BEFORE THE SECRETARY OF INTERIOR

PETITION TO LIST THE BICKNELL'S THRUSH
(*CATHARUS BICKNELLI*)
AS THREATENED OR ENDANGERED UNDER THE ENDANGERED SPECIES ACT

PHOTO: HENRY TROMBLEY

August 24, 2010
CENTER FOR BIOLOGICAL DIVERSITY
PETITIONER

NOTICE OF PETITION

August 24, 2010

Kenneth Salazar, Secretary
Department of the Interior
1849 C Street N.W.
Washington. D.C. 20240

Marvin Moriarty, Northeast Regional Director
U.S. Fish and Wildlife Service
300 Westgate Center Drive
Hadley, MA 01035-9587

Pursuant to Section 4(b) of the Endangered Species Act ("ESA"), 16 U.S.C. §1533(b), Section 553(3) of the Administrative Procedures Act, 5 U.S.C. § 553(e), and 50 C.F.R. §424.14(a), the Center for Biological Diversity hereby petitions the Secretary of the Interior to list the Bicknell's thrush (*Catharus bicknelli*) as threatened or endangered and to designate critical habitat concurrent with listing.

This petition sets in motion a specific process, placing definite response requirements on the Secretary and the U.S. Fish and Wildlife Service (USFWS) by delegation. Specifically, USFWS must issue an initial finding as to whether the petition "presents substantial scientific or commercial information indicating that the petitioned action may be warranted." 16 U.S.C. §1533(b)(3)(A). USFWS must make this initial finding "[t]o the maximum extent practicable, within 90 days after receiving the petition." *Id.* Petitioners need not demonstrate that listing *is* warranted, rather, petitioners must only present information demonstrating that such listing *may* be warranted. While the petitioner believes that the best available science demonstrates that listing the Bicknell's thrush as endangered *is* in fact warranted, there can be no reasonable dispute that the available information indicates that listing the species as either threatened or endangered *may* be warranted. As such, USFWS must promptly make an initial finding on the petition and commence a status review as required by 16 U.S.C. § 1533(b)(3)(B).

PETITIONER

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The Center for Biological Diversity ("the Center") is a nonprofit conservation organization with 255,000 members and online activists dedicated to the protection of endangered species and wild places.

http://www.biologicaldiversity.org

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I. EXECUTIVE SUMMARY

The Bicknell's thrush (*Catharus bicknelli*) was identified as distinct from the Gray-cheeked thrush in 1995, and is widely considered to be one of the most vulnerable passerine species in North America (AOU 1995, Hodgman and Rosenberg 2000). This thrush is a species of high conservation concern for several reasons, primarily because of its limited breeding range, relatively small population numbers, and numerous ongoing threats to its rare and highly fragmented habitat (Rimmer et al. 2005a). Recent analyses yield a global population estimate of 95,000-126,000 birds, and documented annual declines of 7-19 percent in parts of the thrush's range (IBTCG 2010).

Bicknell's thrush is a habitat specialist, restricted to fir-dominated montane forest in the higher peaks of New England and parts of Quebec, New Brunswick, and Nova Scotia. Its preferred habitat is naturally rare, fragmented and vulnerable to anthropogenic stressors such as acid deposition, mercury pollution, and development related to recreation, telecommunications, and wind energy. The most pressing and long-term threat to this limited habitat may be global climate change.

The Endangered Species Act states that a species shall be determined to be endangered or threatened based on any one of five factors (16 U.S.C. § 1533 (a) (1)). Bicknell's thrush is threatened by at least three of these five factors and demonstrably warrants listing as a threatened or endangered species based on the threats posed by:

- **The loss or curtailment of habitat or range**

Climate change has the potential to significantly alter the montane habitat used by Bicknell's thrush; warmer temperatures favor the upslope migration of hardwood forest and decline of high-elevation coniferous forests that this species requires for breeding. Such changes in forest composition could dramatically diminish the amount of Bicknell's thrush habitat in its current range (Lambert et al. 2005b, Rodenhouse et al. 2008, IBTCG 2010). Increased forest pests and pathogens may also result from climate change, further adding to the climatic stressors on high-elevation forests (IBTCG 2010).

Acid precipitation and other air-borne pollutants pose another serious threat to the forest habitat of Bicknell's thrush in the Northeast (Driscoll et al. 2001, Driscoll et al. 2003a).

Development related to recreation, telecommunications, and wind energy, industries that often site projects in Bicknell's thrush habitat (high-elevation areas, ridgelines), further fragment and diminish the extent of this species' already-fragmented habitat (Hart and Lambert 2007).

In the last two decades, intensive logging and pre-commercial thinning, primarily in the species' Canadian range, have caused the landscape-scale destruction and degradation of breeding habitat (COSEWIC 2009, IBTCG 2010). There have been correspondent declines in the population of Bicknell's thrush in Canada. In New Brunswick and Nova Scotia, populations of Bicknell's thrush declined by over 70 percent between 2002 and

2008. There has likely been a sizeable drop in the population of Bicknell's thrush in Quebec over roughly the same period (COSEWIC 2009).

On the winter range of Bicknell's thrush, subsistence farming and logging, along with human-caused fires, have severely diminished forest habitat (Stattersfield et al. 1998, Sergile 2008, IBTCG 2010).

- **The inadequacy of existing regulatory mechanisms**

Though its tenuous conservation status has been recognized by various government agencies and private conservation groups (IBTCG 2010), no existing regulatory mechanisms, whether federal, state, or international, adequately protect the Bicknell's thrush or its habitat. In particular, none of the designations currently applied to the thrush confer any regulatory means of addressing climate change and curbing forest habitat loss, which are the highest priority threats requiring conservation action (IBTCG 2010*)*.

The leading international mechanisms for addressing greenhouse gas emissions contributing to global warming are the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. These mechanisms have been, and continue to be inadequate as a means of regulating and reducing greenhouse gases, and alone cannot address the impacts of global warming that threaten the Bicknell's thrush with extinction. The 2009 Copenhagen Accord , even if fully implemented, would keep the planet on a path to a disastrous global temperature rise of 3.9°C by 2100 (Sustainability Institute 2010). Further, the Accord has no legal force (UNFCCC 2010).

There are currently no legal mechanisms actively regulating greenhouse gas emissions on a national level in the United States (Parker and McCarthy 2009), and existing state measures on their own are insufficient.

Industrial forests, which occupy a large portion of Bicknell's thrush habitat in the more northern portions of its range, occur primarily on private land in the United States, mostly Maine, and primarily on public land in Canada. No state, provincial, or federal laws mandate timberland management practices that are specifically protective of Bicknell's thrush habitat in either country. In Maine, logging in high-elevation forests is subject to regulation (38 M.R.S.A § 480, MLURC 2009), but logging in other Maine forests that may be suitable as Bicknell's thrush habitat (Lambert et al. 2005b, IBTCG 2010) is minimally regulated (Defenders of Wildlife 2000, Scott 2004). Only a little over five percent of Bicknell's thrush habitat on Canadian public land habitat is protected as park or wilderness (COSEWIC 2010).

No specific regulatory mechanisms apply to the Bicknell's thrush and its habitat regarding development related to telecommunications, wind energy, or recreation.

• **Other natural or anthropogenic factors**

Other factors threatening the existence of the Bicknell's thrush include mercury pollution and bioaccumulation of potentially damaging levels of methylmercury; shifts in predator and prey cycles, including abundance and timing of emergence, as a consequence of changing climate; increased catastrophic weather events; and direct take of Bicknell's thrush in the course of timber management activities (IBTCG 2010).

Based on the factors outlined above, Petitioner contends that the Bicknell's thrush warrants listing under the ESA.

II. INTRODUCTION

The Bicknell's thrush is widely recognized as one among a suite of species whose habitat is under grave and ongoing threat by climate change. As a high-elevation spruce-fir forest specialist, Bicknell's thrush will face an increasing shortage of suitable habitat in its breeding range as warming temperatures facilitate the upslope incursion of tree species formerly restricted to lower elevations. The resulting change in forest composition may exclude Bicknell's thrush from all but a minute proportion of its former breeding range (Rodenhouse et al. 2008)

In the northeastern United States, changes in keeping with global warming are already occurring, including rising temperatures, decreasing snow cover, and earlier arrival of spring (Frumhoff et al. 2007). Since 1970, the Northeast as a whole has warmed at a rate of 0.3°C per decade. Winter temperatures have been rising even faster—0.7 °C per decade between 1970 and 2000. Precipitation patterns also are shifting, with winter precipitation increasing about 0.15 inch per decade since 1900. More of this precipitation is falling as rain instead of snow. Extreme weather is also increasing, with the number of heavy precipitation events (defined as more than two inches of rain falling in less than 48 hours) in the Northeast going up in the 1980s and 1990s (UCS 2006).

Scientists are already documenting rapid upward shifts in forest communities over recent decades in the Northeast, with northern hardwoods encroaching upon areas formerly dominated by boreal species, including red spruce (*Picea rubens)* and balsam fir (*Abies balsamea*) (Beckage et al. 2008). These changes are consistent with increasing annual temperature due to climate change. Warming temperatures have been proposed as the major driver of an historical decline in red spruce in New England, as well (Hamburg and Cogbill 1988).

Projected changes in climate and corresponding shifts in the range of tree species are even more dramatic. Temperatures in the Northeast will continue to rise over the next century in response to both past and future greenhouse gas emissions. Under both low and high emission scenarios, winter temperatures will increase more than summer, but even under a low emissions scenario, summer temperatures in the region will rise between 1.6° and 4° C by the century's end (Frumhoff et al. 2007). Winter precipitation will continue to increase, as will the frequency of extreme storms. Winter snowpack will decline, growing season will lengthen, and the arrival of spring, as measured by the first leaf-out and bloom dates of various plants, could occur three weeks earlier by the end of the century under a high emissions scenario (Frumhoff et al. 2007).

Projections of change in Bicknell's thrush's montane forest habitat are sobering. A model of the impact of climate change on trees in the Northeast United States shows that suitable habitat for spruce/ fir forest retreats to the highest summits and most northern latitudes in the region even under a low emissions scenario; under a high greenhouse gas emissions scenario, suitable spruce/fir habitat vanishes from the Northeast (Iverson et al. 2008). The greatest reduction in Bicknell's thrush habitat may occur in response to the first 1° C of warming, with habitat reduced by 48-66 percent in the Northeast. According to one model, with 3° C of warming, 98 percent of Bicknell's thrush habitat in the United States disappears (Lambert and McFarland 2003).

The fragmentary nature of Bicknell's thrush breeding habitat will become more so in the face of climate warming. Other climate-driven dynamics, such as the potential invasion of less cold-tolerant forest pests and pathogens (Iverson et al. 2008), also threaten to diminish the species already limited and vulnerable habitat (Lambert et al. 2005b). Correspondingly smaller populations of Bicknell's thrush could become increasingly fragile, even to the point of localized extirpation, due to yet other stressors, such as disruption of the cone-red squirrel (*Tamiasciurus hudsonicus)* population cycle; increased nest failure due to higher frequency of extreme wind and rain events; or changes in the emergence patterns of insects and other prey species (IBTCG 2010).

While climate change poses the greatest long term threat to Bicknell's thrush and its habitat, numerous other, more immediate factors are also of concern. Chief among these is intensive, industrial-style forest management in the more northern portions of the species' breeding range, primarily in Canada. There, clearcutting and particularly pre-commercial thinning in highland forests has altered, fragmented, and removed large areas of potential habitat for Bicknell's thrush in the last 20 years (COSEWIC 2009). While logging can lead to short-term increases in the amount of the species' habitat due to the high-stem density that occurs in most regenerating forest stands, the quality of this habitat is relatively short-lived. As the trees mature, the forest becomes less suitable as Bicknell's thrush habitat. Further, the now-common practice of pre-commercial thinning at about 15 years post-clearcutting immediately and severely reduces the suitability of the habitat for Bicknell's thrush (COSEWIC 2009).

Acid deposition has been a serious and ongoing threat to the health of high-elevation Northeast forests since at least the 1960s. It is caused primarily by the burning of fossil fuels for electricity generation and for motor vehicles (Driscoll et al. 2001). Decline of red spruce at high elevations in the Northeast is believed to be primarily due to acid deposition (DeHayes et al. 1999).

Mercury deposition is another threat to Bicknell's thrush. Anthropogenic mercury from atmospheric sources is 2-5 times higher in the Northeast's mountain areas than in surrounding low elevation areas (Rimmer et al. 2005b). Mercury in the atmosphere is largely the result of coal burning and waste incineration (IBTCG 2010). Bicknell's thrush carry elevated levels of toxic methylmercury in their tissues, probably as the result of trophic transfer up the food chain (Rimmer et al. 2009b).

Industrial development for recreation, communication, and energy in the Bicknell's thrush's breeding habitat is another concern. Wind energy development is a relatively new but growing threat, as wind projects are being proposed and constructed in the high elevation habitats favored by the species. Forest clearing and fragmentation associated with access roads, turbine strings, and energy corridors can remove and degrade Bicknell's thrush habitat. The turbines themselves may pose a threat of collision (COSEWIC 2009).

Finally, the Bicknell's thrush faces a multiplicity of threats on its limited and vulnerable winter range in the Greater Antilles. These include forest clearing and fragmentation associated with subsistence farming and logging. Introduced predators and feral animals, along with mercury deposition in the montane forests the thrush inhabits in winter, put further pressure on Bicknell's thrush populations (IBTCG 2010). Increased storm frequency and other climate-induced shifts in Bicknell's thrush's winter range could have significant impacts on the species and its habitat over the long term (IBTCG 2010).

Recent estimates of the global population of Bicknell's thrush range from 95,000 to 126,000 birds. Annual population declines of 7-19 percent in parts of the bird's range are cause for serious concern (IBTCG 2010). Combined with the stark and dramatic impact that climate change is predicted to have on Bicknell's thrush habitat in the coming decades, it is clear that immediate and significant protective measures must be taken now to protect the species from the threat of extinction.

In the long run, the survival of the Bicknell's thrush will depend on the health of the rare and restricted forests it utilizes. Because of its close association with the montane spruce-fir forests of the Northeast, Bicknell's thrush is considered an ecological indicator species for this forest type (King et al. 2008). The species' decline in parts of its range is a serious warning that the subalpine zone is under increasing stress from a host of factors, the greatest and most profound of which is global climate change. The bird's winter range is not exempt from climate-induced changes, as well.

Ultimately, while Bicknell's thrush's dependence on fragmented high-elevation habitat makes it particularly sensitive to the impacts of climate change, its fate is not separate from that of many other species threatened by damaging, climate-induced shifts in essential physical and biological parameters. The Bicknell's thrush is the proverbial "canary in the coal mine" of the Northeast. Its decline, if allowed to continue, will be accompanied by a multiplicity of plants and animals in retreat. Numerous species that exemplify the rich, wild heritage of eastern North America are already at risk, and their populations are likely to shrink further in an increasingly warm and chaotic climate. These include the Canada Lynx, native brook trout, spruce grouse, and various boreal tree species, including the red spruce and balsam fir with which Bicknell's thrush is so closely associated. Even the archetypal tree of New England, the sugar maple, is at great risk of fading from most of the region over the next several decades due to the impacts of climate change (Iverson et al. 2008).

The Bicknell's thrush is on a path to extinction in the absence of new protections for the species and its habitat. The mandate of the federal Endangered Species Act is clear: to confer the legal protections this critically imperiled species requires under the law, to enact effective measures for its conservation, and to bring about its recovery, **before it is too late**. Any actions short of these will not protect the species or its habitat over the long run, and are likely to merely forestall the day when the Bicknell's thrush must, by dint of overwhelming evidence, become a federally listed endangered species. And if that day is forestalled for too long, while threats to the species' long term survival continue to intensify, even the most concerted campaign to save the Bicknell's thrush may ultimately prove fruitless.

III. NATURAL HISTORY AND ECOLOGY

A. Taxonomy and description

Bicknell's thrush was first identified in 1881 by E. Bicknell on Slide Mountain in the Catskill Mountains of New York, and was originally classified as a subspecies of the Gray-cheeked thrush (Rimmer et al. 2001). Due in large part to its reclusive nature and preference for terrain not easily accessible by humans, the Bicknell's thrush was largely ignored until the 1930s when Dr. George Wallace chose the bird as the subject of his dissertation. Dr. Wallace revisited the question of its taxonomy and produced his now-classic natural history study on Bicknell's thrush (Wallace 1939). Although he noted numerous differences between Bicknell's thrush and the Gray-cheeked thrush, he recommended that the bird remain a subspecies. The taxonomic status of Bicknell's thrush was not revisited again until genetic and other analyses done in the 1990s led to the recognition of *C. bicknelli* as a distinct species in 1995 (Ouellet 1993, AOU 1995, Rimmer et al. 2001).

Bicknell's thrush is a medium-sized thrush, typically 16-17 cm in length. Weight is approximately 26-30 g. Distinguishing physical characteristics include olive-brown upper parts, white underparts (sometimes slightly yellow-tinged), gray cheeks, a spotted breast, and some chestnut coloration on tail and wings (Ouellet 1993, Rimmer et al. 2001). Males and females are physically indistinguishable outside of breeding condition, except that males tend to be slightly larger than females (COSEWIC 2009).

The song of the Bicknell's thrush has the same flutelike tones heard in the songs of other thrush species, but is distinguishable from other species' vocalizations by a rising inflection, a final high note. Vocal activity is high in June and July but calls are seldom heard at other times of year, generally only at dawn and dusk (Rimmer et al. 2001).

B. Range and distribution

Bicknell's thrush is a Nearctic-Neotropical migratory passerine that breeds in the subalpine forests of the northeastern United States and southeastern Canada, and migrates to the Greater Antilles, where it overwinters in wet broadleaf forests.

The species' breeding range is restricted and highly fragmented (**Fig. 1**). Rimmer et al. (2005a) report that breeding has been documented as far north as southwestern Quebec in Reserve La Vérendrye, southeastern Quebec along the north shore of the St. Lawrence River and Gaspé Peninsula, northwestern and north-central New Brunswick and Cape Breton Island, Nova Scotia, including the small, outlying St. Paul and Scaterie islands. The southern limit of Bicknell's thrush's breeding range is delineated by the Catskill Mountains in New York, Green Mountains in Vermont, White Mountains in New Hampshire, and the mountains of western and central Maine (Rimmer et al. 2005a). Possible but unconfirmed reports of breeding Bicknell's thrush exist from north-coastal Maine (Atwood et al. 1996, Rimmer et al. 2001,). In the southern portion of its range, Bicknell's thrush typically breeds above 1100 m elevation, while in the northern portion of its range, breeding populations have been found as low as 750 m (Rimmer et al. 2005a).

Earlier research on Bicknell's thrush distribution and population suggested that approximately 90 percent of the global breeding population occurred within the United States (Nixon 1999). However, more recent research and modeling of potential habitat indicates that roughly 60 percent of the global breeding population occurs in the United States, with the balance in Canada (IBTCG 2010). Moreover, a new model of potential breeding habitat finds that Canada has 95 percent of Bicknell's thrush potential breeding habitat, and of that, 95 percent of the potential habitat in Canada is in the province of Quebec, with much smaller amounts in New Brunswick and Nova Scotia (Hart et al. in prep., as cited in COSEWIC 2009). These estimates are based on known occurrences of the species across its breeding range, and habitat variables, such as the occurrence of balsam fir-dominated stands and latitude, longitude, and altitude (COSEWIC 2009).

