

## Annotated Bibliography

# Impacts of Noise on Wildlife

Title	Citation	Abstract
<b>Literature Reviews</b>		
	Dooling, R. J., Lohr, B. & Dent, M. L. 2000. Hearing in birds and reptiles. In: <i>Comparative Hearing: Birds and Reptiles</i> (Ed. by R. J. Dooling, R. R. Fay & A. N. Popper), pp. 308–359. New York: Springer–Verlag.	
	Fay, R. R. 1988. <i>Hearing in Vertebrates: a Psychophysics Data Book</i> . Winnetka, Illinois: Hill–Fay.	
<b>Tits, noise and urban bioacoustics</b>	Katti M and Warren PS, 2004, Tits, noise and urban bioacoustics. <b>Trends in Ecology and Evolution</b> 19(3):109-110	Humans, particularly in cities, are noisy. Researchers are only just beginning to identify the implications of an increase in noise for species that communicate acoustically. In a recent paper, Slabbekorn and Peet show, for the first time, that some birds can respond to anthropogenically elevated noise levels by altering the frequency structure of their songs. Cities are fruitful grounds for research on the evolution of animal communication systems, with broader implications for conservation in human-altered environments.
<b>The Effects of Aircraft Noise on Wildlife; a Review and Comment.</b>	Kempf, N. & O. Hueppop, 1997,: “The Effects of Aircraft Noise on Wildlife; a Review and Comment”. <b>Vogel und Luftverkehr</b> , Bd. 1/97: 58-70	The discussion of noise effects involves physical, physiological aspects making an evaluation quite difficult. In humans the effects of noise range from discomfort to severe, irreversible damage. In laboratory animals only strong and long lasting noise causes physiological changes that can affect health. These findings are only partly applicable to wild animals. Field studies have to deal carefully with (1) methodological difficulties in measuring sound pressure levels, (2) interspecific differences of auditory sensitivity, and (3) problems in interpreting behavioural reactions in the field. Non-standardized methods of observations and analysis make a comparison of the results found in the literature almost impossible. Especially the noise of aircraft can scarcely be assessed separately from its optical appearance. Optical or acoustical stimuli taken separately have only minor effects with the optical stimulus evoking the stronger reaction; even soundless paragliders can cause panic flights. In general, noise plays a minor role as a disturbance factor, but in combination with optical stimuli can trigger a reaction. Sonic booms and jet aircraft noise sometimes cause startle responses, which mostly do not result in severe consequences. Apparently, animals can adapt to high noise

		<p>exposure. When animals react to aircraft noise, it is often due to previous experience associating the noise with an aircraft. Aside from a few accident caused by panic flights, negative consequences of aircraft noise per se on individuals and populations are not proven. In contrast aircraft traffic in general can cause a variety of damages. Concerning the effects of noise on wildlife, many questions remain.</p>
<p><b>Responses of cetaceans to anthropogenic noise</b></p>	<p>Nowacek DP, Thorne LH, Johnston DW and Tyack PL, Responses of cetaceans to anthropogenic noise. 2007, <b>Mammal Review</b> 37(2):81-115</p>	<p>1. 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.</p> <p>2. Responses to noise fall into three main categories: behavioural, 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. Behavioural 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.</p> <p>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 modeling of exposure.</p>
<p><b>Avian Communication in Urban Noise: Causes and Consequences of Vocal Adjustment</b></p>	<p>Particelli GL and Blickley JL, 2006, Avian communication in urban noise: causes and consequences of vocal adjustment. <b>The Auk</b> 123(3):639-649</p>	<p>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 fitness and population persistence? The answers to these questions depend on the morphological,</p>

		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.
<b>A Review of the Effects of Aircraft Noise on Wildlife and Humans, Current Control Mechanisms, and the Need for Further Study</b>	Pepper, Christopher B., Nascarella, Marc A.; Kendall, Ronald J. 2003, "A review of the effects of aircraft noise on wildlife and humans, current control mechanisms, and the need for further study". [Article] <b>Environmental Management</b> . 32(4).. 418-432.	Military and civilian aircraft overflights are an issue that may impact the quality of life for millions of United States residents. Aircraft noise annoys many people worldwide and is generally thought to adversely affect some wildlife species. In light of increasing demands being placed on airspace, and because of technological improvements in acoustical testing, there is a need to reexamine the effects of aircraft noise exposure on humans and wildlife. This paper reviews past research, current laws and legislation, and presents an argument for the need to revisit the effects of aircraft noise on humans and wildlife. Some evidence suggests that noise may adversely impact wildlife and humans, however, many of the past studies were inconclusive and based on relatively small sample sizes. Given that aircraft noise abatement legislation has been enacted and because of the recent promulgation of community-based noise awareness programs, future studies should be conducted to resolve public policy problems and debates associated with aircraft noise. The need to further study the effects of aircraft noise on humans and wildlife is critical for creating sustainable land use policies near aircraft installations. Data derived from these studies will be used to create sound public policies that enhance the operational capacity of military and civilian aircraft while reducing the opportunity for human and wildlife exposure to aircraft noise.
<b>The Effect of Noise on Wildlife: A Literature Review</b>	Radle, Lyn Autumn, 1998, "The Effect of Noise on Wildlife: A Literature Review" <b>World Forum for Acoustic Ecology Online Reader</b> <a href="http://interact.uoregon.edu/MediaLit/wfae/readings/radle.html">http://interact.uoregon.edu/MediaLit/wfae/readings/radle.html</a>	Most researchers agree that noise can effect an animal's physiology and behavior, and if it becomes a chronic stress, noise can be injurious to an animal's energy budget, reproductive success and long-term survival. Armed with this understanding it should follow that humans would attempt to minimize the threat to wildlife by reducing the amount of noise that they are exposed to in natural areas; but this has not been the situation. Natural areas continue to be degraded by human-made noise, wildlife continues to suffer from these disturbances, and to date the majority of the debate revolves around the egocentric demands of people to either produce more noise in nature (through motorized recreation, scientific research, military exercises etc.) or experience natural areas in the absence of anthropogenic noise. Neither side has adequately addressed the issue from the biocentric view of wildlife and the known, or as yet undiscovered, damage that our increasingly noisy human-altered environment is inflicting upon them.
<b>Urban bioacoustics: it's</b>	Warren PS, Katti M, Ermann M and Brazel A, 2006, Urban	The acoustic environment has a major influence in shaping animal communication systems. Humans, particularly in cities, profoundly

<b>not just noise</b>	bioacoustics: it's not just noise. <b>Animal Behaviour</b> 71:491-502	alter the acoustic structure of their environment. Recent articles have identified effects of noise on animal communication and behaviour. These studies, however, serve to highlight the surprising dearth of research on the behavioural responses of animals to altered acoustic environments. We argue that noise is not the only aspect of urban bioacoustics that researchers should explore. In addition to elevated noise levels, urban areas are characterized by a spatial heterogeneity in noise levels, predictable diurnal variation in noise levels and the existence of many vertical reflective surfaces. All of these characteristics have parallels in natural environments. We suggest that cities are a fruitful area for future research on the evolution of animal communication systems, with more general implications for conservation in human-altered environments.
<b>Physiological Effects of Noise</b>		
<b>Effects of Environmental Stressors on Deep Body Temperature and Activity Levels in Silver Fox Vixens (Vulpes Vulpes)</b>	<p>Bakken, Morten et.al., 1999, "Effects of environmental stressors on deep body temperature and activity levels in silver fox vixens (<i>Vulpes vulpes</i>)" <b>Applied Animal Behaviour Science</b>, Vol. 64, no. 2 pp. 141-151</p> <p>Notes: N = 6. recorded noise stimuli, four experiments; aircraft noise duration 15 s, 100 dB, machine noise duration 15 s, 90 dB, firing a shotgun duration 1 s, 90 dB, human conversation duration 15 s, 95 dB. Played back and repeated at 20 s intervals during 5 min were tested. Deep body temperature and activity levels were monitored with surgically implanted radio telemetry devices.</p> <p>Sounds tested did not induce stress as measured. Small sample size of previously infanticidal, farm-raised, caged foxes</p>	<p>The present study was performed to investigate the effects of 14 different environmental stimuli on stress-induced hyperthermia (SIH) and levels of locomotor activity in six (three infanticidal, three non-infanticidal) 2.5-year-old silver fox vixens. The effects of contact with humans (six experiments; handling for 5 min, handling of neighbouring animal for 5 min, presence of one person for 20 s, 5 and 90 min, presence of a group of humans for 5 min), exposure to unfamiliar foxes (four experiments; presence of an unfamiliar cagemate [female, male] and an unfamiliar neighbouring animal [female, male] for 90 min), and various recorded noise stimuli (four experiments; aircraft noise [duration 15 s, 100 dB], machine noise [duration 15 s, 90 dB], firing a shotgun [duration 1 s, 90 dB], human conversation [duration 15 s, 95 dB]) played back and repeated at 20 s intervals during 5 min were tested. Deep body temperature and activity levels were monitored with surgically implanted radio telemetry devices. All registrations were made during the 90-min period after stimulus presentation. The presence of humans and other silver foxes, but not exposure to loud recorded noise, resulted in a SIH. Comparison of the SIH between the normally reproducing vixens and the previously infanticidal vixens revealed significant differences. The SIH response was most pronounced in the previously infanticidal vixens, whereas the levels of physical activity were lowest in this group. The present study indicated that important means to improve animal welfare in silver foxes should include an improvement of the general human-animal relationship and emphasises the importance of a stable social environment.</p>
<b>Energetic cost of man-induced disturbance to</b>	Belanger L and Bedard J, 1990, Energetic cost of man-induced disturbance to staging in snow geese. <b>The Journal</b>	We estimated energetic cost of man-induced disturbance to fall-staging greater snow geese ( <i>Chen caerulescens atlantica</i> ) in Qubbec. Two responses of birds to disturbance were considered (1)birds fly

<p><b>staging snow geese</b></p>	<p><b>of Wildlife Management</b> 54(1):36-41</p>	<p>away but promptly resume feeding following a disturbance (Response A) and (2)birds interrupt feeding altogether (Response B). Daylight foraging time decreased by 4 to 51% depending on disturbance levels. Average rate of disturbance (1.46/hr) in Response A resulted in a 5.3% increase in hourly energy expenditure (HEE) combined with a 1.6% reduction of hourly metabolizable energy intake (HMEI). In Response B, HEE increased by 3.4%; HMEI decreased by 2.9 to 19.4%. Increases in nighttime feeding time and daily feeding rate were evaluated as compensatory mechanisms. A 4% increase in night feeding could compensate for energy losses caused solely by disturbance flights (Response A), but a 32% increase in nighttime feeding was required to restore energy losses incurred in Response B. No increase in daily feeding rate was observed between days with different disturbance levels (<math>P &gt; 0.05</math>). We conclude that man-induced disturbance can have significant energetic consequences for fall-staging greater snow geese.</p>
<p><b>Acute and Chronic Blood Pressure Response to Recurrent Acoustic Arousal in Rats</b></p>	<p>Gang Bao, Naira Metreveli and Eugene C. Fletcher, 1999, "Acute and chronic blood pressure response to recurrent acoustic arousal in rats" <b>American Journal of Hypertension</b>, Vol. 12, no. 5, pp. 504-510</p> <p>Notes: N = 10 experimental, 10 control; buzzer noise (500 Hz, 100 dB) presented 6 out of every 30 sec, 7 hr/day for 35 days. dB weighting and detailed frequency characteristics not reported.</p> <p>Conclusions: movement and blood pressure measurements remained above control levels but showed marked signs of habituation</p>	<p>Repetitive episodic hypoxia every 30 sec administered chronically to Sprague-Dawley (SD) rats has been shown by previous studies to cause a sustained increase in daytime blood pressure (BP). Acoustic arousal in humans during wake or sleep produces an acute BP rise. The question then arises as to whether chronic episodic acoustic arousal applied with the same frequency and duration as episodic hypoxia induces elevated BP. We exposed 14-week-old (N = 10) SD rats in individual cages to recurrent buzzer noise (500 Hz, 100 db) 6 out of every 30 sec, 7 h/day for 35 days. Ten other rats were placed in similar cages daily but not exposed to noise, to provide a sham condition. An infrared beam with a detector was positioned at the end of each cage. This allowed us to quantify motion by registering the number of times the rat broke the beam per 7 h period. Mean intraarterial BP was measured in unrestrained conscious animals at baseline and at the end of 35 days of their respective conditions. Acute episodic acoustic stimulation caused an immediate response in BP and heart rate. Habituation occurred in that the movement response to 120 noises per hour was 75% in hour one and 20% in hours two through seven on day one. The movement response was further reduced by day 35 but remained significantly higher than in animals not stimulated by noise. The cardiovascular response to noise also showed signs of habituation. Chronic noise stimulation produced no sustained increases in BP after 35 days of exposure.</p>
<p><b>Avian species differences in susceptibility to noise exposure</b></p>	<p>Ryals BM, Dooling RJ, Westbrook E, Dent ML, MacKenzie A and Larsen ON, 1999, Avian species differences in susceptibility to noise exposure. <b>Hearing Research</b> 131:71-88.</p>	<p>Previous studies of hair cell regeneration and hearing recovery in birds after acoustic overstimulation have involved relatively few species. Studies of the effects of acoustic overexposure typically report high variability. Though it is impossible to tell, the data so far also suggest there may be considerable species differences in the degree of damage and the time</p>

	<p>Notes: damaged created by exposure to 112, 118 or 120 dB for 12-24 hours (at either a2.86 kHz tone or 2-6 kHz noise).</p>	<p>course and extent of recovery. To examine this issue, we exposed four species of birds (quail, budgerigars, canaries, and zebra finches) to identical conditions of acoustic overstimulation and systematically analyzed changes in hearing sensitivity, basilar papilla morphology, and hair cell number. Quail and budgerigars showed the greatest susceptibility to threshold shift and hair cell loss after overstimulation with either pure tone or bandpass noise, while identical types of overstimulation in canaries and zebra finches resulted in much less of a threshold shift and a smaller, more diffuse hair cell loss. All four species showed some recovery of threshold sensitivity and hair cell number over time. Canary and zebra finch hearing and hair cell number recovered to within normal limits while quail and budgerigars continued to have an approximately 20 dB threshold shift and incomplete recovery of hair cell number. In a final experiment, birds were exposed to identical wide-band noise overstimulation under conditions of artificial middle ear ventilation. Hair cell loss was substantially increased in both budgerigars and canaries suggesting that middle ear air pressure regulation and correlated changes in middle ear transfer function are one factor influencing susceptibility to acoustic overstimulation in small birds.</p>
<p><b>Behavioural and Physiological Responses of Pigs to Sound</b></p>	<p>J. C. Talling, N. K. Waran, C. M. Wathes and J. A. Lines, 1996, "Behavioural and physiological responses of pigs to sound" <b>Applied Animal Behaviour Science</b>, Vol. 48, no. 3-4, pp 187-201</p> <p>Notes: Two intensity treatments (85 or 97 dB(lin)) and two frequency treatments (500 Hz or 8 kHz).</p> <p>Conclusion: Heart rate and ambulation scores increased for both treatments with a significant dose effect (except for freq. on ambulation).</p>	<p>Sound is a potential stressor to pigs throughout their lives, The following two studies examined the behavioural acid physiological responses of pigs to both artificial and real sound. In the first study, piglets (n = 8) were exposed to artificially generated sounds, nominal intensities of 85 or 97 dB(Lin), and frequencies of 500 Hz and 8000 Hz for 15 min, during an hour experimental session, In the second study the piglets (n = 8) were exposed to 20 min of four sounds: farm recording, Leq 80 dB(Lin); transport recording, Leq 83 dB(Lin); abattoir recording, Leq 84 dB(Lin) and white noise, Leq 89 dB(Lin). In both studies piglets were exposed to the sounds in an arena to which they had previously become accustomed and a companion pig was present in the experimental room. The behaviour and heart rate of the piglets were recorded pre-, during and post-exposure to all the sounds in both studies. In addition observations were also made in a control session with no sound stimuli, In both studies an increase in heart rate (maximum 20 beats min(-1)) was observed for the first 15 min of exposure to sound (P &lt; 0.05), when compared with controls. An increase in ambulation score (control 4.4 vs 97 dB(Lin) 20.2) due to sound exposure was only observed in Study 1 (P &lt; 0.05). Greater increases were found when the pigs were exposed to the higher</p>

		<p>frequency and higher intensity in Study 1 (<math>P &lt; 0.05</math>). In the second study small differences were found between the treatments, with the transporter causing the greatest increase in heart rate (<math>P &lt; 0.05</math>) and the greatest reduction in ambulation score (<math>P &lt; 0.05</math>). When the specific behaviours of the piglets were compared there was no difference between the different treatments in Study 2 (<math>P &lt; 0.05</math>), however sound exposure in general changed the behaviour of the pigs from resting to aroused and attentive (<math>P &lt; 0.05</math>). The results from these two studies suggest that sound can activate the pigs' defence mechanisms, though habituation occurs when no immediate danger or threat is identified, and that the manifestation of this response depends on properties of the sound stimuli.</p>
<p><b>Cardiac Responses to Acoustic Playback Experiments in the Captive Bottlenose Dolphin (<i>Tursiops Truncatus</i>)</b></p>	<p>Miksis, J L, et.al., 2001, Cardiac responses to acoustic playback experiments in the captive bottlenose dolphin (<i>Tursiops truncatus</i>) <b>Journal of Comparative Psychology</b>, 115(3): 227-32</p>	<p>Acoustic recordings were used to investigate the cardiac responses of a captive dolphin (<i>Tursiops truncatus</i>) to sound playback stimuli. A suction-cup hydrophone placed on the ventral midline of the dolphin produced a continuous heartbeat signal while the dolphin was submerged. Heartbeats were timed by applying a matched-filter to the phonocardiogram. Significant heart rate accelerations were observed in response to playback stimuli involving conspecific vocalizations compared with baseline rates or tank noise playbacks. This method documents that objective psychophysiological measures can be obtained for physically unrestrained cetaceans. In addition, the results are the 1st to show cardiac responses to acoustic stimuli from a cetacean at depth. Preliminary evidence suggests that the cardiac response patterns of dolphins are consistent with the physiological defense and startle responses in terrestrial mammals and birds.</p>
<p><b>Monitoring Stress in Captive Giant Pandas (<i>Ailuropoda Melanoleuca</i>): Behavioral and Hormonal Responses to Ambient Noise</b></p>	<p>Owen, et.al., 2004, Monitoring stress in captive giant pandas (<i>Ailuropoda melanoleuca</i>): Behavioral and hormonal responses to ambient noise <b>Zoo Biology</b>, 23(2): 147-164; 2004</p> <p>Notes: dB measurements taken over 1 min intervals, L-weighted; Daily average decibel level (AvdB) taken from 0700 to 1600 hr—range 60.9-84.2 dB</p>	<p>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. <b>More chronic, moderate-amplitude noise was associated with higher levels of glucocorticoids.</b> 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</p>

		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
<b>Effect of Noise Exposure on Rat Cardiac Peripheral Benzodiazepine Receptors</b>	Salveti, Francesca, et.al., 2000, "Effect of noise exposure on rat cardiac peripheral benzodiazepine receptors" <b>Life Sciences</b> , Vol. 66, no. 13, pp. 1165-1175	Noise is an environmental physical agent, which is regarded as a stressful stimulus: impairment and modifications in biological functions are reported, after loud noise exposure, at several levels in human and animal organs and apparatuses, as well as in the endocrine, cardiovascular and nervous system. In the present study equilibrium binding parameters of peripheral benzodiazepine receptors (PBRs) labelled by the specific radioligand [H-3]PK 11195, were evaluated in cardiac tissue of rats submitted to 6 or 12 h noise exposure and of rats treated "in vivo" with PER ligands such as PK 11195, Ro5-4864, diazepam and then noise-exposed. Results revealed a statistically significant decrease in the maximum number of binding sites (B-max) of [H-3]PK 11195 in atrial membranes of 6 or 12 h noise exposed rats, compared with sham-exposed animals, without any change in the dissociation constant (K-d) The "in vivo" PER ligand pretreatment counteracted the noise-induced modifications of PER density. As PBRs are mainly located on mitochondria we also investigated whether noise exposure can affect the [H-3]PK 11195 binding parameters in isolated cardiac mitochondrial fractions. Results indicated a significant B-max value decrease in right atrial mitochondrial fractions of rats 6 or 12 h noise- exposed. Furthermore, as PER has been suggested to be a supramolecular complex that might coincide with the not-yet-established structure of the mitochondrial permeability transition (MPT)-pore, the status of the MPT-pore in isolated heart mitochondria was investigated in noise- and sham-exposed rats. The loss of absorbance associated with the calcium-induced MPT-pore opening was greater in mitochondria isolated from hearts of 6 h noise-than those of sham-exposed rats. In conclusion, these findings represent a further instance for PER density decrease in response to a stressful stimulus, like noise; in addition they revealed that "in vivo" administration of PER ligands significantly prevents this decrease. Finally, our data also suggest the involvement of MPT in the response of an organism to noise stress.
<b>Gestational Exposure to Loud Noise Alters the Development and Postnatal Responsiveness of Humoral and Cellular Components of the</b>	Sobrian, S. K. et.al., 1997, "Gestational Exposure to Loud Noise Alters the Development and Postnatal Responsiveness of Humoral and Cellular Components of the Immune System in Offspring" <b>Environmental Research</b> , Vol. 73, no. 1-2 pp. 227-241	Gestational exposure of the female to environmental toxins can alter immune function in the offspring. We have recently shown that prenatal maternal stress, that is, stress applied to or induced in the female during pregnancy, can also alter the development of humoral immunocompetence in the offspring and their hormonal and immunologic responses to postnatal stress. This report presents data from two experiments on the effects of prenatal exposure to loud noise-prenatal sound stress (PSS)-on the development and



<p><b>Immune System in Offspring</b></p>	<p>Notes: Noise = 85-90 dB fire bell, weighting not reported and sound not characterized</p>	<p>responsiveness of in vitro and in vivo humoral and cellular immune function in the offspring. Pregnant rats were exposed daily from Day 15 to Day 21 of gestation to an inescapable loud noise (an 85- to 90-decibel fire alarm bell) delivered randomly for 1 hr. In developing offspring, PSS produced age-dependent and mitogen-specific alterations in lymphoproliferative activity and reduced immunoglobulin G levels at Postnatal Day 21. Antibody titers to herpes simplex virus type I were also reduced. Exposure to loud noise before or after infection produced an additional reduction in titers in these offspring. Arthus skin reaction (AR) to old tuberculin was reduced by PSS. Combined prenatal/postnatal sound stress further reduced this response and the AR to bovine serum albumin (BSA). Delayed hypersensitivity reaction to BSA was reduced in PSS offspring; postnatal sound stress enhanced the reaction to both antigens, but only in males. Antibody titers to BSA were increased by PSS; adjuvant-induced inflammation was attenuated by postnatal sound stress. These data suggest that in utero exposure to loud noise, which can occur in the workplace, is toxic to the developing immune system.</p>
<p><b>Fecal Corticosterone Levels in California Spotted Owls Exposed to Low-Intensity Chainsaw Sound</b></p>	<p>Tempel, Douglas J.; Gutierrez, R. J., 2003, "Fecal corticosterone levels in California spotted owls exposed to low-intensity chainsaw sound". <b>Wildlife Society Bulletin</b>, Vol. 31 no. 3, pp. 698-703</p> <p>Notes: chainsaw noise—50-60 dB(A), instantaneous max readings</p> <p>Conclusions: low-intensity noise does not produce a stress response as measured by fecal corticosterone levels</p>	<p>The California spotted owl (<i>Strix occidentalis occidentalis</i>) is a focal management species in Sierra Nevada national forests. To protect the owl from human activity, the United States Forest Service has proposed guidelines that would prohibit timber harvest and road or trail construction within 400 m of active owl nest sites during the breeding season. To guide these efforts, we tested the physiological stress response of 9 nonbreeding wild male owls to the sound of a chainsaw operated 100 m from their roost site, using change in fecal corticosterone level (ng/g dry feces) as the response variable. We employed a cross-over experimental design to control for differences among individuals. Chainsaw exposure did not result in a detectable increase in fecal corticosterone level (<math>F_{1,7}=0.01</math>, <math>P=0.94</math>). These findings corroborate results of a field study that suggested spotted owls can tolerate low-intensity human sound in their environment without eliciting a physiological stress response. However, activities producing chronic and intense noise (e.g., timber harvest, road construction), which might elicit such a response, were not simulated in our experiment. The effects of these activities on California spotted owls will require further research.</p>
<p><b>Time-Dependent Differential Changes of Immune Function in Rats Exposed to Chronic Intermittent Noise</b></p>	<p>Van Raaij, Marcel T. M. et.al, 1996, "Time-Dependent Differential Changes of Immune Function in Rats Exposed to Chronic Intermittent Noise" <b>Physiology &amp; Behavior</b>, Vol. 60, no. 6, pp. 1527-1533</p>	<p>Noise is a highly relevant environmental and clinical stressor. Compared to most other experimental stressors, noise is a modest activator of neuroendocrine pathways that mimic the situation in human health where neuroendocrine activation by environmental stressors is often absent or difficult to establish. Little is known about the effects of noise exposure on the immune system. In the present work, the effects of a low-intensity chronic intermittent unpredictable noise regimen on various parameters of immune function was studied. Male wistar rats were exposed to a randomized noise protocol (white</p>

