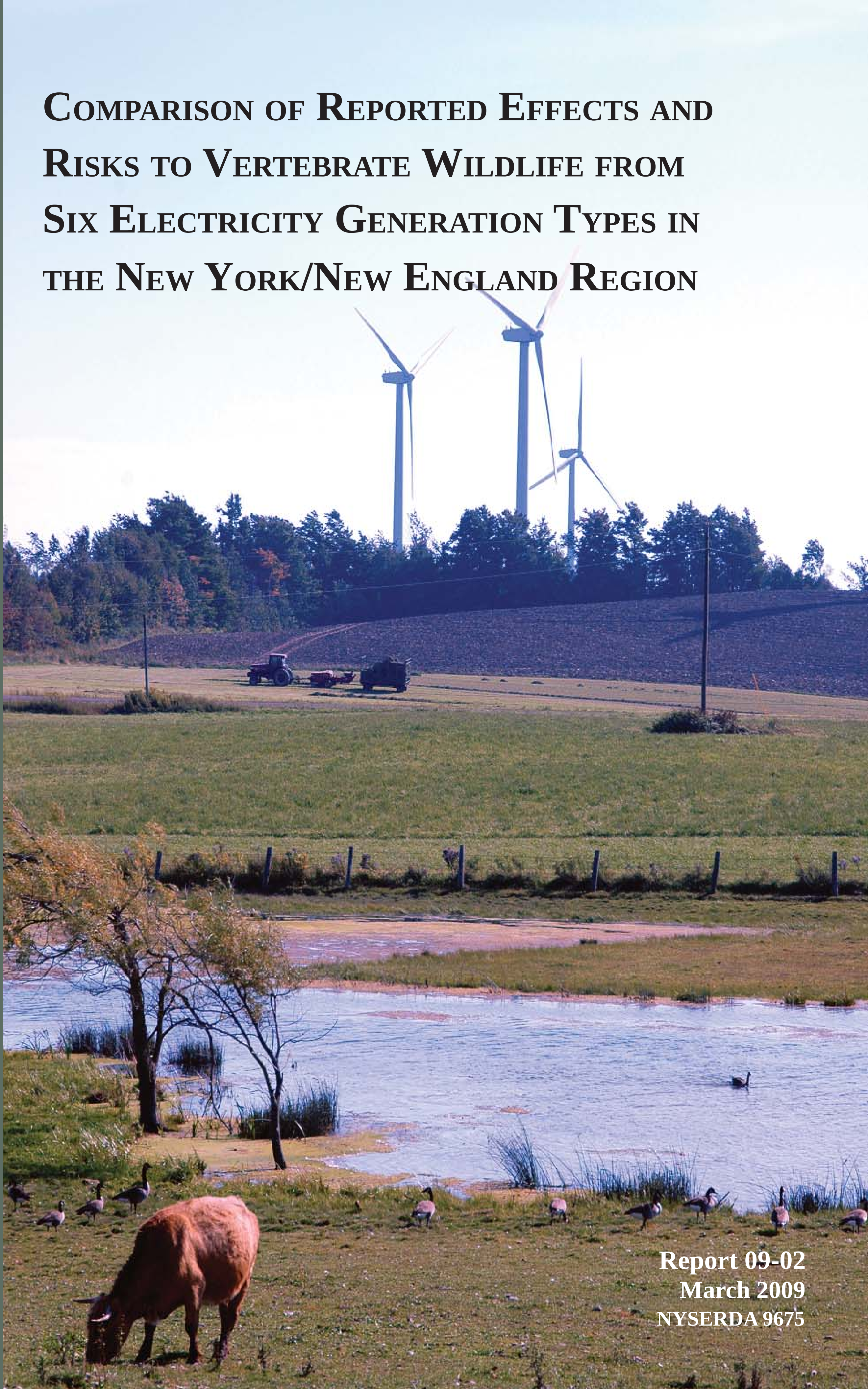
Comparison of Reported Effects and Risks to Vertebrate Wildlife from Six Electricity Generation Types in the New York/New England Region



Report 09-02
March 2009
NYSERDA 9675

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Energy Research and
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NYSERDA New York State Energy Research and Development Authority

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Comparison of Reported Effects and Risks to Vertebrate Wildlife from Six Electricity Generation Types in the New York/New England Region

Final Report

Prepared for the

New York State Energy Research and Development Authority

Albany, NY
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NYSERDA Report 09-02

NYSERDA 9675

March 2009

NOTICE

ABSTRACT

An assessment was conducted of the known and documented effects of electricity generation on vertebrate wildlife in the New York/New England (NY/NE) region. The focus of the literature review was peer-reviewed literature and scientifically accepted and published reports or documents regarding effects of electricity generation on wildlife. Results were used to construct a Comparative Ecological Risk Assessment in order to make objective comparisons among the six types of electricity generation important to the NY/NE region: coal, oil, natural gas, hydro, nuclear, and wind. All life cycles of electricity generation affect wildlife and, therefore, pose risks to wildlife individuals and populations. The degree and extent of the risks depend on the energy generation source. There are many ways to classify the impacts of electricity generation on wildlife. Effects can be direct and/or indirect; acute or chronic; individual or cumulative; and local, regional, or global. Each type of effect was explored in this study. Acidic deposition, climate change, and mercury bioaccumulation are identified as the three most significant and widespread stressors to wildlife from electricity generation from fossil fuels combustion in the NY/NE region. Risks to wildlife vary substantially by life cycle stage. Higher risks are generally associated with the resource extraction and power generation stages, as compared to other life cycle stages. Overall, non-renewable electricity generation sources, such as coal and oil, pose higher risks to wildlife than renewable electricity generation sources, such as hydro and wind. Based on the comparative amounts of SO_2, NO_x, CO_2, and mercury emissions generated from coal, oil, natural gas, and hydro and the associated effects of acidic deposition, climate change, and mercury bioaccumulation, coal as an electricity generation source is by far the largest contributor to risks to wildlife found in the NY/NE region.

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SUMMARY

Electricity generation causes adverse effects on the environment, including wildlife and wildlife habitat. In recent years, concerns about global climate change, caused in part by fossil fuel combustion, have focused enhanced attention on these effects and the need to move toward a mix of electricity generation sources that will reduce adverse effects of all types on the environment. The effects and relative levels of risk vary among the different electricity generation sources.

Before the electricity generation source can turn a turbine to generate electricity, it must be extracted or harnessed. Coal, oil, natural gas, and nuclear materials are extracted from the ground and then transported to the power station, sometimes hundreds or thousands of miles away. Electricity generation by hydro requires a source of flowing water (river or reservoir), whereas electricity generation from wind energy requires a steady and reliable wind flow pattern. Since most electricity is generated in one place and consumed somewhere else, wires are used to transport electricity from where it is made (power station) to where it is used (primarily in cities with homes and businesses). This requires a vast network of transmission and distribution lines known as the national grid system.

All electricity generation sources affect wildlife to some degree, although the mechanism and severity of impacts differ. There are many ways to classify the impacts of electricity generation on wildlife. Effects can be direct and/or indirect; acute or chronic; individual or cumulative; and local, regional, or global. Each type of effect was explored in this study.

In general, three key factors control the status and health of wildlife populations: birth rate, death rate, and availability of habitat. A change in any one of these factors will cause wildlife populations to increase or decrease.

All life cycles of electricity generation affect wildlife and, therefore, pose risks to wildlife individuals and populations. The degree and extent of the risks depends on the energy generation source, although some effects are common across life cycle stages of many electricity generating sources. Effects and risks can range from injury and mortality of individuals to habitat loss and decline in species occurrence. Risks can be classified according to immediacy of response, level of impact (individual to population), electricity generation life cycle stage, and spatial extent of response, as follows:

- Electricity generation can cause acute and immediate effects (such as toxicity of oil spills, exposure to acid mine drainage, collision and electrocution). It can also cause chronic, cumulative, and long-term effects (for example, biomagnification of mercury in the food chain, which can cause toxicity; acidification of soils from acidic deposition, leading to decline in forests or water

quality; and climate change, results in altered timing of wildlife reproduction, disruption of migration patterns, and alteration of species ranges).

- Electricity generation can affect wildlife at the level of individuals (resulting in Lowest to Moderate Potential risks) or populations (resulting in Higher and Highest Potential risks).
- Population-level effects are more likely to be associated with energy resource extraction and power generation than other life cycle stages of electricity generation.
- Effects on wildlife in the New York/New England (NY/NE) region from an electricity generation source can occur locally at the site (such as at a coal mine), regionally (such as regional transport of acidic deposition to the Northeast), and globally (such as climate change).
- Wildlife species differ in the degree to which they are sensitive to adverse impacts from electricity generation. Some species are more sensitive to one electricity generation source than to others. A number of species are considered to be especially vulnerable and at risk in the NY/NE region.

Acidic deposition, climate change, and mercury bioaccumulation are identified as the three most significant and widespread stressors to wildlife from electricity generation from fossil fuels combustion and hydro; these pose Moderate to Highest Potential risks to wildlife. Major conclusions regarding these stressors are as follows:

- Acidic deposition results from electricity generation from coal, oil, and to a lesser extent natural gas. Acidification of forest soils, streams, and lakes causes widespread, and only partially reversible, effects on fish and wildlife and their aquatic and terrestrial habitats throughout major portions of the NY/NE region.
- Mercury bioaccumulation results from electricity generation from coal, oil, and to a lesser extent hydro. Bioaccumulation of mercury has affected wildlife throughout the region, especially fish, birds, and mammals. Although it can be a major risk to wildlife, mercury bioaccumulation and its effects are generally reversible.
- Climate change produces the most widespread effects, posing risks to fish and wildlife and their habitats globally. These effects are not likely to be reversible. Electricity generation from coal, oil, gas, and hydro contribute (albeit unequally) to the risks for climate change.

In order to fully evaluate the potential impacts of a particular electricity generation source, effects at each stage must be considered. Effects are not equally distributed across life cycle stages. During the transmission and delivery stage, bird and bat collisions pose Moderate Potential risks common to all forms of electricity generation; they affect birds and bats to some extent within and outside the NY/NE region. Collision objects vary with electricity generation source, and include offshore drilling platforms (oil and

natural gas), and wind turbines, stacks, and cooling towers during power generation. Wildlife species exhibit varying risk, depending on location and dimensions of the collision objects relative to species ranges, flight patterns, and migratory behavior. The resource extraction stage of oil and natural gas poses Higher Potential risks to local and regional wildlife both within and outside the NY/NE region.
The fuel transportation stage of oil poses Highest Potential risks to local and regional wildlife both within and outside the NY/NE region, largely because of risks of oil spill.

Risks vary substantially by life cycle stage. Since there are more conditions, by-products, and actions in the resource extraction and power generation stages that act as stressors to wildlife, higher risks to wildlife are generally associated with these life cycle stages, as compared to other life cycle stages. The degree and extent of the risks depends on the electricity generation source, although some effects are common across life cycle stages and electricity generation sources. Table 3-1 summarizes the highest wildlife risk level for each electricity generation source during each life cycle stage. Construction, transmission and delivery, and decommissioning stages generally have fewer stressors that affect wildlife. However, the construction, operation, and decommissioning of dams pose relatively Higher Potential risks to ecosystems, fish, and stream habitat.

Overall, non-renewable electricity generation sources, such as coal and oil, pose higher risks to wildlife than renewable electricity generation sources, such as hydro and wind. Based on the comparative amounts of SO_2, NO_x, CO_2; mercury emissions generated from coal, oil, natural gas, and hydro; and the associated effects of acidic deposition, climate change, and mercury bioaccumulation, coal as an electricity generation source is by far the largest contributor to risks to wildlife found in the NY/NE region.

Major risks by source are as follows:

- Coal has risks that range from Lowest to Highest Potential, including unique risks during the resource extraction stage (e.g., Highest Potential risks associated with the effects of strip and mountain top mining). The combustion of coal during the power generation stage contributes disproportionately relative to other energy sources to acidification and mercury bioaccumulation, causing Highest Potential risks to wildlife.

- Oil risks range from Lowest to Highest Potential, with unique risks during the resource extraction and fuel transportation stages, owing to the potential for oil spills. Oil also contributes to acidification risks during the power generation stage.

- Natural gas has Lowest to Higher Potential risks, depending on life cycle stage. A number of the types of effects associated with the power generation life cycle stage of natural gas are similar to oil generation, but the magnitudes of these risks are less, e.g. Moderate Potential risks of habitat change from greenhouse gas emissions associated with natural gas combustion compared to Higher Potential risks from oil combustion.

- Nuclear presents Lowest to Highest Potential risks. Some of these risks are not unique to nuclear, and also are found with other non-renewable electricity generation sources, such as bird collisions with stacks and cooling towers associated with coal and oil generation sources.
- Hydro exhibits Lowest to Highest Potential risks, with some unique risks during the construction, power generation, and decommissioning stages, such as loss of large areas of terrestrial and aquatic upstream habitat, changes to downstream habitats, and blocking fish migration due to reservoir or impoundment construction.
- Wind has Lowest to Moderate Potential risks and high risks of bird and bat collisions with wind turbines during operation. No population-level risks to birds have been noted. Population level risks to bats are unknown at this time.

There are a number of opportunities for future comparisons of wildlife risk that were identified during this study. In particular, it is important to attempt to rank recovery potential of affected populations and habitats. Wildlife species and groups of species have different abilities to handle risks. Some populations have the reproductive potential to offset losses more readily than others. Some habitats can quickly recover once a particular stressor is removed, whereas other habitats may have changed so much that recovery is not possible.

Changes in the recovery potential of wildlife in response to improvement in air quality (e.g., decrease in acidic and mercury deposition) during the past two decades in response to emissions controls have not yet been investigated. It also is important to evaluate changes in wildlife risks in response to future technologies. For example, clean coal technologies should reduce some of the wildlife impacts from power generation via oil combustion.

Not all electricity generation sources in the NY/NE region are equally prevalent. A state-by-state analysis of wildlife risk could be conducted. This would be useful when looking at long-term trends to wildlife risks in the NY/NE region as shifts in electricity generation portfolios occur.

SECTION 1
INTRODUCTION

PURPOSE OF THE REPORT

Electricity generation causes adverse effects on both humans and the environment, including effects on wildlife and its habitat. In recent years, concerns about global climate change caused by fossil fuel combustion have focused attention on these effects and the need to move toward a mix of electricity generation sources that will reduce these adverse effects. The type of effects and relative level of risk vary among the different electricity generation sources. This report compares reported effects to vertebrate wildlife from electricity generation by coal, oil, natural gas, nuclear, hydro, and onshore wind. The scope of this report does not include how mitigation, implementation of new technologies, or future regulations might change these effects, nor does it address human health effects. This report provides a baseline for discussion about cumulative effects.

The focus is on electricity generating sources that are important to New York and the New England states (collectively referred to as the NY/NE region) and their effects on birds, mammals, fish, reptiles, and amphibians. The NY/NE region relies on six electricity generation sources for the electricity it needs (Table 1-1). With the exception of sources in Maine and Vermont, less than 20% of electricity generation in this region is renewable (hydro, wind, solar, etc.). To address this apparent over-dependence on non-renewable sources (coal, oil, natural gas, and nuclear), many states have adopted renewable energy plans (AWEA [nd]).

> All forms of **fossil fuel** (coal, oil, and natural gas) combustion, and also nuclear power, consume energy resources to make electricity and are **non-renewable energy sources.** Electricity generated from wind, sun, or water, does not consume resources in the energy generation process. These forms of energy are described as **renewable energy sources**.

One of the challenges facing the NY/NE region and the rest of the country is that all sources of electricity generation, including renewable energies, have adverse effects on wildlife to some degree. The effects of

Table 1-1. Comparison of percent of electricity generation sources used by state in the NY/NE region.

