Recovery Plan for New York State Populations

of the

SPRUCE GROUSE

(*Falcipennis canadensis*)

New York State Department of Environmental Conservation

Division of Fish, Wildlife & Marine Resources

RECOVERY PLAN FOR NEW YORK STATE POPULATIONS OF THE SPRUCE GROUSE

(*Falcipennis canadensis*)

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MISSION AND GOALS

This recovery plan provides basic information about New York State endangered spruce grouse's natural history and biology, and identifies recovery goals, objectives, strategies and actions for achieving self-sustaining populations of the species in New York. Under ECL 11-0535, 6NYCRR, Part 182.6, the NYSDEC may, at its discretion, prepare and adopt a recovery plan for any listed species. Further, the ECL states, *"A recovery plan will set forth goals and objectives to foster the continued survival, recovery, and eventual de-listing of the species, and will also include the most current information on the biology, needs, management of and threats to the species. Recovery plans are not required, but may be adopted by the department when sufficient information is available on any particular listed species, especially when such information might be helpful in identifying and recommending conservation measures that will aid in the recovery of the species."* To solicit input for the development of this plan, a recovery team of NYSDEC and other interested biologists, non-governmental organizations, foresters, landowners, the public, and other stakeholders was formed. The intention of this plan is to guide actions that, if taken, will achieve a fully-recovered and self-sustaining population of spruce grouse in New York, leading to its eventual delisting.

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EXECUTIVE SUMMARY

Current Status

The spruce grouse occurs in isolated patches of lowland coniferous forests in the northwestern section of the Adirondack Park. The species was once relatively abundant in New York, occurring in at least six counties representing 18 known subpopulations in the northwestern and northcentral Adirondacks. However, since the late 1800s, the population has experienced a gradual and continued decline. The initial decline of the species was precipitated by loss and fragmentation of habitat caused by extensive softwood logging over the period of 1885-1916 (Jenkins 2004). However, despite the relative cessation in recent years of large-scale timber harvesting, the species continues to decline. In 2006, spruce grouse were known to occur in only three counties, representing 15 discrete subpopulations or sites that are distributed in only the northwestern Adirondacks. Of these 15 occupied sites, only 14 of 32 known occupied sites from 1976 – 1987 remained occupied. Over the past 20 years, the Adirondack spruce grouse population has experienced a greater than 50% reduction in geographic range. The continued decline since the early 1900s is due to several factors including (1) the inability of softwoods to become reestablished to former abundance in many locations, and (2) the effects of increased isolation on viability and dispersal of remaining spruce grouse subpopulations. In addition, the even aged structure of spruce forests that have reestablished may be approaching a successional stage that is too old and homogenous in character to be useful as spruce grouse habitat. Due to its increasing rarity, the spruce grouse was listed by NYSDEC as an endangered species in December 1999. Currently, the greatest threat to spruce grouse persistence in New York is the reduction in habitat quantity and quality due to coniferous forest maturation and the spatial distribution of remaining occupied sites and suitable habitat across the landscape.

Habitat Requirements and Limiting Factors

In New York, spruce grouse generally occur in small, isolated populations within lowland coniferous forest dominated by spruce, tamarack and balsam fir. Occupied forest stands are on average, approximately 44 – 49 years old with a substantial component of coniferous (mainly black spruce) trees and ericaceous shrubs. These habitats support a mosaic of dense shrub cover for foraging, nesting and shelter, interspersed with pockets of sedge and moss ground cover used for courtship and foraging. Live tree foliage in the 0.2 – 1.0 m range of the vertical strata is also an important habitat component, providing nest concealment and protection for broods. Factors currently limiting spruce grouse populations in New York State include (1) the distance between patches of suitable habitat and the absence of potential movement corridors between these patches, (2) reduction in occupied habitat quality due to natural succession of lowland boreal plant communities, and (3) small population size.

Recovery Goal

The overall goal of the spruce grouse recovery program is to achieve, protect and maintain self-sustaining populations of the spruce grouse and its essential habitat in New York State, enabling the eventual removal of the species from the New York State Endangered Species

List. More specifically, there should be a 95% probability of having an extant metapopulation of spruce grouse in New York through the next 100 years.

Recovery Criteria

1. Achievement of a network of at least 17 spruce grouse subpopulations in the Adirondack region for at least 25 consecutive years.

2. Average adult and chick mortality is less than or equal to 45.0 ($\pm$ 23 SD)% at 15 subpopulations and 38.5 ($\pm$ 17)% in at least 2 additional subpopulations.

3. Ninety percent of females attempt to breed each year, with successful females having an average clutch size of 5.6 ($\pm$ 1.3) eggs.

Recovery is considered achieved after the following are completed:

- Monitoring at three year intervals over a 25 year period demonstrates that these 17 subpopulations remain stable.

- Long-term habitat dynamics at all scales are sufficiently understood to detect, monitor and manage threats to both habitats and spruce grouse, including but not limited to human development, climate change, forest stand homogeneity, invasive species impacts and predation, such that Best Management Practices for spruce grouse can be prepared.

- Site specific adaptive management plans are written and executed and landowner agreements are in place at all 17 subpopulations.

Actions Needed

1. Refine a population viability analysis for the spruce grouse metapopulation within New York using several management scenarios.

2. Mathematically model the potential success of spruce grouse reintroductions in New York based on efforts by Vermont. Determine which sites in New York have the highest probability of successful reintroductions.

3. Determine the genetic variability and differentiation of spruce grouse within New York populations, between New York and nearest neighboring populations and across the species' range, and effective population size.

4. Determine the effects of experimental spruce grouse habitat management.

5. Evaluate habitat management actions taking place in spruce grouse habitats outside of New York to gain insight on effects of such management and applicability to New York habitats.

6. Reintroduce spruce grouse into at least two areas from which they have become extirpated and monitor their fate, once formerly limiting factors have been identified and understood.

7. Conduct population surveys of all known and historical subpopulations and potential spruce grouse habitat sites at periodic (3 year) intervals using established protocols.

8. Secure long-term protection and management flexibility for spruce grouse populations via conservation easements.

9. Manage and maintain spruce grouse habitat at sites with extant populations, restore habitats at sites with extirpated populations or other sites identified as potentially suitable, and increase site connectivity to ensure continued spruce grouse persistence.

10. Develop and implement an effective outreach and education program about spruce grouse in the Adirondack Region.

11. Protect known extant subpopulations and their habitat using existing regulations and continued administrative support.

Continue to apply those practices which have contributed to the spruce grouse's recovery and monitor results into the future.

Date of Recovery Review

Due to uncertainties related to recovery, such as faster or slower than expected successes, the NYSDEC feels that a recovery date cannot be set ahead of time. However, NYSDEC does believe that date of a status assessment or review of recovery efforts can be set. A review should be completed on or before 2022 that identifies which recovery criteria are met and the current population status at that time. The review should be accompanied by a population viability analysis. If a decision is made not to downlist the species at the time of review, another review should be conducted on or before the end of the following ten years, and so on until all recovery criteria are met.

Downlisting should be initiated once all recovery criteria are met. Delisting should be initiated once evidence indicates that the Adirondack spruce grouse metapopulation continues to be self-sustaining. A population viability analysis must be used to support this evidence.

INTRODUCTION

The spruce grouse (*Falcipennis canadensis*) is listed as an endangered species in New York. Data collected since 1975 indicate that populations in the state are low and declining. In 2002, a study by Ross and Johnson (2008) was funded by the State Wildlife Grants Program to determine reasons for the species' decline. The present recovery plan is one product of the study. To prepare the plan, two meetings were convened with representatives from the New York State Department of Environmental Conservation (NYSDEC), State University of New York (SUNY) Potsdam, SUNY College of Environmental Science and Forestry, the Adirondack Chapter of the Nature Conservancy, the Adirondack Park Agency, the Adirondack Land Trust, the Wildlife Conservation Society, the public and various other stakeholders to decide which management actions should be undertaken to conserve the spruce grouse in New York. Management actions are discussed and analyzed in the present recovery plan. A draft of an earlier recovery plan (Gliddi 1994) was also used to aid in the organization of the present recovery plan.

NYSDEC's overall goal is to maintain self-sustaining populations of spruce grouse and their associated boreal forest community in the state. The spruce grouse is an historic resident and represents an important and visible animal component of the boreal forest community. Conservation of the spruce grouse and the boreal community in which it thrives is important to conserving New York's biodiversity and unique character. The purpose of this recovery plan is to (1) provide background information on life history, habitat characteristics and population status of the spruce grouse and (2) make management recommendations that will promote the persistence of viable populations of spruce grouse in New York.

Geographic Scope

This recovery plan focuses on populations of the spruce grouse in New York State, which occur exclusively in the north-central and northwestern section of the Adirondack Park (Figure 1). In New York, the spruce grouse occurs in disjunct local populations in lowland coniferous forests dominated by spruce (*Picea* spp.) and tamarack (*Larix laricina*), with a lesser component of balsam fir (*Abies balsamea*). New York represents a portion of the southeastern-most extent of the species' range-wide distribution (Figure 2), where the boreal forest meets the northern hardwood forest. These coniferous habitats are inherently patchy, occurring in varying sizes and shapes in a matrix of deciduous and mixed hardwood-conifer forests (Ross 2008).

NATURAL HISTORY

Taxonomy

The spruce grouse is a member of the order Galliformes, family Phasianidae and subfamily Tetraoninae. Grouse and ptarmigan form a circumpolar distribution in the northern hemisphere and comprise 10 species in five genera in North America (Ellsworth et al. 1995). The taxonomy of spruce grouse has long been a subject of debate; it has been shuttled between *Dendragapus*, with blue and dusky grouse, and *Canachites.* The species is now included in the genus *Falcipennis* (Ellsworth et al. 1995). The spruce grouse is most similar to the Siberian spruce grouse (*Falcipennis falcipennis*) of eastern Russia, with which it shares similar plumage and overall appearance.

Three recognized subspecies of spruce grouse are *F. c. canadensis* (taiga), *F. c. franklinii* (Franklin's) and *F. c.* isleibi (Prince of Whales). Members of the *F. c. canadensis* contain a broad chestnut-colored or rufous terminal band on the distal end of the rectrices, whereas *F. c. franklinii* lack the band, but have prominent white bands at the tips of the distal ends of their uppertail coverts. Similar to *F. c. franklinii, F. c. isleibi* lack the rufous tail band and have thin white bands on the uppertail coverts, but these white bands are not as thick as those of *F. c. franklinii.* One behavioral difference between subspecies is that males of *F. c. franklinii* perform a wing-clap as part of their courtship displays that is audible for up to 150 m, whereas males of *F. c. canadensis* do not (MacDonald 1968). The taiga subspecies occurs in New York State.

Physical Description

The spruce grouse is a medium-sized dark-colored bird. The adult spruce grouse is 38-43 cm tall and weighs between 450-650 g (Peterson 1980). Males are slightly larger than females. Its neck is of moderate length and it has a robust body. The bill is short and stout, the upper mandible is convex and the lower slightly convex. The feet are short with tarsi feathered to the base of the toes. Hind toes are small, the third toe is the longest and all are scutellate with the anterior webbed at the base. Claws are blunt. Plumage is full with contour feathers containing an aftershaft. The spruce grouse, like other related species, has short rounded wings with a tail containing more than 12 feathers. The species has a bare red membrane (i.e., comb) over the eye that is more prominent in males.

Males

Males are generally marked with a finely barred gray and black rump and back. The throat is black, as is the well-defined breast patch which is encircled with white-tipped feathers. From a distance, their backs appear as a slaty gray color produced from the combination of approximately 1- 2 mm-wide alternating blue gray and black stripes on each feather along the back and rump. The abdomen is mostly black with white markings, which become more visible along the flanks and toward the tail. Rectrices are black with chestnut-colored terminal bands. Males have scarlet eye combs visible at close range that inflate when the individual is agitated or attempting to attract mates.

Females

Females lack the breast patch present in males and the feathers are blotched with brown, black and white. Overall, the female is a mottled brown with light-colored underparts. The female's back is the same coloration as the males' and rectrices are blackish with small brown flecks concentrated on the vane side distal to the center of the tail. Rectrices are tipped with a chestnut-colored band identical to that of the males'. The female eye comb is less brightly colored; it appears orangey and may be observed at only close range. Eye combs do not inflate or become erect as they do in males.

Where they are sympatric, spruce grouse may be confused with the ruffed grouse (*Bonasa umbellus*), which is a ground-dwelling galliform of young deciduous and mixed woodlands. The ruffed grouse is generally 40-48 cm long and on average weighs approximately 450-790 g (Peterson 1980). Sexes are similar in coloration: mottled with various shades of brown, black and gray. The ruffed grouse has lighter underparts than the spruce grouse and underparts are dark-barred. Two field marks that help distinguish the ruffed grouse from the spruce grouse are the ruffed grouse's broad blackish sub-terminal band on the rectrices and the somewhat triangular partially concealed dark ruff on either side of the neck. Another characteristic lacking in the spruce grouse is the ruffed grouse's long feathers on the head that form a conspicuous crest when erected in both sexes (Atwater and Schnell 1989).

Geographic Range

The spruce grouse is distributed in a transcontinental band across North America that generally conforms to the extent of the boreal forest biome (Aldrich 1963) (Figure 2). The species ranges from Alaska in the west throughout the Yukon and Northwest Territories to Labrador in the east, extending southward into Idaho in the west and Wisconsin, Michigan, New York, Vermont, New Hampshire and Maine in the east (Fritz 1977, Robinson 1980, Bouta 1991, Boag and Schroeder 1992). The species is non-migratory and is considered relatively common in Canada; however, it is considered rare at the southeastern extent of its range in New York and Vermont (Bouta and Chambers 1990, Bouta 1991, Pence et al. 1991). In New York, Vermont and some areas of Maine, the species is limited to isolated patches of lowland coniferous forests dominated by spruce and tamarack with lesser components of balsam fir and white pine (*Pinus strobus*) (Fritz 1977, Bouta and Chambers 1990, Whitcomb 1993, Whitcomb et al.1996).

In New York, the spruce grouse is restricted to 15 small isolated subpopulations located exclusively within the northwestern and northcentral section of the Adirondack Park (Figure 1) (Appendix 1) in St. Lawrence, Franklin, and a very small portion of Essex Counties. Eleven subpopulations are located on private lands and four are located on state-owned lands that are part of the Adirondack Forest Preserve in the Raquette Boreal, Saranac Lakes and Debar

Mountain state land management units. These isolated populations generally occur adjacent to or near water courses in association with peatlands.

BREEDING BIOLOGY AND DEVELOPMENT

Reproduction

The spruce grouse has a polygynous reproductive system and mating begins in early to mid-April and continues through the end of May in New York. Males and females are typically territorial during the breeding season (Herzog and Boag 1977, Robinson 1980, Boag and Schroeder 1992). Males perform flutter jump or flutter flight courtship displays to attract mates, during which they fly noisily from the ground to a tree branch and back (MacDonald 1968). Flutter fight displays also include swishing their rectrices from side to side as they strut with wings held low, ending the sequence with a rapid, simultaneous tail flick and upward jerk of the head. The tail flick is a rapid fanning of the rectrices to the point where each feather can be seen individually for a fraction of a second. This is usually a rapid repeat of two tail-fanning events in succession, with the second more exaggerated than the first. This behavior is accompanied by the simultaneous straightening of the neck upward at approximately a 45 degree angle from the ground. Pecking at branches are also incorporated into the courtship display. No “drumming” is performed as it is in the ruffed grouse, but the two species make a similar sound during flight. Male spruce grouse cease displays sharply when females begin nesting (Keppie 1991).

Characteristics of male courtship habitat and female brood habitat differ slightly. Male display habitat tends to contain larger diameter trees with more open areas on the ground to aid in unobstructed observation by a female during courtship displays. Ericaceous shrubs and small black spruce (*Picea mariana*) are present in areas immediately adjacent to or within the display habitat to provide cover. Areas completely devoid of shrubby vegetation tend not to harbor a displaying male spruce grouse. In contrast, female brood habitat typically contains more understory vegetation than male display habitat and a greater density of smaller diameter trees (Bouta 1991). Low shrub cover likely provides necessary cover for nest concealment.

Nesting and Brood Behavior

Male spruce grouse are territorial during the breeding season and females are territorial during the nesting and, to a limited extent, the brood-rearing season. Nearly all yearling female spruce grouse will attempt to nest. A female copulates with a male in his territory, but there is no evidence that he participates in nest or brood defense (Johnsgard 1983). Following copulation, the female leaves the male’s territory. While areas defended by males tend to contain larger and older trees with open areas for displays, the territory established by a female tends to be in denser stands of small diameter trees and a high concentration of ericaceous plants (Bouta 1991). Brooding habitat provides secluded places for nesting, escape and concealment for the hen and her chicks following hatching (Robinson 1980).

Females will defend their territories from other females, usually through posturing and vocalizations. Territory defense leads to female spacing in available habitat, thus reducing competition for limited resources and ensuring the best chances for brood survival.