		<p>noise, 85 dB, 2-20 kHz) for 10 h per day, 15 min per h over a total period of 3 weeks. Control animals were exposed to ambient sound only. Immune function was monitored after 24 h, 7 days, and 21 days of noise exposure. Noise induced several significant changes in immune function in a time-dependent differential pattern involving both immunosuppression and immunoenhancement. After 24 h, serum IgM levels were increased and peripheral phagocytic activity was decreased. Splenic lymphocytic proliferation to mitogens was significantly decreased after 7 days, but slightly elevated after 3 weeks. The activity of splenic NK cells was increased significantly after 24 h and 7 days, but suppressed after 3 weeks. These results show that various parameters of immune function are affected differentially over time in a period of chronic mild noise stress, possibly due to sequential activation of different physiological mechanisms. Copyright (C) 1996 Elsevier Science Inc.</p>
<b>Effects of Non-Aviation Noise Sources</b>		
<p><b>The Influence of Weapons-Testing Noise on Bald Eagle Behavior.</b></p>	<p>Brown, B. T., et.al, 1999, The influence of weapons-testing noise on bald eagle behavior. <b>Journal of Raptor Research</b>, 33(3): 227-232</p>	<p>Minor/No Impacts We studied the influence of weapons-testing noise on bald eagle (<i>Haliaeetus leucocephalus</i>) behavior at the Aberdeen Proving Ground (APG); Maryland, in 1995. Our objectives were to document and compare eagle behavior at times with and without weapons-testing noise, determine if the frequency of behavior after noise increased with increasing sound levels and compare nest success and productivity on APG with that of adjacent areas of Maryland. Most roosting (72.7%) and nesting (92.7%) eagles showed no activity (i.e., perched motionless) in the 2-sec interval following weapons-testing noise. The most frequent activity following noise was a head turn, exhibited by 18.2% of roosting and 0.7% of nesting eagles; other eagle activities following noise (e.g., body movement, vocalization and flight) were rare at both roosts (9.1%) and nests (6.6%). Frequency of activity after noise differed between adults and juveniles at nests, but did not differ between adults and immatures at roosts. Activity after noise occurred significantly more in roosting than nesting eagles. For roosting eagles, frequency of activity after noise was similar to activity at times without noise. Frequency of no activity versus activity after noise did not vary at sound intensity levels <math>\geq 110</math> and <math>&lt; 110</math> dB for either nesting or roosting eagles. Nest success and productivity on APG did not differ from nest success and productivity in adjacent counties of Maryland from 1990-95, suggesting that weapons-testing noise did not influence eagle reproduction at the population level.</p>
<p><b>Effects of Ecotourists on Bird Behaviour At Loxahatchee National</b></p>	<p>Burger, J; Gochfeld, M , 1998, “Effects of ecotourists on bird behaviour at Loxahatchee National Wildlife Refuge, Florida” <b>Environmental Conservation</b> Vol. 25, no. 1, pp. 13-21</p>	<p>Increasingly, natural areas are exposed to people who come to view, study or photograph wildlife. In order to develop appropriate management plans for both avian and human use of natural environments it is essential to understand how people affect foraging</p>

<p><b>Wildlife Refuge, Florida</b></p>	<p>Notes: sound levels subjective estimates</p>	<p>birds. The foraging behaviour of five species of water-birds at Loxahatchee (Arthur B. Marshall National Wildlife Refuge), part of the Everglades, in Southern Florida was observed, between 1992 and 1994, from a dike that received many visitors. Species examined included common gallinule (<i>Gallinula chloropus</i>), sera rail (<i>Porzana carolina</i>), glossy ibis (<i>Plegadis falcinellus</i>), little blue heron (<i>Egretta caerulea</i>) and Louisiana heron (<i>E. tricolor</i>). These birds were observed before people were near, while people were present, and following the departure of people. Variation in feeding behaviour was largely explained by whether people were present, the number of people present, and the amount of noise made by the people. For all species, time devoted to feeding and number of strikes or pecks decreased while people were present. <b>The percentage of time spent foraging and the number of strikes decreased as the noise made by people increased.</b> Birds that were closer to the path flew away from people more often than birds that were further away. Birds usually swam or flew away from the path while people were present.</p>
<p><b>Effect of Anthropogenic Low-Frequency Noise on the Foraging Ecology of Balaenoptera Whales</b></p>	<p>Croll, Donald A. et.al., 2001, Effect of anthropogenic low-frequency noise on the foraging ecology of Balaenoptera whales <b>Animal Conservation</b>, 4 (1): 13-27</p>	<p>Researchers conducted a field experiment to test the effects of loud, low-frequency noise on foraging fin and blue 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 low-frequency source was and was not transmitting. During transmission, 12-30 percent of the estimated received levels of LFA of whales in the study area exceeded 140 dB re 1µPa. However, the 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 low-frequency sound transmissions</p>
<p><b>Vigilance Behaviour of Polar Bears (<i>Ursus Maritimus</i>) in the Context of Wildlife-Viewing Activities At Churchill, Manitoba, Canada</b></p>	<p>Dyck, MG; Baydack, RK, 2004, “Vigilance behaviour of polar bears (<i>Ursus maritimus</i>) in the context of wildlife-viewing activities at Churchill, Manitoba, Canada” <b>Biological Conservation</b> Vol. 116, no. 3, pp. 343-350</p> <p>Notes: no sound analysis</p>	<p>Viewing of polar bears (<i>Ursus maritimus</i>) from tundra vehicles has been offered at Churchill, Manitoba since the early 1980s. This form of wildlife viewing has provided a unique and safe way for tourists to learn about polar bears. However, these activities have largely been carried out without examining possible effects on polar bear behaviour. We studied vigilance behaviour (a scanning of the immediate vicinity and beyond) of resting polar bears to evaluate impacts from tundra vehicle activity. Focal animal sampling was used to examine whether a difference in vigilance behaviour existed when vehicles were present. We recorded the numbers of head-ups, vigilance bout length, and between-bout intervals for polar bears. In general, the frequency of head-ups increased, and the between-bout intervals decreased for male bears, when vehicles were present. Female bears behaved opposite to males. The vigilance bout lengths did not differ significantly between vehicle presence and absence. Vigilance behaviour of male bears was not magnified with increasing numbers of vehicles;</p>

		therefore the threshold is one vehicle. We suggest that manipulative studies be conducted to examine how distances between vehicles and bears, tundra vehicle activity in the immediate vicinity of a bear during viewing, and noise of tourists affect increased vigilance
<b>Underwater Noise Of Whale-Watching Boats and Potential Effects On Killer Whales (Orcinus Orca), Based On An Acoustic Impact Model</b>	Erbe, Christine, 2002, Underwater <b>noise</b> of whale-watching boats and potential effects on killer whales (Orcinus orca), based on an acoustic impact model <b>Marine Mammal Science</b> , 18(2): 394-418	Underwater noise of whale-watching boats was recorded in the popular killer whale-watching region of southern British Columbia and northwestern Washington State. A software sound propagation and impact assessment model was applied to estimate zones around whale-watching boats where boat noise was audible to killer whales, where it interfered with their communication, where it caused behavioral avoidance, and where it possibly caused hearing loss. Boat source levels ranged from 145 to 169 dB re 1 [mu]Pa [ @ ] 1 m, increasing with speed. The noise of fast boats was modeled to be audible to killer whales over 16 km, to mask killer whale calls over 14 km, to elicit a behavioral response over 200 m, and to cause a temporary threshold shift (TTS) in hearing of 5 dB after 30-50 min within 450 m. For boats cruising at slow speeds, the predicted ranges were 1 km for audibility and masking, 50 m for behavioral responses, and 20 m for TTS. Superposed noise levels of a number of boats circulating around or following the whales were close to the critical level assumed to cause a permanent hearing loss over prolonged exposure. These data should be useful in developing whale-watching regulations. This study also gave lower estimates of killer whale call source levels of 105-124 dB re 1 [mu]Pa.
<b>Logging Truck Noise Near Nesting Northern Goshawks</b>	Grubb, Teryl G., et.al., 1998, Logging truck <b>noise</b> near nesting northern goshawks <b>U.S. Forest Service. Research Note R M</b> , No. 3: 2pp	Data suggest that nesting northern goshawks are not disturbed by noise from logging trucks passing >400 m away from nesting sites.
<b>The Effect of Vessel Noise on The Vocal Behavior of Belugas in The St. Lawrence River Estuary, Canada</b>	Lesage, Veronique, 1999, The effect of vessel noise on the vocal behavior of belugas in the St. Lawrence River Estuary, Canada <b>Marine Mammal Science</b> , 15(1): 65-84	The impact of noise from a small motorboat and a ferry on the vocalizations of belugas was studied during June and July 1991 in the St. Lawrence River, Canada. When the boats were approaching the calling rate decreased, with brief increases in the emission of falling tonal calls. When boats were less than a kilometer away, vocalization rate increased. Frequency bands used by vocalizing belugas shifted from 3.6 kHz to 5.2-8.8 kHz when the boats drew nearer
<b>The Underwater Noise of Vessels in the Hervey Bay (Queensland) Whale Watch Fleet and its Impact on Humpback Whales</b>	McCauley, Robert D.; Cato, 2001, Douglas H. The underwater <b>noise</b> of vessels in the Hervey Bay (Queensland) whale watch fleet and its impact on humpback whales <b>The Journal of the Acoustical Society of America</b> , 109(5, Pt. 2); p. 2455	1994 the underwater noise of 19 vessels involved in whale watching was measured. Vessels ranged from 1.5-70 tons and included yachts, runabouts and high-speed and displacement mono and multihulls. Except for one water-jet trimaran, all vessels were propeller driven. Unlike the directional patterns reported for merchant shipping, each vessel projected lobes of sound fore and aft with lower levels abeam. In the high speed planing vessels this was exacerbated by the deep propellers exposed for ward, and the vessel squat while on the plane. All vessels displayed a linear relationship with broadband noise level and the logarithm of speed. Although unique for each vessel, as a rule of thumb doubling the speed doubled the detection range. The

		<p>response of whales to vessel noise was as much a function of the rate of change of noise as its steady level. Rapid increases in noise produced more responses. Vessels which, by their design, required constant maneuvering to maintain station produced greater adverse responses from whales. Some design criteria important in reducing noise impacts from whale watch vessels include shielding of the propellers in the forward direction, windage in relation to draft, slow speed steerage, machinery noise reduction and passenger viewing access.</p>
<p><b>A GPS-Based Method to Examine Wolf Response to Loud Noise</b></p>	<p>Merrill, SB; Erickson, CR, 2003, "A GPS-based method to examine wolf response to loud noise" <b>Wildlife Society Bulletin</b> Vol. 31, no. 3, pp. 769-773</p> <p>Notes: no sound analysis</p> <p>Conclusion: Wolves move towards firing points</p>	<p>We used Global Positioning System (GPS) telemetry data to examine responses of a breeding male and 2 yearling wolves (<i>Canis lupus</i>) 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 &lt;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 activities.</p>
<p><b>Buffer-Zone Distances to Protect Foraging and Loafing Waterbirds from Disturbance by Personal Watercraft and Outboard-Powered Boats</b></p>	<p>Rodgers, JA; Schwikert, ST, 2002, "Buffer-Zone Distances to Protect Foraging and Loafing Waterbirds from Disturbance by Personal Watercraft and Outboard-Powered Boats" <b>Conservation Biology</b> Vol. 16, no. 1, pp. 216-224.</p> <p>Notes: dB(A), visual and auditory disturbance confounded</p>	<p>Outdoor recreation and ecotourism can have negative effects on wildlife species, so it is important to determine buffer zones within which activities near critical wildlife areas are limited. We exposed 23 species of waterbirds (Pelecaniformes, Ciconiiformes, Falconiformes, Charadriiformes) to the direct approach of a personal watercraft (PWC) and all outboard-powered boat to determine their flush distances. We used 11 sites with a mixture of low, moderate, and high amounts of human activity along the east and west coasts of Florida during September-November 1998 and April-June 1999. We detected considerable variation in flush distances among individuals within the same species and among species in response to both types of vessels. Average flush distances for the PWC ranged from 19.5 m (Least Tern [<i>Sterna antillarum</i>]) to 49.5 m (Osprey [<i>Pandion haliaetus</i>]), whereas average flush distances for the outboard-powered boat ranged from 23.4 m (Forster's Tern [<i>S. forsteri</i>]) to 57.9 m (Osprey). Larger species generally exhibited greater average flush distances for both types of watercraft. A comparison of the flush distances elicited by each watercraft indicated that only the Great Blue Heron (<i>Ardea herodias</i>) exhibited significantly larger flush distances (t test, p&lt;0.01) in response to the approach of the PWC than in response to the outboard, whereas four species (Anhinga [<i>Anhinga anhinga</i>], Little Blue Heron [<i>Egretta caerulea</i>], Willet [<i>Catoptrophorus semipalmatus</i>], and Osprey) exhibited significantly larger flush distances (t test, p&lt;0.05) in response to the approach of the outboard-powered boat than in response to the PWC. Eleven species (68.8%)</p>

		showed no significant difference (t test $p > 0.05$ ) in their flush distances in response to the fast-moving PWC and the outboard-powered boat. Our data suggest that a single buffer-zone distance can be developed for both PWC and outboard-powered vessels. Buffer zones of 180 in for wading birds, 140 in for terns and gulls, 100 in for Plovers and sandpipers, and 150 in for ospreys would minimize their disturbance at foraging and loafing sites in Florida.
<b>Reactions of Seals to Underwater Playbacks of Drilling and Icebreaker Noise</b>	Smultea, M. A., et.al. 2000, Reactions of seals to underwater playbacks of drilling and icebreaker noise <b>Northwestern Naturalist</b> , 81 (2): 87. 2000.	Few previous data are available on reactions of seals to noise from offshore oil exploration and production activities. In this paper, the authors describe observed reactions of ringed ( <i>Phoca hispida</i> ) and bearded seals ( <i>Erignathus barbatus</i> ) to drilling and icebreaker sounds projected underwater along ice edges during spring in the Alaskan Beaufort Sea. Given plans and the potential for development of offshore oil resources in this region and elsewhere, such information is important in assessing potential impacts of these activities on marine mammals. Ice-based observations were conducted during spring 1989-91 and 1994 off Pt. Barrow, Alaska. The authors observed 88 seal groups during a total of 74 h of drilling sound playback, 45 groups during 40 h of icebreaker playback, and 111 during 213 h while the projector was silent. During both playback and quiet periods, most seals surfaced briefly and then dove at distances of 25-500 m from the projector site. During playbacks, more seals were sighted but they departed sooner. Some seals approached the operating projector. Seals apparently avoided the area within 20-25 m of the operating projector, where broadband received levels below the surface were high. Results suggest that some seals tolerate moderately strong (up to at least 50 dB above ambient) underwater noise from simulated drilling and icebreaking.
<b>Separating the Noise From the Noise: A Finding in Support of the "Niche Hypothesis," That Birds are Influenced by Human-Induced Noise in Natural Habitats.</b>	Stone, Eric, 2000, Separating the <b>noise</b> from the <b>noise</b> : a finding in support of the "Niche Hypothesis," that birds are influenced by human-induced <b>noise</b> in natural habitats. <b>Anthrozoos</b> , 13(4): 225-231	Controlling for the confounding influence of physical disturbance, it was possible to test the hypothesis that ambient noise alone would play a role in structuring bird communities in riparian habitats in Boulder, Colorado, USA. Point counts of birds were conducted in open space/minimally disturbed, residential, commercial and industrial neighborhoods. Within the same disturbance parameters and land use, species richness and PIF scores (a weighted value based on species importance) consistently and significantly decreased as ambient noise increased. These results can be viewed as support for the "Niche Hypothesis" (Krause 1987, 1998), that wildlife species' acoustic niches are adversely affected by human-induced noise pollution
<b>Boat Traffic Affects the Acoustic Behaviour of Pacific Humpback Dolphins, <i>Sousa Chinensis</i></b>	Van Parijs, Sofie M.; Corkeron, Peter J, 2001, Boat traffic affects the acoustic behaviour of Pacific humpback dolphins, <i>Sousa chinensis</i> <b>Marine Biological Association of the United Kingdom. Journal</b> , 81(3): 533-538	In this study, the indirect (i.e. boats not involved in dolphin viewing activities) impacts of boat traffic on the acoustic behaviour of Pacific humpback dolphins, <i>Sousa chinensis</i> , were assessed in Moreton Bay, Australia. Humpback dolphin acoustic behaviour is affected by transiting boat traffic. Boats' passage did not affect the rates at which dolphins produced click trains and burst pulse vocalizations. However,

		<p>dolphins significantly increased their rate of whistling immediately after a boat moved through the area. This increase occurred only when boats were less than 1.5 km from the groups. Groups including mother-calf pairs showed an increase in whistles in response to boats' passage. Groups with no calves produced significantly fewer whistles. This evidence suggests that the noise from transiting vessels affects dolphins' group cohesion. Mother-calf pairs appear to be most disturbed by transiting vessels and exhibit an increased need to re-establish vocal contact</p>
<b>Overflights and Aircraft Noise</b>		
<p><b>Response of Nesting Red-Tailed Hawks to Helicopter Overflights</b></p>	<p>Andersen D E.; Rongstad O J;and Mytton W R., 1986, "Response of Nesting Red-Tailed Hawks to Helicopter Overflights" <i>Condor</i>. 91(2).. 296-299.</p> <p>Notes: N = 35 nests. Behavioral study, sound level not estimated</p>	<p>Low-level helicopter overflights of 35 Red-tailed Hawk (<i>Buteo jamaicensis</i>) nests were conducted at two study areas in southeastern and east-central Colorado in 1984 and 1985. Red-tailed Hawks nesting where low-level air traffic was nonexistent prior to 1983 exhibited stronger avoidance behavior than did hawks nesting where helicopter activity had occurred since the late 1950s. Nine (53%) of 17 birds in the first study area flushed from the nest while only one (8%) of 12 birds in the second study area flushed. Age of nestlings at the time an overflight occurred did not influence avoidance behavior, and overflights did not appear to influence nesting success at either study area. Our results are consistent with the hypothesis that Red-tailed Hawks habituate to low-level air traffic during the nesting period. However, naive birds may respond negatively to low-level helicopter activity prior to habituation and other species of raptors may respond differently than Red-tailed Hawks</p>
<p><b>Effects of Fixed-Wing Military Aircraft Noise on California Gnatcatcher Reproduction</b></p>	<p>Aubrey, F. and Hunsaker, D., 1997, Effects of fixed-wing military aircraft noise on California gnatcatcher reproduction <i>The Journal of the Acoustical Society of America</i>, 102(5pt.2): 3177</p>	<p>To test the assumption that high levels of aircraft noise impede bird reproduction, noise analyzers were placed for 1 week in the nesting territory of each of 39 California gnatcatcher pairs on Naval Air Station Miramar. The 1-week average sound levels (7DL) recorded in those nesting territories were then related to the number of nest attempts; number of eggs laid; number of chicks hatched; number of chicks fledged; and number of eggs, chicks, and fledglings per nest attempt. Nest attempts and eggs laid have weak negative correlations (<math>p=0.14</math> and <math>0.28</math>) with 7DL. That is, the birds may tend to build fewer nests and lay fewer eggs in noisier areas, which is consistent with the common observation that bird nesting is more easily disturbed before eggs are laid than after. None of the other indicators is correlated with sound levels. Once a nest is established, with eggs in it, military aircraft noise has no detectable influence on reproductive performance. Gnatcatchers reproduced in places where 1 HL exceeds 80 dB for several hours every day. If fixed-wing aircraft noise impedes California gnatcatcher reproduction, it is overwhelmed by such factors as disturbance, predation, weather, edge effects, and differences in quality of habitat.</p>

<p><b>Responses of Mountain Sheep to Helicopter Surveys.</b></p>	<p>Bleich, V. C., R. T. Bowyer, A. M. Pauli, R. L. Vernoy, and R. W. Anthes, 1990, "Responses of mountain sheep to helicopter surveys" <b>California Fish and Game</b> 76:197-204.</p>	<p>Effects of helicopter surveys on distribution and movements of desert-dwelling mountain sheep, <i>Ovis canadensis</i>, were studied in San Bernardino County, California during April and June 1988. Adult males and females with radio collars moved about 2.5 times farther the day following a helicopter survey than on the previous day. Further, 35-52% of these animals changed polygons (8-83 km<sup>2</sup>) following sampling from a helicopter, whereas only 11% did so the day prior to the survey. Likewise, some animals left the study area following surveys. Sampling intensity (0.8 min/km<sup>2</sup> vs. 2.0 min/km<sup>2</sup>) had little effect on movement of mountain sheep. Similarly, terrain type (steep vs. rolling) did not influence movement of female mountain sheep following helicopter surveys. Movement by mountain sheep during a helicopter survey may violate fundamental assumptions of several population estimators.</p>
<p><b>Mountain Sheep (<i>Ovis Canadensis</i>) and Helicopter Surveys: Ramifications for the Conservation of Large Mammals.</b></p>	<p>Bleich, V.C. et.al., 1994, "Mountain Sheep (<i>Ovis Canadensis</i>) and Helicopter Surveys: Ramifications for the Conservation of Large Mammals" <b>Biological Conservation</b> Vol. 70 pp. 1-7</p> <p>Notes: N = 36 (20 males, 16 females) Behavioral study, sound level not estimated</p>	<p>Mountain sheep <i>Ovis canadensis</i> respond dramatically to helicopter disturbance. Significantly more animals abandoned sampling blocks and moved farther during helicopter surveys than on nonsurvey days throughout the year. Likewise, mountain sheep changed the vegetation type they occurred in more often after than before helicopter surveys: however, this difference was only significant during spring. Mountain sheep did not habituate or become sensitized to repeated helicopter overflights: time since capture was not related to their movements. The negative influence of the helicopter was extreme and may override variables that might otherwise be correlated with movement patterns of mountain sheep: this outcome also may hold for other ungulates. Further, sampling with helicopters may result in the violation of fundamental assumptions of population estimators routinely employed in conservation efforts for large mammals. The consequences of disturbing mountain sheep, such as altering use of habitat, increasing susceptibility to predation, or increasing nutritional stress, need additional study. These factors all have ramifications for the conservation of mountain sheep and other large mammals disturbed by helicopter sampling.</p>
<p><b>Effects of Simulated Aircraft Noise on Hearing, Food Detection, and Predator Avoidance Behavior of the Kit Fox, <i>Vulpes Macrotis</i>.</b></p>	<p>Bowles A. E and Jon F., 1993, "Effects of simulated aircraft noise on hearing, food detection, and predator avoidance behavior of the kit fox, <i>Vulpes macrotis</i>." Paper <b>ASA 125th Meeting Ottawa</b></p>	<p>Four kit foxes were captured south of Gila Bend, Arizona, in an area not overflown by aircraft. Hearing thresholds were measured by startle inhibition with a San Diego Instruments Startle Recording System. Shaped 200-ms tone bursts ranging from 100 Hz to 40 kHz in octave steps were delivered using a step-up, step-down procedure. Startle responses were elicited by a 40-psi air puff 30 ms in duration following 100 ms after the tone burst and startle intensity and latency were measured. Threshold at best frequency lay between -10 and -15 dB re: 20 (μ)Pa at 2--4 kHz and declined rapidly below 1 kHz and above 20 kHz. Foxes were trained to identify simulated prey and predator noise at the minimum level required for detection. Latencies to respond were measured in the absence and presence of simulated</p>