	Non-Renewable Energy (%)					Renewable Energy (%)		
STATE	**Coal**	**Oil**	**Natural Gas**	**Nuclear**	**Total**	**Hydro**	**Other (wind, solar, etc)**	**Total**
New York	14.8	5.4	31.3	29.0	**80.5**	16.9	2.6	**19.5**
Connecticut	11.2	4	30	48.6	**93.8**	1.3	4.6	**5.9**
Maine	2.4	4.8	41.3	0.0	**48.5**	22.5	29.1	**51.6**
Massachusetts	25.1	6.5	52.5	10.8	**94.9**	0.7	4.4	**5.1**
New Hampshire	16.8	2.4	24.4	46.0	**89.6**	5.6	4.8	**10.4**
Rhode Island	0.0	0.6	97.2	0.0	**97.8**	0.1	2.1	**2.2**
Vermont	0.0	0.1	0.0	73.7	**73.8**	18.6	7.5	**26.1**

Source: USDOE 2008a

electricity generation on people and wildlife have been studied since the 1970s; nevertheless, most studies have focused on fossil fuel combustion sources (coal, oil, and natural gas). Until now, no one has attempted an "apples to apples" comparison of wildlife effects from different types of electricity generation, nor has there been a study to compare all six electricity generation source types using a cradle-to-grave approach.

This report is designed to inform scientists, decision makers, and the general public. References to the published literature are primarily confined to the tables, with only limited references in the text. Appendix A contains additional literature citations.

METHODS USED TO RANK RISK OF POTENTIAL HARM TO VERTEBRATE WILDLIFE FROM ELECTRICITY GENERATION SOURCES

A literature review was conducted to provide the basis for a Comparative Ecological Risk Assessment study of the known and documented effects of electricity generation on vertebrate wildlife. The focus was on peer-reviewed literature and scientifically accepted, published reports or documents regarding wildlife effects from electricity generation. No original analyses of source contributions or effects were made. The results of the literature review were used in the Comparative Ecological Risk Assessment to make an objective comparison of the six types of electricity generation important to the NY/NE region (coal, oil, natural gas, nuclear, hydro, and onshore wind). The Assessment was completed by conducting a **Life Cycle Assessment** (Barnthouse et al. 1998; SAIC 2006) within the **Ecological Risk Assessment** framework (USEPA 1998; Henderson et al. 2007).

To objectively and thoroughly compare adverse effects caused by the six electricity generation source types, the total life cycle of electricity generation must be examined. The Life Cycle Assessment identified the stages involved in most forms of electricity generation: resource extraction, fuel transportation, construction of facility, power generation, transmission and delivery, and decommissioning of facility (Table 1-2). Wildlife effects from exposure to stressors encountered at each life cycle stage were identified and compiled from the literature review for each electricity generation source.

> **Life Cycle Assessment** is a cradle-to-grave approach that is typically used to assess industrial systems. Life Cycle Assessment evaluates all stages of a product's life from the perspective that they are interdependent, meaning that one operation leads to the next. Life Cycle Assessment is used to estimate the cumulative environmental impacts resulting from all stages in the product life cycle (e.g., raw material extraction, material transportation, ultimate product disposal, etc.; SAIC 2006).
>
> The **Ecological Risk Assessment Framework** was developed in the 1990s by USEPA to systematically evaluate the likelihood of adverse ecological effects occurring as a result of exposure to one or more stressors. It is comprised of four primary steps, including 1) problem formulation, 2) characterization of exposure, 3) characterization of effects, and 4) characterization of risk.

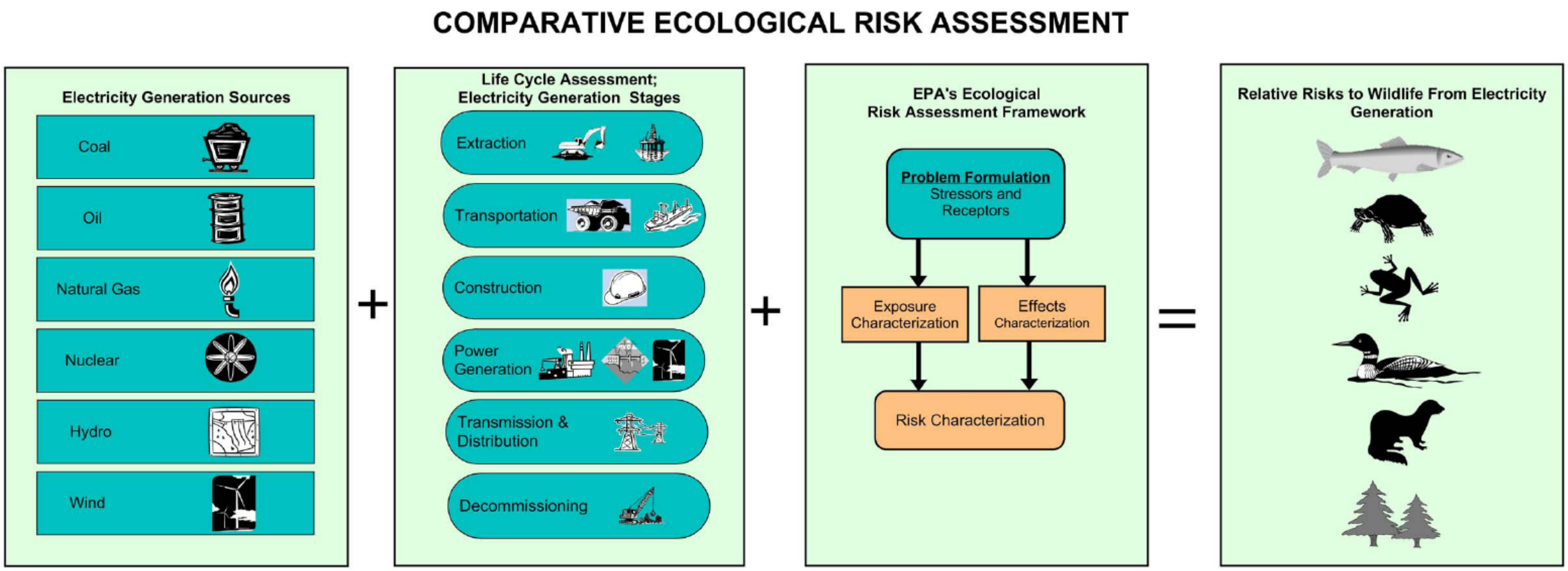

COMPARATIVE ECOLOGICAL RISK ASSESSMENT
Electricity Generation Sources
Coal
Oil
Natural Gas
Nuclear
Hydro
Wind
+
Life Cycle Assessment; Electricity Generation Stages
Extraction
Transportation
Construction
Power Generation
Transmission & Distribution
Decommissioning
+
EPA's Ecological Risk Assessment Framework
Problem Formulation
Stressors and Receptors
Exposure Characterization
Effects Characterization
Risk Characterization
=
Relative Risks to Wildlife From Electricity Generation

Table 1-2. Life cycle stages of electricity generation.

Life Cycle Stage	Definition
Resource Extraction	Getting the raw materials to make electricity and all the associated supporting activities (e.g., waste disposal, road construction). For example, for coal and uranium this includes surface and underground mining. For oil and natural gas this includes onshore and offshore drilling and extraction.
Fuel Transportation	Transporting the raw materials from the mine or well to the electricity generating facility by rail, truck, barge, ship, or pipeline. This includes construction of pipelines.
Construction of Facility	Building the electrical generation facility and associated supporting activities. For coal, oil, natural gas, and nuclear facilities, construction includes power blocks, stacks, cooling ponds or towers, lay-down areas and waste areas, and transmission and distribution lines. For hydro facilities, construction includes the dam, power house, impoundment area, and associated transmission lines and roads. For wind facilities, construction includes turbines, transmission and distribution lines, and roads.
Power Generation	All aspects of operating an electricity generating facility. For coal, oil, and natural gas this includes the combustion of fuels. For nuclear this includes heat energy production by fission. For wind this includes the action of the wind turbine blades. For hydro this includes reservoir management.
Transmission and Delivery	Getting electricity from the generation facility to where it will be used. This includes transmission lines, distribution lines, and substations.
Decommissioning of Facility	The demolition and removal of the electricity generating facility. All electricity generation facilities have a lifespan and must eventually be taken offline and removed. This report does not consider repowering.

Exposure is a measure of the degree to which wildlife has been exposed to a stressor, for example the length of time and amount (or concentration in the environment) of a toxic chemical. A **stressor** is a chemical or physical hazard in the environment that is capable of causing an adverse effect on a receptor (individual, population, habitat). A wildlife **receptor** can be wildlife habitat, individuals, or populations that are subject to potential impacts from a stressor. An **adverse effect** is the result of the stressor causing a negative outcome for an animal or population of animals, such as mortality or injury. **Risk** can be defined as "the probability or likelihood of an adverse effect occurring." A **wildlife effect** is an adverse impact that occurs to wildlife, with the level of risk being used to determine the likelihood of its occurrence.

Information from the literature review and the Life Cycle Assessment was incorporated into an Ecological Risk Assessment framework in order to construct a Comparative Ecological Risk Assessment that identified the **stressors** and **receptors** (wildlife and/or wildlife habitat) for each life cycle stage of each electricity generation source type. Next, the level of **exposure** and types of **wildlife effects** were characterized for each stressor within each life cycle stage of each electricity generation source. This information was used to characterize the relative level of **risk** (or likelihood) of an **adverse effect** occurring.

The potential risks for each life cycle stage were characterized for each electricity generation source, and cumulative effects for each electricity generation source were established by assigning a relative wildlife risk level to each wildlife effect (Table 1-3). The wildlife risk level system was developed to qualitatively

Relative Risk Level for Potential Harm	Potential Effects
Highest Potential	Large scale, population-level mortality and/or habitat destruction Population(s) decline and/or biodiversity is reduced A threat to species survival regionally Biologically significant mortality or reduction in endangered or threatened species
Higher Potential	Limited, but locally to regionally important mortality and/or habitat destruction, with limited population-level effects Any biodiversity declines would be local to regional only No threat to species survival, but demonstrated effects to physiology and/or behavior of exposed individuals Incidental mortality and/or incidental habitat destruction of endangered or threatened species
Moderate Potential	Limited and local mortality and/or habitat destruction, with no population-level effects Biodiversity declines are unlikely Endangered or threatened species may be exposed, but mortality unlikely
Lower Potential	Limited to no mortality or habitat destruction affecting populations, but empirical data suggest potential adverse effects on individuals, although not documented in wild populations No biodiversity declines Exposure of endangered or threatened species unlikely, with minimal adverse effects
Lowest Potential	Mortality, if any, limited to individuals; no empirical data to suggest an adverse effect No biodiversity declines Very limited or no exposure of endangered or threatened species

Table 1-3. Relative wildlife risk levels for potential harm from electricity generation.

rank the relative magnitude of potential harm that could be caused by a stressor and the spatial and temporal occurrence of these effects (exposure) for each life cycle stage of each electricity generation source. Continuous (e.g., emissions), periodic (e.g., bird collisions), and episodic (e.g., major oil spill) levels of exposure were considered in assigning life cycle stressors to potential risk levels. The levels of wildlife risk are evaluated on a relative scale within each electricity generation source and are not meant to infer absolute risks. The final risk ranking for a single life cycle stage of a single electricity generation type is given as the highest relative risk level among all assigned risk levels within that life cycle stage.

The naming of risk ranking categories presents a special concern. The importance of avoiding subjective and unintended interpretations of assigned risk levels cannot be overemphasized. The naming of relative risk categories, therefore, should use terminology acceptable to all stakeholders and not subject to media or political hyperbole. Although such terminology should ideally be value-neutral, the various alternatives all carry some level of social bias. Verbal descriptions are likely to be taken literally; alphabetic scoring is subject to grading bias; numeric scoring may imply a precision that does not exist. This report provides a snapshot in time, with a primary focus on past experience. While future technological advances are not considered in this study, it is recognized that industry responses to existing and anticipated regulations are currently affecting the way electricity is generated and, therefore, the risks associated with that generation. For these reasons, the relative terms described below were selected to describe potential risks that are themselves in the process of continuing change driven by regulatory, technological, and competitive forces.

The level of relative wildlife risk potential is divided into five separate categories (Highest Potential, Higher Potential, Moderate Potential, Lower Potential, Lowest Potential) based on defined criteria. The criteria are based on the extent to which the exposure to a particular wildlife stressor may cause adverse effects to wildlife habitat, individuals, or populations. The adverse effects range from large-scale **population-level risk** of mortality at the Highest Potential risk level to limited or no **individual risk** of mortality at the Lowest Potential risk level.

Population Risk Versus Individual Risk. The basic difference between human health risk assessment (NRC 1983) and ecological risk assessment (USEPA 1998) is that the individual is the important endpoint of the first, whereas the population is the important endpoint of the latter. There is a huge difference between an individual effect and a population effect. Since the disruption of a wildlife population is the endpoint that defines a major wildlife effect, from the ecological perspective, individual mortality is only important when it adversely impacts, or disrupts, the population. However, certain individual effects can be harbingers, or indicators, of potential or real impacts at the population level. Many such "biological indicators" have been identified and extensively studied.

Highest and Higher Potential risk levels are associated with effects on wildlife individuals and populations, while Moderate, Lower, and Lowest Potential risk levels are associated with only wildlife individuals, without evidence of, or reason to expect, an adverse effect at a population level. This does not mean that wildlife effects to individuals are not important, but if an individual effect does not result in a measurable impact on the population, then it is not considered ecologically significant. However, effects to individual animals can be ecologically significant in two situations. First, endangered and threatened species often cannot afford to lose even small numbers of individuals without imperiling the whole population or even the whole species. Second, individuals can become ecologically significant when they are shown to indicate a population-level effect.

VARIABILITY AND UNCERTAINTY

Variability

Variability includes variation in the exposure and effects on receptors (wildlife and wildlife habitat) that could influence the results of this study. A set of criteria reflecting exposure and effects was established to characterize relative wildlife risk potential. The literature was then reviewed to see if the specific receptor(s) met these criteria. If so, a relative risk level for potential harm was assigned, as discussed in Section 1.2. Criteria were designed to account for individual variation in exposure and effects and generally included an evaluation of a range of exposure characteristics. These included: 1) direct versus indirect effects; 2) method of interaction with the stressor (e.g., contact, ingestion, inhalation, or absorption); and 3) temporal context of interaction with the stressor(s) (e.g., continuous, periodic, or episodic). The exposure and effects criteria were designed to be broad enough to account for this variation. Sufficient studies were available to characterize stressors, exposures, receptors, and effects. We attempted to characterize stressors, exposures, and effects on a broad scale and in general terms for all life cycle stages of energy generation sources. We, therefore, did not attempt to quantify exposure and effects where variation could affect the results of the risk rankings.

Uncertainty

Uncertainty means the lack of, or incomplete, knowledge of a particular stressor, stressor pathway, receptor, or effect that could influence the results of this assessment. During this analysis there were occasions when there was insufficient information on key aspects of stressors, exposures, or effects to draw specific conclusions. Such uncertainties were noted to the extent that they affected interpretations or conclusions. For example, there is not sufficient information available to conclude whether the effects on bats from wind turbine collisions will have population-level effects. The relative risk potential could be Moderate, Higher, or Highest Potential. This uncertainty was noted.

In addition, it is generally accepted within the scientific community that climate change is occurring, and the causes of climate change can be attributed in varying degrees to greenhouse gases from electricity generation by coal, oil, and natural gas, and to some extent from hydro power. The Intergovernmental Panel on Climate Change (2007) made the following comments related to reducing greenhouse gas emissions: “Natural gas releases less carbon dioxide per unit of energy than coal or oil. Hence, switching to natural gas is a quick way to cut emissions”, and “Expansion of hydro-electric power, where appropriate, could make a major contribution to lowering greenhouse-gas emissions.” Clearly, our knowledge of the effects of climate change is still developing; there is still uncertainty as to specific effects or the magnitude of those effects. Predictions based on model simulations were used and cited as the basis for reported climate effects.

LIMITATIONS IN INTERPRETING THE RESULTS BASED ON PROJECT ASSUMPTIONS

Wildlife Scope Limitations and Assumptions

- Wildlife covered in this study includes only terrestrial and aquatic vertebrate wildlife and their habitats, not invertebrates such as insects.
- Disturbance to wildlife and wildlife habitat is evaluated for natural habitats, not habitats that are highly disturbed by human activities.