Nesting begins roughly 17 days after the ground snow cover is approximately 50% and coincides with the appearance of the first flowers of trailing arbutus (*Epigaea repens*) and blueberry (*Vaccinium* spp.) (Keppie and Towers 1990). This period begins in approximately mid-May in New York. Females nest on the ground, typically adjacent to the base of a tree, under cover of saplings or other shrubby vegetation and occasionally logs (Boag and Schroeder 1992). Nest sites are typically microsites that are the first to become snow-free (Keppie and Towers 1990). Nests are placed in well concealed locations, often below low branches, in brush or in deep mossy areas in or adjacent to thickets (Johnsgard 1973). In New York, nests have primarily been observed near the base of a black spruce, or under a small spruce or balsam fir sapling. In all instances (n = 5), the females were only lightly covered by surrounding vegetation (i.e., conifer boughs, blueberry or other ericaceous shrubs) and the females' coloration served to conceal both her and her nest (Ross and Johnson, unpublished data).

Spruce grouse breed during their first year of life with varying success. Whitcomb (1996) observed that on Mt. Desert Island during 1992-1993, females attempted to nest 88% of the time with 79% hatching success. In New Brunswick, 94% of females attempted to nest with 81% hatching success (Keppie 1982). Females attempted to nest 100% of the time with 40% hatching success in Minnesota (Haas 1974, cited in Boag and Schroder 1992). In Michigan, Robinson (1980) found that 88% of females attempted to nest with 77% hatching success. In New York, 100% of females attempted to nest with 80% success (Ross and Johnson, unpublished data).

Clutch size ranges from four to seven eggs and means differ between subspecies (Johnsgard 1983). Mean clutch sizes of *F. c. canadensis* are approximately 5.6 (± 1.3) and *F. c franklinii* are 4.8 (±1.1) (Keppie 1982). Incubation is performed exclusively by the female and begins after the last egg has been laid. Incubation lasted approximately 21 days in a captive-bred population (Pendergast and Boag 1971) and averaged 23.5 days in the field for *F. c. franklinii* (McCourt et al. 1973). The chick mortality rate is greatest during the two weeks after hatching (Boag and Schroeder 1992). After the eggs hatch, the female broods her young for up to six hours. When ready to feed, the young discover which materials are edible on their own as the female does not lead them in feeding or show them what to eat. After the young have left the nest, the female provides protection from predators and the weather by keeping the chicks warm and dry. Schroeder and Boag (1985) found brooding is limited mainly to the first 20 days post hatch, although it is still common for up to 40 days. During this period, the young initiate and terminate brooding periods via vocalizations with the female. Females may brood chicks for up to 45 minutes at a time; however, brooding activity is more commonly 10 to 15 minutes in duration. As the chicks age, their thermoregulatory capacity increases and brooding behavior decreases in frequency.

The distance that the foraging young maintain from both their mother and each other increases as the chicks age until fall dispersal of the brood. Chicks generally remain in broods for approximately 70-100 days, at which time the males begin to disperse first (Boag and Schroeder 1992). Females generally disperse greater distances than males (Schroeder 1985). Keppie and Towers (1990) found that juvenile dispersal rates are comparable with or without pressure of adults in the population and that emigration is constant over different densities. In Central Ontario, 92% of females and 74% of males dispersed from the brood range, with females dispersing greater median distances than males in each of 2 years (Beaudette and Keppie 1992). In fragmented forests of Maine, both juveniles and adults make larger movements and have poorer survival, which may be a result of habitat fragmentation rather than an inherent tendency for longer movements of individuals (Whitcomb et al. 1996, Harrison 2001). In New York, adult females move over larger distances and occupy over three times the home range area than males (Ross and Johnson 2008).

NON-BREEDING BIOLOGY

Habitat

Spruce grouse habitat varies regionally. However, regardless of the species' geographic location, it is always strongly associated with coniferous forest across its distribution. At the northern extent of its range, where the boreal forest extends into the tundra as fingers along rivers and streams, the species exhibits a metapopulation structure (Boag and Schroeder 1992). Likewise, at the southeastern extent of the species' range, where the boreal forest meets the northern hardwood forest, also has a metapopulation structure (Fritz 1977, Whitcomb et al. 1996, Ross 2008). These southeastern extremes exist within the northeastern United States where boreal habitat is inherently patchy, existing in varying sizes and shapes in a matrix of deciduous hardwoods and mixed hardwood-conifer. In New York, Vermont and some areas of Maine, the species is restricted to isolated populations within lowland coniferous forests. These isolated populations occur at fringes of bogs and water courses and tend to be associated with peatlands. New Hampshire populations are unique among the rest of the northeastern states in that grouse populations are present at high elevation conifer stands (Boag and Schroeder 1992, Todd 2003). In patchy lowland boreal habitats such as those in New York and some areas of Maine, populations tend to persist in patches that occur within close proximity to a source population (Fritz 1977, Whitcomb et al. 1996, Ross and Johnson 2008).

Other similarities in habitat across the spruce grouse's range-wide distribution are that it is associated with at least one short-needled conifer species (Ellison 1966, Fritz 1977, Boag 1991, Boag and Schroeder 1992), and some habitats are typically fire seres dominated by jack pine (*Pinus banksiana*) and lodgepole pine (*P. contorta*), with some use of islands of unburned areas such as wet lowland spruce (*Picea* spp.) (Boag and Schroeder 1992). In addition, a common theme to all spruce grouse habitat is the presence of an understory of ericaceous vegetation and low hanging branches (Soule 1992).

Generally, the spruce grouse tends to be more closely associated with lowlands toward the eastern reaches of its distribution and high elevations toward the west (Boag and Schroeder 1992). In Ontario, the species is distributed in areas characterized by black spruce and jack pine, and favors areas where the two stand types meet (Lumsden and Weeden 1963). In Algonquin Provincial Park, Ontario, spruce grouse are found in upland jack pine stands at the eastern edge of the park, and low elevation conifer stands dominated by spruce, tamarack and balsam fir toward the west. In southwesten Alberta, the spruce grouse inhabits lodgepole pine forests (Boag and Schroeder 1987, Shroeder and Boag 1991). The species occurs in spruce forests in Alaska (Ellison 1966) and in lodgepole pine and Engelmann spruce (*P. engelmanii*) forests in north-central Washington (Ratti et al. 1984). In the Upper Peninsula of Michigan, spruce grouse are most common in areas where jack pine and spruce intermingle (Robinson 1969). In Maine, spruce grouse use areas dominated by red spruce (*P. rubens*). There is evidence that spruce grouse show some changes in habitat use seasonally (Keppie 1977, Allan 1985), whereby denser conifer stands are used more often during the winter. However, these shifts may reflect dietary shifts (see Diet section below). In New York, the spruce grouse inhabits coniferous forests dominated by black spruce and tamarack with lesser components of balsam fir and white pine, although historically the species also inhabited areas dominated by red spruce in upland habitats.

Diet

The spruce grouse's diet varies by geographic location and season (Crichton 1963, Ellison 1966, Gradoni 1982). For example, during the winter spruce grouse eat mainly black and white spruce (*P. glauca*) in Alaska (Ellison 1966), lodgepole pine needles in Alberta (Pendergast and Boag 1970), jack pine in Michigan (Robinson 1980), jack pine in central Ontario (Crichton 1963) and balsam fir in New York (Gradoni 1982). During the early spring breeding and incubation season, females eat new spruce leaders, apparently for the high calcium content important for egg shell development (Pendergast and Boag 1970). Compared with their winter diet, spring season foods are higher in protein and phosphorus (Naylor and Bendell 1989).

During the spring breeding season in New York, spruce grouse use of balsam fir declines and consumption of spruce increases. At this time, grouse begin to eat insects, fruits and tamarack needles as they become available. During the summer, they generally eat invertebrates and fruits, especially of *Vaccinium* spp. Needles make up a lesser component of the species' diet during the breeding season. However, tamarack needles are a preferred food item when needles are present (Gradoni 1982). Tamarack is especially important after the breeding season when adults are gradually molting plumage. During this time, they eat a greater percentage of tamarack, as its needles contain more crude protein and phosphorus than any other conifer, facilitating feather replacement.
The early fall diet reflects a transition from the more varied summer diet to the fir-dominated winter diet. Consumption of black spruce foliage increases as tamarack needles become unavailable. Reliance on spruce gradually declines throughout the fall until the grouse switch to a balsam fir-dominated winter diet (Gradoni 1982). This change in diet is

accompanied by an increase in the size of the gastrointestinal tract needed to digest conifer foliage.

Populations

Breeding populations of spruce grouse have been recorded at densities ranging from 1.0 to 97.0 birds per 100 ha (Table 1). Higher densities have generally been observed in forests that contain some earlier successional forest stands, whereas lower densities tend to occur in older stands and in isolated patches of conifer forest (Bouta 1991, Whitcomb et al. 1996). Higher densities of spruce grouse have been observed in jack pine plantations with trees 10-25 years old and 4-10 m tall (Szuba and Bendell 1983, 1993), and large local population sizes have been observed in early stages of postfire succession (Boag and Schroeder 1987, Schroeder and Boag 1991). In a study of clearcut landscapes in Quebec, spruce grouse were absent from clearcuts, but used residual spruce-fir buffer strips remaining after forest clearing, albeit to a lower degree than large forested blocks (Potvin and Curtois 2006).

Spruce grouse densities in New York have ranged from 1.0-9.6 adults/100ha during previous studies (Fritz 1979, 1985, Bouta 1991). More recently, New York spruce grouse exhibited a mean density of 1.1-1.6 adults/100 ha based on a 1:1 sex ratio for all populations, but ranged from 0.9-9.8 adults/100 ha depending on the site (Ross and Johnson, unpublished data).

Densities of spruce grouse can be influenced by both intrinsic (i.e., resident birds in the population) and extrinsic (i.e., conditions in the environment) factors. Boag and Schroeder (1987) suggested that increasing densities are correlated with the previous years' productivity, which in turn is correlated with the number of individuals recruited into the population (McKinnon 1983, Boag and Schroeder 1987) and may be regulated by the territorial behavior of territorial individuals.

Williamson et al. (2008) suggested that the New York population was between 1,523 and 6,092 birds. These estimates were based upon a multiplication of the total area of potentially occupied forest as determined by Halasz et al. (2000) by low and high density estimates published in Fritz (1979) and Bouta and Chambers (1990), which were 3.5-8.8 birds/100 ha and 1.0-9.6 birds/100 ha, respectively. Calculated population sizes by Williamson et al. (2008) are most likely considerable overestimates, perhaps by an order of magnitude, and do not reflect survey efforts during those sampling periods or those of subsequent efforts (Johnson and Ross 2008, Ross and Johnson 2008), which determined that most potentially available habitat is unoccupied.

Sex ratios have generally been reported (5 studies) as 1:1 (summarized in Boag and Schroeder 1992). Both males and females are physiologically capable of breeding as one-year olds, and at least for the taiga race (*F. c. canadensis*), most females do (Keppie 1987a, 1987b). It is more difficult to determine if first-year males breed as they do not engage in nest protection or brood rearing. In addition, one study found that only 39% of taiga spruce grouse breed their first year (Szuba and Bendell 1988).

Nest success, measured as the percentage of nests hatching at least one chick, ranges from a low of 29% in Alberta for the Franklin's race (Keppie 1982) to the following for the taiga race: 40% in northern Minnesota (Haas 1974, cited in Boag and Schroeder 1992), 81% in south-central Alaska (Ellison 1974), 81% in New Brunswick (Keppie 1982) and 67-81% in Ontario (Szuba 1989). Two studies found that nest success positively correlates with warmer spring weather (Michigan, Robinson 1980; Alberta, Smythe and Boag 1984). Limited nest success values (n = 5) are available for Adirondack spruce grouse (80%, A. Ross and G. Johnson, unpublished data).

While few studies report survivorship rates, there appears to be a difference between the two races, where the Franklin's race exhibits higher rates (Boag and Schroeder 1992). For the taiga race, Robinson (1980) found mean annual survival to be 37.5% for males and 22.7% for females in Michigan, while Keppie (1987a) reported 44% for males and 49% for females in New Brunswick. Mean annual adult survival in the Adirondacks was observed to be 55% (± 23%) over the period 2002-2006 (A. Ross, unpublished data). Robinson (1980) reported the oldest male at 7.5 years and the oldest female at 5.5 years among 315 banded birds.

Predation and Disease

While predation is generally assumed to be the greatest mortality factor for spruce grouse (Boag and Schroeder 1992), and little data are available for the species, it is likely that few predators specialize on spruce grouse in the Adirondack Region. Potential Adirondack predators include northern goshawk (*Accipiter gentilis*), broad winged hawk (*Buteo platypterus*), Cooper's hawk (*Accipiter cooperii*), red-tailed hawk (*Buteo jamaicensis*), great horned owl (*Bubo virginiana*), barred owl (*Strix varia*), common raven (*Corvus corax*), weasels (*Mustela* spp.), coyote (*Canis latrans*), red fox (*Vulpes vulpes*), fisher (*Martes americana*), and bobcat (*Lynx rufus*). Red squirrels (*Tamiasciurus hudsonicus*) have been implicated as major egg predators (Naylor and Bendell 1987). D'Eon (1997) reported that over half of 67 spruce grouse nests at his study site in Ontario were depredated by red squirrels, red fox, black bear (*Ursus americanus*) and striped skunks (*Mephitis mephitis*). The spruce grouse has a diversity of predators that, in sum, may have significant impacts on both productivity and mortality.

The incidence of significant disease outbreaks in wild spruce grouse populations has not been reported in the literature. However, the species is susceptible to several avian diseases, notably avian pox and histomoniasis (see Boag and Schroeder 1992 for review) and are hosts to several internal parasites (e.g. *Syngamus trachea*) and external blood parasites (mites, hippoboscid flies). Chick growth has been shown to be negatively affected by the spruce budworm pesticide *Bacillus thuringiensis kurstaki*, primarily due to loss of caterpillar larvae in their diets (Norton et al. 2001).

Movements and Home Range

The spruce grouse is a year-round resident throughout its range. However, individuals may undertake short and long migrations between breeding and wintering habitat (Schroeder 1985). Female spruce grouse have been reported to move over greater distances or to have larger home ranges than males (Ellison 1968, Schroeder 1985, Ross 2008) and young females dispersed greater distances than their male counterparts (Schroeder 1985). The farthest spring dispersal and migratory movements that Schroeder (1985) recorded were 11 km and 10 km for females and males, respectively, and females moved distances greater than 2 km significantly more often than males.

To date, spruce grouse home ranges have been reported in only a handful of regions throughout the species' distribution. In the Kenai Peninsula of Alaska, home ranges of 1.82-20.00 ha and 6.10-26.40 ha have been reported for males and females, respectively, using the Minimum Convex Polygon method (MCP) (Ellison 1968). In the Yellow Dog Plains of Michigan, male home ranges have reportedly ranged from 1.5-24.7 ha (MCP) (Robinson 1980). In New York, home ranges have ranged from 12.29-18.46 ha and 16.77-77.88 ha (MCP) for males and females, respectively (Ross and Johnson 2008). Using the adaptive kernel method with least squared cross-validation, home ranges of New York spruce grouse ranged from 5.21-39.01 ha and 18.49-127.58 ha for males and females, respectively, with 15.93 ha as the geometric mean (Ross and Johnson 2008).

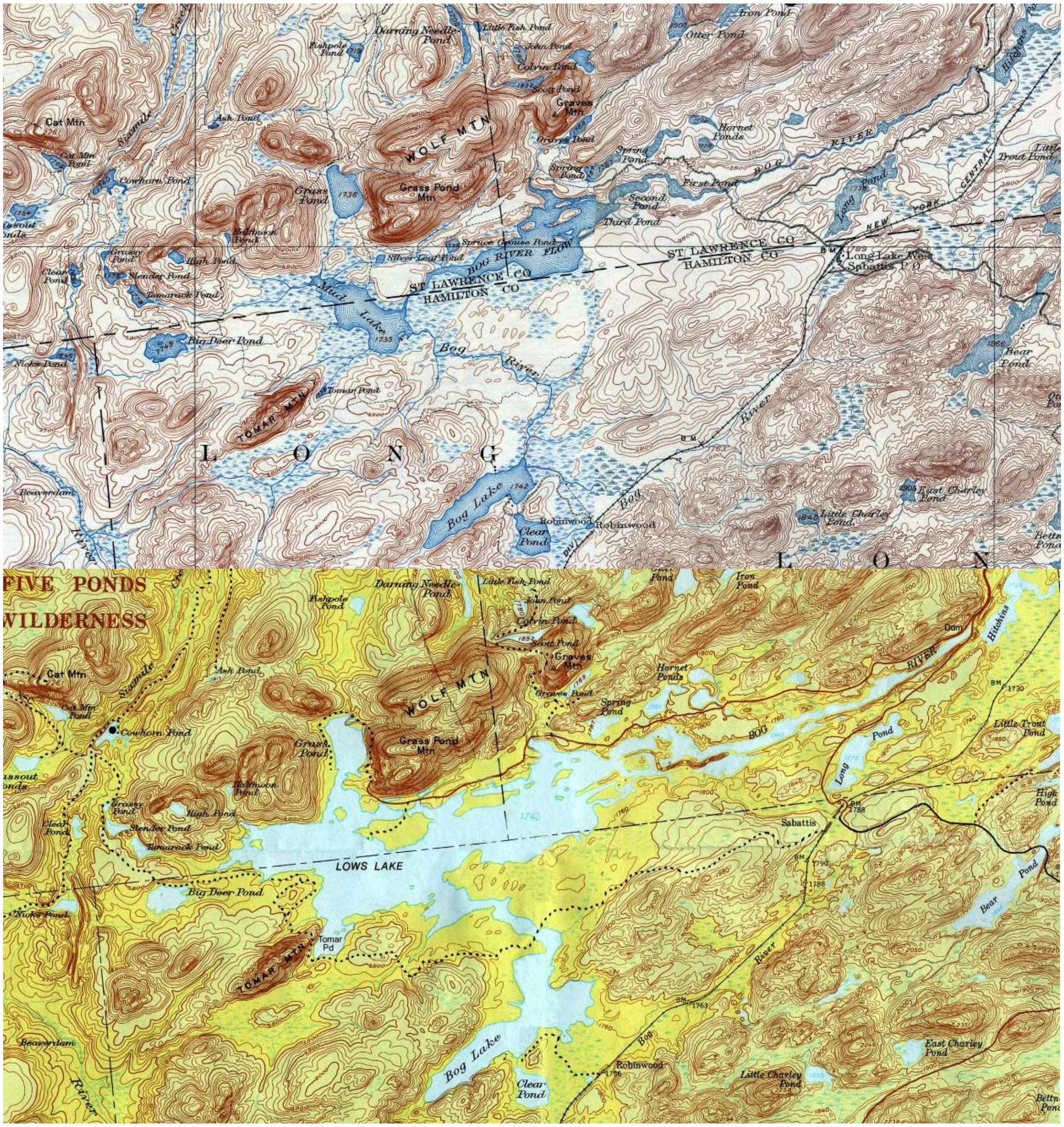
The connection between habitat and home range is further discussed in the section below on studies from 2002-2006.

