# Impacts of Industrial Wind Development On Wildlife and Ridgeline Habitat

## Vermont and New Hampshire Mountains

Photo by Roger Irwin

Sentry on Seneca Mountain

Peak Keepers
OF VERMONT'S MOUNTAINS

Compiled by Fred Person and Dhyan Nirmegh

**DISCLAIMER**

This is not a scientific document, but a limited document with the intent to inform and share with our citizen legislators and the average person to what is happening to our mountains and wildlife habitat concerning the development of industrial wind.

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Making a Stand Photo by Roger Irwin

## Dedication

Every New Englander has a right to have an unencumbered and uncompromised mountain in their backyard. This is dedicated to all New Englanders in the private sector and government who have put their energy, time and money towards the preservation of these fragile mountain landscapes.

For these mountains are a part of their heart and soul. They are about freedom, wildness and diversity. They allow us to step back from our fast-paced world and walk into the future with our past beside us.

Being alone in the woods with its quiet sounds feeds your soul in a way that nothing else can. Aloneness becomes your very essence.

This photo essay is dedicated to all animal species, large and small, that rely on these mountains for their home habitat, for their water, their food and social interaction. They have no say in our world. They cannot decide to tear apart a mountain for their own good. For them there is no such thing as global warming or green energy.

Dhyan Nirmegh

One of Twenty-One Wind Turbine Pads, Lowell Mountain, Vermont Photo by Steve Wright

**DISTURBANCE OF THE ECOSYSTEM**

It is important to emphasize that many proponents of Industrial Wind Turbine projects have little or no experience in this high mountain environment. Frequently these proponents pay a brief visit only after a wind generation facility is built. One can only truly comprehend the scale of disturbance by first visiting an undisturbed mountain ecosystem and then being present for all phases of construction from design to the finished operation.

Will Staats

Both Photos Coos County, New Hampshire

Before Construction of Roadway Toward Mt. Kelsey

Same Roadway After Blasting on Way to Mt. Kelsey

Granite Reliable Wind Project
Including Fish Brook Ridge, Owls Head and Mt. Kelsey

Road to Mt. Kelsey After Blasting Coos County, New Hampshire

**FRAGMENTATION OF WILDLIFE HABITAT**

Removing more forest and inviting more roads, human access and noise into an otherwise unfragmented habitat dramatically increases disturbance and wildlife mortality. Crucial security habitat becomes degraded and wildlife recruitment is compromised, threatening the long-term viability of populations. Acre by acre, disruptions and disappearing habitats represent incremental and cumulative losses. Fragmentation results in habitat patches that are too small and too insular to provide adequate food and security for wildlife.

Chronic noise exposure associated with wind energy construction and operations has definitely been documented to contribute to a broad range of problems which threaten the bio-energetics, foraging success, anti-predation strategies, acoustic social communications success, reproductive success and fitness of many taxa. Ecological consequences of chronic noise exposure have also caused changes in the density and diversity of various bird and mammal species populations, as well as changes in community structure.

Sue Morse

Photo by Roger Irwin

**NORTHERN MOUNTAIN BOBCAT**

Lowell Mountain, Vermont Photo by Steve Wright

**DISRUPTION OF HOME RANGES**

Crucial bobcat habitat and ridgetop trails that serve as travel corridors were severely altered by wind turbine construction on Lowell Mountain.

Dhyan Nirmegh

New England's ridgelines will play an increasing and integral role as global climate change forces countless species of plant and animals to seek new habitats in which to adapt and survive.

Sue Morse

Photo by Roger Irwin

**SNOWSHOE HARE ON SENECA MOUNTAIN**

Uncontrolled Blasting, Lowell Mountain, Vermont Photo by Shirley Nelson

**ECOLOGICAL STRESSES DISRUPT WILDLIFE POPULATIONS**

Over time, and across vast habitats, the cumulative effects of a multitude of stresses causes wildlife to experience behavioral, physiological, demographic and distributional changes. These challenges result in reduced fitness, in necessary and costly energetic expenditures, and avoidance of altered habitats and human infrastructure. In addition, resulting population declines have been further attributed to lowered reproductive rates and recruitment success.

Cumulative Assessment is a relatively new applied environmental science which seeks to more comprehensively measure and predict anthropogenic stresses which have negatively influenced wildlife in the past, are now occurring, and will harmfully influence wildlife in the future.

Sue Morse

Sheffield, Vermont Photo by Steve Wright

Lowell, Vermont Photo by Steve Wright

**NOT SO GREEN MOUNTAINS**

The mountains are integral to our identity as the Green Mountain State, and provide us with clean air and water and healthy wildlife populations. This desecration, in the name of "green" energy, is taking place in Vermont's Northeast Kingdom on one of the largest tracts of private wild land in the state. Throughout New England and Cape Cod, the allure of wind power threatens to destroy environmentally sensitive landscapes.

Erecting those turbines along more than three miles of ridgeline requires building roads with segments of the ridgeline road itself nearly half as wide as one of Vermont's interstate highways—in places where the travel lanes are now made by bear, moose, bobcat and deer.

Ironically, most of the state's environmental groups have not taken a stand on this ecologically disastrous project. Apparently, they are unwilling to stand in the way of "green" energy development no matter how much destruction it wreaks upon Vermont's core asset: the landscape that has made us who we are.

The pursuit of large-scale, ridgeline wind power in Vermont represents a terrible error of vision and planning and misunderstanding of what a responsible society must do to slow the warming of our planet. It also represents a profound failure to understand the value of our landscape to our souls and our economic future in Vermont.

The New York Times – Opinion – Not So Green Mountains – Steve Wright – Sept. 28, 2011

Song Bird in Hobblebush

Photo by Roger Irwin

Photo by Roger Irwin

**GAME BIOLOGIST WITH AMERICAN MARTEN**

Lowell Mountain Wetland before Construction Photo by Justin Lindholm

**MIXED AGED FOREST NEEDED FOR WILDLIFE HABITAT**

These high elevation forests provide stands of trees in an older, aged condition with interspersed gaps in the canopy due to frequent natural disturbances. The mixed softwood and hardwood cover, with its associated complex stand structure, are preferred by American Marten, a species listed as endangered in Vermont and listed as threatened in New Hampshire.

- Some wildlife use mountain ridgelines as a refuge from more developed areas. Black bears seek out these areas for den sites due to their remote location.
- The mountain ridges are the only undeveloped areas in a region that serve as critical corridors for wide ranging species including bobcat, lynx, bears, fisher and marten.
- These animals exist more successfully with infrequent human contact.
- The rarest bird in the Northeast, the Bicknell's thrush, resides exclusively in high elevation forests.

Will Staats

Photo by Roger Irwin

**BARRED OWL ON ALERT**

Bull Moose on Seneca Mountain Photo by Roger Irwin

**MIGRATION TRAILS AND FLYWAYS**

In many places these quieter natural lands are the last stand habitats for wildlife—wildlife that would otherwise face the uncountable hazards of being pushed close to us, where they are not welcome and where premature death most often awaits them.

Migrating birds, bats, moose, bobcats, and other species regularly use these important pathways. Ridgeline travel routes facilitate species and genetic exchange throughout an impressive assemblage of connected habitats both locally and throughout the northeast and neighboring Canada.

Sue Morse

Photos by Roger Irwin

**RED FOX MOTHER AND KITS RELAXING**

Lowell Mountain Development Photo by Steve Wright

**WILDLIFE POPULATION DECLINES**

Large scale habitat loss and disturbances as a consequence of industrial energy exploration and development, mining, timber extraction, and backcountry recreation have been demonstrated to contribute to wildlife population declines.

Described by conservation scientists as “death by a thousand cuts”, individual impacts may be regarded as minor. However, these disturbances are now recognized to be incremental and are collectively significant when measured over time and space.