The Bicknell's thrush overwinters in the Greater Antilles, the group of Caribbean islands comprised of Cuba, Puerto Rico, Jamaica, and Hispaniola (Haiti and the Dominican Republic) (**Fig. 2**), establishing discrete territories there by early November (Townsend and Rimmer 2006). Suitable habitat within this winter range is largely restricted to patches of high-elevation cloud forest. The majority of recorded occurrences are from the Dominican Republic (Rimmer et al. 1997, 1999), where the species seems to be widely distributed below 2200 m elevation. Only a few occurrences, all at higher elevation, are reported from Haiti, where deforestation is extensive. The species is uncommon and localized in Jamaica, found primarily in the Blue Mountains, and it is rare in Puerto Rico. Bicknell's thrush was recently recorded in the Sierra Maestra of eastern Cuba, where it is probably a regular winter resident (unpublished data and pers. comm. as cited in Rimmer et al. 2001, Rompré et al. 2000, COSEWIC 2009, IBTCG 2010). There are no confirmed winter records at other locations.

C. Habitat, foraging, and diet

Bicknell's thrush is an extreme habitat specialist, found in chronically disturbed subalpine spruce-fir forest in its breeding range, and in high-elevation broadleaf cloud and rainforest in its winter range. It has been described as one of the most rare and range-restricted species in eastern North America, largely because of this high degree of habitat specialization (Rimmer et al. 2001).

In its breeding range, the Bicknell's thrush is found in three coniferous forest habitat types: high-elevation spruce/fir forest, coastal lowland forests, and highland-industrial forest. The former habitat type comprises the species' U.S. range, while the two latter types are occupied by the Bicknell's thrush in its Canadian range (COSEWIC 2009).

In the northeastern United States, the Bicknell's thrush nests in dense (>10,000 – 15,000 stems/ha) subalpine forests of balsam fir and red spruce near treeline (Wallace 1939, COSEWIC 2009). This species' association with high-elevation conifer forests is so strong that Lambert et al. (2005b) report that the slope of the latitude-elevation relationship for Bicknell's thrush occurrence (-81.63 m/1° latitude) is nearly identical to the latitude-elevation relationship for treeline in the northern Appalachian Mountains (83 m/l° latitude) (**Fig. 3**).

Montane spruce-fir forests occur in isolated patches near mountaintops, and are separated by valleys with markedly different vegetative composition (King et al. 2008). Thus the habitat preferred by the Bicknell's thrush can be characterized as both rare and naturally fragmented (Atwood et al. 1996). Nests are usually found in dense stands of young to mid-successional fir, and often associated with areas recently disturbed by fir waves, windthrows, ice or snow damage, fire, or insect outbreaks where succession is ongoing (COSEWIC 2009). Suitable habitat is typically characterized by standing dead conifers and dense growth of balsam fir, and nests are frequently found in the dense regrowth along natural or artificially created forest edges (Rimmer et al. 2005a). Bicknell's thrush may also nest in stunted krummholz forest.

Structural attributes favored by the Bicknell's thrush include dense softwood understory, low canopy, and an abundance of snags, stumps, and deadfall (Lambert et al. 2005b). Canopy heights are typically below 6 m (Lambert et al. 2008, Rimmer et al. 2001).The highest densities of Bicknell's thrush are found in areas frequently disturbed by wind and winter ice accumulation (Rimmer et al. 2001). Winter treefall caused by these disturbances facilitates succession, which creates habitat optimal for breeding Bicknell's thrush. Because of this preference for dynamic, often ephemeral habitat, the Bicknell's thrush frequently shifts its distribution in response to changing patterns of disturbance and succession (Rimmer et al. 2001). However, the naturally slow regeneration of trees at high elevation tends to maintain suitable stands for longer periods than those created at lower elevation through timber management practices (Rimmer et al. 2004, COSEWIC 2009).

In the United States, Bicknell's thrush regularly breeds only at elevations above 700 m, though the vast majority of known breeding sites are above 900 m; breeding populations are reported between 730-1280 m in Maine, 850-1460 m in New Hampshire, 880-1430 m in New York, and 820-1250 m in Vermont (Atwood et al. 1996). The species also breeds at both high elevations and in low-lying coastal spruce-fir forests in Quebec, New Brunswick, and Nova Scotia (Wallace 1939, Ouellet 1996, COSEWIC 2009).

The highland industrial forests that make up most of Bicknell's thrush's Canadian habitat are generally at lower elevations than the subalpine habitats of the U.S. Northeast. At the northern end of its range, Bicknell's thrush breeding in inland forests have been found at elevations down to 450 m.

The Canadian habitat of Bicknell's thrush differs from the species' northeastern U.S. habitat in other ways. Most of the forest in the Canadian portion of Bicknell's thrush range has been heavily clearcut and otherwise intensively managed for timber production. The species is found in younger, unthinned, regenerating stands. The species is also found in forests regenerating from natural disturbances, such as insect outbreak (COSEWIC 2009). However, in Quebec and New Brunswick, the species has been reported in older stands where the canopy is closed and stem density is lower (Y. Aubry, unpubl. data, from COSEWIC 2009). In addition to balsam fir and red spruce, tree species found in the Canadian habitat of Bicknell's thrush include black spruce (*Picea mariana*), white spruce (*P. glauca*) and jack pine (*Pinus banksiana*) (Nixon et al. 2001). These species are sometimes planted by timber managers following logging. The mature forests in which Bicknell's thrush is sometimes found in Canada are comprised primarily of black spruce and balsam fir, with some white birch (*Betula papyrifera*).

Forests subjected to pre-commercial thinning—a widespread practice over the last two decades—are not suitable habitat for the species. Bicknell's thrush appears to abandon regenerating forests once stem densities are significantly lowered by thinning (COSEWIC 2009). Even without pre-commercial thinning, the length of time that regenerating industrial forest is suitable for Bicknell's thrush is likely much shorter than it is for the chronically disturbed subalpine forests in which the thrush nests in the United States. This is due, at least in part, to the fact that these industrial forests are located at lower elevations, and thus regenerate more rapidly. In addition, clearcutting—the dominant harvest method over much of the Bicknell's thrush Canadian range—does not reliably result in softwood regeneration. At lower elevations, deciduous tree species often dominate in regenerating stands and are not suitable for the species (COSEWIC 2009).

The localized coniferous coastal lowland forests in which Bicknell's thrush have been reported are characterized by cool sea breezes and high precipitation that maintain dense spruce-fir stands. However, it appears that the species is now extirpated from a number of coastal sites where it was once documented (COSEWIC 2009). The reasons for this apparent disappearance are unknown.

Home range size of the Bicknell's thrush is highly variable; females maintain discrete territories that may be between 1 and 23 ha in extent, while males are non-territorial and may range across the territories of several females (Rimmer et al. 2001, McFarland et al. 2008). COSEWIC (2009) estimates that social groups consisting of a single female and between two and four males require at least 20 ha of suitable habitat.

Bicknell's thrush is consistently reported from mesic to wet broadleaf montane forests throughout the Greater Antilles. Preferred elevation seems to be much more variable in the species' winter range than in its breeding range. Individuals are found at all elevations between sea level and 2200 m in the Dominican Republic, though the majority of occupied sites were higher than 1000 m in elevation, likely due to habitat loss at lower elevations (Rimmer et al. 2001), and were either in cloud/montane or submontane broadleaf rainforest (Rimmer et al. 1999).

The fact that 22 percent of occupied sites in the Dominican Republic are located in regenerating secondary forest may indicate some plasticity in habitat preferences. Much of the primary broadleaf forest preferred by the Bicknell's thrush has been cut or otherwise degraded (Rimmer et al. 2001).

There is some evidence for sexual segregation in Bicknell's thrush's winter range. Several sampled sites showed a strong skewing toward males, while others are occupied by equal proportions of males and females (Townsend et al. 2009b).

Precise data on the diet of Bicknell's thrush are lacking. However, invertebrates, primarily arthropods,are the main food for the bird, particularly during breeding season. After first arriving back on the breeding ground in May, spiders, harvestmen, and ants likely make up the bulk of Bicknell's thrush's diet. Female birds may also feed on snails in order to obtain supplemental calcium for egg production. As the season progresses, Bicknell's thrush appear to feed more on foliage-eating arthropods, including larval lepidopterans, hymenopterans, and hemipterans (Rimmer et al. 2009a). Adult hymenoptera are an important prey item for nestlings. Bicknell's thrush may also feed on blueberries, bunchberries, and wild grapes later in the summer (Rimmer et al. 2001, Wallace 1939).

Preliminary research in the Dominican Republic suggests that on the winter range Bicknell's thrush consume a primarily fruit-based diet at mid-elevations, and primarily an arthropod-based diet at higher elevations. Fruits eaten include those of the *Psychotria berteriana* tree. Arthropods consumed include beetles, diptera and hymenoptera. In keeping with these different diets, Bicknell's thrush at fruit-eating sites have been observed mostly in the forest canopy, whereas birds at arthropod-dominant sites spend a significant amount of time close to or on the ground (Townsend et al. 2010). Birds at both fruit-eating and arthropod-eating sites appear to maintain discrete territories in defense of their food sources (Townsend et al. 2010).

D. Breeding

1. Mating system

The highly unusual mating system exhibited by the Bicknell's thrush has been termed "female-defense polygynandry", a system wherein both males and females mate with multiple partners, multiple paternity in a single clutch is common, and more than one male cares for nestlings in each brood (Briskie 1992, Goetz et al. 2003). Polygynandrous mating systems arise, in large part, from limited food resources on female home ranges. It is believed that female Bicknell's thrush copulate with multiple males primarily for the benefits such behavior confers on their offspring; the added resources provided by multiple provisioning males may make the difference between death and survival (Strong et al. 2004). Indeed, females mating with multiple partners seem to benefit most from increased male provisioning where reproductive success is limited by available sources of food (Goetz et al. 2003). The number of chicks successfully fledged on two Vermont mountains was positively correlated with prey biomass on female home ranges, while the number of provisioning males at a nest was negatively correlated with the same metric, emphasizing the importance of increased parental care in resource-limited habitat (Strong et al. 2004). Empirical studies of other polygynandrous species have shown that female reproductive success increases with the number of provisioning males. Polyandry is most likely where food resources are limited, and monogamy can replace polyandry when food supplies for polyandrous females are supplemented (Goetz et al. 2003).

Probably as a consequence of its breeding system, there is a lack of territoriality among males on the breeding range. Sex ratio among breeding adults is skewed toward males; there were more than two males for every female at two study sites in Vermont (Townsend et al. 2009b). A Quebec study produced similar results (Y. Aubry, CWS/SCF unpubl. data, from IBTCG 2010).

The Bicknell's thrush begins breeding at approximately one year of age, and generally breeds annually (Rimmer et al. 2001). Males return to breeding grounds significantly earlier than do females, and mating activities begin shortly after females arrive, typically in late May (Rimmer et al. 2005a).

Correspondent with their polygynandrous mating system, females occupy small, discrete (non-overlapping) home ranges, while males generally range over larger territories comprised of several female home ranges. Because populations are strongly male-biased, competition over females is intense, leading to a highly opportunistic mating strategy in which mating associations are dynamic and dependent on female fertility, the availability of other mates, and presence of other males (Rimmer et al. 2001, Goetz et al. 2003).

Bicknell's thrush's complex breeding system, in combination with its highly fragmented habitat, makes estimation of breeding densities extremely difficult (Rimmer et al. 2001).

2. Phenology, incubation, and parental care

The earliest confirmed nest construction date is June 1, and 71 percent of clutches are initiated within the first three weeks of June in Vermont (Wallace 1939, Rimmer et al. 2001). Clutch initiation date may be as late as July 14 in New Hampshire (Wallace 1939, Richards 1994). The incubation period ranges from nine to 13 days; hatching dates range from June 23-July 29 (Wallace 1939, Rimmer et al. 2001). Offspring stay in the nest between nine and 13 days after hatching; fledging dates range from July 3-August 3. Fledglings may remain with adults up to 14 days after leaving the nest. Movements of family groups are not well documented, but adults with dependent fledglings have been found up to 280 m away from known nest sites (Rimmer et al. 2005a). While second broods are rare (only one confirmed), re-nesting after early-season clutch failures is common: females typically re-nest approximately a week after the loss of a clutch (Rimmer et al. 2001).

Nests built by Bicknell's thrush are bulky, cup-shaped structures comprised primarily of twigs and moss (Wallace 1939, Rimmer et al. 2001). The outer shell of the nest is constructed of twigs, mainly balsam fir, but sometimes red spruce or paper birch, and moss (Rimmer et al. 2001). Other materials found in nest walls include grasses, sedges, stalks of herbaceous flowering plants or ferns, dry leaves, bark strips, animal hair, and lichen (Wallace 1939, Rimmer et al. 2001). Nests are lined with decayed vegetation, often leaf mold. Nests in Vermont are frequently lined with threadlike, black rhizomorphs of horsehair fungus (*Marasimius androsaceous*) (McFarland and Rimmer 1996). Little information is available about the process of nest selection, but it is believed that females are responsible. Females do not show fidelity to nest sites, constructing nests in difference locations each year (Rimmer et al. 2001).

Eggs are subelliptical, bluish green with variable amounts of light brown spotting, and smooth to semi glossy in surface texture. Eggs have an approximate mean length of 22 mm and mean breadth of 16 mm. First clutches typically contain three or four eggs (Rimmer et al. 2001).

E. Demography

In Vermont, annual reproductive success among males is highly skewed and generally low; certain males sire significantly more offspring than others (Goetz et al. 2003, Rimmer et al. 2005a,). Nest survival rates follow a strong biennal pattern in response to fluctuations in balsam fir cone crop size and red squirrel population cycles. In years when fir cones are abundant, squirrel populations are correspondingly large in the following spring and summer. As one of the primary nest predators on the Bicknell's thrush, burgeoning red squirrel populations substantially reduce nest success (Rimmer et al. 2001).

Juvenile survival rates are poorly known because few juveniles return to their natal sites in subsequent years (Rimmer et al. 2005a). Survivorship of breeding adults seems to vary geographically, and is estimated to be approximately 0.65 for both sexes in Vermont, 0.28 for females in Quebec, and 0.63 for males in Quebec (COSEWIC 2009).

Sex ratio in adult populations is highly skewed—1 female:1.49-3.0 males (COSEWIC 2009). The longevity record for Bicknell's thrush is 11 years, though annual mean age reported by surveys is between 1.73 and 2.44 years (COSEWIC 2009).

F. Migration

Though migratory routes are poorly documented, the Bicknell's thrush is known to be a long-distance migrant, moving between breeding grounds in New England and southeastern Canada and its winter range in the Greater Antilles. In fall, southbound migrants are thought to leave the East Coast from the mid-Atlantic states or the Carolinas, and continue on an overwater route to their winter range. Fall records from states south of Virginia are rare. Northbound spring migrants pass over the southeastern U.S.; records from Florida, Georgia, and points north are common. Both northbound and southbound migration routes are restricted to the area east of the Appalachian Mountains (Rimmer et al. 2001). Migration is nocturnal.

IV. POPULATION STATUS

A. Population Trends

Throughout large portions of its breeding range, Bicknell's thrush appears to be declining. Studies of individual populations have shown consistent decreases, with some shrinking by 7-19 percent annually (IBTCG 2010). Over the last decade, the species has disappeared completely from certain locations where it was once known, primarily in the southernmost portion of its range and along the Canadian Maritime coast. In the highland forests of eastern Canada that make up a significant portion of the species' breeding habitat, counts of Bicknell's thrush have been trending downward since 2001 (COSEWIC 2009). While the American portion of the global population shows signs of stability at this time (IBTCG 2010), the decline of the species in the White Mountains of New Hampshire—the core of its northeastern U.S. range—through the 1990s and the early part of the current decade are nonetheless cause for concern in such a vulnerable species.

Because of the unusual and complex mating system of Bicknell's thrush, and the dense, often inaccessible habitat it prefers, estimating population density is difficult (Rimmer et al. 2001). Biologists do not believe it is possible to accurately estimate the range-wide breeding population of Bicknell's thrush with the information currently available. Even crude estimates are somewhat unreliable, as they rely on numerous unverifiable assumptions (K. McFarland pers. comm.).

In the late 1990s, surveys of Bicknell's thrush were largely limited to the U.S. portion of its range, but since the early 2000s, more field research and monitoring have occurred in both Canada and the U.S., and IBTCG (International Bicknell's Thrush Conservation

Group) (2010) recently used range-wide data on densities and extent of potential habitat to develop a new global population estimate. Applying region-specific density data (derived from point count surveys) to a model of potential habitat yielded estimates of 57,000 to 77,000 Bicknell's thrushes in the U.S. and 37,000 to 49,000 individuals in Canada, resulting in a global population of 95,000 to 126,000 birds (IBTCG 2010).

Although the latest population estimate of Bicknell's thrush is given as a range, rather than a single number, the danger of the estimate being off by a significant margin remains. This is because the numbers are extrapolated from habitat estimates and predicted densities of Bicknell's thrush, rather than actual Bicknell's thrush population numbers. Two assumptions built into the population estimate could result in large error. These are that 1) Bicknell's thrush densities, determined from limited surveys, are constant across their occupied habitat, and that 2) Bicknell's thrush occupy most or at least a substantial portion of available, quality habitat. Instead, there may be considerable variability in both Bicknell's thrush density and the species' use of occupied habitat within specific regions of the breeding range.

Regardless, even if the revised population estimate is accurate, a global population of 100,000 individual Bicknell's thrush is very small for a neotropical songbird species (K. McFarland, pers. comm.). Further, the species' polygynandrous mating system, with a sex ratio highly skewed toward males, means the effective population size of the Bicknell's thrush is even lower than the estimate of 100,000 or so individuals would indicate.

Several continuous monitoring programs of high-elevation songbirds in the Northeast and eastern Canada have yielded data from point count surveys conducted over the last ten years or longer. These surveys have been conducted by volunteers and field technicians in the northeastern U.S. (Mountain Birdwatch), White Mountain National Forest, and Canadian Maritime provinces (High Elevation Landbird Survey). Government and academic biologists have conducted monitoring at sites in Quebec since the late 1990s. Due to its preference for remote, high-altitude habitats, the Bicknell's thrush is poorly represented on the North American Breeding Bird Survey (BBS), but 16 Canadian BBS routes provide data on the species (IBTCG 2010).

The most recent data on population trends are summarized in IBTCG's (2010) Conservation Action Plan.

United States

- 7% decline in White Mountain National Forest (WMNF; New Hampshire), from 1993–2003 (King et al. 2008, Lambert et al. 2008)
- Stable overall trend from 2001–2009 across the U.S., based on Mountain Birdwatch data (VCE, unpubl. data)
- Regionally, abundance appeared to increase in the Adirondack Mountains (New York),

while showing no statistical trend in the Catskills (New York), Green Mountains (Vermont), and the White Mountains (New Hampshire). A disruption of the biennial cone masting cycle in montane forests during this 9-year period may have influenced these results, masking longer-term trends (McFarland et al. 2008).