HISTORICAL STATUS ASSESSMENT

Spruce grouse were reported as relatively abundant in the Adirondacks prior to the 1880s (Eaton 1910, Johnson and Ross 2008). Eaton (1910) wrote about shooting considerable numbers of spruce grouse out of trees, decimating entire family groups. He later noted that by the early 1900s the species had become rare. Museum specimens dating from 1871 to 1974 confirm the species' occurrence in at least six counties (St. Lawrence, Franklin, Hamilton, Essex, Herkimer and Lewis) in which 18 subpopulations occurred (Figure 3) (Bull 1974). From 1976-1980, Chambers et al. (1982) surveyed 115 conifer patches. Of these, they identified 26 occupied patches, seven of which were also identified by Bull (1974), suggesting that by 1980, spruce grouse subpopulations in many of these historical locations or "sites" were extirpated and the species had become rare. In addition, the more recent distribution encompassed less than half of the occupied geographic area outlined by Bull (1974) and therefore represented some of the first evidence that the spruce grouse distribution was shrinking in New York. Surveys conducted from 2002-2006 by Ross and Johnson (2008) have indicated that the spruce grouse distribution had contracted further, encompassing only those subpopulations in the core of the 1976-1980 distribution. These more contemporary subpopulations have been located in only St Lawrence, Franklin and Essex Counties.

Several lines of evidence suggest that there are different causes for the historical decline and the more recent decline of spruce grouse in the state. The historical spruce grouse population decline has been largely attributed to the loss and fragmentation of habitat due to widespread softwood logging and increasing development that took place in the late

1800s and early 1900s (Bouta and Chambers 1990). At one time during this period, spruce was worth more as paper than as lumber, which resulted in large areas being clearcut. After timber in these clearcut areas regenerated, softwood species tended to give way to the more prolific hardwood species, and in many cases, these areas became hardwood-dominated and therefore no longer suitable for spruce grouse occupancy (McCarthy 1919, McMartin 1994, Jenkins 2004). Another contributing factor adding to spruce declines was a blight caused by the spruce beetle (*Dendroctonus rufipennis*), which is thought to have killed an estimated one-third to one-half of spruce trees in the Adirondack Region from 1870-1885, potentially contributing to further habitat fragmentation and population reductions (Fox 1895, Pinchot 1899). In addition, timber harvesting was often accompanied by the damming of rivers to transport softwoods downstream to mills, which resulted in the flooding and additional loss of spruce grouse habitat and likely contributed to further declines (Bouta 1991). Below are topographic maps from the University of New Hampshire's Diamond Library that depict the area around the Bog River from around 1921 (before flooding; top figure) and present day (post flooding; bottom figure), which show the extent of this loss of lowland boreal habitat. Documented collections of spruce grouse from the 1800s were in some of these locations which, due to damming, are currently under water.



The species' relatively unwary behavior and lack of fear of humans, which afforded it the nickname "fool hen," may also have contributed to its decline, as individuals may have provided an easy meal and good source of protein for early settlers. Gabrielson and Lincoln (1959) found that the species quickly disappeared from the vicinity of settlements in Alaska, which supports the notion that human overharvesting can result in local population declines and ultimately may have contributed to the historical population decline.

Continued declines detected by Chambers et al. (1982) from earlier observations are more likely due to habitat changes than direct habitat loss, because widespread timber harvest has been significantly reduced in the lowland boreal forest. These changes include the advancement of natural succession, such that formerly suitable habitats are becoming unsuitable, further increasing isolation.

CURRENT STATUS ASSESSMENT

The spruce grouse is common throughout most of its continental range and it is not protected under federal law. It is regarded as a G5 or globally secure species throughout the main portion of its range in Northern Canada (NatureServe 2009). However, because of low local population densities, hunting is restricted or banned in some states and provinces. The spruce grouse is listed as Endangered in New York and Vermont, Threatened in Wisconsin, a Species of Special Concern in Michigan, a Species of Conservation Concern in New Hampshire and hunting is closed in Maine, Oregon (designated as "State Sensitive") and Nova Scotia ("Protected").

Population Status and Distribution in New York

Although common over most of its continental range, local spruce grouse populations or "subpopulations" in New York are small and declining. In 1987, there were an estimated 175 – 315 spruce grouse present in the state; however, this number was likely closer to 175 individuals (Bouta 1991). In 1999, the species was added to the New York State Endangered Species List. By 2006, only 14 of 32 sites occupied from 1976-1987 (Fritz 1977, Bouta 1991) and one new site were occupied (Ross and Johnson 2008) and there were probably less than 75 – 100 adult spruce grouse in the state (Ross and Johnson, unpublished data). Efforts to increase the species' abundance in New York must be undertaken to conserve the species and ensure its continued persistence in the state.

Numerous studies have taken place in New York State that have documented the recent distribution of spruce grouse (Fritz 1977, Chambers et al. 1982, Bouta and Chambers 1990, Bouta 1991, Ross and Johnson 2008). These studies have indicated that the species is still declining, despite the general cessation of large-scale softwood logging and associated river damming taking place in the Adirondacks during more recent times (Bouta and Chambers 1990, 1995, Ross 2008), as well as the more recent protection of the species from hunting c. 1947 (J. Ozard, pers. comm.). As a result of the species' contemporary decline, the spruce grouse was officially recognized as "threatened" in 1983, and was later upgraded to "endangered" in 1999. Given that extensive logging and damming does not occur to the same extent in the Adirondacks as it did historically, and given that spruce grouse hunting is no longer legal and therefore not likely to be a significant threat, contemporary subpopulation extirpations are likely the result of other factors. Evidence for the interaction of (1) size and isolation of occupied sites across the landscape as well as (2) coniferous forest maturation have been cited as reasons for the more recent population decline (Fritz 1977, 1979, Bouta 1991, Johnson and Ross 2003, Johnson and Ross 2008).

If logging was the sole factor influencing contemporary spruce grouse declines, the species would be abundant within the Forest Preserve and scarce in the managed private forests.

Fritz (1977) reported that 11% or 3 of 26 extant subpopulations were on Forest Preserve lands. A few years later, Bouta (1991) found that only 4% of spruce grouse subpopulations were on the Forest Preserve. From 2002 – 2006, Ross (2008) observed that 4 of 15 or 27% of subpopulations were on Forest Preserve, which appears to suggest that lack of management reflects positively on the species. However, the notion that these data support that increased area of Forest Preserve results in a benefit to the spruce grouse may be misleading for two reasons: (1) they may represent recent land acquisitions by the state and therefore not enough time has passed post land disturbance to show any negative effect on the subpopulations present, or (2) they may be an artifact of how these data are grouped and reported. For example, if we compare land ownership of surveyed lowland boreal habitat patches within the species' historical distribution, we find that 40% of them are on the Forest Preserve, yet only 26% of the portion of total occupied spruce grouse patches are on Forest Preserve land. Moreover, 32% of privately owned lands surveyed were occupied by the species, whereas only 18% of the state owned parcels were occupied. The data from the studies below demonstrate the preference of spruce grouse for younger forest.

Studies from 1976-1980

Fritz (1977) surveyed 67 lowland coniferous forest patches (i.e., sites) in the Adirondacks to determine spruce grouse distribution. In 1976 and 1977, he found evidence of spruce grouse at 26 of these forest patches. Upon making comparisons with data on historical distributions from books (Eaton 1910, Bull 1974), reliable reports and specimen collection locations from museum study skins, he determined that the species had declined in both numbers and distribution. Fritz (1977, 1979, 1985) noted that many sites did not support local populations of the species even though they appeared to have appropriate habitat. He concluded that the species had a metapopulation structure and that the decline was a function of isolation of lowland coniferous forest patches, such that sites more distant from occupied sites tended to be unoccupied. He reasoned that dispersal was insufficient to lead to recolonization of the more distant habitat patches, noting that if isolation was a key factor explaining the distribution of the species, the species was indeed limited by dispersal. The largest movement observed was made by a juvenile female that dispersed from the Grasse River Club site to the Sevey Bog site, a minimum distance of 8.6 km. Fritz (1977, 1979) also noted that larger coniferous forest patches tended to support spruce grouse populations, whereas a greater percentage of small coniferous forest patches (i.e., $\leq$ 50 ha in size) were unoccupied than expected.

Studies from 1985-1987

Bouta (1991) surveyed 29 coniferous forest patches over the period 1985 – 1987, including 22 previously occupied patches from Fritz (1977, 1979 and 1985). He found that 23 sites contained extant subpopulations, two of which had become extirpated since the previous studies (Fritz 1977, 1979). Bouta (1991) estimated the Adirondack breeding population at 175-315 individuals from 1985-1987. He noted that many sites in close proximity to occupied sites were transiently occupied or unoccupied. He hypothesized that local extinctions were a function of the maturation of coniferous forests to older-aged stands no longer suitable for spruce grouse persistence. He measured habitat characteristics at three persistently occupied sites (i.e., sites that contained spruce grouse consistently throughout the study period) and two transiently occupied sites (i.e., sites either not consistently occupied or sites with extirpated subpopulations throughout the 1985-1987 study period) and found that sites with persistent populations were those with younger trees (41 versus 58 years), a greater percentage of live foliar coverage in the 1.0-2.0 m range of the vertical stratum (19.8 versus 12.0%) and less live foliar coverage in the 4.0-6.0 m range of the vertical stratum (25.7 versus 35.3%) than transiently occupied sites. Moreover, Bouta (1991) noted that spruce grouse avoided stands that were greater than 70 years old (Bouta 1991). In addition, persistently occupied sites had a significantly greater percentage of both ericaceous herb cover (16.8 versus 7.4%) and blueberry herb cover (9.0 versus 3.3%) than transiently occupied sites. Herb cover was defined as all vegetation between 8 and 25 cm tall (Bouta 1991).

Studies from 2002-2006

Surveys by Ross and Johnson (2008) have indicated that populations at several sites occupied during the 1976 – 1977 and 1985 – 1987 study periods (Fritz 1977 and Bouta 1991, respectively) have become extirpated and that populations are likely lower than previously recorded. Ross and Johnson (2008) surveyed a total of 55 lowland coniferous patches or sites, which included all occupied sites (*n* = 32) from 1976 – 1987 (Fritz 1977, Bouta 1991) (Figure 4) and 23 new conifer patches. Fourteen of the 32 sites occupied during the previous study periods had evidence of spruce grouse presence and one new site was found to contain spruce grouse (Figure 5). One new site, the Kildare Club Bog, which was in the core of the historical distribution, was consistently occupied throughout the study and had never been surveyed prior to 2002. The Kildare Club Bog may have been occupied as a result of its close proximity (2.2 km) to other occupied habitat patches (Ross and Johnson 2008, Ross 2008).

Ross and Johnson (2008) conducted two types of analyses for evaluating spruce grouse habitat use. The first was a compositional analysis where they compared habitat within spruce grouse home ranges to that of random areas within an occupied site. They found that within occupied sites, spruce grouse preferentially selected younger or stunted spruce forest stands as compared to random areas. The second type of analyses was a comparison between occupied and unoccupied sites. To evaluate habitat between site types, Ross and Johnson (2008) divided sites into three categories similar to Bouta (1991) but defined as follows: (1) persistently occupied sites were those that were consistently occupied throughout the study period and those with evidence of breeding, (2) transiently occupied sites were those that were occasionally occupied or sites where only sign (e.g. scat or feathers) was observed, and (3) sites with extirpated subpopulations were sites that were occupied from 1976-1987 and did not have evidence of grouse presence throughout the study period. Ross and Johnson (2008) measured habitat variables at 17 sites and found that persistently occupied sites (*n* = 7) had 14% younger and 8% shorter trees, 64% greater percentages of live foliage cover in the 0.2 – 1.0 m range of the vertical stratum, 86% greater percentage of blueberry herb and 2.5 times greater blueberry shrub cover, and had >60% more ericaceous and coniferous shrub cover and 33% less balsam fir shrub cover than extirpated sites (n = 6) (Table 2). Shrub cover was defined as any vegetation greater than 25 cm tall and less than 3 cm diameter at breast height. In addition, it was noted that the standard errors of tree and sapling variables were small, suggesting that the measured stands, whether occupied or unoccupied, were fairly even-aged. Ross and Johnson (unpublished data) also noted there were many cut stumps in grouse sites without the accompanying fallen trees, which indicated that the trees were cut and removed. These even-aged stands may have been useful for spruce grouse to a point, past which they no longer served their purpose in maintaining self-sustaining spruce grouse populations in New York.

Ross and Johnson (2008) also measured site area and distances between sites and found that area did not appear to influence site occupancy. However, sites that were in closer proximity to an occupied site tended to be occupied (Figure 6, Appendix 1). It is possible that area may not have influenced site occupancy because all sites visited were greater than 38 ha in size (Table 3), which is well above the likely minimum occupied patch size. This information is corroborated by findings in Maine, where spruce grouse have been found to occur in habitat patches as small as 8 ha (Whitcomb 1996). Results of Ross and Johnson (2008) indicate that both site isolation and successional changes in habitat appear to affect spruce grouse site occupancy, such that historical sites with characteristics of older forest stands and those farther from the core of the historical distribution tend to be extirpated (Figure 7, Appendix 2).

THREATS TO SPECIES

Historically, the dominant threat to spruce grouse populations in the Adirondacks has been and may continue to be habitat loss and fragmentation. Potential mechanisms include incompatible silvicultural practices coupled with natural disturbance processes such as those brought on by fire and storms. In New York, the loss and fragmentation of habitat by selective logging of softwoods in the late 1800s and early 1900s has been noted as a major factor in the species' historical decline, as these practices usually led to a subsequent increase in the more prolific hardwood species (Jenkins 2004, Bouta and Chambers 1990). In addition, spruce budworm outbreaks have led to the further loss of conifer habitat (Fox 1895, Fox 1902) and possibly contributed to the species' decline. Erecting dams to facilitate floating softwoods downstream to be milled exacerbated the problem by flooding large tracts of lowland coniferous habitat (e.g. Lows Lake and Stillwater Reservoir), thus increasing fragmentation and the loss of habitat. Recent surveys have indicated that spruce grouse are still declining (Fritz 1977, Bouta and Chambers 1990, Bouta 1991, Johnson and Ross 2003, Ross and Johnson 2008), despite the relative cessation today of such large-scale timber harvesting operations in the lowland boreal forest. The patchy distribution of local populations and resultant small local population sizes are cited as factors that contribute to the recent decline (Fritz 1979). In addition, changes in species composition and structure of these even-aged coniferous stands due to natural succession resulting from previous logging activity may be an important factor in the declines (Bouta 1991; Ross and Johnson, unpublished data).

Studies of spruce grouse habitat have suggested that the species prefers mid-successional forest stands and is less prevalent in more mature stands (Pence et al. 1990, Boag and Schroeder 1991, Bouta 1991, Ross and Johnson 2008). Studies of spruce grouse in southwestern Alberta by Schroeder and Boag (1991) revealed that spruce grouse may be adapted to a specific successional stage of lodgepole pine forest, as spruce grouse selected areas with shorter and a higher percentage of canopy cover, less shrubs and reduced densities of aspen (*Populus* spp.), pine and spruce. Bouta (1991) presented similar findings in New York bogs when he found that transiently occupied sites were those that contained older trees with less live foliage cover near the ground (1.0-2.0 m). Recent studies of spruce grouse in New York and Vermont have indicated that the species may be declining as forest stands mature (Fritz 1977, Pence et al. 1990, Bouta 1991, Ross and Johnson 2008). Other factors such as site arrangement within the landscape may be responsible for shifts in site occupancy, such that occupied sites tend to be closer to one another than unoccupied sites are to occupied sites (Fritz 1977, Ross 2008). Several authors have suggested that spruce grouse probably do not select a specific height or age class of trees, but instead select stands based on the amount of shrubs and forbs present, both of which are clearly influenced by canopy age, height and cover (Boag and Schroeder 1991, Bouta 1991, Ross and Johnson 2008). Appendix 3 shows two pairs of sites: one typical of an extant population and another typical of an extirpated population in the Adirondack Region of New York.