- Analysis of impacts and risks focuses on the total wildlife impact or risk and does not develop a "net" wildlife impact analysis or risk analysis based on the ability of a specific wildlife population or habitat to recover once the stressor is removed.
- Different wildlife effects exhibit different recovery potentials. For some effects, such as above-ground mining, habitat restoration is possible. It was outside the scope of work to consider if, and over what period of time, populations exposed to these risks might recover or what the net effects and results would be. For example, some improvement in the condition of lakes, watersheds, and wildlife has occurred in the last 10 to 20 years resulting from implementation of the Clear Air Act and associated reduction in atmospheric sulfur emissions, especially from coal-fired power plants. This improvement, if it continues, could lower the regional risks and effects. This aspect was not covered in this study.
- For some stressors, exposure, receptor, and effect relationships are known to exist but are not reported in the literature (e.g., loss of habitat from land clearing activities for a power plant). In such cases, professional judgment was used to characterize these effects and risk.
- Certain catastrophic events and associated effects on wildlife, such as a nuclear reactor incident releasing a significant amount of radiation into the environment or a catastrophic breaching of a hydro dam, were not evaluated because of the very low probability of the event occurring and the lack of sufficient information on the resulting wildlife effects.
- Issues dealing with storage and transport of spent radioactive waste have not been resolved and, therefore, have not been evaluated with respect to wildlife risks.

Life Cycle Assessment Limitations and Assumptions

- This study does not advocate reliance on one electricity generation source over another; rather, it characterizes and reports the presently understood risks to wildlife among these electricity generation sources.
- Wildlife and energy policy implications were not within the scope of this study.
- This study does not address the degree to which renewable energy displaces or reduces atmospheric emissions from fossil fuel sources.
- The life cycle assessment does not include wildlife effects from manufacturing of the components of electricity generation facilities (such as climate change effects due to emissions of greenhouse gases from the manufacturing of building materials) or the production and combustion of fuels for transportation.

- The stressors, exposures, and effects only address the impacts from current and existing electricity generation designs, not future designs, policies, or regulations that may reduce or eliminate certain stressor(s) that cause effects to wildlife.
- No attempt was made to quantify and compare the relative wildlife risks by considering electricity generation sources of the same size, such as risk per megawatt (MW). The life cycle risks can vary considerably depending on the size of the facilities. For example, the collision risk with stacks associated with a 500 MW nuclear plant is likely to be considerably smaller than a wind project with hundreds of wind turbines. Therefore, such a comparison is likely to be unrealistic. For some effects, including bird and bat collisions with structures, quantitative information can be developed to characterize the relative contribution of different electricity generation sources to risks.

DATA GAPS

In reviewing the literature and conducting this analysis, a number of data gaps involving the effects and risks to wildlife were identified.

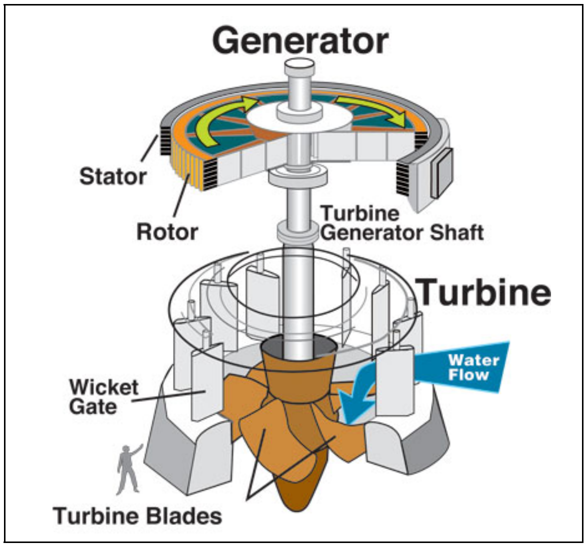
- Stressors and effects on reptiles are not well documented. Compared to other wildlife groups, effects on reptiles are under-reported in the scientific literature.
- Collision risk to birds and bats from wind turbines and transmission lines are widely reported. Equivalent recent information on collision risks associated with stacks and cooling towers have not been systematically reported and are therefore less readily available for quantitative comparison.
- Effects of most air toxics on wildlife have not been measured at the individual level or evaluated at the population level.
- Data on aquatic toxicity from chemical effluents of electricity generating facilities (except wind) are generally limited to standardized laboratory bioassays.

SECTION 2
BACKGROUND INFORMATION

This section considers important background information needed to fully understand the results of the Comparative Ecological Risk Assessment. Section 2.1 briefly explains how electricity is generated, which provides the context for understanding the life cycle stages. Sections 2.2 and 2.3 explain different criteria that have to be considered in order to properly address the various wildlife effects.

HOW ELECTRICITY IS GENERATED

Electricity generation is the process of converting some form of energy into electricity. For all six forms of electricity generation considered here, a turbine must be turned to drive a shaft in a generator. The generator produces electricity by spinning copper coils, or armature, through a magnetic field. A source of energy is needed to turn the turbine. Four of these electricity generation sources (coal, oil, natural gas, and nuclear) turn the turbine by creating heat that is used to boil water, which in turn makes steam that under pressure turns the turbine. The other two electricity generation sources (hydro and wind) turn turbines directly with pressure; water turns a wheel that is connected to a turbine, and wind turns blades that are connected to a turbine.



Simple view of a hydroelectric generator. Source: U.S. Army Corps of Engineers

Before the electricity generation source can turn the turbine, it must be extracted or harnessed. Coal, oil, natural gas, and nuclear materials are extracted from the ground and then transported to the power station, sometimes hundreds or thousands of miles away. Electricity generation by hydro requires a ready source of flowing water (river or reservoir), whereas electricity generation from wind energy requires a steady and reliable wind flow pattern.

Since most electricity is generated in one place and consumed somewhere else, wires are used to transport electricity from where it is made (power station) to where it is used (cities with homes and businesses). This requires a vast network of transmission and distribution lines known as the national grid system.

GENERAL EFFECTS ON WILDLIFE

Electricity generation sources affect wildlife to different degrees and in different ways. In general, three key factors control the status and health of wildlife populations: birth rate, death rate, and availability of habitat. A change in any one of these factors will cause wildlife populations to increase or decrease. Both natural and human activities influence birth rates and death rates of wildlife populations, as well as the presence of wildlife in different habitats. Populations will remain stable when the birth rate equals the death rate, a condition that often exists in high-quality habitat. Changes that affect the birth rate and death rate may occur quickly or slowly, and they may occur over a wide area, such as a region, or locally in a narrowly confined area. This implies that increases or decreases in wildlife populations can be subtle or obvious, depending on how fast and over how wide an area a wildlife population is affected. For example, the populations of many songbirds that spend summers in North America have been declining steadily over the last several decades. There are various causes (such as habitat loss, habitat fragmentation, and predation by domestic cats), but none have been severe enough to cause abrupt die-offs that draw attention to the problem.

There are four categories of adverse effects on wildlife:

1. Physical injury and/or mortality
2. Chemical injury and/or mortality
3. Disruption of normal behavior
4. Destruction and damage of wildlife habitat

Populations of many songbirds that spend summers in North America have been declining steadily over the last several decades.

Physical Injury and/or Mortality

Wildlife can be injured or killed when they come in contact with the equipment and facilities used in all stages of the electricity generation life cycle. Examples include the observations that fish and other aquatic species can become trapped in cooling water intake systems; birds and bats collide with wind turbines, oil structures, distribution lines, power lines, substations, and offshore oil and gas platforms; other wildlife are killed on roads associated with fuel transportation; and bird electrocutions occur on power lines and substations when they come into contact with two energized parts.

Chemical Injury and/or Mortality

Exposure to harmful chemicals can have toxic effects on wildlife. Chronic effects over a long period of time can include mercury (Hg) poisoning from mercury deposition. Acute effects can include accidental spills or other pollution incidents. Some acute effects, such as oil spills, have long-term chronic effects after the immediate polluting effects have passed. Chemical toxicity can cause direct physiological and reproductive effects and behavior changes that can interfere with migration patterns and reproduction, such as egg-laying. For example, mercury levels in the blood of loon chicks can cause behavioral changes (Nocera and Taylor 1998). The quality of forage for grazing animals can be reduced, which affects the availability and nutritional value of food supplies.

Mercury is an example of a natural element that is released by some forms of electricity generation. Under certain environmental conditions, it can be converted by bacteria to a form of organic mercury (called methylmercury), a very toxic chemical prone to bioaccumulation. Persistent chemicals are those that are not easily broken down by the normal activities of organisms like bacteria and fungi. This can lead to biomagnification, during which a chemical is passed up the food chain and is concentrated in the process. Other examples of chemical pollution include acidification of water bodies and the associated release of toxic aluminum that causes habitat degradation and mortality of fish, die off of birds exposed to oil during an oil spill, and mortality to fish and other aquatic organisms from runoff of toxic wastes.

Disruption of Normal Behavior

Noise and other disruptions associated with resource extraction, fuel transportation, and power generation can disturb normal wildlife movements, and, in extreme cases, result in displacement from their normal range. Changes in habitat use can cause disruptions of the normal behavior of wildlife species, which, in turn, can result in decreased reproduction and/or increased mortality. For example, in Prudhoe Bay AK, caribou cows within oil fields gained less weight and exhibited lower calving rates as compared with those outside oil fields. Similarly, calf survival rates were lower for cows inside oil fields compared to cows outside oil fields (Schoen 2008).

Changes in habitat use can cause disruptions of the normal behavior of wildlife species. Caribou cows within oil fields gained less weight and exhibited lower calving rates as compared with those outside oil fields.

<u>Destruction and Damage of Habitat</u>

Effects on terrestrial wildlife habitat include damage to vegetation, soil, food resources, and landscape. These effects may be acute and direct, as occurs when vegetation is cleared and removed from an area. Strip mining of coal in the Appalachian Mountain region causes large-scale habitat loss. Chronic and indirect effects include habitat alteration and fragmentation (e.g., from transmission line corridors, service roads, and elevated pipelines) that can negatively impact the ability of a wildlife species to survive, making it more difficult to find food, shelter, and mates.

Effects on aquatic wildlife habitat include all four of the categories described above. Destruction and damage to aquatic habitats associated with electricity generation include lower water quality and quantity due to a combination of water extraction (to cool power plants, for example) and pollution (from release of waste by-products, such as mine tailings). These can have negative effects on food resources, aquatic vegetation, and spawning grounds. Depleted oxygen levels in estuarine and near-shore marine waters can be one component of the process of eutrophication (a condition caused by overproduction of algae in response to atmospheric deposition of nitrogen oxides emitted by fossil fuel power plants). Siltation or sedimentation is another common by-product of human activity close to water that can seriously degrade the quality of aquatic habitat. Lastly, the impoundment of water behind dams effectively fragments what was a continuous aquatic habitat, causing major disruptions to a wide variety of aquatic wildlife. Construction and dismantling of dams also can result in dramatic loss of terrestrial and aquatic habitats.

HOW AND WHERE THESE EFFECTS OCCUR

The effects of electricity generation on wildlife can be direct or indirect; acute or chronic; individual or cumulative; and local, regional, or global.

A direct effect occurs when a stressor causes direct harm to an individual or population. For example, direct bird injury and mortality can be caused by electrocution and/or collision with power lines and wind turbines or from contact with an oil spill. An indirect effect occurs when the original stressor causes and is responsible for additional harm or secondary effects to the environment. Power line rights-of-way can cause habitat fragmentation, which opens up the forest and increases competition from wildlife that thrive in edge or open habitats. This, in turn, can cause a decline in wildlife adapted to the interior of intact forests, such as the ovenbird and Bicknell’s thrush. Oil spills may have chronic indirect effects that go well beyond the immediate pollution, such as those documented in studies of the Exxon Valdez oil spill in Alaska. More than 300 seals, several thousand sea otters, and 250,000 seabirds were killed (Peterson et al. 2003), some in areas removed from the location of the oil spill. Although there is debate about the long-term effect of this incident (Harwell and Gentile 2006, Landis 2007), the immediate effects were dramatic. Mercury released to the atmosphere by burning fossil fuels (particularly coal) and deposited in a favorable environment, may be transformed by bacteria into methylmercury. Methylmercury accumulates in predators further up the aquatic and terrestrial food chains, sometimes resulting in injury or mortality to the predators.

An **acute effect** is usually severe and occurs quickly to individuals or populations. A **chronic effect** is usually less severe immediately, but occurs from repeated or continuous exposure of an individual or population to a stressor over a longer period of time. Exposure to a stressor and the consequent physiological response also may be separated by a latent period of varying duration. Acute and/or chronic effects may result from exposure to either physical or chemical stressors. This exposure may be continuous, (e.g., atmospheric mercury deposition), periodic (e.g., bird collisions with power lines), or episodic (e.g., large oil spills). The mortality of birds from collisions with wind turbines is an acute effect, while mercury toxicity from exposure through the food chain is chronic. Both acute and chronic effects can be **cumulative** (additive), such as occurs with multiple losses of breeding habitat across an entire region (caused by, for example, large-scale strip mining). A wildlife effect can be **local** (the vicinity of an electricity generating source), **regional** (effects limited to one or more regions), or **global** (changes that occur across continents). The more widespread a wildlife effect is, the more likely it is to affect wildlife populations rather than just individuals.

Acute Effect Example: Bird mortality due to oil spill.
Chronic Effect Example: Decreased brook trout reproduction due to gradual lake water acidification in response to atmospheric sulfur deposition.
Local Effect Example: Bird and bat mortality from collisions with wind turbines.
Cumulative Effect Example: Loss of bird breeding habitat due to multiple effects associated with coal mining and operation of coal-fired power plant.
Regional Effect Example: Mountain-top removal mining causing destruction of habitat for wildlife in West Virginia.
Global Effect Example: Greenhouse gas emissions from coal, oil, natural gas, and hydro power generation that contribute to climate change, which impacts wildlife globally.

The reasons for varying levels of geographical impacts are related to the stressor type, life cycle stage, and distribution. For example, oil extraction in the Gulf of Mexico primarily affects wildlife that live in or pass through the Gulf of Mexico. Conversely air pollutants from power generation inside the NY/NE region are transported by weather patterns to areas inside and outside the NY/NE region, and thus pose a risk to wildlife populations regionally and globally.

SECTION 3
RESULTS: RISKS TO WILDLIFE FROM EACH ELECTRICITY SOURCE

This section describes the specific wildlife effects and risks associated with each type of electricity generation. All the effects and their relative level of risk are shown in tables, but only the effects associated with Highest Potential, Higher Potential, and Moderate Potential are discussed in any detail.

Risks that are common to life cycle stages of several electricity generation sources are discussed in Section 3.1, followed by sections focused on each electricity generation source. Each section illustrates where the risks occur for each life cycle stage, and a table lists the known wildlife effects and the relative level of risk associated with a specific effect. Citations are provided to support the information presented, except in a few cases where no specific reference was found (such as loss of vegetation from site clearing activities for construction of a facility). In such cases, professional judgment was used. Specific examples and case studies are presented where effects and risks have been documented in the NY/NE region, including the vulnerable species and habitats identified by state wildlife action plans.

OVERALL WILDLIFE EFFECTS AND RISKS

All life cycles of electricity generation affect wildlife and, therefore, pose risks to wildlife individuals and populations. The degree and extent of the risks depends on the energy generation source, although some effects are common across life cycle stages of many electricity generation sources. Table 3-1 summarizes the highest wildlife risk level for each electricity generation source during each life cycle stage.

Coal, oil, natural gas, and nuclear (non-renewable) have wildlife risks during each of the six life cycle stages, while hydro and wind (renewable) have wildlife risks in only four of the life cycle stages. This

Table 3-1. The potential highest levels of relative wildlife risks for each life cycle stage of each electricity generation source.

Source	Relative Wildlife Risk Level for Potential Harm					
	Resource Extraction	Fuel Transportation	Construction of Facility	Power Generation	Transmission and Delivery	Decommissioning of Facility
Coal	Highest Potential	Lower Potential	Lower Potential	Highest Potential	Moderate Potential	Lower Potential
Oil	Higher Potential	Highest Potential	Lower Potential	Higher Potential	Moderate Potential	Lower Potential
Natural Gas	Higher Potential	Moderate Potential	Lowest Potential	Moderate Potential	Moderate Potential	Lowest Potential
Nuclear	Highest Potential	Lowest Potential	Lowest Potential	Moderate Potential	Moderate Potential	Lowest Potential
Hydro	None	None	Highest Potential	Moderate Potential	Moderate Potential	Higher Potential
Wind	None	None	Lowest Potential	Moderate Potential	Moderate Potential	Lowest Potential

difference is because non-renewable electricity generation sources have to be extracted from the ground and transported to the facility where electricity will be generated. Renewable electricity generation sources do not require resource extraction and may be harnessed at the location where the electricity is generated.