Canada

- 17% annual decline in New Brunswick, from 2002-2009 (BSC/EOC, unpubl. data)
- 15% annual decline in Nova Scotia, from 2002–2009 (BSC/EOC, unpubl. data)
- 29% decrease in probability of occupancy at Mont Gosford, Québec from 2001-2007, with no change in detection probability (Y. Aubry, CWS/SCF, unpubl. data)
- 60% fewer individuals detected at Mont Gosford, Québec, from 2001-2007 (Y. Aubry, CWS/SCF, unpubl. data).
- 9% annual decline in abundance across Canada (BBS) from 1966–2008 (P. Blancher, Environment Canada, unpubl. data).

Annual surveys in the Northeast between 2001 and 2004 reported a 9 percent annual decline in Bicknell's thrush on 47 routes located in New York, Vermont, New Hampshire, and Maine (Lambert 2005, Rimmer et al. 2005c). However, breeding bird point counts conducted at sites on Mount Mansfield, Vermont between 1991 and 2009 indicate non-significant decline over the last 18 years (Rimmer et al. 2009a). Nonetheless, the 7 percent decline documented in the White Mountains of New Hampshire between 1993 and 2003 is troubling because the White Mountains constitute the core of the species' breeding range in the northeastern U.S. (Lambert et al. 2008). However, more recent information from the White Mountains indicates no statistical trend.

Canadian surveys yield similar results, though they have been less comprehensive and of shorter duration. The High Elevation Landbird Program (Bird Studies Canada 2009) revealed a 7 percent annual decline in Bicknell's thrush in New Brunswick and a 9 percent annual decline in Nova Scotia between 2003 and 2006 (Campbell et al. 2007).

Additionally, the Bicknell's thrush seems to have been extirpated from a number of historical breeding sites. The species has not been observed in 10 years on Quebec's Montagne Noire, on Mont Sir-Wilfrid, Mont des Éboulements, and at some historical sites in the Zec des Martres, Mont Comi, in Métis-sur-Mer, Mont St. Pierre, Bonaventure Island, and on the Magdalen Islands. Nor is it recently recorded from the southern half of New Brunswick, on Grand Manan Island, from mainland Nova Scotia, Seal and Mud Islands, and parts of Cape Breton Island (COSEWIC 2009). No records exist after 1990 from several historic sites in the U.S., including Mt. Greylock in Massachusetts; from Bromley Mountain, Mount Ascutney, Mount Aeolus, and Mount Glebe in Vermont; and from Mount Monadnock in New Hampshire (Atwood et al. 1996, VCE unpubl. data as cited in COSEWIC 2009).

Population and trend data from the Bicknell's thrush winter range are much more spotty. No true population surveys are ongoing. The only consistent monitoring program is spot-mapping and banding at a protected cloud forest site in the Dominican Republic. However, a preliminary examination of data from this site over the last 15 years shows a population decline (C. Rimmer pers. comm.). There are few data on local extirpations on the winter range. A few sites have been reported, including the Parque del Este and Cordillera Oriental in the eastern lowlands of the Dominican Republic, as locations where Bicknell's thrush were formerly known and now are no longer found (C. Rimmer pers. comm.).

That decline and disappearance are so consistently and widely reported is cause for major concern over the long term viability of Bicknell's thrush, given the limited and fragmented nature of this species' preferred habitat, and current threats to both breeding and wintering habitats (Rimmer et al. 2005a,c). It is possible that recent disappearances of the species from historic southern and coastal breeding sites are early signals of the effects of climate change (Lambert and McFarland 2003). Projected, future impacts of climate change on the species' habitat (Lambert and McFarland 2003, Rodenhouse et al. 2008) are likely to cause far more than localized extirpations; significant retraction of the species' breeding range is predicted with projected temperature increases (Lambert and McFarland 2003, Rodenhouse et al. 2008). When climate impacts are considered in combination with the restricted range of the Bicknell's thrush, other ongoing threats to the species and its habitat, and its relatively small global population size, it is clear that the species is vulnerable to extinction in the immediate and foreseeable future.

B. Conservation status

Though the tenuous status of the Bicknell's thrush has been recognized by both government agencies and non-government organizations, no formal listing has been undertaken and no designations currently afforded to the species confer any substantive protection, regulatory or otherwise.

In the U.S., Bicknell's thrush is a Regional Forester Sensitive Species in Region 9 (Eastern Region) (USFS 2000), and was a former C2 candidate for listing by the U.S. Fish and Wildlife Service prior to the abolishment of that category in 1996. It is currently considered by the Service to be a Bird Species of National Concern (USFWS 2008c).

In Canada, the status of the Bicknell's thrush under COSEWIC was updated from Special Concern to Threatened in November 2009, due to consistent signs of decline. According to the COSEWIC (2009) assessment summary: "…all the available indices on trends point to significant declines in population and area of occupancy. Preliminary results…suggest a 40% decline in the area occupied over the last three generations" (COSEWIC 2009).

Bicknell's thrush is listed as a Species of Special Concern by the Vermont Department of Fish and Wildlife, the New York Department of Environmental Conservation, and the Maine Department of Inland Fisheries and Wildlife. It is a Species of Special Concern Category B (Responsibility Species) in New Hampshire. It is also designated as Vulnerable in Nova Scotia under the Nova Scotia Endangered Species Act and May Be at Risk by New Brunswick Natural Resources (New Brunswick Natural Resources 2010) and Quebec (IBTCG 2010).

The Audubon Society lists the species on its 2007 Watchlist as red, indicating that the species is declining rapidly with very small populations on limited ranges and faces major conservation threats (Audubon Society 2007). Partners in Flight designates the Bicknell's thrush as the top conservation priority among Neotropical migrants in the Northeast, placing the species on its Continental Watch List (Wells 2007).

In 2000, 2004, and 2008, Bicknell's thrush was listed as globally Vulnerable by the IUCN (IUCN 2010), indicative of a perceived high risk of extinction (IUCN 2008).

State and provincial Natural Heritage programs have designated the Bicknell's thrush as S1 (critically imperiled) in Nova Scotia; S2 (imperiled) in New Hampshire and New York; and S3 (Vulnerable) in Maine, New Brunswick, Quebec, and Vermont. (Natureserve.org as cited in IBTCG 2010).

V. BICKNELL'S THRUSH WARRANTS LISTING UNDER THE ESA

Under the ESA, 16 U.S.C. § 1533(a)(1), USFWS is required to list a species as threatened or endangered if it is in danger of extinction or threatened by possible extinction in all or a significant portion of its range. In making such a determination, USFWS must analyze the status of Bicknell's thrush in light of five statutory listing factors:

(A) The present or threatened destruction, modification, or curtailment of its habitat or range;
(B) Overutilization for commercial, recreational, scientific, or educational purposes;
(C) Disease or predation;
(D) The inadequacy of existing regulatory mechanisms;
(E) Other natural or manmade factors affecting its continued existence.
16 U.S.C. § 1533(a)(1)(A)-(E); 50 C.F.R. § 424.11(c)(1) - (5).

Petitioner believes that at least three of these five factors have contributed to the decline of the Bicknell's thrush, and continue to threaten the species' long term persistence.

A species is "endangered" if it is "in danger of extinction throughout all or a significant portion of its range" due to one or more of the five listing factors. 16 U.S.C. § 1531(6). A species is "threatened" if it is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." 16 U.S.C. § 1531(20). While the ESA does not define the "foreseeable future," the USFWS must use a definition that is reasonable, that ensures protection of the petitioned species, and that gives the benefit of the doubt regarding any scientific uncertainty to the species. Because global warming is one of the foremost threats to Bicknell's thrush, the USFWS should consider the time frames used in climate modeling. The minimum time period that meets these criteria is 100 years. Predictions of impacts in the next 100 years or more are routine in the climate literature, demonstrating that impacts within this timeframe are inherently "foreseeable." The IUCN threatened species classification system also uses a time frame of 100 years. Moreover, in planning for species recovery, the USFWS (as well as its sister agency, the National Marine Fisheries Service) routinely considers a 75-200 year foreseeable future threshold (Suckling 2006). For example, the Alaska Region has previously stated in the Steller's Eider Recovery Plan:

> The Alaska-breeding population will be considered for delisting from threatened status when: The Alaska-breeding populations has <1% **probability of extinction in the next 100 years**; AND Subpopulations in each of the northern and western subpopulations have <10% probability of extinction in 100 years and are stable or increasing. The Alaska-breeding population will be considered for reclassification from Threatened to Endangered when: The populations has > 20% **probability of extinction in the next 100 years** for 3 consecutive years; OR The population has > 20% probability of extinction in the next 100 years and is decreasing in abundance (USFWS 2002 (emphasis added)).

With regard to the Mount Graham red squirrel, the USFWS stated "At least 10 years will be needed to stabilize the Mt. Graham red squirrel population and **at least 100 to 300 years will be needed to restore Mt. Graham red squirrel habitat**" (Suckling 2006 (emphasis added)). With regard to the Utah prairie dog, the Service defined the delisting criteria as "[t]o establish and maintain the species as a self-sustaining, viable unit with retention of 90 percent of its genetic diversity **for 200 years**" (Suckling 2006 (emphasis added)). The National Marine Fisheries Service stated of the Northern right whale: "[g]iven the small size of the North Atlantic population, downlisting to threatened **may take 150 years** even in good conditions" (Suckling 2006 (emphasis added)).

Perhaps most importantly, the time period the USFWS uses in its listing decision must be long enough so that actions can be taken to ameliorate the threats to the petitioned species and prevent extinction. Slowing and reversing impacts from anthropogenic greenhouse gas emissions, a primary threat to the Bicknell's thrush, will be a long-term process for a number of reasons, including the long-lived nature of carbon dioxide and other greenhouse gases and the lag time between emissions and climate changes.

For all these reasons, Petitioner suggests a minimum of 100 years as the "foreseeable future" for analyzing the threats to the continued survival of the Bicknell's thrush. The use of less than 100 years as the "foreseeable future" in this rulemaking would clearly be unreasonable, frustrate the intent of Congress to have imperiled species protected promptly and proactively, and fail to give the benefit of the doubt to the species as required by law. USFWS must include these considerations in its listing decision.

VI. THREATS

A. Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

Habitat loss is the primary threat to the long term persistence of the Bicknell's thrush. The montane ecosystems that host populations of the Bicknell's thrush are small and fragmented, heightening their vulnerability to a number of complex, interrelated threats. Foremost among these threats is global climate change. As temperatures rise, the distribution of the tree species that currently comprise the montane forest where the Bicknell's thrush breeds are likely to disappear from most of their current ranges in the northeastern United States. Such changes will fundamentally alter the composition of the high-elevation forests that are essential to the continued presence of the Bicknell's thrush.

However, climate change is only one of a suite of factors that threatens Bicknell's thrush habitat in the Northeast. Numerous additional environmental stressors are contributing to the rapid decline of montane forests. Acid deposition, ground-level ozone, forest pests, and habitat loss caused by the development of ski resorts, communications infrastructure, and wind energy all play roles in the continued loss and degradation of this species' habitat (Atwood et al.1996, Hart and Lambert 2007). In the future, increased storm frequency and severity could play more of a role in altering the forest habitats where Bicknell's thrush lives. Many of these stressors are amplified by environmental shifts driven by climate change.

In the more northern reaches of Bicknell's thrush's breeding range, industrial timber management practices, including clearcutting and pre-commercial thinning, are a significant threat to the bird's habitat in the highland forests of Quebec and the Maritime provinces (COSEWIC 2009).

While some threats affect both breeding (summer) and winter habitat, others are relevant only to one range or the other; geographical differences are addressed within the subsection devoted to each individual threat.

1. Climate Change

Climate change represents the gravest threat to the long-term survival of the Bicknell's thrush as a species, and will affect populations in several different ways. Primarily, climate change will alter the geographic distribution of spruce-fir forest by reducing climatic suitability within its current range, potentially eliminating this forest type from the northeastern United States and facilitating the in-migration of tree species now more typical of mid-Atlantic or southern regions. Larger and more widely distributed populations of forest pests, and an increased incidence of major disturbance events may expedite this transition between forest types, and may also directly affect the reproductive success and survival of breeding thrushes. Climate change is also projected to cause significant drying in the Caribbean basin, which may negatively affect this species' winter range. Cumulatively, the multiple avenues by which climate change is likely to affect the Bicknell's thrush are wholly unsustainable by this already-threatened species.

In its most recent 2007 report, the Intergovernmental Panel on Climate Change (IPCC)[1] expressed in the strongest language possible its finding that global warming is occurring: "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level" (IPCC 2007: 5). The international scientific consensus of the IPCC is that most of the recent warming observed has been caused by human activities and that it is "very likely" due to increased concentrations in anthropogenic greenhouse gases (IPCC 2007).

One of the most troubling recent findings is that the concentration of atmospheric carbon dioxide, the biggest contributor to global warming, has been rapidly increasing throughout the 2000s and is generating stronger-than-expected and sooner-than-predicted climate forcing (Canadell et al. 2007, Raupach et al. 2007). Studies that have used climate projections to examine the ecological consequences of global warming have forecast catastrophic species extinctions. Using a mid-range climate scenario, Thomas et al. (2004) predicted that 15-37 percent of species will be committed to extinction by 2050. Malcolm et al. (2006) estimated that 11-43 percent of endemic species in biodiversity hotspots will go extinct by the end of the century under a scenario of doubled carbon dioxide concentrations, which includes an average of 56,000 endemic plants and 3,700 endemic vertebrate species.

The basic physics underlying climate change are well established. The earth absorbs heat in the form of radiation from the sun, which is then redistributed by atmospheric and oceanic circulations and also radiated back to space (Le Treut et al. 2007). The earth's climate is the result of a state in which the amount of incoming and outgoing radiation is approximately in balance (Le Treut et al. 2007). Changes in the earth's climate can be caused by any factor that alters the amount of radiation that reaches the earth or the amount that is lost back into space, or that alters the redistribution of energy within the atmosphere and between the atmosphere, land, and ocean (Le Treut et al. 2007). A change in the net radiative energy available to the global earth-atmosphere system is called "radiative forcing" (Le Treut et al. 2007). Positive radiative forcings tend to warm the earth's surface, while negative radiative forcings tend to cool it (Albritton et al. 2001).

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[1] The IPCC was established by the World Meteorological Organization and the United Nations Environment Programme in 1988 (IPCC 2001). The IPCC's mission is to assess available scientific and socio-economic information on climate change and its impacts and the options for mitigating climate change and to provide, on request, scientific and technical advice to the Conference of the Parties to the United Nations Framework Convention on Climate Change (IPCC 2001). Since 1990, the IPCC has produced a series of reports, papers, methodologies, and other products that have become the standard works of reference on climate change (IPCC 2001). The IPCC's comprehensive Assessment Reports are produced approximately every seven years and build upon and expand past IPCC products. The *Fourth Assessment Report* was released in 2007.

Radiative forcings are caused by both natural and anthropogenic factors (Albritton et al. 2001, ACIA 2004, Le Treut et al. 2007). Nevertheless, it is clear that the level of scientific understanding of these different forcings varies widely, and the forcings themselves and interactions between them are complex (Le Treut et al. 2007). The primary cause of climate change is society's production of massive amounts of "greenhouse gases," such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and halocarbons that cause positive radiative forcings (Forster et al. 2007, Le Treut et al. 2007).

The "enhanced greenhouse effect" is caused by increasing concentrations of these greenhouse gases in the earth's atmosphere[2] (EPA 2009a). As greenhouse gas concentrations increase, more heat reflected from the earth's surface is absorbed by these greenhouse gases and radiated back into the atmosphere and to the earth's surface. Increases in the concentrations of greenhouse gases slow the rate of heat loss back into space and warm the climate, much like the effect of a common garden greenhouse (Forster et al. 2007). The higher the level of greenhouse gas concentrations, the larger the degree of warming experienced. Carbon dioxide is the most important greenhouse gas because anthropogenic emissions of carbon dioxide dwarf those of all other compounds (Forster et al. 2007, Le Treut et al. 2007). While much smaller amounts of other greenhouse gases are emitted, these other gases still make an important contribution to climate change because they have global warming potentials[3] many times that of carbon dioxide (Foster et al. 2007). Increases in the most important greenhouse gas pollutants and their contribution to climate change are reviewed below.

The Fourth Assessment Report from the Intergovernmental Panel on Climate Change (IPCC 2007) sets forth the best available science on climate change. By the time the IPCC's Fourth Assessment Report was released in 2007, the atmospheric concentration of carbon dioxide had increased by 36 percent since 1750 to a level that has not been exceeded during the past 650,000 years and likely not during the past 20 million years (Denman et al. 2007). About three-fourths of manmade carbon dioxide emissions come from fossil fuel burning, and most of the remaining emissions are due to land-use changes, primarily deforestation (Denman et al. 2007). Carbon dioxide is considered the most important greenhouse gas overall because the volume emitted is greater than all the other greenhouse gases combined. Carbon dioxide emissions increased during the period from 2000 to 2005 (4.1 ±0.1 GtC yr-1) compared to emissions during the 1990s (3.2 ± 0.1 GtC yr-1) (Denman et al. 2007). Not surprisingly, the rate of increase of total atmospheric carbon dioxide concentrations is speeding up as well. As of June 2010,

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[2] An increase in the natural process of the greenhouse effect, brought about by human activities, whereby greenhouse gases such as carbon dioxide, methane, chlorofluorocarbons and nitrous oxide are being released into the atmosphere at a far greater rate than would occur through natural processes and thus their concentrations are increasing. This causes, in turn, greater trapping of infra-red radiation and increased warming influence on the climate. Referred to also as anthropogenic greenhouse effect or climate change.

[3] The concept of a global warming potential (GWP) was developed to compare the ability of each greenhouse gas to trap heat in the atmosphere relative to another gas. The definition of a GWP for a particular greenhouse gas is the ratio of heat trapped by one unit mass of the greenhouse gas to that of one unit mass of CO_2 over a specified time period (EPA 2006).

according to measurements at the NOAA/ESRL Mauna Loa Observatory[4], the atmospheric carbon dioxide concentration is 392 ppm (CO_2Now 2010) and rising at over 2 ppm per year (Shukman 2006).

Halocarbons are carbon compounds that contain fluorine, chlorine, bromine, or iodine (Forster et al. 2007). Most types of halocarbons are produced exclusively by human activities (Forster et al. 2007). Halocarbons that contain chlorine, like chlorofluorocarbons ("CFCs"), also cause depletion of the stratospheric ozone layer and are regulated under the Montreal Protocol (Forster et al. 2007). The combined tropospheric abundance of ozone-depleting gases peaked in 1994 and is now declining slowly (Forster et al. 2007). However, some compounds which have been promoted as substitutes for now-regulated CFCs are themselves greenhouse gases, and concentrations of these gases, such as hydrochlorofurocarbons ("HCFCs") and hydrofluorocarbons ("HFCs") are now increasing (Forster et al. 2007). There are many different types of halocarbons, which have global warming potentials that vary between 12 and 12,000 times that of carbon dioxide (Forster et al. 2007).