		<p>aircraft noise, simulated by recordings of F-4 fighter aircraft played for 40 min at 96 dB re: 20 (mu)Pa with onset rate of 25 dB/s. Foxes were also exposed to aircraft noise for 3 h while asleep during the day. Results available to date indicate that foxes can detect test signals and respond in the presence of aircraft noise; latencies to response are altered during tests but not after; and no changes in activity are detected during daytime exposures.</p>
<p><b>Sonic Boom/Animal Stress Project Report on Elk, Antelope, and Rocky Mountain Bighorn Sheep.</b></p>	<p>Bunch T. D and. Workman, G. W, 1993, "Sonic boom/animal stress project report on elk, antelope, and Rocky Mountain bighorn sheep." Paper <b>ASA 125th Meeting</b> Ottawa</p>	<p>The experimental animals included elk, antelope, and Rocky Mountain bighorn sheep. These animals were instrumented with heart rate and body temperature transmitters, which were surgically implanted in the animals. The animals were released in large enclosures, and in some cases were released to the wild for disturbance tests. This was done to determine effects of various disturbances on heart rate and to establish a baseline physiologic database of normal heart rate and body temperature. The animals were subjected to various types of disturbances, including people on foot, motorcycles, four-wheeled vehicles, fixed wing aircraft, helicopters, and F-16 jet aircraft flown subsonic and supersonic, etc. These projects indicated that animals habituated to most disturbance factors in a short period of time. The exceptions included people on foot who entered the research enclosures where the animals were kept; fixed wing aircraft at low levels of flight; and helicopter flights at low elevations near the animal enclosures. The animals habituated to subsonic and supersonic jet overflights after about four passes over the animals. This habituation seemed to be permanent, as these same animals did not respond when tested at a later date.</p>
<p><b>Effects of Aircraft Noise on Time-Activity Budgets of Wintering Black Ducks.</b></p>	<p>Collazo, J and Fleming, J., 1993, "Effects of aircraft noise on time-activity budgets of wintering black ducks" Paper <b>ASA 125th Meeting</b> Ottawa</p>	<p>The primary goal of this study was to determine if the time-activity budget (TAB) of wintering black ducks (<i>Anas rubripes</i>) was significantly altered by military aircraft noise at the U. S. Marine Corps target range in Piney Island, North Carolina. Sound levels were measured concurrently with behavioral observations. Over a sampling period of 81 days, exceedances &gt;80 dB occurred on 289 occasions, the mean duration of exceedances was 5.09 s, and the mean sound pressure was 85.7 dB. Black ducks spent between 0.2% and 0.5% of their time reacting to aircraft. Correspondingly, the energetic costs of these reactions were low. TABs of black ducks in the high noise environment of Piney Island were within the expected range of those in low noise environments based on published literature. In a follow-up study, captive black ducks were subjected to simulated jet noise at levels approximately those recorded in the field. Measured levels of reactions to noise stimuli indicated that ducks habituated within 1 day. These results suggest that low reaction levels recorded in the field reflect the species' habituation capabilities to some kinds of disturbance. [Work supported by USMC and USAF.]</p>

<p><b>Dabbling Duck Behavior and Aircraft Activity in Coastal North Carolina</b></p>	<p>Conomy, John T., et. al., 1998, “Dabbling Duck Behavior and Aircraft Activity in Coastal North Carolina” <b>Journal of Wildlife Management</b>. vol. 62, no. 3, pp. 1127-1134 Notes: N = 311 duck/overflight observations. Recorded sound levels of overflights, 85 dB(A)</p>	<p>Requests to increase military aircraft activity in some training facilities in the United States have prompted the need to determine if waterfowl and other wildlife are adversely affected by aircraft disturbance. We quantified behavioral responses of wintering American black ducks (<i>Anas rubripes</i>), American wigeon (<i>A. americana</i>), gadwall (<i>A. strepera</i>), and American green-winged teal (<i>A. crecca carolinensis</i>) exposed to low-level flying military aircrafts at Piney and Cedar islands, North Carolina, in 1991 and 1992. Waterfowl spent 1.4% of their time responding to aircraft, which included flying, swimming, and alert behaviors. Mean duration of responses by species ranged from 10 to 40 sec. Costs to each species were deemed low because disruptions represented a low percentage of their time-activity budgets, only a small proportion of birds reacted to disturbance (13/672; 2%), and the likelihood of resuming the activity disrupted by an aircraft disturbance event was high (64%). Recorded levels of aircraft disturbance (i.e., <math>x = 85.1</math> dBA) were not adversely affecting the time-activity budgets of selected waterfowl species wintering at Piney and Cedar islands</p>
<p><b>Do Black Ducks and Wood Ducks Habituate to Aircraft Disturbance</b></p>	<p>Conomy, JT; Dubovsky, JA; Collazo, JA; Fleming, WJ, 1998, “Do black ducks and wood ducks habituate to aircraft disturbance” <b>Journal of Wildlife Management</b> Vol. 62, no. 3, pp. 1135-1142  Notes: An aircraft disturbance was quantified as an overflight that exceeded 80 dB(A).</p>	<p>Requests to increase military aircraft activity in some training facilities in the United States have prompted the need to determine if waterfowl and other wildlife are adversely affected by aircraft disturbance. We quantified behavioral responses of wintering American black ducks (<i>Anas rubripes</i>), American wigeon (<i>A. americana</i>), gadwall (<i>A. strepera</i>), and American green-winged teal (<i>A. crecca carolinensis</i>) exposed to low-level flying military aircrafts at Piney and Cedar islands, North Carolina, in 1991 and 1992. Waterfowl spent 1.4% of their time responding to aircraft, which included flying, swimming, and alert behaviors. Mean duration of responses by species ranged from 10 to 40 sec. Costs to each species were deemed low because disruptions represented a low percentage of their time-activity budgets, only a small proportion of birds reacted to disturbance (13/672; 2%), and the likelihood of resuming the activity disrupted by an aircraft disturbance event was high (64%). Recorded levels of aircraft disturbance (i.e., <math>x = 85.1</math> dBA) were not adversely affecting the time-activity budgets of selected waterfowl species wintering at Piney and Cedar islands.</p>
<p><b>Mountain Goat Responses to Helicopter Disturbance.</b></p>	<p>Cote, S.D., 1996, “Mountain Goat Responses to Helicopter Disturbance” <b>Wildlife Society Bulletin</b> Vol. 24 pp. 681-685  Notes: N = 109 animals (98 marked), including 9 adult males, 43 adult females, 8 two-year old males, 10 two-year-old females, 13 yearling females and 24 kids.</p>	<p>Mountain goat (<i>Oreamnos americanus</i>) responses to helicopter traffic were investigated at Caw Ridge (Alberta) from June to August 1995. A population of 109 marked individuals inhabited the ridge during the study. As measured by their overt responses, mountain goats were disturbed by 58% of the flights and were more adversely affected when helicopters flew within 500 m. Eighty-five percent of flights within 500 m caused the goats to move &gt;100 m; 9% of the flights &gt;1,500 m away caused the goats to move similar distances. Helicopter visibility and height above ground, number of goats in the group, group type (bachelor or nursery), and behavior of groups just prior to helicopter</p>

	Date, time and helicopter model noted but sound level not estimated.	flights did not appear to influence reactions of goats to helicopters. Helicopter flights caused the disintegration of social groups on greater than or equal to 5 occasions and resulted in 1 case of severe injury to an adult female. Based on these observations, restriction of helicopter flights within 2 km of alpine areas and cliffs that support mountain goat populations is recommended.
<b>Unfriendly Skies : The Threat of Military Overflights to National Wildlife Refuges</b>	Defenders of Wildlife, 1994. <b>Unfriendly Skies : the threat of military overflights to national wildlife refuges</b> Washington, D.C	This report shows that military flights disturb wildlife on at least 35 National Wildlife refuges. It discusses the impact these overflights have on the wildlife in these areas.
<b>Assessment of training noise on the red-cockaded woodpecker: final report</b>	Delaney, D. K., L. L. Pater, R. H. Melton, B. A. MacAllister, R. J. Dooling, R. Lohr, B. F. Brittan-Powe, L. L. Swindell, T. A. Beaty, L. D. Carlile, and E. W. Spadgenske, 2002. SERDP Project CS-1083.	Assessed the effects of military training noise on red-cockaded woodpeckers. Disturbed and undisturbed nest sites did not differ significantly in the number of eggs, number of nestlings, or number of young fledged. 7 of 25 nesting attempts at disturbed sites were second attempts; none of the 16 nesting attempts at undisturbed sites were second attempts (n. s., p>.05). Noise recorded in cavities was up to 15 dB louder (at 250 Hz) than levels recorded at the base of the same tree. No flushes at SEL noise levels below 87 dB <sub>A</sub> or beyond 1800m for large caliber noise. No flush when small arms were >1000m or SEL less than 63 dB <sub>A</sub> . 83 helicopter passes during 45 data sessions at 19 RCW clusters failed to elicit a flush response, at distances as low as 30m and sound levels of 102 dB unweighted. Studies that have examined the effects of aircraft activity on nesting birds (e.g., Platt 1977; Windsor 1977; Ellis 1981; Anderson et al. 1989; Delaney et al. 1999) have often noted a slight but insignificant decrease in nesting success and productivity for disturbed versus undisturbed nests. Anderson et al. (1989) reported that two of 29 Red-tailed Hawk nests were abandoned after being flushed by helicopter flights, compared with zero of 12 control nests. Ellis et al. (1991) found only one of 19 Prairie Falcon ( <i>Falco mexicanus</i> ) nests were abandoned when exposed to frequent low-altitude jet flights during the nesting season (no control sites used). Platt (1977) reported similar rates with only one of 11 Gyrfalcon ( <i>F. rusticolus</i> ) nests failing (reportedly due to snow damage), compared with zero of 12 control nests. Of the six Peregrine Falcon ( <i>F. peregrinus</i> ) nests exposed to helicopter flights, only one was abandoned (also apparently due to inclement weather) compared with zero of three control sites (Windsor 1977). Snyder et al. (1978) reported that Snail Kites ( <i>Rostrhamus sociabilis</i> ) did not flush even when noise levels were up to 105 decibels, A-weighted (dBA) from commercial jet traffic. This result was qualified by the fact that test birds were living near airports and may have habituated to the noise. Edwards et al. (1979) found a dose-response relationship for flush responses of several species of gallinaceous birds when approach distances were between 30 and 60 m and noise levels approximated 95 dBA. Brown et al. (1999) reported no difference in

		<p>the frequency of Bald Eagle activity and non activity behaviors when noise levels were &lt; 110 dBP (unweighted Peak) and &gt; 110 dBP for either roosting or nesting eagles. Delaney et al. (1999) reported that Mexican Spotted Owls did not flush during the nesting season when the Sound Exposure Level (SEL) for helicopters was <math>\leq 102</math> owl-weighted, dBO (<math>\leq 92</math> dBA) and the Equivalent Average Sound Level (LEQ) for chain saws was <math>\leq 59</math> dBO (<math>\leq 46</math> dBA). Delaney et al. (2000, 2001) and Pa-ter et al. (1999) developed noise response thresholds for RCWs based on a number of mili-tary noise sources. Their preliminary results show that woodpeckers do not flush during the nesting season when the SEL for artillery simulators are &lt; 89 dB, unweighted (&lt; 84 dBA); .50-caliber blank fire was &lt; 82 dB, unweighted (&lt; 72 dBA); military helicopter overflights were &lt; 102 dB, unweighted (&lt; 85 dBA); small-caliber live fire events were &lt; 79 dB, un-weighted (&lt; 77 dBA); large-caliber live fire events were &lt; 103 dB, unweighted (&lt; 85 dBA); and grenade simulators were &lt; 91 dB, unweighted (&lt; 84 dBA).</p>
<p><b>Effects of Helicopter Noise on Mexican Spotted Owls</b></p>	<p>Delaney, DK; Grubb, TG; Beier, P; Pater, LL; Reiser, MH, 1999, "Effects of helicopter noise on Mexican spotted owls" <b>Journal of Wildlife Management</b> Vol. 63, no. 1, pp. 60-76</p> <p>Notes: Sample size varied from 24 to 112 nest manipulations and 8-22 sites depending on year and manipulation. Abstract included detailed metric/methods information.</p>	<p>Military helicopter training over the Lincoln National Forest (LNF) in southcentral New Mexico has been severely limited to protect nesting Mexican spotted owls (<i>Strix occidentalis lucida</i>). To evaluate nesting and nonnesting 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 nonmanipulated 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-sec) 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 nonmanipulated nest sites did not differ in reproductive success (<math>P = 0.59</math>) or the number of young fledged (<math>P = 0.12</math>). 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 &gt;105 m away. <b>Spotted owls returned to predisturbance behavior within 10-15 min after a stimulus event.</b> 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 nonnesting (13.3%) and nesting seasons (13.6%; <math>P = 0.34</math>). Spotted owls did not flush when the SEL noise level for helicopters was <math>\leq 102</math> dBO (92 dBA) and the LEQ level for chain saws was <math>\leq 59</math> dBO (46 dBA). Chain saws were more disturbing to</p>

		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.
<b>Dall's Sheep Responses to Overflights by Helicopter and Fixed-Wing Aircraft</b>	<p>Frid, Alejandro, 2003, "Dall's Sheep Responses to Overflights by Helicopter and Fixed-Wing Aircraft." <b>Biological Conservation</b> Vol. 110 pp387-399</p> <p>Notes: N = Adult male focal groups: 18, Female-young focal groups: 38, Mother focal individuals: 48, Adult female without young focal individuals: 33.</p> <p>Conclusions: Results indicate fixed-wing aircraft are less disturbing than helicopters. When minimum distance was <math>\leq</math> 0.5 km, all 25 groups of sheep studied fled during helicopter overflights but only 53-58% of 53 individual sheep closely studied ('focal' sheep) fled or interrupted rest during fixed-wing overflights.</p>	High rates of behavioural disruption caused by human activities could jeopardize the body condition and reproductive success of wildlife. I exposed Dall's sheep ( <i>Ovis dalli dalli</i> ) of the Yukon Territory to experimental overflights by a fixed-wing aircraft and a helicopter. Aircraft approaches that were more direct (as determined by the aircraft's elevation and horizontal distance from sheep) were more likely to elicit fleeing or to disrupt resting. Latency to resume feeding or resting after fixed-wing overflights was longer during more direct approaches. During indirect approaches by helicopters, sheep far from rocky slopes were much more likely to flee than sheep on rocky slopes. Sheep did not flee while nearby helicopters flew along the opposite side of a ridge, presumably because the obstructive cover buffered disturbing stimuli. Results provide preliminary parameters for predicting energetic and fitness costs incurred as a function of overflight rates, and can help mitigate disturbance by guiding temporal and spatial restrictions to aircraft
<b>Disturbance of Emperor Penguin Aptenodytes Forsteri Chicks by Helicopters</b>	<p>Giese, Melissa and Riddle, Martin, 1999 "Disturbance of emperor penguin <i>Aptenodytes forsteri</i> chicks by helicopters" <b>Polar Biology</b>. 22(6) 366-371.</p> <p>Notes: N = 1 group of 1100 chicks and 300 adults. Helicopter noise level, dB(A), estimated every 5 s during overflight.</p>	Creching emperor penguin ( <i>Aptenodytes forsteri</i> ) chicks were exposed to two overflights by a Sikorsky S-76, twin engine helicopter at 1000 m (3300 ft), a current operational guideline of the Australian Antarctic Division for helicopter activity in Antarctica. The flights were conducted on the same day but under different wind conditions: a morning flight with a 10-knot (18 km h <sup>-1</sup> ) katabatic wind blowing perpendicular to the direction of helicopter travel, and an afternoon flight with virtually no wind. Background noise levels recorded in the morning before the helicopter flight were significantly higher than in the afternoon, but these differences were not detectable when the helicopter was overhead. There were also no significant differences in the way chicks responded to helicopters between the morning and afternoon flight. All chicks became more vigilant when the helicopter approached and 69% either walked or ran, generally moving less than 10 m toward other chicks (i.e. not scattering). Most chicks (83%) displayed flipper-flapping, probably indicating nervous apprehension. This behaviour was seldom displayed in the absence of disturbance. Although all effects were relatively transitory, the results support the introduction of a more conservative guideline of 1500 m (5000 ft) minimum overflight altitude for helicopter operations around breeding localities of this species.
<b>Mountain goat response to helicopter overflights in</b>	Goldstein MI, Poe AJ, Cooper E, Yonkey D, Brown BA and McDonald TL, 2005, Mountain goat response to helicopter	The number of helicopter flights used to gain access to backcountry has increased in recent years. Biologists, land managers, and the

<p><b>Alaska</b></p>	<p>overflights in Alaska. <b>Wildlife Society Bulletin</b> 33(2):688-699.</p> <p>Notes: Claim to have assessed behavior every 10 seconds at a distance of 1.6 km with spotting scopes to arrive at 30.7 sec. recovery time.</p>	<p>public have expressed concern about disturbance impacts to mountain goats (<i>Oreamnos americanus</i>) 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 &gt;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.</p>
<p><b>Dose-response relationships of harlequin duck behavior to noise from low-level military jet over-flights in central Labrador</b></p>	<p>Goudie RI and Jones IL, 2004, Dose-response relationships of harlequin duck behavior to noise from low-level military jet over-flights in central Labrador. <b>Environmental Conservation</b> 31(4):289-298</p> <p>Notes: N = 95 (treatment site), N = 45 (control site), level measurement in dB(A)</p>	<p>Concern for the lack of field studies on the effects of low-level military jet over-flights on wildlife resulted in directed research in the Military Training Area of Labrador, 1999–2002. At Fig River, a tributary of the Lower Churchill River, a before-after-control-impact (BACI) study design quantified effects of aircraft overflights on behaviour of individual harlequin ducks (<i>Histrionicus histrionicus</i>) in the 130 000km<sup>2</sup> Military Training Area of central Labrador. Noise generated from low-level passes (30–100m above ground level) by military jets was sudden in onset and high in amplitude (&gt;100 dBA), substantially above background sound levels both at Fig Lake outlet (40–50 dBA) and rapid sections of Fig River (60–70 dBA). Harlequin ducks reacted to noise from military jets with alert behaviour, showing a positive dose-response that especially intensified when noise exceeded 80 dBA. Residual effects, in other words, <b>deviations from normal behaviour patterns after initial responses, were decreased courtship behaviour for up to 1.5 h after, and increased agonistic behaviour for up to 2 h after military jet over-flights.</b> Direct behavioural responses to military jet over-flights were of short duration (generally &lt;1 min), and were unlikely to affect critical behaviours such as feeding and resting in the overall time-activity budgets of breeding pairs. However, the presence of residual effects on behaviour implied whole-body stress</p>

		<p>responses that were potentially more serious; these require further study because they are potentially more detrimental than immediate responses, and may not be detected in studies that focus on readily observed overt responses. A dose-response curve relating particular behaviours of harlequin ducks to associated noise of over-flights could be a valuable conservation tool for the research and mitigation of environmental impacts of aircraft and other noise.</p>
<p><b>Multivariate behavioural response of harlequin ducks to aircraft disturbance in Labrador</b></p>	<p>Goudie RI, 2006, Multivariate behavioural response of harlequin ducks to aircraft disturbance in Labrador. <b>Environmental Conservation</b> 33(1):28-35</p> <p>Notes: N = 95 (treatment site), N = 45 (control site), level measurement in dB(A)</p>	<p>The effects of low-level aircraft over-flights on behaviour of harlequin ducks (<i>Histrionicus histrionicus</i>) breeding in central Labrador were quantified during 2000–2002. The Canadian Department of National Defence supports a low-level training programme in the 130 000 km<sup>2</sup> 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 behavioural categories of paired male and female harlequin ducks was modelled, and a canonical variable representing alert behaviour, 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. Behavioural responses of harlequin ducks to military jets were 23 times stronger than their responses to floatplanes, helicopters and military cargo planes, and the significant interaction of aircraft type and noise indicated that noise may be the primary stressor affecting behaviour. 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 behavioural categories associated with disturbance that was not originally detected in univariate analyses, suggesting the importance of integrating behaviours other than overt responses. The significant effects of military jet over-flights on harlequin duck behaviour emphasize the need to evaluate potential population consequences of aircraft disturbance.</p>
<p><b>A Technique for Dorsal Subcutaneous Implantation of Heart Rate Biotelemetry Transmitters in Black Ducks: Application in an Aircraft Noise Response Study</b></p>	<p>Harms, Craig A.; Fleming, W. James; .and Stoskopf, Michael K., 1997, “A technique for dorsal subcutaneous implantation of heart rate biotelemetry transmitters in black ducks: Application in an aircraft noise response study” <b>Condor</b>. 99(1) 231-237.</p> <p>Notes: N = 6. Background noise level not reported</p>	<p>A technique for heart rate biotelemetry transmitter implantation was developed to monitor heart rate fluctuations of Black Ducks (<i>Anas rubripes</i>) in response to simulated aircraft noise in a large outdoor enclosure. A dorsal subcutaneous approach, with subcutaneous tunneling of lead wires, was employed for placement of the 32 g transmitters. A base-apex lead configuration, with leads anchored at the dorsal cervico-thoracic junction and the caudal keel, yielded the maximal ECG wave-form deflection for triggering the transmitter. Heart rates of six Black Ducks (three in each of two separate trials) were monitored for 3 days pre-noise to establish a baseline, and then for 4 days of simulated aircraft noise. The noise stimulus replicated an FB-111 military jet, and was played 48 times per day at a peak volume of 110 dB. Daily mean heart rates, used as indicators of metabolic rates,</p>

		did not increase in response to noise. Recognizable acute heart rate increases corresponding with a noise event occurred with increased frequency during the first day of noise presentation, but on subsequent days the responses did not differ significantly from baseline. Acute heart rate responses to aircraft noise diminished rapidly, indicating the ability of Black Ducks to habituate to the auditory component of low altitude aircraft overflights.
<b>Calving Success of Woodland Caribou Exposed to Low-level Jet Fighter Overflights</b>	Harrington, F.H., Veitch, A.M., 1992, "Calving Success of Woodland Caribou Exposed to Low-level Jet Fighter Overflights" <i>Arctic</i> Vol. 45 pp. 213-218	Effects on woodland caribou ( <i>Rangifer tarandus caribou</i> ) of low-level military jet training at Canadian Forces Base - Goose Bay (Labrador) were studied during the 1986-88 training seasons. Calf survival was periodically monitored during 1987 and 1988 in a sample of 15 females wearing satellite-tracked radiocollars. During 1987, each female's exposure to low-level overflights was experimentally manipulated on a daily basis. In 1988, daily exposure was determined by analyzing jet flight tracks following the low-level flying season. Calf survival was monitored by survey flights every 3-4 weeks. A calf survival index, the number of survey periods (maximum = 4) that a cow was accompanied by a calf, was negatively correlated with the female's exposure to low-level jet overflights during the calving and immediate post-calving period and again during the period of insect harassment during summer. No significant relationship between calf survival and exposure to low-level flying was seen during the pre-calving period, during the late post-calving period prior to insect harassment, and during fall. In view of the continued depression of population growth in the woodland caribou population within the low-level training area, jets should avoid overflying woodland caribou calving range at least during the last week of May and the first three weeks of June.
<b>Military Jet Activity and Sonoran Pronghorn</b>	Krausman, P. R., Harris, Lisa K., 2002, "Military Jet Activity and Sonoran Pronghorn." <i>Zeitschrift Fuer Jagdwissenschaft</i> . 48(Supplement).. 140-147.  Notes: N = 15,339 observations of ~21 animals (4 radiocollared). Sound level not estimated	Forty percent of the habitat for the endangered Sonoran pronghorn ( <i>Antilocapra americana sonoriensis</i> ) in the United States is on the Barry M. Goldwater Range (BMGR), a bombing and gunnery range located in southwestern Arizona, USA. Wildlife and land managers have expressed concerns that military aircraft activity may be detrimental to Sonoran pronghorn. We observed the response of Sonoran pronghorn to military jet activity from 4 vantage points, BMGR from February 1998 to June 2000. We obtained behavioral observations on 172 days and obtained 44,773 observation events (i.e., 1 observation / 30 seconds). Pronghorn were exposed to 109 direct military overflights, but only 6 were <305 in above ground level. Overall, behavior of males and females was not significantly different and the presence of military aircraft did not cause changes in behavior.
<b>The Effects of Aircraft Noise on Pronghorn and Other Species</b>	Krausman, Paul R, Lisa K. Harris, and Jennifer S. Ashbeck, 1998, <b>The Effects of Aircraft Noise on Pronghorn and Other Species</b> Special report Cooperative National Park	Out of Print - Searching for copy of report