In my opinion, it appears that the entire northeast is rushing into wind energy development without responsibly undertaking Cumulative Effects Assessment. While this science is certainly highly technical and requires long term research commitment and a much larger budget, we must insist on doing these projects properly, or not at all.

Sue Morse

Natural Resource Caucus in Seneca Mountains Photo by Roger Irwin

**HIGH ELEVATION WINTER GATHERING**

We have long known that moose typically seek shelter during winter months in the coniferous cover found in high elevation forests.

I consider the mountain ash the most important mast producing species found at high elevations. The abundant red fruit is an important food source for a wide variety of mammals and birds. During the winter months the bark is highly favored by the moose.

Will Staats

Quiet Time Photo by Roger Irwin

**MOOSE NEED HIGH ELEVATION FORESTS**

Cool wet seeps in the mountain habitat provide birthing areas for moose calves in spring. As the climate changes, these cooler altitudes will become increasingly important for moose seeking relief from warmer temperatures in both summer and winter.

Roads, and even trails that follow along power line corridors, introduce significant stress factors within the foraging, resting and denning habitats that sustain numerous species of animals.

Will Staats

Photo by Steve Wright

**AERIAL VIEW OF BALD MOUNTAIN WEST OF THE SENECAS**

Photo by Steve Wright

**ONE ARM OF THE SENECAS**

**INTEGRITY AND LAND USE**

In the 1920's Aldo Leopold synthesized an ethic for use of the land: A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community. We need integrity in our public dialogue, and we must avoid deception. There is a national guideline for discussing renewable energy that has been violated thousands of times in Vermont.

It was violated when the Lowell project was first presented to the public; it was violated when the citizens of Lowell were mailed descriptions of this project before their vote; it has been violated in testimony before the Public Service Board. The guideline is simple and best illustrated with an example. The example comes directly from the Federal Trade Commission, the national institution charged with assuring integrity in the marketplace.

This is the example. A toy manufacturer places solar panels on the roof of its plant to generate power and advertises that its plant is 100-percent solar powered. The manufacturer, however, sells renewable energy certificates based on the renewable attributes of all the power it generates. Even if the manufacturer uses the electricity generated by the solar panels, it has, by selling the renewable energy certificates, transferred the right to characterize that electricity as renewable. The manufacturer's claim is, therefore deceptive, because reasonable consumers would likely interpret this claim to mean that the manufacturer uses renewable energy.

Climate change is a global problem and, for all the world's citizens to effectively address this problem, we must address it with integrity. I recommend that the State of Vermont adopt the Federal Trade Commission guidelines for describing renewable energy in all its work, legislation, publications, and deliberations, in place of the current practices fostered by the energy corporations and their lobbyists that serve private and not global interests.

Anne Morse

Canada Jay on Spruce Branch

Photo by Rodger Irwin

Photo by Roger Irwin

**MOTHER HAWK WITH CHICKS IN ASH TREE**

Photo by Roger Irwin

**RUFFED GROUSE ON THE LOOKOUT**

Roadway Foundation Coos County, New Hampshire

**PLIGHT OF MOUNTAINTOP HABITAT**

My name is Will Staats and I live in the Northeast Kingdom town of Victory, Vermont. I make my living as a professional Wildlife Biologist but also run a small guide business in my spare time. I am an avid hunter, trapper and have spent a good portion of my life exploring wild places. For the record I believe in global warming. It is this very fact that causes me concern about the plight of our sensitive mountain ridgeline habitat. In fact, as the climate warms, these high elevation islands of fragile habitat will become even more important.

Wildlife Biologists and Natural Resource Managers are expressing their growing concerns regarding large scale wind development and its impacts to sensitive mountain habitats. High elevation habitats are a scarce resource in the Northeast and are limited to approximately three percent of Vermont's total land area.

For the past four years I have been closely involved with the environmental review of an industrial wind turbine project consisting of 33 Turbines in Northern New Hampshire. This project covered four mountain summits. I've monitored all phases of this project including hiking the alignment, review of turbine locations, providing testimony, helping to formulate

mitigation and developing pre and post construction studies. This project has given me a firsthand knowledge of what a mountain looks like before and after construction and has helped me to better understand the process of proper siting, construction and resulting effects on the mountain ecosystem.

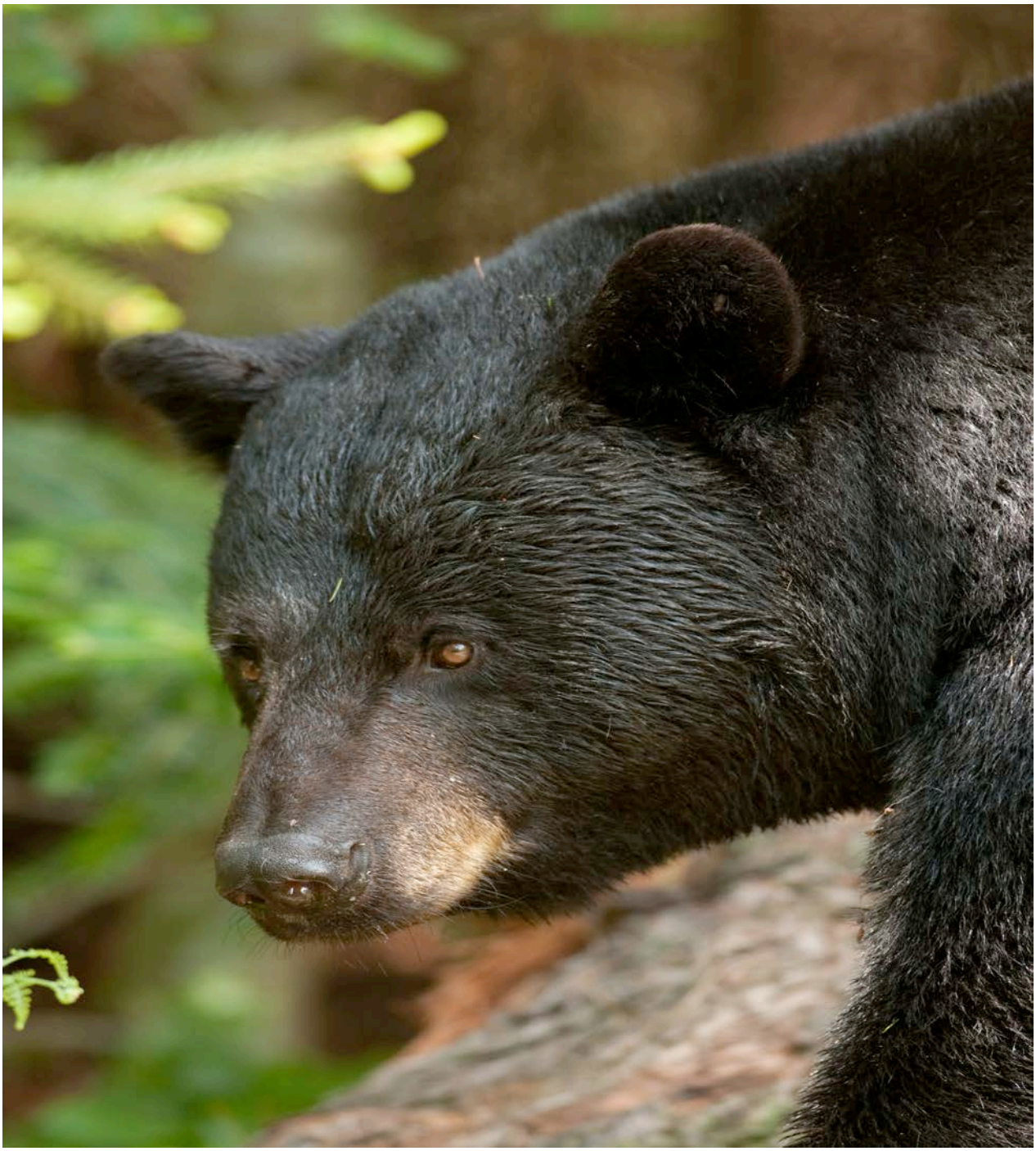
As part of this work, my agency has spear-headed two ground breaking wildlife studies on the affected mountain ridges, studying the ecology and the impacts to the American marten and Bicknell's thrush. These are the very first studies of this kind, performed in this habitat, involving these species.