Many other natural and human-caused factors that are less well understood than greenhouse gases also contribute to positive or negative radiative forcing, including aerosol emissions, land-use changes, and changes in solar and volcanic activity, water vapor, and cloud cover (Le Treut et al. 2007). Nevertheless, scientists now know that greenhouse gases are the most important force driving climate change, and that carbon dioxide is in turn the most important of the greenhouse gases (Forster et al. 2007, Solomon et al. 2007). Carbon dioxide emissions from fossil fuel burning are virtually certain to remain the dominant factor affecting trends in atmospheric carbon dioxide concentrations during this century (Forster et al. 2007).

As scientific understanding of climate change has advanced, so too has the urgency of the warnings from scientists about the consequences of greenhouse gas emissions. Scientists now predict, with a high degree of certainty, that additional warming of more than 1º C (1.8º F) above year 2000 levels will constitute "dangerous climate change," with particular reference to sea level rise and species extinction (Hansen et al. 2006, Hansen et al. 2007).

Since the year 2000, however, greenhouse gas emissions have continued to rise; carbon dioxide emissions have increased by two percent per year since 2000 (Denman et al. 2007).[5] If this growth continues for just ten more years, the resulting 35 percent increase in CO_2 emissions between 2000 and 2015 will make it impractical if not impossible to

[4] The continuous, high-precision measurement of changes in atmospheric CO_2 concentrations was started at the Mauna Loa Observatory in Hawaii, U.S.A. in 1958. CO_2 is well mixed in the atmosphere, so observations from a single site like the Mauna Loa Observatory are an adequate indicator of world trends for atmospheric CO_2.

[5] The Northeast region's greenhouse gas emissions have risen over the last twenty years, in parallel with global emissions. Northeast States for Coordinated Air Use Management (NESCAUM), a non-profit association located in Boston, Massachusetts, found in a 2004 report that greenhouse gas emissions in New England and the Eastern Canadian Region rose from 332 to 367 million metric tons of CO_2 equivalent between 1990 and 2000. This was an increase of 10.5 percent. (NESCAUM 2004).

keep global temperature rise since year 2000 below 1°C (Hansen et al. 2006, Hansen et al. 2007). Moreover, the difference between keeping global warming to less than 1º C and having warming of 2-3º C or more may depend upon a relatively small difference in anthropogenic greenhouse gas emissions (Hansen et al. 2006, Hansen et al. 2007). This is because warming of greater than 1º C may induce positive climate feedbacks, such as the release of large amounts of methane from thawing arctic permafrost, that will further amplify the warming (Hansen et al. 2006, Hansen et al. 2007).

If greenhouse gas emissions stay on their current trajectories, in just ten years the planet will be on a near-certain path of climate disaster. Dr. James E. Hansen, Director of the NASA Goddard Institute for Space Studies, and NASA's top climate scientist, has stated: "In my opinion there is no significant doubt (probability > 99 percent) that…additional global warming of 2º C would push the earth beyond the tipping point and cause dramatic climate impacts including eventual sea level rise of at least several meters, extermination of a substantial fraction of the animal and plant species on the planet, and major regional climate disruptions" (Hansen 2006).

In order to avoid truly unacceptable consequences of climate change, we must stop the growth of greenhouse gas emissions, and, in a relatively short amount of time, begin reducing them. Achieving the reductions necessary to keep additional climate change between the years 2000-2100 within 1º C will be extremely challenging, and will require deep reductions in emissions from industrialized nations such as the United States.

a. Impacts of climate change on habitat used by the Bicknell's thrush

Forests within the breeding range of the Bicknell's thrush are already shifting significantly in response to climate change. Projections of upward and northward migration of suitable habitats for Northeast trees, particularly the boreal species with which Bicknell's thrush is so closely associated, are even more dramatic. As mean temperatures in the region continue to rise, the species' existing forest habitat will be increasingly stressed by a variety of climate-related factors. On the winter range, projected drying in the Caribbean and increased frequency of hurricanes and other intense weather events also threaten the long-term existence of the tropical forests Bicknell's thrush inhabits. The restricted and fragmentary nature of Bicknell's thrush's habitat in both its summer and winter range makes this species particularly vulnerable to the multiple, interacting, and intensifying forces of climate change.

i. Direct effects of climatic change on forest composition

Breeding habitat

Scientists consider montane habitats to be particularly vulnerable due to their restricted geographic distribution, exposure to atmospheric deposition, and the potential for future constriction due to climate change (King et al. 2008). In the montane zone of the Northeast United States, increased temperatures and alteration of precipitation patterns are expected to have sizeable impacts on forest composition, productivity, and sustainability (Lambert et al. 2005). A rise in average temperatures in the region will result in an upslope advance of hardwoods and a corresponding loss of the subalpine spruce-fir habitat to which Bicknell's thrush is restricted (Lambert et al. 2005b).

Scientists are already documenting upward shifts of forest communities in the Northeast over recent decades. Beckage et al. (2008) found that in the northern hardwood-boreal forest ecotone in the Green Mountains of Vermont, there was a 19 percent increase in the dominance of northern hardwoods over a 40 year span. Between 1962 and 2005, the upper limits of the ecotone shifted up by 91 to 119 m. Regional climate change was consistent with this upward shift. Based on a 1.1°C increase in temperature over the study period, a 208 m upslope movement of the ecotone would be predicted, not accounting for lag time of forest migration. The degree to which the actual ecotone tracked the shifting temperature upslope indicates there may be little inertia to climate-induced range shifts in montane forests. As Beckage et al. conclude: "…high-elevation forests may be jeopardized by climate change sooner than anticipated."

Mean July temperature and the spruce-fir/deciduous forest boundary in the mountains of the Northeast are closely linked (Cogbill and White 1991). Between 1895 and 1999, statewide summer temperatures increased by 0.3° C in New York and 0.6° in New Hampshire and Vermont (Keim and Rock 2001). Hamburg and Cogbill (1988) and Friedland (1989) proposed that warming temperatures have been the major driver of an historical decline in red spruce in New England over the last century.

Projections of change due to climate in Bicknell's thrush's montane forest habitat indicate much more substantial change is yet to come. A model of the impact of climate change on trees in the Northeast U.S. shows that suitable habitat for spruce-fir forest retreats to the highest summits and most northern latitudes in the region under a low emissions scenario. Under a high greenhouse gas emissions scenario, suitable habitat for spruce-fir vanishes from the Northeast (Iverson et al. 2008) (**Fig. 4**).

Montane spruce-fir forest currently covers less than one percent of the Northeast's landscape (Cogbill and White 1991). Changes in summer temperature projected to occur this century could eventually reduce the availability of spruce-fir habitat for the Bicknell's thrush by over 95 percent (Rodenhouse et al. 2008). Models that incorporate the latitudinal/elevational drivers of forest compositional change, climate projections, and suitability parameters for Bicknell's thrush habitat predict that an increase of 1°C in mean summer temperature is likely to reduce the amount of habitat suitable for the Bicknell's thrush in the Northeast by more than half (Lambert and McFarland 2003). Suitable habitat for Bicknell's thrush would be entirely lost from the Catskill Mountains of New York, and there would be significant losses of habitat in the Green Mountains of Vermont, the southern Adirondacks of New York, northern New Hampshire, and western Maine (Lambert and McFarland 2003).

Some authors have suggested that because the habitat lost at 1° C warming would be more at the margins, and of lower quality, for Bicknell's thrush, that it might not be as significant for the population as a whole, despite the large areal extent of the loss

(Lambert and McFarland 2003). However, low quality habitat may still play a very crucial role in population dynamics and viability (Donovan et al. 1995, as cited in Rodenhouse 2008). And the loss of even a small number of individuals could be significant in a species that that is already at risk, in part, due to its small global population.

An increase of 2°C is predicted to render unsuitable all current breeding sites in New York and Vermont, and an increase of 3°C may eliminate nearly all (88-98 percent) suitable habitat from the Northeast (Lambert and McFarland 2003). Remnant patches may remain in New Hampshire's Presidential Range and on Maine's Mount Katahdin after 5°C of warming, but no habitat is projected to remain beyond 6°C (Rodenhouse et al. 2008) (**Fig. 5**).

The question remains open whether montane spruce-fir forest will move up into current alpine zones of the Northeast as temperatures increase. With small increases in temperature, the forces of wind, ice damage, and snow depth may maintain alpine communities and prevent the migration of forest to summits except in more protected pockets (Kimball 2009). The highest summits in the region may maintain their alpine habitat because they stand above the regional atmospheric boundary layer, and are subject to fog and rime ice deposition (Seidel et al. 2009). At greater extremes of warming, however, stunted krummholtz forest may be able to gain hold in present unforested alpine habitats. The amount of area offered by the Northeast's highest elevation zone is extremely limited in any case (Rodenhouse 2008). The small patches of summit spruce-fir forest that may result from the higher projected temperature increases in the region would likely offer far too little habitat to sustain Bicknell's thrush in the long term.

Climate models project an increase of between 2.8 and 5.9°C mean summer temperature in the Northeast, based on low and high emissions scenarios (UCS 2006). Temperature increases within this range will eliminate the majority of habitat suitable for the Bicknell's thrush within its subalpine breeding range.

Recent disappearances of Bicknell's thrush from coastal locations in Canada, and earlier disappearances of the species from low mountains, mostly at the southern reaches of its range, are thought to be possible early signals of climate change and its harmful effect on Bicknell's thrush habitat (Lambert and McFarland 2003). These occurrences are "consistent with range shifts attributable to climate change in other animal species" (Lambert et al. 2005b).

The fragmentary nature of Bicknell's thrush breeding habitat will become more so in the face of climate warming. Other climate-driven dynamics, such as the potential invasion of less cold-tolerant forest pests and pathogens (Iverson et al. 2008), also threaten to diminish the species' already limited and vulnerable habitat (Lambert et al. 2005b). Correspondingly smaller populations of Bicknell's thrush could become increasingly fragile, even to the point of localized extirpation, due to yet other stressors, such as disruption of the cone-red squirrel (*Tamiasciurus hudsonicus)* population cycle; increased nest failure due to higher frequency of extreme wind and rain events; or changes in the emergence patterns of insects and other prey species (IBTCG 2010). Climate-induced stress to montane forest habitat may be amplified by interaction with yet other threats such as acid deposition. Multiple stressors acting simultaneously can result in rapid change (Driscoll 2001). As geographical ranges of plant species shift as a result of climate change "population sizes will decrease, and forests may have increased susceptibility to disease and other forms of disturbance" (Davis and Zabinski 1994).

Climate modeling for the highland forests utilized by Bicknell's thrush in Canada does not yet appear to have been done. Elevations for these forests are generally lower than for the mountain habitat occupied by Bicknell's thrush in the Northeast United States. How climate may interact with these lower forests, in combination with ongoing intensive timber management, is unclear. However, logging, as an artificial disturbance, may cut short the natural lag time that would otherwise occur between temperature shift and a change in the composition and structure of the forest community.

Winter habitat

Habitat quality in the Greater Antilles is reduced by drought induced by the El Niño-Southern Oscillation. Global warming could be increasing the intensity of this periodic climate event (Sillet et al. 2000). The projected drying trend for islands in the Caribbean Basin is also expected to reduce the suitability of habitat in this region for Neotropical migrant species, including Bicknell's thrush (Neelin et al. 2006). More frequent tropical storms and more erratic weather in the Caribbean region are also expected as a result of climate change (Angeles et al. 2007). Bicknell's thrush winter habitat could be subject to damage or destruction from more severe weather events (IBTCG 2010).

ii. Forest Pests and Diseases

Breeding habitat

Changing climate will likely alter the disturbance dynamics of native forest insects and diseases, as well as facilitate the establishment and spread of non-indigenous species (Hunt et al. 2006). The rate at which most pests develop is dependent on temperature and every species has a particular "threshold temperature" above which development can occur, and below which development ceases (Collier 2008). As temperatures rise, some pest species may be able to breed more generations in a year (Hunt et al. 2006). Thus, the ability of non-native forest pests to establish and spread may be improved, as the range of suitable environments expands (Hunt et al. 2006).

While the Bicknell's thrush relies on various forms of forest disturbance, including insect outbreaks, to perpetuate the high-stem density stands it favors, sudden and large scale forest die-off could prove disastrous for a species already at risk.

The balsam woolly adelgid (*Adelges picaeae*) is an exotic pest insect introduced from northern Europe that has decimated stands of balsam fir in the southern Appalachians but is currently controlled in the Northeast by cold winter conditions (Lambert et al. 2005b). Low temperatures in winter are all that shield northeastern fir forests from the balsam woolly adelgid (Iverson et al. 1999). As temperatures rise, destructive insects such as this may invade forests from which they are now excluded.

In the Northeast and eastern Canada a native forest insect pest known as the eastern spruce budworm (*Choristoneura fumiferana*) can also have devastating impacts on large swaths of spruce-fir forest. Despite the species' name, it is most damaging to balsam fir in the eastern United States, though the budworm will also attack spruce (Kucera 2010). Spruce mixed with balsam fir is more likely to suffer budworm damage than spruce in pure stands (Kucera 2010).

The budworm's range, as with other insects, appears to be strongly related to weather and temperature. Budworm outbreaks seem to follow drought; warmer temperatures are correlated with greater numbers of budworm eggs (Gitay et al. 2001). Outbreaks can affect vast areas and last for 5-15 years, killing most trees in mature stands (Gitay et al. 2001). While a budworm outbreak might provide an initial boon to avian arthropod predators, such as Bicknell's thrush, high larval populations may exceed the capacity of resident birds to control them (Gitay et al. 2001) and result in longer term damage to the fir and spruce trees, and therefore the species' spruce-fir habitat.

Increasing temperatures, particularly if synchronous with drought, could lead to more frequent budworm outbreaks. Warmer springs may also decouple patterns of emergence between budworm populations and the phenology of their parasitoid and avian predators (Gitay et al. 2001).

In large portions of the Canadian range, spruce budworm outbreaks in the mid 1970s and early 1980s reduced habitat for the species (Nixon 1999). Balsam fir regenerated in the wake of the spruce die-off, but pre-commercial thinning again dramatically reduced the amount of regenerated forest that was suitable habitat for the bird (COSEWIC 2009).

Bicknell's thrush biologists recognize that climate-induced changes in forest pathogens and pests on the breeding range are likely to diminish habitat quality (Lambert et al. 2005b) and will likely interact with other threats to forest habitat to decrease the amount of suitable habitat available to the species.

Winter habitat

While little, if any, information appears to be available on the potential impacts of climate change on forest pests and pathogens within Bicknell's thrush's winter habitat, the projected climatic changes for the Caribbean suggest that present forest health dynamics will shift, potentially dramatically.

iii. Increased incidence of natural disasters

Breeding habitat

Climate change is projected to not only reduce the extent of Bicknell's thrush habitat, but also to cause more erratic and severe weather events. How these events, which could include increased frequency of hurricanes, microbursts and windthrow, ice damage, and even wild fire, would affect the long-term persistence of the bird's spruce-fir habitat is unknown. Balsam fir is the least fire-resistant conifer in the northeast U.S. and may not recolonize a burned area for 30-50 years (Rodenhouse et al. 2008). Under more stable climatic conditions, subalpine coniferous trees or stands lost to a catastrophic weather event would regenerate over time to the previous forest type. However, in a rapidly warming environment, the loss of spruce, fir and other subalpine tree species, whether due to severe storms or other factors, may constitute a "recruitment opportunity" for northern hardwoods currently confined to lower elevation slopes (Beckage et al. 2008).

Winter habitat

Climate change is predicted to result in more intense and frequent El Niño Southern Oscillation events (Kerr 1999). In the Caribbean, increased possibilities of both drought and flood (USGCRP 2000) have implications for Bicknell's thrush habitat. More severe and frequent wind and rain events could damage the forest habitats used by Bicknell's thrush in winter (IBTCG 2010).

2. Acid deposition

Acid deposition poses a serious threat to Bicknell's thrush habitat throughout its high elevation habitat in the Northeast. The extensive die-off of red spruce over the last several decades due to acid deposition has likely diminished the quality of the bird's habitat by opening up the canopy, and allowing the encroachment of less suitable tree species, such as hardwoods (Beckage et al. 2008, IBTCG 2010). The more open canopy resulting from high spruce mortality may also place the Bicknell's thrush at risk of greater predator exposure. Birds may need to invest greater time in finding suitable cover than in foraging and attending to other vital needs. Large areas of dead and dying spruce in the subalpine zone may constitute much poorer habitat for Bicknell's thrush, with fewer feeding, roosting and nesting sites (Bredin 2009). It is possible that fir and spruce regeneration following acid deposition-induced mortality could be suitable habitat for Bicknell's thrush (C. Rimmer, pers. comm.). However, this would not be the case where dying spruce trees are replaced by hardwood species (e.g., McNulty et al. 2005, Beckage et al. 2008). Further, the changes in soil chemistry caused by acid deposition may slow or inhibit the regeneration of spruce and other tree species (Driscoll et al. 2001).

The decline of high elevation forests in the northeastern U.S. during the 1960s and 1970s was well-documented, with pronounced dieback of red spruce and, to a lesser extent, balsam fir (Rimmer et al. 2001b, Miller-Weeks and Smoronk 1993). As our understanding of this phenomenon has become more refined, it has become clear that acid deposition is also an ongoing threat to forest health, with numerous and profound repercussions upon various aspects of the high elevation forest community, including terrestrial wildlife (see discussion about direct effects of acid deposition on Bicknell's thrush in Section E).

The causes of acid deposition are intimately linked with many of the same human activities that are the major causes of global climate change. Acid deposition is caused primarily by the burning of fossil fuels for electricity generation and for motor vehicles (Driscoll et al. 2001). In the United States, roughly two-thirds of all sulfur dioxide and one-quarter of all nitrogen oxides come from electric power generation that relies on burning fossil fuels, like coal (EPA 2007b). These gases react with water, oxygen, and oxidants to form acidic compounds. Wind carries these compounds hundreds of miles, and they are eventually deposited in a variety of forms: rain, snow, fog, dry solid and gaseous (EPA 2008a).

Eastern North America's acid deposition comes primarily from the Midwest, borne on prevailing winds. More sulfur and nitrogen oxides are emitted in the Midwest than in any other region of country (Driscoll 2001). Despite the passage of the 1990 Clean Air Act Amendments, acid deposition is still a problem. This is in part because while sulfur emissions have declined, nitrogen emissions have not in some regions, and in the eastern U.S. they have actually increased (Driscoll 2001). Compounding the problem is that the neutralizing ability of ecosystems has declined over time, making recovery slow, despite improvements in air pollution control.

Particularly relevant for high-elevation forests is the effect that acid deposition has on soils. Acid deposition accelerates the leaching of important nutrients from soils, such as calcium. The amount of calcium in soils at Hubbard Brook Experimental Forest in New Hampshire's White Mountains, for example, has declined by 50 percent in the past few decades (Driscoll 2001). Further, acid deposition increases the amount of aluminum in soils and waters. Aluminum can block the uptake of water and nutrients trees need (Hairston et al. 2003).

While the decline of red spruce in the Northeast has been strongly linked to climate warming (see Hamburg and Cogbill 1988), other researchers point to acid deposition as the primary cause of the tree's worsening condition throughout the eastern U.S. (DeHayes et al. 1999).