	Resources Studies Unit (Tucson, Ariz.) School of Renewable Natural Resources, University of Arizona,	
<b>Pronghorn Use of Areas With Varying Sound Pressure Levels</b>	<p>Krausman, Paul, 2003, Pronghorn use of areas with varying sound pressure levels <b>Southwestern Naturalist</b>, 48(4): 725-728</p> <p>Notes: N = 31 radiocollared animals. dB weighting not reported</p> <p>Conclusions: Pronghorn use quieter areas more than expected and louder areas less than expected.</p>	<p>The Sonoran pronghorn (<i>Antilocapra americana sonoriensis</i>), a subspecies in danger of extinction, inhabits an area of the Barry M. Goldwater Range (BMGR) in southwestern Arizona. Since 1941, BMGR has been a training site for military pilots. We evaluated whether this subspecies of pronghorn used areas, as defined by noise levels produced by military aircraft, in proportion to their availability. Radiocollar-equipped pronghorn were monitored during September 1994 to August 1998, and their locations were recorded on a map of sound levels. In general, pronghorn used areas with lower levels of noise (&lt;45 decibels (dB)) more than expected and areas with higher levels (&gt;55 dB) less than expected. More intensive monitoring, habitat influences, and additional measurements of noise in the area, could produce a clearer picture of the factors that determine areas of use within the BMGR by Sonoran pronghorn.</p>
<b>Effects of Jet Aircraft on Mountain Sheep</b>	<p>Krausman, PR; Wallace, MC; Hayes, CL; DeYoung, DW, 1998, "Effects of jet aircraft on mountain sheep" <b>Journal of Wildlife Management</b> Vol. 62, no. 4, pp. 1246-1254</p> <p>Notes: N = 12 (1 yearling female, 8 adult females, 1 yearling male and 4 adult males). dB weighting not reported</p>	<p>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 (<i>Ovis canadensis nelsoni</i>) 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 preoverflight, during the overflight, and postoverflight. 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.</p>
<b>Short-term impacts of military overflights on caribou during the calving</b>	<p>Lawler JP et al, 2005, Short-term impacts of military overflights on caribou during calving season. <b>Journal of Wildlife Management</b> 69(3):1133-1146</p>	<p>The Fortymile Caribou Herd (FCH) is the most prominent caribou herd in interior Alaska. A large portion of the FCH calving and summer range lies beneath heavily used Military Operations Areas (MOA) that are important for flight training. We observed the behavior of Grant's</p>

<p><b>season</b></p>		<p>cow caribou (<i>Rangifer tarandus granti</i>) and their calves before, during, and immediately following low-level military jet overflights. We also monitored movements of radiocollared cow caribou and survival of their calves. We conducted fieldwork from mid May through early June 2002. We concluded that military jet overflights did not cause deaths of caribou calves in the FCH during the calving period nor result in increased movements of cow-calf pairs over the 24-hour period following exposure to overflights. Short-term responses to overflights were generally mild in comparison to caribou reactions to predators or perceived predators. Caribou responses to overflights were variable, but responses were generally greater as slant distances decreased and jet speeds increased. A-10 jets caused less reaction than F-15s and F-16s. Although we found that short-term reactions of caribou to jet overflights were mild, we advise against assuming there are no long-term effects on calving caribou from jet overflights.</p>
<p><b>Modelling Energy and Reproductive Costs in Caribou Exposed to Low Flying Military Jet Aircraft</b></p>	<p>Luick, J. A., J. A. Kitchens, R. G. White, and S. M. Murphy, 1996, "Modelling energy and reproductive costs in caribou exposed to low flying military jet aircraft." <i>Rangifer</i> Special Issue 9: 209-211</p>	<p>Requested Article Through Interlibrary Loan</p>
<p><b>Responses of Caribou to Overflights by Low-Altitude Jet Aircraft</b></p>	<p>Maier, JAK; Murphy, SM; White, RG; Smith, MD, 1998, "Responses of caribou to overflights by low-altitude jet aircraft." <i>Journal of Wildlife Management</i> . Vol. 62, no. 2, pp. 752-766</p> <p>Notes: N = 10 collared caribou in two groups. Individual collared caribou were used as independent data points. dB(A) sound levels monitored with recording devices attached to radiocollars on caribou.</p>	<p>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 (<i>Rangifer tarandus</i>) 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, postcalving, 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 postcalving 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 postcalving. 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 postcalving.</p>
<p><b>Nursing By Muskox</b></p>	<p>Miller F L; Gunn A.; and Barry S J.; 1988, "Nursing By</p>	<p>Nursing bouts by 15 muskox (<i>Ovibos moschatus</i>) calves were</p>

<p><b>Calves Before During and After Helicopter Overflights</b></p>	<p>Muskox Calves Before During And After Helicopter Overflights” <b>Arctic</b>. 41(3) 231-235.</p>	<p>measured to evaluate potential use of nursing behaviour as an indicator of muskox responses to helicopters. The muskox calves nursed 225 times during 313 hours of observation: 63% under undisturbed conditions; 12% when helicopter overflights took place; and 25% following those overflights. During exposure to the helicopter, the calf moved to the cow and then sometimes took the opportunity to nurse. Younger calves nursed relatively longer and more often than older calves; they also performed 68% of the nursings that occurred during helicopter overflights. Frequency and duration of nursing bouts are known to be related to the age of calves. This paper demonstrates that these aspects of nursing vary within or among muskox herds and concludes that observations of nursing at this level of effort cannot be employed with any confidence as a monitoring indicator of muskox response to helicopters.</p>
<p><b>A Simulation Model of Helicopter Disturbance of Molting Pacific Black Brant</b></p>	<p>Miller, M. W.; Jensen, K. C.; Grant, W. E.; and Weller, M. W., 1994, “A simulation model of helicopter disturbance of molting Pacific black brant” <b>Ecological Modelling</b>. 73(3-4) 293-309.</p> <p>Notes: Physiological model of weight loss due to disturbance from overflights in black brants. Model does not incorporate sound level.</p>	<p>We describe a simulation model designed to study the effects of helicopter disturbance on molting Pacific black brant near Teshekpuk Lake, Alaska. Locations of 18 118 brant were digitized into the model based on 10 years of population survey data. Bell 206 and Bell 412 helicopters were simulated flying across the molting grounds along two routes between two airfields. The model determined the behavioral and energetic response of birds encountered by the aircraft during an overflight. Attitude and frequency of overflights were held constant during a simulated 28-day molting period, but were varied among simulations. The model provided the degree of weight loss these birds experienced due to helicopter disturbance. The effects of overflights on brant were classified into five risk categories based on weight. For both routes, the number of flocks and birds in each category was determined for each altitude, aircraft type, and overflight frequency. Simulation results indicated that the model can be used to identify flight-line modifications that result in significantly decreased disturbance to the birds</p>
<p><b>Observations of golden eagle (<i>Aquila chrysaetos</i>) predation on Dall sheep lambs.</b></p>	<p>Nette T, Burles D and Hoefs M, 1984, Observations of golden eagle (<i>Aquila chrysaetos</i>) predation on Dall sheep lambs. <b>Canadian Field Naturalist</b> 98:252-254</p>	<p><b>During helicopter disturbance, a Dall’s sheep lamb straying behind its fleeing mother fell prey to a golden eagle.</b></p>
<p><b>Effects of Jet Aircraft Overflights on Parental Care of Peregrine Falcons</b></p>	<p>Palmer, Angela G., Nordmeyer, Dana L., Roby, Daniel D., 2003, “Effects of jet aircraft overflights on parental care of peregrine falcons” <b>Wildlife Society Bulletin</b>. 31(2).. 499-509</p> <p>Notes: N = 16 overflown nests, 13 control nests. 3 year study, some nests monitored over multiple years. Overflights recorded if noise level exceeded 85 dB. Weighting not</p>	<p>Concerns voiced by resource managers caused us to examine the hypothesis that low-altitude jet aircraft overflights affect parental care by peregrine falcons. Specifically, we studied effects on nest attendance, time-activity budgets, and provisioning rates of peregrine falcons (<i>Falco peregrinus</i>) breeding along the Tanana River, Alaska in 1995, 1996, and 1997. We detected subtle effects of jet overflights on peregrine falcon parental behavior, but found no evidence that overall attendance patterns differed depending on exposure to overflights. Nest attendance and time-activity budgets of peregrine falcons during periods of overflights differed from those of peregrines at reference</p>

	reported.	<p>nests (nests rarely overflow). Differences depended on stage of the nesting cycle and gender. During the incubation and brooding stages of the nesting cycle, males attended the nest ledge less when overflights occurred than did males from reference nests. Females attended the nest ledge more during overflow periods compared to females from reference nests. Additionally, while females were still brooding nestlings, they were less likely to be absent from the nest area during periods when overflights occurred than females from reference nests. Although we found differences in nest attendance and time-activity budgets between overflow and reference nests, we did not observe differences between periods with overflights and periods without overflights at the same nests. Nor did we detect a relationship between nest attendance and the number of overflights occurring within a given time period, the cumulative number of above-threshold noise events at each nest, or the average sound-exposure level of overflights. Furthermore, we found no evidence that nestling provisioning rates were affected by overflights.</p>
<p><b>Aircraft Sound and Disturbance to Bowhead and Beluga Whales During Spring Migration in the Alaskan Beaufort Sea.</b></p>	<p>Richardson, W. John, 2002, Aircraft sound and disturbance to bowhead and beluga whales during spring migration in the Alaskan Beaufort Sea. <i>Marine Mammal Science</i>, 18(2): 309-335</p>	<p>Short-term behavioral responses of bowhead whales (<i>Balaena mysticetus</i>) and beluga whales (<i>Delphinapterus leucas</i>) 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 [ltoreq]150 m and lateral distances [ltoreq]250 m. Belugas reacted significantly more frequently during overflights at lateral distances [ltoreq]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 ([ltoreq]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 [ltoreq]182 m and lateral distances [ltoreq]250 m. However, the proportions reacting, especially to low-altitude flights (e.g., [ltoreq]182 m), were underestimated for both species because observation opportunities were brief. Even so, reactions were more common when the aircraft was low ([ltoreq]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</p>

		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.
<b>Flushing Responses of Wintering Bald Eagles to Military Activity</b>	Stalmaster, Mark V. and Kaiser, James L., 1997, "Flushing responses of wintering bald eagles to military activity" <b>Journal of Wildlife Management</b> . 61(4) 1307-1313.  Notes: N = 1,452 observed eagles. No sound analysis	We studied flushing responses of wintering bald eagles ( <i>Haliaeetus leucocephalus</i> ) to military firing activity, helicopter overflights, and boating on the Nisqually River and Muck Creek on the Fort Lewis Army Reservation, Washington, during 1991-94. Eight percent of 1,452 eagles monitored near Muck Creek flushed during 373 firing events; 4.5% from ordnance explosions, 9% from automatic weapons fire, 6% from artillery impacts, 4% from mortar impacts, and 3% from small arms fire. Flushing by eagles decreased with increasing distance from firing events (16% flushed at 0.5-1.0 km, 9% at 1-2 km, 4% at 2-4 km, and <1% at 4-6 km). Forty-seven percent of 919 eagles flushed in response to 48 helicopter overflights, 37% on the Nisqually River and 53% on Muck Creek. Sixty-one percent of 1,825 eagles flushed in response to 52 experimental boat disturbances on the Nisqually River. Subadults flushed more often than adults, and eagles feeding or standing on the ground flushed more often than those perching in trees. Our data suggest that ordnance explosions, low-level helicopter overflights, and boating should be restricted near eagle foraging areas.
<b>Conflicts in National Parks: A Case Study of Helicopters and Bighorn Sheep Time Budgets at the Grand Canyon</b>	Stockwell, Craig A. and Gary C. Bateman, 1991, "Conflicts in National Parks: A Case Study of Helicopters and Bighorn Sheep Time Budgets at the Grand Canyon" <b>Biological Conservation</b> Vol. 56 pp. 317-328  Notes: N = 297. No sound analysis	Wildlife in numerous national parks of the United States experience frequent overflights by aircraft. Such activities may disturb wildlife populations. We analysed time budgets for desert bighorn sheep <i>Ovis canadensis nelsoni</i> in the presence and absence of helicopter overflights at Grand Canyon National Park (GCNP) to determine the extent to which food intake may be impaired. Bighorn were sensitive to disturbance during winter (43% reduction in foraging efficiency) but not during spring (no significant effect). This seasonal difference may have arisen because the sheep were farther from helicopters during the spring after they had migrated to lower elevations. Further analyses indicated a disturbance distance threshold of 250-450 m. The conservation implications of these results are discussed.
<b>Effects of Low-Level Jet Aircraft Noise on the Behavior of Nesting Osprey</b>	Trimper, Perry G., et. al., 1998, "Effects of Low-Level Jet Aircraft Noise on the Behavior of Nesting Osprey" <b>The Journal of Applied Ecology</b> Vol. 35 no. 1 pp. 122-130.  Notes: N = 7 nesting pairs (5 treatment, 2 control). Median	Nesting osprey <i>Pandion haliaetus</i> L. were exposed to controlled low-level CF-18 jet aircraft overflights along the Naskaupi River, Labrador, Canada, during 1995. Jet aircraft flew near five nests at distances ranging from 2.5 nautical miles (nm) to directly overhead at speeds of 400-440 knots. 2. Maximum noise levels (L1) and other noise metrics were influenced by many factors including topography, distance, altitude, wind speed and direction. 3. Based on 240 h of observations

	<p>sound level measured at the nests was 89 dB (weighting not reported) with a range of 66.3 to 95.5 dB.</p>	<p>from blinds, we recorded osprey nest attendance and egg exposure during 139 individual overflights. Similar observations were completed at two control nests. Overflights as low as 30 m above ground occurred during incubation, nestling and pre fledging only when observers were present. 4. Osprey behaviour did not differ significantly (P = 0.126) between pre- and post-overflight periods. Despite L1 values occasionally exceeding 100 decibels, adult osprey did not appear agitated or startled when overflown. 5. Osprey were attentive to and occasionally flushed from nests when float planes, other osprey or raptors entered territories, and when observers were entering or exiting blinds</p>
<p><b>Response of Fall-Staging Brant and Canada Geese to Aircraft Overflights in Southwestern Alaska</b></p>	<p>Ward, DH; Stehn, RA; Erickson, WP; Derksen, DV , 1999, "Response of fall-staging brant and Canada geese to aircraft overflights in southwestern Alaska" <b>Journal of Wildlife Management</b> Vol. 63, no. 1, pp. 373-381.</p> <p>Notes: N = 1,545 flocks (10-30,000 birds) of brant during 356 overflights and N = 535 flocks of Canada geese during 209 overflights. Sound level quantified as high or low with a 76 dB(A) for fixed wing aircraft and 80 dB(A) for helicopters.</p>	<p>Because much of the information concerning disturbance of waterfowl by aircraft is anecdotal, we examined behavioral responses of Pacific brant (<i>Branta bernicla nigricans</i>) and Canada geese (<i>B. canadensis taverneri</i>) to experimental overflights during fall staging at Izembek Lagoon, Alaska. These data were used to develop predictive models of brant and Canada goose response to aircraft altitude, type, noise, and lateral distance from flocks. Overall, 75% of brant flocks and 9% of Canada goose flocks flew in response to overflights. Mean flight and alert responses of both species were greater for rotary-wing than for fixed-wing aircraft and for high-noise than for low-noise aircraft. Increased lateral distance between an aircraft and a flock was the most consistent predictive parameter associated with lower probability of a response by geese. Altitude was a less reliable predictor because of interaction effects with aircraft type and noise. Although mean response of brant and Canada geese generally was inversely proportional to aircraft altitude, greatest response occurred at intermediate (305-760 m) altitudes. At Izembek Lagoon and other areas where there are large concentrations of waterfowl, managers should consider lateral distance from the birds as the primary criterion for establishing local flight restrictions, especially for helicopters.</p>
<p><b>Effects of Simulated Jet Aircraft Noise on Heart Rate and Behavior of Desert Ungulates</b></p>	<p>Weisenberger, ME; Krausman, PR; Wallace, MC; De Young, DW; Maughan, OE, 1996, "Effects of simulated jet aircraft noise on heart rate and behavior of desert ungulates" <b>Journal of Wildlife Management</b>. vol. 60, no. 1, pp. 52-61</p> <p>N = 6 mule deer and 5 mountain sheep. dB weighting not reported.</p>	<p>The effects of simulated low-altitude jet aircraft noise on the behavior and physiology of 6 captive desert mule deer (<i>Odocoileus hemionus crooki</i>) and 5 mountain sheep (<i>Ovis canadensis mexicana</i>) were evaluated. Heart rate and behavior in relation to ambient temperature, number of simulated overflights/day, and noise levels [range =92--112 decibels (dB)] that the animals were exposed to were measured. Heart rates during simulated overflights (n=112/treatments/season) were compared to data collected prior to and following treatment periods. Differences between heart rates for animals, noise levels, and number of overflights between seasons were documented. All animals became habituated to sounds of low-altitude aircraft. Although heart rates increased during overflights they returned to resting rates in (less than or equal to)2 min.</p>

<b>Population and Ecological Impacts from Noise</b>		
<p><b>Energetic Cost of Man-Induced Disturbance to Staging Snow Geese.</b></p>	<p>Bélanger, L., and J. Bédard, 1990, “Energetic cost of man-induced disturbance to staging snow geese.” <b>Journal of Wildlife Management</b> 54:36-41</p> <p>Notes: N = 155 observations. No sound analysis.</p>	<p>Energetic cost of man-induced disturbance to fall-staging snow geese in Québec was estimated. Two responses of birds to disturbance were considered: (1) birds fly away but promptly resume feeding following a disturbance (Response A), and (2) birds interrupt feeding altogether (Response B). Daylight foraging time decreased by 4% to 51% depending on disturbance levels. Average rate of disturbance (1.46/hr) in Response A resulted in a 5.3% increase in hourly energy expenditure (HEE) combined with a 1.6% reduction of hourly metabolizable energy intake (HMEI). In Response B, HEE increased by 3.4% and HMEI decreased by 2.9% to 19.4%. A 4% increase in night feeding could compensate for energy losses caused solely by disturbance flights (Response A), but a 32% increase in nighttime feeding was required to restore energy losses incurred in Response B. No increase in daily feeding rate was observed between days with different disturbance levels (<math>P &gt; 0.05</math>). Authors concluded that man-induced disturbance had significant energetic consequences for fall-staging greater snow geese</p>
<p><b>Reindeer (<i>Rangifer tarandus</i>) avoidance of a highway as revealed by lichen measurements.</b></p>	<p>Dahle B, Reimers E and Colman JE, 2007, Reindeer (<i>Rangifer tarandus</i>) avoidance of a highway as revealed by lichen measurements. <b>Eur J Wildl Res Online</b> Early</p> <p>Notes: Focus on roads but distances that Reindeer avoid roads (8 km) may indicate sound as a factor</p>	<p>Reindeer and caribou <i>Rangifer tarandus</i> are reported to avoid human infrastructure such as roads, high-voltage power lines, pipelines, and tourist resorts. Lichens are important forage for reindeer during winter, and their relatively slow growth rates make them vulnerable to overgrazing. Height and volume of lichens are often used as an indicator of grazing pressure by reindeer and, thus, as an indirect measure of <i>Rangifer</i> avoidance of human infrastructure. We sampled lichen height in <i>Cetraria nivalis</i>-dominated communities along 4 and 3 parallel transects located on two parallel mountain ridges in Hardangervidda, south central Norway. The lichen measurements were analyzed in relation to altitude and the distance from four tourist cabins in the area and a highway (Rv7) running perpendicular to the 7 transects. The mountain ridge with 4 transects is part of a much used migratory corridor for wild reindeer <i>R. tarandus tarandus</i>. Along the nonmigratory ridge, lichen height decreased 35% over an 8-km distance from Rv7 and a tourist cabin, indicating reindeer aversion toward Rv7 and/or a tourist cabin. No similar relationship was found for the migration ridge in relation to distance from Rv7 or the tourist cabins. Our results suggest that avoidance of human infrastructure by wild reindeer might be limited where reindeer use of winter pastures is influenced by herd traditions and/or motivation to follow established migration corridors. This has important implications for addressing the use of similar pasture measurements when testing for <i>Rangifer</i> aversion toward human disturbances.</p>
<p><b>Human-caused</b></p>	<p>Frid, A., and Dill, L.M., 2002, “Human-caused Disturbance</p>	<p>A growing number of studies quantify the impact of nonlethal human disturbance on the behavior and reproductive success of animals.</p>

<p><b>Disturbance Stimuli as a Form of Predation Risk</b></p>	<p>Stimuli as a Form of Predation Risk” <b>Conservation Ecology</b> Vol. 6 no.1</p>	<p>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 antipredator 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 antipredator behavior has a cost to other activities, and that this trade-off is optimized when investment in antipredator behavior tracks short-term changes in predation risk. Prey have evolved antipredator 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.</p>
<p><b>Why Behavioural Responses May Not Reflect the Population Consequences of Human Disturbance</b></p>	<p>Gill J. A., K. Norris, and W. J. Sutherland, 2001, “Why behavioural responses may not reflect the population consequences of human disturbance.” <b>Biological Conservation</b> 97:265-268</p>	<p>The effect of human disturbance on animals is frequently measured in terms of changes in behaviour in response to human presence. The magnitude of these changes in behaviour is then often used as a measure of the relative susceptibility of species to disturbance; for example species which show strong avoidance of human presence are often considered to be in greater need of protection from disturbance than those which do not. In this paper we discuss whether such changes in behaviour are likely to be good measures of the relative susceptibility of species, and suggest that their use may result in confusion when determining conservation priorities.</p>
<p><b>Predicting the Consequences of Human Disturbance from Behavioral Decisions</b></p>	<p>Gill, J.A., Sutherland, W.J., 2000, “Predicting the Consequences of Human Disturbance from Behavioral Decisions” in Gosling, L.M. and Sutherland, W.J. (eds.) <b>Behavior and Conservation</b>. Cambridge: Cambridge University Press</p>	<p>Book Chapter – Requested Book Through Interlibrary Loan</p>
<p><b>A Method to Quantify the</b></p>	<p>Gill, J.A., Sutherland, W.J., Watkinson, A.R., 1996, “A</p>	<p>1. The extent and consequences of human disturbance on populations</p>



<p><b>Effects of Human Disturbance on Animal Populations</b></p>	<p>Method to Quantify the Effects of Human Disturbance on Animal Populations” <b>Journal of Applied Ecology</b> Vol. 33 pp.786-792</p>	<p>of vertebrates are contentious issues in conservation. As recreational and industrial uses of the countryside continue to expand, it is becoming increasingly important that the effects of such disturbance on wildlife are quantified.                  2. This study describes a method of quantifying the effect of disturbance, based on measuring the trade-off between resource use and risk of disturbance. This approach is based on one used by ethologists to study the effects of predation risk on patch use.                  3. Pink-footed geese, <i>Anser brachyrhynchus</i>, feeding on arable fields, are highly responsive to disturbance from surrounding roads. The extent to which these fields are exploited declines linearly with increasing risk of disturbance. The reduction in use of these feeding grounds caused by disturbance can be quantified by translating the biomass of food not exploited into the number of birds that this food could have supported.                  4. This approach allows both quantification of the impact of disturbance on a population, and exploration of the potential consequences of changes in disturbance on the size of populations.</p>
<p><b>Does Risk of Predation Influence Population Dynamics?</b></p>	<p>Hik, D. S., 1995, “Does risk of predation influence population dynamics?” <b>Wildlife Research</b> 22:115-129</p>	<p>Different patterns of survival and changes in body mass were observed in the presence and absence of terrestrial predators. On the CONTROL area, female body mass and fecundity declined, even though sufficient winter forage was apparently available in all years. A similar decrease in body mass was observed on the FOOD treatment, but only during the third year of the population decline. In contrast, female body mass remained high throughout the decline in the absence of terrestrial predators in the FENCE+FOOD and FENCE treatments. Winter survival declined on CONTROL and FENCE areas during the first year of the population decline (1991), but remained higher on FOOD until 1992 and FENCE+FOOD until 1993. These results generally supported the PSF hypothesis where terrestrial predators were present (CONTROL and FOOD grids). Where terrestrial predators were absent (FENCE and FENCE+FOOD), the results supported the alternative condition constraint hypothesis. The evidence suggests that a cascade of sublethal behavioural and physiological effects associated with increased predation risk contribute to the population decline and delayed recovery of cyclic low-phase populations of snowshoe hares.</p>
<p><b>Mountain Goat Population Changes in Relation to Energy Exploration Along Montana’s Rocky Mountain Front</b></p>	<p>Joslin, G., 1986, “Mountain Goat population changes in relation to energy exploration along Montana’s Rocky Mountain Front” <b>Biennial Symposium of the Northern Wild Sheep and Goat Council</b> 5, 253-271</p>	<p>Where caribou have been hunted or chased (passively or actively) herds are more likely to experience additional stress from associating man with danger, and are especially sensitive during the calving and rut periods. Harassment of unhabituated caribou to human disturbance may have immediate impacts as well as long term effects. Where humans or their machines are perceived as a threat, caribou often experience increased stress levels and subsequently expend more</p>