Wildlife is impacted by industrial wind turbine development at both forest landscape and the forest stand level. Impacts are dependent on wildlife species, location of the ridgeline and the greater landscape context. At a stand level, forest cover is removed and permanently lost for some species due to the project footprint. Important wetlands are compromised and destroyed during construction. Headwater wetlands, seeps and feeder streams are directly impacted. At a landscape level, habitat connectivity and resiliency across the forest landscape is compromised. For birds and bats, turbines pose a new source of mortality in these habitats.

Over the years I have come to recognize the significance of high elevation habitat for the American marten in Vermont. We have learned that marten, due to their small size and heavily furred feet, are able to exploit deep snow environments. Fisher, coyotes and other predators can be direct competitors with these animals but are less able to negotiate the deep fluffy snow conditions found on our mountain ridgelines. Here marten can more readily avoid competitors commonly found at lower elevations. However, our research in northern New Hampshire has demonstrated that turbine access roads built on these remote mountains become vectors for coyotes and foxes.

Maintenance vehicles traveling to and from the turbines continually pack the snow providing a firm base on which these canines travel from lower elevations to the ridgelines. We have followed tracks of these animals demonstrating this behavior on numerous occasions. Windswept turbine pads and road cuts contribute to the creation of a packed snow surface in the unbroken forest adjacent to these openings. Canine predators can now penetrate the mountain forest where the snow would previously have consisted of a loose and fluffy surface. As a result of the project construction, the ecological community of these forests have been drastically changed, putting added stressors on the endangered marten. An alarming number of these animals were killed near the project area by coyotes, foxes and fisher.

Will Staats



Northeast Kingdom Black Bear Photo by Roger Irwin

**STATEMENT TO THE FRIENDS OF GRAFTON, VERMONT**

"Birds, bats and bears are expendable" in order to keep the "planet safe."

Governor Peter Shumlin July 2013

Coos County, New Hampshire

**DESTRUCTION OF HIGH ELEVATION HYDROLOGY**

I am a stormwater hydrologist and Principal of Watershed Consulting Associates in Waitsfield, VT. My firm specializes in modeling, designing, and permitting stormwater management systems. I have conducted water quality research and designed stormwater systems in high elevation watersheds. I have also closely reviewed stormwater designs and permit applications for the Sheffield Wind, Kingdom Community Wind, and Deerfield Wind Expansion projects.

High elevation areas of Vermont include numerous seemingly insignificant seeps, where groundwater oozes from the subsurface and begins to concentrate to form discrete stream channels. These headwater streams and wetland areas are the birthplace of our surface water resources. They constitute the greatest percentage of total stream length in an undisturbed river system, but are also mostly unmapped. They are vitally important for providing clean and cold water, habitat, and flood control; however, they can only provide such services if they are protected from disturbance.

With continued development in Vermont and our nation, conversion of undeveloped pervious surfaces to impervious and the potential impact to the hydrological water balance from climate change, protection of these headwater resources is a very wise investment for a sustainable future.

We now know the best way to keep pollution out of our surface waters and to preserve stream hydrology is to control the overall volume of stormwater being generated on a

developed site, by designing sites to replicate natural conditions. Current State stormwater regulation was not developed on this premise.

Preserving high elevation hydrology cannot be successful by playing defense; the approach must be holistic and include minimizing the project footprint as the primary consideration.

Lowell, Sheffield, Deerfield, and Georgia Mountain will result in the creation of 81 acres of new impervious surface, not considering the acres of newly exposed bedrock. This is more than eight Williston Wal-Mart facilities combined.

The only solution to water quality protection is to downscale the infrastructure required for these projects.

Monitoring, before and after development, is an absolutely key component to a successful strategy.

This monitoring plan must allow for instream testing on the project site, where the small headwater areas are located and at the points of stormwater discharge, not just at locations a mile or more downstream of the project site, as was done in Lowell and Sheffield.

Many acres of roads have been constructed to service the Lowell and Sheffield projects. Shortly after construction, these roadways have compacted to form an impervious surface akin to pavement.

I have repeatedly expressed my concerns to ANR on this issue but have been disregarded. If precipitation events intensify, as predicted, with the onset of climate change, the inaccurate modeling of runoff from these projects will result in even more water quality impact and downstream flooding impacts.

Andres Torizzo

Moose River in Vermont Photo by Roger Irwin

Coos County, New Hampshire, Photo by Vermonters for a Clean Environment

**ADDED INFRASTRCUTURE**

Industrial Turbine Sprawl, Lowell, Vermont Photo by Steve Wright

**WHO DECIDES?**

The transformation to 90% renewable energy will require unprecedented changes in our state, and our choices have tremendous implications for our landscape. It seems undemocratic to make those decisions about what our landscape will look like in 100 years by an appointed three-person public service board. And so I'm suggesting that we need to do something outside the permitting process as a more comprehensive land use plan that has more public input.

Ann Ingerson

Tower Looming above Forest Floor, Lowell Mountain, Vermont Photo by Steve Wright

**ENDANGERMENT OF BATS AND SONGBIRDS**

Air pressure drops caused by spinning turbine blades results in bat and songbird deaths. These animals die of lung damage as a consequence of being sucked into a low pressure area behind the turbine blades.

Bats are obligate insectivores and contribute immeasurably to human society by their daily consumption of millions of insects that would otherwise destructively affect forest and wildlife health, agricultural crops, and pose health hazards to people, livestock and pets.