Logging may have been a factor in the initial declines of spruce grouse populations in New York. However, timber harvesting performed to enhance the growth of greater ericaceous and spruce understory vegetation and provide more live branches that meet the ground may be necessary to promote the persistence of the spruce grouse in the state. Data from Fritz (1977), Bouta (1991) and Ross (2008) all suggest that mid-successional stage lowland boreal forest is preferred by spruce grouse and habitat management that promotes this forest type is essential. While natural disturbances can achieve this end, such disturbances are not predictable in time and space, and in some cases, such as fires, these disturbances may be quickly suppressed. In addition, natural disturbances are increasingly rare in the remaining isolated patches of lowland boreal forest and therefore should not be relied upon as a management technique to promote self-sustaining spruce grouse populations.

Although unlikely, accidental shooting of spruce grouse may contribute to the species' recent decline. Gabrielson and Lincoln (1959) commented that the species is so easily hunted that it quickly disappears from the vicinity of settlements in Alaska. Although the species has not been hunted legally since c. 1947 in New York, there are still instances of accidental shooting. One individual was shot near the center of the species' current distribution in 2004, when mistaken for a ruffed grouse by a local resident (Dan Christmas, pers. comm. 2004). Ruffed grouse are known to occur within spruce grouse habitat in the Adirondacks (A. Ross, pers. observation). The seemingly "tame" behavior of spruce grouse may make them more susceptible to accidental kills by hunters. However, accidental hunting is not likely a significant factor due to the reluctance of the species to flush when disturbed and unlikeliness of hunters to be in the lowland boreal during the hunting season.

The possibility that acid deposition may be causing a decrease in the dietary value of spruce foliage by reducing calcium availability has been proposed as a factor contributing to the contemporary spruce grouse decline (Jenkins et al. 2007). In addition, mercury deposition from atmospheric pollution may also impact the species. Studies of mercury in Adirondack bird, herpetofauna and mammal populations are currently underway (N. Schoch, pers. comm.).

CLIMATE CHANGE

While the extent of the impacts of global climate change on the spruce grouse distribution is difficult to predict (Williamson et al. 2008), there may be considerable effects on the distribution and abundance of lowland boreal habitats in the Adirondacks. If the average temperature continues to rise as predicted by current climate models and Adirondack winters become shorter and even possibly devoid of significant snow and ice cover, the continued survival of the boreal plants and animals may be in doubt (Jenkins 2004, 2010). Since spruce grouse are so tightly linked to the presence of lowland conifer forest, a warming climate and resulting significant habitat changes may lead Adirondack spruce grouse populations, as well as other boreal forest obligates, into an extinction ratchet ending in extirpation. Additionally, warming trends could result in the emergence of disease outbreaks that may threaten spruce grouse populations.

DATA GAPS

Population Demography

Information on survival rates by sex and age class, mean lifespan, recruitment and dispersal rates is sorely needed for New York populations of spruce grouse. Given the current low population numbers and the concomitant low potential sample sizes, coupled with the limited resources available to conduct such studies over meaningful timeframes, much of this information will likely not be available to assist management efforts. However, it is both possible and critical to obtain this information during any proposed population augmentation effort.

Genetics

In 2008, researchers began a genetic study of mitochondrial DNA variation in the New York spruce grouse population to obtain information regarding the genetic structure of spruce grouse within and between New York subpopulations and to assess the genetic relatedness of the New York population and neighboring populations. This work was performed by Dr. Jeremy Kirchman, the curator of birds at the New York State Museum and is based on blood samples obtained from birds captured in New York by A. Ross and G. Johnson. Twenty-two individuals were sampled from nearly all extant New York populations and six samples were obtained from birds in Algonquin Park, Ontario. Complete mitochondrial Control Region sequences (1150bp) obtained from these samples indicate that New York's spruce grouse population has a very low level of genetic diversity even relative to the much smaller sample from Ontario. Two polymorphic nucleotide sites define only three haplotypes among 22 New York spruce grouse. Nineteen individuals are identical at all nucleotides. Five haplotypes were found among the six Ontario birds. No haplotypes are shared between New York and Ontario, but divergence between these populations is very slight. Ongoing research by Kirchman to characterize Control Region variation among historic museum specimens collected in New York over the past 150 years indicates that much genetic variation has been lost from New York spruce grouse in the last century. Additional data from historic specimens, and from extant populations from Vermont, New Hampshire and Maine would also be necessary to determine the best source populations for a reintroduction program.

Metapopulation Dynamics

The influence of habitat distribution on spruce grouse occupancy has not been adequately determined. Analyses of habitat distributions have been conducted; however, the importance of these relationships in regard to habitat quality is not completely understood. Movements of individuals between sites have been restricted to areas connected by lowland conifer cover and no movements greater than 2 km have been observed within recently occupied habitat patches in New York (Ross and Johnson 2008). An analysis that (1) addresses the importance of habitat distribution, and (2) assesses the quality and suitability of such habitats, would be meaningful to determine the efficacy of improving connectivity by creating new habitats between existing sites to help restore the species.

Forest Management

In New York, the spruce grouse is declining as a result of habitat fragmentation and successional changes in forest structure and species composition (Ross and Johnson 2008). Information regarding which forest management techniques would promote the creation or regeneration of suitable spruce grouse habitat is lacking, but it is necessary before any significant restoration efforts may be considered. A study was begun in 2008 by Ross and Johnson (unpublished data) to test for differences in spruce grouse use in a spruce-tamarack-fir forest using three management techniques. Treatments were designed to leave various densities of trees within these 1-ha blocks with a 100 m buffer in between each managed block. Treatments applied were mechanical thinning of trees to different densities, where six blocks were treated with three replicates at two different densities, and three blocks were a control. Monitoring the success of such management techniques is ongoing, with results expected within five years.

RECOVERY STRATEGY

Goal: The ultimate goal of the spruce grouse recovery program is to restore, protect and maintain self-sustaining and secure populations of the spruce grouse and its habitat and associated boreal forest community in New York State, enabling sequential downlisting to Threatened status and the eventual removal of the species from the New York State Endangered Species List.

More specifically, the goal is to achieve a 95% probability of maintaining an extant population of spruce grouse in New York through the next 100 years (i.e., from 2010-2110).

Recovery Objectives: As determined by a population viability analysis (PVA) by A. Ross (unpublished data), the spruce grouse will be considered recovered to the point where they may be downlisted to Threatened in New York when there are (1) at least two subpopulations or sites where habitat manipulations[a] have taken place that result in at least a 13% increase in adult and chick survivorship from current estimates (increase in adult survivorship from 55.0% to 61.5%), and (2) after successful reintroduction of 30 individuals into each of two additional sites formerly occupied by spruce grouse that results in establishment of breeding populations[b] (Table 4).

A change from endangered to threatened status will be achieved after a reasonable time frame post habitat management, and will require periodic monitoring to ensure that the reintroduced populations are still extant. We recommend follow-up surveys of the four sites each year for the first five years and every other year until year 15. Periodic monitoring should occur thereafter every three years to facilitate adaptive management of the subpopulations.

The spruce grouse will be considered fully recovered in New York when there exists for at least 25 years a minimum of (1) 15 breeding subpopulations with an average adult and chick annual mortality of less than 45.0 ($\pm$23 SD)% and (2) two additional subpopulations with an

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[a] The sensitivity analysis showed that the model was sensitive to only changes in mortality rates. Specific habitat manipulations resulting in an increase in survivorship to 61% have not been specifically identified. However, several studies have shown that conspecifics experience varying survivorship rates in areas of varying habitat quality (Brown et al. 2002, Crawford et al. 2004, Vreeland, et al. 2004, Patten et al. 2005), hence we decided that altering survivorship rates could be used as a surrogate for altering habitat quality. Research on habitat manipulations begun in 2008 by Ross and Johnson (unpublished data) will provide information necessary to guide such management.

[b] Before translocation of individuals from outside populations is conducted, information regarding the genetics of New York spruce grouse populations is necessary. In 2008, Kirchman, Ross and Johnson (unpublished data) began a study to elucidate the genetic differentiation of populations within New York and between New York populations and outside populations. This information is necessary to ensure that donor and native populations are similar enough to each another that managers will not release individuals with genotypes that are poorly adapted to the Adirondack environment, as such may lead to increased mortality.

average adult and chick mortality of less than 38.5 (±17)% and (3) 90% of females breeding with an average clutch size of 5.6 (±1.3) hatchlings per female. Periodic effective habitat management may be necessary to sustain these subpopulations and a follow-up PVA can be used to select sites where effective habitat manipulations should take place. Several potential sites have been identified.

Monitoring at periodic intervals is critical to determine if spruce grouse populations remain secure over time. Such monitoring can begin once individual spruce grouse or a subpopulation has been detected at a site. Monitoring should also be conducted outside of known occupied sites in lowland boreal habitat to detect new colonizations. A monitoring program should begin immediately at the 15 currently known occupied sites and the 17 sites with extirpated populations. As occupancy is discovered or artificially established at new sites, annual monitoring shall proceed immediately and continue for at least five years, after which less frequent monitoring can be conducted.

Within each occupied spruce grouse recovery unit, defined as the Spruce Grouse Conservation Focus Area and Satellite Conservation Areas 1 and 2 (Figures 8-11), site specific adaptive management plans and landowner agreements will need to be in place to ensure that natural succession will no longer lead to habitat loss and fragmentation to the Adirondack spruce grouse population. See below for a description of these focus areas.

Recovery Areas

Spruce Grouse Conservation Focus Area

Authors developed the Spruce Grouse Conservation Focus Area (Figure 9) by adding a buffer equal to the maximum recorded dispersal distance of a spruce grouse in New York State (Bouta 1991) to the boundaries of known occupied spruce grouse sites from 2002-2006 in ArcGIS. The area defined within the buffers thereby represents a high potential for spruce grouse to have been present during the most recent region-wide surveys (2002-2006). Therefore, the Focus Area serves to guide and focus recovery efforts and management priorities with maximum efficiency and effectiveness. The Focus Area includes the boundary of the southern portions of St. Lawrence and Franklin Counties. It also includes a portion of the northwestern section of Essex County.

The Spruce Grouse Conservation Focus Area is approximately 154,292 ha in size with 29.3% (43,822 ha) in New York State conservation easements on privately owned lands and 28.4% (45,170 ha) in state owned Forest Preserve. The remaining 42.3% (65,300) ha are in private ownership not subject to conservation easements.
The portion of land in conservation easements consist of approximately 12 relatively large parcels. A similar number of large private parcels also occur within the Focus Area. Since habitat management involving the cutting of trees is not legal on Forest Preserve lands, the remaining area where habitat management would be possible is 110,470 ha (71.6%), which represents private land holdings with and without conservation easements. Habitat

management for the spruce grouse in the Focus Area will therefore need to take place in cooperation with private landowners on a voluntary basis.

Satellite Conservation Focus Areas

Satellite Conservation Areas 1 and 2 (Figure 8) were developed by (1) applying a 2 km buffer (i.e., the distance of the maximum movement range) of New York spruce grouse monitored over the period of 2002-2006 to the sites unoccupied during that period, and (2) including pre-1976 occupied sites as found in Bull (1974). We applied a smaller buffer to sites in these Satellite Areas relative to the Conservation Focus Area because these Satellite Areas are less likely to be occupied, and therefore will likely require more targeted efforts to ensure spruce grouse recolonization. Because sites cannot be defined as unoccupied with 100% certainty, it is possible that these sites may have been transiently occupied at some point between 2002-2006, and are therefore important to consider in conservation efforts. In addition, the Satellite Conservation Areas are important because they can serve as places to focus future efforts after subpopulations in the Spruce Grouse Conservation Focus Area begin to recover.

Satellite Areas 1 and 2 are more difficult to quantify with regard to land ownership, because sites with historical records were not delineated. In addition, some of these areas are known only by name from museum study skin records and may no longer exist as boreal habitat. However, extirpated subpopulations that were extant between 1976-1987 were used to delineate part of Satellite Area 1 and may be discussed.

The portion of Satellite Area 1 that consists within known historical site boundaries represents 23,311 ha of public and privately owned land (Figure 10). There are approximately three large contiguous parcels of Forest Preserve that represent 32.5% (7,585 ha) of the land mass within Satellite Area 1. The remainder consists of 31.3% (7,297 ha) of the total area which is protected by conservation easements, and the remaining are 37.2% (8,429 ha) is private land. The pre-1976 historical sites are distributed as follows: three on private lands with no conservation easements, and three on the Forest Preserve. There are three pre-1976 historical sites located in Satellite Area 2, two of which are on private lands with no easements, and the remaining located along the border of conservation easement land and Forest Preserve land (Figure 11). Again, since habitat management is not legal on Forest Preserve lands, using only the areas of sites that can be delineated in Satellite Area 1, the area where habitat management would be possible is 16,356 ha (70.2%), which represents both private land holdings with and without conservation easements. Therefore, any habitat management for the spruce grouse in the Satellite Areas 1 and 2 will need to take place on a voluntary basis in cooperation with private landowners.

PRIORITIZED RECOVERY ACTIONS

1. Refine a population viability analysis for the spruce grouse metapopulation within New York using several management scenarios.

2. Mathematically model the potential success of spruce grouse reintroductions in New York based on efforts by Vermont. Determine the sites in New York with the highest probability of successful reintroductions.

3. Determine the genetic variability and differentiation of spruce grouse within New York populations, between New York and nearest neighboring populations and across the species' range.

4. Determine the effects of experimental spruce grouse habitat management.

5. Evaluate habitat management actions taking place in spruce grouse habitats outside of New York to gain insight on effects of such management and its applicability to New York habitats.

6. Reintroduce spruce grouse into at least two areas from which they have become extirpated and monitor their fate, once formerly limiting factors have been identified and understood.

7. Conduct population surveys of all known and historical subpopulations and potential spruce grouse habitat at periodic (3 year) intervals using established protocols.

8. Secure long-term protection and management flexibility for spruce grouse populations via conservation easements.

9. Manage and maintain spruce grouse habitat at extant subpopulations, restore habitats at sites with extirpated subpopulations or other sites identified as suitable, and increase site connectivity to ensure continued spruce grouse persistence.

10. Develop and implement an effective outreach and education program about spruce grouse in the Adirondack Region.

11. Protect known extant subpopulations and their habitat using existing regulations and continued administrative support.

MANAGEMENT STRATEGY

ACTION 1. Refine a population viability analysis for the spruce grouse metapopulation within New York using several management scenarios.

First attempt completed for present recovery plan – 2010; estimates that include breeding depression and lower values for carrying capacity may need to be included.

Rationale: In 2010, there were approximately 14 local populations of spruce grouse in New York of 32 that were known to be extant beween 1976-1987 and at one site not surveyed prior to 2004. It is likely that these local populations are part of a single metapopulation. In 2010, Ross (unpublished data) began working on a sensitivity and population viability analysis (PVA) of this metapopulation to determine the sensitivity of various parameters in the model and to help prioritize and define the recovery criteria (Table 4). Results of sensitivity analysis indicated that the metapopulation is very sensitive to changes in adultand chick mortality and changes in numbers of extant local populations. Results of the PVA sugg est that if researchers can (1) increase survivorship by 13% and (2) reintroduce 30 spruce grouse into each of two local populations within the Spruce Grouse Conservation Focus Area (Figures 8, 9), the spruce grouse metapopulation will be viable for the following 100 years with 95% certainty (Table 4). A 13% increase in survivorship is feasible if proper habitat management is conducted. However, at this time, methods of proper habitatmanagement that result in increased survivorship are not completely understood. Studies that lead to better knowledge of spruce grouse response to habitat manipulations are ongoing (A. Ross and G. Johnson, unpublished data) and may address this information gap. It is anticipated that by 2015 there may be enough information to determine the efficacy of these habitat manipulations. It is likely that population sample sizes will not be great enough to detect differenc es in spruce grouse use within managed sites, therefore correlates of good habitat, such as measures of habitat structure and composition, have been and will need to be measured to gauge success. It will be necessary to add to these measures of microclimatic conditions within managed and control sites to make inferences about nesting habitat condition.

Approach:

Using existing demographic, genetic and distribution data from New York, we performed a PVA that determined extinction risk using currently available software, such as VORTEX (Lacey et al. 2003). We estimated the probability of extinction over 100 years with 95% confidence with 500 simulations. See Table 4 for input parameters and model results. If no management is conducted, the average time to extinction of the metapopulation is 23 years and the probability of extinction over 100 years is 83.6%. Within the Spruce Grouse Management Focus Area, if two sites undergo habitat management and two additional sites undergo a single reintroduction of 30 individuals each, the probability of extinction over 100 years is 0.4%. These reintroduction sites will need to be maintained at the appropriate sucessional stage through management intervention. The feasibility of reintroduction and habitat management should be discussed and planned immediately. Our model did not incorporate effects of climate change and therefore our results are not conservative. Models incorporating climate change should be explored.