		<p>energy attempting to avoid the disturbance. Flight is the most common response for unhabituated animals that perceive humans as predators. This flight response uses up vital body reserves, increases the chance of physical injury or death during stampedes and may cause herd fragmentation. Utilisation of essential body fat and protein, especially during harsh climatic conditions, can lead to increased cow/calf mortality, and may effectively reduce productivity of the herd. Long term displacement from home range (especially during calving period) may result in increased mortality, decreased reproductive success, increased predation, altered habitat use and decreased caribou densities. Human activities within caribou range which do not necessarily destroy caribou habitat may still result in a functional loss of usable space by the disturbance and resulting displacement. The relatively isolated areas caribou live in may make them more responsive to human disturbance, eliciting high stress responses. Human activities such as hiking, snowmobiling, low altitude flights and ATV use, which briefly stress caribou are likely to have significant negative effects if animals are displaced out of their preferred habitat.</p>
<p><b>Stress and Decision Making Under The Risk of Predation: Recent Developments From Behavioral, Reproductive, and Ecological Perspectives</b></p>	<p>Lima, S. L., 1998, "Stress and decision making under the risk of predation: recent developments from behavioral, reproductive, and ecological perspectives". <i>Advances in the Study of Behavior</i> 27:215-290.</p>	<p>Requested Article Through Interlibrary Loan</p>
<p><b>Ecological and Physiological Aspects of Caribou Activity in Response to Aircraft Overflights</b></p>	<p>Maier, J., 1996, <b>Ecological and Physiological Aspects of Caribou Activity in Response to Aircraft Overflights.</b> Dissertation, University of Alaska, Fairbanks</p>	<p>Resource management agencies are concerned about the potential effects of these overflights on important species of ungulates. I hypothesized that low-altitude overflights would affect activity and movements of caribou, and thereby constitute a disturbance with negative consequences on energetics. I used caribou of the Delta Herd (DCH) and captive animals at the Large Animal Research Station (LARS) to address the hypotheses: caribou (1) exhibit equal activity day and night; (2) do not time activity to light; and (3) activity patterns do not change seasonally in response to daylength. Caribou were nychthemeral and exhibited uniform activity with no apparent timing to light. DCH caribou responded to seasonal changes in the environment by modifying activity (increased activity in response to insect harassment), whereas LARS caribou altered activity in response to fluctuating physiological variables (increased activity during rut). Changes in daylength did not affect activity. Data on activity from LARS and DCH caribou were compared with extant data on caribou of the Denali and Porcupine herds. Poor quality forage in winter was inferred from long resting bouts, and low availability of forage was</p>

		<p>inferred from long active bouts of post-calving caribou of the DCH. In midsummer, caribou of the DCH exhibited significantly longer active and shorter resting bouts than did LARS caribou, consistent with a moderate level of insect harassment. Responses of caribou to overflights were mild in late winter and, thus, overflights did not constitute a disturbance. Post-calving caribou responded to overflights by increasing daily activity, linear movements, incremental energy cost, and average daily metabolic rate. Energetic responses and movements were significantly related to the loudest overflight of the day. In the insect season, activity levels increased significantly in response to overflights but with no corresponding increase in linear movements or energetics. My recommendations are to prohibit aircraft overflights of caribou during calving and post-calving periods and during key feeding times in insect harassment seasons. Research indicates the possibility of more severe effects in nutritionally stressed animals.</p>
<p><b>Optimally Foraging Mice Match Patch Use with Habitat Differences in Fitness</b></p>	<p>Morris, D. W., and D. L. Davidson, 2000, "Optimally foraging mice match patch use with habitat differences in fitness." <i>Ecology</i> 81:2061-2066</p>	<p>We tested the fundamental assumption of the "optimality paradigm" that the foraging behavior of individual organisms corresponds to what we would expect if it had been honed by natural selection to match habitat differences in reproductive success. First, we used long-term studies of life history and habitat selection in white-footed mice to illustrate that the fitness of females living in the forest is greater than that of females living in forest-edge habitat. Second, we used short-term foraging studies to evaluate whether food patches located in the forest provided more value to foragers than did those in the edge. Third, we used foraging studies and data on the occurrence of predators to demonstrate that animals foraging in areas with little cover face higher risks than when they forage in areas with more cover. We confirmed three a priori predictions: (1) Individual mice abandoned foraging patches at higher harvest rates in edge habitat than they did in forest. (2) Individuals harvested resource patches to lower quitting harvest rates under cover than they did when patches were located in the open. (3) The difference in quitting-harvest rate between "open" and "covered" patches was less in the safe forest habitat than it was in the risky edge habitat. Our results yield an impressive fit with our previous knowledge of habitat differences in reproductive success and substantiate the premise that short-duration strategic decisions by individuals match habitat differences in fitness.</p>
<p><b>Displacement of <i>Orcinus orca</i> (L.) by high amplitude sound in British Columbia, Canada</b></p>	<p>Morton, AB and Symonds HK, 2002, Displacement of <i>Orcinus orca</i> (L.) by high amplitude sound in British Columbia, Canada. <i>ICES Journal of Marine Science</i> 59:71-80</p>	<p>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 (<i>Orcinus orca</i>) 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</p>

		<p>on already existing salmon farms in the Broughton Archipelago, in attempts to deter predation on fish pens by harbour seals (<i>Phoca vitulina</i> 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.</p>
<p><b>Reproductive Success of Elk Following Disturbance by Humans During Calving Season</b></p>	<p>Phillips, G. and Alldredge, A., 2002, "Reproductive Success of Elk Following Disturbance by Humans During Calving Season" <b>Journal of Wildlife Management</b> 64, 521-530</p>	<p>Restricting human activity in elk (<i>Cervus elaphus</i>) calving areas during calving season can be controversial because of increasing human uses of elk habitat, and little evidence exists to evaluate impacts of these activities on elk populations. We evaluated effects of human-induced disturbance on reproductive success of radiocollared adult female elk using a control-treatment study in central Colorado. Data were collected during 1 pretreatment year and 2 treatment years. Treatment elk were repeatedly approached and displaced by study personnel throughout a 3-4-week period of peak calving during both treatment years, while control elk did not receive treatment. We observed elk on alpine summer ranges in July and August on both areas to estimate the proportion of marked cows maintaining a calf. Calf/cow proportions for the control area remained stable, but those for the treatment area declined each year. Average number of disturbances/elk/year effectively modeled variation in calf/cow proportions, supporting treatment as the cause of declining calf/cow proportions. Average decrease in calf/cow proportion in the treatment group was 0.225. Modeling indicated that estimated annual population growth on both study areas was 7% without treatment application given that existing human activities cause some unknown level of calving-season disturbance. With an average of 10 disturbances/cow above ambient levels, our model projected no growth. Our results support maintaining disturbance-free areas for elk during parturitional periods.</p>
<p><b>Potential Energetic Effects of Mountain Climbers on Foraging Grizzly Bears</b></p>	<p>White, D., Jr., K. C. Kendall, and H. D. Picton, 1999, "Potential energetic effects of mountain climbers on foraging grizzly bears." <b>Wildlife Society Bulletin</b> 27:146-151.</p>	<p>Most studies of the effects of human disturbance on grizzly bears (<i>Ursus arctos horribilis</i>) have not quantified the energetic effects of such interactions. In this study, we characterized activity budgets of adult grizzly bears as they foraged on aggregations of adult army cutworm moths (<i>Euxoa auxiliaris</i>) in the alpine of Glacier National Park, Montana, during 1992, 1994, and 1995. We compared the activity budgets of climber-disturbed bears to those of undisturbed bears to estimate the energetic impact of climber disturbance. When bears detected climbers, they subsequently spent 53% less time foraging on moths, 52% more time moving within the foraging area, and 23% more time behaving aggressively, compared to when they</p>

		were not disturbed. We estimated that grizzly bears could consume approximately 40,000 moths/day or 1,700 moths/hour. At 0.44 kcal/moth, disruption of moth feeding cost bears approximately 12 kcal/minute in addition to the energy expended in evasive maneuvers and defensive behaviors. To reduce both climber interruption of bear foraging and the potential for aggressive bear-human encounters, we recommend routing climbers around moth sites used by bears or limiting access to these sites during bear-use periods.
<b>Behavior Responses and Reproduction of Mule Deer Does Following Experimental Harassment with an All-Terrain Vehicle</b>	Yarmoloy, C., et. al., 1988, "Behavior Responses and Reproduction of Mule Deer Does Following Experimental Harassment with an All-Terrain Vehicle." <b>Canadian Field-Naturalist</b> 102, 425-429	Five mule deer were habituated to an ATV for 12 weeks. Three of the females were then followed by an ATV for 9 minutes per day for 15 days. The harassed females, but not the other females shifted feeding into darkness, used cover more frequently, left home ranges more often, and increased flight distance from the ATV. The harassed females also showed significant decreases in reproduction success.
<b>Habituation</b>		
<b>Pronghorn Foraging Economy and Predator Avoidance in A Desert Ecosystem: Implications for the Conservation of Large Mammalian Herbivores.</b>	Berger J., D. Daneke, J. Johnson, and S. H. Berwick, 1983, "Pronghorn foraging economy and predator avoidance in a desert ecosystem: implications for the conservation of large mammalian herbivores." <b>Biological Conservation</b> 25:193-208.	Assumptions of optimal foraging theory were applied to the feeding ecology of pronghorn to address issues of immediate relevance to conservation biology in the Great Basin Desert of North America. The relationships between foraging efficiency and (1) group size; (2) habitat; and (3) disturbance history were examined in two study sites. Individual foraging efficiency increased with group size to a point in both study sites, but animals in the disturbed area remained in larger groups despite foraging less profitably. The hypothesis that individuals in a disturbed environment remain together for enhanced protection from (human?) predators was supported and interpreted in light of proposed habitat alterations in vast portions of this unique desert ecosystem.
<b>Discrimination of the Threat of Direct Versus Tangential Approach to the Nest By Incubating Herring and Great Black-Backed Gulls</b>	Burger, J., and M. Gochfeld, 1981, "Discrimination of the threat of direct versus tangential approach to the nest by incubating herring and great black-backed gulls." <b>Journal of Comparative and Physiological Psychology</b> 95:676-684	Requested Article
<b>Risk Discrimination of Direct Versus Tangential Approach By Basking Black Iguanas (Ctenosaura Similis):</b>	Burger, J., and M. Gochfeld, 1990, "Risk discrimination of direct versus tangential approach by basking black iguanas (Ctenosaura similis): variation as a function of human exposure." <b>Journal of Comparative Psychology</b> 104:388-394	Requested Article

<b>Variation As A Function of Human Exposure.</b>		
<b>Responses of Bald Eagles to Human Activity During the Summer in Interior Alaska</b>	Steidl, R. J., and R. G. Anthony, 1996, "Responses of Bald Eagles to human activity during the summer in interior Alaska." <b>Ecological Applications</b> 6:482-491	Along narrow rivers, spatial restriction of human use based on wildlife responses can effectively eliminate the entire river corridor from human use. Therefore, if river use by both wildlife and humans is a goal, an alternative management strategy is necessary. We measured flush response rate and flush distance of breeding and nonbreeding Bald Eagles ( <i>Haliaeetus leucocephalus</i> ) to recreational boating along the Gulkana River in interior Alaska from 1989 to 1992. Eagle responses to our nonmotorized boat were governed by the context within which human-eagle encounters occurred. Flush response rate of nonbreeding eagles decreased as perch height and its distance from the river's edge increased, increased as the season progressed and as eagle group size increased, was lower for juveniles (20%) than other age classes (49-65%), and varied with the existing level of human activity in geographic location ( $P < 0.001$ for all parameters). Flush distance of nonbreeding eagles increased as the distance a disturbance was first visible to a perched eagle increased, as perch height and its distance from the river's edge increased, and as the season progressed. In contrast to flush response, flush distance was strongly associated with age and was greatest for adults, least for juveniles, and intermediate for subadults. Breeding adults were much less likely to flush than nonbreeding adults, and flushed at lesser distances. We recommend that along narrow wilderness rivers, the impacts of human activity on Bald Eagle populations be regulated with temporal, rather than spatial, restrictions.
<b>Predictors of Vigilance for American Crows Foraging in An Urban Environment</b>	Ward, C., and B. S. Low, 1997, "Predictors of vigilance for American Crows foraging in an urban environment" <b>Wilson Bulletin</b> 109:481-489	We examined ways in which American Crows ( <i>Corvus brachyrhynchos</i> ) foraging in an urban environment balance the conflicting demands of finding food and avoiding predators. As individual vigilance (i.e., scanning) decreased, time devoted to foraging increased. Significant predictors of vigilance varied with location and included time of day, temperature, food availability, distance to nearest source of disturbance, cover distance, and size of foraging group. Group size and, secondarily, distance from cover accounted for most of the variability in vigilance. Crows were more vigilant in areas of high human disturbance than in areas of low human disturbance.
<b>Noise Effects on Signal Design: Amplitude shifts</b>		
<b>Noise-dependent song amplitude regulation in a territorial songbird</b>	Brumm H and Todt D, 2002, Noise-dependent song amplitude regulation in a territorial songbird. <b>Animal Behaviour</b> 63:891-897	Some animals that use sound to communicate compensate for interference from background noise by adjusting the amplitude of their vocalizations as environmental noise levels vary. Territorial songbirds may have evolved a different strategy, since they can be expected to benefit from maximizing the amplitude of their songs to defend

	<p>Notes: N=10, playback of white noise (45-30,000 Hz) at 55-75 dB(A). Background noise 0.1-3.5 kHz, 31-38 dB(A).</p> <p>Conclusions: All birds increased the sound level of their songs in response to an increase in white noise broadcast to them. A second experiment revealed that noise in the spectral region of their own songs was most effective in inducing the birds to increase vocal intensity.</p>	<p>territories and attract females. We tested this hypothesis with calibrated measurements of the song level of male nightingales, <i>Luscinia megarhynchos</i>. All birds increased the sound level of their songs in response to an increase in white noise broadcast to them. A second experiment revealed that noise in the spectral region of their own songs was most effective in inducing the birds to increase vocal intensity. These findings show that nightingales do not maximize song amplitude but regulate vocal intensity dependent on the level of masking noise. The adjustment of vocal amplitude may serve to maintain a specific signal-to-noise ratio that is favourable for signal production. Concurrently, increasing the intensity of songs can maintain a given active space for communication. Thus, vocal amplitude in a territorial songbird can be interpreted as a flexible trait, which is individually regulated according to ecological demands from signal transmission.</p>
<p><b>The impact of environmental noise on song amplitude in a territorial bird</b></p>	<p>Brumm H, 2004, The impact of environmental noise on song amplitude in a territorial bird. <b>Journal of Animal Ecology</b> 73:434-440.</p> <p>Notes: N=15, sound level estimated with instantaneous (time constant 125 ms), A-weighted dB readings. Background noise subtracted and distance to mic factored.</p> <p>Conclusion: Males at louder locations, sing louder</p>	<ol style="list-style-type: none"> <li>1. The impact of environmental background noise on the performance of territorial songs was examined in free-ranging nightingales (<i>Luscinia megarhynchos</i> 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.</li> <li>2. This is the first evidence of a noise-dependent vocal amplitude regulation in the natural environment of an animal.</li> <li>3. The results yielded demonstrate that the birds tried to mitigate the impairments on their communication caused by masking noise. This behaviour may help to maintain a given transmission distance of songs, which are used in territory defence and mate attraction. At the same time, birds forced to sing with higher amplitudes have to bear the increased costs of singing.</li> <li>4. This suggests that in songbirds the level of environmental noise in a territory will contribute to its quality and thus considerably affect the behavioural ecology of singing males.</li> </ol>
<p><b>Acoustic communication in noise: regulation of call characteristics in a New World monkey</b></p>	<p>Brumm H, Voss K, Kollmer I and Dietmar T, 2004, Acoustic communication in noise: regulation of call characteristics in a New World monkey. <b>Journal of Experimental Biology</b> 207: 443-448.</p> <p>Notes: N=4, broadcast white noise at 40, 50, 60 and 65 dB. Background noise level ~30 dB.</p> <p>Conclusion: Marmoset calls increased in duration and</p>	<p>This study on common marmosets <i>Callithrix jacchus</i> is the first to examine noise-dependent mechanisms of vocal plasticity in a New World monkey. Since acoustic communication can be considerably impaired by environmental noise, some animals have evolved adaptations to counteract its masking effects. The studied marmosets increased the sound level of their spontaneous calls in response to increased levels of white noise broadcast to them. Possibly, such noise-dependent adjustment of vocal amplitude serves to maintain a specific signal-to-noise ratio that is favourable for signal production. Concurrently, the adjustment of vocal amplitude can maintain a given active space for</p>

	<p>amplitude in accordance with increasing masker level.</p>	<p>communication. In contrast to some bird species, no noise-induced increase in the number of syllables per call series could be found, showing that an increased serial redundancy of vocal signals was not used to communicate under noisy conditions. Finally, we examined a possible noise-dependent prolongation of vocal signals. This approach was guided by the findings of perceptual studies, which suggest an increased detection probability of prolonged signals in noise by temporal summation. Marmosets indeed increased the duration of their call syllables along with increasing background noise levels. This is the first evidence of such mechanism of vocal plasticity in an animal communication system.</p>
<p><b>Amplitude regulation of vocalizations in noise by a songbird, <i>Taeniopygia guttata</i></b></p>	<p>Cynx J, Lewis R, Tavel B and Tse H, 1998, Amplitude regulation of vocalizations in noise by a songbird, <i>Taeniopygia guttata</i>. <b>Animal Behaviour</b> 56:107-113</p> <p>Notes: N=2 zebrafinch, N=3 humans. Masking noise presented in 5 dB steps at 60-90 dB(A). Background noise level, 40-50 dB(A).</p> <p>Conclusion: Curvilinear responses to increasing levels of masking noise suggesting that birds may quickly reach an intensity threshold over which they can not compensate.</p>	<p>Bird vocalizations are produced under various noise conditions. It could therefore benefit birds to alter the amplitude of their signals as noise conditions change. We tested this by recording male and female zebra finches, <i>Taeniopygia guttata</i>, as they were subjected to various levels of white noise. Both sexes increased amplitude levels of vocalization in response to increased levels of noise. Similar results were obtained with humans (the 'Lombard effect'). The results are discussed in terms of the 'active space' of bird song and honest signalling.</p>
<p><b>Ambient noise and the design of begging signals</b></p>	<p>Leonard ML and Horn AG, 2005, Ambient noise and the design of begging signals. <b>Proc. R. Soc. B</b> 272:651-656.</p> <p>Notes: 3 experiments. 1: In the field, amplitude, call length and Hz range increase with increased ambient noise level- 41-67 dB(C) range. 2: playback of white noise at 65 dB(C) in lab resulted in increased call amplitude. 3: Begging calls played back at 65 vs 55 dB(C) stimulated significantly more feeding during simultaneous playback of 60 dB(C) white noise.</p>	<p>The apparent extravagance of begging displays is usually attributed to selection for features, such as loud calls, that make the signal costly and hence reliable. An alternative explanation, however, is that these design features are needed for effective signal transmission and reception. Here, we test the latter hypothesis by examining how the begging calls of tree swallow (<i>Tachycineta bicolor</i>) nestlings and the response to these calls by parents are affected by ambient noise. In a field study, we found that call length, amplitude and frequency range all increased with increasing noise levels at nests. In the laboratory, however, only call amplitude increased in response to the playback of noise to nestlings. In field playbacks to parents, similar levels of noise abolished parental preferences for higher call rates, but the preference was restored when call amplitude was increased to the level that nestlings had used in the laboratory study. Our results show that nestling birds, like other acoustic signallers, consistently increase call amplitude in response to ambient noise and this response appears to enhance discrimination by receivers. Thus, selection for signal efficacy may explain some of the seemingly extravagant features of begging</p>



<p><b>Control of vocal intensity in budgerigars (<i>Melopsittacus undulatus</i>): Differential reinforcement of vocal intensity and the Lombard effect</b></p>	<p>Manabe K, Sadr EI and Dooling RJ, 1998, Control of vocal intensity in budgerigars (<i>Melopsittacus undulatus</i>): Differential reinforcement of vocal intensity and the Lombard effect. <b>J. Acoust. Soc. Am.</b> 103(2):1190-1198</p> <p>Notes: 70 dB masker. N = 1-5 over 5 experiments.</p> <p>Conclusion: Noise in spectral region of contact calls (1.5-4.5 kHz) most effective at causing an upward amplitude shift.</p>	<p>displays.</p> <p>Call production in budgerigars was studied using operant conditioning. In several experiments, budgerigars were reinforced with food for producing calls that were above or below a criterion level of intensity. This differential reinforcement procedure was successful in controlling vocal intensity in both directions showing that the intensity with which budgerigars produce vocalizations is under voluntary control. In additional experiments, call intensity maintained by food reinforcement was measured both in the quiet and in the presence of various levels of broadband noise. Call intensity in budgerigars increased significantly in noise, paralleling the well-known Lombard effect in humans which is the reflexive increase in speech intensity during communication in noise. Call intensity was measured in broadband noise and in a notched noise (no energy between 1.5 and 4.5 kHz) with the same overall level. Results show that noise in the spectral region of contact calls is most effective in causing an increase in vocal intensity. In aggregate, these experiments show that budgerigars have voluntary control over the intensive aspect of their vocalizations, that they normally monitor their vocal output though external auditory feedback, and, like humans, they exhibit the Lombard effect.</p>
<p><b>Regulation of vocal amplitude by the blue-throated hummingbird, <i>Lampornis clemenciae</i></b></p>	<p>Pytte CL, Rusch KM and Ficken MS, 2003, Regulation of vocal amplitude by the blue-throated hummingbird, <i>Lampornis clemenciae</i>. <b>Animal Behaviour</b> 66:703-710</p> <p>Notes: N =13, Playback of 70 dB(C?) masker mimicking creek noise increased call intensity. dB estimated at 5-10 m from singers.</p>	<p>Animals that rely on vocal communication must broadcast sound so that a perceptible signal is transmitted over an appropriate distance. We found that male blue-throated hummingbirds modified the amplitude of their vocalizations in response to both naturally occurring and experimenter-controlled changes in ambient noise levels. This phenomenon is known as the Lombard effect and may increase the efficiency of acoustic signalling. This study demonstrates the effect under natural field conditions and documents the first hummingbird species (Apodiformes: Trochilidae) to show this behaviour. We measured sound pressure levels (SPLs) of Serial Chip territorial advertisement calls across a natural range of ambient noise, primarily due to creeks within male territories. We found a significant correlation between the amplitude of Serial Chips and the amplitude of background noise. To test this relationship, we broadcast recordings of creek noise at high and low amplitudes</p>

		<p>while target individuals were producing Serial Chip vocalizations. We measured vocal SPLs before and during the playback. Individuals responded to changes in playback creek noise by changing the amplitude of Serial Chip production. We also measured transmission properties of Serial Chip calls through natural habitat to calculate the approximate amplitude of vocalizations at the position of the calling bird. We suggest that amplitude regulation of vocalizations contributes to signal transmission distance along with the established relationships between singing behaviour, acoustic structure and habitat.</p>
<p><b>Noise Effects on Signal Design: Frequency shifts</b></p>		
<p><b>Anthropogenic Noise and its Effect on Animal Communication: An Interface Between Comparative Psychology and Conservation Biology</b></p>	<p>Rabin LA, McCowan B, Hooper SL and Owings DH, 2003, Anthropogenic noise and its effect on animal communication: An interface between comparative psychology and conservation biology. <b>International Journal of Comparative Psychology</b> 16:172-192</p> <p>Notes: Review + case study of ground squirrel vocalizations in masking noise. Alarm vocalization in a 60-70 dB(C) site vs a 82-86 dB(C) site. Calls shift to higher harmonic in louder site resulting in 1.2-2.7 kHz change.</p>	<p>Conservation biology and comparative psychology rarely intersect, in part because conservation biology typically emphasizes populations whereas comparative psychology concentrates on individual organisms. However, both fields could benefit from their integration. Conservation biology can profit from an enhanced understanding of individual-level impacts of habitat alteration and the resulting implications for conservation mitigation strategies. Comparative psychology can gain from increased attention to the mechanisms of adjustment used by organisms to “in vivo experiments” created by anthropogenic change. In this paper, we describe a conceptual framework useful for applying our understanding of animal communication to conservation biology. We then review studies of animal communication with conservation implications, and report our own preliminary work that demonstrates our framework in action.</p>
<p><b>The impact of roads on birds: Does song frequency play a role in determining susceptibility to noise pollution?</b></p>	<p>Rheindt FE, 2003, The impact of roads on birds: Does song frequency play a role in determining susceptibility to noise pollution? <b>J. Ornithology</b> 144:295-306</p> <p>Notes: Weak but significant relationship between road proximity and dominant frequency in song. Body size and detectability controlled. 12 species in the community (great spotted woodpecker, winter wren, European robin, European blackbird, song thrush, blackcap, chiffchaff, firecrest, European nuthatch, tree creeper, blue tit, great tit, hawfinch, chaffinch)</p>	<p>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 carded 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 analysed 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</p>