Sue Morse

**NO NATURAL SUBSTITUTES FOR BATS**

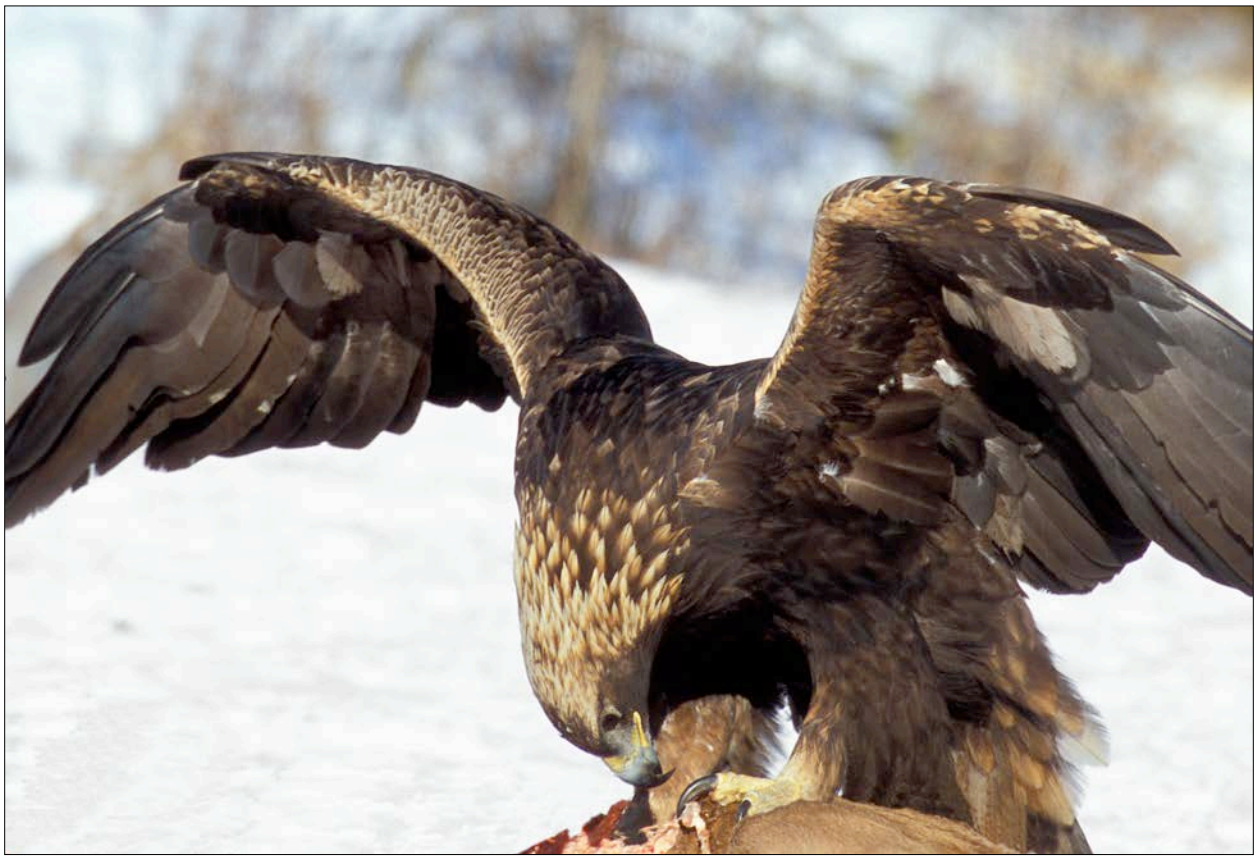
Prior to the appearance of the invasive fungal disease, white-nose syndrome, bat biologists viewed wind energy as the most potent threat that bats had ever faced. The tree bats were believed to be the ones in trouble. Dramatic bat mortality events were documented at wind energy sites along forested ridges in various locations in the eastern U.S.; notably Virginia and West Virginia. The majority of dead bats were hoary bats. Red bats and silver-haired bats were also vulnerable to the wind energy operations. Wind turbines also kill cave bats, particularly little brown bats and tri-colored bats.

Today, Vermont's bats, nine species in total, face a double whammy: white-nose syndrome and wind energy. The tree bats do not get white-nose syndrome, but are likely being badly affected by wind energy. Most of the cave bats are unaffected by wind energy, but because their numbers are now so low, any losses from any additional cause, such as wind turbine operations, could be extremely significant to the population as a whole. In effect, an entire suite of mammals is now at great risk, both in Vermont, and in the eastern United States, because of these dual threats.

The Center for Biological Diversity asks the Vermont Agency of Natural Resources to take a broader view of bat conservation than simply issuing take permits for listed species. The state of Vermont is in jeopardy of losing the ecological services of its primary night-flying insectivores. Essentially, there are no natural substitutes for bats. Their precarious status must be seen as a broad threat to the state's ecosystems as well as the human environment.

Scientists have estimated that the value of bats to American agriculture is between $3.7 billion and $53 billion per year. Bats eat thousands of tons of insects every summer. Without them, farmers will either suffer more crop losses or be forced to turn to greater use of pesticides. The loss of bats is likely to have impacts on the rest of us, as well, with bats no longer eating pesky, biting insects such as mosquitoes, and bats no longer feeding on moths and beetles that cause damage to valuable timber.

Mollie Matteson



Golden Eagle Feeding Photo by Roger Irwin

**ECONOMIC COSTS FOR VERMONT COMMUNITIES OPPOSING INDUSTRIAL WIND**

While Big Wind has pockets deep enough to pay for lobbyists, PR and lawyers such that they can overwhelm thoughtful opposition, the case has not been made to my satisfaction that Industrial Wind is a viable component of a responsible energy policy for Vermont. Since there are several major wind projects already in operation, there is ample opportunity to evaluate their contributions, as well as their costs, in the next few years.

Steven B. Young

Rural Vermont communities do not have deep pockets. The communities of East Haven, Sheffield and Lowell, have populations ranging from 300 to 750 people. The Public Service Board process costs have ranged from $250,000 to $700,000 for each of these towns. It is an unlevel playing field. The new proposals for energy siting policy do not offer a means by which towns or individuals can afford to participate in a consequential way.

Lesley Becker

**ENORMOUS COSTS ASSOCIATED WITH INDUSTRIAL WIND DEVELOPMENT**

My academic specialty for over forty years has been research on long-term climate change and its effects of ecosystems

There is no question that there are enormous costs associated with industrial wind development. We are not merely installing wind turbines; we are destroying mountain ranges. The damage is physical, in terms of geological and hydrologic effects. It is biological, in that it destroys critical habitat and migration routes, and it is aesthetic and cultural, not least in that it has caused deep divisions in the environmental community—divisions that play directly into the hands of corporate interests whose roots lie outside Vermont.

Over a generation ago, the conservation community applauded Act 250 and its commitment to protect areas that lie above the 2,500 foot elevation level. The main developer and supporter of this concept, Dr. Hub Vogelmann, made a strong pitch that the lower limit should be 2,000 feet. There is good reason for his suggestion. The peaks and ridges of our lesser mountain ranges are the most pristine environments and ecosystems in Vermont. They are too low to have been built up for ski areas and too far off the beaten path to support major hiking trail systems. They are too high and cold, and have too little soil, ever to have supported agriculture, and they are generally too precipitous and the trees too small to have been heavily logged.

These areas support the most extensive boreal forest ecosystems in the state. They are critical for species such as lynx and pine marten, which are repopulating Vermont after a long absence. The ridges sustain air currents that make them critical for the migration of many birds, especially hawks and eagles. The effect of wind turbines on these flight patterns, and bird mortality, are not yet known.

Steven B. Young

White-Tailed Doe in the Brush

Photo by Rodger Irwin

Lowell Mountain Photo by Steve Wright

**MOUNTAIN-TOP MINING**

**COMMUNITIES TORN APART**

I'm a wildlife biologist. I've worked for years on endangered species issues across the United States and at the federal level. When this project first started, I basically had my head in the sand, but, I also felt as a Vermonter for all my life that our environmental laws and our environmental groups would look out for our wildlife on that mountain top. As I drive to Jay to go skiing now and see how many wildlife species have been displaced up there. I am appalled!

I also read the information that was put out by the wind people and I've never seen a worst-prepared, if you want to call it an environmental impact statement, for wildlife. It was terrible. I've worked at the federal level on endangered species, and I expected that some endangered species could have been addressed at the federal level, but I never came upon any of it. Hopefully the Island Pond and Newark project will be a whole different story.

As a Vermonter I have seen how wind projects have destroyed communities, people against people. I don't believe the Public Service Board has the credential or capability to look at projects of this size. They don't have the knowledge. Three people to look at something like this? The impact it's going to have on our environment is huge. I was flabbergasted how fast this project went through and that Act 250 isn't even a part of it. Act 250 above 2,000 feet – I mean it's like, no, you can't do anything above 2,000, no roads, no nothing. I know these laws, and I felt, as a Vermonter, this would be addressed. It wasn't. So I ask that you, as the siting commission, to address these issues, because people don't understand in our state that Act 250 isn't part of these siting – decisions.

Take into consideration that Vermont doesn't need this. And the incidental take permit. Incidental take is, if a bat gets killed by the turbines, it is only being monitored by the company. It should be monitored by outside people. Any incidental take permit is to be monitored either by a U. S. Fish and Wildlife service biologist or somebody outside of the company.