ACTION 2. Mathematically model potential success of spruce grouse reintroductions in New York based on efforts in Vermont. Determine sites with the highest probability for success by reintroductions.

Partially completed in 2010 with population viability software (Ross unpublished data).

Rationale: Ross and Johnson (2008) suggested that habitat management may be necessary to help restore spruce grouse populations in New York. However, there may be too few remaining individuals for habitat management to be the only action necessary to maintain self-sustaining populations. PVA results show that both reintroductions and habitat management will be necessary to ensure that extant spruce grouse populations will be present in New York in the future (Table 4). Therefore, it will be necessary to supplement information gathered from the PVA with data from other studies to determine the reintroduction sites with the greatest probability of success prior to translocating spruce grouse. This analysis can be completed using information gathered from other spruce grouse reintroduction studies, such as Vermont.

Reintroductions of spruce grouse have taken place in Vermont beginning in the summer of 2008 (C. Alexander pers. comm.). Researchers in Vermont radio-tagged spruce grouse prior to release and tracked their movements via triangulation. Individuals released were collected from Quebec populations. Surveys using playback recordings to determine grouse densities in the release area began in 2010. No microhabitat data have been collected; however, forest stand data are available from Vermont for GIS analyses to determine the cover type and stand age in which translocated individuals established home ranges. Determining which habitat types were selected by reintroduced Vermont spruce grouse will help elucidate which sites in New York will have the greatest probability of successful reintroduction. A determination of equivalent forest stands in New York will help to prioritize sites for reintroduction.

Objectives:

(1) Develop a spatial model of the probability of success at potential sites targeted for spruce grouse reintroduction based on data gathered from reintroductions in Vermont from 2008-2009 and data from PVA (Ross, unpublished data).

(2) Determine how many spruce grouse will be introduced into each priority reintroduction site (PVA shows 30 in each site is acceptable).

(3) Write a reintroduction plan that addresses methods of establishing priority reintroduction sites, details about acquisition of donor stock, captive management protocols, release methods and monitoring programs.

Approach:

(1) Acquire necessary data such as spruce grouse location data and GIS data from Vermont and New York studies.

(2) Assemble all relevant New York State GIS data.

(3) Review datasets from New York and Vermont and adjust so that they are comparable.

(4) Analyze reintroduced spruce grouse movements to create shapefiles of home ranges and overlay these with GIS cover type data from Vermont.

(5) Conduct a composition analysis of Vermont data that can be compared to New York data.

(6) Make comparisons between Vermont and New York GIS data and determine probability of successful reintroductions in all sites with extirpated subpopulations, Adirondack Park Agency Megawetlands and other potential sites.

(7) Use PVA to calculate probabilities of successful reintroductions in these release sites as a check.

Ongoing Work: NYSDEC and Vermont have begun data sharing in 2009 to begin the process of modeling success of potential reintroductions in New York.

ACTION 3. Determine the genetic variability and differentiation of spruce grouse (1) within and between Adirondack subpopulations, (2) between Adirondack and the nearest neighboring populations and (3) across the species' range.

Rationale: Fragmentation of a landscape into increasingly smaller habitat "islands" can lead to a variety of potentially negative consequences to natural populations, including local extinction. Conservation biologists are concerned that habitat fragmentation can lead populations to drop below minimum viable numbers, such that the potentially deleterious effects of inbreeding and loss of genetic variability through drift will occur (Lande 1988). Geographic isolation can limit gene flow in species with low vagility and may have dramatic effects on the distribution of genetic resources. Without recruitment of new genetic material, a loss of polymorphism and inbreeding depression may result as evidenced by studies with domestic and zoo animals from wild populations. Inbreeding is associated with a reduction in fitness in many normally outbreeding populations; disease and genetic disorders can more readily cause local extinction (Hedrick and Kalinowski 2000). Conversely, a reduction in fitness may result from the mixing of naturally divergent gene pools, a phenomenon known as outbreeding depression (Templeton et al. 1990). Small, isolated populations may diverge genetically from other populations through drift or selective forces. Breakup of co-adapted gene complexes resulting from local adaptation by recombination may result in fitness reduction (Templeton et al. 1990). While it has been suggested that selection should eliminate the occurrence of outbreeding depression, in small populations with a low biological replacement rate, even a temporary reduction in fitness could prove disastrous.

Given these arguments, it is clearly necessary to determine the genetic structure of small, genetically isolated populations prior to any plans that include genetic management (Dodd and Seigel 1991). This knowledge, including estimates of effective population size and how genetically distinct isolated populations are from each other, will be useful in the development of a recovery strategy for spruce grouse by helping define conservation management units based on genetic structure. Genetic management may include population augmentation from other demes, reintroductions and "headstarting" within demes.

If New York populations are determined to be genetically distinct by containing unique alleles, some significant component of the species' genetic diversity is contained in New York demes, enhancing the conservation value of these populations. It may be possible to designate New York populations as a Distinct Population Segment under the federal Endangered Species Act, thus justifying increased conservation focus by New York State.

Objectives:

(1) Measure the genetic structure within Adirondack subpopulations of spruce grouse by using mtDNA and microsatellite markers and determine if New York populations are viable.

(2) Assess the degree of relatedness between allopatric spruce grouse populations across the species' range-wide distribution by the same molecular techniques as above. Priority should be given to neighboring, out-of-state populations that may serve as donor populations.

(3) Infer historical and present-day population genetic processes to be used as a guide for future spruce grouse conservation efforts.

(4) Determine effective population size of remaining subpopulations.

Ongoing Work: Since 2004, blood samples of spruce grouse from New York and Algonquin Provincial Park in Ontario, Canada, have been collected to determine the species' genetic structure in both regions. In 2009, preliminary analyses of spruce grouse mitochondrial DNA have begun in cooperation with Jeremy Kirchman at the New York State Museum. Partners in Vermont and Maine are performing microsatellite DNA analyses and are willing to share DNA with New York. Efforts to coordinate data sharing need to be established.

ACTION 4: Determine the effects of experimental spruce grouse habitat management on spruce grouse site use.

Rationale: Alexander and Chipman (1993) provided a set of habitat management guidelines for spruce grouse based on consensus from wildlife biologists (Appendix 4). However, their approaches have not been tested. To date, only a couple of scientifically-sound habitat management projects designed specifically for the benefit of spruce grouse have taken place. In 2008, one such study was begun to test for differences in spruce grouse use in a spruce-tamarack-fir forest using three management techniques. Treatments were a mechanical thinning of trees to varying densities within these 1-ha blocks with a 100 m buffer between each managed block (Potvin and Courtois 2006). Treatments applied were mechanical thinning of trees to different densities, where six blocks were treated with three replicates at two different densities, and three blocks were a control. Results are expected to show an increase in earlier successional tree species and increased shrub density in treated areas, both of which have been suggested as necessary for spruce grouse persistence (Ross and Johnson 2008). Spruce grouse survey data and limited telemetry data exist for the managed site since 2002, and extensive habitat measurements have been conducted since one year prior to management. Monitoring the success of management techniques is ongoing.

Treatment blocks will need to be monitored into the future as it is currently unknown whether or not the tested management techniques will successfully increase spruce grouse use. In addition, if any treatment results in the creation of spruce grouse habitat in the future, it is unknown how long it will be before such habitat is created and used. It is expected that nesting spruce grouse will experience the greatest benefit of a management technique that is intended to increase density of the shrub layer. A study to compare the microclimate and shrub density in treatment areas versus nest sites will be necessary to determine the success of these treatments without the intensive effort and low power associated with attempting to detect increased spruce grouse use in the treatment areas. Surveys and habitat monitoring are ongoing (A. Ross unpublished data), but management techniques such as additional tree densities and size and shape of new management blocks should be tested either on lands presently managed or on new parcels to determine if other treatments would provide a greater benefit to the species.

To our knowledge, there have been no published studies specifically designed to create spruce grouse habitat anywhere in North America to date. Therefore, it is important to remember that monitoring must be a priority in habitat that is created or enhanced experimentally. Surveys of preexisting vegetative structure and composition and spruce grouse use should be conducted prior to management in all new treated areas to develop a baseline for comparison with future studies. An information baseline will be necessary to improve power of detection, which will improve success of monitoring efforts.

Objectives:

(1) Determine which habitat management techniques increase spruce grouse use and density, or improve conditions for spruce grouse use as measured by correlates of grouse use (i.e., habitat composition and structure, food availability, and microclimate).

(2) Determine the time it takes to achieve both initial spruce grouse site use and maximum spruce grouse density. This can be measured using correlates of grouse use (see [1] above).

(3) Elucidate the effects of habitat management on percent shrub cover (black spruce, tamarack and ericaceous shrubs), temperature, relative humidity and invertebrate diversity and abundance. Specific questions to evaluate are whether these parameters differ between potential or "artificial" nest sites and natural (i.e., reference) nest sites (1) between treatments within management blocks and (2) between managed and control blocks.

Approach:

(1) Increase the amount of area in experimental habitat management in the Spruce Grouse Conservation Focus Area to test the effects of various tree clearing densities and size and shape of experimental management patches on spruce grouse site use and densities. Leave at least 100 m of buffer of coniferous forest between treatment sites as these buffers will ensure that spruce grouse have refuges in managed areas (Potvin and Courtois 2006). Aim for testing habitat treatments at four or five sites in areas where spruce grouse may benefit.

(2) Survey for spruce grouse within treated sites before experimental treatments take place and at yearly intervals thereafter to determine trends in spruce grouse site use and densities.

(3) Evaluate microhabitat within treated sites before experimental treatments take place and at yearly intervals thereafter to determine post-treatment habitat changes.

(4) Implant temperature and relative humidity sensors at artificial nest sites in treated areas and reference nest sites in untreated areas to compare microclimate.

(5) Sample invertebrate communities at or near artificial nest sites in treated areas and at reference nest sites in untreated areas to compare species' diversity and abundance. This will allow researchers to develop an index of brood food availability by treatment type and track it through time.

(6) Evaluate microhabitat at artificial nest sites in treated areas and at reference nest sites in untreated areas to determine which habitat treatments provide sufficient nesting cover and the length of time needed for regeneration of such cover.

ACTION 5: Evaluate habitat management actions taking place in spruce grouse habitats outside of New York to gain insight on effects of management and its applicability to New York habitats.

Rationale: The spruce grouse is a forest interior species that persistently occupies sites in New York where the mean tree age is approximately 45 years (Table 2). Currently, there are no reported results in the published literature of active habitat management conducted specifically for spruce grouse across its range. Alexander and Chipman (1993) proposed a set of forest management guidelines that would likely benefit spruce grouse (Appendix 4); these guidelines were developed by consensus among several wildlife biologists active in spruce grouse research. In addition, reports suggest that spruce grouse initially respond negatively to large clearcuts in boreal forest (Turcotte et al. 2000), but may persist in residual forest strips (Potvin and Courtois 2006). Anecdotal evidence suggests that 20 years post-harvest in large commercial forest blocks in northern Maine (described in Homyack et al. 2004), spruce grouse populations, or at least sightings, increased significantly (F. Servello and D. Harrison, Univ. Maine, Orono, pers. comm.).

A habitat management study is currently underway in an occupied site in New York (A. Ross and G. Johnson unpublished data); however, findings from this study may not be realized immediately. As a result, it may be necessary to study the results of habitat manipulation or timber harvesting in areas similar to New York to gain a better understanding about which management techniques will provide the greatest benefit to the species and the time that results may be expected. Maine may be a good location to evaluate habitat manipulation techniques on spruce grouse use and densities because (1) it has both more spruce-fir forests that have been manipulated for pulpwood production in recent history, (2) the state contains more spruce grouse than New York, and (3) like New York, Maine is also at the southern extent of the spruce grouse distribution and the species occurs in similar habitats to those of New York (Fritz 1979, Bouta 1991, Whitcomb 1993).

Objectives:

(1) Determine the effects of various methods of timber harvesting on spruce grouse densities and site use.

(2) Elucidate the effects of varying time since harvesting on spruce grouse site use and population densities.

(3) Determine which timber harvesting treatments produce the greatest spruce grouse densities and the time since harvesting to achieve maximum densities.

Approach:

(1) Review timber harvesting records from Maine and categorize stands by date since timber harvesting and site area and shape.

(2) Find a set of reference sites in Maine of comparable size to base comparisons. Pair sites based on site size and shape.

(3) Evaluate densities of spruce grouse during the breeding season by conducting surveys using methods outlined in Action 7 below.

(4) Write a habitat management plan for New York spruce grouse sites that can be legally managed.

ACTION 6. Reintroduce spruce grouse into at least two areas from which they have become extirpated and monitor their fate, once formerly limiting factors have been identified and understood.

Rationale: Spruce grouse populations may be limited by both dispersal and lack of habitat. Fritz (1977) suggested that low species' vagility may have been a factor limiting site occupancy (Fritz 1977). However, more recent studies suggest that the interaction of habitat quality and site distribution across the landscape play an important role limiting site occupancy (Ross and Johnson 2008, Ross 2008). Experimentally introducing spruce grouse into extirpated subpopulations may be necessary to determine if reintroductions are effective in restoring subpopulations. A well-planned reintroduction study may also provide information as to the quality of the reference (i.e., native) spruce grouse subpopulations, by allowing researchers to compare survivorship and productivity of both reference and experimentally reintroduced subpopulations. Before reintroduction is conducted, there must be overwhelming evidence to suggest that intermixing of spruce grouse from a potential donor population will not harm the native population by decreasing its fitness through outbreeding depression. The results of a genetics study to determine differences between the populations whose individuals will be translocated and those of the native populations must be understood prior to any reintroduction (see Action 3 above). If it is found that there is significant genetic variability between donor and native populations, headstarting young by raising eggs may be a viable option and should be explored. Since chick mortality is typically greatest during the first two weeks after hatching, collecting chicks from New York broods at this age may be a viable option for reintroductions elsewhere with little impact on the population.

If there is evidence that spruce grouse differ substantially from donor populations, another option would be to conduct a fate study to test how well individuals from donor populations survive in New York. This can be done by releasing them into areas where there would be no potential for interchange. If studies suggest that there is no difference in survivorship and productivity of reintroduced and reference populations, we can infer that intermixing of genetic material would not lead to a decrease in native grouse population fitness. This study could be conducted before genetics analyses are complete, and would allow researchers to determine whether reintroductions can be successful at establishing a subpopulation, and ultimately, would help aid in the species' recovery. A site with a willing landowner has been identified for this purpose.

Objectives:

(1) Determine whether reintroducing spruce grouse from donor populations into New York subpopulations is effective in establishing extirpated subpopulations.

(2) Determine if individuals from artificially augmented subpopulations have different movements patterns, survivorship and productivity than reference (i.e., native) subpopulations.

Approach:

(1) Extirpated subpopulations that are located within the Spruce Grouse Conservation Focus Area should be chosen for reintroduction (Figures 5, 8, 9). Individuals collected from wild populations as opposed to pen-raised should be released into New York as these tend to have the greatest success rates (Fischer and Lindenmayer 2000). Two sites were identified as high priorities for reintroductions based on modeling efforts. Additional potential release sites have also been identified. All are relatively large and presently unoccupied. Release sites should be discussed further and decisions should be based primarily on results of modeling efforts, with additional consideration given to habitat quality and site accessibility.

(2) Healthy individuals from donor populations whose genetic structure is not significantly different from New York populations should be chosen for translocation into New York.

(3) A minimum of 30[a] individuals should be released at each site selected for reintroduction. Efforts to release equal numbers of males and females should be made to keep the New York sex ratio constant, unless better information becomes available to suggest that there are more appropriate sex ratios to use. Efforts to release females with broods should be made as they may increase likelihood of success.

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[a] This number was determined based on consultation with researchers in Vermont. The number may be adjusted upward based on donor bird availability and size and habitat conditions at selected release sites. The PVA model suggests that increasing the number of reintroduced birds does not provide a commensurate improvement in the model results. However, inbreeding depression was not incorporated into the model, so researchers should aim for releasing $\geq$30 individuals into each of two populations.

(4) Individuals chosen for a release should be fully screened for avian diseases and parasites. It will be necessary to quarantine individuals in a location where an accidental release will not compromise the existing population for at least 30 days. This is similar to methods of Vermont's reintroduction study (C. Alexander, pers. comm.).

(5) Released individuals should be fitted with radio transmitters and periodically tracked to determine the time to establishment, movements before and after establishment, survivorship and productivity. This information will be necessary to evaluate success of recovery efforts, and will serve to inform management by reintroduction.

(6) Individuals from a reference subpopulation selected *a priori* should be radio tracked for comparisons to reintroduced individuals. Telemetry data exist for multiple subpopulations and multiple years that may be used for comparisons if radio telemetry at reference subpopulations is not feasible, or researchers are not successful in achieving adequate sample sizes.

(7) Sites with artificially augmented populations and sites with reference subpopulations should be surveyed each year to compare spruce grouse density and observations per unit time. All new individuals should be individually marked with bands and radio transmitters.