		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.
<b>Habitat-dependent ambient noise: Consistent spectral profiles in two African forest types</b>	Slabbekoorn H, 2004, Habitat-dependent ambient noise: Consistent spectral profiles in two African forest types. <i>J. Acoust. Soc. Am.</i> 116(6):3727-3733.	Many animal species use acoustic signals to attract mates, to defend territories, or to convey information that may contribute to their fitness in other ways. However, the natural environment is usually filled with competing sounds. Therefore, if ambient noise conditions are relatively constant, acoustic interference can drive evolutionary changes in animal signals. Furthermore, masking noise may cause acoustic divergence between populations of the same species if noise conditions differ consistently among habitats. In this study, ambient noise was sampled in a replicate set of sites in two habitat types in Cameroon: contiguous rainforest and ecotone forest patches north of the rainforest. The noise characteristics of the two forest types show significant and consistent differences. Multiple samples taken at two rainforest sites in different seasons vary little and remain distinct from those in ecotone forest. The rainforest recordings show many distinctive frequency bands, with a general increase in amplitude from low to high frequencies. Ecotone forest only shows a distinctive high-frequency band at some parts of the day. Habitat dependent abiotic and biotic sound sources and to some extent habitat-dependent sound transmission are the likely causes of these habitat-dependent noise spectra.
<b>Birds sing at a higher pitch in urban noise</b>	Slabbekoorn H and Peet M, 2003, Birds sing at a higher pitch in urban noise. <i>Nature</i> 424:267  Notes: Brief communication. Abstract is key data paragraphs. N = 32. 42-63 dB range in habitat sound levels. Louder habitats = up to 50 Hz change.	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: $r=0.42, d.f.42, F_{44.74}, P_{0.017}$ ), with regard to both amplitude level

		(#43.02, P40.005) and spectral distribution (#412.0, P40.055). 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.
<b>Habitat-dependent song divergence in the little greenbul: an analysis of environmental selection pressures on acoustic signals</b>	<p>Slabbekoorn H and Smith TB, 2002, Habitat-dependent song divergence in the little greenbul: an analysis of environmental selection pressures on acoustic signals. <b>Evolution</b> 56(9):1849-1858</p> <p>Notes: N=134 individuals from 12 populations/ acoustic measurements taken from 26 individuals from 12 populations. Relative dB estimated only.</p> <p>Conclusion: Lower ambient noise = lower minimum frequency</p>	<p>Bird song is a sexual trait important in mate choice and known to be shaped by environmental selection. Here we investigate the ecological factors shaping song variation across a rainforest gradient in central Africa. We show that the little greenbul (<i>Andropadus virens</i>), previously shown to vary morphologically across the gradient in fitness-related characters, also varies with respect to song characteristics. Acoustic features, including minimum and maximum frequency, and delivery rate of song notes showed significant differences between habitats. In contrast, we found dialectal variation independent of habitat in population-typical songtype sequences. This pattern is consistent with ongoing gene flow across habitats and in line with the view that song variation in the order in which songtypes are produced is not dependent on habitat characteristics in the same way physical song characteristics are. Sound transmission characteristics of the two habitats did not vary significantly, but analyses of ambient noise spectra revealed dramatic and consistent habitat-dependent differences. Matching between low ambient noise levels for low frequencies in the rainforest and lower minimal frequencies in greenbul songs in this habitat suggests that part of the song divergence may be driven by habitat-dependent ambient noise patterns. These results suggest that habitat-dependent selection may act simultaneously on traits of ecological importance and those important in prezygotic isolation, leading to an association between morphological and acoustic divergence. Such an association may promote assortative mating and may be a mechanism driving reproductive divergence across ecological gradients.</p>
<b>Sound transmission and song divergence: A comparison of urban and forest acoustics</b>	<p>Slabbekoorn H, Yeh P and Hunt K, 2007, Sound transmission and song divergence: A comparison of urban and forest acoustics. <b>The Condor</b> 109:67-78</p> <p>Notes: Urban vs. rural populations. Intensity level not quantified.</p> <p>Conclusion: Significantly higher minimum frequency in urban population vs. 3 of 4 forest populations/</p>	<p>Degradation of acoustic signals during transmission presents a challenging selection pressure for animals dependent on vocal communication. Sound transmission properties differ among habitats and may drive the evolution of vocal signals in different directions. Urban habitat is expanding worldwide and an increasing number of species, including many birds, must now communicate around buildings and over concrete. Urban habitats are evolutionarily new, although to some extent they may acoustically resemble rocky habitat such as cliffs and canyons. Neither urban nor these natural habitats have been studied in any detail for the selection pressure they may exert on animal communication. Dark-eyed Juncos (<i>Junco hyemalis</i>) commonly inhabit montane pine forests across North America, but for about 25 years an isolated population has been successfully breeding in an urban environment in southern California.</p>

		<p>We investigated potentially divergent selection pressures on junco songs, using sound transmission experiments with artificial sound stimuli, in natural forest habitat and in this urban habitat. Transmission properties differed significantly, resulting in tails of reflected sound with gradually declining amplitude in the forest and in multiple discrete echoes in the urban environment. We expected environmental selection in urban habitat to favor shorter songs with higher frequencies and slower trill rates. Despite the presence of relatively short urban songs, there was no significant shortening overall. There were also no differences in trill rates, but we did find a significantly higher minimum frequency in the urban junco population compared to three of four forest populations. Although the pattern of song divergence was not consistent and it is difficult to draw firm conclusions from this single urban population, our transmission results suggest that echoes could be important in shaping urban birdsong.</p>
<p><b>Song sparrow (<i>Melospiza melodia</i>) song varies with urban noise</b></p>	<p>Wood WE and Yezerinac SM, 2006, Song sparrow (<i>Melospiza melodia</i>) song varies with urban noise. <b>The Auk</b> 123(3):650-659</p> <p>Notes: N=28. Background/habitat noise varied from 54.8-71.3 dB(A).</p> <p>Conclusion: minimum freq. of song increased with increasing background level</p>	<p>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 low-frequency portions, to minimize masking by anthropogenic noise. Such modifications have been observed in Great Tits (<i>Parus major</i>) in The Netherlands, as well as in some mammals. We studied Song Sparrows (<i>Melospiza melodia</i>), which are common in both urban and rural environments in much of North America, and recorded the songs of 28 freeliving males in Portland, Oregon. We also measured the amplitude and spectrum of ambient noise at singing locations. Song Sparrows singing at noisier locations exhibited higher-frequency 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.</p>
<p><b>Auditory response characteristics of the piebald odorous frog and their implications</b></p>	<p>Yu Z-L, Qiu Q, Xu Z-M and Shen J-X, 2006, Auditory response characteristics of the piebald odorous frog and their implications. <b>J Comp Physiol A</b> 192:801-806</p> <p>Notes: Evolutionary frequency shift. Neuro verification of ultrasonic sensitivity in frogs w/evolutionary history near streams that create substantial ultrasonic background noise.</p>	<p>The piebald odorous frog (<i>Odorrana schmackeri</i>), the large odorous frog (<i>Odorrana livida</i>) and the concave-eared torrent frog (<i>Amolops tormotus</i>) are sympatric species living near the same torrent streams in the vicinity of Mt. Huangshan, China. A recent study demonstrated that <i>A. tormotus</i> can use sound signals involving ultrasonic components for communication in a noisy environment, and another sympatric species, <i>O. livida</i>, can also perceive ultrasonic sound. Here we report data on the hearing range of <i>O. schmackeri</i> by studying auditory evoked potentials and single-unit data from the torus semicircularis. This frog exhibits its two most sensitive peaks at 2 kHz and 3.5–4.0 kHz with thresholds &lt;42 dB</p>

		SPL, with an upper frequency limit of hearing at 8.5 kHz with threshold of 87 dB SPL. The upper limit is much lower than those of <i>O. livida</i> and <i>A. tormotus</i> , at 22 and 34 kHz, respectively. It suggests that sympatric species may respond differently to similar environmental selection pressures sculpting auditory communication systems.
<b>Noise Effects on Signal Design: Temporal shifts</b>		
<b>Is there a sound reception window in coastal environments? Evidence from shorebird communication systems</b>	Douglas HD and Conner WE, 1999, Is there a sound reception window in coastal environments? Evidence from shorebird communication systems.	Surf-generated noise forms a sound reception window in the coastal environment. This window has characteristics that tend to raise the frequency and compress the duration of animal signals. This pattern is manifest in the long-distance acoustical signal of the willet ( <i>Catoptrophorus semipalmatus</i> ). The signal of the eastern willet ( <i>C.s. semipalmatus</i> ), an obligate coastal breeder, is higher in frequency and shorter in duration than that of the western willet ( <i>C.s. inornatus</i> ), an obligate inland breeder. Thirty other shorebird species have signal characteristics that match the frequency parameters of this hypothetical window relatively well, suggesting that it has influenced animal communication.
<b>Tracking silence: adjusting vocal production to avoid acoustic interference</b>	Egnor SER, Wickelgren JG and Hauser MD, 2007, Tracking silence: adjusting vocal production to avoid acoustic interference. <b>J. Comp. Physiol. A</b> 193:477-483  Notes: N = 8 (4 males, 4 females) Studied contact calls given in isolation. Bursts of patterned 80 dB(?) white noise. 10 min sessions, 1 session per day.  Conclusion: Cotton-top Tamarin monkey restrict calls to periodic silent intervals in white noise. Call amplitude increases in patterned noise. Call duration decreases over time in patterned noise.	Organisms that use vocal signals to communicate often modulate their vocalizations to avoid being masked by other sounds in the environment. Although some environmental noise is continuous, both biotic and abiotic noise can be intermittent, or even periodic. Interference from intermittent noise can be avoided if calls are timed to coincide with periods of silence, a capacity that is unambiguously present in insects, amphibians, birds, and humans. Surprisingly, we know virtually nothing about this fundamental capacity in nonhuman primates. Here we show that a New World monkey, the cotton-top tamarin ( <i>Saguinus oedipus</i> ), can restrict calls to periodic silent intervals in loud white noise. In addition, calls produced during these silent intervals were significantly louder than calls recorded in silent baseline sessions. Finally, average call duration dropped across sessions, indicating that experience with temporally patterned noise caused tamarins to compress their calls. Taken together, these results show that in the presence of a predictable, intermittent environmental noise, cottontop tamarins are able to modify the duration, timing, and amplitude of their calls to avoid acoustic interference.
<b>Daytime noise predicts nocturnal singing in urban robins</b>	Fuller RA, Warren PH, Gaston KJ, 2007, Daytime noise predicts nocturnal singing in urban robins. <b>Biology Letters</b> 3:368-370  Notes: 121 point locations measured twice. A-weighted sound measurements.	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 <i>Erithacus rubecula</i> , 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.
<b>Anthropogenic sounds differentially affect amphibian call rate</b>	<p>Sun JWC and Narins PM, 2005, Anthropogenic sounds differentially affect amphibian call rate, <b>Biological Conservation</b> 121:419-427</p> <p>Notes: Airplane flyover levels estimated at 68-76 dB(C). Motorcycle noise played back at unspecified level greater than 80 dB(C).</p> <p>Conclusion: Three frogs (<i>Microhyla butleri</i>, <i>Rana nigrovittata</i> and <i>Kaloula pulchra</i>) decreased calling rate to anthropogenic sounds. One, <i>Rana taipehensis</i>, increased calling rate, likely due to the decrease of the three dominant members of the anuran chorus.</p>	<p>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 pondedge species (<i>Microhyla butleri</i>, <i>Rana nigrovittata</i> and <i>Kaloula pulchra</i>) significantly decreased their calling rate. Yet under the identical stimulus regime, <i>Rana taipehensis</i> 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 <i>R. taipehensis</i> 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.</p>
<b>The effects of rain on acoustic communication: tawny owls have good reason for calling less in wet weather</b>	<p>Lengagne T and Slater PJB, 2002, The effects of rain on acoustic communication: tawny owls have good reason for calling less in wet weather. <b>Proc. R. Soc. Lond. B</b> 269:2121-2125</p> <p>Notes: Tests of sensory discrimination threshold, N = 6, Field measurements of tawny calling behavior in the field, N = 22. Ambient noise measurements -- 20 instantaneous measurements (linear scale, slow setting) during dry (mean 33.4 dB(C)) and rainy (mean 52.2 dB(C)) nights.</p> <p>Conclusion: Even during the courtship period owls stop calling on rainy nights.</p>	<p>Numerous attempts have been made to quantify ecological factors that affect the calling range of animal signals. The various processes leading signals to become distorted and embedded in background noise have been described in many habitats (ranging from forest to savannah) and the propagation path in these biomes has thereby been characterized. However, the impact of climatic factors on acoustic communication has been little studied. Surprisingly, to our knowledge, the importance of rain, a regular phenomenon occurring in all habitats except deserts, has never been investigated. <b>Here, we describe a 69-fold advantage in area reached by the call of a territorial bird, the tawny owl (<i>Strix aluco</i>) in dry versus rainy conditions. In support of this, we found a marked reduction in the calling of tawny owls in rainy conditions.</b> Constraints imposed by a rainy propagation path are likely to modify the reliability of acoustic information and thus calling behaviour of many animals.</p>
<b>Reduced Listening Area</b>		
<b>Chronic industrial noise affects pairing success and age structure of ovenbirds</b>	<p>Habib L, Bayne EM and Boutin S (2007) Chronic industrial noise affects pairing success and age structure of ovenbirds <i>Seiurus aurocapilla</i>. <b>Journal of Applied Ecology</b>. 44:176-</p>	<p>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</p>

<p><i>Seiurus aurocapilla</i></p>	<p>184.</p> <p>Notes: N = 20 compressor sites (54 birds) and N = 21 control sites (56 birds). No acoustic analysis.</p>	<p>strong conclusions.</p> <p>2. We assessed pairing success and age distribution of male ovenbirds <i>Seiurus aurocapilla</i> 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.</p> <p>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%).</p> <p>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.</p> <p>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.</p>
<p><b>Noise, predation risk compensation and vigilance in the chaffinch <i>Fringilla coelebs</i></b></p>	<p>Quinn JL, Whittingham MJ, Butler SJ and Cresswell W, 2006, Noise, predation risk compensation and vigilance in the chaffinch <i>Fringilla coelebs</i>, <b>Journal of Avian Biology</b> 37:601-608</p> <p>Notes: N = 22 White noise played back at 65 dB(A)</p> <p>Conclusion: Increased vigilance (specifically inter-visual scan interval) during noise treatment, reduced food intake rate</p>	<p>Background noise should in theory hinder detection of auditory cues associated with approaching danger. We tested whether foraging chaffinches <i>Fringilla coelebs</i> 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</p>



		<p>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.</p>
<p><b>The effects of wind turbines on antipredator behavior in California ground squirrels (<i>Spermophilus beecheyi</i>)</b></p>	<p>Rabin LA, Coss RG, Owings DH (2006) The effects of wind turbines on antipredator behavior in California ground squirrels (<i>Spermophilus beecheyi</i>). <b>Biological Conservation</b> in press</p> <p>Notes: Sound clips recorded at control (mean 79.8 dB, range 70-88 dB) and experimental (mean 110.2 dB, range 93-118 dB) sites, elicited by a dog predator. Sound level at each site (dB weighting not reported, assume C) estimated with 20, 5 sec readings taken on hold with B&amp;K 2209 set at Impulse_Hold—readings averaged.</p> <p>N = 42 (8 adults, 34 juveniles) at the turbine site, N = 52 (7 adults, 45 juveniles) at the control site</p>	<p>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 (<i>Spermophilus beecheyi</i>) 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.</p>
<b>Masking</b>		
<p><b>Masking interference and the evolution of the acoustic communication system in the Amazonian dendrobatid frog <i>Allobates femoralis</i></b></p>	<p>Amezquita A, Hodl W, Lima AP, Castellanos L, Erdtmann L and De Araujo MC, 2006, Masking interference and the evolution of the acoustic communication system in the Amazonian dendrobatid frog <i>Allobates femoralis</i>. <b>Evolution</b> 60(9):1874-1887.</p> <p>Notes: Geographic presence of conspecifics calling in a similar frequency range effect receiver characteristics.</p>	<p>The efficacy of communication relies on detection of species-specific signals against the background noise. Features affecting signal detection are thus expected to evolve under selective pressures represented by masking noise. Spectral partitioning between the auditory signals of co-occurring species has been interpreted as the outcome of the selective effects of masking interference. However, masking interference depends not only on signal's frequency but on receiver's range of frequency sensitivity; moreover, selection on signal frequency can be confounded by selection on body size, because these traits are often correlated. To know whether geographic variation in communication traits agrees with predictions about masking interference effects, we tested the hypothesis that variation in the male-male communication system of the Amazonian frog, <i>Allobates</i></p>

		<p><i>femoralis</i>, is correlated with the occurrence of a single species calling within an overlapping frequency range, <i>Epipedobates trivittatus</i>. We studied frogs at eight sites, four where both species co-occur and four where <i>A. femoralis</i> occurs but <i>E. trivittatus</i> does not. To study the sender component of the communication system of <i>A. femoralis</i> and to describe the use of the spectral range, we analyzed the signal's spectral features of all coactive species at each site. To study the receiver component, we derived frequency-response curves from playback experiments conducted on territorial males of <i>A. femoralis</i> under natural conditions. Most geographic variation in studied traits was correlated with either call frequency or with response frequency range. The occurrence of <i>E. trivittatus</i> significantly predicted narrower and asymmetric frequency-response curves in <i>A. femoralis</i>, without concomitant differences in the call or in body size. The number of acoustically coactive species did not significantly predict variation in any of the studied traits. Our results strongly support that the receiver but not the sender component of the communication system changed due to masking interference by a single species.</p>
<p><b>Localisation of an acoustic signal in a noisy environment: the display call of the king penguin <i>Aptenodytes patagonicus</i></b></p>	<p>Aubin T and Jouventin P, 2002, Localisation of an acoustic signal in a noisy environment: the display call of the king penguin <i>Aptenodytes patagonicus</i>. <b>Journal of Experimental Biology</b> 205:3793-3798</p>	<p>King penguin chicks identify their parents by an acoustic signal, the display call. This call consists of a succession of similar syllables. Each syllable has two harmonic series, strongly modulated in frequency and amplitude, with added beats of varying amplitude generated by a two-voice system. Previous work showed that only one syllable of the call is needed for the chick to identify the calling adult. Both the frequency modulation pattern of the syllable and the two-voice system play a role in the call identification. The syllabic organisation of the call, the harmonic structure and the amplitude modulations of the syllables apparently do not contribute to individual recognition. Are these acoustic features useless? To answer to this question, playback experiments were conducted using three categories of experimental signals: (i) signal with only the fundamental frequencies of the natural call, (ii) signal with the amplitude of each syllable kept at a constant level and (iii) signals with only one syllable, repeated or not. The responses of chicks to these experimental signals were compared to those obtained with the calls of their natural parents. We found that these acoustic features, while not directly implicated in the individual recognition process, help the chicks to better localise the signal of their parents. In addition, the redundant syllabic organisation of the call is a means of counteracting the masking effect of the background noise of the colony.</p>
<p><b>Penguins and their noisy world</b></p>	<p>Aubin T, 2004, Penguins and their noisy world. <b>Anais da Academia Brasileira de Ciencias</b> 76(2):279-283</p> <p>Notes: Good summary of Aubin's extensive work on how</p>	<p>Penguins identify their mate or chick by an acoustic signal, the display call. This identification is realized in a particularly constraining environment: the noisy world of a colony of thousands of birds. To fully understand how birds solve this problem of communication, we have done observations, acoustic analysis, propagation and playback</p>

	penguins use acoustic signals to find each other in the noise of the colony (~75dB).	experiments with 6 species of penguins studied in the field. According to our results, it appears that penguins use a particularly efficient "anti-confusion" and "anti-noise" coding system, allowing a quick identification and localization of individuals on the move in a noisy crowd.
<b>A software model to estimate zones of impact on marine mammals around anthropogenic noise</b>	Erbe C and Farmer DM, 2000, A software model to estimate zones of impact on marine mammals around anthropogenic noise. J. Acoust. Soc. Am. 108(3):1327-1331	Anthropogenic noise impacts marine mammals in a variety of ways. In order to estimate over which ranges this happens, we first need to understand the propagation of noise through the ocean away from the noise source, and, second, understand the relationship between received noise levels and impact thresholds. A software package combining both aspects is presented. ~1! A sound propagation model based on ray theory was developed to calculate received noise levels as a function of range, depth, and frequency. ~2! Current knowledge of noise impact thresholds for marine mammals was gathered and included in software routines predicting zones of impact on marine mammals around industrial underwater noise sources. As input parameters, this software package requires the source level and spectrum of the noise of interest; physical oceanography data about the local ocean environment such as bathymetry, bottom and surface loss data, and sound speed profiles; and bioacoustical information about the target species in the form of an audiogram, critical auditory bandwidths, spectra of typical animal vocalizations, reported sound levels of disturbance, and criteria for hearing damage. As output, the software produces data files and plots of the zones of audibility, masking, disturbance, and potential hearing damage around a noise source.
<b>Masking of acoustic signals by the chorus background noise in the green tree frog: a limitation on mate choice</b>	Gerhardt HC and Klump GM, 1987, Masking of acoustic signals by the chorus background noise in the green tree frog: a limitation on mate choice. Animal Behavior 36(3):1247-1249	No abstract: see Wollerman's work for current treatment of problem
<b>Comodulation masking release in a songbird</b>	Klump GM and Langemann U, 1995, Comodulation masking release in a songbird. Hearing Research 87:157-164.	Comodulation masking release (CMR) describes the reduced masking of a pure tone when the masking is a noise that is coherently amplitude modulated (comodulated) over the total range of the spectrum compared to masking by an unmodulated noise of the same bandwidth and overall energy. The masking release results from cues available within a critical band and from cues generated by comparisons across critical bands ('true' CMR). Here we report data on masking release and 'true' CMR in a songbird, the European starling ( <i>Sturnus vulgaris</i> ), that was demonstrated in a psychoacoustic experiment using a GO/NOGO paradigm. Masked thresholds for 2-kHz tones centered in digitally generated continuous masking noise

		<p>of different bandwidths were determined, and the amount of masking release was calculated as the threshold difference between the unmodulated and the comodulated condition. In the first experiment the modulator was a 50-Hz lowpass noise. A masking release of 11.8 dB was found for the noise masker with the largest bandwidth (1600 Hz). With the masker bandwidth decreasing to 50 Hz, the birds' release from masking was reduced to 1.6 dB. The starling's 'true' CMR was 4 dB or 8 dB, depending on the definition that was applied. In a second experiment the masker bandwidth was constant (1600 Hz) and the cut-off frequency of the modulator was varied. A release from masking of 17.8 dB was found for a modulator cut-off frequency of 12.5 Hz. It decreased to 6.1 dB with an increase in the modulator cut-off frequency to 400 Hz. The duration of the test signal (100-750 ms) had little effect on the release from masking. Given the similarities in the release from masking and in CMR of starlings and humans, the starling may provide an excellent model for studying the mechanisms that underlie the generation of CMR.</p>
<p><b>Detection and discrimination of natural calls in masking noise by birds: estimating the active space of a signal</b></p>	<p>Lohr B, Wright TF and Dooling RJ, 2003, Detection and discrimination of natural calls in masking noise by birds: estimating the active space of a signal. <b>Animal Behaviour</b> 65:763-777</p> <p>Notes: Signals (3-5 kHz tones and calls) were masked by white noise but not by traffic noise. White noise = bandlimited 900-8000 Hz, ~ equal energy at all freq. played back at 50, 60 and 70 dB(A). Traffic noise was created using the above flat noise with a -2.87 dB/kHz drop-off above 1400 Hz (taken from several traffic noise studies).</p> <p>Conclusion: when predicting the masking effects of continuous noise, the specific spectral shape of the noise is less important than the signal-to-noise level within the frequency band of maximum signal power.</p>	<p>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, <i>Melopsittacus undulatus</i>, and zebra finches, <i>Taeniopygia guttata</i>, on natural contact calls of budgerigars, zebra finches and canaries, <i>Serinus canaria</i>. 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.</p>
<p><b>Additivity of masking in normally hearing and hearing-impaired subjects</b></p>	<p>Oxenham AJ and Moore BCJ, 1995, Additivity of masking in normally hearing and hearing-impaired subjects. <b>J. Acoust. Soc. Am.</b> 98(4):1921-1934</p>	<p>See pdf</p>

