on motorcycle noise and quieter pavements to help parks predict and minimize noise and the use of quantitative and qualitative criteria in assessing the potential impact to aviation noise. It also explains the benefits of natural sounds which can be determined by a comprehensive program.

Roche, B. E., et al. (1999). "Route choice by deer mice (Peromyscus maniculatus): reducing the risk of auditory detection by predators." The American Midland Naturalist 142(1): 194-197.

The influence of predation risk on microhabitat selection in male adult deer mice (Peromyscus maniculatus) was examined using an enclosure experiment. The relative amount of time spent by the deer mice on coniferous leaf litter, hardwood leaf litter and logs was measured. Mice preferred dry coniferous litter over dry hardwood litter, but had no preference when both litter types were wet. Deer mice traveled more along logs placed on hardwood litter than on coniferous litter. Nocturnal mammalian and avian predators of deer mice often use sound to locate their prey, and mice rustling in hardwood leaf litter should be more easily detected. Therefore, deer mice restrict their movements to routes that reduce the risk of auditory detection by predators.

Rodgers, J. (2009). "Soundscape management at Grand Canyon National Park." Park Science 26(3): 1-4.

The article presents a case study concerning the Grand Canyon National Park in Arizona. It states that the National Park Service-Federal Aviation Administration Grand Canyon Working Group was established to restore the natural quiet at the park. Apart from the overflights monitoring, the park has also organized activities such as collection and analysis of acoustic data. Moreover, the park plans to develop a soundscape management plan and implement the overflights environmental impact statement.

Rolland, R. M., et al. (2012). "Evidence that ship noise increases stress in right whales." Proceedings of the Royal Society of London B: Biological Sciences 279(1737): 2363-2368.

Baleen whales (Mysticeti) communicate using low-frequency acoustic signals. These long-wavelength sounds can be detected over hundreds of kilometres, potentially allowing contact over large distances. Lowfrequency noise from large ships (20–200 Hz) overlaps acoustic signals used by baleen whales, and increased levels of underwater noise have been documented in areas with high shipping traffic. Reported responses of whales to increased noise include: habitat displacement, behavioral changes and alterations in the intensity, frequency and intervals of calls. However, it has been unclear whether exposure to noise results in physiological responses that may lead to significant consequences for individuals or populations. Here, we show that reduced ship traffic in the Bay of Fundy, Canada, following the events of 11 September 2001, resulted in a 6 dB decrease in underwater noise with a significant reduction below 150 Hz. This noise reduction was associated with decreased baseline levels of stress-related faecal hormone metabolites (glucocorticoids) in North Atlantic right whales (Eubalaena glacialis). This is the first evidence that exposure to low-frequency ship noise may be associated with chronic stress in whales, and has implications for all baleen whales in heavy ship traffic areas, and for recovery of this endangered right whale population.

Romano, T., et al. (2004). "Anthropogenic sound and marine mammal health: measures of the nervous and immune systems before and after intense sound exposure." Canadian Journal of Fisheries and Aquatic Sciences 61(7): 1124-1134.

Anthropogenic sound is a potential stressor for marine mammals that may affect health, as has been demonstrated in other mammals. Therefore, we have initiated investigations on the effects of intense underwater sounds on nervous system activation and immune function in marine mammals. Blood samples were obtained before and after sound exposures (single underwater impulsive sounds (up to 200 kPa) produced from a seismic water gun and (or) single pure tones (up to 201 dB re 1 μPa) resembling sonar pings from a white whale, Delphinapterus leucas, and a bottlenose dolphin, Tursiops truncatus, to measure neural-immune parameters. Norepinephrine, epinephrine, and dopamine levels increased with increasing sound levels and were significantly higher after high-level sound exposures (>100 kPa) compared with lowlevel sound exposures (<100 kPa) or controls ($P = 0.003$, 0.006, and 0.020) for the white whale. Alkaline phosphatase decreased over the experimental period ($P < 0.001$), while γ-glutamyltransferase increased over the experimental period ($P < 0.001$). Significant neural-immune measurements for the dolphin after exposure to impulsive sounds included an increase in aldosterone ($P = 0.003$) and a decrease in monocytes ($P = 0.006$). Neural-immune changes to tonal sound exposures were minimal, although changes were observed in multiple neural-immune measures over time.

Roux, D. S. L. and J. R. Waas (2012). "Do long-tailed bats alter their evening activity in response to aircraft noise?" Acta Chiropterologica 14(1): 111-120.

Human-generated noise may alter animal activity patterns and mask vocal signals. We used field-based observations and a playback experiment to investigate whether aircraft activity and noise alter the evening activity of New Zealand long-tailed bats (Chalinolobus tuberculatus) a cryptic threatened species. Low-altitude aircraft activity temporally overlapped bat activity near the runway of an international airport, but was unlikely to mask echolocation pulses as aircraft noise was most intense at ≤ 10 kHz. There was no statistically significant difference in mean bat activity during and after overflights compared with pre-aircraft activity.

The experiment revealed that playback stimuli (aircraft passes and two controls: silent tracks and blackbird (Turdus merula) calls) differed in their effect on bat activity at two sites, one with low and one with high aircraft activity. Simulated aircraft noise and silent tracks reduced bat activity when compared with blackbird calls ($P < 0.05$). Bats may have found it easier to detect observers during the playback of silent tracks (sampling involved walking circuits with hand-held detectors), and may have reduced activity to a perceived threat. This result suggests that broadcasted aircraft noise is no more disturbing than researcher presence during playback trials. Evidence for a site × playback stimuli interaction ($P = 0.054$) suggests that bats at the site with high aircraft activity may have habituated to aircraft noise. Both correlative and experimental data suggests that aircraft activity and noise may not have major impacts on long-tailed bat activity.

Saha, D. C. and P. K. Padhy (2011). "Effect of air and noise pollution on species diversity and population density of forest birds at Lalpahari, West Bengal, India." Science of the Total Environment 409(24): 5328-5336.

The Rajmahal-type quality stones for building purposes are found abundantly in Birbhum district, West Bengal, India, where stone mining and crushing have become the main industrial activity. Although crusher dust is injurious to health, demand for crushed stone is ever-increasing as a result of rapid infrastructural growth in the country. Most of the crusher units at Rampurhat are situated along the roadways adjacent to forest under Tumboni Beat of Rampurhat Range of Birbhum Forest Division. Excessive load of air pollution in this area has led to degradation of this forest. The status of the ambient air and noise level was evaluated. The effect of air and noise pollution on abundance and variability of birds in this forest have been compared to an almost non-polluted forest of the same bio-geographic zone. Both species diversity and population density of birds were found to decrease in the polluted forest, especially in the areas adjacent to crushers. For comparing the pollution status of two different forest sites and for establishing whether the density of birds have any correlation between the sites, the Student's t-test and the chi-square test were applied respectively. Most of the results proved to be significant.

Saxen, S. W. (2008). Park visitors and the natural soundscape: Winter experience dimensions in Yellowstone National Park.

The natural soundscape is becoming increasingly recognized as a threatened park resource. A variety of policies, laws, and regulations have rapidly been established that affect the National Park Service mandate and require the agency and individual parks to protect, preserve, and restore natural sounds. National Parks are grappling with how to manage the newly legitimized natural soundscape resource and this research provides some of the first significant knowledge of visitor experiences of park soundscapes and preferences for management policies. The role of the natural soundscape in visitor experiences was explored through both interview and survey data with the primary goal of documenting dimensions of the experiences of natural sounds. Findings from this research highlight that not only do the majority of winter visitors to Yellowstone National Park believe that natural sounds are important to their experience of the park, but that deep meanings and complexity characterize visitor perceptions of the role of the natural soundscape to the overall value of the park and influence perceptions of the role of mechanized sounds in the park. While differences among the three primary user groups (cross-country skiers, snow coach riders, and

snowmobilers) do exist, the data reflects a much greater degree of common ground and general agreement on most issues related to the park natural soundscape that were explored in this research.

Schaub, A., et al. (2008). "Foraging bats avoid noise." Journal of Experimental Biology 211(19): 3174-3180.
Ambient noise influences the availability and use of acoustic information in animals in many ways. While much research has focused on the effects of noise on acoustic communication, here, we present the first study concerned with anthropogenic noise and foraging behavior. We chose the greater mouse-eared bat (Myotis myotis) as a model species because it represents the especially vulnerable group of gleaning bats that rely on listening for prey rustling sounds to find food (i.e. `passive listening'). In a choice experiment with two foraging compartments, we investigated the influence of background noise on foraging effort and foraging success. We tested the hypotheses that: (1) bats will avoid foraging areas with particularly loud background noise; and (2) the frequency–time structure of the noise will determine, in part, the degree to which it deters bats. We found a clear effect of the type of noise on the allocation of foraging effort to the compartments and on the distribution of prey capture events. When playing back silence, the bats made equal use of and were equally successful in both compartments. In the other three treatments (where a non silent sound was played back), the bats avoided the playback compartment. The degree to which the background noise deterred bats from the compartment increased from traffic noise to vegetation movement noise to broadband computer-generated noise. Vegetation noise, set 12 dB below the traffic noise amplitude, had a larger repellent effect; presumably because of its acoustic similarity with prey sounds. Our experimental data suggest that foraging areas very close to highways and presumably also to other sources of intense, broadband noise are degraded in their suitability as foraging areas for such `passive listening' bats.

Scholik, A. R. and H. Y. Yan (2002). "Effects of boat engine noise on the auditory sensitivity of the fathead minnow, Pimephales promelas." Environmental Biology of Fishes 63(2): 203-209.
Fishes are constantly exposed to various sources of noise in their underwater acoustic environment. Many of these sounds are from anthropogenic sources, especially engines of boats. Noise generated from a small boat with a 55 horsepower outboard motor was played back to fathead minnows, Pimephales promelas, for 2 h at 142 dB (re: 1 μPa), and auditory thresholds were measured using the auditory brainstem response (ABR) technique. The results demonstrate that boat engine noise significantly elevate a fish's auditory threshold at 1 kHz (7.8 dB), 1.5 kHz (13.5 dB), and 2.0 kHz (10.5 dB), the most sensitive hearing range of this species. Such a short duration of noise exposure leads to significant changes in hearing capability, and implies that man-made noise generated from boat engines can have far reaching environmental impacts on fishes.