Resource Extraction

Habitat alteration and spills of various kinds are often associated with the resource extraction phase. Coal, oil, natural gas, and nuclear each use a unique resource extraction process, and the risks are unique to each electricity generation source. The specific effects and risks will be discussed in the individual energy sections. It is recognized that air emissions can be associated with the reprocessing of fuel (e.g., emissions from oil refineries, natural gas clean-up, and nuclear material refining). These were difficult to quantify and are generally captured in the power generation stage.

Fuel Transportation

Coal, oil, natural gas, and nuclear fuels are all transported to the power plant, but oil is the only electricity generation source that has a Highest Potential wildlife risk during transportation, due to the risk of episodic and catastrophic oil spills. The other three do pose wildlife risks during the transportation phase, but all are at Moderate, Lower, or Lowest potential risk levels. Causes of wildlife effects in the fuel transportation stage of these four electricity generation sources include habitat fragmentation caused by pipelines and service roads and wildlife collisions with vehicles transporting fuel to power generation facilities.

Construction of Facility

During the construction of facility stage, only hydro was found to pose Highest Potential risks to wildlife. The other wildlife effects, which are common to all the electricity generation sources, include habitat destruction, wildlife displacement or disturbance, and habitat fragmentation. All of these effects are characterized as posing Lowest to Lower Potential risks to wildlife.

Power Generation

The power generation stage was found to have the most wildlife effects and also poses the highest risks to wildlife within NY/NE and globally. These higher risks are associated with coal, oil, and hydro. The most important effects in this stage are regional and global: climate change, acidic deposition, and mercury bioaccumulation (discussed in Section 3.2). These effects are from multiple electricity generation sources and from generally continuous air emissions, result in Higher to Highest Potential risk levels.

Other power generation effects associated with coal, oil, natural gas, and nuclear pose important local wildlife risks associated with cooling the power plants (entrainment and impingement; Lewis and Seegert 2000), thermal discharge effects, and chemical discharge effects.

Because of current strict regulatory controls, population-level risks from these stressors are now largely avoided; they are, therefore, considered Moderate Potential risks when these electric energy generation facilities use once-through cooling for generators or reactors. During once-through cooling, water is taken in from a water body and run through the facility for cooling purposes. During impingement, the cooling system turbines draw water into the facility causing direct injury or mortality to aquatic wildlife from collisions with the turbines or by getting caught on filtering screens. Thermal discharge effects include injury, mortality, and/or behavioral changes in fish and other aquatic life from the change in temperature of water leaving the facility or plant.

Chemical discharge effects also include injury, mortality and/or behavioral changes in fish, other aquatic life, and/or aquatic dependent wildlife such as wading birds. These effects can be a result of the concentration of salts and contaminants from heated water or accidental discharges of chemical wastes from the plant. These effects pose Moderate Potential risks to wildlife for coal, oil, and nuclear.

Collision is another effect of power generation associated with five of the six electricity generation sources (excluding hydro). Collision effects cause direct and acute injury or mortality to birds and bats that fly into tall structures, such as wind turbines at wind farms and cooling towers and smoke stacks at coal, oil, gas, and nuclear power plants. Except for collisions with wind turbines, these are considered Moderate Potential risks because there is limited individual mortality, no population mortality, and no decline in biodiversity. Three regional and global effects and risks occur in the power generation stage of several electricity generation sources: acidic deposition, climate change, and mercury bioaccumulation. These are described in detail in Section 3.2.

<u>Transmission and Delivery</u>

The transmission and delivery stage of all six types of electricity generation affects wildlife. After electricity is produced it must be moved to the locations where it will be used. This is accomplished through a network of power lines (transmission and distribution lines) and substations. Transmission lines bring high voltage electricity from the power station to a substation. The substation distributes the electricity at a lower voltage to distribution lines. The distribution lines also bring this lower voltage electricity to homes and businesses.

Graphic rendition of one risk of power transmission: wildlife contact with power lines. Power lines pose risk of collision and electrocution to birds and bats.

The largest wildlife effects from the transmission and delivery stage are periodic and episodic wildlife collisions and electrocutions, mainly for birds. Numerous studies have documented these effects and many show that waterfowl, gulls, and wading birds are more susceptible to collisions than other bird groups. Collisions can occur with all types of power lines, but they are more common with higher voltage (>39kV) power lines (transmission lines; APLIC 2006). The type of effects and risk vary depending on the type of power lines. Electrocutions of birds are primarily associated with lower voltage (<39kV) power lines (distribution lines). Different groups of birds are more at risk depending on whether they are exposed primarily to electrocutions (e.g., hawks and eagles) or collisions (e.g., duck and geese).

The transmission and distribution stage presents Moderate Potential risks to birds and some bats for injury and mortality from electrocutions (APLIC 2006) and/or collisions (APLIC 1994). These risks are limited and cause local mortality with no reported population-level effect. Biodiversity declines are unlikely, although endangered or threatened species also may be exposed to collisions or electrocutions. Recent designs have reduced the occurrence of injury and mortality. Habitat fragmentation caused by the maintenance of right-of-ways (ROW) is another effect of this stage. The potential effects to most wildlife from habitat fragmentation are at a Lower Potential risk level (Willard et al. 2004).

Bird Mortality at Power Plant Stacks. Many studies have documented bird mortality from power plant stacks. In a study in Citrus County, Florida, stacks were searched systematically from 1982 to 1986 and 2,301 dead birds were found (Maehr and Smith 1988). From this enumeration, the authors estimated that 541.4 birds were killed per year. Fatalities included 50 species, most of which were neotropical migratory passerines. In Ontario, Canada, systematic surveys over a four-year period yielded 8,531 dead birds. Again, most of these were passerines (Weir 1976; Erickson et al. 2005).

Decommissioning of Facility

At some point, all electricity generation facilities need to be decommissioned, although they may be re-engineered or relicensed many times before they are taken offline. Effects, such as displacement and disturbance, are likely for all electricity generation sources, and injury or mortality are likely from contamination from coal, oil, gas, and nuclear, but these risks are at Lower or Lowest Potential risk levels. For hydro, risks could be at Higher to Moderate Potential risk levels for dam demolition because of downstream habitat degradation from release of sediments built up behind the dam (Stokstad 2006).

REGIONAL AND GLOBAL WILDLIFE EFFECTS AND RISKS

Three regional and global effects and risks occur during the power generation stage of several electricity generation sources: acidic deposition, climate change, and mercury bioaccumulation. Because several electricity generation sources contribute to these effects and risks, they are described in detail here.

Acidic Deposition

Acidic deposition refers to a mixture of wet and dry material deposited from the atmosphere that contains higher than normal amounts of nitric and sulfuric acids. These acids come from both natural sources, such as volcanoes and decaying vegetation, and man-made sources, primarily emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_x) from fossil fuel combustion. In the United States, roughly two-thirds of all SO_2 and one-fourth of all NO_x emissions come from fossil fuel electricity generation. When SO_2 and NO_x are released from power plants and other sources, prevailing winds blow these compounds across state and national borders, sometimes over hundreds of miles (USEPA 2007).

Acidification of NY Lakes. Currently 30% to 65% of Adirondack Lakes are considered to have acidified due to acidic deposition, with 20% to 40% considered moderately acidic and 10% to 25% highly acidic, with pHs below 5.0. Adirondack fish diversity and the number of fishless lakes have been shown to increase as pH decreases. Extinction of fish populations has occurred, with one third of the fishless lakes believed to be fishless because of acidic deposition. (Source: Jenkins et al. 2005).

Sources of acidic deposition impacting the NY/NE region are primarily external to the region, notably from the midwestern United States. Acidic deposition also has been shown to change soil conditions, such as leaching loss of calcium from soils in forest habitats. Calcium depletion can contribute to vegetation damage and mortality, such as in sugar maple (Yani 2005), and it disrupts calcium availability and transport in food chains. In the NY/NE region, these effects have negatively impacted tree species, such as the red spruce and sugar maple, which provide habitat for many species of wildlife (Driscoll et al. 2003a,b).

The two key wildlife effects from acidic deposition are aquatic habitat degradation, including loss of fish and their prey, from water acidification and upland habitat degradation from injury and plant mortality from soil acidification. These effects are indirect and chronic and can result in large-scale population-level mortality and habitat destruction. Therefore, wildlife risks are Highest Potential for coal and Higher Potential for oil. For natural gas, acidic deposition risks are Moderate Potential because the proportional contribution of SO_2 and NO_x is less. While the effects from acidic deposition are global, effects are regionally concentrated (Driscoll et al. 2003a, b; Jenkins et al. 2005; Longcore et al. 1993). For example, hundreds of lakes in the Adirondack Mountains in New York are considered acidified. Acidic deposition also is responsible for episodic acidification events that flush inorganic aluminum from soils into surface waters, causing short-term habitat degradation and fish mortality (NYSERDA 2005a).

In New York State, acidifying pollutants have the greatest effect on wildlife at higher elevations and in areas where soil is already compromised and cannot absorb more acid without damage. Where soils include sufficient quantities of calcium (areas where limestone is common) and other **base cations**, acidic deposition tends to be less of a problem. Higher elevations are often shrouded by clouds, and if these are laced with SO_2 and NO_x, then mountain habitats are exposed to acidity for extended periods. The Adirondack Mountains contain soils that have little calcium. This, together with increased elevation, has resulted in the acidification of many lakes and streams, leading to widespread habitat degradation, both aquatic and terrestrial. The buffering capacity of soils has also been compromised by acidic deposition faster than weathering can replace base cations. This may restrict the ability of lakes to recover from acidification as emissions of SO_2 and NO_x are reduced (Sullivan et al. 2007).

Habitats and Species in the NY/NE Region Vulnerable to Acidic Deposition. The following is a compilation of species and habitats in the NY/NE region considered vulnerable or at risk from acidic deposition by the state wildlife agencies as reported in state wildlife action plans (Maine Department of Inland Fisheries and Wildlife 2005, New Hampshire Fish and Game Department 2005, New York State 2005, Rhode Island Department of Environmental Management 2005, Vermont Department of Fish and Wildlife 2005).

Vulnerable Habitats

- Adirondack Mountain and Catskill Mountain forests in New York and all of Vermont's forests
- Alpine (summits and tablelands above tree line)
- Aquatic and shoreline type communities
- Cliffs and talus slopes
- Coastal waters
- Connecticut River and Merrimack River mainstems

- Deciduous and mixed forest
- Estuarine emergent salt marsh
- Fluvial type communities
- Hardwood swamp
- Hemlock-hardwood-pine forests
- High-elevation spruce forest
- Lacustrine communities
- Lakes and ponds
- Lowland spruce forest
- Montane watersheds
- Vernal pools

Vulnerable Species

<u>Fish</u>

- Eastern brook trout
- Slimy sculpin
- Rainbow smelt

<u>Amphibians</u>

- Jefferson salamander
- Marbled salamander
- Mole salamander

<u>Birds</u>

- American black duck
- American three-toed woodpecker
- Bay breasted warbler
- Bicknell's thrush
- Blackpoll warbler
- Black-throated blue warbler
- Cape May warbler
- Cerulean warbler
- Common loon
- Kentucky warbler
- Louisiana water thrush
- Northern parula
- Olive-sided flycatcher
- Prothonotary warbler
- Red-headed woodpecker
- Rusty blackbird
- Scarlet tanager
- Sharp-shinned hawk
- Spruce grouse
- Tennessee warbler
- Wood thrush
- Worm-eating warbler

<u>Mammals</u>

- American martin
- Cinereous or masked shrew
- Long-tailed or rock shrew
- Northern river otter
- Smokey shrew
- Water shrew

Climate Change

Many chemical compounds found in the Earth's atmosphere, especially carbon dioxide (CO_2), act as greenhouse gases. Greenhouse gases also include methane and nitrous oxide, among others. Coal, oil, and natural gas release CO_2 by burning fossil fuels, while hydro releases methane when organic matter decomposes in water impoundments (WCD 2000, Pacca 2007). Current studies indicate that the increase in greenhouse gas emissions is directly related to burning coal, oil, and other fuels for electricity and heating and to a lesser extent the impounding of water. Coal contributes 82% of the national average greenhouse gas emissions created by electricity generation (USDOE 2008b), while oil, gas, hydro, and other fuels account for the remaining 18%. While these percentages vary across states and regions, local influences may result in greater source fluctuations of greenhouse gases and may be misleading for future planning as opposed to relying on national averages.

Greenhouse gases allow sunlight to enter the atmosphere freely. When sunlight strikes the Earth's surface, some of it is reflected back toward space as infrared radiation (heat). Greenhouse gases absorb this infrared radiation and trap the heat in the atmosphere. Over time, the amount of energy sent from the sun to the Earth's surface should be about the same as the amount of energy radiated back into space, which leaves the temperature of the Earth's surface roughly constant. However, this balance has changed in the last 150 years. The atmospheric levels of several important greenhouse gases have increased by about 25% since large-scale industrialization began around 150 years ago. During the past 20 years, about three-quarters of human-made CO_2 emissions were from burning fossil fuels (USDOE 2008b).

Graphic rendition of one potential consequence of global warming: reduction in polar bear habitat.

Climate change is one of the biggest environmental, economic, and social issues facing the NY/NE region and the world. There already have been documented wildlife effects globally and regionally from climate change (Fischlin et al. 2007, Thomas et al. 2004), and there is great concern that those effects will continue and expand. The following are a few examples of how climate change affects wildlife globally. Climate change has been found to be responsible for massive coral bleaching that has decimated numerous coral reef habitats around the world (Hoegh-Guldberg et al. 2007). Polar habitats are threatened, as evidenced by diminished feeding opportunities for polar bears (Derocher et al. 2004). Climate change also has resulted in range expansion of pest species such as the mountain pine beetle (Carroll and Kurz 2007) and may contribute to the spread of Lyme disease as more temperate conditions increase tick populations (UNFCC 2007).

Decrease of Songbirds and Neotropical Birds in the U.S. from Climate Change. There is a risk that changes in regional climate will change the number of bird species in the U.S. and where they will be found in the future. Price and Glick (2002) estimate that up to 53% of neotropical birds in the Great Lakes region will disappear. Additionally they hypothesize that as regional temperatures rise, bird habitat in the Northern Hemisphere will shrink and songbirds will shift north seeking their preferred habitat and food. When these species move to different ranges, they will face new prey, predators, and competitors, as well as different habitats. So-called "optimal" habitats for many species may no longer exist, at least in the short term, and their former ranges will likely be filled by species from farther south (Price and Glick 2002).

Climate change risks are Highest Potential for coal and Higher Potential for oil. For natural gas and hydro, climate change risks are Moderate Potential because the proportional contribution is less. Climate change effects are complex and range from direct to indirect, acute to chronic, and local to regional and global. The most important wildlife-related climate change effect is habitat change and ultimately habitat loss. Most notably, wildlife populations in habitats that are dependent on colder temperatures are already showing effects from climate change. In the NY/NE region, these effects are most evident in alpine areas and high-elevation forests. These cold-dependent habitats are seeing a reduction in size and are being replaced with more temperate habitats and wildlife species. Ecosystem and habitat loss in response to climate change will result in changes in species population ranges, species abundance, migration, emergence and hibernation, and breeding activities (Price et al. (nd); Frumhoff et al. 2007; Price and Glick 2002; Root et al. 2005; Kerr and Packer 1998).

<u>Habitats and Species in the NY/NE Region Vulnerable to Climate Change</u>. The following is a compilation of species and habitats in the NY/NE region considered vulnerable or at risk from climate change by the state wildlife agencies as reported in state wildlife action plans (Maine Department of Inland Fisheries and Wildlife 2005, New Hampshire Fish and Game Department 2005, New York State 2005, Rhode Island Department of Environmental Management 2005, Vermont Department of Fish and Wildlife 2005).