High-elevation forests are especially susceptible to acid deposition exposure, and sensitive to the complex and interactive chemical, biological, and environmental processes that result. Forest soils at high elevations are generally more shallow and poorly buffered than those at lower altitudes (Driscoll 2001). Further, montane forests in the Northeast are often enveloped in acidic clouds and fog that is more acidic than rain (EPA 2007a, DeHayes et al. 1999). The constant bathing of leaves in acidic fog strips leaves and needles of nutrients, and leaves them more vulnerable to damage from other environmental factors. This is especially true of red spruce, which appears to be much more susceptible to freezing injury as a result of acid deposition (DeHayes et al. 1999). "Increased winter freezing injury of spruce, possibly mediated through reductions in calcium reserves, may be directly linked to high levels of acidic deposition" (Rimmer et al. 2001). Freezing injury can weaken individual trees, and can lead to eventual tree death.

In New York's Adirondacks and Vermont's Green Mountains more than half the large canopy of red spruce has died since the 1960s. In New Hampshire's White Mountains, one-quarter of the large canopy red spruce has died (Driscoll et al. 2001). This is a dramatic change in Bicknell's thrush's mountain habitat over the last several decades.

3. Ground-level ozone and nitrogen atmospheric deposition

The Northeast region receives some of the greatest amounts of atmospheric deposition on the continent, due to its position downwind from large urban and industrial sources (Lovett and Tear 2008). In addition to acid deposition, discussed above, these pollutants include ground-level ozone, nitrogen, and mercury (discussed in Section E). High elevation forests in the Northeast are at particular risk from air-borne pollution (USGCRP 2003). In combination with other habitat stressors, including the long-term, overwhelming threat of climate change, atmospheric pollution threatens the montane forest habitat that Bicknell's thrush needs.

Tropospheric, or ground-level ozone is an air contaminant known to compromise the long-term sustainability of temperate forests (Campbell et al. 2007). Ozone is the product of nitrogen oxide and hydrocarbon emissions that react in the presence of sunlight in the atmosphere, and it can cause damage to leaves and reduce rates of photosynthesis and growth (Lovett and Tear 2008). Ozone at the levels most often found in the Northeast do not kill plants outright, but it can make them more vulnerable to other, lethal stressors, such as disease and insect pests (Lovett and Tear 2008).

Greater ozone exposure occurs at higher elevations, putting higher elevation plants at risk (USFS 2010). Research on impacts of ozone on coniferous trees has largely occurred in California and the West (see Campbell et al. 2007), so specific information about ozone impacts to montane red spruce and balsam fir is not as readily available. However, the injury and slowed growth observed in western conifers, along with ozone damage documented for other trees in the eastern U.S. and elsewhere, are strongly suggestive that ozone is yet one more air pollutant putting Bicknell's thrush habitat at risk of long term and potentially irreversible decline.

The high elevations of the Northeast also receive substantial levels of anthropogenic nitrogen deposition in the form of clouds and fog (Driscoll et al. 2003a). While initial additions of nitrogen to forests can accelerate growth, forests eventually become saturated with continued input. There is evidence suggesting that coniferous forests reach this point much sooner than hardwoods, and once the saturation point is reached, the forest begins leaching excess nitrogen into the environment (Driscoll et al. 2003a). Thus, nitrogen deposition at high elevations contributes to soil acidification, leaching of vital nutrients, and mobilization of harmful aluminum in the soil (Driscoll et al. 2003b). These impacts can eventually lead to forest decline and changes in composition of species (Driscoll et al. 2003a). For example, a study of nitrogen additions to a forest on Mount Ascutney, Vermont, showed that additional nitrogen increased mortality of red spruce (McNulty et al. 1996 as cited in Driscoll et al. 2003a). Timing of spruce dieback in the Northeast in the 1980s correlated with nitrogen deposition rates, leading scientists to believe that conifer forests were more sensitive to these inputs than broad-leaved deciduous forests. Forests experience foliar damage and reduced tolerance of other stressors, with exposure to nitrogen deposition, and increased nitrogen may make insect attacks more likely (Lovett and Tear 2008). It is estimated that forest productivity is diminished by as much as 14 percent in the Northeast, due to nitrogen deposition.

Atmospheric nitrogen deposition has remained fairly constant in the Northeast region since the 1960s, despite the enactment of the Clean Air Act and the 1990 Clean Air Act Amendment. The 1990 amendment helped to significantly reduce sulfur emissions, but it did not substantially decrease nitrogen emissions (Driscoll et al. 2003a).

Major sources of nitrogen oxides in the Northeast include off-road motorized vehicles and equipment, fossil-fuel based electrical generation, and industry. Nitrogen oxides and ammonia are also transported into the region from the Midwest and Mid-Atlantic areas, as well as portions of southern Canada (Driscoll et al. 2003a).

Nitrogen deposition constitutes yet one more threat to the East's high elevation forests, and to Bicknell's thrush habitat (IBTCG 2010).

4. Recreational development (ski areas)

Habitat loss and fragmentation by ski area development has been identified as a threat to the Bicknell's thrush within its breeding range in the northeastern United States (Rimmer et al. 2004). Telemetry data indicate that Bicknell's thrush avoids crossing large openings, such as those created by the development of ski slopes (Rimmer et al. 2004). Open ski trails reduce the amount of suitable habitat, although ski areas can be managed to provide suitable habitat between runs (Rimmer et al. 2004). Increased summer use and potential expansion of existing ski areas are of concern.

However, increased awareness about Bicknell's thrush in the region seems to be muting this particular threat to some degree. The proposed expansion of the state-run Whiteface ski area in the Adirondack Mountains posed a potential threat to nearby Bicknell's thrush habitat, which is designated an Important Bird Area by the Audubon Society's New York chapter (Foderaro 2006, Worsham 2003). In this particular case, after initial protests by conservationists, Bicknell's thrush biologists provided guidance to the Olympic Regional Development Authority on how to design the project and schedule the trail clearing and construction to minimize disturbance to the species (Foderaro 2006). Another ski area expansion in New Hampshire's White Mountains was similarly planned to keep disruption of Bicknell's thrush habitat to a minimum (Mathison 2009).

Of greater concern to the species than any individual ski area is the cumulative impact of multiple ski areas, including those already established as well as potential new areas and expansions. Increasing infrastructure and development for snow-making equipment may become a concern, as ski areas have to turn to snowmaking equipment more frequently with warming winter temperatures and changes in precipitation patterns.

5. Development of infrastructure for telecommunications and wind energy

Other forms of commercial/industrial development may currently pose greater, new threats to Bicknell's thrush habitat than ski areas. Both telecommunications and wind energy require open, exposed sites. As a result, infrastructure for these industries is often constructed on ridgelines or other high elevation sites, and typically results in loss and disturbance of surrounding forest habitat (Hart and Lambert 2006).

Wind turbine development may pose a significant threat to the Bicknell's thrush as construction activities alter or destroy remaining habitat patches. Many high-elevation areas ideal for siting new wind energy projects are also important areas of suitable nesting habitat for the Bicknell's thrush (COSEWIC 2009).

For example, East Mountain in East Haven, Vermont is the site of the largest remaining unit of montane forest habitat in the Northeast Highland physiographic region, and thus likely hosts its largest breeding population of Bicknell's thrush. East Mountain may very well be a regional core habitat, providing a population source for dispersal and recolonization for surrounding peaks, and enabling the species to persist in the region (Rimmer et al. 2007). The construction and operation of even a small wind turbine development threatens this important patch of habitat, and clearly exemplifies the vulnerability of Bicknell's thrush due to the restricted and fragmented nature of its habitat.

The expansion of communications infrastructure for radio, TV, and cell phone use also poses a threat to the habitat of the Bicknell's thrush. As with wind energy developers, communications tower planners look for summits and high places. Such development may be escalating, as electronic communications proliferate (Bredin et al. 2009). As with other forms of industrial development, communications infrastructure is associated with forest clearing, road building, power line installation, the erection of buildings, and night lighting (Bredin et al. 2009). Such development in Bicknell's thrush habitat is probably more of a threat in Canada than the United States, because the majority of habitat in the northeastern U.S. is on public land, and therefore is afforded some measure of protection from commercial development, at least new construction.

6. Logging and forest fragmentation

Intensive logging and fragmentation of Bicknell's thrush's habitat in its northern reaches (Canada, possibly northern Maine) is a prime threat to the continued existence of the species (IBTCG 2010). Dramatic drops at Canadian monitoring sites over the last one to two decades suggests that forestry practices applied to large swaths of the bird's highland habitat are damaging and threaten the long term survival of the species.

Considerable research remains to be done on the relationship between Bicknell's thrush population dynamics and trends, and their use of highland industrial forest in Canada and possibly parts of northern Maine. While Bicknell's thrush do occupy heavily logged landscapes in Quebec, as well as portions of New Brunswick (COSEWIC 2009), it is unclear how well they are doing in that landscape overall (C. Rimmer pers. comm.) or if they use it preferentially. There is very little known occupancy of heavily managed timberlands in the United States (C. Rimmer pers. comm.). So, it is possible that Bicknell's thrush chooses other habitats (such as unmanaged subalpine forests) when it has a choice. Only a very small portion of Bicknell's thrush's Canadian habitat is protected from logging, and there may simply not be enough unmanipulated habitat to accurately gauge whether lands subject only to natural disturbances (e.g. fire, insect outbreaks), rather than short rotation forestry, would be of the same or better quality.

Heavy logging over the last two decades in southeastern Canada has created a broad landscape of extensive clearcuts, fragmented by roads. This highland industrial forest is what Bicknell's thrush uses, for the most part, for breeding habitat in Canada (COSEWIC 2009). While it is unclear how much industrial forests as a whole constitute high quality habitat for the species, biologists have observed certain forestry practices that clearly render areas unsuitable for Bicknell's thrush, at least for a period of time. Chief among these techniques is pre-commercial thinning, which is utilized over a large area of the thrush's Canadian range (COSEWIC 2009).

Pre-commercial thinning is used to reduce stem density and promote tree growth, and is generally done 15-20 years post clearcutting. Densities go from approximately 40,000 stems/ha to 5,700 stems/ha in New Brunswick, and to less than 2,500 stems/ha in Quebec (Chisholm and Leonard 2008 as cited in COSEWIC 2009). Immediately after thinning, Bicknell's thrush numbers in the stand drop (Chisholm and Leonard 2008, COSEWIC 2009). Breeding in thinned stands has not been documented, and thrushes may not return to thinned stands for breeding for at least seven years, and possibly not even after 10-20 years (COSEWIC 2009). The large extent of area treated with pre-commercial thinning has brought about the loss of a significant part of the species' habitat and this lost lasts for at least for a couple decades (COSEWIC 2009). (It is also possible that thinning directly takes nests and eggs, as it usually occurs between June and August, when the thrush is engaged in its breeding and nesting activities. (COSEWIC 2009)). The precise impacts of pre-commercial thinning on thrush populations over the medium to long term are not known (IBTCG 2010). However, substantial declines have been observed in recent years in several Canadian monitoring programs, suggesting that the widespread practice of thinning does have an impact.

In the industrial highland forest, clearcutting is the norm, and Bicknell's thrush's use of regenerating forest beginning some 10-15 years after clearcutting confuses the question of whether clearcutting is a help or a harm. Certainly a new clearcut is unuseable by

Bicknell's thrush. It is used, if allowed to regenerate, when stem density exceeds 10,000-15,000 stems/ha, and where the forest canopy is greater than 2 m in height (COSEWIC 2009). The utility of this habitat for Bicknell's thrush may be quite short-lived however, as pre-commercial thinning typically occurs at just about 15 years after clearcutting. Even if thinning does not occur, the better growing conditions of the lower elevation "highlands" (as compared with the Northeast U.S. mountains' subalpine zone) lead to quicker maturation of the forest. Without new disturbance (natural or artificial) a particular patch in the highlands of Canada becomes unsuitable for Bicknell's thrush much more rapidly than a forest patch at high elevation.

It is also possible that Bicknell's thrush uses mature forest to some extent in its Canadian range. Individuals have been observed in uncut forests adjacent to logged areas for a few years following cutting (IBTCG 2010). No studies have been conducted to determine to what extent mature highland forest is suitable for the species.

Suppression of natural disturbance (such as fire and insect outbreaks) also constitutes a threat to Bicknell's thrush, where this results in fewer forest stands regenerating to a stage where they are useable by the species for breeding. Where this management practice combines with a decrease in the extent and/or frequency of logging over large areas, as may be the case in New Brunswick (a decline in demand for wood due to market forces), the result may be a significant reduction in suitable, disturbed/young forest habitat for the species (IBTCG 2010).

B. Overutilization for commercial, recreational, scientific, or educational purposes

Capture of Bicknell's thrushes for scientific study is unlikely to jeopardize populations, and it is very unlikely that irresponsible or unpermitted scientific or amateur collecting ever occurs (Rimmer et al. 2001).

C. Disease or Predation

1. Predation

Few predators are known to take adult Bicknell's thrushes, but eggs and juveniles often fall prey to various nest predators (e.g., red squirrels, *Tamiasciurus hudsonicus*) or species that take fledglings. Sharp-shinned hawks, *Accipter striatus,* have been frequently documented to consume young Bicknell's thrush, and long-tailed weasels (*Mustela frenata*) and northern saw-whet owls (*Aegolius acadius*) are also known predators (Rimmer et al. 2001). As previously mentioned, red squirrel population dynamics (as shaped by a typical two year cycle in fir cone crop size) play a significant role in annual nest success rates (Rimmer et al. 2005a, Rimmer et al. 2001).

On the winter range, introduced rats were the only cause of mortality to Bicknell's thrush during a multi-year study in the Dominican Republic. Both black rats (*Rattus rattus*) and

Norway rats (*R. norvegicus*) were present within the habitat of Bicknell's thrush, and were found in greater densities in the broadleaf cloud forest than in nearby pine forests. Predation pressure by nocturnal rats may be driving Bicknell's thrush to roost in pine habitat, despite their use of broadleaf forest during the day (Townsend et al. 2009a)

Though there is, as yet, no evidence of this threat, climate change may eventually introduce novel predators into habitat used by the Bicknell's thrush. As high-elevation conditions become more tolerable for formerly low- or mid-elevational species, meso-predators (e.g, raccoons) may move into previously unoccupied habitat, presenting new threats to nesting Bicknell's thrush.

Climate change may also bring about a shift in the population cycles of red squirrels, and hence could change the balance between the bird and its rodent predator. Predictions by some scientists that a warming climate will mean more frequent cone crops in balsam fir do not bode well for Bicknell's thrush. More abundant red squirrel populations, in more years would mean that Bicknell's thrush would have fewer years when it could experience high nest success and successful reproduction (USFWS 2010).

2. Disease

Rising prevalence of blood parasites may be another stressor for the Bicknell's thrush (Rimmer et al. 2005b). Avian malarial parasites are very common throughout New England. Studies show that roughly 40 percent of sampled birds are infected (VCE 2009). Though bird populations have largely adapted to malarial parasites, increases in environmental mercury levels have raised new concerns. Researchers are currently exploring correlations between malaria infections, mercury burdens, and body condition of breeding songbirds (VCE 2009). Birds may be able to overcome low-level mercury contamination or exposure to malaria, but in combination with other stressors, such as West Nile virus, climate change, or habitat modifications, these afflictions could have a substantial effect on population viability.

D. The Inadequacy of Existing Regulatory Mechanisms

No existing regulatory mechanisms, whether federal, state, or international, adequately protect the Bicknell's thrush or its habitat. Most urgently, existing international and U.S. regulatory mechanisms to reduce global greenhouse gas emissions are clearly inadequate to safeguard the Bicknell's thrush against extinction resulting from climate change.

1. Inadequacy of Federal Regulatory Mechanisms

a. Migratory Bird Treaty Act

The Bicknell's thrush is protected by the Migratory Bird Treaty Act 16 U.S.C. §703 et seq. It provides that "it shall be unlawful at any time, by any means or in any manner," to, among many other prohibited actions, "pursue, hunt, take, capture, [or] kill" any migratory bird included in the terms of the treaties. 16 U.S.C. § 703. However, the Migratory Bird Treaty Act does not protect habitat. Habitat loss is the greatest threat facing Bicknell's thrush.

b. Migratory Bird Conservation Act

The Migratory Bird Conservation Act (16 U.S.C. § 715) applies to species protected under the Migratory Bird Treaty Act. 16 U.S.C. § 715j. The Act authorizes the Commission[6] to consider and approve any areas of land and/or water recommended by the Secretary of the Interior for purchase or rental by the U.S. Fish and Wildlife Service. However, this act does not require the protection of habitat, and the most pressing challenge for the Bicknell's thrush is the loss of habitat.

c. Neotropical Migratory Bird Conservation Act

Bicknell's thrush is included in the Neotropical Migratory Bird Conservation Act. 16 U.S.C. § 6101. The purpose of the Act is to perpetuate healthy populations of neotropical migratory birds; assist in the conservation of neotropical migratory birds by supporting conservation initiatives in the United States, Canada, Latin America, and the Caribbean; and provide financial resources and foster international cooperation for those initiatives. 16 U.S.C. § 6102. In the last few years, discretionary conservation grants have been approved that may eventually benefit the Bicknell's thrush. However, such protection is uncertain and it is not guaranteed to continue until the species is no longer at risk.

In March 2008, a grant was approved under this Act to protect the Bicknell's thrush. The project title is *Designing Conservation Strategies for Winter Habitat of Bicknell's Thrush: A Participatory Stakeholder Workshop in the Dominican Republic* (USFWS 2008a). The project aimed to educate local stakeholders about the importance of the area for conservation of biodiversity and ecosystems services in the Dominican Republic; inform stakeholders about landscape features and land use practices to conserve avian winter habitat, with a focus on Bicknell's thrush.

In May 2009, an additional grant was approved under this Act addressing the Bicknell's thrush (USFWS 2009). This grant is for a project to acquire voluntary conservation easements on four parcels of land within core areas of Canada's Appalachian Corridor that are key to implementing a transborder conservation strategy and to monitor

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[6] The Migratory Bird Conservation Commission was established on February 18, 1929, by the passage of the Migratory Bird Conservation Act. It was created and authorized to consider and approve any areas of land and/or water recommended by the Secretary of the Interior for purchase or rental by the U.S. Fish and Wildlife Service, and to fix the price or prices at which such areas may be purchased or rented. In addition to approving purchase and rental prices, the Commission considers the establishment of new waterfowl refuges. The staff support for the Commission is provided by the U.S. Fish and Wildlife Service, Division of Realty (U.S. Fish and Wildlife Services 2008(b)).

neoptropical migrants at risk, including includes peregrine falcons, Bicknell's thrush, chimney swifts, and gold-winged warblers. This area is of importance because it is the last remaining wild area at the southern extremity of Quebec, where substantial blocks of forest have not been fragmented. The project will also involve public and community outreach through a variety of activities and capacity building for local conservation groups.

In May 2009, another grant was also approved under this Act to protect the Bicknell's thrush. The project is titled *A Multidisciplinary, Community-based Approach to Protect Biodiversity and Bicknell's thrush Habitat in the Dominican Republic* (USFWS 2009). This project is specifically aimed at conserving Bicknell's thrush habitat in the Dominican Republic.