Scholik, A. R. and H. Y. Yan (2002). "The effects of noise on the auditory sensitivity of the bluegill sunfish, Lepomis macrochirus." Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology 133(1): 43-52.
As concerns about the effects of underwater anthropogenic noises on the auditory function of organisms increases, it is imperative to assess if all organisms are equally affected by the same noise source. Consequently, auditory capabilities of an organism need to be evaluated and compared interspecifically. Teleost fishes provide excellent models to examine these issues due to their diversity of hearing capabilities.

Broadly, fishes can be categorized as hearing specialists (broad hearing frequency range with low auditory thresholds) or hearing generalists (narrower frequency range with higher auditory thresholds). The goal of this study was to examine the immediate effects of white noise exposure (0.3–2.0 kHz, 142 dB re: 1 μPa) and recovery after exposure (1–6 days) on a hearing generalist fish, bluegill sunfish (Lepomis macrochirus). Noise exposure resulted in only a slight, but not statistically significant, elevation in auditory threshold compared to fish not exposed to noise. In combination with results from our previous studies examining effects of noise on a hearing specialist fish, the fathead minnow (Pimephalespromelas), this study provides evidence supporting the hypothesis that fish's auditory thresholds can be differentially affected by noise exposure.

Schroeder, J., et al. (2012). "Passerine birds breeding under chronic noise experience reduced fitness." PLoS ONE 7(7): e39200.
Fitness in birds has been shown to be negatively associated with anthropogenic noise, but the underlying mechanisms remain obscure. It is however crucial to understand the mechanisms of how urban noise impinges on fitness to obtain a better understanding of the role of chronic noise in urban ecology. Here, we examine three hypotheses on how noise might reduce reproductive output in passerine birds: (H1) by impairing mate choice, (H2) by reducing territory quality and (H3) by impeding chick development.

Schulte-Fortkamp, B. (2011). Soundscape Approaches Public Space Perception and Enhancement Drawing on Experience Nauener Platz in Berlin. Brighton Soundscape Workshop, April.

Sebastianutto, L., et al. (2011). "How boat noise affects an ecologically crucial behavior: the case of territoriality in Gobius cruentatus (Gobiidae)." Environmental Biology of Fishes 92(2): 207-215.
Gobius cruentatus emit sounds during agonistic interactions. In order to evaluate the effect of boat noise exposure on G. cruentatus territorial behavior, we played a field-recorded diesel engine boat noise during aggressive encounters between an intruder and a resident fish in a laboratory-controlled tank. We tested two factors: role (resident vs. intruder) and condition (noisy vs. silent); the test animals underwent all the treatments in a round-robin design. Agonistic behavior of the residents was modified by boat noise: during the playback residents were more submissive and won less encounters than in the control (silent) condition. We suggest that sound production is an effective tool for territorial defense, since the impairment of acoustic communication due to the recreational boat noise diminished the ability of the resident to maintain its territory.

Seger-Fullam, K. D., et al. (2011). "Urban noise predicts song frequency in northern cardinals and American robins." Bioacoustics 20(3): 267-276.
We examined the extent to which acoustic noise in urban environments influences song characteristics and singing behavior of Northern Cardinals Cardinalis cardinalis and American Robins Turdus migratorius. We predicted that, in response to loud noise, birds would improve signal transmission by (1) increasing singing rate and (2) adjusting song characteristics such as pitch and length. From May—July 2006, 42 cardinals and 53 robins were recorded in forests located within four acoustic environments in central Ohio: rural, residential, commercial, and highway. Following each recording, we measured ambient noise level

and recorded information describing location, weather, habitat, and conspecific presence within 75 m. As predicted, frequency range was positively correlated with noise level for both species, but neither song length nor rate was related to noise level for either species. These data support the idea that anthropogenic noise influences avian singing behavior and acts as a selective force in urban areas.

Selleck, J. (2009). "Generator noise along the U.S.-Mexico border." Park Science 26(3): 53-54.

Sembulingam, K., et al. (1998). "Effect of chronic noise stress on some selected stress indices in albino rats." Journal of Environmental Biology 19(1): 63-66.

Shamoun-Baranes, J., et al. (2011). "Birds flee en mass from New Year's Eve fireworks." Behavioral Ecology 22(6): 1173-1177.

Anthropogenic disturbances of wildlife, such as noise, human presence, hunting activity, and motor vehicles, are becoming an increasing concern in conservation biology. Fireworks are an important part of celebrations worldwide, and although humans often find fireworks spectacular, fireworks are probably perceived quite differently by wild animals. Behavioral responses to fireworks are difficult to study at night, and little is known about the negative effects fireworks may have on wildlife. Every year, thousands of tons of fireworks are lit by civilians on New Year's Eve in the Netherlands. Using an operational weather radar, we quantified the reaction of birds to fireworks in 3 consecutive years. Thousands of birds took flight shortly after midnight, with high aerial movements lasting at least 45 min and peak densities measured at 500 m altitude. The highest densities were observed over grasslands and wetlands, including nature conservation sites, where thousands of waterfowl rest and feed. The Netherlands is the most important winter staging area for several species of waterfowl in Europe. We estimate that hundreds of thousands of birds in the Netherlands take flight due to fireworks. The spatial and temporal extent of disturbance is substantial, and potential consequences are discussed. Weather radar provides a unique opportunity to study the reaction of birds to fireworks, which has otherwise remained elusive.

Shannon, G., et al. (2014). "Road traffic noise modifies behavior of a keystone species." Animal Behavior 94: 135-141.

Prey species have to balance their foraging and vigilance behavior in order to maximize nutritional and energetic intake while avoiding predation. Anthropogenic noise, a ubiquitous form of human disturbance, has the potential to influence antipredator behavior through its effects on predator detection and perceived risk. Noise might increase perceived risk as predicted by the risk disturbance hypothesis, reduce risk by providing protection from disturbance-sensitive predators, or have no effect on antipredator behavior if animals are tolerant of nonlethal forms of human disturbance. Road traffic is a pervasive source of anthropogenic noise, but few studies have experimentally isolated the effects of road noise on behavior. Using systematic playback experiments, we investigated the influence of traffic noise on foraging and vigilance in a keystone species in North American prairie systems, the prairie dog, Cynomys ludovicianus. Exposure to road traffic noise significantly lowered aboveground activity, reduced foraging and increased vigilance, as predicted by the risk disturbance hypothesis. These effects were prevalent irrespective of

temperature, a strong influence on such behaviors, and they were consistent across the 3-month study period, providing no evidence of habituation. Our results provide the first experimental investigation of the potential costs of this ubiquitous disturbance in a free-ranging mammal, demonstrating that road noise can alter key survival behaviors of this ecologically pivotal species. These findings highlight that the presence of animals in a location is no guarantee of population and ecological integrity, while also underlining the potential synergistic impacts of noise on a species that has already experienced severe declines across its historic range due to human disturbance. Globally, roadways have profound impacts on biodiversity, and quantifying the behavioral and fitness costs associated with different forms of disturbance such as noise is crucial for mitigation

Shieh, B.-S., et al. (2012). "Acoustic adaptations to anthropogenic noise in the cicada Cryptotympana takasagona Kato (Hemiptera: Cicadidae)." Acta Ethologica 15(1): 33-38.
Anthropogenic noise produced by human activities affects acoustic communication in animals living in urban habitats. We recorded the calling songs of the cicada Cryptotympana takasagona in the Kaohsiung metropolitan areas of southern Taiwan to investigate possible acoustic adaptations to anthropogenic noise. C. takasagona did not call more in noise gaps. Acoustic features (peak frequency, quartile 25%, quartile 50%, and quartile 75%) of calling songs significantly increased with ambient noise levels. C. takasagona shifted the energy distribution of calling songs to higher frequencies in the presence of higher noise levels. We suggest that the acoustic adaptation by which song frequencies increase with levels of anthropogenic noise in C. takasagona may result from a size-dependent calling strategy in which small-sized males call more in noise conditions or large-sized males adjust their song frequency by changing their abdominal cavities.

Shier, D., et al. (2012). "Beyond masking: Endangered Stephen's kangaroo rats respond to traffic noise with footdrumming." Biological Conservation 150(1): 53-58.
On-road vehicles have become a pervasive source of low frequency noise in both urban environments and natural protected areas. Because many species rely on low-frequency signals to communicate with conspecifics, they are likely to be especially vulnerable to signal masking and the concomitant biological effects associated with exposure to traffic noise. Here, we show that the spectral characteristics of traffic noise overlap extensively with footdrumming signals of the endangered Stephens' kangaroo rat (Dipodomys stephensi; SKR). Playbacks of footdrumming overlaid with experimental and control background noises indicate that traffic noise masks and may mimic footdrumming signals. SKR showed no response to footdrumming playbacks overlaid with traffic noise. Yet, traffic noise itself may mimic footdrumming and prompt a false response in SKR – playbacks of traffic noise alone and footdrumming overlaid with control sounds elicited similar behavioral responses. These results provide the first evidence that anthropogenic noise may function as a deceptive signal to wildlife, causing animals to engage in false responses that may be energetically and biologically costly. More broadly, these results indicate that anthropogenic noise can have multiple, concurrent effects. For SKR, the combined effects of communication disruption and signal deception may further tax already endangered populations. Roads and road margins on and off reserves serve as dispersal corridors and refugia for SKR and other semifossorial taxa; these areas may therefore function as ecological traps if anthropogenic roadway noise negatively affects population persistence.

Siemers, B. M. and A. Schaub (2011). "Hunting at the highway: traffic noise reduces foraging efficiency in acoustic predators." Proceedings of the Royal Society of London B: Biological Sciences 278(1712): 1646-1652.