Peggy Struhsacker

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**Lowell Protesters**
**Photo by Mountain Occupiers**

White-tailed Buck Photo by Roger Irwin

**OLD WARRIOR WATCHING FROM THE FIRS**

## EDITORS

**Dhyan Nirmegh**. I am a Vermonter working and moving through these mountains and hills. Woodcutter, tree farmer, stonemason, conservation and environmental activist. The massive destruction of the topography has assailed my sense of cultural identity.

**Fred Person** provided technical support and conceptual layout of the material. He was unwavering in his patience and thoughtfulness. His tenacity to follow through with the job was the key to this project. Master of Extension Education, UVM.


## ACKNOWLEDGEMENTS

**Will Staats**. Wildlife biologist. Knowledgeable woodsman, writer, illustrator, wilderness canoeist, hunter and wildlife guide.

**Sue Morse**. Founder of Keeping Track, a non-profit organization. She has spent well over three decades researching wildlife and documenting her findings in articles and public presentations. Her research includes monitoring wildlife and documenting the presence and habitat needs of bobcat, cougar, black bear and Canadian lynx. Wildlife photographer and the eyes of the woods.

**Steve Wright**. Aquatic biologist. Former Commissioner of Vermont Department of Fish and Wildlife. He considers Vermont his home no matter where he is at, and has worked tirelessly to protect its “billion year old mountains.”

**Roger Irwin**. Vermonter, farmer, woodsman, logger and wildlife photographer, one of Vermont’s best.

**Justin Lindholm**. Vermont Fish and Wildlife Board. Hunter and outdoorsman. Knowledgeable and steadfast in his dedication to the preservation of Vermont’s mountains.

**Ann Morse**. Wilderness advocate, educator, canoeist. Teacher, Outdoor Education, Sterling College.

**Andres Trizzo**. Stormwater hydrologist. He has conducted water quality research and designed stormwater managemnent systems in high elevation watersheds.

**Ann Ingerson**. Natural resource economist, focusing on how to live on the earth without destroying it with development. Degree in Agricultural Economics, Oxford, England.

**Mollie Matteson**. Conservation advocate at the Center for Biological Diversity. She is the driving force to place the Bicknell’s thrush and little brown bat on the federal endangered species list.

**Steven Young**, **Ph.D**. Anthropologist, botanist and founder of the Center for Northern Studies in Wolcott, Vermont.

**Lesley Becker.** Playwright, *Winds of Change*, a play about the impact of industrial wind development on a rural family and their community. Appreciation for editorial guidance.

**Peggy Struhsacker**. Wilderness advocate from Northern Vermont. She has a keen appreciation of the land she lives in.

**Annette Smith**. Environmental advocate. Executive director, Vermonters for a Clean Environment. Director and organizer of groups questioning this destructive push for industrial wind development.

**Elizabeth Cooper**, Environmental advocate, and experienced naturalist, outdoor educator, and land use planner. She works with Vermonters for a Clean Environment.

**Don and Shirley Nelson**, Their life and farm now under the Lowell wind turbines, have faced numerous obstacles with power companies and politicians. They continue with courage and persistence.

**Peak Keepers**, Is an ad hoc working group of scientists, educators and advocates focused on protecting and promoting the integrity of Vermont's mountains and their environmental, cultural, and economic value.

**Special thanks to: Luke Snelling, Vermonters for a Clean Environment, Energize Vermont, Mountain Talk, Craftsbury Conservation Commission, Save the Seneca's, Newark Neighbors United, Brighton Ridge Protectors, Citizens for the Preservation of Georgia Mountain, Holland-Derby Citizens for Responsible Energy, Ridgeline Protectors, Save Vermont's Ridgelines, Friends of Grafton's Heritage, Friends of Northfield Ridge, Kingdom Commons Group, Friends of Grandpas Knob and The Ira Group.**

Photo by Justin Lindholm

**PITTSFORD RIDGE NEAR RUTLAND, VERMONT**

## CONCLUSION

We as humans are connected to our wildlife. Destroying their habitat we destroy our selves.

Most of the animals featured in this booklet are the top tier of Vermont's wildlife. They have the legs and mobility to move out of the way of the construction process.

When using thousands and thousands of pounds of explosives and heavy machinery for a project across our mountain tops, all other wildlife and its habitats are assaulted.

Squirrels, chipmunks, mice, voles, porcupines, raccoons, ground birds, insects, frogs, newts, salamanders and toads are immediately killed by blasting, by concussion, and by compaction.

It raises the question, do we have to destroy so many species of plants and animals in order to save them later?

We wouldn't normally think of doing this to our mountains and wildlife but it seems global warning has become a "just cause". And we humans have been known to avoid our responsibility of our actions for a "just cause".

So what is the answer?

**Dhyan Nirmegh**

Near Rutland, Vermont Photo by Vermonters for a Clean Environment

**PITTSFORD RIDGE LOOKING TOWARD GRANDPA'S KNOB**

**ONE OF VERMONTS PROPOSED INDUSTRIAL WIND SITES**

Near Island Pond, Newark and Ferdinand, Vermont Photo by Steve Wright

**VERMONT'S SENECA MOUNTAIN PROPOSED INDUSTRIAL WIND SITE**

Ruffed Grouse Eggs at base of Yellow Birch Photo by Roger Irwin

**SENECA RANGE**

# Use of Ears and Auditory Senses of Animals Living In the Woods of the Vermont Mountains

Photo by Roger Irwin

Fox listening from Den of Old Hard Maple

Compiled by Roger Irwin, Fred Person and Dhyan Nirmegh

Public Service Board, Sound Workshop, July 29, 2014

## Introduction

I am Dhyan Nirmegh of Starksboro, Vermont co author of the Booklet, "Impacts of Industrial Wind Development on Wildlife and Ridgeline Habitat". The photos that I am submitting today are taken by Roger Irwin of Maidstone and Shirley Nelson of Lowell, Vermont

Some of last month's sound experts painted a rosy picture of people living with Wind Power sound in Europe. One expert said there was little opposition and alluded to the fact that problems with sound in Europe had been addressed by changing the blades degrees and gear boxes.

It's quite the opposite.

There are many problems.

In a Norway study, Sveinulf Vagene, says that the World Health Organization report entitled "Burden of Disease form Environmental Noise" concluded that Wind turbines noise is not just an annoyance it can cause major health problems. He states people are sick but Norway still has little understanding of how the noise is affecting people.

Germany and Denmark have halted some facilities in order to do further studies.

Germany, France and Canada have major protests taking place. European people have been fighting aliments from which they said are caused by Noise from Wind Turbines.

Under the European Umbrella Organization EPAW (European Platform Against Wind Development) there are 621 subgroups in 24 countries. These groups are desperate people whose lives have been downgraded by Wind Power Noise.

People have been dying of heart attacks, and had a myriad of other aliments.

Vibro Acustic disease is where low frequency noise causes change in the vascular system. This research is only being studied at the University of Portugal according to the Norwegian study.

What about Wildlife?

Do we just focus on bears?

There are hundreds of species of Birds, Bats, animals and amphibians that are affected. And yet, I have yet to see any detailed studies of animal hearing and the effects of sound, low frequency sound and Infrasound.

If doctors say there is even a slight chance of people getting heart disease, what is it doing to our wildlife?

Some people that have camps hear these wind turbines say that the amount of wildlife has diminished, but if animals are actually staying in these areas how are they adapting or how are they coping? I have only heard of one study of wildlife after the turbines are up and that has been done in New Hampshire with the Bicknell's Thrush.

Last session sound experts talked only about sensitive monitoring devices above ground. There are no sound devices that are put into the ground or into seeps, streams or vernal pools.

What happens when the sound and vibrations travel through rock edges, water and ground? I did my own experiment at Lowell. I submerged my head in fresh snow pack and could hear the towers still.

What happens when the snow cover is solid? Animals use the ground for cover, borrowing into, for homes, hibernation, resting and raising young.

Birds and animals have very keen hearing.