These grants are not adequate to protect the Bicknell's thrush because their effectiveness is unknown and none compel through regulatory action the cessation or restriction of activities harmful to the species.

d. Birds of Conservation Concern 2008

Bicknell's thrush is listed on the Birds of Conservation Concern (BCC) list prepared by the U.S. Fish and Wildlife Service Division of Migratory Bird Management (USFWS 2008c). Birds included in the BCC list are deemed the highest priorities for conservation actions (USFWS 2008c). The BCC's purpose is to stimulate and collaborate proactive conservation actions among federal, state, tribal, and private partners. While the purpose of the list is to promote greater study and protection of the habitats and ecological communities upon which these species depend, no direct protection of the Bicknell's thrush has yet occurred pursuant to this listing mechanism.

e. Clean Air Act

Congress amended and strengthened the Clean Air Act in 1990. These amendments have not been effective, however, in alleviating the harmful effects of mercury, acid deposition, ground-level ozone, and nitrogen on the Bicknell's thrush and its habitat. (Greenhouse gas emissions are addressed separately, in Section D.3)

i. Mercury

Inadequate federal regulation of hazardous air pollutants, including mercury, harms Bicknell's thrush (Rimmer et al. 2009b). In the 1990 amendments to the Clean Air Act, Congress listed mercury as a hazardous air pollutant, and many provisions sought to compel EPA to move forward quickly with regulation of mercury and other hazardous air pollutants. Ten years later, in 2000, EPA finally found it "necessary and appropriate" to regulate mercury emissions from coal-fired power plants (the largest sources of mercury emissions in the country) using "maximum achievable control technology" (MACT). In 2005, however, EPA dramatically changed direction by promulgating the "Clean Air Mercury Rule (CAMR)," which (if implemented) would have utilized a cap-and-trade system instead of the more stringent MACT system. The goal of CAMR was to reduce utility emissions of mercury from 48 tons a year to 15 tons, a reduction of nearly 70 percent, with full implementation scheduled to occur by 2018 (EPA 2009b). On February 8, 2008, however, the D.C. Circuit vacated the CAMR rule, finding that EPA's approach violated the plain language of the Clean Air Act. Since then, EPA has not yet promulgated any MACT standard for mercury emissions from power plants. Given that EPA has delayed regulating mercury for decades despite clear statutory mandates and deadlines, it is not uncertain if or when any new mercury rule will be forthcoming.

ii. Acid Deposition and Ground-Level Ozone

Likewise, the passage of the 1990 CAA amendments did not solve the problem of acid rain. Current research shows that the target of the acid rain trading program (50 percent reduction of sulfur dioxide (SO_2) emissions from power plants) was not ambitious enough to adequately address the acid rain problem (Driscoll 2001). In addition, research shows that the ability of some water bodies and terrestrial ecosystems to neutralize acid deposition has diminished over time, delaying the recovery of forests, lakes, and streams (Driscoll 2001). Acid deposition has altered and continues to alter soils in parts of the Northeast (Driscoll 2001).

A key factor in the severe ground-level ozone problem faced by northeastern states is the emission of nitrogen dioxide (NO_x) by power plants in upwind states, primarily in the Midwest. The 1990 CAA amendments did not place a cap on total annual emissions of nitrogen oxides or otherwise impose any significant controls on NO_x emissions. Subsequent regional NO_x trading programs implemented under the CAA have helped reduce NO_x emissions significantly. However, much greater reductions are needed to achieve attainment with national ambient air quality standards for ozone in the Northeast. Until such standards are achieved, ground-level ozone will continue to damage Bicknell's thrush's habitat and threaten the viability of the species.

Much like the Bush administration's failed attempt to implement a cap-and-trade program for mercury with its CAMR rule, its attempt to address NOx and SO_2 emissions on a more national scale through a cap-and-trade program (known as the Clean Air Implementation Rule or CAIR) was struck down by the D.C. Circuit (North Carolina v. EPA, No. 05-1244). Since many facilities had already begun making operational changes based on the CAIR rule, the court temporarily reinstated it until EPA responds to the court decision. However, it is not clear whether or to what extent the regulated industry is required to comply with the vacated CAIR rule or the pre-exiting regional NO_x trading program. In light of this uncertainty, facilities are not making the aggressive investments in NO_x and SO_2 controls that are needed to adequately address the problems of both acid rain and ground-level ozone.

2. International Regulatory Mechanisms

a. Mercury

The Obama administration has called for a legally binding international treaty to reduce mercury pollution. A U.S.-drafted proposal would form a negotiating committee in conjunction with the U.N. Environment Program to help countries reduce their mercury use, clean up contaminated sites, and find environmentally sound ways to store mercury (MSNBC 2009). However, negotiations on limiting mercury just began last year and are set to continue for the next three years. The European Union has banned mercury exports, but this ban will only go into effect starting in 2011. The U.S. has a similar ban that will become effective in 2013 (MSNBC 2009).

b. Canadian regulatory mechanisms

The Bicknell's thrush was designated as a "species of special concern" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 1999; this status was revised and the species upgraded to "threatened" status in November 2009. Nova Scotia listed Bicknell's thrush as "vulnerable" under the Nova Scotia Endangered Species Act in 2002. These designations reflect a finding that the species is experiencing "imminent threats" (Bredin 2009). A "vulnerable" species is defined as "a species of special concern due to characteristics that make it particularly sensitive to human activities or natural events and that is listed as a vulnerable species pursuant to section 12" (Bill No. 65, Endangered Species Act- Chapter 11 (3)(s)). Despite these acknowledgments, however, the Bicknell's thrush's designation as a vulnerable species affords it no specific protection under the Nova Scotia Endangered Species Act.

Under the Nova Scotia Wildlife Act, it is an offense to take or kill any wildlife species, including the Bicknell's thrush, unless there is a regulated open hunting season for that species. In addition, section 51 of the Act makes it an offense to harm bird nests and eggs. The species and its nest are also protected in Canada under the federal Migratory Bird Convention Act of 1994 (Bredin 2009).

3. National and International Regulation of Greenhouse Gas Emissions

The effect of climate change on the montane habitat of the Bicknell's thrush is the most serious threat to its continued existence. National and international emissions reductions are urgently needed to protect this species from extinction.

The best-available science indicates that the atmospheric concentration of CO_2 must be reduced from the current level of ~390 ppm to at most 350 ppm to protect species and ecosystems from anthropogenic climate change. Numerous scientific studies indicate that climate change resulting from greenhouse gases currently in the atmosphere already constitutes "dangerous anthropogenic interference" with regard to species and ecosystems (Warren 2006, Hansen et al. 2008, Lenton et al. 2008, Jones et al. 2009, Smith et al. 2009). Climatic changes experienced so far, including the ~0.7°C temperature rise and 30 percent increase in ocean acidity since the pre-industrial era, have resulted in significant changes in distribution, phenology, physiology, demographic rates, and genetics across taxa and regions, which have lead to population declines and species extinctions (Walther et al. 2002, Parmesan and Yohe 2003, Root et al. 2003, Walther et al. 2005, Parmesan 2006, Warren 2006, Walther 2010). Moreover, the impacts to biodiversity from the greenhouse gases currently in the atmosphere have not been fully realized. Due to thermal inertia in the climate system, there is a time lag between the emission of greenhouse gases and the full physical climate response to those emissions. The delayed effects from existing emissions are known as the "climate commitment." Based on the greenhouse gases already emitted, the Earth is committed to additional warming estimated at 0.6°C to 1.6°C within this century (Meehl et al. 2007, Ramanathan and Feng 2008), which commits species and ecosystems to further impacts.

Continuing greenhouse gas emissions, which are occurring at a rapid rate, tracking the most fossil-fuel intensive emissions scenario of the Intergovernmental Panel on Climate Change (IPCC) (Raupach et al. 2007, Richardson et al. 2009), further jeopardize species and ecosystems. The IPCC has warned that 20 to 30 percent of plant and animal species will face an increased risk of extinction if global average temperature rise exceeds 1.5 to 2.5°C (relative to 1980-1999), with an increased risk of extinction for up to 70 percent of species worldwide if global average temperature rise exceeds 3.5°C relative to 1980-1999 (IPCC 2007). Thomas et al. (2004) projected that 15-37 percent of species will be committed to extinction by 2050 under a mid-level emissions scenario, which the world has been exceeding.

Hansen et al. (2008) presented evidence that the safe upper limit for atmospheric CO_2 needed to avoid "dangerous climate change" and "maintain the climate to which humanity, wildlife, and the rest of the biosphere are adapted" is at most 350 ppm. Hansen et al. (2008) found that our current CO_2 level has committed us to a dangerous warming commitment of ~2°C temperature rise still to come and is already resulting in dangerous changes: the rapid loss of Arctic sea-ice cover, 4 degree poleward latitudinal shift in subtropical regions leading to increased aridity in many regions of the earth; the near-global retreat of alpine glaciers affecting water supply during the summer; accelerating mass loss from the Greenland and west Antarctic ice sheets; and increasing stress to coral reefs from rising temperatures and ocean acidification. Hansen et al. (2008) concluded that the overall target of at most 350 ppm CO_2 must be pursued on a timescale of decades since paleoclimatic evidence and ongoing changes suggest that it would be dangerous to allow emissions to overshoot this target for an extended period of time:

> If humanity wishes to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted, paleoclimate evidence and ongoing climate change suggest that CO_2 will need to be reduced from its current 385 ppm to at most 350 ppm, but likely less than that. (Hansen et al. 2008:217).

In order to reach a 350 ppm CO_2 target or below, numerous studies indicate that global CO_2 emissions must peak before 2020 followed by rapid annual reductions bringing emissions to or very close to net zero by 2050. The IPCC found that to reach a 450 ppm CO_2eq target, the emissions of the United States and other developed countries should be reduced by 25 to 40 percent below 1990 levels by 2020 and by 80-95 percent below 1990 levels by 2050 (Gupta et al. 2007); thus reductions to reach a 350 ppm CO_2 target must be more stringent. Baer and Athanasiou (2009) outlined a trajectory to reach 350 ppm CO_2 target by 2100 that requires 2020 global emissions to reach 42 percent below 1990 levels, with emissions reaching zero in 2050. Negative emissions options make such a pathway more feasible. They concluded that Annex I (developed country) emissions must be more than 50 percent below 1990 levels by 2020 and reach zero emissions in 2050 (Baer and Athanasiou 2009).

With atmospheric carbon dioxide at ~390 ppm and worldwide emissions continuing to increase by more than 2 ppm each year, rapid and substantial reductions are clearly needed immediately to protect the Bicknell's thrush and prevent dangerous levels of climate change.

a. United States climate initiatives are ineffective

The United States is responsible for approximately 20 percent of worldwide annual carbon dioxide emissions (EIA 2010), yet it does not currently have adequate regulations to reduce greenhouse gas emissions. This was acknowledged by the Department of Interior in the final listing rule for the polar bear, which concluded that regulatory mechanisms in the United States are inadequate to effectively address climate change (73 Fed. Reg. 28287-28288). While existing laws including the Clean Air Act, Energy Policy and Conservation Act, Clean Water Act, Endangered Species Act, and others provide authority to executive branch agencies to require greenhouse gas emissions reductions from virtually all major sources in the U.S., these agencies are either failing to implement or only partially implementing these laws for greenhouse gases. For example, the EPA has recently issued a rulemaking regulating greenhouse gas emissions from automobiles (75 Fed. Reg. 25324, Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule), but has to date failed to implement the majority of other Clean Air Act programs, such as the new source review, the new source pollution standards, or the criteria air pollutant/national ambient air quality standards programs, to address the climate crisis (See, e.g. 75 Fed. Reg. 17004, Reconsideration of Interpretation of Regulations That Determine Pollutants Covered by Clean Air Act Permitting Programs). While full implementation of these flagship environmental laws, particularly the Clean Air Act, would provide an effective and comprehensive greenhouse gas reduction strategy, due to their non-implementation, existing regulatory mechanisms must be considered inadequate to protect the Bicknell's thrush from climate change.

b. International climate initiatives are ineffective

The primary international regulatory mechanisms addressing greenhouse gas emissions are the United Nations Framework Convention on Climate Change and the Kyoto Protocol. As acknowledged by the Department of Interior in the final listing rule for the polar bear, these international initiatives are inadequate to effectively address climate change (73 Fed. Reg. 28287-28288). The Kyoto Protocol's first commitment period only sets targets for action through 2012. Importantly, there is still no binding international agreement governing greenhouse gas emissions in the years beyond 2012. While the 2009 U.N. Climate Change Conference in Copenhagen called on countries to hold the increase in global temperature below 2°C (an inadequate target for avoiding dangerous climate change), the **non-binding** "Copenhagen Accord" that emerged from the conference failed to enact binding regulations that limit emissions to reach this goal. Even if countries did meet their pledges, analyses of the Accord found that collective national pledges to cut greenhouse gas emissions are inadequate to achieve the 2°C, and instead suggest emission scenarios leading to a 3 to 3.9°C warming (Pew 2010, Rogelj et al. 2010). Thus international regulatory mechanisms must be considered inadequate to protect the Bicknell's thrush from climate change.

4. State, Regional, and Local Regulatory Mechanisms

Estimates of the total area of habitat suitable for the Bicknell's thrush in the United States range from 111,346 to 136,250 hectares (Lambert 2003, Rimmer et al. 2005a). Eighty-one percent of this habitat occurs on conservation lands managed by a variety of private and public owners, with varying levels of restriction on use and activities. However, not all conservation lands receive the same level of protection and it is important to evaluate specific conservation measures throughout the range of the Bicknell's thrush.

GAP analysis, a classification system that assigns a conservation status number of 1 through 4 according to the level of conservation protections on the land, is a common means of assessing the extent of protections afforded to particular areas of land. GAP 1 (or "status 1") areas are given permanent protection and a management plan to maintain their natural state is mandatory. GAP 2 areas have permanent protection and are mandated though long-range planning to maintain a primarily natural state. This means that these areas may be affected by practices that adversely affect the quality of existing natural communities, including the suppression of natural disturbance regimes. The majority of a GAP 3 area receives permanent protection, but resource extractive practices such as logging or mining may also be permitted (Two Countries, One Forest 2007). GAP 4 areas lack irrevocable easements and are not required to prevent conversion or destruction of natural habitat, nor is intensive use or resource extraction restricted.

The following is a state-by-state breakdown of GAP status designations and conservation measures that affect Bicknell's thrush habitat in New York and New England.

a. New York

New York State contains approximately 26,850 hectares (or 24 percent) of the potential Bicknell's thrush habitat in the United States. (Lambert 2003, Lambert et al. 2005). The U.S. Geological Survey (USGS) estimates that 89 percent of potential Bicknell's thrush habitat in New York is currently in GAP Status 1 or 2 (USGS 2001). Nearly 92 percent of land (about 24,634 hectares) identified as suitable for Bicknell's thrush is conserved as Forest Preserve within Adirondack Park and Catskill Park, and an additional 1 percent (about 313 hectares) occurs on private conservation lands. Lands designated as Forest Preserve receive the greatest level of protection under New York jurisdiction. The protection is constitutional:

> The lands of the state, now owned or hereafter acquired, constituting the forest preserve as now fixed by law, shall be forever kept as wild forest lands. They shall not be leased, sold or exchanged, or be taken by any corporation, public or private, nor shall the timber thereon be sold, removed or destroyed. (N.Y. CONST. art. XIV, §1).

Forest Preserve lands are managed by the Department of Environmental Conservation (DEC) according to specific Unit Management Plans (UMPs) that are developed based on park-wide land classifications.[7] (New York State Legislature 1998). These plans regulate recreational use of Forest Preserve lands and generally allow for passive conforming uses, prohibit the construction or expansion of non-conforming structures, mandate the removal of non-conforming structures, and restrict motorized vehicle and all-terrain bicycle use (Adirondack Park Agency 2001). For example, much of New York's Bicknell's thrush habitat is found on land designated as "wilderness" within the 77,977-hectare High Peaks Wilderness Area, which includes 36 of the Adirondack's High Peaks (above 4,000 feet). The High Peaks Wilderness Complex UMP regulates recreational use

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[7] The 2.6 million acre Forest Preserve is divided into different classification by the Adirondack State Land Master Plan (ASLMP) based on their characteristics and capacity to withstand use. The following is a brief summary of classifications: **Wilderness Areas:** These areas comprise about 1.1 million acres or 42 percent of the Forest Preserve. Camping, hunting, fishing, skiing, hiking, and other non-motorized activities are allowed in Wilderness areas. **Primitive Areas:** These areas comprise 45,670 acres or 3 percent of the Forest Preserve. Activities allowed in Primitive areas are similar to those allowed in Wilderness Areas. **Canoe Area:** This area comprises 17,634 acres or .7 percent of the Forest Preserve and consists of numerous lakes and rivers that provide remote recreation in a wilderness setting. **Wild Forest Areas:** These areas comprise about 1.3 million acres or 50 percent of the Forest Preserve. Along with activities allowed in Wilderness areas, mountain bicycles and snowmobiles are also allowed in Wild Forest areas. I**ntensive Use Areas:** These areas comprise about 19,508 acres or .75 percent of the Forest Preserve. These are areas where the state provides facilities for outdoor recreation. Types of Intensive Use areas are campgrounds, day use areas, ski centers, beaches, and boat launching facilities. **Historic Use Areas:** These are areas that have buildings, structures or sites that are significant in the history, architecture, archeology or culture of the Adirondack Park. These areas comprise about 530 acres of Forest Preserve or .03 percent. **State Administrative Use Areas:** These areas comprise about 1,554 acres or about .1 percent of the Forest Preserve. These are areas where the state provides facilities for a variety of specific state purposes that are not primarily designed to accommodate visitors to the Park. **Pending Classification:** These are areas that have not yet been classified under the State Land Master Plan. These areas comprise about 34,931 acres and represent about 1.5 percent of the Forest Preserve. For a full description of land designations and conforming uses (The Adirondack State Lands Master Plan at 14).

within the area by prohibiting fire in sensitive areas and requiring permits for large groups or lengthy stays. Furthermore, the APSLMP requires the DEC to determine the physical, biological and social carrying capacity and to use UMPs to manage recreation accordingly:

> Each individual unit management plan will seek to determine the physical, biological and social carrying capacity of the wilderness resource. Where the degree and intensity of permitted recreational uses threaten the wilderness resource, appropriate administrative and regulatory measures will be taken to limit such use to the capability of the resource. APLSMP

These measures protect large tracts of suitable Bicknell's thrush habitat from development and resource extraction and minimize threats related to recreational overuse.

b. Vermont

Estimates of suitable Bicknell's thrush habitat in Vermont range from 8,780 to 11,580 hectares, which represents about 8 percent of available habitat in the United States. (Lambert 2003, Rimmer et al. 2005a). Approximately 7,277 hectares (83 percent) occurs on conservation lands, although the USGS estimates that only 30 percent is on GAP Status 1 or 2 lands (USGS 2008). Ownership and management of these lands are diverse. The majority is managed as State Forest (35 percent of suitable habitat statewide) and National Forest (28 percent of suitable habitat), with lesser amounts conserved as State Parkland (5 percent), easements on timberland (9 percent), and private conservation lands (3 percent) (Rimmer et al. 2005a).