Noise pollution from human traffic networks and industrial activity impacts vast areas of our planet. While anthropogenic noise effects on animal communication are well documented, we have very limited understanding of noise impact on more complex ecosystem processes, such as predator–prey interactions, albeit urgently needed to devise mitigation measures. Here, we show that traffic noise decreases the foraging efficiency of an acoustic predator, the greater mouse-eared bat (Myotis myotis). These bats feed on large, ground-running arthropods that they find by listening to their faint rustling sounds. We measured the bats' foraging performance on a continuous scale of acoustically simulated highway distances in a behavioral experiment, designed to rule out confounding factors such as general noise avoidance. Successful foraging bouts decreased and search time drastically increased with proximity to the highway. At 7.5 m to the road, search time was increased by a factor of five. From this increase, we predict a 25-fold decrease in surveyed ground area and thus in foraging efficiency for a wild bat. As most of the bats' prey are predators themselves, the noise impact on the bats' foraging performance will have complex effects on the food web and ultimately on the ecosystem stability. Similar scenarios apply to other ecologically important and highly protected acoustic predators, e.g. owls. Our study provides the empirical basis for quantitative predictions of anthropogenic noise impacts on ecosystem processes. It highlights that an understanding of the effects of noise emissions and other forms of 'sensory pollution' are crucially important for the assessment of environmental impact of human activities.

Slabbekoorn, H. (2013). "Songs of the city: noise-dependent spectral plasticity in the acoustic phenotype of urban birds." Animal Behavior 85(5): 1089-1099.

Urbanization leads to homogenization of avian communities through local extinction of rare bird species and increasing numbers of the same common urban bird species over large geographical areas. Successful city birds often persist through some sort of behavioral plasticity that helps them survive and reproduce close to humans, in built-up areas, with all the typical urban feasts and hazards. In this review, I address whether behavioral plasticity of the acoustic phenotype can be an additional factor in explaining which species end up as urban survivors. Anthropogenic noise has been shown to negatively affect avian distribution and reproduction, especially for species that rely on relatively low-frequency songs for mediating territorial conflicts and attracting partners for mating. Spectral differences between songs of city and forest populations of the same species and correlations between individual song frequency use and local noise levels suggest that many successful city species shift song frequency upward under noisy urban conditions. Experimental evidence has confirmed the ability of several species to show rapid spectral adjustments as well as perceptual benefits of singing at higher frequency in noisy habitats. However, empirical evidence of fitness benefits for birds showing the ability and tendency of noise-dependent spectral adjustment is still lacking. Furthermore, depending on the species and the underlying mechanism for spectral change, there may also be fitness costs through a compromise on signal function. These two aspects are only two of many remaining avenues for future studies. The acoustic phenotype of urban birds provides a great model system to study fundamental processes such as causes and consequences of environmentally induced

signal changes, 'cultural assimilation', and the relationship between phenotypic and genotypic evolution. Furthermore, the current and expected rate of urbanization remains high at a global scale, which will lead to further spread in time and space of artificially elevated noise levels. This should guarantee the continued interest of scientists, politicians and conservationists for many years ahead.

Slabbekoorn, H., et al. (2010). "A noisy spring: the impact of globally rising underwater sound levels on fish." Trends in Ecology & Evolution 25(7): 419-427.

The underwater environment is filled with biotic and abiotic sounds, many of which can be important for the survival and reproduction of fish. Over the last century, human activities in and near the water have increasingly added artificial sounds to this environment. Very loud sounds of relatively short exposure, such as those produced during pile driving, can harm nearby fish. However, more moderate underwater noises of longer duration, such as those produced by vessels, could potentially impact much larger areas, and involve much larger numbers of fish. Here we call attention to the urgent need to study the role of sound in the lives of fish and to develop a better understanding of the ecological impact of anthropogenic noise.

Slabbekoorn, H. and A. den Boer-Visser (2006). "Cities change the songs of birds." Current Biology 16(23): 2326-2331.

Worldwide urbanization and the ongoing rise of urban noise levels form a major threat to living conditions in and around cities 1, 2, 3 and 4. Urban environments typically homogenize animal communities, and this results, for example, in the same few bird species' being found everywhere 5 and 6. Insight into the behavioral strategies of the urban survivors may explain the sensitivity of other species to urban selection pressures. Here, we show that songs that are important to mate attraction and territory defense have significantly diverged in great tits (Parus major), a very successful urban species. Urban songs were shorter and sung faster than songs in forests, and often concerned atypical song types. Furthermore, we found consistently higher minimum frequencies in ten out of ten city-forest comparisons from London to Prague and from Amsterdam to Paris. Anthropogenic noise is most likely a dominant factor driving these dramatic changes 7, 8 and 9. These data provide the most consistent evidence supporting the acoustic-adaptation hypothesis since it was postulated in the early seventies 10, 11 and 12. At the same time, they reveal a behavioral plasticity that may be key to urban success and the lack of which may explain detrimental effects on bird communities that live in noisy urbanized areas or along highways.

Slabbekoorn, H. and M. Peet (2003). "Ecology: Birds sing at a higher pitch in urban noise." Nature 424(6946): 267-267.

The ongoing spread of urban areas, highways and airports throughout the world makes anthropogenic noise almost omnipresent. We have found that urban great tits (Parus major) at noisy locations sing with a higher minimum frequency, thereby preventing their songs from being masked to some extent by the predominantly low-frequency noise. They have presumably learned selectively from a restricted range of their repertoire — a behavioral plasticity that may be critical for breeding success in a noisy world.

Cars, planes and all sorts of machinery create a new selection pressure on wildlife species that use acoustic

signals to achieve reproductive success. This might create two groups of species: one that can adapt their signals to the competing noise, and another that cannot. Although there is a decline in species density and diversity associated with sprawling cities and highways1, 2, 3, 4, there is no evidence yet for a direct role of sound pollution 5, 6, nor is there much insight into how successful urban species cope under noisy circumstances 7, 8.

We investigated an urban population of great tits in the Dutch city of Leiden. Noise-amplitude measurements, taken with a sound-pressure meter, varied markedly between territories. Mean amplitude levels per territory ranged from 42 to 63 decibels, from very quiet in residential areas to extremely noisy near a highway or a busy crossing. We used a highly directional microphone for song recordings and an omnidirectional microphone for independent noise recordings at a height of 5 m. The spectral composition of ambient noise was generally characterized by loud, low-frequency sounds.

We compared noise amplitude with the spectral distribution of sound energy within the range of the minimum frequency of great-tit song and found that in noisy territories there is a greater proportion of sound energy in the lower half of this range than in quiet territories (Pearson's $r = 0.78$, $P < 0.001$).

We measured the acoustic characteristics of 32 male great tits, each of which had a repertoire of between three and nine distinct song types. Mean song frequencies varied considerably between individual birds. The average minimum frequency ranged from 2.82 to 3.77 kHz and was significantly correlated with ambient noise (multiple regression: $n = 32$, d.f. = 2, $F = 4.74$, $P = 0.017$), with regard to both amplitude level ($t = 3.02$, $P = 0.005$) and spectral distribution ($t = -2.0$, $P = 0.055$). Noisy territories were home to great-tit males whose songs had a high average minimum frequency. Birds in quiet territories sang more notes that reached the lowest frequencies measured for the population (Fig. 1).

Slabbekoorn, H. and E. A. Ripmeester (2008). "Birdsong and anthropogenic noise: implications and applications for conservation." Molecular Ecology 17(1): 72-83.

The dramatic increase in human activities all over the world has caused, on an evolutionarytime scale, a sudden rise in especially low-pitched noise levels. Ambient noise may bedetrimental to birds through direct stress, masking of predator arrival or associated alarmcalls, and by interference of acoustic signals in general. Two of the most important func-tions of avian acoustic signals are territory defence and mate attraction. Both of thesefunctions are hampered when signal efficiency is reduced through rising noise levels,resulting in direct negative fitness consequences. Many bird species are less abundant nearhighways and studies are becoming available on reduced reproductive success in noisyterritories. Urbanization typically leads to homogenization of bird communities over largegeographical ranges. We review current evidence for whether and how anthropogenic noiseplays a role in these patterns of decline in diversity and density. We also provide details ofa case study on great tits (Parus major), a successful urban species. Great tits show featuresthat other species may lack and make them unsuitable for city life. We hypothesize thatbehavioural plasticity in singing behavior may allow species more time to adapt tohuman-altered environments and we address the potential for microevolutionary changesand urban speciation in European

blackbirds (Turdus merula). We conclude by providingan overview of mitigating measures available to abate noise levels that are degrading birdbreeding areas. Bird conservationists probably gain most by realizing that birds andhumans often benefit from the same or only slightly modified measures.

Solé, M., et al. (2013). "Does exposure to noise from human activities compromise sensory information from cephalopod statocysts?" Deep Sea Research Part II: Topical Studies in Oceanography 95: 160-181.

Many anthropogenic noise sources are nowadays contributing to the general noise budget of the oceans. The extent to which sound in the sea impacts and affects marine life is a topic of considerable current interest both to the scientific community and to the general public. Cepaholopods potentially represent a group of species whose ecology may be influenced by artificial noise that would have a direct consequence on the functionality and sensitivity of their sensory organs, the statocysts. These are responsible for their equilibrium and movements in the water column. Controlled Exposure Experiments, including the use of a 50–400 Hz sweep (RL=157±5 dB re 1 µPa with peak levels up to SPL=175 dB re 1 µPa) revealed lesions in the statocysts of four cephalopod species of the Mediterranean Sea, when exposed to low frequency sounds: (n=76) of Sepia officinalis, (n=4) Octopus vulgaris, (n=5) Loligo vulgaris and (n=2) Illex condietii. The analysis was performed through scanning (SEM) and transmission (TEM) electron microscopical techniques of the whole inner structure of the cephalopods' statocyst, especially on the macula and crista. All exposed individuals presented the same lesions and the same incremental effects over time, consistent with a massive acoustic trauma observed in other species that have been exposed to much higher intensities of sound: Immediately after exposure, the damage was observed in the macula statica princeps (msp) and in the crista sensory epithelium. Kinocilia on hair cells were either missing or were bent or flaccid. A number of hair cells showed protruding apical poles and ruptured lateral plasma membranes, most probably resulting from the extrusion of cytoplasmic material. Hair cells were also partially ejected from the sensory epithelium, and spherical holes corresponding to missing hair cells were visible in the epithelium. The cytoplasmic content of the damaged hair cells showed obvious changes, including the presence of numerous vacuoles and electron-dense inclusions not seen in the control animals. The lesions described here are new to cephalopod pathology. Given that low-frequency noise levels in the ocean are increasing (e.g. shipping, offshore industry, and naval manoeuvres), that the role of cephalopods in marine ecosystems is only now beginning to be understood, and that reliable bioacoustic data on invertebrates are scarce, the present study and future investigations will bring an important contribution to the sustainable use of the marine environment.