Ongoing Work: In 2008, Vermont began a reintroduction program for spruce grouse collected in Maine and Quebec. Discussions with Cedric Alexander (Vermont Fish and Game Department) have taken place and will be necessary in the future to help determine reintroduction methods, including minimum quarantine time of individuals and diseases for which to be tested, whether and how long to house individuals in a release area before reintroduction, and which individuals to collect (e.g., family groups best). Vermont's efforts did include genetics analyses, but results were not known before spruce grouse individuals were reintroduced because biologists determined that there was little chance of individual interchange between the reintroduced and native populations. A reintroduction program should be begun in New York in subpopulations where interchange of individuals is possible only after genetics analyses or fate studies indicate that it will not harm the native spruce grouse population.

ACTION 7. Conduct population surveys of all known, historical and potential spruce grouse habitat at periodic (3 year) intervals using established protocols.

Rationale: The spruce grouse is declining throughout its range in New York. In 2010, approximately 15 sites were known to be occupied in the state (Figure 5). Maintaining current knowledge of which sites remain occupied will allow NYSDEC to elucidate any changes in the species' status and will help inform NYSDEC management.

Surveys should be conducted periodically within all three conservation areas at representative sites, with priority given to the Spruce Grouse Conservation Focus Area, followed by Satellite Conservation Area 1, and finally, Satellite Conservation Focus Area 2 (Figures 8-11). Periodic surveys of sites in Satellite Conservation Area 1 should be conducted in appropriate habitat at three-year intervals. In addition, any potential habitat should also be surveyed to document novel subpopulations established by immigrating individuals.

Objectives:

(1) Determine site occupancy of the 32 sites that were occupied during the 1976-1977 and 1985-1987 studies (Fritz 1977 and Bouta 1991, respectively) (Figure 4).

(2) Determine the site occupancy of historical sites that were occupied prior to 1974 (Bull 1974) (Figures 3, 7).

(3) Determine site occupancy of areas with lowland boreal habitat that are within the Spruce Grouse Conservation Focus Area (Figures 8, 9). Priority sites to be surveyed include, but are not limited to, occupied and extirpated sites from 1976-2006 (Fritz 1977, Bouta 1991, Ross and Johnson 2008) and APA Megawetlands.

(4) Maintain a Geographic Information System database to store and analyze results of these surveys in conjunction with the New York Natural Heritage Program.

Approach:

Population Detection & Survey Protocols

At least three surveys of each site should be conducted during the responsive period of spruce grouse each survey year: two in the early season (1 April through 31 May) and at least one in the late season (21 June through 31 August). Standard survey protocol consists of survey teams of 3-4 observers broadcasting aggressive female playback recordings in the early season, when resident males respond by “flutter flight” displays (MacDonald 1968, Fritz 1977), and distressed chick playback recordings in the late season to elicit a response by females (Bouta 1991, Johnson and Ross 2003). Survey teams typically consist of three people walking parallel at a distance of about 15-25 m from one another with the center person an additional 25 m ahead broadcasting the recording. Observers should periodically stop and listen without broadcasting to detect wing flutter of distant birds. Crews of four may be used by walking in the same fashion as three-person crews with the fourth person walking approximately 20-30 m behind the leading surveyor.

It is important to target all potential spruce grouse habitat during both early and late season surveys as male and female spruce grouse use slightly different areas for displays and brood rearing (Bouta 1991). Male display habitat is characterized by stands of spruce and tamarack with sparse cover on the ground and greater visibility, whereas female brood habitat has thicker ericaceous shrubs and denser trees and saplings (Bouta 1991).

The numbers and locations of birds or presence of sign (e.g. scats and feathers) at each site should be recorded using a Wide-Angle Augmentation System (WAAS)-corrected Global Positioning System receiver with approximately 5 meter accuracy. Special attention should be given to dusting areas, as they may contain scats or feathers. Both feathers and scats should be collected to decrease the probability of confusing them with new sign during subsequent surveys.

Population Estimation

An index of population density for each surveyed site can be determined as the number of birds observed per unit time. This index can be used to compare sites and detect population trends within sites between years.

Population size may be inferred by applying a correction factor to the number of birds that respond to vocalizations (2002-2006 studies found a 100% detection probability of two year old males [Ross and Johnson 2008]): the total number of birds of the same sex (whichever is higher) observed by responses to female vocalizations or chick vocalizations (whichever is higher) multiplied by the inverse of the correction factor and then by two. For example, if 50% (or 0.50) of birds are found to respond to recordings and observers have recorded five adult males and two adult females, the estimated population size would be 5 (males) x (1 / 0.50) x 2 (for both sexes) or 20 spruce grouse. Each round of surveys should recalibrate detection probability. Where sign is found and no individuals are observed, a reasonable estimate of population size is two individuals (i.e., one male and one female) (Bouta 1991). In cases where the number of males and females observed are not equivalent, the population size may be estimated by applying a 1:1 sex ratio, as sex ratios seldom deviate from 1:1 (Lumsden and Weeden 1963, Zwickel and Bringham 1970, Johnsgard 1973, Ellison 1974, Robinson 1980). A local population or site should not be considered extirpated until no evidence of sign has been observed for at least three consecutive surveys. Occupancy modeling should be used to corroborate this criterion. Sites with no evidence of sign that contain habitat should be surveyed at least three times, twice during the early season and once during the late season. See Ross and Johnson (2008) for capture and marking methodology.

ACTION 8. Secure long-term protection and management flexibility for spruce grouse populations by establishment of conservation easements.

Rationale: Land purchases can be an effective method of ensuring habitat protection for endangered species. However, land acquisition within the Adirondack Park is a special case because once a parcel is purchased by New York State, it is protected as Forest Preserve and thereafter restricted in perpetuity from habitat management. Evidence suggests that the spruce grouse is a mid-successional species and tends to be absent from older-aged stands (Bouta 1991, Ross and Johnson 2008). Without intervention, successional changes occurring in forest stands on most parcels with extant spruce grouse subpopulations will likely lead to the species' extirpation in that parcel unless an extremely rare disturbance occurs that sets back succession to an earlier stage. Since fires are suppressed in New York State and other types of disturbances have become increasingly unlikely to occur in these small and isolated patches of habitat, active habitat management will be an important tool to promote spruce grouse subpopulation persistence. Recognizing that spruce grouse recovery requires active habitat management, conservation easements will be an appropriate means of spruce grouse habitat protection. Establishing conservation easements and other forms of private landowner agreements is becoming increasingly common and is recognized as a significant conservation tool (Jenkins 2008).

Historically, some lowland boreal habitat along creeks and rivers that were dammed for logging supported spruce grouse populations. In areas where there is the potential to restore such formerly suitable habitat, easements or other landowner agreements should be pursued to allow for the flexibility of land managers to restore the natural processes that maintained suitable lowland boreal habitats. Many of these areas are important in providing habitat connectivity across the landscape for dispersing spruce grouse and other boreal forest associated species.

Approach:

Secure conservation easements and landowner agreements from willing landowners designed to protect the spruce grouse and its habitat in areas where there are extant or historical spruce grouse populations. Easement language should include the possibility or requirement of either the NYSDEC or the landowner in cooperation with the NYSDEC to manage for spruce grouse in areas within the newly created database of easement acquisition from Action 11 below.

Easement acquisition should concentrate on parcels within 8.6 km (i.e., the maximum dispersal range) of the boundary of any extant subpopulation or within the area designated as the Spruce Grouse Conservation Focus Area (Figures 8 and 9). The Spruce Grouse Conservation Focus Area encompasses the highest priority sites for easement acquisition because it includes area into which the spruce grouse may readily disperse to from sites with extant populations. If necessary and agreeable to the land owner, easements already present within this area should be updated to include new provisions encouraging spruce grouse conservation. Additional easements should be established within 8.6 km of both historically occupied sites and sites with high potential to support spruce grouse (see Action 7). Finally, a system should be established to incorporate both newly-discovered occupied and potential sites into this action step. See Appendix 4 for a list of sites, ownership and dates of last spruce grouse observation.

ACTION 9: Manage and maintain spruce grouse habitat at extant subpopulations, restore habitats at sites with extirpated subpopulations or other sites identified as suitable, and increase site connectivity to ensure continued spruce grouse persistence.

Rationale: Securing and enhancing spruce grouse populations in New York may be possible if habitat can be conserved and expanded to provide corridors for dispersal to facilitate interchange between isolated subpopulations. Increasing habitat connectivity by creating or enhancing corridors for dispersal and movement may also help mitigate the effects of a changing global climate.

Recent evidence suggests that spruce grouse populations are limited by habitat and dispersal (Fritz 1977, Ross and Johnson 2008). In 2006, there were 15 known occupied subpopulations centered around Tupper Lake, New York (Ross and Johnson 2008). Individuals move between sites through small patches of deciduous forest and across streams and roads. The largest linear movement on record in New York is 8.6 km, which was made by a female spruce grouse in the 1970s (Fritz 1977). This distance is considered the maximum dispersal distance that can generally be expected by a spruce grouse in New York. Therefore, management efforts should focus on increasing both the amount of available habitat and increasing habitat connectivity within areas no farther than 8.6 km from an extant spruce grouse site (e.g. the area designated as the Spruce Grouse Conservation Focus Area) (Figure 9). According to population viability analyses, the goal should be to conduct habitat management within at least two sites that results in a 13% increase in annual survivorship. Since we are not sure exactly which management techniques are necessary to aid in such an increase in survivorship, we recommend attempting to experimentally manipulate habitat in 3-5 sites and monitor results of habitat manipulations begun in 2008 at an additional site (A. Ross and G. Johnson unpublished data). Effective management should be achieved and additional restored subpopulations should be considered extant by 2025.

Although little is currently known about the effects of habitat manipulation on spruce grouse, some timber management techniques have been known to create habitat that spruce grouse will occupy. For example, timber harvesting was conducted in Maine in the early 1980s in hardwood stands ranging from 2 – 40 acres in size where spruce grouse were not previously known to occur. These stands were treated with herbicide before being clearcut and allowed to regrow to spruce-fir, later to be pre-commercially thinned. Spruce grouse moved into these areas and have been reported to occur at relatively high densities in recent times (F. Servello pers. comm.).

However, since no published studies have been specifically designed to create spruce grouse habitat anywhere in the North America, it is important that habitat be created or enhanced as an experiment, with intensive monitoring until knowledge of the best methods to create or enhance habitat are established. Surveys of preexisting vegetative structure and composition and spruce grouse use should be conducted prior to management in all treatment areas to develop a baseline for comparison with future surveys.

Objectives:

(1) Enhance and create new spruce grouse experimental habitat management in at least two sites with extirpated subpopulations and within APA Megawetlands within the Spruce Grouse Conservation Focus Area (Figure 9). Fully characterize habitat conditions before conducting habitat management.

(2) After initial habitat management is begun, focus on increasing habitat connectivity between extant and extirpated sites and between these sites and APA Megawetlands, where it is possible to increase population resiliency to cope with climate change. Initial efforts should focus on restoring and enhancing connectivity between the Spruce Grouse Conservation Focus Area and Satellite Conservation Area 1.

(3) Maintain spruce grouse habitat in extant subpopulations within the Spruce Grouse Conservation Focus Area (Figure 9). It may be necessary to experimentally manage habitat and monitor results in occupied sites to help determine effective management strategies.

(4) By 2025, if monitoring results indicate that spruce grouse populations are still declining after completion of initial habitat manipulations aimed at benefitting the population, it may be necessary to expand habitat management into areas outside the Spruce Grouse Conservation Focus Area, such as within Satellite Conservation Areas 1 and 2 (Figures 8, 10, 11). An additional PVA modeling exercise may be necessary to determine the likelihood of successful management in these areas.

Approach:

(1) Secure landowner buy-in and support on parcels with potential management sites.

(2) Use scientifically-tested methods to manage habitat within spruce grouse sites and APA Megawetlands and monitor before and after.

(3) Manage habitat initially in at least two (preferably 3 – 5) extirpated sites within the Spruce Grouse Conservation Focus Area before 2020 (Figure 8). Management of APA Megawetlands may also be considered, but need to be supported by a PVA.

(4) Develop and establish a rapid habitat quality assessment protocol to guide possible management at sites in the future. This information should be combined with periodic monitoring surveys.

(5) Manage habitat at additional sites where deemed necessary based on periodic monitoring and rapid habitat assessments. Include habitat management at APA Megawetlands where beneficial and necessary.

(6) Expand habitat management into areas outside of the Spruce Grouse Conservation Focus Area if necessary (Figure 8). Focus habitat management on corridors between the Spruce Grouse Conservation Focus Area and Satellite Conservation Area 1 (Figures 8-10).

(7) Maintain an understanding of efficacy of habitat management methods via monitoring and adjust methods when and where necessary.

ACTION 10. Develop and implement an effective outreach and education program about spruce grouse in the Adirondack Region.

Rationale: Effective outreach and education can have multiple positive impacts on a successful recovery program. Raising awareness about this species within New York State among various stakeholders, landowners and members of the general public can lead to increased support, including lobbying legislators and providing conservation dollars for research, monitoring and protection. For example, due to its rarity, people are willing to travel long distances and expend a great deal of energy to potentially see a spruce grouse in New York; seeing one is easily among the most sought-after experiences by birders within New York State.

Effective outreach and education can have positive effects on both the species and consumptive resource users. Of notable concern is the occasional accidental take of a spruce grouse by a firearm. If a take occurs within the species' core distribution, where subpopulations are likely to be sources for nearby satellite subpopulations, it may have dramatic negative effects on the population. In addition, accidental take may also have dramatic negative effects on the resource user, who did not intend to take an endangered species. Spruce grouse are still reportedly shot today by licensed hunters. Educating these stakeholders on spruce grouse identification and habitat may be the only means of decreasing these incidences.

In addition, various landowners own property that harbor spruce grouse subpopulations and may want to enhance habitat for the species. Providing scientific assistance and advice to landowners is necessary to ensure that the species will be managed for in a scientifically sound manner, and that monitoring before and after management will occur to ensure that effects of management are fully documented and understood.

Objectives:

(1) Inform landowners who own land with or within close proximity of spruce grouse populations about the presence or potential presence of the spruce grouse, and the value of having the species on their land.

(2) Improve landowner and NYSDEC cooperation in managing habitat for spruce grouse by meeting with landowners and discussing management options.

(3) Provide technical assistance to landowners who wish to manage for spruce grouse. Begin a monitoring program on these lands before and after experimental management.

(4) If managing for spruce grouse is not of interest to the landowner, increase landowners' knowledge about how to work with NYSDEC to manage their land in a way that benefits the landowner without harming the spruce grouse.

(5) Increase public knowledge of the presence of spruce grouse populations on public hunting lands.

Approach:

Record ownership of all parcels of private land that contain extant spruce grouse subpopulations or habitat thereof into a database with landowner contact information. Send information pamphlets or letters to these landowners that inform them that they have an endangered species on their land. Include information on (1) the benefits of engaging in open discussions with NYSDEC before performing activities that may negatively affect spruce grouse or their habitat and (2) how to cooperate with NYSDEC on any habitat manipulations that may affect spruce grouse, such as, but not limited to road widening and timber harvesting. See Figures 8-11 for Spruce Grouse Conservation Areas and sites with ownership overlays.

Update or add signage showing the difference between spruce grouse and ruffed grouse at parcels that contain extant or historical spruce grouse subpopulations. Older signs do not have the updated status of the species as Endangered. New signs should be placed at roads that lead into habitat and along roads where there is habitat, especially where hunting is legal.

Action Steps:

1. Identify target audiences for expanding education and outreach (e.g.sportsman's shows; New York State Fair; County Fair, Adirondack schools; ORV groups; large landowners; sportsman clubs; Visitor's Interpretive Centers, The Wild Center, and other relevant museums or places designed to deliver outreach).

2. NYSDEC and educators at SUNY College of Environmental Science and Forestry have already produced a series of fact sheets, information brochures, slide shows and a video designed to increase awareness of the spruce grouse. These factsheets and information brochures need to be updated and distributed.

3. Continue to present information to various segments of the Adirondack community about the natural history, conservation and value of spruce grouse in the Adirondack Park, using such venues as the Adirondack Interpretive/Ecological Centers, The Wild Center in Tupper Lake, The Adirondack Birding Festival, The Northern New York

Audubon chapter, various Nature Centers, etc. Add venues such as Conservation Field Days, Trapper's Associations and Sportsman's Federation Meetings.

4. Develop a spruce grouse management workshop for NYSDEC biologists and foresters, forest land managers, independent foresters, large landowners and other stakeholders. A habitat management guide should be produced and provided to these stakeholders at or in lieu of these meetings.

ACTION 11. Protect known extant populations and their habitat using existing regulations and continued administrative support.

Rationale: Current regulations are in place in New York that prohibit the take of endangered species and their habitat. In addition, New York State wetland laws (Articles 15 and 24 Freshwater Wetlands Act) and strict Adirondack Park Agency (APA) regulations provide legal protection for most stream and wetland habitats. A considerable amount of spruce grouse protection can be achieved by using these existing regulations. However, improved information exchange is necessary between stakeholders (i.e., NYSDEC, private landowners, lease holders and the public) that will allow these regulations to be greater understood and thus more effective.

Approach:

(1) Protect Populations: Update existing signage showing the difference between spruce grouse and ruffed grouse and add signs to parcels that contain extant or historical spruce grouse populations. Signs have been created by a partnership of NYSDEC and SUNY College of Environmental Science and Forestry. However, the do not have the updated status of the species as endangered and the phone number is not current. New signs should be placed at roads that lead into habitat and along roads where there is habitat, especially where hunting is legal. Sign information should also include directions on what to do if a spruce grouse is accidentally shot or otherwise taken. Such carcasses can be useful for conservation as DNA can be collected for analysis and location data can be entered in a database.