The Green Mountain National Forest (GMNF) contains between 2,494 and 3,151 hectares of suitable Bicknell's thrush habitat, representing about 28 percent of the potentially suitable habitat statewide. (Lambert 2003, Rimmer et al. 2005a). Of this habitat, 75 percent occurs on either statutorily designated wilderness or remote backcountry forest. Logging and the construction of roads or facilities is generally prohibited in these areas. Vegetation management is similarly restricted, except to the extent necessary to maintain trails or habitat for threatened or endangered species (Rimmer 2005a, USFS 2006). Development and designation of sites for wind and communication towers are also prohibited (USFS 2006a). Of the remaining suitable habitat within the GMNF, 11.8 percent occurs in areas designated by the Forest Service as Diverse Backcountry where wildlife and timber management activities are selected, scheduled, and located to ensure that backcountry recreation is protected (Rimmer et al. 2005a). Wind and communication tower development are prohibited (USFS 2006a); 7.8 percent occurs on newly acquired lands where "management options will be kept open until inventories can be done."; and 5.7 percent occurs on lands where recreation benefits are emphasized, including 46 ha on Mount Snow designated for potential ski area expansion. Adjacent lands contain hundreds of additional unconserved hectares, including 313 ha on Stark Mountain, 178 ha on Mount Equinox and Little Equinox, and 79 ha on the northeast slope of Stratton Mountain (Rimmer et al. 2005a).

Vermont's state forests and state parks contain approximately 3,097 (35 percent of statewide habitat) and 474 hectares (5 percent of statewide habitat), respectively, of potentially suitable Bicknell's thrush habitat. State-owned lands are managed by the Vermont Agency of Natural Resources according to Long-range Management Plans (LMPs). Management goals for state lands include the promotion of sustainable natural resource use, protection of public and ecological health, and the promotion of sustainable outdoor recreation (VT ANR 2002). High-elevation forests are typically designated High Sensitivity Areas (HSA) under governing LMPs. In HSAs, human activities is kept to a minimum and managed to protect the features of the area, the negative impacts of existing uses are to be mitigated, and logging is prohibited (VT ANR 2002). High-elevation forests are generally well protected. For example, biodiversity protection is the top management priority for Mt. Mansfield State Forest, and protection of high-elevation montane spruce-fir habitat is specifically listed as a management objective. The Mt. Mansfield LMP bases its HSA designation of montane spruce-fir forests in part because of its importance for Bicknell's thrush.

State lands are also currently protected from wind project development. Under an ANR policy adopted in 2005, all lands managed by ANR "are unavailable for purposes of developing large-scale renewable energy projects." (VT ANR 2004). However, while ANR recognizes that its "lands, particularly its high elevation lands most desirable for wind energy development, contain many important natural resources and are among the most sensitive and troublesome sites from a development perspective," it also acknowledges that "[i]f future information conclusively demonstrates that the most appropriate site(s) for large-scale wind energy or other renewable energy development in Vermont are on ANR lands and that the public interest will clearly be served by using these lands in such a manner, this policy may be revised" (VT ANR 2004).

Timberland easements owned by a number of land trusts, including the Vermont Land Trust and the Nature Conservancy, protect about 9 percent of Bicknell's thrush statewide habitat from development. These lands are still subject to logging. Under many agreements, logging operations must be conducted according to sustainable forestry plans, subject to review by the holder of the easement. Easement goals generally include conservation of natural resources including wildlife habitat. For example, the primary objectives of timberland easements held by the Vermont Land Trust "are to establish and maintain productive forestry resources on the Protected Property and, in consideration of the contribution timber products make to the economy and communities of the region and the State, to encourage the long-term, professional management of those resources, and to facilitate the economically sustainable production of forest resources in a manner that minimizes negative impact and the duration of impact on surface water quality, recreational benefits to the public, wildlife habitat, and other conservation values" (VLT 2010).

Vermont's Act 250 may also indirectly protect Bicknell's thrush habitat on both public and private land. Construction activities for commercial, industrial, or residential use (including logging operations) above an elevation of 2,500 feet require Act 250 certification. (VT State Legislature 2010). Development opponents can challenge an Act

250 permit by demonstrating that the proposed development will destroy or significantly imperil necessary wildlife habitat, and that one of the following circumstances applies: (1)the public benefit derived by the proposed development does not outweigh the public loss from the destruction or imperilment of the habitat; (2) all feasible and reasonable means of mitigating the impact on the habitat have not been or will not continue to be applied; or (3) a reasonable acceptable alternative site is owned or controlled by the applicant which would allow the development or subdivision to fulfill its intended purpose. § 6086(a)(8). Act 250 defines "necessary wildlife habitat" as habitat which is "identifiable and is demonstrated as being decisive for the survival of a species of wildlife at any period in its life including breeding and migratory periods. § 6001(12).

Vermont also regulates "heavy cutting" of more than 40 acres at all elevations through Act 15, 10 V.S.A § 2625. Under Act 15, the proponent of a heavy cut must provide 15 days notice of intent with the Department of Forests, Parks and Recreation. The proposal is subject to authorization by the Department, who reviews the plan proposal for conformity with department rules and USFS silvicultural guides and handbooks (VT ANR 1997).

c. New Hampshire

New Hampshire contains approximately 49,586 (about 45 percent) of the potentially suitable habitat for Bicknell's thrush in the United States. Approximately 94 percent of that land is in some type of legal conservation status conserved, with the majority (79 percent) occurring in the White Mountain National Forest (WMNF). The remaining conserved habitat is found on state forest (4 percent), private conservation lands (4 percent), timberland with conservation easements (4 percent), Forest Preserve (2 percent), state parks, National Park (<1 percent) and Town Forest (<1 percent) (Lambert 2003). The USGS estimates that 84 percent occurs on GAP Status 1 or 2 lands (USGS 2008).

Habitat in the WMNF accounts for 35 percent of potential U.S. habitat for the Bicknell's thrush (Rimmer et al. 2001). The WMNF Forest Plan does not specifically manage habitat for Bicknell's thrush, but the species likely benefits from other policies. For example, high elevation spruce-fir habitat throughout New Hampshire is protected by a no-cut zone on all federal, state, and private conservation lands above 2,700 feet, including the WMNF (NH DFG 2005). This effectively protects all Bicknell's thrush habitat (which in NH occurs between 3,500 and 4,500 feet in elevation) on state and federal land in New Hampshire from timber harvest. And although the USFS plan does not summarily prohibit ski area expansion, communication towers, utility corridors, or wind development on WMNF land, the White Mountain National Forest Plan strictly limits eligible locations and requires projects to result in no net decrease of suitable Bicknell's thrush habitat (USFS 2005). The plan further allows for promotion of Bicknell's thrush habitat through vegetation manipulation to compensate for loss of habitat caused by other resource activities (USFS 2005).

Several regulatory mechanisms and agreements protect Bicknell's thrush habitat on private non-conservation lands. First, a High Elevation Memorandum of Understanding (MOU) between the New Hampshire Fish and Game, the Department of Resources and Economic Development, and most of the large land owners in northern NH sets parameters on harvesting timber above 2,700 feet (NH DFG 2008). The MOU allows logging but provides guidelines and specific goals for forest size class distribution above 2,700 ft. The guidelines prohibit timber harvest on 10 percent of areas covered by the MOU, requires 60 percent of an area remain in forested stands with at least a 4" diameter breast height (trunk diameter at 4.5' off the ground), and that no more than 30 percent of an area be in stands of less than 4" diameter breast height. The document also makes recommendations on road building and the timing of harvesting activities (New Hampshire 2008).

Additionally, local zoning boards have recognized the importance of high elevation forests. The Coos County Unincorporated Towns Planning Board has designated these areas as a Protected District (PD), which is defined as an "area where development would jeopardize significant natural, recreational, and or historic resources." Areas above 2,700 feet are defined as PD6 zones. The specific purpose of the PD6 zone is to "regulate certain land use activities in mountain areas in order to preserve the natural equilibrium of vegetation, geology, slope, soil and climate in order to reduce danger to public health and safety posed by unstable mountain areas, to protect water quality, and to preserve mountain areas for their scenic values and recreational opportunities." Due to their designation as a PD6 zone, any activities at these elevations require a permit from the Coos County Planning Board. Historically, the Board has relied on New Hampshire Fish and Game to review and comment on these permit applications (New Hampshire 2008).

d. Maine

Maine contains approximately 26,130 hectares (about 23 percent) of the United States' potentially suitable Bicknell's thrush habitat. Less than half (41 percent) is currently conserved. Still less habitat (29 percent) is on GAP Status 1 or 2 lands, leaving the largest conservation gap in the United States (USGS 1998).

About 18 percent of available habitat statewide is statutorily preserved as "forever wild" within Baxter State Park. 12 M.R.S.A. § 900. ("As a public forest it shall remain in its natural wild state…." *Id*.) All land within Baxter State Park must remain in its natural state, undisturbed by man, in perpetuity. An additional 2,615 hectares, representing about 10 percent of Bicknell's thrush habitat in Maine is found on Public Reserve Lands (Lambert 2003). These lands are managed "to demonstrate exemplary land management practices, including silvicultural, wildlife, and recreation management practices, as a demonstration of state policies governing management of forested and related types of lands." (12 M.R.S.A. 1847.1).

Public Reserved Lands are managed for multiple-uses under a "dominant use" system which ensures that sensitive resources such as rare plants and backcountry recreation areas are not disturbed by more intensive management activities (Maine Landowner

Relations Program 2008). Multiple use management plans are required for Public Reserved Lands pursuant to Title 12 MRSA § 1847 (2), and must be prepared in accordance with the *Integrated Resource Policy* adopted in December 2000 by the Bureau. (ME DEC 2000). These laws and policies direct the Bureau of Parks and Lands to identify and protect important natural, ecological, and historic attributes; enhance important fisheries and wildlife habitat; provide opportunities for a variety of quality outdoor recreation experiences; and provide a sustained yield of forest products by utilizing forest management techniques and silvicultural practices that enhance the forest environment. (12 M.R.S.A. 1833.2). There is, however, no specific mandate to protect or manage Bicknell's thrush habitat.

The majority of Bicknell's thrush habitat on Public Reserve Lands is found within the Flagstaff Management Area, including approximately 1,250 hectares of subalpine spruce-fir forest in The Horns Ecological Reserve and 2,139 hectares of alpine and sub-alpine habitat within the Mt. Abraham Ecological Reserve (ME DEC 2007). Ecological reserves are statutorily defined as "area[s] owned or leased by the State and under the jurisdiction of the Bureau [of Parks and Lands], designated by the Director, for the purpose of maintaining one or more natural community types or native ecosystem types in a natural condition and range of variation and contributing to the protection of Maine's biological diversity, and managed: A) as a benchmark against which biological and environmental change can be measured, B) to protect sufficient habitat for those species whose habitat needs are unlikely to be met on lands managed for other purposes; or C) as a site for ongoing scientific research, long-term environmental monitoring, and education." (12 M.R.S.A.1801). Timber harvest, road, and commercial development are prohibited within Ecological Reserves.

The Natural Resources Protection Act (NRPA), 38 M.R.S.A. 480, affords additional protections to Bicknell's thrush habitat on public and private lands. All land over 2,700 feet is designated as "fragile mountain area" for the purposes of the act (Id. at § 480-B). Most disruptive activities occurring at elevation require a NRPA permit from the Maine Land Use Regulation Commission. Specifically, dredging, bulldozing, removing, or displacing soil, sand, vegetation, or other materials; draining or otherwise dewatering; filling, including adding sand or other material to a beach or sand dune, and; constructing, repairing or altering any permanent are subject to NRPA permitting if conducted at or above 2700 feet. (*See* http://www.maine.gov/dep/blwq/docstand/ip-nrpa.htm).

In order to secure a NRPA permit, the permittee must demonstrate that the proposed activity will not unreasonably interfere with existing scenic, aesthetic, recreational, or navigational uses; cause unreasonable erosion of soil or sediment, or prevent naturally occurring erosion; unreasonably harm any significant wildlife, fisheries or aquatic habitat; unreasonably interfere with the natural flow of any surface or subsurface waters; lower water quality; cause or increase flooding; unreasonably interfere with supply or movement of sand to sand dune areas; cross a river segment identified in the NRPA as "outstanding" unless no other alternative having less adverse impact on the river exists. "Significant wildlife habitat" is defined in the act as habitat for species appearing on the state or federal endangered or threatened species list and does not include Bicknell's thrush habitat. 38 M.R.S.A § 480-B. Nevertheless, high-elevation habitat receives some protection from development and resource use under the act.

The Maine Land Use Regulatory Commission (MLURC) also protects Bicknell's thrush habitat on private lands indirectly through zoning. To protect the fragile environment associated with high mountain areas, the Commission has placed lands at elevations above 2,700 feet in the Mountain Area Protection (P-MA) zone (MLURC 2009). The P-MA zone regulates certain land use activities, such as timber harvesting, and excludes activities, such as development, in part to preserve mountain areas for their scenic value as well as to protect water quality, and recreational opportunities (MLURC 2009). These restrictions preserve the natural equilibrium of vegetation, geology, slope, soil, and climate. This protection zone also preserves mountain areas for remoteness, wildlife habitat, recreational opportunities, and other uses. Approximately one hundred mountains in the jurisdiction meet the general criteria for P-MA zoning (MLURC 2009).

Concerns about liquidation logging over the last two decades spurred the passage of a Maine Liquidation Harvesting Rule in 2005, but its numerous exemptions and reliance on economic incentives call into question its effectiveness at actually reducing clearcutting that is then followed by land disposal and real estate development (Scott 2004).

Restrictions imposed on conservation lands largely protect the Bicknell's thrush from the habitat loss resulting from anthropogenic development or resource extraction, but they do nothing to address what is likely to be greatest threat to this species: habitat loss driven by global climate change. Models that incorporate the latitudinal/elevational drivers of forest compositional change, climate projections, and suitability parameters for Bicknell's thrush habitat predict that an increase of 1°C in mean summer temperature is likely to reduce the amount of habitat suitable for the Bicknell's thrush in the Northeast by more than half, an increase of 2°C will render unsuitable all current breeding sites in New York and Vermont, and an increase of 3°C may eliminate nearly all suitable habitat from the Northeast. Remnant patches may remain in New Hampshire's Presidential Range and on Maine's Mt. Katahdin after 5°C of warming, but no habitat is projected to remain beyond 6°C (Rodenhouse et al. 2008). Climate models project an increase of between 2.8 and 5.9°C (based on low and high emissions parameters) in mean summer temperature in the Northeast; temperatures within this range will be sufficient to eliminate the majority of habitat suitable for the Bicknell's thrush within its breeding range.

5. Winter range territories and countries

a. Puerto Rico

Puerto Rican law provides protection for migratory birds (12 L.P.R.A. § 107). The statute protects "Any bird covered under the provisions of the 'Migratory Bird Treaty Act,' of August 16, 1916, and those that emigrate to Puerto Rico from countries non-signatory of said Treaty, be they resident or migratory species, or any mutation or hybrid of any of these species…" 12 L.P.R.A. § 107. Since the United States is a signatory country of the treaty, the Bicknell's thrush is a protected species under this law in Puerto Rico.

Puerto Rico was awarded a Neotropical Migratory Bird Conservation Act Grant in 2008 (USFWS 2009). This grant is meant to protect neotropical migrants from invasive species from Desecheo Island and provides funding for the protection and restoration of the neotropical migratory birds on Desecheo Island that are threatened. Neotropical migratory birds, such as Bicknell's thrush, will benefit from this grant by the removal of invasive species. This project's goal is to increase the population of neotropical migrant species in Puerto Rico. However effective the grant may be, it does nothing to address the bigger picture of habitat loss for the Bicknell's thrush

b. Dominican Republic

Current protections are minimal: though the primary areas of Bicknell's thrush habitat in the Dominican Republic are located within conservation areas and national parks, lack of funding has kept protections from being enforced in these critical habitats. The largest areas of the species' preferred habitat are found on the western edge of Hispaniola's Sierra de Neiba mountain range (in the Dominican Republic, Townsend and Rimmer 2006) and though this part of the mountain range obtained "park" status in 1995, ongoing human disturbance, mainly illegal logging and slash-and-burn agriculture, is evident throughout the area (Townsend and Rimmer 2006).

Madres de las Aguas Conservation Area (an aggregation of five Dominican Republic National Parks and one scientific reserve) is located in the island's central mountain chain and contains the best representations of coniferous pine, montane broadleaf, and cloud forest on the island. Though Madre de las Aguas is purportedly protected, deforestation from commercial logging, agriculture, cattle ranching, and the resulting soil erosion and sedimentation of aquatic areas still cause ongoing harm to critical Bicknell's habitat. (TNC 2008c).

The Jaragua-Barahoruco-Enriquillo biosphere reserve, which is located in the southwest of the Dominican Republic, is the largest protected area in the country (TNC 2008b). Though the area is considered protected, this pivotal Bicknell's habitat is similarly threatened by forest clearing for agriculture, charcoal production, and cattle ranching (TNC 2008b). Poaching and drug running within the park have also posed a substantial threat to these protected lands (TNC 2008b).

Similarly, the Del Este National Park, which is on the southern coast at the easternmost end of the Dominican Republic, faces threats that will affect essential Bicknell's thrush wintering habitat. (TNC 2008a). It also includes the 110-sq. km. Isla Saona from which it is separated by the Catuano channel. Colonization, agriculture, and deforestation for charcoal production, are all current threats to the park. Approximately eight percent of this important bird area has been affected by agriculture (e.g. coconut crops), mostly on Isla Saona (TNC 2008a). The modification of park boundaries has rendered the coastal area vulnerable to unsustainable tourist development (TNC 2008a).

It is believed that Bicknell's thrush occupies the remaining fragments of suitable forest habitat along the Haiti-Dominican Republic border, most of which fall within Loma Nalga De Maco-Rio Limpio National Park, located in the northern region of the Dominican Republic, toward the westernmost end of the Cordillera Central and close to the border with the Republic of Haiti (Birdlife 2000). The park is owned and managed by various parties; Nalga de Maco is a national park created by the Dominican Republic in 1995 and ratified by law in 2000 and 2004. The Río Limpio area borders Nalga de Maco, but contains private lands and is not legally protected. Among the predominant threats to this important bird area are agriculture (including slash-and-burn practices), cattle ranching, forest fires, and human settlement.

c. Cuba

Bicknell's thrush winters in Cuba in a very limited area in the highest mountains of Sierra Maestra mountain range, between 1,600 and 1,960 m in elevation, from Paso del Cadete, Pico Cuba, Paso de las Angustias, Pico Turquino to the adjacent areas of the Pico Regino (Oviedo et al. 2001). Cloud forest is the dominant habitat in this region, though localized subalpine shrub is also present, mainly on southern slopes. Agricultural development presents the greatest threat to this habitat; except for the most rugged slopes, forested areas are almost entirely occupied by cacao and coffee plantations (Bisse 1988). Mining, logging, urban expansion, cattle grazing, poaching, tourism, and introduced species (mongoose, domestic cats and dogs) are also problematic (Davis et al. 1997).