- They depend on it to escape predators
- Depend on it to breed and continue the species
- Depend on it to communicate
- They depend on quite areas to nurture and relax.

Many of the large animals have long cupped hears.

- Full of fine hair, which helps pull in sound vibrations
- Ears are directional on most large animals. They can move to the sides and forward on the head without the head moving
- Example of Owls having large facial disks that funnel sound to their ultrasensitive ears.
- It's not always sound they pick up. It is also frequency and minute vibration these animals are picking up on.

There are very few scientific studies being done on how animals are affected by Wind Turbines noise. Why?

We have capable Universities and Colleges and capable grad students, capable Wildlife programs and we at present already have four Industrial Wind Facilities in the State of Vermont.

Why is it that we can't take the time to do Wildlife studies?

We share this land with Wildlife and are the big pivotal manual in these eco systems. We feel like we need to be in control but we are shirking our responsibility of being stewards of our environment.

The last time the Public Service Board held a hearing on sound, April 13th, 2014, we heard from half the people that said the noise of the turbines didn't bother them. They may be right they don't hear it or was not affected by it and maintain that animals aren't bothered. Some people event hunt on Lowell Mountain.

The people that are not affected say they see the wildlife, "the animals are in their yards". Well, if they are not hearing the sound, then why not

The concerns of the people that hear the turbine sound, live it and are real!

Dhyan Nirmegh

Immediate Wildlife Destruction Photo by Shirley Nelson

Road Construction Photo by Steve Wright

Wind Tower Construction near the Nelsons Farm, Lowell Mountain Photo by Steve Wright

## Low Frequency Sound and Infrasound

Low frequency noise and Infrasound (such as emitted by wind turbines) are sound waves that are felt by the body rather than heard, probably by the utricle. Depending upon the amplitude or intensity, it produces feelings of extreme discomfort, a feeling that the body is vibrating. Depending upon the frequency and intensity, infrasound can keep you awake, or induce sleep. Therefore, it can cause sleep deprivation.

Infrasound induces stress and causes the body to secrete the hormone Cortisol. This effect is a medically recognized danger of long-term infrasound exposure.

Cortisol, plays a vital role in preparing our body for stressful “fight or flight” episodes. It increases blood pressure and blood sugar levels, and has an immunosuppressive action that provides needed alertness and energy during stressful experiences. However, during long term stress, or if Cortisol production is prolonged, its effects on the human body can become severe. A weakened or suppressed immune system will allow existing health problems to accelerate, and make it easier for new ones to be created.

Exposure to infrasound during early sleep hours can be particularly harmful. This is when the body normally produces the lowest levels of Cortisol. This might explain my 3am awakening and subsequent wakefulness. Artificially stimulating Cortisol production during sleep means that the Cortisol is not used and remains in the body, potentially damaging essential body functions.

A sound wave in air is a sequence of pressure changes. A sound wave in a liquid or solid is more like a vibration. This helps explain how Low Frequency Noise and Infrasound travel great distances and easily pass through solid walls, and can set up vibrations or resonances in rooms and body cavities.

Andrew Vivers (4/14/2014)
Arniefol, Glamis, Scotland

https://www.windturbinesyndrome.com/2014/turbine-headache-scotland/

Infrasound (20Hz or less) can affect the bodies of animals and humans.

## Hearing Ranges

| Species | Range (Hz) |
|---|---|
| Humans | 20-23,000 |
| Coyotes | 50-46,000 |
| Cats | 45-65,000 |
| Frogs | 100-3,000 |
| Birds | 200-12,000 |
| Rodents | 1,000-100,000 |
| Rabbits | 360-45,000 |
| Turtles | 20-1000 |
| White-tailed Deer | 250-12,800 |
| Owl | 120-12,000 |

Photo by Roger Irwin

## Moose Have Excellent Hearing

They have been known to communicate to other moose using a low ‘hiccip call (which is imperceptible to humans) over a distance of 2 miles. Their ability to hear is enhanced by the reflective surface of their very large ears (about 67 sq. in.) coupled with the distance between their ears which gives them enhanced stereophony. On top of that, their ears move independently of each other which allow them to enlarge both the angle and the space of perception.

The Ecology of Management of the North American Moose.

Photo by Roger Irwin

## Antlers and Moose's Sharp Hear

Moose's antlers are some of the most extravagant headgear in the animal kingdom.

- Act as elaborate hearing aids that help males to find calling females.
- Antlers' sound-gathering qualities boost hearing by 19%
- Their ears are 20 times larger than humans
- It has been found that bulls with wide antlers have had better results in finding mates.

James Randerson, The Guardian, Thursday, 20 March 2008

White-tailed Fawn listening While Sleeping Photo by Roger Irwin

White-tailed Buck Listening Photo by Roger Irwin

**White-tailed Deer Hearing**

White-tailed deer hearing is its most important sense.

- Hearing range (250 Hz to 12,800Hz)
- Very large ears, along with independently angle and rotation deer are able to pinpoint where the sound is coming from
- Unfamiliar, out of the ordinary sounds of their environment warrants attention.

Black Bear Photos by Roger Irwin

Young bears ears develop to full size sooner than any other part of their body. It is the black bears first line of defense. In a thick forest, hearing is the most crucial sense the bear can have. The bear often locates sound before using its sense of smell. Like dogs, bears hearing capability exceeds human range and sensitivity.

Photos by Roger Irwin

## Emerging from A Winters Nap

Bobcats hear higher frequency sounds than humans.  Their hearing is extremely acute.

- They have 30 different muscles in their ears they can recognize a sound, tone and locate the source of the sound instantly.
- They can independently rotate their ears in a 180 degrees.
- The shape of the ear directs and funnels sound to the center of the cats middle ear.

# Mountain Predators

Eastern Coyote, Red Fox, Weasel and Mink Photos by Roger Irwin

## These Predators have the Ability to Change Hunting Territories

- The Coyote hearing range is 45 KHz which is 3 times that of humans
- The fox has the hearing range up to 150 yards at 60 KHz.
- There is evidence that the Weasel and Mink's have high hearing ranges similar to the Coyote and Fox.

# Ground Animals

Beaver Photo by Shirley Nelson

## Beavers Hear Excellently both on Land and Under Water

- The medium of water conducts sound better than the medium of air.
- Beavers spend most of their time in water.
- Ears are small flaps of skin perched high on the sides of their heads.
- Under water a flap of skin covers their inner ear and protects it from water.
- Their high hearing sensitivity is due to the large inner ear organs.
- The Beavers lodge is constructed such that half is below water and half above water.
- The beaver's environment, create wet lands, a hone for other species of animals, amphibians, and plants, while helping to curtail climate change.

# Beaver Pond Community

Otter

Painted Turtle, Frog and Rabbit

Photos by Roger Irwin

# Ground Animals

Snowshoe Hare with Articulating Ears Photo by Roger Irwin

Rabbits hear much like humans but are able to hear higher pitch sounds than humans. Their ears move forward and backwards. With large erect ears that move independently, rabbits are able to pick up sounds a mile away. Hearing being its most vital sense, a rabbit can be hiding behind objects with their long ears sticking up and are able to hear predators and understand the acoustic landscape surrounding them.

# Ground Animals

Vermont Woodchuck Photo by Roger Irwin

Red Squirrel Photo by Roger Irwin

# Birds

Blue Jay Photo by Roger Irwin

Nesting Bird Photo by Roger Irwin

- Birds have a smaller hearing range than humans
- They have strong recognition skill that can sort out the difference of the songs of other birds.
- Their ears located just behind the eyes covered with light feathers called auriculars
- Their calls can be masked with wind turbine noise.

Barred Owl Photo by Roger Irwin

Large facial disc around eyes covered with fine feathers help funnel sounds to ears slightly offset on the side of their head. This takes the owl less than 100$^{th}$ of a second to determine the path of their prey.