(2) Protect Habitat: Current regulations exist that prohibit the take of an endangered species and its habitat. Similar to Action Item 10, add ownership of all parcels of private land that contain extant spruce grouse populations and their habitat into a database with landowner contact information. Send information pamphlets or letters to these landowners that inform them that they have an endangered species on their land. Include information on (1) the benefits of engaging in open discussions with NYSDEC when conducting activities that may negatively affect spruce grouse or their habitat and (2) how to cooperate with NYSDEC on any habitat manipulations that may affect spruce grouse, such as, but not limited to road widening and timber harvesting. See Figures 8-11 for Spruce Grouse Conservation Areas and sites with ownership overlays.

(3) By adopting this recovery plan, New York has identified three areas: the Spruce Grouse Conservation Focus Area and two Spruce Grouse Satellite Conservation Areas that will facilitate and help prioritize conservation efforts (Figure 8-11). These Conservation Areas are based upon the history and current fate of all known spruce grouse subpopulations in New York State. The Spruce Grouse Conservation Focus Area contains all known current spruce grouse populations and has been identified in this plan as the highest priority area for management (Figure 9).

(4) Create a mechanism to adequately screen development projects and permits that may affect spruce grouse and their habitat. Ensure that the New York State Natural Heritage Program Database contains the Spruce Grouse Conservation Focus Area and Satellite Conservation Area maps and that "hits" are adequately screened early in the planning process. In addition, delineate spruce grouse habitat outside of historical and known sites within these Conservation Areas. Train NYSDEC and APA administrators and staff at the state and regional levels to recognize spruce grouse habitat on the ground. Keep regulators informed about threats to the species and its habitat.

(5) Maintain a database with current contact information of the Spruce Grouse Recovery Team and establish a regular (annual) meeting of this team to discuss the Recovery Plan action status.

ACTION 12. Continue to apply those practices which have contributed to the spruce grouse's recovery and monitor results into the future.

CONSEQUENCES OF NO ACTION

Population viability analysis (PVA) modeling (A. Ross, unpublished data) indicates that lack of action will lead to the species extirpation in New York State, since forests in areas occupied by spruce grouse are aging to the point where they may no longer provide the species' necessary requirements for the species. The PVA indicated that the probability of extinction was 84.8% over the next 100 years and the average time to first extinction was 23.06 years (SE = 0.93 years) using Adirondack population data (A. Ross, unpublished data) (Table 4). A random disturbance (blowdown, fire, etc.) that sets back succession in a spruce grouse site is so rare that it would not be feasible to rely on such a disturbance to maintain or create habitat in the Adirondacks to the degree necessary for spruce grouse restoration. Therefore, the "no action alternative" should not be followed. However, it may be the best course of action in specific sites at specific times when there are exemplary habitat and spruce grouse populations present. If it is found that conditions have changed and these once exemplary sites are no longer suitable, management should be undertaken to improve habitat conditions. As with any habitat management. Monitoring populations and habitat before and after manipulations should be conducted to properly gauge management success.

Coda

The spruce grouse is clearly a peripheral species at the southern edge of its range in New York State and populations here are more likely to be imperiled than those more centrally located. Allocation of conservation resources toward such peripheral populations, especially those that are locally rare but globally common, may be subject to debate. However, these populations may be important both ecologically and socio-politically within a regional context. They may possess characteristics, at the genetic level, that make them valuable for conservation within the species' broader range (Hunter and Hutchinson 1994, Lesica and Allendorf 1995). Species at the southern periphery of their range may be critically important in understanding adaptation to climate change, and the preservation of genetic diversity found at the periphery may be critical to a species' ability to cope with these changes. Conservation of a peripheral species, such as spruce grouse in New York, may provide additional values within the region by focusing conservation efforts and by serving as an umbrella for the protection of, in this case, all lowland boreal inhabitants.

In these times of increasing need for conservation efforts directed towards myriad threatened species and degraded ecosystems all competing for shrinking conservation dollars, it is clear that priorities need to be set to maximize such efforts to meet conservation goals. It is the opinion of the principal authors of this plan and the Department that all of the proposed action steps must be taken to accomplish the short-term goal of stabilizing the current population and the long-term goal of removing the spruce grouse from the New York State Endangered Species List.

IMPLEMENTATION OF RECOVERY ACTIONS

Action 1. Refine a population viability analysis for the spruce grouse metapopulation within New York using several management scenarios.

Researchers with the New York State Department of Environmental Conservation should complete this action with SUNY Potsdam, both entities partnering on spruce grouse management and research. Partners have collected and analyzed data to be used in PVA models.

Action 2. Mathematically model the potential success of spruce grouse reintroductions in New York based on efforts by Vermont. Determine the sites in New York with the highest probability of successful reintroductions.

Researchers with the New York State Department of Environmental Conservation has been working with partners from Vermont Fish and Wildlife to determine efficacy of releases in New York State. Analyzing results of releases using ArcGIS data will be necessary to facilitate comparisons between New York and Vermont.

Action 3. Determine the genetic variability and differentiation of spruce grouse within New York populations, between New York and nearest neighboring populations and across the species' range.

Researchers with the New York State Department of Environmental Conservation and the New York State Museum are currently working on these genetics analyses. Collection of DNA samples from Vermont, Maine, New Hampshire and Quebec will be necessary to complete these analysis. Currently, there are samples from New York State and Algonquin Park, Ontario.

Action 4. Determine the effects of experimental spruce grouse habitat management.

Researchers with the New York State Department of Environmental Conservation and SUNY Potsdam have planned and monitored experimental habitat management in New York with a private landowner in the Spruce Grouse Conservation Focus Area. Researchers have been monitoring these management areas since 2008 and will continue to monitor these areas into the future. More experimental habitat management is necessary on new lands to provide more replicates, or to provide different treatment types (shapes or sizes). The Nature Conservancy and other private landowners such as paper companies located in the Spruce Grouse Conservation Focus Area may provide good opportunities for additional experimental habitat management. Agreements with these landowners and management plans should be pursued.

Action 5. Evaluate habitat management actions taking place in spruce grouse habitats outside of New York to gain insight on effects of such management and its applicability to New York habitats.

This action could be completed by either the New York State Department of Environmental Conservation or with various partners to be determined. Researchers at the University of Maine have begun this work.

Action 6. Reintroduce spruce grouse into at least two areas from which they have become extirpated and monitor their fate, once formerly limiting factors have been identified and understood.

This work should be conducted by the New York State Department of Environmental Conservation in partnership with private landowners. The Nature Conservancy and the Shingle Shanty Preserve and Research Station are potential partners.

Action 7. Conduct population surveys of all known and historical subpopulations and potential spruce grouse habitat at periodic (3 year) intervals using established protocols.

The New York State Department of Environmental Conservation is the logical entity to conduct this type of long term monitoring in New York. In addition, Memoranda of Understanding with state agencies or state assistance contracts with local universities may also be used to complete work on this action.

Action 8. Secure long-term protection and management flexibility for spruce grouse populations via conservation easements.

The New York State Department of Environmental Conservation will need to coordinate with private landowners to draw up easement language to ensure that activities on new easements support spruce grouse conservation and habitat management. Moreover, updating older easements to ensure that silvicultural or other land management practices are compatible with spruce grouse conservation.

Action 9. Manage and maintain spruce grouse habitat at extant subpopulations, restore habitats at sites with extirpated subpopulations or other sites identified as suitable, and increase site connectivity to ensure continued spruce grouse persistence.

The New York State Department of Environmental Conservation is the logical entity to run a region wide management and conservation program for spruce grouse. State biologists will need to maintain knowledge of spruce grouse status and determine where local threats may warrant increased conservation action.

Action 10. Develop and implement an effective outreach and education program about spruce grouse in the Adirondack Region.

Providing technical advice to landowners is the responsibility of the New York State Department of Environmental Conservation. An effective outreach program can be developed by the New York State Department of Environmental Conservation and partners such as SUNY or other local universities. Other partners may include The Nature Conservancy.

Action 11. Protect known extant subpopulations and their habitat using existing regulations and continued administrative support.

The New York State Department of Environmental Conservation should update signage that alerts landowners that spruce grouse may be encountered on private lands. In addition, creating and maintaining a database of landowners' contact information will be the responsibility of the New York State Department of Environmental Conservation. Creating a regulatory project screening tool will also be under the purview of the New York State Department of Environmental Conservation.

TIMELINE FOR RECOVERY ACTION IMPLEMENTATION

Refine a population viability analysis for individual spruce grouse subpopulations and for a metapopulation within New York using several management scenarios.
Begin now and finish by early 2013. This has largely been completed, but may need refinement.

Mathematically model the potential success of spruce grouse reintroductions in New York based on efforts in Vermont. Determine the sites in New York with the highest probability of successful reintroductions using Vermont and New York data and check results with PVA software.
Begin work now and finish by 2013.

Determine the genetic variability and differentiation of spruce grouse within New York populations, between New York and nearest neighboring populations and across the species range.
Begin work now and complete analyses by the end of 2013.

Determine the effects of experimental spruce grouse habitat management.
Begun in 2008 and complete work by the end of 2015.

Evaluate habitat management actions taking place in spruce grouse habitats outside of New York to gain insight on the effects of such management and applicability to New York habitats.
Begin work now and complete by 2015.

Reintroduce spruce grouse into at least two areas from which they have become extirpated once formerly limiting factors have been identified and understood.
After genetics analysis is complete (2013) release birds as soon as practicable. Plan to release birds well before 2020 (while PVA should not be used for absolutes, models suggest that there is a 35% probability that spruce grouse will be extirpated in New York by 2020). Monitor results of releases every year for the first five years (include year-round radio tracking), then monitor populations every other year until year 15. At the end of the 15th year, periodic monitoring may be scaled back to once every three years.

Conduct population surveys of all known and historical subpopulations and potential spruce grouse habitat at periodic (3 year) intervals using established protocols.
Begin work during the summer of 2011. Plans were to survey sites in 2010, but habitat work took precedence and only 10 of 60 or so sites were surveyed (A. Ross, unpublished data).

Secure long-term protection for spruce grouse populations via conservation easements.
Ongoing. No deadline.

Manage and maintain spruce grouse habitat at extant subpopulations and restore habitats at sites with extirpated subpopulations or other sites identified as suitable. Increase site connectivity to ensure continued spruce grouse population persistence.
Complete management at a minimum of two sites before 2020. Maintain and restore habitats as needed based on results of periodic surveys and habitat monitoring. Monitor results of all management at periodic intervals.

Develop and implement an effective outreach and education program about spruce grouse in the Adirondack Region.
Begin now and complete by 2015.

Protect known extant subpopulations and their habitat using existing regulations and continued administrative support.
This is being done presently and should continue indefinitely.

Evaluate delisting in 2035 based on results of monitoring and new population viability analysis.

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TABLES

Table 1. Spruce grouse breeding population densities (grouse/100 ha) for New York and other areas of the species' range.

Locality	Habitat	Density Range	Source
Alaska	Pre- and post-fire Kenai Peninsula	40.0 - 97.0	Ellison 1975
Alaska	Kenai Peninsula	7.7 - 11.6	Ellison 1974
Alaska	Prince of Wales Island (spruce-fir)	2.5 - 2.5	Russell 1999
Alberta	Lodgepole pine	4.6 - 8.9	McCourt 1969, McLachlin 1970
Alberta	Lodgepole pine	10.5 - 19.3	Boag et al. 1979
Alberta	Lodgepole pine	4.9 - 29.1	Boag and Schroeder 1987
Maine	Black spruce-tamarack	11.5 - 14.0	Whitcomb et al. 1996
Michigan	Jack pine	4.9 - 9.0	Robinson 1980
Montana	Lodgepole pine	3.1 - 3.1	Stoneberg 1967
New Brunswick	Spruce-fir	9.8 - 21.9	Keppie 1987a
New York	Spruce-tamarack	3.5 - 8.8	Fritz 1979
New York	Spruce-tamarack	8.6 - 8.6	Fritz 1985
New York	Spruce-tamarack	1.0 - 9.6	Bouta and Chambers 1990
New York	Spruce-tamarack	1.1 - 1.6	Ross and Johnson (unpublished data)
Ontario	Black spruce	2.0 - 30.0	Szuba and Bendell 1983
Ontario	Jack pine 10-25 years old	40.0 - 80.0	Keppie 1995
Ontario	Jack Pine 11-32 years old	12.0 - 80.0	Szuba and Bendell 1983
Quebec	Black spruce-jack pine uncut patches	5.0 - 5.0*	Turcotte et al. 2000
Quebec	Black spruce residual forest strips	3.3 - 15.0*	Potvin and Courtois 2006
Vermont	Spruce-fir	15.0 - 15.0	Pence et al. 1990
Yukon	White spruce	5.0 - 30.0	Boutin et al. 1995

* Density of only males

Table 2. Estimates of habitat parameters for spruce grouse contrasted by whether site supported a population that was persistent, transient or extirpated in the Adirondack Park, New York, USA from 2002-2006. Asterisks indicate significant *P* - values after Bonferroni adjustment.

variable	Mean (lower SE - upper SE)			*F*	*P*
	persistent (*n* = 98)	transient (*n* = 49)	Extirpated (*n* = 100)		
trees and saplings[a]					
tree dbh (cm)	15.08 (14.87-15.30)	15.28 (15.06-15.50)	16.04 (15.85-16.23)	3.22	0.042
tree Height (m)	12.19 (12.08-12.30)A[b]	13.08 (12.91-13.25)AB	13.22 (13.07-13.36)B	5.38	0.005
tree Age (yrs)	44.61 (44.13-45.11)A	47.80 (47.02-48.60)AB	51.87 (51.14-52.61)B	7.32	<0.001
tree Density (stems/ha)	1242.65 (1198.83-1288.07)	1342.19 (1280.24-1407.15)	1101.90 (1061.15-1144.23)	0.33	0.717
sapling dbh	6.20 (6.14-6.26)	6.74 (6.66-6.81)	6.30 (6.23-6.37)	2.38	0.096
sapling Height	5.67 (5.59-5.75)	6.93 (6.80-7.06)	5.91 (5.81-6.01)	4.6	0.011
sapling Density	1617.56 (1540.65-1698.31)A	875.53 (799.00-959.39)B	1192.20 (1129.74-1258.11)AB	5.35	0.006
cover in the following strata %				chi-sq[c]	
percent canopy	67.15 (66.18-68.10)	69.08 (67.70-70.43)	70.17 (69.10-71.22)	1.05	0.59
0 – 0.2 m	71.69 (69.88-73.45)	72.34 (69.69-74.88)	76.92 (74.90-78.86)	0.44	0.803
0.2 – 1.0 m	56.70 (54.65-58.72)	41.95 (39.02-44.84)	39.88 (37.77-41.97)	12.79	0.002*
1.0 – 2.0 m	27.98 (26.52-29.42)	9.23 (8.04-10.41)	19.77 (18.56-20.98)	20.39	<0.001*
2.0 – 4.0 m	35.61 (33.88-37.33)	16.32 (14.38-18.26)	27.51 (25.90-29.12)	16.3	<0.001*
4.0 – 6.0 m	39.71 (38.27-41.16)	26.25 (24.56-27.92)	29.00 (27.46-30.53)	11.95	0.003
above 6.0 m	56.68 (54.82-58.51)	59.16 (56.31-61.94)	64.36 (62.39-66.30)	1.28	0.527
ground cover %					
conifers	0.58 (0.49-0.67)	0.33 (0.27-0.39)	3.04 (2.76-3.32)	13.46	0.001*
ericaceae	0.97 (0.83-1.11)	1.80 (1.47-2.13)	1.45 (1.26-1.65)	0.21	0.898
blueberry	2.51 (2.23-2.79)	3.71 (3.28-4.13)	1.43 (1.26-1.60)	8.51	0.014
sedges	2.14 (1.68-2.60)	4.28 (3.38-5.17)	6.09 (5.47-6.70)	21.99	<0.001*
Sphagnum spp.	23.39 (21.60-25.18)	29.66 (26.82-32.47)	51.30 (49.57-53.02)	29.48	<0.001*
other Moss	29.26 (27.53-30.99)	33.88 (31.34-36.39)	19.38 (17.84-20.92)	13.11	0.001*
litter	40.37 (38.76-41.96)	29.41 (27.19-31.63)	17.75 (16.41-19.10)	35.04	<0.001*
herb cover %					
conifers	1.27 (1.02-1.51)	1.96 (1.64-2.29)	3.01 (2.67-3.33)	8.14	0.017
ericaceae	7.13 (6.49-7.78)	7.70 (6.79-8.61)	3.90 (3.42-4.38)	8.7	0.013
blueberry	7.85 (7.23-8.49)	9.69 (8.83-10.55)	4.04 (3.59-4.50)	21.18	<0.001*
sedges	4.09 (3.41-4.78)	5.49 (4.05-6.92)	3.39 (2.72-4.05)	1.21	0.546
deciduous species	1.68 (1.47-1.89)	0.31 (0.25-0.37)	2.52 (2.22-2.82)	8.05	0.0218
shrub cover %					
conifers	28.02 (26.79-29.24)	17.28 (16.08-18.48)	20.73 (19.70-21.75)	9.65	0.008
ericaceae	0.11 (0.11-0.12)	0.12 (0.11-0.13)	0.06 (0.05-0.06)	23.4	<0.001*
deciduous Species	10.04 (9.36-10.72)	9.23 (8.28-10.17)	11.75 (10.87-12.63)	0.373	0.83
blueberry	0.06 (0.06-0.07)	0.08 (0.07-0.09)	0.03 (0.03-0.03)	19.42	<0.001*
balsam Fir	5.21 (4.60-5.83)	4.21 (3.50-4.91)	11.87 (10.95-12.79)	14.7	<0.001*
black Spruce	22.89 (21.59-24.18)	11.24 (10.27-12.21)	7.27 (6.67-7.86)	33.87	<0.001*
ferns	3.48 (3.00-3.97)	1.86 (1.40-2.32)	5.21 (4.62-5.80)	6.51	0.039
sedges	2.46 (1.88-3.04)	1.24 (0.94-1.54)	0.77 (0.05-0.10)	2.23	0.327

[a] tree and sapling means contrasted with ANOVA.
[b] means with the same letter are not significantly different ($P < 0.05$).
[c] percent cover data contrasted with Kruskal-Wallis Test.