Cuban pine forest also provides critical wintering habitat for the Bicknell's thrush. However, these fire-dependent forests are compromised by inadequate management: natural fire regimes are suppressed by agricultural or urban encroachment, fragmentation, or other anthropogenic factors (O'Brien 2005).

E. OTHER NATURAL OR ANTHROPOGENIC FACTORS

1. Mercury

Mercury is a potent neurotoxin which poses a significant ecological and public health concern. Mercury may decrease immunocompetence (the ability of the body to produce a normal immune response) magnifying the effects of diseases such as malaria (VCE 2009). The northeastern United States receives atmospheric mercury (Hg) deposition from a combination of local, regional, and global sources (Driscoll et al. 2007). Many researchers are studying the effects of mercury on the Northeast because the region receives elevated mercury deposition and contains ecosystems sensitive to mercury inputs (VCE 2009). Important sources of mercury include electric utilities, industrial manufacturing, and wastewater treatment plants. "Intensive air and precipitation monitoring has led scientists to conclude that most of the mercury originates from coal-fired power plants" (VCE 2009). Approximately two-thirds of atmospheric mercury emissions are from anthropogenic sources, with coal-fired power plants comprising about 50 percent of anthropogenic sources (Driscoll et al. 2007).

Mercury pollution poses a risk to wildlife as it is transported to watersheds and accumulates up the food chain (Driscoll et al. 2007). When mercury enters the water, it is transformed into a more toxic substance called methylmercury (Driscoll et al. 2007). Methylmercury (MeHg) is absorbed more easily by bacteria and small plants, and with a bioaccumulation factor of about 10 million, methylmercury accumulates to toxic levels at the top of the aquatic food chain (Driscoll et al. 2007). Methylmercury has the ability to build up in bodies of living organisms over time (bioaccumulation) and increase in concentration as one organism eats another (biomagnifications) (Evers 2005).

It is well established that elevated levels of atmospheric mercury deposition and methylmercury bioavailability in the northeastern United States influence wildlife populations (Rimmer et al. 2005b). "Birds are an important taxon for sampling because they are well-established bioindicators of MeHg availability" (Rimmer et al. 2005b). Problems associated with toxic levels of mercury in fish and birds that feed primarily on fish are well documented, but recently the "most significant discovery has been documenting the pervasiveness of mercury burdens in terrestrial montane songbirds" (Rimmer and McFarland 2005, Evers 2005). A recent study indicates "that songbirds in montane forests are bioaccumulating mercury, nearly 100 percent of which is sequestered in toxic methylmercury form" (Rimmer and McFarland 2005). This suggests that methylation rates in montane forests may be high and confirms that mercury is accumulating in food webs within high elevation forests in the northeast, a recent surprise to many ecologists and atmospheric scientists (Evers 2005).

Rimmer and McFarland's study showed that, of the four bird species sampled, blood mercury concentrations were highest in Bicknell's thrush (Rimmer and McFarland 2005), though there was a great deal of heterogeneity in MeHg availability across Northeast U.S. mountains (Rimmer et al. 2005b). Atmospheric deposition of airborne mercury is two to five times higher in montane forests than in surrounding low elevation areas (Rimmer et al. 2001, Lawson 1999). Birds in the southern part of the Bicknell's thrush breeding range have overall higher Hg blood and feather concentrations than birds in northern areas. This finding is in keeping with the notion that the source for Hg is atmospherically deposited from more distant sources to the west and south (Rimmer et al. 2005b).

Further, scientists have documented higher mercury blood concentrations in areas with increased mercury deposition. There were significantly higher Hg blood concentrations among thrushes on Stratton Mountain (south) than among Bicknell's thrushes on Mount Mansfield (north), and this was in parallel with modeled deposition amounts at the two sites (Rimmer et al. 2005b). This "correlation between regional litterfall Hg flux patterns and blood Hg concentrations in Bicknell's thrush demonstrates on-site availability of MeHg" (Rimmer et al. 2005b). Thus, higher blood mercury levels in Bicknell's thrush seen in the southern verses northern Green Mountains parallels mercury deposition estimates for those areas (Evers 2005).

Bicknell's thrush are exposed to even greater levels of mercury during months spent on their winter grounds in the Greater Antilles. The decline of blood Hg levels during the breeding season suggests that much of the Hg uptake into blood and feathers occurs from feeding on the wintering grounds (Rimmer et al. 2005b).

2. Decreased dietary calcium due to acid deposition

Acid deposition can affect the Bicknell's thrush directly by altering available soil calcium levels (IBTCG 2010). Acid precipitation leaches calcium ions from forest soils. Reduced calcium availability can affect the abundance and quality of invertebrate prey that Bicknell's thrush relies on and high levels of acid deposition have been linked to reductions in the size and abundance of snails, earthworms, millipedes, and other invertebrate prey (Driscoll 2001). The correspondent reduction in dietary calcium consumed by breeding Bicknell's thrush compromises breeding females' ability to form eggshells and provide the nutrients necessary to nestlings' developing skeletal structures (Bredin 2009, King et al. 2008). The abundance of invertebrates in forests with high acid deposition is reported to be up to eight times less than in forests not exposed to acid deposition (Bredin 2009). Though no studies specifically link acid deposition with Bicknell's thrush population declines, Hames et al. (2002) report that the reduced abundance of insect prey in acidified forests is correlated with declining wood thrush (*Hylocichla mustelina*) populations.

3. Direct mortality due to climate change

Increased storm frequency and intensity have the potential to impact not only Bicknell's thrush habitat, but could also kill birds directly. Intense storms during migration, especially, could cause significant mortality (Rodenhouse 2008, IBCTG 2010). Adult migratory songbirds in general experience the vast majority of annual mortality during seasonal migration (Sillet and Holmes 2002).

4. Increased interspecific competition with climate change

Climate change will increase the potential for encroachment by competitors of the Bicknell's thrush into previously unoccupied habitat. Species formerly restricted to lower elevations by cold temperatures may move upslope in response to warming temperatures and associated changes in prey base or other resources (Lambert et al. 2005). The only potential competitor discussed in the literature is Swainson's thrush (*Catharus ustulatus*), whose current elevational distribution is somewhat overlapping with the lower reaches of Bicknell's thrush's range (Lambert et al. 2005). Antagonistic interactions between Bicknell's thrush and *C. ustulatus*, American robins (*Turdus migratorius*), and white-throated sparrows (*Zonotrichia albicollis*) have been observed in breeding habitat (Rimmer et al. 2001, pers. obs. as cited in COSEWIC 2009).

5. Disturbance by recreationists

Preliminary data indicate that Bicknell's thrush exhibit some degree of tolerance to human activity (Rimmer et al. 2001). Nevertheless, recreational use is another potential contributor to declines in Bicknell's thrush populations. National Forests experienced a 12 percent annual increase in visitation between 1965 and 1994 (USFS 2006b). The White Mountain National Forest, the heart of the species' range in the Northeast U.S., had nearly 7 million visitors in 2005 (USFS 2006b). Of these visitors to the White Mountain National Forest, about 31,400 visited the backcountry (King et al. 2008). Studies indicate that some birds avoid recreational trails and might even experience higher nest predation in more heavily used areas (King et al. 2008). More study is needed to investigate this potential threat. Research suggests that nesting Bicknell's thrush are able to tolerate moderate levels of human traffic (foot or bicycle), though this assertion bears further study (Rimmer et al. 2001).

VII. CONSERVATION RECOMMENDATIONS

Various measures taken by landowners or managers afford some level of protection to the Bicknell's thrush and its habitat from threats posed by logging, commercial development, or other direct anthropogenic threats. The Conservation Action Plan for Bicknell's Thrush recently issued by the IBTCG (2010) provides a list of conservation measures focused on habitat management, protection, and restoration. These measures include partnering with timber companies to manage and maintain Bicknell's thrush habitat on the breeding range, as well as protecting winter range habitat through actions such as increased enforcement, protection and acquisition of priority areas and buffer zones, and promotion of sustainable agriculture for cacao and coffee. Research actions are also recommended in the IBTCG Conservation Action Plan.

Rimmer et al. (2005a and 2004) had recommend these actions five years prior to the Conservation Action Plan, and they still are supported by the research conducted since that time:

- Restrict the timing of activities that may disturb breeding Bicknell's thrushes or habitat to before May 15 or after August 1
- Avoid logging or otherwise disturbing areas where natural disturbance regimes can maintain suitable habitat
- Consolidate small, adjoining patches of habitat on developed peaks to minimize fragmentation
- Manage vegetation in ski areas or other intensively managed sites to maintain and/or enhance suitable habitat; Bicknell's thrush prefers to stay hidden in dense thickets, rarely crossing into open areas. Ski area development should maintain forested "islands" as large as possible between ski trails, minimize the width of trails, and maximize habitat connectivity in developed areas to increase suitability for nesting and foraging.

COSEWIC (2009) recommends that if pre-commercial thinning cannot be avoided within suitable habitat in the range of Bicknell's thrush, thinning and related activities should at least occur outside of breeding season. This will prevent the direct destruction of nests, eggs, nestlings, fledglings, and adults, although it will not maintain the particular site as suitable habitat for the Bicknell's thrush . Timber managers should also seek to maintain patches of intact (un-thinned) forest (BirdStudies Canada 2009).

Neither the IBTCG action plan (2010) or the COSEWIC assessment (2009) provide specific steps, except further research, to protect the habitat of Bicknell's thrush from the impacts of atmospheric pollution such as acid deposition and mercury.

Further, it should be clearly emphasized that the above-mentioned mitigation measures, while potentially helpful to Bicknell's thrush in the short term, are wholly insufficient to address climate change, which is the greatest threat to this species' habitat in the foreseeable future. Without prompt and decisive political action, regional efforts to protect habitat will eventually be eclipsed by ecosystem-scale shifts in forest composition, and climate-associated changes in the dynamics of weather, prey, predators, disease, and other factors. If conservation actions to protect and restore Bicknell's thrush do not include tackling climate change aggressively and quickly, the species will almost surely be destined for extinction, no matter the degree and intensity of efforts to appropriately manage its habitat on the ground.

VIII. CRITICAL HABITAT

The ESA mandates that when the USFWS lists a species as endangered or threatened the agency generally must also concurrently designate critical habitat for that species. Section 4(a)(3)(A)(i) of the ESA states that, "to the maximum extent prudent and determinable," the USFWS shall, concurrently with making a determination . . . that a species is an endangered species or threatened species, designate any habitat of such species which is considered to be critical habitat . . .

16 U.S.C. § 1533(a)(3)(A)(i); see also id. At § 1533(b)(6)(C). The ESA defines the term "critical habitat" to mean: i. the specific areas within the geographical area occupied by the species, at the time it is listed . . . , on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and ii. specific areas outside the geographical area occupied by the species at the time it is listed . . . upon a determination by the Secretary that such areas are essential for the conservation of the species. *Id.* At § 1532(5)(A).

Petitioner expects that USFWS will comply with this unambiguous mandate and designate critical habitat concurrently with the listing of the Bicknell's thrush . We believe that all current and historic nesting sites on the mountaintops of upstate New York, Vermont, New Hampshire and Maine meet the criteria for designation as critical habitat and must therefore be designated as such. Further, any current habitat within U.S.

territory in the winter range of Bicknell's thrush (i.e., Puerto Rico) should also be designated as critical habitat.

IX. CONCLUSION

Based on the threats discussed above, the Bicknell's thrush is in danger of extinction or likely to become so in the foreseeable future throughout its known range. The widespread threats to this species have been acknowledged by several federal, state, and private agencies, but no formal regulatory protections have yet been afforded to this ecologically specialized and sensitive songbird. The protections conferred by federal ESA listing are essential to the recovery and long-term persistence of the Bicknell's thrush.

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XII. FIGURES

Figure 1. *Bicknell's thrush breeding range. Reprinted from IBTCG 2010.*

Figure 2. *Bicknell's thrush winter range. Reprinted from IBTCG 2010.*

Figure 3. *Elevation and latitude of locations where Bicknell's thrush (BITH) was detected (n =172) and not detected (n= 30) during 2000–20002 surveys in the northeastern United States, shown in relation to elevation mask. Large circles represent new survey locations (n =72); small circles represent locations first surveyed by Atwood et al. (1996) and resampled (n =130) for study by Lambert et. al (2005), from which this graph is reprinted.*

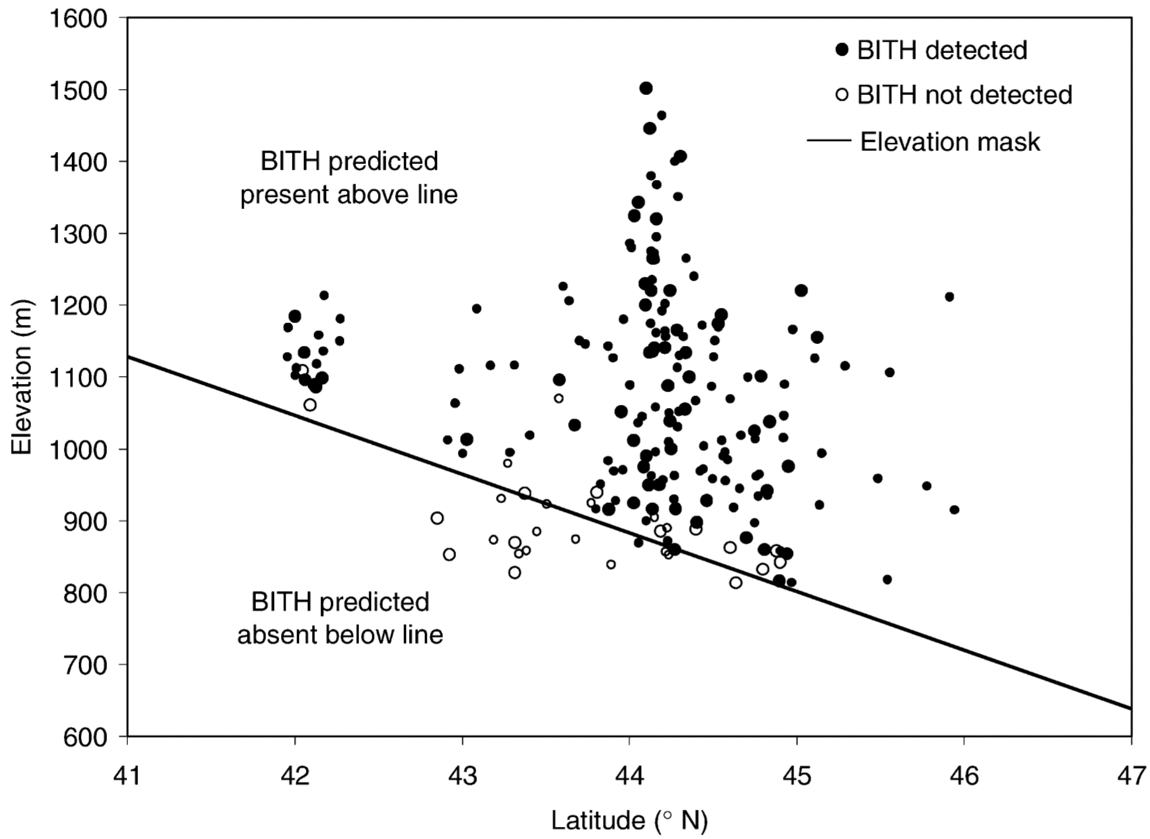

Figure 4. *Forest-type maps for the northeastern United States based on combining individual species maps of importance. Suitable habitat for spruce-fir forest type (teal color) virtually disappears even under low emissions scenario. Reprinted from Iverson et al. 2008.*

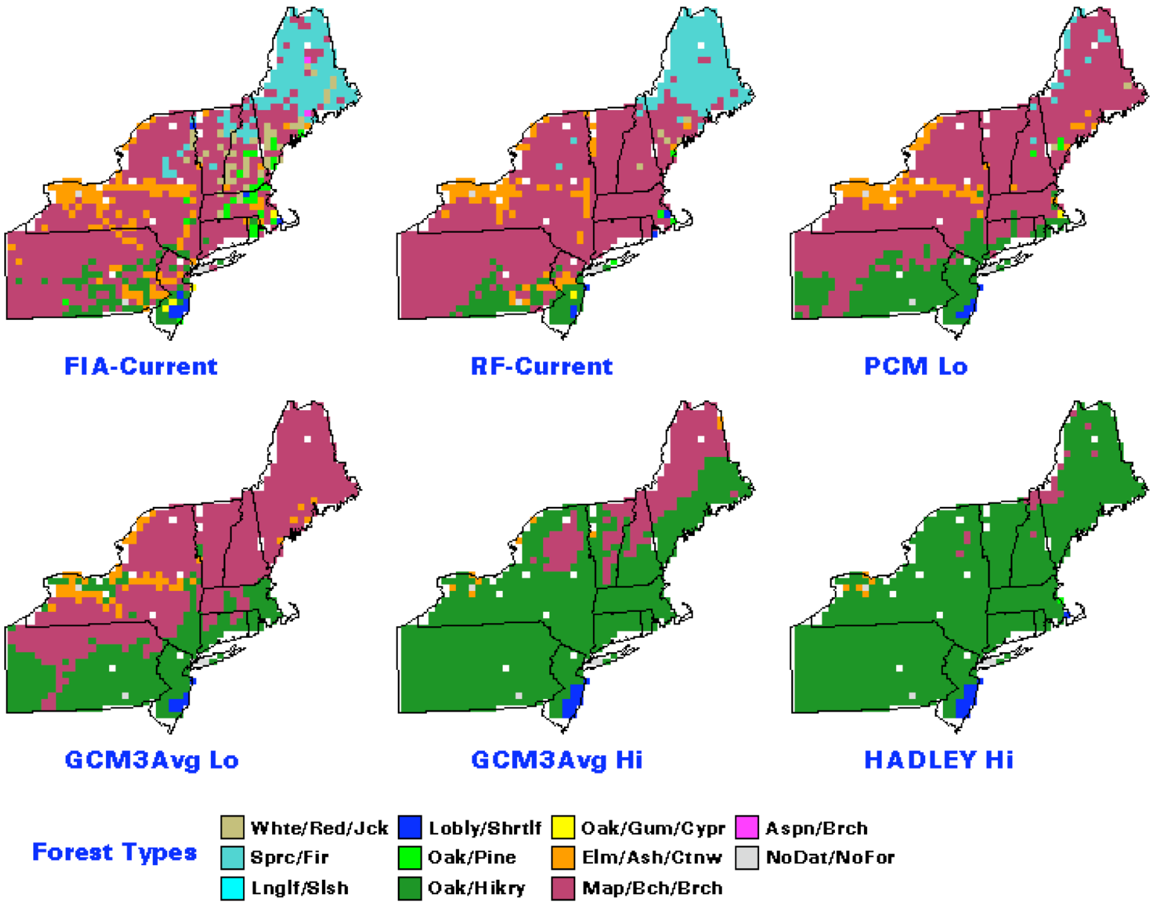

Figure 5. *Pattern of proposed Bicknell's thrush habitat loss in northeastern U.S. based on modeling for temperature increases of 1° C to 3° C. Reprinted from Lambert and McFarland 2003.*