Vulnerable Habitats

- Adirondack Mountain and Catskill Mountain forests in New York and all of Vermont's forests
- Alpine (summits and tablelands above tree line)
- Coastal islands

- Connecticut River and Merrimack River mainstems
- Hemlock-hardwood pine forest
- High Allegheny bogs and fens
- High elevation spruce-fir
- Mountaintop forest (includes krummholz)
- Northern hemlock coniferous forest

Vulnerable Species

Fish

- American eel

Birds

- American pipit
- American three-toed woodpecker
- Bald eagle
- Bay breasted warbler
- Bicknell's thrush
- Blackpoll warbler
- Canada warbler
- Cape May warbler
- Common loon
- Common tern
- Olive-sided flycatcher
- Rusty blackbird
- Spruce grouse
- Tennessee warbler

Mammals

- American martin
- Lynx

For climate change effects in New York, a specific list of vulnerable bird species was developed by the National Wildlife Federation and American Bird Conservancy (Price and Glick 2002).

Vulnerable Species in New York (Price and Glick 2002)

Species whose future climatic range may be excluded in New York during the summer:

- Least flycatcher
- Bank swallow
- Cliff swallow
- Boreal chickadee
- Redbreasted nuthatch
- Winter wren
- Sedge wren
- Blueheaded vireo
- Philadelphia vireo
- Golden-winged warbler
- Tennessee warbler
- Nashville warbler
- Magnolia warbler
- Cape May warbler

- Yellowrumped warbler
- Black-throated green warbler
- Blackburnian warbler
- Bay-breasted warbler
- Northern waterthrush
- Mourning warbler
- Hooded warbler
- Wilson’s warbler
- Canada warbler
- Claycolored sparrow
- Lincoln’s sparrow
- White-throated sparrow
- Dark-eyed junco
- Rusty blackbird
- Purple finch
- Pine siskin
- Evening grosbeak

Species whose climatic summer ranges in New York might be reduced:

- Tree swallow
- Blackcapped chickadee
- House wren
- Gray catbird
- Warbling vireo
- Blue-winged warbler
- Northern parula
- Yellow warbler
- Chestnut-sided warbler
- Black-throated blue warbler
- Black-and-white warbler
- American redstart
- Ovenbird
- Scarlet tanager
- Tanager
- Rose-breasted grosbeak
- Vesper sparrow
- Savannah sparrow
- Song sparrow
- Swamp sparrow
- Bobolink

Mercury Bioaccumulation

Mercury occurs naturally in the environment in several ways, but the primary sources of mercury to many surfaces waters are emissions from the combustion of fossil fuels and waste incineration. Mercury emissions from coal-fired power plants are the largest single source of mercury in the Northeast and the United States. Mercury also is released into lakes and streams from various industrial sources, such as discharges from wastewater treatment plants and leaching and runoff from industrial facilities and urban areas.

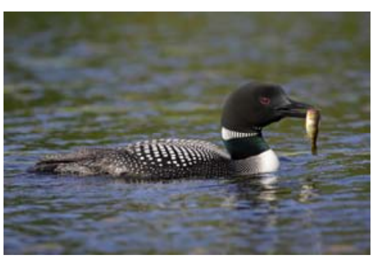
Mercury release occurs during the power generation stage for coal and the construction stage for hydro. Mercury risks are Higher Potential for coal and Moderate Potential for hydro because hydro effects are only regional. Oil and natural gas do not significantly contribute to mercury deposition (Wilhelm and Bloom 1999). Coal releases mercury into the atmosphere through the combustion process during power generation, which causes mercury deposition regionally and globally. Hydro contributes to the mobilization of mercury when water is impounded during construction.

Mercury is transported and deposited in the NY/NE region primarily from other areas in North America, Europe, and Asia, although total mercury deposition coming from New York sources, as estimated at three receptors in New York State, averaged from 11% to 21% (Seigneur et al. 2002). High amounts are deposited in the forests of the Northeast and around large emission sources. Biological mercury hotspots in the Northeast have been identified based on the accumulation of mercury in fish and wildlife. These hotspots range from Nova Scotia to the Adirondack Mountains in New York (Driscoll et al. 2007a). Analysis of lake sediments shows that the current rate of mercury deposition in the Northeast is generally two to five times greater than historical levels (before ~ 60 yrs ago; Perry et al. 2005).

Mercury Contamination In Nearctic-Neotropical Migratory Songbirds in Mountain Forest Ecosystems of Vermont. Mercury contamination has been documented in the blood of Bicknell's thrush (*Catharus bicknelli*) and other species of songbirds in Vermont. Southern parts of the breeding range tended to be at greater risk than northern parts. Overall concentrations of mercury in the blood were significantly greater in wintering areas than in breeding areas. Mercury exposure profiles for four passerine species on Mt. Mansfield, Vermont, indicated greatest methyl-mercury uptake in Bicknell's Thrush and Yellow-rumped Warbler (*Dendroica coronata*) and lowest in Blackpoll Warbler *(Dendroica striata)* and White-throated Sparrow *(Zonotrichia albicollis)*. Adult thrushes had significantly higher concentrations of feather mercury than did young-of-the-year. Older male Bicknell's Thrushes that breed in New England are therefore likely at greatest risk (Rimmer et al. 2005a,b).

Three forms of inorganic mercury generally are present in emissions from combustion sources: elemental mercury, oxidized mercury, and particulate mercury. The problem with mercury in the environment occurs when these emissions are deposited in ecosystems and converted to methylmercury through bacterial transformation. Methylation also converts mercury found in soils (from natural and atmospheric sources) to methylmercury when watersheds are flooded during reservoir formation following the construction of hydro dams.

Methylmercury enters the aquatic food chain at all levels. Fish accumulate methylmercury both through gill absorption and by ingestion of insects and small aquatic species. Small fish are eaten by larger fish, birds,



Species such as the common loon, bald eagle, and river otter have mercury levels above thresholds of concern in the northeastern United States and southeastern Canada.

or mammals, and the mercury becomes concentrated in their tissues through the process of biomagnification. Methylmercury is highly toxic to wildlife as well as to humans. Once certain levels are reached in animals, behavioral, neurological, reproductive, and other physiological effects can occur. High levels of methylmercury have been found in several species in the NY/NE region including yellow perch, mink, common loon, Bicknell's thrush, and bald eagle (Table 3-2).

Table 3-2. Mercury (Hg) levels above thresholds of concern in fish, birds, and mammals in northeastern United States and southeastern Canada.

Species	Sample Size	Mean +/- SD	Range	Hg Level of Concern	% Samples with Hg Concentration > Level of Concern
Brook trout	319	0.31 ± 0.28	< 0.05–2.07	0.16 (whole fish)	75
Yellow perch [a]	(841)[b]	0.23 ± 0.35	< 0.05–3.18	0.16 (whole fish)	48
Common loon [c]	1,546	1.74 ± 1.20	0.11–14.2	3.0 (blood)	11
Bald eagle	217	0.52 ± 0.20	0.08–1.27	1.0 (blood)	6
Mink	126	19.50 ± 12.1	2.80–68.50	30.0 (fur)	11
River otter	80	20.20 ± 9.30	1.14–37.80	30.0 (fur)	15

Source: Adapted from Evers et al. 2007
Note: All data are in wet weight except for fur, which is on a fresh-weight basis.

[a] Whole-body mercury in yellow perch is based on individuals with a standardized length of 13 cm. Whole-body mercury for yellow perch was converted to fillet mercury.
[b] The sample population of 841 yellow perch examined for whole-body mercury is included with the 4089 fillets (i.e., the total number of all biotic data layers does not double-count yellow perch).
[c] Egg mercury for the common loon was converted to the adult blood equivalent.

Thirteen percent of the common loons, a fish eating bird, in the Adirondack Park have been reported to be at risk from the effects of mercury, including risk for behavioral effects and lower reproductive success (Schoch et al. 2007). In another study, songbirds (e.g., red-eyed vireo, palm warbler, and wood thrush) have been found to biomagnify mercury in New York's terrestrial food chain (Duron et al. 2007). Bats in New York have elevated mercury levels, with 16% having mercury concentrations in their fur above levels known to cause toxic effects in laboratory mice (Yates et al. 2007).

Habitat and Species in the NY/NE Region Vulnerable to Mercury Bioaccumulation. The following is a compilation of species and habitats in the NY/NE region considered vulnerable or at risk from mercury bioaccumulation by the state wildlife agencies as reported in state wildlife action plans (Maine Department of Inland Fisheries and Wildlife 2005, New Hampshire Fish and Game Department 2005, New York State 2005, Rhode Island Department of Environmental Management 2005, Vermont Department of Fish and Wildlife 2005).

Vulnerable Habitats

- Lakes and ponds, rivers and streams
- Emergent marshes
- Forested wetlands
- Shrub scrub wetlands
- Mountaintop forest (includes krummholz)
- Alpine (summits and tablelands above tree line)

Vulnerable Species

<u>Fish</u>

- Eastern brook trout
- Yellow perch

Fish consumption advisories in New York State include the Adirondack Park and Catskill Park Regions (New York State Department of Health 2007).

<u>Amphibians</u>

- Jefferson salamander

<u>Birds</u>

- Bald eagle
- Bicknell's thrush
- Common loon
- Common tern
- Nelson's sharptailed sparrow
- Osprey
- Peregrine falcon
- Roseate tern
- Saltmarsh sharptailed sparrow
- Willet

<u>Mammals</u>

- Eastern small-footed bat
- Little brown myotis
- Mink
- Northern long-eared myotis
- Otter
- Puma

<u>Habitat and Species in the NY/NE Region Vulnerable to Multiple Effects</u>. Several habitats and species in the NY/NE region show vulnerabilities from acidic deposition, climate change, and/or mercury bioaccumulation.

Acidic Deposition, Climate Change, and Mercury Bioaccumulation

Vulnerable Habitats

- All Vermont's forests
- Alpine (summits and tablelands above tree line)
- Mountaintop forest (includes krummholz)
- Northern hardwood forest
- Spruce-fir northern hardwood forest

Vulnerable Species

Birds

- Bicknell's thrush
- Common loon

Acidic Deposition and Mercury Bioaccumulation

Vulnerable Species

Fish

- Eastern brook trout

Amphibians

- Jefferson salamander

Acidic Deposition and Climate Change

Vulnerable Species

Birds

- American black duck
- American three-toed woodpecker
- American pipit
- Rusty blackbird
- Spruce grouse
- Blackpoll warbler
- Cape May warbler
- Olive-sided flycatcher
- Tennessee warbler

Mammals

- American marten
- Eastern red bat
- Hoary bat
- Long-tailed or rock shrew
- Lynx
- Northern bog lemming
- Rock vole
- Southern bog lemming
- Water shrew
- Woodland vole

RISKS FROM COAL

Electricity generation from coal has wildlife effects at every stage of its life cycle. Resource extraction and power generation have the greatest number of effects and pose the greatest risk to wildlife. Geographically, the wildlife risks from coal are extensive.

Bulldozing a mountain of coal.

Table 3-3. Reported existing effects and relative wildlife risk levels for potential harm from electricity generation by coal.

Life Cycle Effects – Coal	Relative Level of Risks
Resource Extraction	
Destruction of terrestrial and aquatic habitat from above-ground mining (e.g., strip mining, open pit mining, mountaintop removal mining; Wickham et al. 2007; Weakland and Wood 2002; Mac et al. 1998; Martin and Platts 1981; Yuill 2002).	Highest Potential
Destruction of habitat and wildlife effects is limited in size from below-ground mining (e.g., deep shaft mining versus strip mining).	Lower Potential
Degradation of habitat or direct injury and death to wildlife from toxic (e.g., acid, materials) runoff into water bodies from mining operations; affects all wildlife, including fish and aquatic organisms (USEPA 2000; Mac et al. 1998; Martin and Platts 1981; Boccardy and Spaulding 1968).	Higher Potential
Injury or death to wildlife and habitat from mine fires, e.g., Centralia, PA (Bergerson and Lave 2002).	Lower Potential
Fuel Transportation	
Injury or death to wildlife from vehicle collisions from all types of traffic is limited (Case 1978; Puglisi et al. 1974).	Lower Potential
Injury or death to wildlife and habitat contamination, if any, is limited from fuel spills.	Lowest Potential
Construction of Facility	
Destruction of limited area of habitat through land clearing for facilities (Scientific Certification Systems 2005).	Lower Potential
Loss of habitat through habitat fragmentation from the construction of electric transmission facilities and roads (Willard et al. 2004).	Lower Potential
Possible wildlife disturbance and displacement from construction noise and activity.	Lowest Potential

Power Generation	
Aquatic habitat degradation from acidification of lakes and streams caused by air emissions (e.g., SO_2, NO_x,) deposited as dry and wet deposition, e.g., acidic deposition (Driscoll et al. 2003a,b,c; Jenkins et al. 2005; Lambert and Driscoll (nd); Longcore et al. 1993; Gorham 1998).	Highest Potential
Upland and alpine habitat degradation from injury or death to vegetation caused by acidic deposition (e.g., acidification of soils, calcium leaching; Driscoll et al. 2003b; Lovett and Mitchell 2004; Longcore et al. 1993; Gorham 1998).	Highest Potential
Habitat loss from climate changes caused by greenhouse gas emission (Frumhoff 2007; Rodenhouse et al. 2007).	Highest Potential
Geographical range changes, abundance changes, change in timing of migration or emergence, change in timing of breeding activities, and change in food sources of wildlife from climate change caused by greenhouse gas emissions (Price et al. [nd]; Frumhoff 2007; Price and Glick 2002; Root et al. 2005; Lambert and McFarland (nd); Derocher et al. 2004; Carroll et al. 2007; Kerr and Packer 1998; Root and Schneider 2002).	Highest Potential
Mortality, injury, and behavioral changes to wildlife caused by accumulation of mercury in the food chain from air emissions (Driscoll et al. 2007a,b; Rimmer et al. 2005a,b; Scheuhamer et al. 2007; Bank et al. 2006; Kamman et al. 2005).	Higher Potential
Injury and mortality to birds and bats from collision with vertical structures (e.g., stacks, cooling towers; Temme and Jackson 1979; Maehr et al. 1983; Jain et al. 2007; Veltri and Klem 2004; Avery 1979).	Moderate Potential
Injury, mortality, and behavioral changes in fish from thermal discharge from cooling systems (Bimber and Nigro 1982; NYSDEC 1991).	Moderate Potential
Injury and mortality to aquatic wildlife from cooling water intake systems (entrainment or impingement; e.g., Lewis and Seegert 2000; Acres International Corporation 2005).	Moderate Potential
Injury, mortality, and behavioral changes in fish from chemical discharges to surface waters (e.g., Opresko and Hannon 1979).	Moderate Potential
Mortality, injury, and behavioral changes to wildlife caused by other toxic air emissions (Newman 1980; Newman and Schreiber 1984).	Lower Potential
Transmission and Delivery	
Mortality to birds caused by electrocutions from power lines and substations (APLIC 2006; Manville 2005; Faanes 1987).	Moderate Potential
Injury and mortality to birds from collisions with transmission and distribution lines (APLIC 1994; Manville 2005; Faanes 1987).	Moderate Potential
Habitat fragmentation from maintained ROWs (Willard et al. 2004).	Lower Potential
Decommissioning of Facility	
Limited and local injury and mortality from contamination of aquatic systems caused by mobilizing electricity generation wastes.	Lower Potential
Limited wildlife disturbance and displacement, if any, from demolition process due to noise and activity.	Lowest Potential

Table 3-4. Geographical location of wildlife risks associated with coal.

Resource Extraction	Fuel Transportation	Construction Facility	Power Generation	Transmission and Delivery	Decommissioning of Facility
Appalachia, Midwest, and western regions	NY/NE & other regions	Local	Local, NY/ NE & other regions, globally	Local, NY/NE region	Local

Discussion of Highest, Higher, and Moderate Potential Risks

In the resource extraction stage, the wildlife effects and risks from coal are unique because of the way coal is extracted by above-ground and below-ground mining. Above-ground mining includes strip mining, open pit mining, and mountaintop mining and valley fill. Above-ground mining poses Highest Potential risks to wildlife populations because of the resulting large-scale habitat destruction. For example, mountaintop mining removes the top of a mountain to uncover the coal seams near the surface. The spoils from the removal are dumped in nearby valleys. The wildlife effects are substantial and impact all types of wildlife and habitats including those in the area of the mining and in valleys where the spoils are dumped. For example, 65,000 acres in West Virginia were permitted in 2002 for mountain top removal coal mining; this is where much of the coal for the NY/NE region originates. Comparatively, local risks associated with below-ground mining, such as deep shaft mining, are Lower Potential because little habitat is affected compared to above-ground mining.