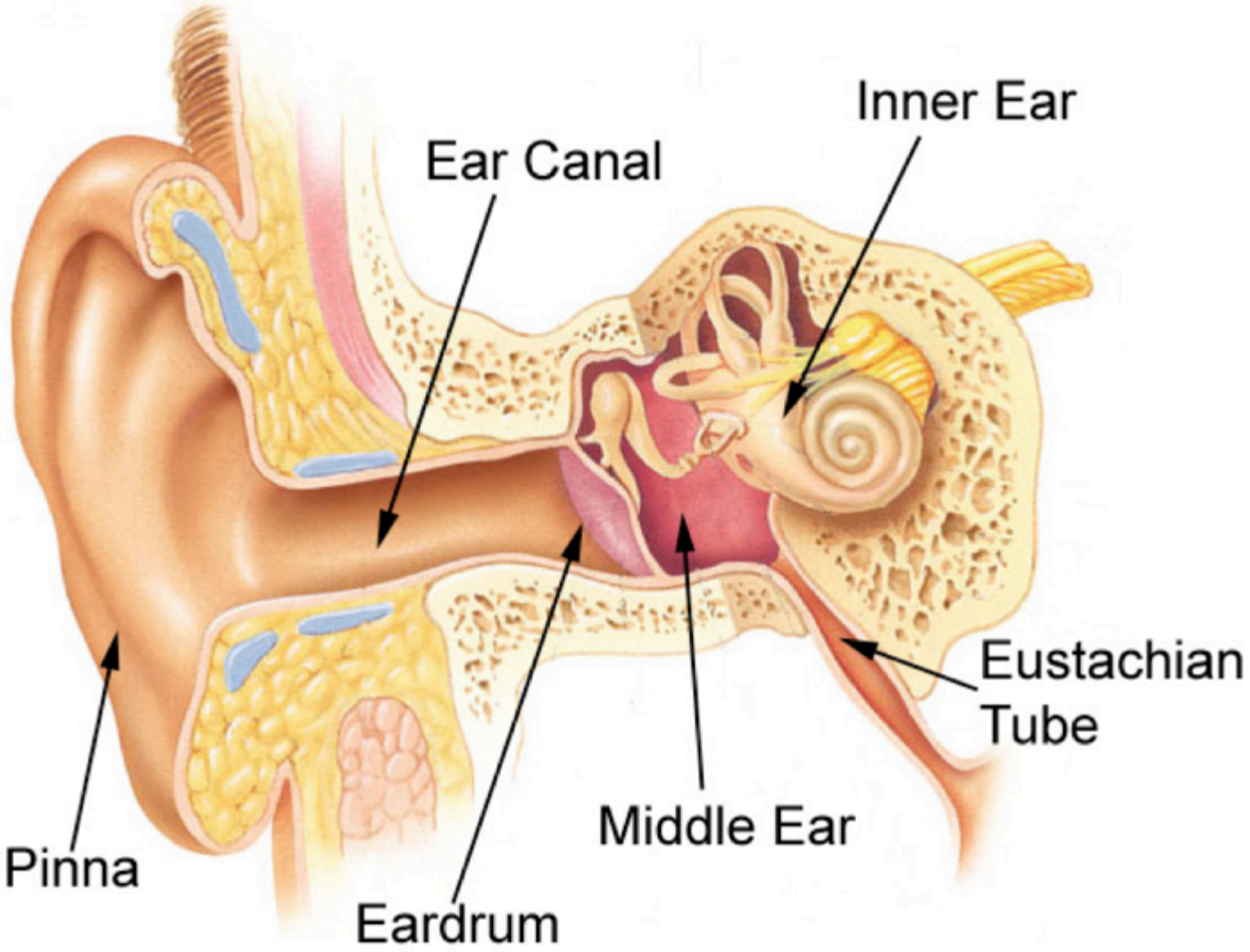
IN THE QUIET VERMONT WOODS Photo by Roger Irwin

# Use of Ears and Auditory Senses of Animals Living In the Woods of the Vermont Mountains

*Fox listening from Den of Old Hard Maple*

Compiled by Roger Irwin, Fred Person and Dhyan Nirmegh
Public Service Board, Sound Workshop, July 29, 2014
Montpelier, Vermont

# The Human Ear



# POPULATION ECOLOGY OF AMERICAN MARTEN IN NEW HAMPSHIRE: IMPACT OF WIND FARM DEVELOPMENT IN HIGH ELEVATION HABITAT

*By ALEXEJ PEDER KELLY SIREN B.A., Vermont College 2009, Thesis Submitted to the University of New Hampshire in Partial Fulfillment of the Requirements for the Degree of Master of Science In Natural Resources: Wildlife and Conservation Biology Sept. 2013*

- This study examined marten ecology relative to wind farm development using radio-marked marten, camera trapping, and snow track surveys to meet study objectives.
- Mortality (predation) was biased towards females and young.
- Disturbance from wind farm construction resulted in less use and periodic displacement of marten, although marten maintained presence in the study area.
- Winter access by competitor canids was enhanced by maintained roads and snowmobile trails at high elevation.

# Impacts of Wind Development on the Abundance and Distribution of high-elevation birds in Northern New Hampshire, with a focus on Bicknell's Thrush

*A report submitted to New Hampshire Department of Fish and Game*
*by Clinton R. Parrish Department of Biological Sciences*
*Plymouth State University, June 2013*

We determined that avian responses to wind development could be attributed to one or more of the following three factors:

(1) Direct loss of forested area for turbine pads and access roads

(2) Fragmentation

(3) Influence of turbine presence (noise, collision potential).

# Bears

- Mitigation lands for First Wind's Sheffield Wind project logged
- No change in forest management plan

# Bats

- Stantec's counting area minimizes findings by limited search area
- 70 – 80 m search area extrapolated out to 200 feet for 112 m long turbine blades

# Estimates of bird collision mortality at wind facilities in the contiguous United States

*Scott R. Loss, Tom Will, Peter P. Marra,, Migratory Bird Center, Smithsonian Conservation Biology Institute, National Zoological Park, Washington, DC., U.S. Fish and Wildlife Service, Division of Migratory Birds, Midwest Regional Office, Bloomington, MN*

- We estimate that between 140,000 and 328,000 (mean = 234,000) birds are killed annually by collisions with monopole turbines in the contiguous U.S.
- We found support for an increase in mortality with increasing turbine hub height and support for differing mortality rates among regions, with per turbine mortality lowest in the Great Plains.
- Evaluation of risks to birds is warranted prior to continuing a widespread shift to taller wind turbines.

# Preliminary studies on the reaction of growing geese to the proximity of wind turbines

*J. Mikołajczak, S. Borowski, J. Marć-Pieńkowska,*
*G. Odrowąż-Sypniewska, Z. Bernacki, J. Siódmiak, P. Szterk*

- The impact of infrasound noise, emitted by wind turbines, on the health of geese and other farm animals has not previously been evaluated. Therefore, the aim of this study was to determine the effect of noise, generated by wind turbines, on the stress parameters (cortisol) and the weight gain of geese kept in surrounding areas.
- Geese from gaggle I gained less weight and had a higher concentration of cortisol in blood, compared to individuals from gaggle II. Lower activity and some disturbing changes in behavior of animals from group I were noted.
- Results of the study suggest a negative effect of the immediate vicinity of a wind turbine on the stress parameters of geese and their productivity.