	Notes: Two equally effective nonsimultaneous maskers increase amount of masking by 3-4 dB	
<b>Suppression and the upward spread of masking</b>	Oxenham AJ and Plack CJ, 1998, Suppression and the upward spread of masking. <b>J. Acoust. Soc. Am.</b> 104(6):3500-3510	The purpose of this study is to clarify the role of suppression in the growth of masking when a signal is well above the masker in frequency ~upward spread of masking!. Classical psychophysical models assume that masking is primarily due to the spread of masker excitation, and that the nonlinear upward spread of masking reflects a differential growth in excitation between the masker and the signal at the signal frequency. In contrast, recent physiological studies have indicated that upward spread of masking in the auditory nerve is due to the increasing effect of suppression with increasing masker level. This study compares thresholds for signals between 2.4 and 5.6 kHz in simultaneous and nonsimultaneous masking for conditions in which the masker is either at or well below the signal frequency. Maximum differences between simultaneous and nonsimultaneous masking were small ~,6 dB! for the on-frequency conditions but larger for the off-frequency conditions ~15–32 dB!. The results suggest that suppression plays a major role in determining thresholds at high masker levels, when the masker is well below the signal in frequency. This is consistent with the conclusions of physiological studies. However, for signal levels higher than about 40 dB SPL, the growth of masking for signals above the masker frequency is nonlinear even in the nonsimultaneous-masking conditions, where suppression is not expected. This is consistent with an explanation based on the compressive response of the basilar membrane, and confirms that suppression is not necessary for nonlinear upward spread of masking.
<b>Masking by inaudible sounds and the linearity of temporal summation</b>	Plack CJ, Oxenham AJ and Drga V, 2006, Masking by inaudible sounds and the linearity of temporal summation. <b>Journal of Neuroscience</b> 26(34):8767-8773	Many natural sounds, including speech and animal vocalizations, involve rapid sequences that vary in spectrum and amplitude. Each sound within a sequence has the potential to affect the audibility of subsequent sounds in a process known as forward masking. Little is known about the neural mechanisms underlying forward masking, particularly in more realistic situations in which multiple sounds follow each other in rapid succession. A parsimonious hypothesis is that the effects of consecutive sounds combine linearly, so that the total masking effect is a simple sum of the contributions from the individual maskers. The experiment reported here tests a counterintuitive prediction of this linear-summation hypothesis, namely that a sound that itself is inaudible should, under certain circumstances, affect the audibility of subsequent sounds. The results show that, when two forward maskers are combined, the second of the two maskers can continue to produce substantial masking, evenwhenit is completely masked by the first masker. Thus, inaudible sounds can affect the perception of subsequent sounds. A model incorporating instantaneous compression (reflecting the nonlinear response of the

		basilar membrane in the cochlea), followed by linear summation of the effects of the maskers, provides a good account of the data. Despite the presence of multiple sources of nonlinearity in the auditory system, masking effects by sequential sounds combine in a manner that is well captured by a time-invariant linear system.
<b>Masking patterns in the bullfrog (<i>Rana catesbeiana</i>). I: Behavioral effects</b>	Simmons AM, 1988, Masking patterns in the bullfrog ( <i>Rana catesbeiana</i> ). I: Behavioral effects. <b>J. Acoust. Soc. Am.</b> 83(3):1087-1092	See pdf
<b>The role of synchronized calling, ambient light, and ambient noise, in anti-bat-predator behavior of a treefrog</b>	Tuttle MD and Ryan MJ, 1982, The role of synchronized calling, ambient light, and ambient noise, in anti-bat-predator behavior of a treefrog. <b>Behav. Ecol. Sociobiol.</b> 11:125-131  Notes: Levels poorly or not measured. Relevant finding-frogs called from areas of higher ambient noise (i.e. near waterfalls) and bats preferred to hunt in areas of lower ambient noise.	Male treefrogs, <i>Smilisca sila</i> (Hylidae), produce calls of varying complexity and demonstrate a remarkable ability to synchronize their calls with those of neighbors. The bat <i>Trachops cirrhosus</i> 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, <i>S. sila</i> 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. <i>S. sila</i> 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 <i>S. sila</i> 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.
<b>Effects of ship noise on the detectability of communication signals in the Lusitanian toadfish</b>	Vasconcelos RO, Amorim MCP, Ladich F, 2007, Effects of ship noise on the detectability of communication signals in the Lusitanian toadfish. <b>Journal of Experimental Biology</b> 210:2104-2112	Underwater noise pollution is an increasing environmental problem which might affect communication, behaviour, 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, <i>Halobatrachus didactylus</i> . 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

		<p>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.</p>
<p><b>Background noise from a natural chorus alters female discrimination of male calls in a Neotropical frog</b></p>	<p>Wollerman L and Wiley RH, 2001, Background noise from a natural chorus alters female discrimination of male calls in a Neotropical frog. <i>Animal Behaviour</i> 62:</p>	<p>Many animals communicate in environments with high levels of background noise. Although it is a fundamental prediction of signal detection theory that noise should reduce both detection and discrimination of signals, little is known about these effects in animal communication. Female treefrogs, <i>Hyla ebraccata</i>, in Costa Rica choose mates in large noisy multispecies choruses. We tested gravid females for preferences between computer-synthesized calls with carrier frequencies of 3240 and 2960 Hz (values near the mode and the fifth percentile of the population, respectively) in four levels of background noise from a natural chorus. In the absence of noise (signal/noise ratio &gt;25 dB), females preferred the lower frequency. With moderate signal/noise ratios (6 and 9 dB), they did not discriminate between these frequencies. With low signal/noise ratios (3 dB), females preferred the frequency near the mode for the population. Similar experiments had previously demonstrated that females can detect the presence of a male's calls with signal/noise ratios of 3 dB or greater. Thus moderate levels of natural background sound reduced a female's ability to discriminate between males' calls even when she could detect them. In high levels of background sound, females abandoned discrimination for low-frequency calls and reverted to the task of detecting signals with modal properties for the population. These results justify recent theoretical analyses of the importance of receivers' errors in the evolution of communication.</p>
<p><b>Acoustic interference limits call detection in a Neotropical frog <i>Hyla ebraccata</i></b></p>	<p>Wollerman L, 1999, Acoustic interference limits call detection in a Neotropical frog <i>Hyla ebraccata</i>. <i>Animal Behaviour</i> 57:529-536</p>	<p>Problems associated with communication in noisy environments include detection, discrimination, and localization of appropriate signals. I investigated the effects of broadband background noise on call detection by female <i>Hyla ebraccata</i>, a Neotropical treefrog. In playback experiments, I offered females a choice between two stimuli: chorus noise alone or chorus noise plus a computer-synthesized call. By systematically increasing the level of chorus noise, I determined that females could no longer reliably choose between the two speakers when the signal-to-noise ratio was +1.5 dB or lower. By taking the distribution of calling males into account, I estimated that females detect only the nearest male. If a female were to sample more than a very few males, she would need to move around the chorus. By</p>

		doing so, she probably increases the costs of mate choice. Thus, the noise of a chorus impairs the ability of females to detect conspecific calls and thereby limits their ability to choose between mates. These limitations could have serious implications for the evolution of signallers' and receivers' behaviour.
<b>Vigilance</b>		
<b>Induced or routine vigilance while foraging</b>	Blanchard P and Fritz H, 2007, Induced or routine vigilance while foraging. <b>Oikos OnlineEarly</b>	Notes: Impalas experimentally alarmed raised their heads faster and subsequently chewed less both in total and per second of time spent vigilant. Animals reduced chewing probably to listen for predators (and possibly to stabilize the visual field). Authors argue for two types of vigilance. One, Induced, being more costly.
<b>A simple rule for the costs of vigilance: empirical evidence from a social forager</b>	Cowlshaw G, Lawes MJ, Lightbody M, Martin A, Pettifor R and Rowcliffe JM, 2003, A simple rule for the costs of vigilance: empirical evidence from a social forager. <b>Proc. R. Soc. Lond. Series B</b> 271:27-33  Notes: Model challenged by Fortin et al. 2004	It is commonly assumed that anti-predator vigilance by foraging animals is costly because it interrupts food searching and handling time, leading to a reduction in feeding rate. When food handling does not require visual attention, however, a forager may handle food while simultaneously searching for the next food item or scanning for predators. We present a simple model of this process, showing that when the length of such compatible handling time $H_c$ is long relative to search time $S$ , specifically $H_c / S \gg 1$ , it is possible to perform vigilance without a reduction in feeding rate. We test three predictions of this model regarding the relationships between feeding rate, vigilance and the $H_c / S$ ratio, with data collected from a wild population of social foragers (samango monkeys, <i>Cercopithecus mitis erythrarchus</i> ). These analyses consistently support our model, including our key prediction: as $H_c / S$ increases, the negative relationship between feeding rate and the proportion of time spent scanning becomes progressively shallower. This pattern is more strongly driven by changes in median scan duration than scan frequency. Our study thus provides a simple rule that describes the extent to which vigilance can be expected to incur a feeding rate cost.
<b>Does an opportunistic predator preferentially attack nonvigilant prey?</b>	Cresswell W, Lind J, Kaby U, Quinn JL and Jakobsson S, 2003, Does an opportunistic predator preferentially attack nonvigilant prey? <b>Animal Behaviour</b> 66:643-648  Notes: Punchline: opportunistic predators attack vigilant and nonvigilant- stalking predators attack nonvigilant	The dilution effect as an antipredation behaviour is the main theoretical reason for grouping in animals and states that all individuals in a group have an equal risk of being predated if equally spaced from each other and the predator. Stalking predators, however, increase their chance of attack success by preferentially targeting nonvigilant individuals, potentially making relative vigilance rates in a group relatively important in determining predation compared with the dilution effect. Many predators, however, attack opportunistically without stalking, when targeting of nonvigilant individuals may be less likely, so that the dilution effect will then be a relatively more important antipredation reason for grouping. We tested whether an opportunistically hunting predator, the sparrowhawk, <i>Accipiter nisus</i> , preferentially attacked vigilant or feeding prey models presented in pairs. We found that sparrowhawks attacked vigilant and



		<p>feeding mounts at similar frequencies. Our results suggest that individuals should prioritize maximizing group size or individual vigilance dependent on the type of predator from which they are at risk. When the most likely predator is a stalker, individuals should aim to have the highest vigilance levels in a group, and there may be relatively little selective advantage to being in the largest group. In contrast, if the most likely predator is an opportunist, then individuals should simply aim to be in the largest group and can also spend more time foraging without compromising predation risk. For most natural systems this will mean a trade-off between the two strategies dependent on the frequency of attack of each predator type.</p>
<p><b>Good foragers can also be good at detecting predators</b></p>	<p>Cresswell W, Quinn JL, Wittingham MJ and Butler S, 2003, Good foragers can also be good at detecting predators. <b>Proc. R. Soc. Lond. Series B</b> 270:1069-1076</p> <p>Notes: N = 50.</p>	<p>The degree to which foraging and vigilance are mutually exclusive is crucial to understanding the management of the predation and starvation risk trade-off in animals. We tested whether wild-caught captive chaffinches that feed at a higher rate do so at the expense of their speed in responding to a model sparrowhawk flying nearby, and whether consistently good foragers will therefore tend to respond more slowly on average. First, we confirmed that the time taken to respond to the approaching predator depended on the rate of scanning: <b>as head-up rate increased so chaffinches responded more quickly.</b> However, against predictions, as peck rate increased so head-up rate increased and mean length of head-up and head-down periods decreased. <b>Head-up rate was probably dependent on peck rate because almost every time a seed was found, a bird raised its head to handle it. Therefore chaffinches with higher peck rates responded more quickly.</b> Individual chaffinches showed consistent durations of both their head-down and head-up periods and, therefore, individuals that were good foragers were also good detectors of predators. In relation to the broad range of species that have a similar foraging mode to chaffinches, our results have two major implications for predation/starvation risk trade-offs: <b>(i) feeding rate can determine vigilance scanning patterns; and (ii) the best foragers can also be the best at detecting predators.</b> We discuss how our results can be explained in mechanistic terms relating to fundamental differences in how the probabilities of detecting food rather than a predator are affected by time. In addition, our results offer a plausible explanation for the widely observed effect that vigilance continues to decline with group size even when there is no further benefit to reducing vigilance.</p>
<p><b>Predator detection and avoidance by starlings under differing scenarios of predation risk</b></p>	<p>Devereux CL, Whittingham MJ, Fernandez-Juricic E, Vickery JA, Krebs JR, 2006, Predator detection and avoidance by starlings under differing scenarios of predation risk. <b>Behavioral Ecology</b> 17(2):303-309</p> <p>Notes: Increased predation = decreased foraging, increased</p>	<p>Practically all animals must find food while avoiding predators. An individual's perception of predation risk may depend on many factors, such as distance to refuge and group size, but it is unclear whether individuals respond to different factors in a similar manner. We tested whether flocks of foraging starlings responded in the same way to an increased perception of predation risk by assessing three factors: (1) neighbor distances, (2) habitat obstruction, and (3) recent exposure to a predator. We found that in all three scenarios of increased risk,</p>

	<p>vigilance. Starlings slower to respond to predation when head is down and more so in visually-obstructed vs. open habitats.</p>	<p>starlings reduced their interscan intervals (food-searching bouts), which increased the frequency of their vigilance periods. We then examined how one of these factors, habitat obstruction, affected escape speed by simulating an attack with a model predator. Starlings were slower to respond in visually obstructed habitats (long grass swards) and slower when they had their head down in obstructed habitats than when they had their head down in open habitats. In addition, reaction times were quicker when starlings could employ their peripheral fields of vision. Our results demonstrate that different sources of increased risk can generate similar behavioral responses within a species. The degree of visibility in the physical and social environment affects both the actual and perceived risk of predation.</p>
<p><b>Increasing the costs of conspecific scanning in socially foraging starlings affects vigilance and foraging behavior</b></p>	<p>Fernandez-Juricic E, Smith R and Kacelnik A, 2005, Increasing the costs of conspecific scanning in socially foraging starlings affects vigilance and foraging behaviour. <i>Animal Behaviour</i> 69:73-81</p> <p>Notes: Some information about conspecifics is gathered when head is down, thus head-up is not a perfect measure of vigilance.</p>	<p>Social foragers receive and use information both about companions (social information) and about events external to the group, such as presence of potential predators. Scanning behaviour is often incorporated in theoretical models using simplifying assumptions in relation to the trade-off in information gathering between body postures (head-up versus head-down); however, some avian visual systems may allow individuals to scan in both body postures. We studied these issues experimentally, using starlings, <i>Sturnus vulgaris</i>, foraging in enclosures on natural fields. We varied the availability of information from conspecifics by placing visual barriers that blocked the view when the subjects were in head-down position and by manipulating the distance between group members. We found that as social information was reduced, starlings spent more time scanning (on and off the ground) and head-up scanning was mainly oriented towards conspecifics. The visual-obstruction effects imply that some information about conspecifics is normally gathered while starlings are foraging head-down. Neighbour distance and visual obstruction negatively affected food-searching rates and intake rates in two ways: (1) the effect of obstruction was mediated mostly through time competition between foraging and scanning on the ground, and (2) the effect of distance was due to a reduction in the rate of prey returns per searching effort while the birds were head-down. We conclude that the head-up posture is only one component of scanning, that the effects of head-down scanning should also be considered in species with ample visual fields, and that scanning in starlings is strongly connected to monitoring other flock members.</p>
<p><b>Foraging costs of vigilance in large mammalian herbivores</b></p>	<p>Fortin, D, Boyce MS, Merrill EH and Fryxell, 2004, Foraging costs of vigilance in large mammalian herbivores. <i>Oikos</i> 107:172-180</p> <p>Notes: Despite models (Cowlshaw et al. 2003) and time budget analysis (bison and elk: this study) that predict that</p>	<p>Vigilance has been assumed to reduce food intake by taking away time from food processing. Such foraging costs of vigilance have been predicted to have profound effects on the structure of communities. Recently, however, it has been argued that mammalian herbivores might be capable of maintaining their rate of food intake despite being vigilant, because of their ability to scan the environment while chewing vegetation. We conducted behavioral observations to evaluate whether vigilance decreases the bite rate of free-ranging</p>

	<p>chewing time exceeds the time animals spend searching for food, interacting with conspecifics and scanning, there was not a positive correlation between duration of scanning bouts and the number of consecutive bites taken just before vigilance events. Thus vigilance is costly. As vigilance increases, bite rate decreases.</p>	<p>female bison (<i>Bison bison</i>) in Prince Albert National Park and elk (<i>Cervus canadensis</i>) in Yellowstone National Park. Modeling of foraging processes indicated that chewing time exceeded the time that bison and elk spent searching for food, interacting with conspecifics, and scanning. Consequently, bison and elk might have been capable of maintaining their rate of food intake despite vigilance. The maintenance of intake rate would have required bison and elk to match scanning events closely with chewing bouts, but we did not detect a positive correlation between the duration of scanning bouts and the number of consecutive bites taken just before vigilance events. As a result, vigilance was costly, and as it increased, bite rate declined for both herbivore species. Scanning still overlapped partially with food handling. Indeed, we estimated that 31% of feeding time being vigilant decreased bite rate by 20% for bison and 26% for elk, whereas total absence of overlap between chewing and scanning should have reduced bite rate by 31%. While we observed that vigilance induced foraging costs, these costs were less important than traditionally assumed.</p>
<p><b>Scanning behavior of rats during eating under stressful noise</b></p>	<p>Krebs H, Weyers P, Macht M, Weijers H-G and Janke W, 1997, Scanning behavior of rats during eating under stressful noise. <i>Physiology and Behavior</i> 62(1):151-154</p> <p>Notes: 60 dB hardly seems like a 'control' condition</p>	<p>In the present experiment, eating speed and scanning behavior during eating were measured in 36 rats in 5 consecutive test sessions under stressful noise (95 dB white noise, n = 18) and control conditions (60 dB, n = 18) after the animals had been habituated to the test environment. Intense noise induced an increase of scanning rate and eating speed. These effects are similar to those reported for novel and light environments.</p>
<p><b>Back to the basics of antipredatory vigilance: can nonvigilant animals detect attack?</b></p>	<p>Lima SL and Bednekoff PA, 1999, Back to the basics of antipredatory vigilance: can nonvigilant animals detect attack? <i>Animal Behaviour</i> 58:537-543</p>	<p>Many birds and mammals respond to a heightened risk of predation, especially that associated with smaller group sizes, with an increase in vigilance. All interpretations of the way in which vigilance responds to changes in predation risk assume that animals feeding with their heads down (i.e. animals in a nonvigilant state) cannot detect approaching predators. We provide the first explicit test of this assumption by 'flying' a mounted hawk down a 15-m chute towards actively feeding, free-living, dark-eyed juncos, <i>Junco hyemalis</i>. Juncos were targeted individually for simulated attack when they had either a 'head-down' view up the chute, or a completely unobstructed view; a junco with a head-down view could see up the chute only when it lowered its head to feed. Juncos with an unobstructed view almost always detected the hawk at the maximum distance of 15 m. Juncos with a head-down view usually detected the attack at a distance of 10–15 m against a grey background, but detection distances were shorter when attacks occurred against a camouflaged background. The results demonstrate that these birds have a considerable ability to detect approaching predators even when not overtly vigilant, although their detection ability is greater when they raise their heads. Vigilance sequences, therefore, probably consist of bouts of low-quality detection (active feeding) interspersed with bouts of higher</p>

		<p>quality detection (overt vigilance) that can only be accomplished at the expense of feeding. This realization has major implications for current interpretations of the vigilance group size effect and antipredator vigilance in general.</p>
<p><b>Vigilance while feeding and its relation to the risk of predation</b></p>	<p>Lima SL, 1986, Vigilance while feeding and its relation to the risk of predation. <b>J. Theor. Biol.</b> 124:303-316</p>	<p>A simple model was developed to examine the relationship between vigilance while feeding and several determinants of the risk of predation. It was found that the relationship between vigilance and the risk of predation depends greatly upon the factor in question. An increase in attack rate leads to an increase in vigilance. A decrease in vigilance follows an increase in group size. An increase in the distance to cover (safety) may lead to either an increase or a decrease in vigilance, depending upon the situation examined. Visual obstructions in the environment may also lead to either an increase or decrease in vigilance, depending upon the nature of the environment and how such obstructions manifest themselves in the time budget. In general, vigilance should not necessarily increase with the risk of predation, yet there is an apparent consensus in the literature that this is the case. Part of this discrepancy may represent covariation among model parameters such that scanning may indeed generally increase with the risk of predation. For instance, the common observation that vigilance increases with the distance to cover may follow from an undetected positive relationship between this factor and the attack rate. Such possibilities lead to the realization that animals and investigators may very differently perceive experimental manipulations related to the risk of predation. Further developments in the study of vigilance in feeding animals will require a greater understanding of the risk of predation, in addition to the role of seemingly unrelated factors such as environmental uncertainty.</p>
<p><b>Determining the fitness consequences of antipredator behavior</b></p>	<p>Lind J and Cresswell W, 2005, Determining the fitness consequences of antipredator behavior. <b>Behavioral Ecology</b> 16(5):945-956</p> <p>Notes: Detailed review (including many vigilance studies) arguing that predator-prey studies should focus on multiple antipredator behaviors simultaneously in order to determine fitness consequences. Alternatively, study the predator.</p>	<p>Any animal whose form or behavior facilitates the avoidance of predators or escape when attacked by predators will have a greater probability of surviving to breed and therefore greater probability of producing offspring (i.e., fitness). Although in theory the fitness consequences of any antipredation behavior can simply be measured by the resultant probability of survival or death, determining the functional significance of antipredation behavior presents a surprising problem. In this review we draw attention to the problem that fitness consequences of antipredation behaviors cannot be determined without considering the potential for reduction of predation risk, or increased reproductive output, through other compensatory behaviors than the behaviors under study. We believe we have reached the limits of what we can ever understand about the ecological effects of antipredation behavior from empirical studies that simply correlate a single behavior with an apparent fitness consequence. Future empirical studies must involve many behaviors to consider the range of potential compensation to predation risk. This is because antipredation behaviors are a composite of many behaviors that an animal can</p>