Loss of Appalachian Interior Forest Habitat from Mountaintop Removal Mining. Landscape modeling indicates that since 1992, mountaintop mining caused the disappearance of 20% of the interior forest habitat in a 19-county study area in southern West Virginia, southwestern Virginia, and eastern Kentucky. This is a major shift in forest habitat from interior forest to edge forest. Loss of interior forest was 1.75 to 5.00 times greater than the direct loss of forest habitat to mountaintop mining. Since interior forest occupied only 0.4 % of the total forest habitat of the area, it is predicted that the remaining interior forest habitat will be eliminated with the present scope of mountaintop mining (Wickham et al. 2007).

Both above- and below-ground mining also cause habitat degradation and direct injury and death to wildlife from toxic runoff into waterbodies, which creates Higher Potential risks to wildlife. Mine tailings, mine wastes, and coal processing wastes are highly acidic and often contain trace elements at toxic concentrations. The majority (75%) of acid runoff is associated with underground mining (Mac et al. 1998). This acid runoff from mine tailings (acid mine drainage) can reach streams and injure and kill fish and other aquatic wildlife. It is estimated that about 6,400 streams in the mid-Atlantic and southeastern United States have been affected by toxic mine drainage and runoff, primarily from coal mining in West Virginia and Pennsylvania (Herlihy et al. 1990), which are major coal sources for electricity generation in the NY/NE region.

Mid-Atlantic and Southeastern U.S. Streams Affected by Acid Mine Drainage. In 1989, a USEPA survey of 64,300 stream reaches in the mid-Atlantic and southeastern U.S. found that almost 10% of the stream reaches in the Northern Appalachians sub-region were acidic during spring baseflow conditions due to acid mine drainage. An estimated 2852 miles (± 1037) of streams were acidic due to acid mine drainage and another 3591 miles (± 1299) of streams were strongly impacted, but not acidic (Herlihy et al.1990).

Underground mine fire is another unique wildlife effect from coal. Although not a common occurrence, these fires release toxic emissions and can last for years or decades. They pose a Lower Potential risk to wildlife and wildlife habitats in the vicinity of the underground mine fire. Local mortality and habitat destruction have been documented in Centralia, PA, where fires have been burning underground since 1962.

Because coal is a fossil fuel, when it burns during the power generation stage it releases multiple emissions (such as SO_2, NO_x, CO_2, Hg, etc.) that cause regional and global wildlife effects.   As a result, electricity generation from coal is a significant contributor to acidic deposition, climate change, and mercury bioaccumulation, which are Highest or Higher Potential risks to wildlife. These effects also are common to other generation types and were discussed in detail in Section 3.2. Other wildlife effects associated with power generation from coal include collision with power plant facilities and effects from power plant cooling (once-through cooling) and chemical discharges to surface waters. These pose Moderate Potential risks to wildlife. Effects associated with transmission and delivery include injury and mortality from collision and electrocution associated with power lines, which pose Moderate Potential risks as discussed in Section 3.1. Habitats and species vulnerable to effects and risks from fossil fuel electricity generation are identified in the discussion on regional and global wildlife effects and risks from climate change, acidic deposition, and mercury bioaccumulation (Section 3.2).

RISKS FROM OIL

Electricity generation from oil has wildlife effects at every stage of its life cycle. Like coal, resource extraction, fuel transportation, and power generation have the most wildlife effects and pose the greatest risk to wildlife. Oil is the only electricity generation source that has a Highest Potential risk during fuel transportation. Geographically, the wildlife risks from oil are extensive.


Offshore oil rig platform in the ocean.

<u>Discussion of Highest, Higher, and Moderate Potential Risks</u>

The effects and risks to wildlife during the resource extraction stage for oil are different for onshore and offshore drilling. For onshore drilling, the wildlife risks range from Moderate to Higher Potential. Oil pits containing oil wastes are created in the vicinity of onshore oil wells. Wildlife that contact or ingest the oil from the pits are at risk for death or injury, and this can have regional and local population effects.

Most of the oil used for electricity generation in NY/NE originates from outside the region, but small amounts of oil production occur in western New York (Cattaraugus, Allegany, Chautauqua, Steuben, and Erie counties; NYSERDA 2005b). Drilling operations in New York are small-scale and of short duration (NYSERDA 2005b). Thus, the risks from oil extraction in NY/NE region are considered Lower Potential.

Table 3-5. Reported existing effects and relative wildlife risk levels for potential harm from electricity generation by oil.

Life Cycle Effects – Oil	Relative Level of Risks
Resource Extraction	
Injury or death to wildlife and habitat degradation from oil spills and wastes in oil pits from onshore extraction (Trail 2006; Ramirez 1999).	**Higher Potential**
Injury or death to wildlife and habitat degradation from accidental oil spills and discharge of cuttings and production water as a result of offshore oil exploration and extraction (Burger 1997).	**Moderate Potential**
Injury and mortality to wildlife (e.g., birds and bats) from collision with offshore oil and gas platforms (Russell 2005).	**Moderate Potential**
Injury and mortality to wildlife (birds) from exposure to toxic emissions and fire from stacks of onshore and offshore oil and gas platforms (Bjorge 1987; Manville 2005).	**Moderate Potential**
Fuel Transportation	
Injury or death to wildlife and habitat contamination, especially aquatic habitats, from oil spills (Samuels and Ladino 1984; Piatt and Roseneau 1999; Burger 1997; Landis 2007; Peterson et al. 2003; Harwell and Gentile 2006).	**Highest Potential**
Habitat fragmentation along ROW leading to invasion of edge species and displacement of interior species, barriers to wildlife movement. In Alaska, interference with migrating caribou populations could occur (Argonne National Laboratory 2001).	**Higher Potential**
Construction of Facility	
Destruction of habitat through land clearing for facilities (smaller footprint than coal facility; Scientific Certification Systems 2005).	**Lowest Potential**
Wildlife disturbance and displacement from construction noise and activity.	**Lowest Potential**
Loss of habitat through habitat fragmentation from the construction of electric transmission facilities and roads.	**Lower Potential**
Power Generation	
Aquatic habitat degradation from acidification of lakes and streams caused by air emissions (e.g., SO_2, NO_x) deposited as dry and wet deposition, such as acidic deposition (Driscoll et al. 2003a,b,c; Jenkins et al. 2005; Lambert and Driscoll (nd); Longcore et al. 1993; Gorham 1998).	**Higher Potential**
Upland and alpine habitat degradation from injury or death to vegetation caused by acidic deposition (e.g., acidification of soils, calcium leaching; Driscoll et al. 2003b; Lovett and Mitchell 2004; Longcore et al. 1993; Gorham 1998).	**Higher Potential**
Habitat loss from climate changes caused by greenhouse gas emissions (Frumhoff 2007; Rodenhouse et al. 2007).	**Higher Potential**
Geographical range changes, abundance changes, change in timing of migration or emergence, change in timing of breeding activities, and change in food sources of wildlife from climate change caused by greenhouse gas emissions (Price et al. [nd]; Frumhoff 2007; Price and Glick 2002; Root et al. 2005; Lambert and McFarland (nd); Derocher et al. 2004; Carroll et al. 2007; Kerr and Packer 1998; Root and Schneider 2002).	**Higher Potential**
Injury and mortality to birds and bats from collision with vertical structures (e.g., stacks, cooling towers; Temme and Jackson 1979; Maehr et al. 1983; Jain et al. 2007; Veltri and Klem 2004; Avery 1979).	**Moderate Potential**
Injury, mortality, and behavioral changes in fish from thermal discharge from cooling systems (Bimber and Nigro 1982; NYSDEC 1991).	**Moderate Potential**
Injury and mortality to aquatic wildlife from cooling water intake systems (entrainment or impingement; e.g., Lewis and Seegert 2000; Acres International Corporation 2005).	**Moderate Potential**
Injury, mortality, and behavioral changes in fish from chemical discharges to surface waters (e.g., Opresko and Hannon 1979).	**Moderate Potential**

Mortality, injury, and behavioral changes to wildlife caused by accumulation of mercury in the food chain from air emissions (Driscoll et al. 2007; Rimmer et al. 2005a,b; Scheuhamer et al. 2007; Bank et al. 2006; Kamman et al. 2005).	**Lower Potential**
Mortality, injury, and behavioral changes to wildlife caused by toxic air emissions (Newman 1980; Newman and Schreiber 1984).	**Lower Potential**
Transmission and Delivery	
Mortality to birds caused by electrocutions from power lines and substations (APLIC 2006; Manville 2005; Faanes 1987).	**Moderate Potential**
Injury and mortality to birds from collisions with transmission and distribution lines (APLIC 1994; Manville 2005; Faanes 1987).	**Moderate Potential**
Habitat fragmentation from maintained ROWs (Willard et al. 2004).	**Lower Potential**
Decommissioning of Facility	
Injury and mortality from contamination of aquatic systems caused by mobilizing electricity generation wastes and oil spills from decommissioning refineries.	**Lower Potential**
Wildlife disturbance and displacement from demolition process due to noise and activity.	**Lowest Potential**

Table 3-6. Geographical location of wildlife risks associated with oil life cycle stages.

Resource Extraction	Fuel Transportation	Construction of Facility	Power Generation	Transmission of Facility	Decommissioning of Facility
Gulf Coast; Alaska, New York, other states; Canada	Oceans and coastal regions, NY/NE and other regions	Local	Local, NY/NE and other regions, globally	NY/NE	Local

Offshore oil extraction can result in injury or death to wildlife and habitat degradation from spillage and discharge of drilling muds, cuttings, and production water (New England Aquarium 1984). These risks are considered Moderate Potential because the effects generally are limited to the vicinity of the drilling range. There are no population-level effects from mortality and habitat destruction. Endangered or threatened species such as whales may be exposed, but the effects are not at the population level.

Onshore and offshore extraction put wildlife at risk from toxic emissions and from fire from flare stacks, which cause bird mortality and are considered Moderate Potential wildlife risks. The flare stacks and offshore platforms also cause collisions. Studies in the Gulf of Mexico show that periodic collisions with oil and gas platforms can occur for migrating birds, primarily neotropical migrants. These are considered Moderate Potential risks with local mortality, but they do not have population-level effects. The exposure is greatest during the migratory seasons and with conditions of low visibility.

Oil is the only electricity generation source that was found to have Highest Potential risks during the fuel transportation stage. Oil is transported to power plants by pipeline, oil tanker, or barge. Injury, death, and habitat contamination are documented effects of fuel spills from barges and tankers. These risks are

> **Collision of Seabirds with Drilling Platforms in the North Atlantic.** Seabirds aggregate around oil drilling platforms and rigs in above average numbers due to night lighting, flaring, food, and other visual cues. Bird mortality has been documented as resulting from collisions due to impact with the structure as well as from oiling and incineration by the flare. The environmental circumstances for offshore fossil fuel extraction in the northwest Atlantic are unique because of the harsh climate, cold waters, and the enormous seabird concentrations that inhabit and move through the Grand Banks in autumn (storm-petrels, *Oceanodroma* spp), winter (dovekies, *Alle alle;* murres, *Uria* spp), spring and summer (shearwaters, *Puffinus* spp). Many species are attracted to artificial light sources. Most of the seabirds in the region are long-distance migrants. Fossil fuel extraction in the northwest Atlantic could affect both regional and global breeding populations (Wiese et al. 2001).

characterized as Highest Potential with large-scale population-level mortality and habitat destruction (Samuels and Ladino 1984). Although these spills are relatively infrequent, the extent can be widespread, such as in the Exxon Valdez oil spill in Alaska (Burger 1997). The pipelines used to transport oil pose a Higher Potential risk to some wildlife because of habitat fragmentation and destruction. Pipelines can act as barriers to wildlife movement. For example, in Alaska, studies have shown population declines and changes in wildlife behavior, such as in Barren Ground Caribou migration patterns.

Like coal, oil has many wildlife effects during the power generation stage that pose Higher and Moderate Potential wildlife risks. Because oil is a fossil fuel, when it burns it releases multiple emissions that cause regional and global wildlife effects, although to a lesser extent than coal. As a result, power generation from oil contributes to acidic deposition and climate change, which pose Higher Potential risks to wildlife, and to a minor extent mercury bioaccumulation. Because of the relatively low amounts of mercury in oil emissions compared to coal, a Lower Potential risk is assigned. These effects are common to other generation sources and were discussed in detail in Section 3.2. Other wildlife effects associated with power generation from oil include collisions with power plant facilities and effects from power plant cooling (once-through cooling) and chemical discharges to surface waters, which pose Moderate Potential risks to wildlife.

Effects associated with transmission and delivery pose Moderate Potential risks, as discussed in Section 3.1. These include injury and mortality from collisions and electrocutions associated with power lines.

Habitats and Species in the NY/NE Region Vulnerable to Oil Spills. The following is a compilation of species and habitats in the NY/NE region considered vulnerable or at risk from oil spills by the state wildlife agencies as reported in state wildlife action plans (Maine Department of Inland Fisheries and Wildlife 2005, New Hampshire Fish and Game Department 2005, New York State 2005, Rhode Island Department of Environmental Management 2005, Vermont Department of Fish and Wildlife 2005).

Vulnerable Habitats

- Estuarine emergent salt marshes
- Lakes and ponds
- Marine open water areas
- Rocky coastline sand islands

Vulnerable Species

<u>Birds</u>

- Leach's storm petrel
- Long tailed duck
- Red knot
- Ruddy turnstone
- Saltmarsh sharp-tailed sparrow
- Sanderling
- Short-billed dowitcher
- Whimbrel

<u>Mammals</u>

- Fin whale
- Northern right whale
- Sei whale
- Sperm whale

RISKS FROM NATURAL GAS

Electricity generation from natural gas has wildlife effects at every stage of its life cycle. As is the case for coal, fuel extraction and power generation have the most wildlife effects and pose the greatest risk to wildlife. Geographically, the wildlife risks from natural gas are extensive.

Gas power plant.

<u>Discussion of Highest, Higher, and Moderate Potential Risks</u>

As is the case for oil, natural gas has documented population effects during the fuel extraction stage. Gas extraction is similar to oil extraction and is often done simultaneously with oil drilling. The wildlife risks are Higher Potential for oil pits associated with obtaining natural gas from onshore crude oil pumping. Offshore gas extraction can result in injury or death to wildlife and habitat degradation from spillage and discharge of drilling muds, cuttings, and production water; these are Moderate Potential risks. Bird mortality from contact with the toxic emissions and fire from flare stacks can occur and is considered a Moderate Potential risk. Injury and mortality to wildlife (e.g., birds and bats) from collision with offshore gas platforms poses Moderate Potential risks with limited and local mortality and no population-level effects.

Table 3-7. Reported existing effects and relative wildlife risk levels for potential harm from electricity generation by natural gas.