Southall, B. L. (2009). Addressing the Effects of Human-Generated Sound on Marine Life: An Integrated Research Plan for US federal Agencies, Joint Subcommittee on Ocean Science & Technology, Interagency Task Force on Anthropogenic Sound and the Marine Environment.

Southall, B. L., et al. (2008). "Marine mammal noise-exposure criteria: initial scientific recommendations." Bioacoustics 17(1-3): 273-275.

Stack, D. W., et al. (2011). "Reducing visitor noise levels at Muir Woods National Monument using experimental management." The Journal of the Acoustical Society of America 129(3): 1375-1380.
Noise impacts resources and visitor experience in many protected natural areas, and visitors can be the dominant source of noise. This experimental study tested the efficacy and acceptability of signs asking visitors to be quiet at Muir Woods National Monument, California. Signs declaring a "quiet zone" (at the park's Cathedral Grove) or a "quiet day" (throughout the park) were posted on a randomized schedule that included control days (no signs). Visitor surveys were conducted to measure the cognitive and behavioral responses of visitors to the signs and test the acceptability of these management practices to visitors. Visitors were highly supportive of these management practices and reported that they consciously limited the amount of noise they produced. Sound level measurements showed substantial decreases on days when signs were posted.

Stanley, G. R. (2012). Ozark National Scenic Riverways-Boat Noise Measurement Summary Report. 41st International Congress and Exposition on Noise Control Engineering 2012, INTER-NOISE 2012, August 19, 2012 - August 22, 2012, New York, NY, United states, Institute of Noise Control Engineering of the USA.
The fundamental purpose of all national park units includes conserving park resources and providing for the enjoyment of park resources such as the acoustic environment. National Park Service policy directs superintendents to monitor noise caused by mechanical devices. Park managers are directed to identify levels and sounds that may hinder visitor enjoyment and specifically, to monitor mechanical noise that may adversely affect opportunities to enjoy park soundscapes. Ozark National Scenic Riverways (OZAR) staff requested technical assistance from the Natural Sounds and Night Skies Division (NSNSD), including measurement of pass-by noise from typical jet boats, canoes, and kayaks for use in efforts to understand how the recreational activities may affect the park's soundscape. This report provides tables, plots, data summaries, and references to applicable regulations to help assist OZAR and NSNSD staff in understanding jet boat noise along its riverways.

Staples, J. (2012). "Changes in dive behavior during naval sonar exposure in killer whales, long-finned pilot whales, and sperm whales." The PhysiologicalConsequences of Breath-Hold Diving in Marine Mammals; The Scholander Legacy: 144.

Steinhart, P. (1978). "Off We Go, into the Wild Green Yonder." National Wildlife 16(4): 16.
Increased airplane traffic has caused growing concern among conservationists about the effect of airplanes on human wilderness experiences and on wildlife. Wilderness users complain that the quiet they seek is being disrupted by aircraft noise. Studies on the effects of aircraft noise on wildlife show that birds may experience nesting failures, mammals undergo behavioral changes, and insects' reproductive capacities are reduced. The FAA places few noise pollution restrictions on pilots. An advisory circular suggests that pilots maintain a 2000 FT altitude over parks, wilderness areas, and wildlife refuges, but these have not been located on aviation charts. The advisory is widely disregarded. Suggestions for further reducing the aircraft noise problem are given.

Stokes, J. B., et al. (1999). "Citizens get relief from recreational noise: The case in the skies from Hawaii." Noise Control Engineering Journal 47(4): 142-146.

Due to the exponential growth of large-scale, commercial, fixed-wing aircraft and helicopter tourism in the state of Hawaii since the late 1980s, native wildlife habitat has been degraded, and hikers and others seeking tranquility in wilderness areas throughout the state have been greatly disturbed. Aviation activity results in an unacceptable degree of noise pollution over or near Hawaii Volcanoes National Park on the island of Hawaii, and Haleakala National Park on the island of Maul, The same is true of state lands with wilderness character such as the Na Pali Coast, Waimea Canyon, and Koke'e State parks on the island of Kauai and Kula, and Kahikinui State forests on the island of Maul, In all these locations, noise intrusions occur continuously throughout the day, often for sustained periods of over one hour. The problem is particularly acute at Haleakala, where sound is amplified due to the park's unique geologic configuration (a small erosional depression, high above the clouds) that concentrates and amplifies aviation noise. The: bulk of Haleakala and Hawaii Volcanoes National Parks are part of the federal wilderness system, Both parks are International Biosphere Reserves designated by the United Nations; aviation noise is inconsistent with such designation. (C) 1999 Institute of Noise Control Engineering. [S0736-2501(99)00404-X] Primary subject classification: 66.1; Secondary subject classification: 13.1.

Stokstad, E. (2014). "US regulators unveil new ocean noise rules for marine mammals." Science 343(6167): 128-128.

Humans create all kinds of noise in the ocean—from sonars, blasts of bubbles used to map the sea floor with sound, thumping pile drivers, and underwater explosions triggered by the military and construction projects. Now, new guidance from the National Marine Fisheries Service will require more sophisticated analyses than are now required of how these sounds might injure marine mammals, including whales, dolphins, and seals. Environmentalists hope the guidance, which caps a 10-year effort to synthesize the best science on how sound affects the animals, will lead to greater protection, but others aren't so sure.

Summers, P. D., et al. (2011). "Are the negative effects of roads on breeding birds caused by traffic noise?" Journal of Applied Ecology 48(6): 1527-1534.

1. The effects of roads on wildlife populations are widespread and well documented. Many studies have shown that bird abundance, occurrence and species richness are reduced near roads, with the largest reductions where traffic levels are high. Negative correlations have been reported between bird richness/ abundance and traffic noise but the possible causes of road effects are inter-correlated. It is important to disentangle the different effects so that appropriate mitigation measures can be implemented.
2. We tested the hypothesis that traffic noise is a key negative effect by testing three predictions: (i) bird richness/ abundance should reach a maximum at the same distance from roads that traffic noise reaches a minimum; (ii) the effect of traffic noise on bird richness/abundance should be stronger than the effect of distance from the road on bird richness/abundance; and (iii) sites with more traffic noise at a given distance from the road should show lower bird richness/abundance than sites with less traffic noise at the same distance.
3. We collected breeding bird occurrence and traffic noise data along twenty 600-m transects perpendicular

to roads at 10 high-traffic road sites.

4. Traffic noise decreased and bird species richness increased with increasing distance from the roads. However, none of the predictions derived from the traffic noise hypothesis was supported.
5. Synthesis and applications. Our results suggest that traffic noise is not the main cause of the negative relationship between bird species richness/abundance and proximity to roads. Instead, traffic mortality may be the main mechanism causing this relationship. We suggest that mitigation of road impacts on birds should focus mainly on reducing mortality rather than reducing traffic noise. In particular, engineering road surfaces, tyres and vehicle engines to reduce noise would not mitigate road effects; instead, structures to keep birds away from roads or force them to fly above the traffic would be more effective.

Sun, J. W. and P. M. Narins (2005). "Anthropogenic sounds differentially affect amphibian call rate." Biological Conservation 121(3): 419-427.

The effects of airplane flyby noise and playbacks of low-frequency motorcycle sounds on calling activity were examined in a mixed-species anuran calling assemblage in central Thailand. In response to these stimuli, three of the most acoustically active pond-edge species (Microhyla butleri, Rana nigrovittata and Kaloula pulchra) significantly decreased their calling rate. Yet under the identical stimulus regime, Rana taipehensis consistently increased its calling rate. Moreover, during the occasional natural lulls in the chorus in which males collectively stop calling, resulting in a conspicuous reduction in chorus intensity, calls of R. taipehensis would appear to emerge from the background noise. These results suggest that man-made acoustic interference may affect anuran chorus behavior either directly by modulating call rates of the chorus participants or indirectly, by suppressing calling behavior of one set of species which in turn stimulates calling in other species. The results of our playback experiment coupled with the natural calling behavior of these species support the latter hypothesis.

Swaddle, J. P. and L. C. Page (2007). "High levels of environmental noise erode pair preferences in zebra finches: implications for noise pollution." Animal Behavior 74(3): 363-368.

Male–female pair bonds are common to most bird species, and these bonds affect fundamental aspects of mating systems and the strength of selection, for example, by limiting extrapair paternity. Therefore, understanding factors that strengthen and erode pair bonds are important in elucidating the selection pressures that avian populations will experience. Here, we studied the effects of environmental noise on pair bonds and the strength of pair preferences (i.e. preferences for a pair-bonded partner versus an unfamiliar individual) in the monogamous zebra finch, Taeniopygia guttata, a model species in studies of sexual selection. Based on a previous study, we hypothesized that high-amplitude environmental noise would decrease the strength of pair preferences. Explicitly, we tested whether females' relative preference for their pair-bonded males, compared with extrapair males, decreased as the amplitude of environmental white noise increased. Our results generally supported our hypothesis, as females' preference for their pairbonded males significantly decreased under conditions of high environmental noise. This erosion of preference may result from the masking or distortion of the paired males' pair-bond maintaining call, although the decrease in preference could also occur because a female cannot recognize her pair-bonded male. Our findings suggest that songbird populations in areas with high environmental noise may have (temporarily or

permanently) weakened pair bonds, suggesting that extrapair behaviors could increase in areas of greater environmental noise.