# Acquired flexural deformation of the distal interphalangeal joint in foals

*Teresa Margarida Costa Pereira e Curto,* TECHNICAL UNIVERSITY OF LISBON, Faculty of Veterinary Medicine, Dissertation in Veterinary Medicine, *2012*

- Since 2008, the high prevalence of acquired flexural limb deformities front was observed in the Lusitano stud farm. The present study aimed at studying the acquired flexural deformities of the distal interphalangeal joint (DFAAID) foals on a stud farm which, in previous years, showed variations in their environmental conditions due to the installation of wind towers on adjacent land.
- Histologically the most significant alterations were the dissociation of myofibrils of the smooth muscle. This was predominantly seen in the small intestine but also in the walls of small capillary vessels, including those of the tendon vasculature.
- In the case series presented here, there was no obvious cause for the development of this problem, therefore we hypothesized that unusual environmental conditions might have played an important role in the development of this condition, especially those introduced in recent years.

# Study of Equines Exposed to Low Frequency Noise

*Nuno Castelo Branco, Mariana Alves-Pereira, et al,14th International Meeting on Low Frequency Noise and Vibration and its Control, Aalborg, Denmark 9 – 11 June 2010*

- This report is a follow-up to the 2007 case of family R, exposed to Low Frequency Noise (LFN) generated by Wind Turbines (WT), and who had begun to develop signs of LFN-induced pathology consistent with vibroacoustic disease.
- Mr. R must remain to care for thoroughbred Lusitanian horses and bull that he breeds for bullfighting.
- The pattern of onset of equine flexural deformities before and after the installation of WT in the farm's vicinity, led to check ligament biopsies of 4 foals raised on Mr. R's farm, and of 1 foal purchased by Mr. R from another breeder. It was shown that all 3 foals raised on Mr. R's farm disclosed the classical signs of LFN-induced responses: thickening of blood vessel walls due to proliferation of collagen in the absence of inflammatory processes. The purchased yearling foal did not exhibit these morphological features.
- The results presented herein strongly suggest that the presence of LFN-generating WT in the vicinity of this horse breeding farm can play a significant role in the triggering and onset of equine flexural limb deformities.

# Mink Farm in Denmark

- It happened two weeks ago. Minks began to bite their puppies and each other
- … since they [the wind turbines] began to spin last fall, the number of stillbirths and deformed puppies increased fivefold, says Kaj Olesen Bank.
- The proportion of females that refused to mate has quadrupled as compared to last year, when there were no wind turbines behind his mink farm.

*– June 2014*

# Goats in Taiwan

**Wind farm 'kills Taiwanese goats'**

- A large number of goats in Taiwan may have died of exhaustion because of noise from a wind farm.
- A farmer on an outlying island told the BBC he had lost more than 400 animals after eight giant wind turbines were installed close to his grazing land.
- The Council of Agriculture says it suspects that noise may have caused the goats' demise through lack of sleep.
- Abnormal noises could affect growth and feeding of the goats, officials say. – May 2009

# Noise-induced gastric lesions: a light and electron microscopy study of the rat gastric wall exposed to low frequency noise

*Jorge Fonseca[I]; José Martins-dos-Santos[I]; Pedro Oliveira[I]; Nuno Laranjeira[I]; Artur Aguas[II]; Nuno Castelo-Branco[III]*

- CONCLUSIONS: Deeper layers of gastric wall undergo alterations, including fibrosis of the submucosa caused by collagen IV deposition, an early marker of neoangiogenesis.
- Vascular alterations included thickening and thrombotic phenomena, but also images of newly formed vessels.
- This study suggests that, at least in the stomach, LFN-induced fibrosis could be linked with neoangiogenesis.

# Effects of infrasound on hippocampus-dependent learning and memory in rats and some underlying mechanisms

*Yuan H, Long H, Liu J, Qu L, Chen j, Mou X. Environ toxicol Pharmacol. 2009 Sept.*

- To investigate the effect of infrasound on the hippocampus-dependent spatial learning and memory as well as its underlying mechanisms, we measured the changes of cognitive abilities, brain-derived neurotrophic factor receptor signal transduction pathway and neurogenesis in the hippocampus of rats.
- The results showed that rats exposed to infrasound exhibited longer escape latency and shortened time staying in water maze.
- These results provided novel evidences that the infrasound of a certain exposure parameter can impair hippocampus-dependent learning and memory, in which the downregulation of the neuronal plasticity-related BDNF-TrkB signal pathway and less neurogensis in hippocampus might be involved.

# Infrasound increases intracellular calcium concentration and induces apoptosis in hippocampi of adult rats

*Liu Z, Gong L, Li X, Ye L, Wang B, Liu J, Qiu J, Jiao H, Zhang W, Chen J, Wang J. Mol Med Report. 2012 Jan*

- In the present study, we determined the effect of infrasonic exposure on apoptosis and intracellular free $Ca^{2+}$ ($[Ca^{2+}]i$) levels in the hippocampus of adult rats. Adult rats were randomly divided into the control and infrasound exposure groups.
- Elevated $[Ca^{2+}]i$ levels were observed on days 14 and 21 after rats received daily treatment with 90 or 130 dB sound pressure level (SPL) infrasonic exposure ($p<0.01$ vs. control).
- Apoptosis in hippocampal neurons was found to increase on day 7 following 90 dB SPL infrasound exposure, and significantly increased on day 14.
- These results demonstrate that a period of infrasonic exposure induced apoptosis and upregulated $[Ca^{2+}]i$ levels in hippocampal neurons, suggesting that infrasound may cause damage to the central nervous system (CNS) through the $Ca^{2+}$-mediated apoptotic pathway in hippocampal neurons.

# Involvement of microglial cells in infrasonic noise-induced stress via upregulated expression of corticotrophin releasing hormone type 1 receptor

*Du F, Yin L, Shi M, Cheng H, Xu X, Liu Z, Zhang G, Wu Z, Feng G, Zhao G. Neuroscience. 2010 May*

- Infrasound is a kind of environmental noise and threatens the public health as a nonspecific biological stressor.
- In this work, we exposed Sprague-Dawley rats and in vitro cultured microglial cells to infrasound.
- We found that infrasound exposure resulted in a significant activation of microglia cells and upregulated their expression of CRH-R1 in the PVN in vivo.
- Our in vitro data further revealed that in the absence of neurons, infrasound can directly induce microglial activation and upregulate their CRH-R1 expression.
- These findings suggest that in addition to the PVN neurons, microglial cells are the effector cells for infrasound as well, and involve in the infrasound-induced stress through upregulated expression of CRH-R1.

# Infrasound-induced changes on sexual behavior in male rats and some underlying mechanisms

*Zhiqiang Zhuang, Zhaohui Pei, Jingzao Chen*

- To investigate some bioeffects of infrasound on copulation as well as underlying mechanisms, we inspected the changes of sexual behavior, serum testosterone concentration and mRNA expression levels of steroidogenic factor 1 (SF-1), steroidogenic acute regulatory protein (StAR) and cytochrome P450 cholesterol side chain cleavage enzyme (P450scc) in testes of rats exposed to infrasound of 8 Hz at 90 or 130 dB for 1, 7, 14 and 21 days (2 h/day), respectively.
- Our conclusion is that adverse bioeffects of infrasound on reproduction depend on some exposure parameters, the mechanism of which could involve in the decreased expression of some key enzymes or regulator for testosterone biosynthesis.

# Infrasound-Induced Hemodynamics, Ultrastructure, and Molecular Changes in the Rat Myocardium

*Zhaohui Pei, Hanfei Sang, Ruiman Li, Pingxi Xiao, Jiangui He, Zhiqiang Zhuang, Miaozhang Zhu, Jingzao Chen, Hong Ma*

- Recent interest in adverse effects of infrasound on organisms arises from health concerns.
- We assessed the association between infrasound exposure of 5 Hz at 130 dB and changes of cardiac ultrastructure and function in rats.
- Our experiments suggested that infrasound exposure of 5 Hz at 130 dB directly damnify rat myocardial ultrastructure and tend to aggravate cardiac function.
- The effects of infrasound on the cardiovascular system should be further studied.