Life Cycle Effects – Natural Gas	Relative Level of Risks
Resource Extraction	
Injury or death to wildlife and habitat degradation from oil spills and wastes in oil pits when natural gas is extracted from onshore crude oil pumping (Trail 2006).	**Higher Potential**
Injury or death to wildlife and habitat degradation from accidental oil spills and discharge of drilling muds, cuttings, and production water as a result of simultaneous offshore oil and natural gas exploration and extraction (Burger 1997).	**Moderate Potential**
Injury and mortality to wildlife (e.g., birds and bats) from collision with offshore oil and gas platforms (Russell 2005).	**Moderate Potential**
Injury and mortality to wildlife (birds) from exposure to toxic emissions and fire from stacks of onshore and offshore oil and gas platforms (Bjorge 1987; Manville 2005).	**Moderate Potential**
Fuel Transportation	
Habitat fragmentation along pipeline ROW leading to invasion of edge species and displacement of interior species. Pipeline gas leaks (e.g., methane, a contributor to greenhouse gasses; Litto et al. 2006).	**Moderate Potential[1]**
Construction of Facility	
Destruction of habitat through land clearing for facilities.	**Lowest Potential**
Wildlife disturbance and displacement from construction noise and activity.	**Lowest Potential**
Loss of habitat through habitat fragmentation from the construction of electric transmission facilities and roads (Willard et al. 2004).	**Lowest Potential**
Power Generation	
Aquatic habitat degradation from acidification of lakes and streams caused by air emissions (e.g., SO_2, $NO_{x,}$) deposited as dry and wet deposition, e.g., acidic deposition (Driscoll et al. 2003a,b,c; Jenkins et al. 2005; Lambert and Driscoll (nd); Longcore et al. 1993; Gorham 1998).	**Moderate Potential[1]**
Upland and alpine habitat degradation from injury or death to vegetation caused by acidic deposition (e.g., acidification of soils, calcium leaching; Driscoll et al. 2003b; Lovett and Mitchell 2004; Longcore et al. 1993; Gorham 1998).	**Moderate Potential[1]**
Habitat loss from climate changes caused by greenhouse gas emission (Frumhoff 2007; Rodenhouse et al. 2007).	**Moderate Potential[1]**
Geographical range changes, abundance changes, change in timing of migration or emergence, change in timing of breeding activities and change in food sources of wildlife from climate change caused by greenhouse gas emission (Price et al. [nd; Frumhoff 2007; Price and Glick 2002; Root et al. 2005; Lambert and McFarland (nd); Derocher et al. 2004; Carroll et al. 2007; Kerr and Packer 1998; Root and Schneider 2002).	**Moderate Potential[1]**
Injury, mortality, and behavioral changes in fish from thermal discharge from cooling systems (Bimber and Nigro 1982; NYSDEC 1991).	**Moderate Potential**
Injury and mortality to aquatic wildlife from cooling water intake systems (entrainment or impingement; e.g., Lewis and Seegert 2000; Acres International Corporation 2005).	**Moderate Potential**
Injury, mortality, and behavioral changes in fish from chemical discharges to surface waters (e.g., Opresko and Hannon 1979).	**Lower Potential**
Injury and mortality to birds and bats from collision with vertical structures (e.g., stacks, cooling towers; Temme and Jackson 1979; Maehr et al. 1983; Jain et al. 2007; Veltri and Klem 2004; Avery 1979).	**Moderate Potential**
Mortality, injury, and behavioral changes to wildlife caused by toxic air emissions (Newman 1980; Newman and Schreiber 1984).	**Lowest Potential**

Transmission and Delivery	
Mortality to birds caused by electrocutions from power lines and substations (APLIC 2006; Manville 2005; Faanes 1987).	**Moderate Potential**
Injury and mortality to birds from collisions with transmission and distribution lines (APLIC 1994; Manville 2005; Faanes 1987).	**Moderate Potential**
Habitat fragmentation from maintenance of transmission facilities (Willard et al. 2004).	**Lower Potential**
Decommissioning of Facility	
Injury and mortality from contamination of aquatic systems caused by mobilizing electricity generation wastes.	**Lowest Potential**
Wildlife disturbance and displacement from demolition process due to noise and activity.	**Lowest Potential**

[1] Although natural gas contributes to overall risks from acidic deposition and climate change, the contribution to these risks from natural gas emissions is proportionally low. To account for this we have assigned a risk level of Moderate Potential for all climate change and acidic deposition risks attributed to natural gas.

Table 3-8. Geographical location of wildlife risks associated with natural gas life cycle stages.

Resource Extraction	Fuel Transportation	Construction of Facility	Power Generation	Transmission and Delivery	Decommissioning of Facility
Louisiana, New Mexico, New York, Oklahoma, Texas, and Wyoming; Canada	NY/NE & other regions	Local	Local, NY/NE & other regions, globally	NY/NE	Local

As with oil drilling, gas drilling operations in New York are small scale and of short duration (NYSERDA 2005b). As a consequence, the risks for fuel extraction in the NY/NE regional are considered Lower Potential.

Fuel transportation effects from natural gas are Moderate Potential risks (rather than Highest Potential risks like oil) because gas leaks (e.g., methane) from pipelines do not affect wildlife unless a fire starts. However, methane gas leaks are significant contributors to greenhouse gasses (Litto et al. 2006).

Like coal and oil, power generation from natural gas contributes to risks from acidic deposition and climate change. However, the proportional contribution is less, and thus a risk of Moderate Potential is assigned. These effects also are common to other generation types and were discussed in detail in Section 3.2. Like coal and oil, other wildlife effects associated with the power generation from natural gas include collision with power plant

Birds Killed at an Oil Industry Flare Stack in Northwest Alberta.
Approximately 3,000 individuals of at least 26 species were found dead within 75 m of a 104-m flare stack in late May 1980. Warblers of 12 species accounted for 77% of all identified birds, with Yellow Warbler and Blackpoll Warbler the most abundant. The presence of pulmonary congestion and edema in specimens examined suggests that death may have been related to stack emissions. Death from striking the tower or guy wires was unlikely for the majority of casualties (Bjorge 1987).

facilities and effects from power plant cooling (depending on the type of cooling, i.e., once-through cooling), which pose Moderate Potential risks to wildlife.

Effects associated with transmission and delivery for natural gas include injury and mortality from collision and electrocution associated with power lines, which pose Moderate Potential risks as discussed in Section 3.1. Habitats and Species vulnerable to fossil fuel electricity generation are identified in the discussion on regional and global wildlife effects and risks from climate change, acidic deposition, and mercury bioaccumulation (Section 3.2).

RISKS FROM NUCLEAR POWER

Electricity generation from nuclear power has wildlife effects at every stage of its life cycle. Unlike fossil fuel electricity generation sources, nuclear does not pose any population-level risks to wildlife in the United States. Geographically, the wildlife risks from nuclear are either local or regional, depending on the particular life cycle stage.

A nuclear power plant on the Hudson River in New York State.

<u>Discussion of Highest, Higher, and Moderate Potential Risks</u>

Similar to coal, the effects from resource extraction from above-ground surface mining have a Highest Potential risk to wildlife because of the amount of surface habitat that is destroyed. Below-ground mining is considered to have a Lower Potential because of the limited habitat disturbance associated with underground mining compared to above-ground surface mining. Toxic runoff from mining tailings has a Moderate Potential risk for injury and death to wildlife.

During the power generation stage, nuclear power plants, like coal-fired power plants, create incredible amounts of heat and require water to cool the generator. If the cooling process involves drawing water from a lake, river, or ocean (such as in once-through cooling), it poses Moderate Potential risks to wildlife. Other wildlife effects associated with power generation from nuclear include collisions with facilities and effects from chemical discharges to surface waters, which pose Moderate Potential risks to wildlife.

Table 3-9. Reported existing effects and relative wildlife risk levels for potential harm from electricity generation by nuclear power.

Life Cycle Effects – Nuclear Power	Relative Level of Risks
<u>Resource Extraction</u>	
Destruction of terrestrial and aquatic habitat from above-ground mining.	**Highest Potential**
Loss of habitat from below-ground mining (e.g., *in-situ* mining).	**Lower Potential**
Degradation of habitat or direct injury and death to wildlife from toxic (e.g., acid, radioactive materials) runoff into water bodies from mining operations. Affects all wildlife, including fish and aquatic organisms.	**Moderate Potential**
<u>Fuel Transportation</u>	
Injury or death to wildlife from vehicle collisions associated with fuel transportation.	**Lowest Potential**
<u>Construction of Facility</u>	
Destruction of habitat through land clearing for facilities (small footprint).	**Lowest Potential**
Wildlife disturbance and displacement from construction noise and activity.	**Lowest Potential**
Loss of habitat through habitat fragmentation from the construction of electric transmission facilities and roads.	**Lowest Potential**
<u>Power Generation</u>	
Injury and mortality to birds and bats from collision with vertical structures (e.g., cooling towers; Temme and Jackson 1979; Maehr et al. 1983; Jain et al. 2007; Rybak et al. 1973; Veltri and Klem 2004; Avery 1979).	**Moderate Potential**
Injury, mortality, and behavioral changes in fish from thermal discharge from cooling systems (Bimber and Nigro 1982; NYSDEC 1991).	**Moderate Potential**
Injury and mortality to aquatic wildlife from cooling water intake systems (entrainment or impingement; e.g., Lewis and Seegert 2000).	**Moderate Potential**
Injury, mortality, and behavioral changes in fish from chemical discharges to surface waters (e.g., Opresko & Hannon 1979; Meyers-Schone and Talmage 2003).	**Moderate Potential**
Mortality, injury, and behavioral changes to wildlife caused by accumulation of radioactive materials in the food chain from accidental emissions and waste materials.	**Lowest Potential**
<u>Transmission and Delivery</u>	
Mortality to birds caused by electrocutions from power lines and substations (APLIC 2006; Manville 2005; Faanes 1987).	**Moderate Potential**
Injury and mortality to birds from collisions with transmission and distribution lines (APLIC 1994; Manville 2005; Faanes 1987).	**Moderate Potential**
Habitat fragmentation from maintenance of transmission facilities.	**Lower Potential**
<u>Decommissioning of Facility</u>	
Injury and mortality from contamination of aquatic systems caused by radioactive leaks (Meyers-Shone and Talmage 2003).	**Lowest Potential**
Wildlife disturbance and displacement from demolition process due to noise and activity.	**Lowest Potential**

Table 3-10. Geographical location of wildlife risks associated with nuclear power life cycle stages.

Resource Extraction	Fuel Transportation	Construction of Facility	Power Generation	Transmission and Delivery	Decommissioning of Facility
Operating mines in Texas, Wyoming, Nebraska; abandoned mines in the southwestern U.S. and Colorado Plateau regions	NY/NE & other regions	Local	Local, NY/NE region	NY/NE	Local

Nuclear energy has the potential for accidental or catastrophic release of radioactive materials. In this event, the wildlife risks would be large; however, there have been no such occurrences in the United States and for good reason. The worst example outside the United States was the Chernobyl accident in the former Soviet Union; the associated wildlife effects from this would be characterized as Higher Potential risks. The likelihood of a similar instance in the NY/NE region is virtually nonexistent because the faulty Chernobyl-style reactor design and its lack of containment would not be licensed in the United States. The most serious accident in the history of U. S. nuclear facilities was a partial meltdown of the Three Mile Island-2 reactor core in 1979. This resulted in only very small offsite releases of radioactivity but had a huge effect on regulatory oversight by the Nuclear Regulatory Commission, with an end result of substantially enhanced safety (USNRC 2007, NEI 2007, Rhodes 1993). Therefore, the wildlife effects from a catastrophic nuclear power event were not considered in this study. There is, however, a Lowest Potential risk that injury and mortality may occur during nuclear power generation from accidental release of a small amount of radioactive emissions or effluent discharge. There may be some bioaccumulation of strontium-90, but this would likely be limited to individuals and not populations.

***M*igratory Bird Mortality at Nuclear Power Plants.** In 1979, a study was conducted of migratory bird mortality from collisions with cooling towers and other associated structures at the Davis-Besse Nuclear Power Plant on the southeast shore of Lake Erie near Port Clinton, New York. The majority of birds that collided with the tower were small songbirds. Most were nocturnal migrating species, especially warblers (family Parulidae), vireos (Vironidae), and kinglets (Sylviidae). During the spring migrations, 483 carcasses (30.9%) were found, consisting mostly of warblers (55.7%), fringillids (10.4%), and others, which included rails, thrushes, blackbirds, vireos, brown creepers, woodpeckers, and pigeons. Golden-crowned kinglets and ruby-crowned kinglets rarely were found in spring at the Davis-Besse structures. In fall seasons after nesting, kills (1071 specimens [68.9%]) were more frequent because of the higher numbers of birds migrating. Again, warblers were most affected (56.5%). Both species of kinglets, (23.0%) were well represented (in contrast to the spring seasons), while the numbers of mimids and finches were lower. Late in the season, both species of kinglets, magnolia warbler, yellowthroat, and the red-eyed vireo were found in relatively large numbers. Seventy-seven percent of the carcasses were found around the cooling tower. The remainder of dead birds were found around the power block (14%) and the meteorological tower (7%). Although waterfowl were abundant, no dead waterfowl were found (Temme and Jackson 1979).

Like fossil fuels, nuclear energy facilities (e.g., stacks and cooling towers) also can result in collision mortality, posing Moderate Potential risks to wildlife. Effects associated with the transmission and delivery stage include injury and mortality from collisions and electrocutions associated with power lines, which pose Moderate Potential risks, as discussed in Section 3.1.

State wildlife plans did not identify any specific vulnerable habitat and species at risk in the NY/NE region from nuclear power electricity generation.

A dam on the Genesee River in New York State.

RISKS FROM HYDRO

Electricity generation from hydro has only four stages in its life cycle stage and each has wildlife effects. Like wind, hydro is renewable energy, and the water needed to generate electricity is harnessed at the source. Hydro is the only electricity generation source that has high risks during the construction and decommissioning stages. Geographically, most of the wildlife risks from hydro are local or regional.

Discussion of Highest, Higher, and Moderate Potential Risks

The risk to wildlife from construction of a hydro power plant is at the Highest Potential level because of the terrestrial and aquatic habitat clearing and the inundation of these habitats when the reservoir or impoundment is filled with water. The loss of habitat includes not only the inundated terrestrial watershed,

Table 3-11. Reported existing effects and relative wildlife risk levels for potential harm from electricity generation by hydro.

Life Cycle Effects – Hydro	Relative Level of Risks
Resource Extraction	**N/A**
Fuel Transportation	**N/A**
Construction of Facility	
Destruction of habitat through land clearing for facilities (Nilsson and Berggren 2000).	**Highest Potential**
Loss of habitat (e.g., spawning-fish, foraging, nesting) through reservoir or impoundment filling process (Nilsson and Berggren 2000).	**Highest Potential**
Wildlife disturbance and displacement from construction noise and activity.	**Lower Potential**
Loss of habitat through habitat fragmentation from the construction of electric transmission facilities and roads.	**Lower Potential**
Change in species composition and populations caused by dams blocking upstream movement of fish (e.g., annual migration of fish from oceans to fresh water streams, normal fish movement; Poff and Hart 2002; Wentworth 2004; Goode 2006).	**Higher Potential**
Invasion of exotic plants and animals (Johnson et al. 2008).	**Moderate Potential**
Habitat loss and effects to wildlife from climate changes caused by greenhouse gas emissions. Methane release from reservoir management practices (Pacca and Horvath 2002; Pacca 2007; Frumhoff 2007; Rodenhouse et al. 2007).	**Moderate Potential**[1]
Geographical range changes, abundance changes, change in timing of migration or emergence, change in timing of breeding activities and change in food sources of wildlife from climate change caused by greenhouse gas emission (Price et al. [nd]; Frumhoff 2007; Price and Glick 2002; Root et al. 2005; Lambert and McFarland (nd); Derocher et al. 2004; Carroll et al. 2007; Kerr and Packer 1998; Root and Schneider 2002).	**Moderate Potential**[1]
Mortality, injury, and behavioral changes to wildlife caused by methylation of mercury through flooding of the watershed (Zillioux et al. 1993).	**Moderate Potential**
Power Generation	
Injury and mortality to aquatic wildlife from water release to generate power (entrainment or impingement; Acres International Corp. 2005).	**Moderate Potential**
Fish mortality downstream from low oxygen discharge from hydro dams.	**Lower Potential**
Transmission and Delivery	
Mortality to birds caused by electrocutions from power lines and substations (APLIC 2006; Manville 2005; Faanes 1987).	**Moderate Potential**
Injury and mortality to birds from collisions with transmission and distribution lines (APLIC 1994; Manville 2005; Faanes 1987).	**Moderate Potential**
Habitat fragmentation from maintenance of transmission facilities (Willard et al. 2004).	**Lower Potential**
Decommissioning of Facility	
Mortality to wildlife and degradation of downstream aquatic habitat from release of sediments due to dismantled reservoirs (Doyle et al. 2000; Shafroth et al. 2002; Pizzuto 2002).	**Higher Potential**
Loss of created upstream aquatic habitat (lake systems) from dismantling of dams (Shafroth et al. 2002).	**Higher Potential**
Mortality or higher predation rates to upstream aquatic wildlife (fish) as drawdown occurs in the dismantling of dams.	**Moderate Potential**
Wildlife disturbance and displacement from demolition process due to noise and activity.	**Lowest Potential**

[1] Although greenhouse gas emissions from all sources account overall for Highest Potential population risks, contribution to these risks from emissions from impoundments is proportionally low. To account for this we have assigned a risk level of Moderate Potential for all climate change risks attributed to hydro.