Taff, D., et al. (2014). "The role of messaging on acceptability of military aircraft sounds in Sequoia National Park." Applied Acoustics 84: 122-128.
Highlights: [•] We evaluated the role of messaging on acceptability of military aircraft sounds. [•] We discuss the role of theory, communication strategies and visitor management. [•] Messaging increased visitor acceptability of aircraft sounds by as much as 15%. [•] Messaging concerning military aircraft in Sequoia may improve visitor experiences. [ABSTRACT FROM AUTHOR]

Thompson, P. M., et al. (2010). "Assessing the responses of coastal cetaceans to the construction of offshore wind turbines." Marine Pollution Bulletin 60(8): 1200-1208.
The expansion of offshore renewables has raised concerns over potential disturbance to coastal cetaceans. In this study, we used passive acoustic monitoring to assess whether cetaceans responded to pile-driving noise during the installation of two 5 MW offshore wind turbines off NE Scotland in 2006. Monitoring was carried out at both the turbine site and a control site in 2005, 2006 and 2007. Harbour porpoises occurred regularly around the turbine site in all years, but there was some evidence that porpoises did respond to disturbance from installation activities. We use these findings to highlight how uncertainty over cetacean distribution and the scale of disturbance effects constrains opportunities for B-A-C-I studies. We explore alternative approaches to assessing the impact of offshore wind farm upon cetaceans, and make recommendations for the research and monitoring that will be required to underpin future developments.

Tian, F., et al. (2014). "GIS-based analysis of soundscape spatial pattern in Zijin Mountain National Forest Park." Journal of Nanjing Forestry University (Natural Sciences Edition) 38(6): 87-92.
In order to fill the academic blank of soundscape research in the current forest park planning management field, Zijin Mountain National Forest Park was chosen as the research object, while a soundscape spatial database was set up based on the platform of ArcGIS 9.3 by combing field survey data and questionnaire survey method. Eleven environmental factors closely related with soundscape, such as stand, terrain and human disturbance were generated to do surface trend analysis, geographically weighted regression (GWR) of soundscape on the platform of ArcGIS 9.3. Research results showed; Spots with high soundscape harmony value was mainly distributed on the northeast of the mountain, while the spots with low harmony value was located at the south and the northwest edge of the park. The spatial pattern of soundscape harmony value showed a zonal distribution trend that the spots with high harmony value was located at east, medium in the center, the lowest on the edge. Soundscape harmony value is positively correlated with forest growth status,

altitude of the scenic forest, and the slope, negatively correlated with density of the settlement and road. In terms of the results of the study, a pattern of "one nuclear and four areas" would be put forward to establish the frame of preliminary soundscape plan.

Todd, S., et al. (1996). "Behavioral effects of exposure to underwater explosions in humpback whales (Megaptera novaeangliae)." Canadian Journal of Zoology 74(9): 1661-1672.
Humpback whale (Megaptera novaeangliae) entrapment in nets is a common phenomenon in Newfoundland. In 1991 – 1992, unusually high entrapment rates were recorded in Trinity Bay on the northeast coast of Newfoundland. The majority of cases occurred in the southern portion of the bay close to Mosquito Cove, a site associated with construction operations (including explosions and drilling) that presumably modified the underwater acoustic environment of lower Trinity Bay. This study reports the findings of the resulting assessment conducted in June 1992 on the impact of the industrial activity on humpback whales foraging in the area. Although explosions were characterized by high-energy signatures with principal energies under 1 kHz, humpback whales showed little behavioral reaction to the detonations in terms of decreased residency, overall movements, or general behavior. However, it appears that the increased entrapment rate may have been influenced by the long-term effects of exposure to deleterious levels of sound.

Trevino, K. and F. Turina (2012). Laws, Policies, and Authorities for the Protection of Soundscapes in the National Parks. 41st International Congress and Exposition on Noise Control Engineering 2012, INTER-NOISE 2012, August 19, 2012 - August 22, 2012, New York, NY, United states, Institute of Noise Control Engineering of the USA.
An integral part of the National Park Service (NPS) mission, derived from the Organic Act of 1916 and subsequent legislation, is protecting the natural and cultural sounds in national park units. This mandate motivated the formation of the Natural Sounds and Night Skies Division to assist parks in developing and implementing actions to protect, preserve, and restore the acoustical environment. The Division also works in partnership with parks and others to increase scientific understanding and inspire public appreciation of the value and character of soundscapes. Currently, more than 300,000 hours of acoustical data have been collected in more than 60 park units. These data reveal that many parks enjoy some of the lowest ambient sound levels ever measured, providing an expansive listening experience for park visitors. However, noise is a burgeoning problem for NPS. This session will provide an overview of agency mandates, authorities, and regulations for addressing soundscape management issues in national park units. This paper discusses the role of the Organic Act of 1916, NPS Management Policies, Director's Order 47, the National Parks Air Tour Management Act, and other policies and regulations related to the protection of park soundscapes.

Tripovich, J. S., et al. (2012). "The behavioral response of Australian fur seals to motor boat noise." PLoS ONE 7(5): e37228.
Australian fur seals breed on thirteen islands located in the Bass Strait, Australia. Land access to these islands is restricted, minimising human presence but boat access is still permissible with limitations on approach distances. Thirty-two controlled noise exposure experiments were conducted on breeding

Australian fur seals to determine their behavioral response to controlled in-air motor boat noise on Kanowna Island (39°10'S, 146°18'E). Our results show there were significant differences in the seals' behavior at low (64–70 dB) versus high (75–85 dB) sound levels, with seals orientating themselves towards or physically moving away from the louder boat noise at three different sound levels. Furthermore, seals responded more aggressively with one another and were more alert when they heard louder boat noise. Australian fur seals demonstrated plasticity in their vocal responses to boat noise with calls being significantly different between the various sound intensities and barks tending to get faster as the boat noise got louder. These results suggest that Australian fur seals on Kanowna Island show behavioral disturbance to high level boat noise. Consequently, it is recommended that an appropriate level of received boat sound emissions at breeding fur seal colonies be below 74 dB and that these findings be taken into account when evaluating appropriate approach distances and speed limits for boats.

Tucker, D., et al. (2014). "Linking ecological condition and the soundscape in fragmented Australian forests." Landscape Ecology 29(4): 745-758.

Natural landscapes are increasingly subjected to anthropogenic pressure and fragmentation resulting in reduced ecological condition. In this study we examined the relationship between ecological condition and the soundscape in fragmented forest remnants of south-east Queensland, Australia. The region is noted for its high biodiversity value and increased pressure associated with habitat fragmentation and urbanisation. Ten sites defined by a distinct open eucalypt forest community dominated by spotted gum (Corymbia citriodora ssp. variegata) were stratified based on patch size and patch connectivity. Each site underwent a series of detailed vegetation condition and landscape assessments, together with bird surveys and acoustic analysis using relative soundscape power. Univariate and multivariate analyses indicated that the measurement of relative soundscape power reflects ecological condition and bird species richness, and is dependent on the extent of landscape fragmentation. We conclude that acoustic monitoring technologies provide a cost effective tool for measuring ecological condition, especially in conjunction with established field observations and recordings.[PUBLICATION ABSTRACT]

Turina, F. (2009). "Protecting the acoustic conditions at Great Sand Dunes National Park and Preserve." Park Science 26(3): 52-53.

Turina, F. and K. Trevino (2012). Framework for Addressing Noise Generated by National Park Operations. 41st International Congress and Exposition on Noise Control Engineering 2012, INTER-NOISE 2012, August 19, 2012 - August 22, 2012, New York, NY, United states, Institute of Noise Control Engineering of the USA.

Natural Sounds and Night Skies Division (NSNSD) noise analyses have indicated that in many areas, routine park operation and maintenance activities represent a significant source of noise. In response, the NSNSD is developing the Soundscape Protection and Restoration Initiative (SPRI), a new approach to protecting acoustic resources from park-generated noise, with an emphasis on creating more consistent, resource-based, mission-driven criteria. The goal of the SPRI is to develop a toolbox of replicable administrative and management actions that can be implemented to effectively protect soundscape resources from noise

generated by park operations and maintenance. The actions will be based on the identification and use of Best Available Technology (BAT) for park equipment, vehicles, and other noise sources coupled with Best Management Practices (BMP) for minimizing noise impacts when conducting park operations. BAT and BMPs will be based on recommendations from a working group consisting of NPS, private sector, non-profit and government experts in park management, noise source characterization, and acoustics. BAT and BMPs will be tested through monitoring and social science surveys to determine maximum efficacy for protecting resources. Once data collected from SRI parks are analyzed, the NSNSD will develop a BAT and BMP toolbox and conduct service-wide training and information workshops.

Tuttle, M. D. and M. J. Ryan (1982). "The role of synchronized calling, ambient light, and ambient noise, in anti-batpredator behavior of a treefrog." Behavioral Ecology and Sociobiology 11(2): 125-131.
Male treefrogs, Smilisca sila (Hylidae), produce calls of varying complexity and demonstrate a remarkable ability to synchronize their calls with those of neighbors. The bat Trachops cirrhosus eats frogs and uses the frogs' advertisement calls as locational cues. The bats are less likely to respond to synchronous calls than to asynchronous calls, and when given a choice prefer complex calls to simple calls.

Experiments with bat models indicate that, like other frogs, S. sila probably uses visual cues to detect hunting bats. In response to bat models the frogs decreased both the number and the complexity of their calls. The calling behavior of the frogs was sampled in the field during periods with and without artificial illumination. The frogs produced fewer and less complex calls, and they tended to call from more concealed sites, during the period without illumination, when presumably it would have been more difficult for the frogs to detect hunting bats.

S. sila tended to call from sites with higher ambient noise level, the noise primarily originating from waterfalls. The frequencies of the dominant energies in the waterfall sounds completely overlapped the frequency range of the S. sila call; thus waterfalls might mask the frog calls. When given a choice between calls produced near and away from waterfall sounds, bats preferred the latter.

Tyack, P. L. (2008). "Implications for marine mammals of large-scale changes in the marine acoustic environment." Journal of Mammalogy 89(3): 549-558.
The amount of underwater sound from ship traffic, commercial, research, and military sound sources has increased significantly over the past century. Marine mammals and many other marine animals rely on sound for short- and long-range communication, for orientation, and for locating prey. This reliance has raised concern that elevated sound levels from human sources may interfere with the behavior and physiology of marine animals. The dominant source of human sound in the sea stems from propulsion of ships. Shipping noise centers in the 20- to 200-Hz band. Frequencies this low propagate efficiently in the sea, and shipping has elevated the global deepwater ambient noise 10- to 100-fold in this frequency band. Baleen whales use the same frequency band for some of their communication signals, and concern has been raised that elevated ambient noise may reduce the range over which they can communicate. Marine mammals have a variety of mechanisms to compensate for increased noise, but little is known about the maximum

range at which they may need to communicate. Some of the most intense human sources of sound include air guns used for seismic exploration and sonar for military and commercial use. Human sources of sound in the ocean can disturb marine mammals, evoking behavioral responses that can productively be viewed as similar to predation risk, and they can trigger allostatic physiological responses to adapt to the stressor. Marine mammals have been shown to avoid some human sound sources at ranges of kilometers, raising concern about displacement from important habitats. There are few studies to guide predictions of when such changes start to lower the fitness of individuals or have negative consequences for the population. Although acute responses to intense sounds have generated considerable interest, the more significant risk to populations of marine mammals is likely to stem from less visible effects of chronic exposure.