		<p>adjust to accomplish its ends. We show that observed variation in antipredation behavior does not have to reflect fitness and we demonstrate that few studies can draw unambiguous conclusions about the fitness consequences of antipredation behavior. Lastly, we provide suggestions of how future research should best be targeted so that, even in the absence of death rates or changes in reproductive output, reasonable inferences of the fitness consequences of antipredation behaviors can be made.</p>
<p><b>Life cycle period and activity of prey influence their susceptibility to predators</b></p>	<p>Molinari-Jobin A, Molinari P, Loison A, Gaillard J-M and Breitenmoser U, 2004, Life cycle period and activity of prey influence their susceptibility to predators. <b>Ecography</b> 27:323-329</p> <p>Notes: Chamois predated by Lynx when feeding, roe deer predated mainly while ruminating—implications for vigilance. Feeding head down, ruminating impairs audition</p>	<p>In a multi-prey system, predators kill different kinds of prey according to their availability, where “availability” is a function of prey abundance and vulnerability (e.g. anti-predator behavior). We hypothesized that prey availability changes seasonally, for instance because reproduction leads to a higher abundance of young in spring and summer or because changes in behavior such as during the mating season makes the prey periodically more vulnerable. We tested this hypothesis in a simple predator-prey system in the Jura Mountains of Switzerland and France, where a single large mammalian predator, the Eurasian lynx, preys upon two ungulate species, the roe deer and the chamois. In 1996 and 1997 we were able to assign a total of 190 roe deer and 54 chamois killed by lynx to a specific age and sex class (males, females or juveniles). As expected, the proportion of juveniles killed varied considerably among periods, being at the highest from 1st of June to 15th of August. No significant seasonal differences were detected regarding the frequency of predation on males versus females. In particular, the interaction between species and period, expected because of different timing of the rutting period between roe deer and chamois, was not significant. Females were killed only slightly more often during gestation. The relationship between prey abundance and vulnerability is highly complex, as the lynx’ prey selection needs to be analyzed not only horizontally (changes of a specific prey category with season) but also vertically (an increase in the vulnerability of one category releases predation pressure on others). Second, we predicted that certain activities, such as feeding, expose prey to predation more than others. We found more chamois predated when feeding, whereas roe deer were predated mainly when ruminating. This interspecific discrepancy reflects differences either in the anti-predator behavior of roe deer and chamois or in the relative time allocation to feeding and ruminating between the two species.</p>
<p><b>Predator hunting and prey vulnerability</b></p>	<p>Quinn JL and Cresswell W, 2004, Predator hunting behaviour and prey vulnerability. <b>Journal of Animal Ecology</b> 73:143-154</p> <p>Notes: Five direct measures of redshank behavior indicated</p>	<p>1. Game theoretic models of how animals manage predation risk have begun to describe predator responses to prey behaviour relatively recently. This is partly because our understanding of how terrestrial predators select vertebrate prey is often limited to numerical and functional responses to measures of prey abundance. Prey vulnerability, however, may improve our understanding of predation because predators could maximize foraging success by selecting prey</p>

	<p>that sparrowhawks attack more vulnerable prey.</p>	<p>on this basis.</p> <p><b>2.</b> We tested the hypothesis that sparrowhawks (<i>Accipiter nisus</i> L.), a typical generalist predator, hunt redshanks (<i>Tringa tetanus</i> L.), a favoured prey species on coastal shores, primarily on the basis of their vulnerability rather than their abundance.</p> <p><b>3.</b> Five direct measures or indicators of redshank behaviour predicted sparrowhawk attack success in a multipredictor statistical model and therefore serve as measures of redshank vulnerability.</p> <p><b>4.</b> These and other vulnerability measures influenced whether sparrowhawks decided to hunt redshanks on saltmarsh habitat. A model that included most of these measures predicted correctly whether sparrowhawks hunted redshanks (attack decision) 90% of the time and accounted for up to 75% of variation. Prey abundance accounted for no additional variation.</p> <p><b>5.</b> Thus the hunting behaviour of some predators can only be predicted well by several highly dynamic and interacting factors related to prey vulnerability. These results mean that, theoretically at least, the management of prey populations may sometimes be achieved best by manipulating prey vulnerability, rather than by culling their predators.</p>
<p><b>Disturbances by dog barking increase vigilance in coots <i>Fulica atra</i></b></p>	<p>Randler C, 2006, Disturbances by dog barking increase vigilance in coots <i>Fulica atra</i>. <i>Eur J Wildl Res</i> 52:265-270</p> <p>Notes: Playback 75 dB(A) at 1 m</p>	<p>Animals frequently interrupt their activity to look up and to scan their surrounding environment for potential predators (vigilance). As vigilance and other activities are often mutually exclusive, such behaviours are at the expense of feeding, sleeping or preening. Authors of many wildlife disturbance studies found that people with free-running dogs provoked the most pronounced disturbances (e.g. greater flushing distances and more birds affected). However, dogs on leash may also negatively affect wild animals, and barking dogs may lead to an increase in vigilance. In this study, I tested this hypothesis in coots (<i>Fulica atra</i>) using three different playback procedures: (1) dog barks, (2) conspecific coot alarm calls and (3) chaffinch song. The trials were conducted in spring and autumn 2005 at three study sites in southwestern Germany. <b>During the dog playbacks, vigilance increased significantly from 17 to 28%. This increase in vigilance is comparable to the presence of a natural predator.</b> As expected, vigilance also increased significantly during conspecific coot alarm calls but not during playbacks of the chaffinch song control. Two main findings result from the study: (1) coots respond to acoustic traits of dogs and may be able to acoustically recognise this predator and (2) this increase in vigilance might have implications for conservation, especially when considering buffer zones around sensitive areas.</p>
<p><b>The effect of limited</b></p>	<p>Whittingham MJ, Butler SJ, Quinn JL and Cresswell W,</p>	<p>Foraging animals frequently change their pattern of vigilance when</p>

<p><b>visibility on vigilance behaviour and speed of predator detection: implications for the conservation of granivorous passerines</b></p>	<p>2004, The effect of limited visibility on vigilance behaviour and speed of predator detection: implications for the conservation of granivorous passerines. <i>Oikos</i> 106:377-385</p>	<p>they move from a patch with a clear view to one with a relatively obstructed view. This has been widely interpreted as compensation for a reduced ability to detect approaching predators in obstructed habitats. We test the extent to which changes in vigilance may compensate for the effect of reduced visibility on an animal's ability to detect predators. We measured the vigilance, foraging and speed of predator-response behaviours of lone chaffinches <i>Fringilla coelebs</i> that fed on seeds (800 per m<sup>2</sup>) scattered on artificial stubble habitats (with either a clear view of surroundings or an obstructed view). On both treatments, individuals with more rapid head-up rates responded more quickly to a flying model sparrowhawk <i>Accipiter nisus</i> (<math>P &lt; 0.04</math>); as did individuals with shorter food-search times (<math>P &lt; 0.02</math>). However, neither head-up rate nor food-search period varied with obstruction. Based on research previously published using this system, we suggest that this is because individuals are constrained in their ability to increase headup rate because doing so is largely determined by their individually determined foraging efficiency. Instead chaffinches increased the duration of their head-up periods by 13% in the visually obstructed treatment (long stubble) and peck rates were 13% lower. Despite this presumed attempt to compensate for reduced visibility, duration of headup period had no effect on response time of the fast-moving predator in our experiment and birds were 24% slower to respond in the long stubble. Rather than being maladaptive, increasing head-up duration may have been related to enhanced detection of other predator types, for example stalkers. Our results have implications for the conservation of wild granivorous birds. They support the view that agroecological decisions that affect micro-habitat structure over a large scale could affect predation risk, habitat choice and the conservation status of granivorous birds.</p>
<p><b>Disturbance</b></p>		
<p><b>Human-caused disturbance stimuli as a form of predation risk</b></p>	<p>Frid A and Dill L, 2002, Human-caused disturbance stimuli as a form of predation risk. <i>Conservation Ecology</i> 6(1):11(online)</p>	<p>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 antipredator 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 antipredator behavior has a cost to other activities, and that this trade-off is optimized when investment in antipredator behavior tracks short-term changes in predation risk. Prey have evolved antipredator</p>

		<p>responses to generalized threatening stimuli, such as loud noises and rapidly approaching objects. Thus, when encountering disturbance stimuli ranging from the dramatic, lowflying 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.</p>
<p><b>Disturbance by traffic of breeding birds: evaluation of the effect and considerations in planning and managing road corridors</b></p>	<p>Reijnen R, Foppen R and Veenbaas G, 1997, Disturbance by traffic of breeding birds: evaluation of the effect and considerations in planning and managing road corridors. <b>Biodiversity and Conservation</b> 6:567-581</p>	<p>In wildlife considerations in planning and managing road corridors little attention has been given to the effects of disturbance by traffic on populations of breeding birds. Recent studies, however, show evidence of strongly reduced densities of many species of woodland and open habitat in broad zones adjacent to busy roads. The density reduction is related to a reduced habitat quality, and traffic noise is probably the most critical factor. Because density can underestimate the habitat quality, the effects on breeding populations are probably larger than have been established. In consequence, species that did not show an effect on the density might still be affected by traffic noise. On the basis of this recent knowledge, methods have been developed that can be used in spatial planning procedures related to main roads, and in road management practice, and some practical points are discussed. An example of application shows that the effects are probably very important in The Netherlands with a dense network of extremely crowded main roads. For 'meadow birds', which are of international importance, the decrease in population in the West of The Netherlands may amount to 16%. Because breeding birds suffer from many other environmental influences there is also a great risk of an important cumulation of effects.</p>
<p><b>Ecological Importance of Sound</b></p>		
<p><b>Does information of predators influence general wariness?</b></p>	<p>Adams JL, Camelio KW, Orique MJ and Blumstein DT, 2006, Does information of predators influence general wariness. <b>Behavioral Ecology and Sociobiology</b> 60:742-7474</p>	<p>Antipredator behavior includes several qualitatively distinct activities, but few studies have determined the degree to which these activities are independent. If behaviors are not independent, then the nature of the relationship would illustrate potential performance constraints. We studied crimson rosellas (<i>Platycercus elegans</i>) and first focused on acoustic predator discrimination. We measured time allocation</p>



	<p>Notes: Rosellas distinguish among the calls of different avian predators played back at ~ 26m at 98 dB (at 1 m).</p>	<p>before and after playback of one of three experimental treatments (peregrine falcons—<i>Falco peregrinus</i>, wedge-tailed eagles—<i>Aquila audax</i>, and crimson rosellas) to determine whether or not rosellas discriminated predators from non-predators, and specifically whether or not they discriminated large from small predators. We then focused on the decision to flee. We experimentally approached subjects and measured the distance at which they oriented to us (alert distance) and the distance at which they fled (flight initiation distance; FID). We found that rosellas could distinguish among predators; however, there was no effect on general wariness as measured by FID. These two processes of antipredator behavior may, thus, be independent.</p>
<p><b>Selective phonotaxis by male wood frogs (<i>Rana sylvatica</i>) to the sound of a chorus</b></p>	<p>Bee MA, 2007, Selective phonotaxis by male wood frogs (<i>Rana sylvatica</i>) to the sound of a chorus. <b>Behavioral Ecology and Sociobiology</b> 61:955-966.</p>	<p>Frogs and toads commonly form large choruses around suitable breeding habitat during the mating season. Although often regarded as a constraint on the acoustic behavior of signalers and receivers, the sounds of a chorus could also serve as an acoustic beacon that allows some frogs to locate the breeding aggregation. Attraction to chorus sounds might be particularly important for explosively breeding frogs. In these species, which often mate just one or a few days during the year, the timing and location of breeding aggregations can be unpredictable because their formation often depends on local climatic factors, such as rainfall or a change in temperature. I used laboratory playback experiments to test the hypothesis that male wood frogs (<i>Rana sylvatica</i>), an explosively breeding frog, exhibit positive phonotaxis toward the sound of a conspecific chorus. Males were released at the center of a rectangular arena with a speaker positioned in each corner facing toward the release point. In a single-stimulus experiment, more males approached a speaker broadcasting a conspecific chorus than the three silent speakers in the arena. In a two-stimulus experiment, more males approached a speaker broadcasting a conspecific chorus compared to the two silent speakers or a fourth speaker simultaneously broadcasting the spectrally overlapping sound of a heterospecific (<i>R. septentrionalis</i>) chorus. These results are consistent with the hypothesis that male wood frogs could use the sound of a chorus as a beacon to locate a short-lived breeding aggregation.</p>
<p><b>Sexual differences in the behavioral response of tungara frogs, <i>Physalaemus pustulosus</i>, to cues associated with increased predation risk</b></p>	<p>Bernal XE, Rand AS and Ryan MJ, 2007, Sexual differences in the behavioral response of tungara frogs, <i>Physalaemus pustulosus</i>, to cues associated with increased predation risk. <b>Ethology</b> 113:755-763.</p> <p>Notes: Predation stimuli, low frequency: bullfrog calls and sounds of frog-eating bats wingbeats</p>	<p>Engaging in mating behaviors usually increases exposure to predators for both males and females. Anti-predator 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 tungara frogs, <i>Physalaemus pustulosus</i>. We compared the responses</p>

		<p>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.</p>
<p><b>Information and its use by animals in evolutionary ecology</b></p>	<p>Dall SRX, Giraldeau L-A, Olsson O, McNamara JM and Stephens DW, 2005, Information and its use by animals in evolutionary ecology. <i>Trends in Ecology and Evolution</i> 20(4):</p>	<p>Information is a crucial currency for animals from both a behavioural and evolutionary perspective. Adaptive behaviour relies upon accurate estimation of relevant ecological parameters; the better informed an individual, the better it can develop and adjust its behaviour to meet the demands of a variable world. Here, we focus on the burgeoning interest in the impact of ecological uncertainty on adaptation, and the means by which it can be reduced by gathering information, from both 'passive' and 'responsive' sources. Our overview demonstrates the value of adopting an explicitly informational approach, and highlights the components that one needs to develop useful approaches to studying information use by animals. <b>We propose a quantitative framework, based on statistical decision theory, for analysing animal information use in evolutionary ecology.</b> Our purpose is to promote an integrative approach to studying information use by animals, which is itself integral to adaptive animal behaviour and organismal biology.</p>
<p><b>Rapid acquisition of an alarm response by a neotropical primate to a newly introduced avian predator</b></p>	<p>Gil-da-Costa R, Palleroni A, Hauser MD, Touchton J and Kelley JP, 2003, Rapid acquisition of an alarm response by a neotropical primate to a newly introduced avian predator. <i>Proc. R. Soc. Lond. B</i> 270:605-610</p>	<p>Predation is an important selective pressure in natural ecosystems. Among non-human primates, relatively little is known about how predators hunt primate prey and how primates acquire adaptive responses to counteract predation. In this study we took advantage of the recent reintroduction of radio-tagged harpy eagles (<i>Harpia harpyja</i>) to Barro Colorado Island (BCI), Panama to explore how mantled howler monkeys (<i>Alouatta palliata</i>), one of their primary prey, acquire anti-predator defences. Based on the observation that harpies follow their prey prior to attack, and often call during this pursuit period, we broadcast harpy eagle calls to howlers on BCI as well as to a nearby control population with no harpy predation. Although harpies have been extinct from this area for 50–100 years, results indicate that BCI howlers rapidly acquired an adaptive anti-predator response to harpy calls, while showing no response to other avian vocalizations; howlers maintained this response several months after the removal of the eagles. These results not only show that non-human primates can rapidly acquire an alarm response to a newly introduced predator, but that they can detect and identify predators on the basis of acoustic</p>

		<p>cues alone. These findings have significant implications both for the role of learning mechanisms in the evolution of prey defence and for conservation strategies, suggesting that the use of 'probing' approaches, such as auditory playbacks, may highly enhance an <i>a priori</i> assessment of the impact of species reintroduction.</p>
<p><b>Sensory ecology of prey rustling sounds: acoustical features and their classification by wild Grey Mouse Lemurs</b></p>	<p>Goerlitz HR and Siemers BM, 2007, Sensory ecology of prey rustling sounds: acoustical features and their classification by wild Grey Mouse Lemurs. <b>Functional Ecology</b> 21:143-153</p>	<p>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.</p> <p>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.</p> <p>3. In subsequent behavioural 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 <i>Microcebus murinus</i> 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.</p> <p>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.</p> <p>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.</p>
<p><b>Observational and experimental evidence for the function of tail flicking in Eurasian moorhen <i>Gallinula chloropus</i></b></p>	<p>Randler C, 2007, Observational and experimental evidence for the function of tail flicking in Eurasian moorhen <i>Gallinula chloropus</i>. <i>Ethology</i> 113:629-639</p>	<p>Tail movements such as wagging, flicking or pumping are reported from many bird species but their adaptive functions remain poorly understood. To investigate whether tail flicking functions as an alarm signal, either to predators or neighbouring birds, or as a signal of submission to conspecifics, I observed this behaviour in moorhen in a natural context, and conducted playback experiments using vocalizations of predators, conspecifics and heterospecifics. I found positive relationships between flicking and vigilance and nearest neighbour distance, and negative relationships between flicking and moorhen flock size and total flock size. Moorhen at the edge of a flock flicked at a higher rate. Single moorhen flicked more often compared with individuals in groups, both in single and mixed-species flocks, and there was a tendency that single moorhen flicked more often than single moorhen within a mixed-species flock. <b>Moorhen responded differently to conspecific and predator calls. While in both cases</b></p>

		<p><b>vigilance increased, tail flick rate was higher during predator playbacks and lower during conspecific playbacks.</b> Furthermore, moorhen remained rather motionless when conspecific calls were played back, but not during predator calls, and, moorhen resumed to a baseline level of tail flicking more quickly after the playback of conspecific calls. Taken together, the results suggest that flicking may be considered as a honest signal of vigilance directed towards ambushing predators.</p>
<p><b>Effect of acoustic clutter on prey detection by bats</b></p>	<p>Areltaz, R., G. Jones, and P. A. Racey , 2001, Effect of acoustic clutter on prey detection by bats. <i>Nature</i> 414: 742-745</p>	<p>Bats that capture animal prey from substrates often emit characteristic echolocation calls that are short-duration, frequencymodulated (FM) and broadband. Such calls seem to be suited to locating prey in uncluttered habitats, including flying prey, but may be less effective for finding prey among cluttered backgrounds because echoes reflecting from the substrate mask the acoustic signature of prey. Perhaps these call designs serve primarily for spatial orientation. Furthermore, it has been unclear whether the acoustic image conveyed by FM echoes enables fine texture discrimination, or whether gleaning bats that forage in echo-cluttering environments must locate prey by using other cues, such as prey-generated sounds. Here we show that two species of insectivorous gleaning bats perform badly when compelled to detect silent and immobile prey in clutter, but are very efficient at capturing noisy prey items among highly cluttered backgrounds, and both dead or live prey in uncluttered habitats. These findings suggest that the short, broadband FM echolocation calls associated with gleaning bats are not adapted to detecting prey in clutter.</p>
<p><b>Gleaning bats as underestimated predators of herbivorous insects: diet of <i>Micronycteris microtis</i> (Phyllostomidae) in Panama</b></p>	<p>Kalka, M., and E. K. V. Kalko, 2006, Gleaning bats as underestimated predators of herbivorous insects: diet of <i>Micronycteris microtis</i> (Phyllostomidae) in Panama</p>	<p>Predators of herbivorous insects play important roles in tropical ecosystems as herbivory may affect structure and diversity of plant populations. Although insectivorous bats are particularly abundant and diverse in the tropics, their impact on herbivorous insects is little understood. To assess prey consumption, we observed the gleaning bat <i>Micronycteris microtis</i> (Phyllostomidae) continuously for 3 months including 16 full nights at a nightly feeding roost on Barro Colorado Island in Panama using infrared videotaping combined with collection of prey remains. Individual bats consumed about 61–84% of their body mass in arthropods per night. Diet analysis revealed a high percentage of herbivorous insects, constituting more than half (51%) of all prey and over 70% of prey biomass. Dominant prey were caterpillars (33% of prey biomass), and other herbivores including crickets, katydids, scarab beetles and phasmids. Furthermore, a novel feeding behaviour was observed as <i>M. microtis</i> selectively discarded parts of intestines of phytophagous insects before consumption, probably to avoid intake of plant material either for ballast reduction and/or for protection from secondary plant compounds. Combined with estimated feeding rates of insects in sympatric bat species, our data suggest that gleaning bats are important predators of herbivorous insects and might be underestimated reducers of herbivory in the tropics.</p>

<b>Cost of Habituation</b>		
<b>Interpreting short-term behavioural responses to disturbance within a longitudinal perspective</b>	<p>Bejder L, Samuels A, Whitehead H, Gales N, 2006, Interpreting short-term behavioural responses to disturbance within a longitudinal perspective. <b>Animal Behaviour</b> 72:1149-1158</p> <p>Notes: Dolphins exposed to boat traffic appeared to behavioral habituate in acute study but long-term population data indicates population significantly declined. Implication: sensitive individuals departed before behavioral study.</p> <p>See population study below.</p>	<p>We documented immediate, behavioural responses of Indo-Pacific bottlenose dolphins (<i>Tursiops</i> sp.) to experimental vessel approaches in regions of high and low vessel traffic in Shark Bay, Western Australia. Experimental vessel approaches elicited significant changes in the behaviour of targeted dolphins when compared with their behaviour before and after approaches. During approaches, focal dolphin groups became more compact, had higher rates of change in membership and had more erratic speeds and directions of travel. Dolphins in the region of low vessel traffic (control site) had stronger and longer-lasting responses than did dolphins in the region of high vessel traffic (impact site). In the absence of additional information, the moderated behavioural responses of impact-site dolphins probably would be interpreted to mean that long-term vessel activity within a region of tourism had no detrimental effect on resident dolphins. However, another study showed that dolphin-watching tourism in Shark Bay has contributed to a long-term decline in dolphin abundance within the impact site (Bejder et al., in press, Conservation Biology). Those findings suggest that we documented moderated responses not because impact-site dolphins had become habituated to vessels but because those individuals that were sensitive to vessel disturbance left the region before our study began. This reinterpretation of our findings led us to question the traditional premise that short-term behavioural responses are sufficient indicators of impacts of anthropogenic disturbance on wildlife.</p>
<b>Decline in relative abundance of bottlenose dolphins exposed to long-term disturbance</b>	<p>Bejder L, Samuels A, Whitehead H, Gales N, Mann J, Conner R, Heithaus M, Watson-Capps, Flaherty C and Krutzen M, 2006, Decline in relative abundance of bottlenose dolphins exposed to long-term disturbance. <b>Conservation Biology</b> 20(6):1791-1798</p>	<p>Studies evaluating effects of human activity on wildlife typically emphasize short-term behavioral responses from which it is difficult to infer biological significance or formulate plans to mitigate harmful impacts. Based on decades of detailed behavioral records, we evaluated long-term impacts of vessel activity on bottlenose dolphins (<i>Tursiops</i> sp.) in Shark Bay, Australia. We compared dolphin abundance within adjacent 36-km<sup>2</sup> tourism and control sites, over three consecutive 4.5-year periods wherein research activity was relatively constant but tourism levels increased from zero, to one, to two dolphin-watching operators. A nonlinear logistic model demonstrated that there was no difference in dolphin abundance between periods with no tourism and periods in which one operator offered tours. As the number of tour operators increased to two, there was a significant average decline in dolphin abundance (14.9%; 95% CI=-20.8 to -8.23), approximating a decline of one per seven individuals. Concurrently, within the control site, the average increase in dolphin abundance was not significant (8.5%; 95% CI=-4.0 to +16.7). Given the substantially greater presence and proximity of tour vessels to dolphins relative to research vessels, tour-vessel</p>

		activity contributed more to declining dolphin numbers within the tourism site than research vessels. Although this trend may not jeopardize the large, genetically diverse dolphin population of Shark Bay, the decline is unlikely to be sustainable for local dolphin tourism. A similar decline would be devastating for small, closed, resident, or endangered cetacean populations. The substantial effect of tour vessels on dolphin abundance in a region of low-level tourism calls into question the presumption that dolphin-watching tourism is benign.
<b>Behavioural and ecological consequences of limited attention</b>	<p>Dukas, R, 2002, Behavioural and ecological consequences of limited attention. <b>Phil. Tran. R. Soc. Lond. B</b> 357:1539-1547</p> <p>Notes: Flip side of habituation. Cost of attending to anthropogenic sound is lost processing of more behavioral-relevant cues.</p>	Ecological research in the past few decades has shown that most animals acquire and respond adaptively to information that affects survival and reproduction. At the same time, neurobiological studies have established that the rate of information processing by the brain is much lower than the rate at which information is encountered in the environment, and that attentional mechanisms enable the brain to focus only on the most essential information at any given time. Recent integration of the ecological and neurobiological approaches helps us to understand key behaviours with broad ecological and evolutionary implications. Specifically, current data indicate that limited attention affects diet choice and constrains animals' ability simultaneously to feed and attend to predators. Recent experiments also suggest that limited attention influences social interactions, courtship and mating behaviour.
<b>Why behavioural responses may not reflect the population consequences of human disturbance</b>	<p>Gill JA, Norris K and Sutherland WJ, 2001, Why behavioural responses may not reflect the population consequences of human disturbance. <b>Biological Conservation</b> 97:265-268</p> <p>Notes: Verbal argument that quality of resource and availability of alternative habitats profoundly influences disturbance and 'habituation' behavior</p>	The effect of human disturbance on animals is frequently measured in terms of changes in behaviour in response to human presence. The magnitude of these changes in behaviour is then often used as a measure of the relative susceptibility of species to disturbance; for example species which show strong avoidance of human presence are often considered to be in greater need of protection from disturbance than those which do not. In this paper we discuss whether such changes in behaviour are likely to be good measures of the relative susceptibility of species, and suggest that their use may result in confusion when determining conservation priorities.