Table 3-12. Geographical location of wildlife risks associated with hydro life cycle stages.

Resource Extraction	Fuel Transportation	Construction of Facility	Power Generation	Transmission and Delivery	Decommissioning of Facility
Not a part of the life cycle	Not a part of the life cycle	Local	Local, NY/NE and other regions, globally	NY/NE	Local

but also the stream or river habitats, which poses risks to spawning, foraging, and nesting habitats for fish. This stressor can affect hundreds of acres of terrestrial habitats and tens of miles of stream habitat within the watershed when the reservoir is filled with water. There is also risk of reduction or change in wildlife and fisheries biodiversity. Changes in species composition and populations caused by dams blocking upstream movement of fish can have large-scale reproduction implications for fish (e.g., blocking normal fish movement and migration to spawning habitat). Depending upon the location of the dam, there could be a threat to species survival regionally and biologically significant habitat loss for endangered or threatened species. The consequences of the risk are continuous as long as the dam is in place.

Fish Spawning Habitat Loss. Numerous studies in the NY/NE region show the impact of hydro development on fish spawning habitat. In New York, herring stocks have been greatly reduced because of blockage of available suitable spawning and nursery habitat. In the 1920s, a series of dams built on the lower reaches of the Susquehanna River in Maryland closed off one of the largest rivers used by American shad. Historically, these fish traveled as much as 300 miles inland from Chesapeake Bay to spawn at Binghamton, New York (NYSDEC 2007). This type of impact has also been documented in Vermont where the construction of the Peterson Dam in 1948 eliminated most of the historical spawning habitat used by salmon, walleye, sturgeon, and other fishes. The dam is the first barrier encountered by fish moving upstream from Lake Champlain. The lost habitat has affected six endangered species, two threatened species, and six rare fish and mussel species (Wentworth 2001).

The impounded water in hydro dams is a source of methylmercury formation (Bodaly et al. 1984), the result of flooding of habitats. This flooding mobilizes mercury in the watershed, creating conditions that stimulate bacterial transformation of inorganic mercury to methylmercury, its most toxic form. Natural mercury and atmospherically deposited mercury accumulated over long periods from both natural and anthropogenic sources might be mobilized as a result of disturbance of wetlands systems (Zillioux et al. 1993). Methylmercury formed from bacterial actions in impoundments bioaccumulates in the aquatic and terrestrial food chains and can lead to mortality, injury, and behavioral changes. Mercury emission from coal electricity generation poses a Higher Potential risk. With hydropower, mercury is typically not released in such large quantities into the atmosphere, so the effects are primarily local to the affected watershed, and the risks are considered Moderate Potential. Greenhouse gases also are emitted from the impounded water of a hydro dam (WCD 2000, Pacca 2007). As discussed in Section 3.2 the greenhouse gases from hydro pose Moderate Potential risks to wildlife from the effects of climate change.

During dam operation, upstream fish are injured and killed during releases of water when they become trapped (entrainment and impingement) in the discharge of water for power. These are considered Moderate Potential risks.

Effects associated with transmission and delivery include injury and mortality from collision and electrocution associated with power lines. These pose Moderate Potential risks, as discussed in Section 3.1.

Reservoir construction, operation and decommissioning impact fish movement and habitat.

Hydro is the only electricity generation source that poses Higher Potential risks during the decommissioning of facility stage. Reservoir decommissioning causes mortality to aquatic wildlife and degradation of downstream aquatic habitat from release of sediments during the draining of the reservoir. As discussed in Section 3.1, risks could be Higher to Moderate Potential for dam demolition (Stokstad 2006). The dismantling also results in the loss of the artificially created upstream lake habitat. Mortality or higher predation rates for fish can occur as drawdown proceeds, leaving fish stranded in shallow pools. The risk is considered Moderate Potential for the fish and other aquatic life that have been using these created habitats.

Rivers, Habitats, and Species in the NY/NE Region Vulnerable to Dam Construction and Operation. The following is a compilation of species and habitats in the NY/NE region considered vulnerable or at risk from dam construction and operation by the state wildlife agencies as reported in state wildlife action plans (Maine 2005, New Hampshire 2005, New York State 2005, Rhode Island 2005, Vermont 2005).

Vulnerable Rivers

- Housatonic River of Massachusetts and Connecticut
- Lamolle River of Vermont
- Merrimack River of New Hampshire and Massachusetts
- Penobscot River of Maine
- Susquehanna River of New York

Vulnerable Habitats (and wildlife in these habitats)

- Aquatic and shoreline type communities
- Fluvial type communities hardwood swamps
- Medium rivers
- Riparian forest in Massachusetts
- Small streams in the Connecticut River and Merrimack River mainstems
- Softwood swamps in Vermont

Vulnerable Species

Fish

- American eel
- American shad
- Atlantic salmon
- Atlantic sturgeon
- Blueback herring
- Burbot
- Eastern silvery minnow
- Hickory shad
- Lake sturgeon
- Longnose dace
- Longnose sucker
- Rainbow smelt
- Redfin pickerel
- Shortnose sturgeon
- Striped bass
- Walleye
- White sucker

RISKS FROM WIND

Electricity generation from wind has only four stages in its life cycle and each has wildlife effects. Like hydro, wind is a renewable energy source, and the wind needed to generate electricity is harnessed at the source. Wind is not considered to have population effects, but the risks for some bat species are unknown at this time. Geographically, the wildlife risks from wind are all local or regional.

Wind farm at sunset.

Discussion of Highest, Higher, and Moderate Potential Risks

The most commonly cited effect from wind power generation is injury and mortality to birds and bats from collision with wind turbines. For birds, these risks are considered Moderate Potential, and they are limited to the site. Local mortality to individuals is likely to occur with no population-level effects and a high degree of species recovery (NRC 2007). Biodiversity declines are unlikely for birds. Endangered or threatened bird species in the NY/NE region may be exposed to potential injury or mortality, although they are at no more risk than other species.

Table 3-13. Reported existing effects and relative wildlife risk levels for potential harm from electricity generation by wind.

Life Cycle Effects – Wind	Relative Level of Risks
Resource Extraction	**N/A**
Fuel Transportation	**N/A**
Construction of Facility	
Destruction of habitat through land clearing for facilities (this has a smaller footprint than coal; Guyonne and Clave 2000, NRC 2007) .	**Lowest Potential**
Wildlife disturbance and displacement from construction noise and activity (NRC 2007).	**Lowest Potential**
Loss of habitat through habitat fragmentation from the construction of electric transmission facilities and roads (NRC 2007).	**Lowest Potential**
Power Generation	
Injury and mortality to birds and bats from collision with wind turbines (NRC 2007, Kingsley and Whittam 2007, Arnett et al. 2008) .	**Moderate Potential (Possibly Higher Potential for Bats)**
Transmission and Delivery	
Mortality to birds caused by electrocutions from power lines and substations (APLIC 2006; Manville 2005; Faanes 1987).	**Moderate Potential**
Injury and mortality to birds from collisions with transmission and distribution lines (APLIC 1994; Manville 2005; Faanes 1987).	**Moderate Potential**
Habitat fragmentation from maintenance of transmission facilities.	**Lower Potential**
Decommissioning of Facility	
Wildlife disturbance and displacement from demolition process due to noise and activity.	**Lowest Potential**

Table 3-14. Geographical location of wildlife risks associated with wind life cycle stages.

Resource Extraction	Fuel Transportation	Construction of Facility	Power Generation	Transmission and Delivery	Decommissioning of Facility
Not a part of the life cycle	Not a part of the life cycle	Local	Local	NY/NE	Local

Tree Bats and Wind Turbines. Of the 11 species of bats found killed by wind turbines in the United States, 75% are tree bat species, including eastern red bats (*Lasiurus borealis*), hoary bats (*Lasiurus cinerus*), and silver-haired bats (*Lasionycteris noctivagans*), all of which are found in the NY/NE region. In the eastern United States, hoary bats account for 28.9% of bat mortality and eastern red bats for 34.4% of overall mortality (NRC 2007) .

For bats, especially tree bats, the risk posed by wind turbines may be Higher Potential, but this is uncertain because of the lack of accurate population information and mortality studies at wind farms. Ongoing research is looking at the effects and risks to birds and bats from wind farms, but at this time there are no documented population-level effects. However, based on the few available studies, there is general consensus from the scientific community that bats are likely to be at the greatest risk.

Effects associated with transmission and delivery include injury and mortality from collision and electrocution associated with power lines. These pose Moderate Potential risks as discussed in Section 3.1.

SECTION 4
SUMMARY AND CONCLUSIONS

RELATIVE WILDLIFE RISKS

1. All electricity generation sources pose adverse risks to vertebrate wildlife including fish, amphibians, reptiles, birds, and mammals. These effects and risks can range from injury and mortality of individuals to habitat loss and decline in species occurrence. Risks can be classified according to immediacy of response, level of impact (individual to population), electricity generation life cycle stage, and spatial extent of response, as follows:

   - Electricity generation can cause acute and immediate effects (such as toxicity of oil spill, exposure to acid mine drainage, collision, or electrocution). It also can cause chronic, cumulative, latent, and long-term effects (for example, biomagnification of mercury in the food chain; acidification of soils from acidic deposition, which leads to decline in forests; and climate change, which results in altered timing of reproduction, disruption of migration patterns, or alteration in species ranges).
   - Electricity generation can affect wildlife at the level of individuals (resulting in Lowest to Moderate Potential risks) or populations (resulting in Higher and Highest Potential risks).
   - Population-level effects (Higher to Highest Potential risks) are more likely to be associated with energy resource extraction and power generation than other life cycle stages of electricity generation.
   - Effects on wildlife in the NY/NE region from an electricity generation source can occur locally at the site (such as coal mined in West Virginia), regionally (such as regional transport of acidic deposition to the Northeast), and globally (such as climate changes).

2. Acidic deposition, climate change, and mercury bioaccumulation are identified as the three most significant and widespread stressors to wildlife from electricity generation from fossil fuels and hydro; these pose Moderate to Highest Potential risks to wildlife. Major conclusions regarding these stressors are as follows:

   - Acidic deposition results from electricity generation from coal, oil, and to a minor extent natural gas. Acidification of forests, streams, and lakes has widespread effects on fish and wildlife and their aquatic and terrestrial habitats throughout major portions of the NY/NE region.
   - Mercury bioaccumulation results from electricity generation from coal, oil, and hydro. Bioaccumulation of mercury has affected wildlife, especially fish, birds, and mammals, in the NY/NE region. Although it is a major risk to wildlife, mercury bioaccumulation and its effects are generally reversible, as evidenced by reported reductions of both mercury emissions and biotic

uptake since the late 1980s in the United States, at locations where both sources and deposition have been measured.

- Of the potential effects of electricity generation, climate change would produce the most widespread effects, posing risks to fish and wildlife and their habitats globally. Some of these effects are not likely to be reversible. Electricity generation from coal, oil, gas, and hydro contribute (albeit unequally) to the risks for climate change.

Relative risks to wildlife can be evaluated and classified in a variety of ways. Major conclusions regarding relative risks are highlighted below.

3. A number of species are considered vulnerable and at risk in the NY/NE region. Some species are at risk from more than one of these effects, such as Bicknell's thrush and common loon.
4. The magnitude of effects associated with various life cycle stages of electricity generation vary with source types. Important conclusions regarding life cycle stages include:

- During the transmission and delivery stage, bird and bat collisions are Moderate Potential risks common to all forms of electricity generation; they affect birds and bats to some extent within and outside the NY/NE region. Collision objects vary with electricity generation source and include offshore drilling platforms (oil and natural gas), wind turbines, stacks, and cooling towers during power generation.
- The resource extraction stage of oil and natural gas poses Higher Potential risks to local and regional wildlife both within and outside the NY/NE region.
- The fuel transportation stage of oil poses Highest Potential risks to local and regional wildlife both within and outside the NY/NE region, largely because of risks of oil spill.

ELECTRICITY GENERATION SOURCE RISKS

The following overview conclusions can be drawn concerning the comparative risks among the various electricity generation options available in the NY/NE region:

5. Based on the comparative amounts of SO_2, NO_x, CO_2, and Hg emissions generated from coal, oil, natural gas, and hydro, and the associated effects of acidic deposition, climate change, and mercury bioaccumulation, coal as an electricity generation source is by far the largest contributor to these risks to wildlife in the NY/NE region.
6. Overall, non-renewable electricity generation sources, such as coal and oil, pose potentially higher risks to wildlife than renewable electricity generation sources, such as hydro and wind.

7. Major risks by source are as follows:

   - Coal has risks that range from Lowest to Highest Potential, including unique risks during the resource extraction stage (e.g., Highest Potential risks associated with effects of strip and mountain top mining). The combustion of coal during the power generation stage contributes to acidification and mercury bioaccumulation, causing Highest Potential risks to wildlife.
   - Oil has Lowest to Highest Potential risks, with unique risks during the resource extraction and fuel transportation stages owing to the potential for oil spills. Oil contributes to acidification risks during the power generation stage.
   - Natural gas has Lowest to Higher Potential risks for wildlife. A number of the types of effects associated with the power generation life cycle stage are similar to oil generation sources, but the magnitudes of these risks are less, e.g. Moderate Potential risks from habitat change from greenhouse gas emissions compared to Higher Potential risks from oil because of the lower magnitude of the contribution of natural gas emissions.
   - Nuclear presents Lowest to Highest Potential risks. Some of these risks are not unique to nuclear, and they also are found with other non-renewable electricity generation sources, such as bird collisions with stacks and cooling towers associated with coal and oil generation sources.
   - Hydro has Lowest to Highest Potential and unique risks during the construction, power generation, and decommissioning stages, such as loss of large areas of terrestrial and aquatic upstream and downstream habitats and blocking fish migration due to reservoir or impoundment construction.
   - Wind has Lowest to Moderate Potential risks during operation (i.e., bird and bat collisions with wind turbines). No population-level risks to birds have been noted. Population-level risks to bats are uncertain at this time.

8. Since there are more conditions, by-products, and actions in the resource extraction and power generation stages that act as stressors to wildlife, higher risks to wildlife generally are associated with these life stages than in other life cycle stages.

9. Construction, transmission and delivery, and decommissioning stages generally have fewer stressors that affect wildlife. However, the construction, operation, and decommissioning of dams pose relatively Higher Potential risks to ecosystems, fish, and habitats.

The degree and extent of the risks depends on the electricity generation source, although some effects are common across life cycle stages and electricity generation sources. See Table 3-1 for a summary of the highest potential wildlife risks (Highest, Higher, Moderate) levels for each electricity generation source during each life cycle stage.

SECTION 5

OPPORTUNITIES FOR FUTURE COMPARISONS OF WILDLIFE RISK

The following opportunities for future comparisons of wildlife risk were identified during this study. They are not presented in any order of importance.

1. Discuss and rank recovery potential of affected populations and habitats. Various at-risk wildlife groups have different abilities to handle risks. Some populations have the reproductive potential to offset losses that might occur. Some habitats can readily recover once the stressor is removed (e.g., spill in a stream), while other habitats may have changed so much that recovery is not possible (e.g., mountain top mining habitat loss and climate change effects to sensitive habitats).
2. Consider relative risk from the improvement in air quality (e.g., decrease in acidic deposition and mercury) in the last 20 years related to recovery potential.
3. Compare the existing wildlife risks to future technologies. For example, clean coal technologies should reduce the wildlife impacts from power generation. Discuss to what extent this can occur.
4. Evaluate the wildlife risks associated with other renewable energy technologies, such as offshore wind, biomass, solar, etc.
5. Discuss contributive risk. Not all electricity generation sources in the NY/NE region are equally prevalent. A state-by-state analysis of wildlife risk could be conducted. This would be useful in looking at long-term trends to wildlife risks in the NY/NE region as shifts in the electricity generation portfolios occur.
6. Quantify comparative wildlife risks from different facilities of the same electricity generation size.
7. Discuss policy implications of the wildlife Comparative Ecological Risk Assessment, including identification of the best use(s) of available data.

SECTION 6
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APPENDIX A
ADDITIONAL RESOURCES

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