Tyack, P. L., et al. (2011). "Beaked whales respond to simulated and actual navy sonar." PLoS ONE 6(3): e17009.

Beaked whales have mass stranded during some naval sonar exercises, but the cause is unknown. They are difficult to sight but can reliably be detected by listening for echolocation clicks produced during deep foraging dives. Listening for these clicks, we documented Blainville's beaked whales, Mesoplodon densirostris, in a naval underwater range where sonars are in regular use near Andros Island, Bahamas. An array of bottom-mounted hydrophones can detect beaked whales when they click anywhere within the range. We used two complementary methods to investigate behavioral responses of beaked whales to sonar: an opportunistic approach that monitored whale responses to multi-day naval exercises involving tactical mid-frequency sonars, and an experimental approach using playbacks of simulated sonar and control sounds to whales tagged with a device that records sound, movement, and orientation. Here we show that in both exposure conditions beaked whales stopped echolocating during deep foraging dives and moved away. During actual sonar exercises, beaked whales were primarily detected near the periphery of the range, on average 16 km away from the sonar transmissions. Once the exercise stopped, beaked whales gradually filled in the center of the range over 2–3 days. A satellite tagged whale moved outside the range during an exercise, returning over 2–3 days post-exercise. The experimental approach used tags to measure acoustic exposure and behavioral reactions of beaked whales to one controlled exposure each of simulated military sonar, killer whale calls, and band-limited noise. The beaked whales reacted to these three sound playbacks at sound pressure levels below 142 dB re 1 μPa by stopping echolocation followed by unusually long and slow ascents from their foraging dives. The combined results indicate similar disruption of foraging behavior and avoidance by beaked whales in the two different contexts, at exposures well below those used by regulators to define disturbance.

Uran, S., et al. (2012). "Rat hippocampal alterations could underlie behavioral abnormalities induced by exposure to moderate noise levels." Brain Research 1471: 1-12.

Noise exposure is known to affect auditory structures in living organisms. However, it should not be ignored that many of the effects of noise are extra-auditory. Previous findings of our laboratory demonstrated that noise was able to induce behavioral alterations that are mainly related to the cerebellum (CE) and the hippocampus (HC). Therefore, the aim of this work was to reveal new data about the vulnerability of developing rat HC to moderate noise levels through the assessment of potential histological changes and hippocampal-

related behavioral alterations. Male Wistar rats were exposed to noise (95–97 dB SPL, 2 h daily) either for 1 day (acute noise exposure, ANE) or between postnatal days 15 and 30 (sub-acute noise exposure, SANE). Hippocampal histological evaluation as well as short (ST) and long term (LT) habituation and recognition memory assessments were performed. Results showed a mild disruption in the different hippocampal regions after ANE and SANE schemes, along with significant behavioral abnormalities. These data suggest that exposure of developing rats to noise levels of moderate intensity is able to trigger changes in the HC, an extra-auditory structure of the Central Nervous System (CNS), that could underlie the observed behavioral effects.

van Polanen Petel, T. D., et al. (2006). "An assessment of the audibility of sound from human transport by breeding Weddell seals (Leptonychotes weddellii)." Wildlife Research 33(4): 275-291.
Anthropogenic noise generated through travel in the Antarctic has the potential to affect the region's wildlife. Weddell seals (Leptonychotes weddellii) in particular can be exposed to anthropogenic noise because they live under, and breed on, the fast ice on which humans travel. To investigate the potential effects of anthropogenic noise on Weddell seals we developed sound profiles for pedestrian travel, over-snow vehicles, aircraft and watercraft operating at various distances and altitudes from breeding seals. The received 1/3-octave noise levels were then related to an assumed detection threshold for the Weddell seal. We found that most noise levels generated by the pedestrian, quad (4-wheeled, all-terrain vehicle) and Hagglunds (tracked, all-terrain vehicle) were commonly categorised in the inaudible and barely audible range of detection (both in-air and underwater), while noise levels generated by the helicopter, Twin Otter aircraft and Zodiac boat were categorised more commonly in the barely audible and clearly audible range. Experimental underwater recordings of vocal behavior of Weddell seals exposed to continuous lowamplitude over-snow vehicle noise (i.e. Hagglund operation) were also made. Weddell seals underwater did not alter individual call types in response to low-level Hagglunds noise, but they did decrease their calling rate.

Vargas-Salinas, F. and A. Amézquita (2013). "Traffic noise correlates with calling time but not spatial distribution in the threatened poison frog Andinobates bombetes." Behavior 150(6): 569-584.
Acoustically communicating species have evolved adaptations that allow them to transmit information and overcome signal masking where their habitat is disturbed by anthropogenic noise. To investigate whether calling behavior or spatial distribution is related to road traffic noise we studied the poison frog Andinobates bombetes in a mid-elevation forest remnant that has been exposed to heavy traffic noise throughout more than four decades. To test whether frogs avoid call during noise episodes generated by passing trucks, we compared background noise levels between calling and non-calling times. To test whether traffic noise is correlated with frogs spatial distribution, we measured frog abundance, ambient noise, and environmental covariates throughout a set of 24 sampling plots between 15 and 300 m from two forest edges, one bordered by the road and another one by an agricultural field. Frogs called more often when traffic noise level was lower. Frogs abundance was only marginally correlated with distance to noisy edges but was predictable from the abundance of bromeliad tanks, an alleged limiting resource for their reproduction. Apparently, to avoid calling during episodes with higher noise level allowed frogs to reduce the detrimental masking effects of anthropogenic noise; if so, it would explain why frog distribution is poorly correlated with distance to the noisy road.

Vasconcelos, R. O., et al. (2007). "Effects of ship noise on the detectability of communication signals in the Lusitanian toadfish." Journal of Experimental Biology 210(12): 2104-2112.
Underwater noise pollution is an increasing environmental problem which might affect communication, behavior, fitness and consequently species' survival. The most common anthropogenic noises in aquatic habitats derive from shipping. In the present study we investigated the implications of noise pollution from a ship on the sound detectability, namely of conspecific vocalizations in the Lusitanian toadfish, Halobatrachus didactylus. Ambient and ferry-boat noises were recorded in the Tagus River estuary (Portugal), as well as toadfish sounds, and their sound pressure levels determined. Hearing sensitivities were measured under quiet lab conditions and in the presence of these masking noises at levels encountered in the field, using the auditory evoked potentials (AEP) recording technique. The Lusitanian toadfish is a hearing generalist, with best hearing sensitivity at low frequencies between 50 and 200 Hz (below 100 dB re. 1 μPa). Under ambient noise conditions, hearing was only slightly masked at lower frequencies. In the presence of ship noise, auditory thresholds increased considerably, by up to 36 dB, at most frequencies tested. This is mainly because the main energies of ferry-boat noise were within the most sensitive hearing range of this species. Comparisons between masked audiograms and sound spectra of the toadfish's mating and agonistic vocalizations revealed that ship noise decreased the ability to detect conspecific acoustic signals. This study provides the first evidence that fishes' auditory sensitivity can be impaired by ship noise and that acoustic communication, which is essential during agonistic encounters and mate attraction, might be restricted in coastal environments altered by human activity.

Verzijden, M., et al. (2010). "Immediate spectral flexibility in singing chiffchaffs during experimental exposure to highway noise." Journal of Experimental Biology 213(15): 2575-2581.
Sound plays an important role in the life of many animals, including many bird species. Typically, male birds sing to defend a territory and to attract mates. Ambient noise may negatively affect the signal efficiency of their songs, which may be critical to reproductive success. Consequently, anthropogenic noise may be detrimental to individual birds and to populations in cities and along highways. Several bird species that are still common in urban areas have been shown to sing at higher frequency at locations where there is more low-frequency traffic noise. Here we show that chiffchaffs along noisy highways also sing with a higher minimum frequency than chiffchaffs nearby at a quiet riverside. Furthermore, through experimental exposure to highway noise we show that these birds are capable of making such adjustments over a very short time scale. The first 10 songs sung during the noise exposure revealed an immediate shift to higher frequencies, with a return to pre-exposure levels in recordings without noise the following day. In a transmission rerecording experiment we tested the impact of a potential measurement artifact by recording playback of the same songs repeatedly under different controlled noise conditions. We found an upward shift in the minimum frequency measurement associated with more noisy recordings of the same song, but this artifact was not of a scale that it could explain the noise-dependent spectral shifts in chiffchaffs.

Wahlberg, M. and H. Westerberg (2005). "Hearing in fish and their reactions to sounds from offshore wind farms." Marine Ecology Progress Series 288: 295-309.
The current knowledge on detection of, and reaction to, sound by fish is reviewed, with special emphasis

on underwater noise from offshore wind farms. The detection distance to wind farms for 3 species of fish representing various hearing capabilities varies between 0.4 and 25 km at wind speeds of 8 to 13 m s–1. The detection distance depends on the size and number of windmills, the hearing abilities of the fish, background noise level, wind speed, water depth and type of sea bottom. The noise from windmills may decrease the effective range for sound communication of fish; however, it is not known to what extent this decrease affects the behavior and fitness of fish. Windmill noise does not have any destructive effects upon the hearing abilities of fish, even within distances of a few metres. It is estimated that fish are consistently scared away from windmills only at ranges shorter than about 4 m, and only at high wind speeds (higher than 13 m s–1). Thus, the acoustic impact of windmills on fish is restricted to masking communication and orientation signals rather than causing physiological damage or consistent avoidance reactions. These conclusions must be viewed with great caution, however, as the existing data are prone to large uncertainties. Further studies on more detailed measurements of the sound-field and of fish behavior around windmills are needed.

Wale, M. A., et al. (2013). "Noise negatively affects foraging and antipredator behavior in shore crabs." Animal Behavior 86(1): 111-118.

Acoustic noise has the potential to cause stress, to distract and to mask important sounds, and thus to affect behavior. Human activities have added considerable noise to both terrestrial and aquatic habitats, and there is growing evidence that anthropogenic noise affects communication and movement patterns in a variety of species. However, there has been relatively little work considering the effect on behaviors that are fundamental to survival, and thus have direct fitness consequences. We conducted a series of controlled tank-based experiments to consider how playback of ship noise, the most common source of underwater noise, affects foraging and antipredator behavior in the shore crab, Carcinus maenas. Ship noise playback was more likely than ambient-noise playback to disrupt feeding, although crabs experiencing the two sound treatments did not differ in their likelihood of, or speed at, finding a food source in the first place. While crabs exposed to ship noise playback were just as likely as ambient-noise controls to detect and respond to a simulated predatory attack, they were slower to retreat to shelter. Ship noise playback also resulted in crabs that had been turned on their backs righting themselves faster than those experiencing ambient-noise playback; remaining immobile may reduce the likelihood of further predatory attention. Our findings therefore suggest that anthropogenic noise has the potential to increase the risks of starvation and predation, and showcases that the behavior of invertebrates, and not just vertebrates, is susceptible to the impact of this pervasive global pollutant.

Wardle, C., et al. (2001). "Effects of seismic air guns on marine fish." Continental Shelf Research 21(8): 1005-1027.

Observations of marine fish and invertebrates on an inshore reef were made using TV and acoustic tags one week before, during, and four days after a seismic triple G. air gun (three synchronised airguns, each gun 2.5 l and 2000 psi) was deployed and repeatedly fired. The guns were fired once/min for eight periods on four days at different positions. The structure and intensity of the sound of each triple G. gun explosion was recorded and calibrated. Peak sound pressure levels of 210 dB (rel to 1 μPa) at 16 m range and 195 dB (rel to 1 μPa) at 109 m range were measured at positions where the fish were being observed. The final

position of the triple G. gun, at 5.3 m range, had a peak pressure level of 218 dB (rel to 1 μPa). Neither the fish, nor the invertebrates, showed any signs of moving away from the reef. Firing the guns did not interrupt a diurnal rhythm of fish gathering at dusk and passing the TV camera position while the guns were firing. The longterm day-to-night movements of two tagged pollack were slightly changed by the arrival and banging of the guns particularly when positioned within 10 m of their normal living positions. Those reef fish, watched by the TV camera, always showed involuntary reactions in the form of a Mauthner cell reflex, C-start, at each explosion of the guns at all ranges tested (maximum range was 109 m, 195 dB rel to 1 μPa). When the explosion source was not visible to the fish, the C-start reaction was cut short and the fish continued with what they were doing before the stimulus. When the G. gun rack was sunk to the seabed (depth 14 m) visible to the fish and the TV camera, those fish that were observed approaching the G. gun rack when the guns were fired were seen to turn and flee from the very visible explosion. When the gun rack was suspended midwater (5 m depth) and just outside visible range at 16 metres, the fish receiving a 6 ms peak to peak, 206 dB (rel to 1 μPa) pressure swing exhibited a C-start and then continued to swim towards the gun position, their intended swimming track apparently unaltered. The sound of the G. guns had little effect on the day-to-day behavior of the resident fish and invertebrates.

Watts, G., et al. (2013). "Tranquillity and soundscapes in urban green spaces-- predicted and actual assessments from a questionnaire survey." Environment & Planning B: Planning & Design 40(1): 170-181.
A previous pilot study demonstrated the utility of a tranquillity prediction tool TRAPT for use in three green open spaces in a densely populated area. This allows the calculation of perceived levels of tranquillity in open spaces. The current study expands the range of sites to eight and, importantly, considers the views of visitors to these spaces. In total 252 face-to-face interviews were conducted in these spaces. An important aim of the survey was to determine the extent to which reported tranquillity obtained from the questionnaire survey could be predicted by a previously developed prediction tool TRAPT. A further aim was to determine what other factors may need to be considered in addition to the purely physical descriptors in TRAPT. The questions included the sounds and sights that were noticed, factors affecting tranquillity, as well as questions related to the benefits of visiting these areas. Predictions were considered satisfactory and could be improved further by taking account of issues surrounding personal safety. Examining the trends in these data, it was also shown that the percentage of people feeling more relaxed after visiting the spaces was closely related to overall assessments of perceived tranquillity. Further trends and their implications are presented and discussed. [ABSTRACT FROM AUTHOR]

Watts, G. R. and R. J. Pheasant (2015). "Tranquillity in the Scottish Highlands and Dartmoor National Park – The importance of soundscapes and emotional factors." Applied Acoustics 89: 297-305.

The findings of a wildness study are presented where audio–visual stimuli (video footage), were assessed by experimental subjects under controlled conditions, in order to obtain reliable estimates of perceived tranquillity together with a number of other rated qualities including calmness and pleasantness. A wide range of mainly natural scenes totalling 46 were presented including footage from the Scottish Highlands and Dartmoor National Park. The findings clearly demonstrate that rated tranquillity relates closely to rated calmness and pleasantness and this agrees with earlier studies of soundscape categorisation. The effect of adding man-made sounds to the soundscape was shown to seriously degrade perceived tranquillity though ratings of wildness were not nearly as affected. Attempts to improve the level of tranquillity further by adding natural sounds were largely unsuccessful. It was considered important to determine if the previously employed Tranquillity Rating Prediction Tool (TRAPT) successfully validated for mainly urban open spaces could usefully predict tranquility in remote wildland areas. In fact results demonstrated the relatively close relationship between predicted and actually rated tranquillity in these remote areas which further extended the range of validity of the prediction tool. The findings of this study will challenge the notion that characterization of landscapes is purely a visual exercise and that soundscape quality needs to be considered as an integral part of this assessment process. For this reason the findings will be of interest to those responsible for managing and marketing protected areas such as National Parks, practitioners involved in carrying out landscape character assessments, cartographers and landscape architects involved in designing tranquil spaces across a range of scales. [ABSTRACT FROM AUTHOR]

Weilgart, L. S. (2007). "The impacts of anthropogenic ocean noise on cetaceans and implications for management." Canadian Journal of Zoology 85(11): 1091-1116.

Ocean noise pollution is of special concern for cetaceans, as they are highly dependent on sound as their principal sense. Sound travels very efficiently underwater, so the potential area impacted can be thousands of square kilometres or more. The principal anthropogenic noise sources are underwater explosions (nuclear and otherwise), shipping, seismic exploration by mainly the oil and gas industries, and naval sonar operations. Strandings and mortalities of especially beaked whales (family Ziphiidae) have in many cases been conclusively linked to noise events such as naval maneuvers involving tactical sonars or seismic surveys, though other cetacean species may also be involved. The mechanisms behind this mortality are still unknown, but are most likely related to gas and fat emboli at least partially mediated by a behavioral response, such as a change in diving pattern. Estimated received sound levels in these events are typically not high enough to cause hearing damage, implying that the auditory system may not always be the best indicator for noise impacts. Beaked whales are found in small, possibly genetically isolated, local populations that are resident year-round. Thus, even transient and localized acoustic impacts can have prolonged and serious population consequences, as may have occurred following at least one stranding. Populations may

also be threatened by noise through reactions such as increased stress levels, abandonment of important habitat, and "masking" or the obscuring of natural sounds. Documented changes in vocal behavior may lead to reductions in foraging efficiency or mating opportunities. Responses are highly variable between species, age classes, behavioral states, etc., making extrapolations problematic. Also, short-term responses may not be good proxies of long-term population-level impacts. There are many examples of apparent tolerance of noise by cetaceans, however. Noise can also affect cetaceans indirectly through their prey. Fish show permanent and temporary hearing loss, reduced catch rates, stress, and behavioral reactions to noise. Management implications of noise impacts include difficulties in establishing "safe" exposure levels, shortcomings of some mitigation tools, the need for precaution in the form of reducing noise levels and distancing noise from biologically important areas, and the role of marine protected areas and monitoring in safeguarding cetaceans especially from cumulative and synergistic effects.

Weinzimmer, D., et al. (2014). "Human Responses to Simulated Motorized Noise in National Parks." Leisure Sciences 36(3): 251-267.

Natural sounds contribute to high-quality experiences for visitors to protected areas. This study investigated the effects of three common sources of recreational motorized noise on laboratory participants' evaluations of landscape scenes. Seventy-five study participants completed landscape assessments along eight aesthetic and experiential dimensions while listening to audio clips of natural sounds, propeller planes, motorcycles, and snowmobiles. The change from the natural sound baseline for each motorized source of noise was calculated. Results indicated that all motorized sources of noise had detrimental impacts on evaluations of landscape quality compared with natural sounds. Motorcycle noise was demonstrated to have the largest negative impact on landscape assessments. In addition to confirming that noise from motorized recreation has significant impacts on the experiences of potential park visitors, this simulation suggests that the specific source of the noise is an important factor in determining observer evaluations of the quality of the natural environment. [ABSTRACT FROM AUTHOR]

Weisenberger, M. E., et al. (1996). "Effects of simulated jet aircraft noise on heart rate and behavior of desert ungulates." The Journal of Wildlife Management: 52-61.

Many landscapes underlying military designated air spaces have been established as national parks, wildlife refuges, or wilderness areas. The juxtaposition of public, wilderness, and military uses has led to questions of compatibility between aircraft and wildlife. We evaluated the effects of simulated low-altitude jet aircraft noise on the behavior and heart rate of captive desert mule deer (Odocoileus hemionus crooki) (n = 6) and mountain sheep (Ovis canadensis mexicana) (n = 5). We measured heart rate and behavior related to the number of simulated overflights per day (range = 1-7) and noise levels (range = 92-112 decibels [dB]) that

animals were exposed to. We compared heart rates and behavior of mountain sheep and desert mule deer before, during, and after simulated overflights (n = 112 overflights/season) during 3 seasons. The heart rates of ungulates increased related to dB levels during simulated overflights (P < 0.05), but they returned to pre-disturbance levels in 60-180 seconds. Animal behavior also changed during overflights but returned to pre-disturbance conditions in <252 seconds (P _ 0.005) All animal responses decreased with

Wiciak, J., et al. (2015). "Quietness in the Soundscape of the Białowieza National Park." Acta Physica Polonica, A. 128(1A): A-79-A-84.

The quietness, defined as the near or complete absence of sound, in the context of the natural environment protection, may be considered a state in which no undesired of foreign sounds occur, and, by analogy to noise, analyzed in two aspects: that pertaining to measurements and the subjective one. The article discusses the lowest levels of sounds recorded at night in the soundscape of the Białowieza Forest. Due to low levels of the examined sounds and the technical problems that occurred while the sounds were being measured and registered, the acoustic examination of the measurement set-up in an anechoic chamber has also been presented. The research is aimed at defining precisely the concept of quietness prevailing in the nature in the subjective aspect by determining both the range of levels and the characteristics of preferred sounds. [ABSTRACT FROM AUTHOR]

Wilkens, S., et al. (2012). "Induction of settlement in mussel (Perna canaliculus) larvae by vessel noise." Biofouling 28(1): 65-72.

Underwater sound plays an important role in the settlement behavior of many coastal organisms. Large steel-hulled vessels are known to be a major source of underwater sound in the marine environment. The possibility that underwater sound from vessels may promote biofouling of hulls through triggering natural larval settlement cues was investigated for the mussel, Perna canaliculus. The mussel larvae showed significantly faster settlement when exposed to the underwater noise produced by a 125-m long steel-hulled passenger and freight ferry. Median time to attachment on the substrata (ie settlement) was reduced by 22% and the time taken for all experimental larvae to settle was reduced by 40% relative to a silent control. There was no difference in the survival of the mussel larvae among the various noise treatments. The decrease in settlement time of the mussel larvae appeared to correlate with the intensity of the vessel sound, suggesting that underwater sound emanating from vessels may be an important factor in exacerbating hull fouling by mussels.

Withers, J. and G. Adema (2010). "Soundscapes monitoring and an overflight advisory group: Informing real-time management decisions at Denali." Park Science 26(3): 42-45.

Wood, W. E. and S. M. Yezerinac (2006). "Song sparrow (Melospiza melodia) song varies with urban noise." The Auk 123(3): 650-659.

In urban environments, anthropogenic noise may mask bird song, especially the notes occurring at lower frequencies (1–2 kHz). Birds living in urban environments may modify their songs, particularly the lowfrequency portions, to minimize masking by anthropogenic noise. Such modifications have been observed in Great Tits (Parus major) in The Netherlands, as well as in some mammals. We studied Song Sparrows (Melospiza melodia), which are common in both urban and rural environments in much of North America, and recorded the songs of 28 free- living males in Portland, Oregon. We also measured the amplitude and spectrum of ambient noise at singing locations. Song Sparrows singing at noisier locations exhibited higherfrequency low notes and had relatively less energy (amplitude) in the low-frequency range of their songs (1– 4 kHz), where most anthropogenic noise also occurred. Although the mechanism(s) producing the correlation are as yet undetermined, the observed match between song and noise may result from behavioral plasticity. We discuss explanations for these patterns and how to test them.

Wright, A. J., et al. (2007). "Anthropogenic noise as a stressor in animals: a multidisciplinary perspective." International Journal of Comparative Psychology 20(2).

Consequences of extreme noise exposure are obvious and usually taken into some consideration in the management of many human activities that affect either human or animal populations. However, the more subtle effects such as masking, annoyance and changes in behavior are often overlooked, especially in animals, because these subtleties can be very difficult to detect. To better understand the possible consequences of exposure to noise, this review draws from the available information on human and animal physiology and psychology, and addresses the importance of context (including physiological and psychological state resulting from any previous stressor exposure) in assessing the true meaning of behavioral responses. The current consensus is that the physiological responses to stressors of various natures are fairly stereotyped across the range of species studied. It is thus expected that exposure to noise can also lead to a physiological stress response in other species either directly or indirectly through annoyance, a secondary stressor. In fact many consequences of exposure to noise can result in a cascade of secondary stressors such as increasing the ambiguity in received signals or causing animals to leave a resourceful area, all with potential negative if not disastrous consequences. The context in which stressors are presented was found to be important not only in affecting behavioral responses, but also in affecting the physiological and psychological responses. Young animals may be particularly sensitive to stressors for a number of reasons including the sensitivity of their still developing brains. Additionally, short exposure to stressors may result in long-term consequences. Furthermore, physiological acclimation to noise exposure cannot be determined from apparent behavioral reactions alone due to contextual influence, and negative impacts may persist or increase as a consequence of such behavioral changes. Despite the lack of information available to managers, uncertainty analysis and modeling tools can be coupled with adaptive management strategies to support decision making and continuous improvements to managing the impacts of noise on free-ranging animals.

Würsig, B., et al. (2000). "Development of an air bubble curtain to reduce underwater noise of percussive piling." Marine Environmental Research 49(1): 79-93.

Underwater bubbles can inhibit sound transmission through water due to density mismatch and concomitant reflection and absorption of sound waves. For the present study, a perforated rubber hose was used to produce a bubble curtain, or screen, around pile-driving activity in 6–8-m depth waters of western Hong Kong. The percussive hammer blow sounds of the pile driver were measured on 2 days at distances of 250, 500, and 1000 m; broadband pulse levels were reduced by 3–5 dB by the bubble curtain. Sound intensities were measured from 100 Hz to 25.6 kHz, and greatest sound reduction by the bubble curtain was evident from 400 to 6400 Hz. Indo-Pacific hump-backed dolphins (Sousa chinensis) occurred in the immediate area of the industrial activity before and during pile driving, but with a lower abundance immediately after it. While hump-backed dolphins generally showed no overt behavioral changes with and without pile driving, their speeds of travel increased during pile driving, indicating that bubble screening did not eliminate all behavioral responses to the loud noise. Because the bubble curtain effectively lowered sound levels within 1 km of the activity, the experiment and its application during construction represented a success, and this measure should be considered for other appropriate areas with high industrial noises and resident or migrating sound-sensitive animals.

Wysocki, L. E., et al. (2006). "Ship noise and cortisol secretion in European freshwater fishes." Biological Conservation 128(4): 501-508.

Underwater noise pollution is a growing problem in aquatic environments and as such may be a major source of stress for fish. In the present study, we addressed the effects of ship noise and continuous Gaussian noise on adrenal activity in three European freshwater species. Underwater ship noise recorded in the Danube River and two Austrian lakes was played back to fish at levels encountered in the field (153 dB re 1 µPa, 30 min). Post exposure cortisol secretion was compared with control situations. Cortisol was measured with enzyme immunoassay techniques (EIA, ng cortisol/l water/g fish) in extracted aquarium water with corrections for fish mass. In the first series, two hearing specialists, the common carp (Cyprinus carpio) and the gudgeon (Gobio gobio) and one hearing generalist, the European perch (Perca fluviatilis) were exposed to ship noise. The noise level was well above hearing thresholds in these species. In a second series, fish were exposed to continuous Gaussian noise at a similar level (156 dB) which is known to induce temporary hearing loss in hearing specialists. All three species responded with increased cortisol secretion when exposed to ship noise. Interestingly, no elevation was observed when fish were exposed to continuous Gaussian noise. Our results indicate that ship noise characterized by amplitude and frequency fluctuations, constitutes a potential stressor in contrast to continuous noise. Surprisingly, the data also demonstrate no apparent differences between species possessing excellent hearing abilities (hearing specialists) and species with poor hearing abilities like perch.

Yasuhiko, W., et al. (1995). "A mouse model of a sudden death induced by noise exposure is useful to investigate human responses to physical stress." Industrial Health 33(1): 29-33.

Stress has become an increasingly important occupational health matter in Japan. We found that noise exposure, 6kHz wave and its higher harmonics at the sound pressure level of 112dB, induced typical audiogenic seizures in the MRL/l mouse strain. The seizures are often fatal. Wild running preludes to seizures. Inhibition of wild running by restricting animal's activities successfully prevented the seizures,

suggesting that an excessive physical load is a necessary step. The present finding indicates that MRL/l mice may be a useful model for human sudden deaths after excessive work loads.

Zhang, M., et al. (2012). "Effect of traffic noise on black-faced spoonbills in the Taipa–Coloane Wetland Reserve, Macao." Wildlife Research 39(7): 603-610.
Context: Nearly 20% of black-faced spoonbills (Platalea minor), a globally endangered species, winter along the coasts of the Pearl River Estuary, China. However, these wintering habitats are threatened by urban development. Especially in Macao, road construction for the tourism industry has resulted in habitat deterioration.

Zurcher, A. A., et al. (2010). "Why the bat did not cross the road?" Acta Chiropterologica 12(2): 337-340.
Roadways are nearly ubiquitous parts of the modern landscape, but their impact on bats remain relatively unknown. We studied the influence of vehicular traffic on the behavior of commuting bats near the Indianapolis International Airport. A previous study at this site documented that Indiana bats (Myotis sodalis) were much more likely to cross roads with low traffic volumes. One potential interpretation of this result is that bats perceive motor vehicles as a threat and exhibit avoidance behavior whether or not the bats are in immediate danger. To test this hypothesis, we observed 211 cases of bats approaching roads that bisected their commuting routes. Information recorded at the time included the presence or absence of vehicles, the height the bat was flying, whether a bat reversed course prior to crossing the road and if so the distance from the road or vehicle (if present) when it altered its direction, and finally the speed, type and relative level of noise emitted by vehicles. Results revealed that bats were more than twice as likely to reverse course when vehicles were present as opposed to their absence. When automobiles were present 60% of bats exhibited avoidance behavior, reversing course at an average of 10 m from a vehicle. Conversely, when no automobiles were present, only 32% of bats reversed their course and 68% crossed the road. The height a bat flew, speed of the vehicle, type of vehicle or level of noise emitted by vehicles had no effect on the likelihood of bats reversing course. These data support the hypothesis that bats perceive vehicles as a threat and display anti-predator avoidance behavior in response to their presence.