Table 3. Area, perimeter and perimeter to area ratio of sites with persistent (P), transient (T), and extirpated (E) populations from 2002-2006. 'Not Present' (NP) denotes sites that were not surveyed during previous studies (Fritz 1977, Bouta 1991) and '?' denotes sites that were previously occupied (Fritz 1977, Bouta 1991), but site status could not be determined with 100% certainty during the 2002-2006 study (Ross and Johnson 2008).

Site	Area (ha)	Perimeter (km)	Perimeter/Area (km/ha)	Site Status
Bear Brook	343.7	7.4	21.6	P
Beaver Lake	259.4	13.4	51.7	?
Black Brook	64.5	4.2	65.8	P
Black Pond Swamp	193.9	7.8	40.1	E
Bloomingdale Bog	276.1	15.3	55.2	T
Bog Lake	263.3	11.5	43.6	E
Bog Stream I	199.8	10.8	54.0	E
Bog Stream II	392.4	13.9	35.5	?
Brandon Road	184.9	13.6	73.6	E
Dead Creek I	394.8	9.6	24.3	?
Dead Creek II	306.7	9.3	30.4	E
Elbow Brook	231.5	11.3	48.9	P
Ferd's Bog*	62.1	4.8	12.9	NP
Grasse River Club	255.2	7.7	30.0	P
Hedgehog Club	237.3	10.9	46.0	P
Indian Rock Club	54.3	3.6	67.0	T
Joe Indian Pond	96.8	6.2	64.1	E
Jordan River	114.4	7.1	61.7	T
Kildare Club Bog*	142.4	9.1	64.3	T
Kildare Pond	158.9	7.5	47.2	E
Kildare Road	101.3	5.2	51.7	P
Lake Lila	670.8	13.8	20.5	E
Long Pond	694.6	19.8	28.6	P
Lows Lake*	96.4	6.5	67.7	NP
Madawaska Pond	254.7	11.1	43.6	E
McDonald Pond	139.4	6.4	46.0	E
Oregon Plains Road*	361.1	8.4	23.3	NP
Potter Pond Outlet	60.9	7.8	127.4	T
Rock Pond	124.9	8.4	67.6	T
Round Lake*	110.1	10.4	94.8	NP
Sevey Bog	201.7	8.5	42.3	E
Shingle Shanty	137.4	10.4	76.0	E
Spring Pond Bog	428.7	13.6	31.7	T
Ton-Da-Lay North	140.0	6.2	44.6	T
Ton-Da-Lay South[a]	38.8	2.9	73.7	NP
Willis Brook Bog	157.6	5.6	35.5	P
Windfall Brook	141.2	9.6	67.8	E
Wolf Pond	290.9	11.5	39.6	?

* Non-historical sites

[a] Surveyed, but spruce grouse habitat not contiguous with that of the Ton-Da-Lay historical site.

Table 4. Population Viability Analysis Framework for Adirondack Spruce Grouse Populations. Input parameters specified for each recovery scenario: control, habitat management, reintroduction, and both habitat management and reintroduction. Input data from Ross and Johnson (2008) and other literature relevant to northeastern spruce grouse populations where available.

Parameter	Control	Reintroduction	Habitat	Both
Inbreeding depression	No	No	No	No
Environmental variation correlation among populations	1	1	1	1
Reproduction correlated with survival	No	No	No	No
Age 1st female reproduction	1	1	1	1
Age 1st male reproduction	1	1	1	1
Maximum age of reproduction	5	5	5	5
Sex ratio at birth	1:1	1:1	1:1	1:1
Maximum brood size	7	7	7	7
% Females with litter/year	90	90	90	90
Female mortality at age 0-1	45 (23)	45 (23)	45 (23) 38.5 (13)[a]	45 (23) 38.5 (13)[a]
Adult female mortality	45 (23)	45 (23)	45 (23) 38.5 (13)[a]	45 (23) 38.5 (13)[a]
Male mortality at age 0-1	45 (23)	45 (23)	45 (23) 38.5 (13)[a]	45 (23) 38.5 (13)[a]
Adult male mortality	45 (23)	45 (23)	45 (23) 38.5 (13)[a]	45 (23) 38.5 (13)[a]
Number of catastrophes (probability)	3 (1)	3 (1)	3 (1)	3 (1)
% Reduction in reproduction (catastrophe)	0	0	0	0
% Reduction in survival (catastrophe)	25	25	25	25
% of Adult males breeding	100	100	100	100
Starting population size (populations)	15	17	15	17
Carrying capacity (SD)	30 ($\pm$5)/km^2	30 ($\pm$5)/km^2	30 ($\pm$5)/km^2	30 ($\pm$5)/km^2
% Change in K per year	0	0	0	0
Probability of Extinction	**84.8**	**83.6**	**5.6**	**0.4**[b]

[a] Mortality estimate at two sites undergoing habitat management.
[b] This scenario is the only acceptable scenario consistent with our management goals of 95% probability of maintaining an extant spruce grouse population in New York throughout the next 100 years.

FIGURES

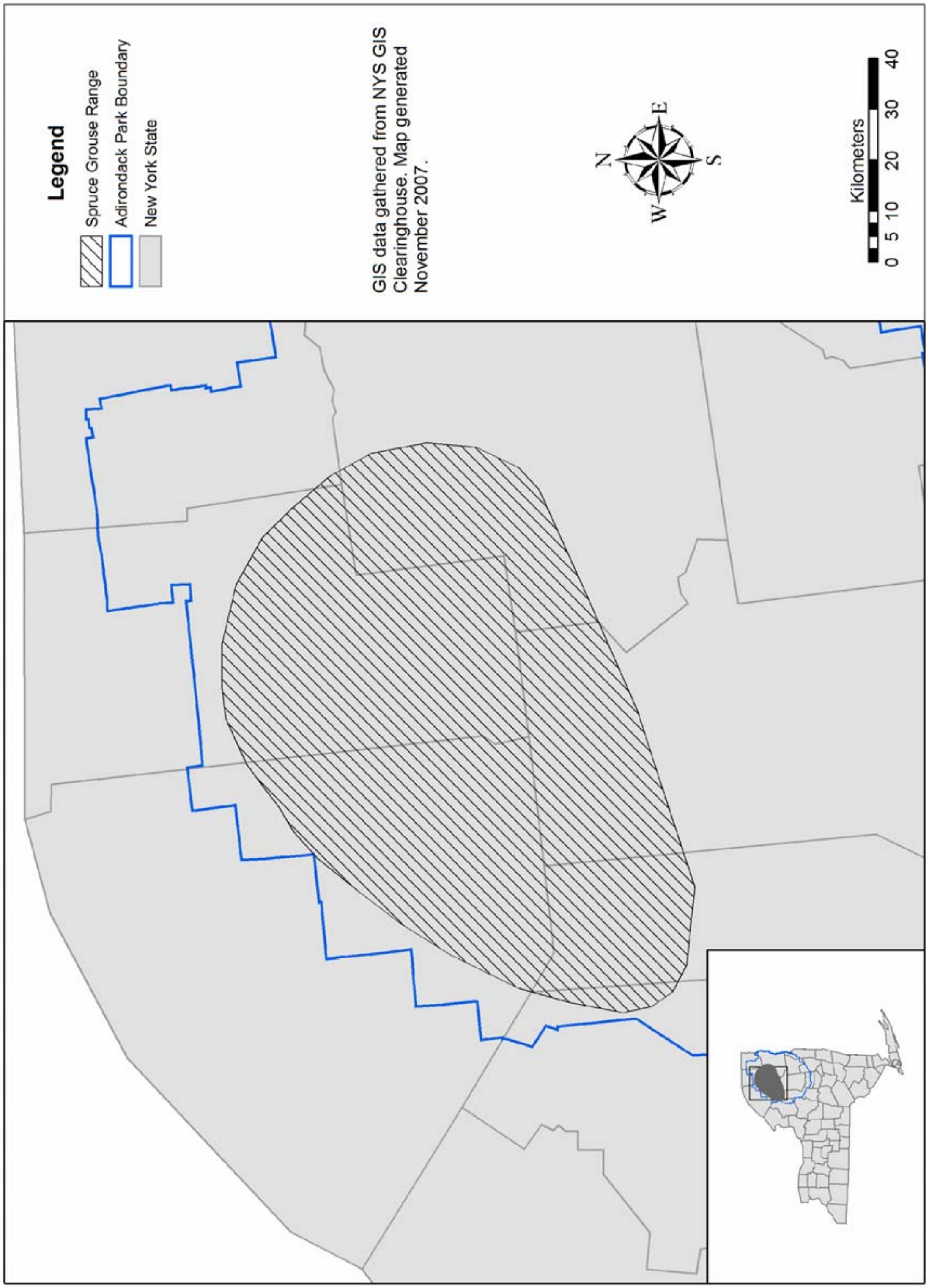

Figure 1. The spruce grouse (*Falcipennis canadensis*) range in New York State (modified from Bouta 1991). Spruce grouse are found in disjunct populations in their New York range. Gray lines are county boundaries.

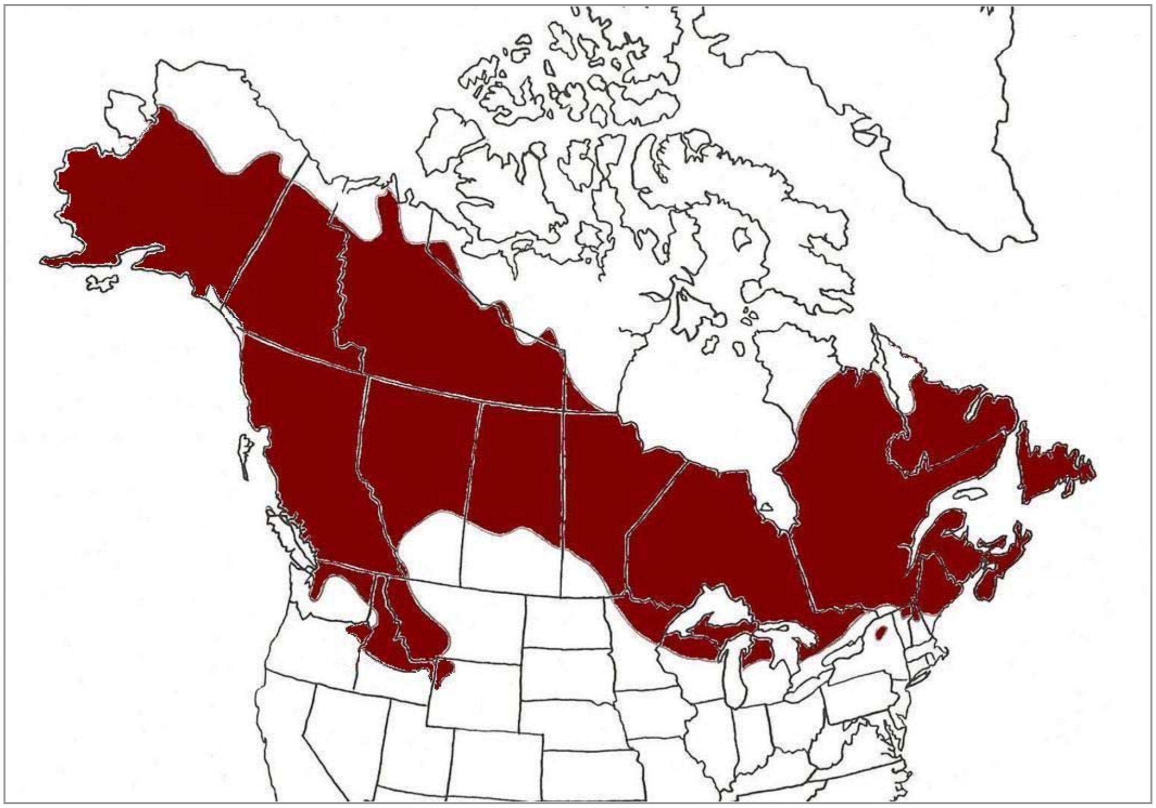

Figure 2. Spruce grouse (*Falcipennis canadensis*) distribution in North America (modified from Johnsgard 1973). Note the isolated nature of New York State populations. Not shown is isolated population in Mt. Desert Island, Maine.

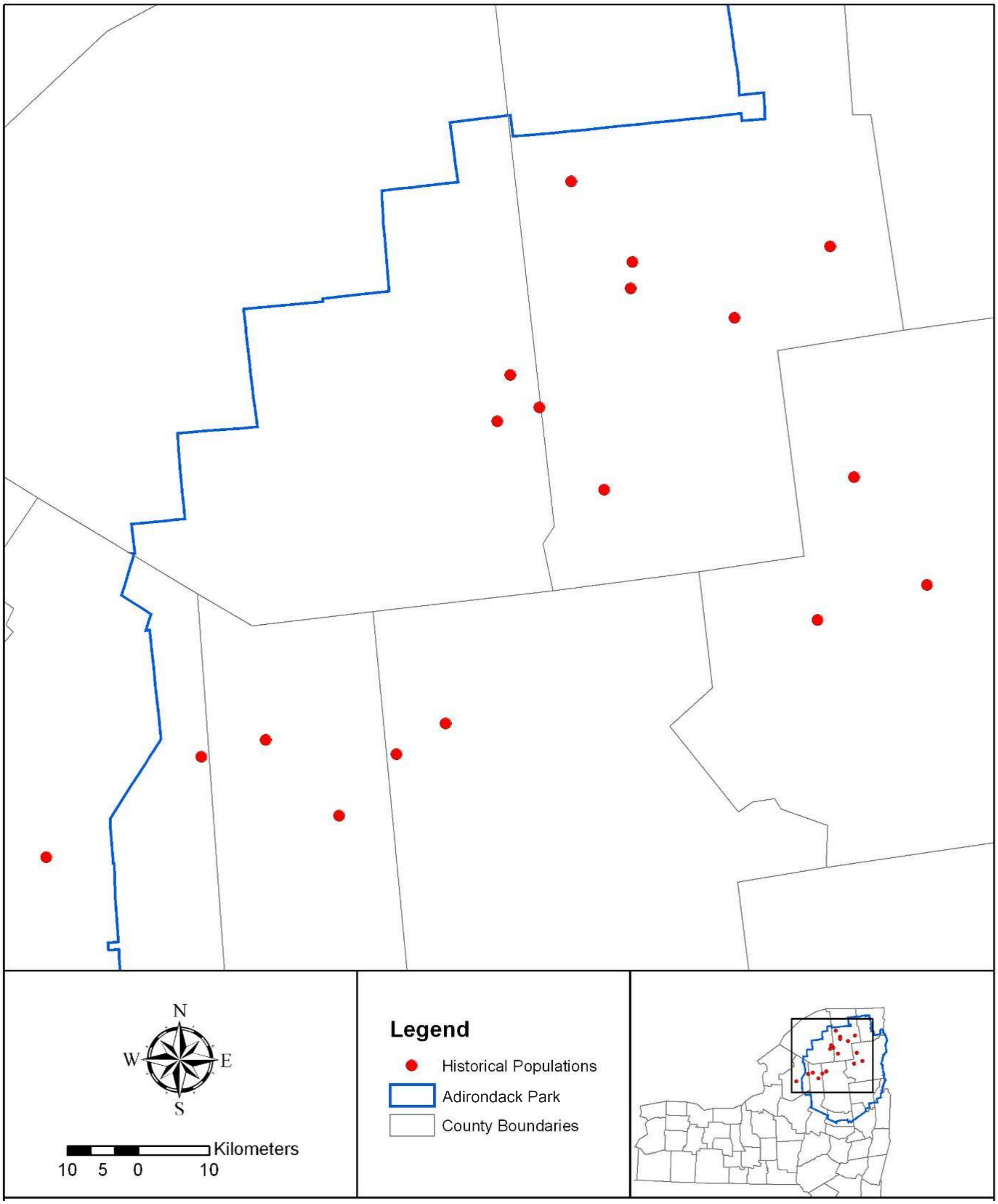

Figure 3. Locations of centers of historically occupied spruce grouse sites in New York prior to 1974 (modified from Bull 1974).

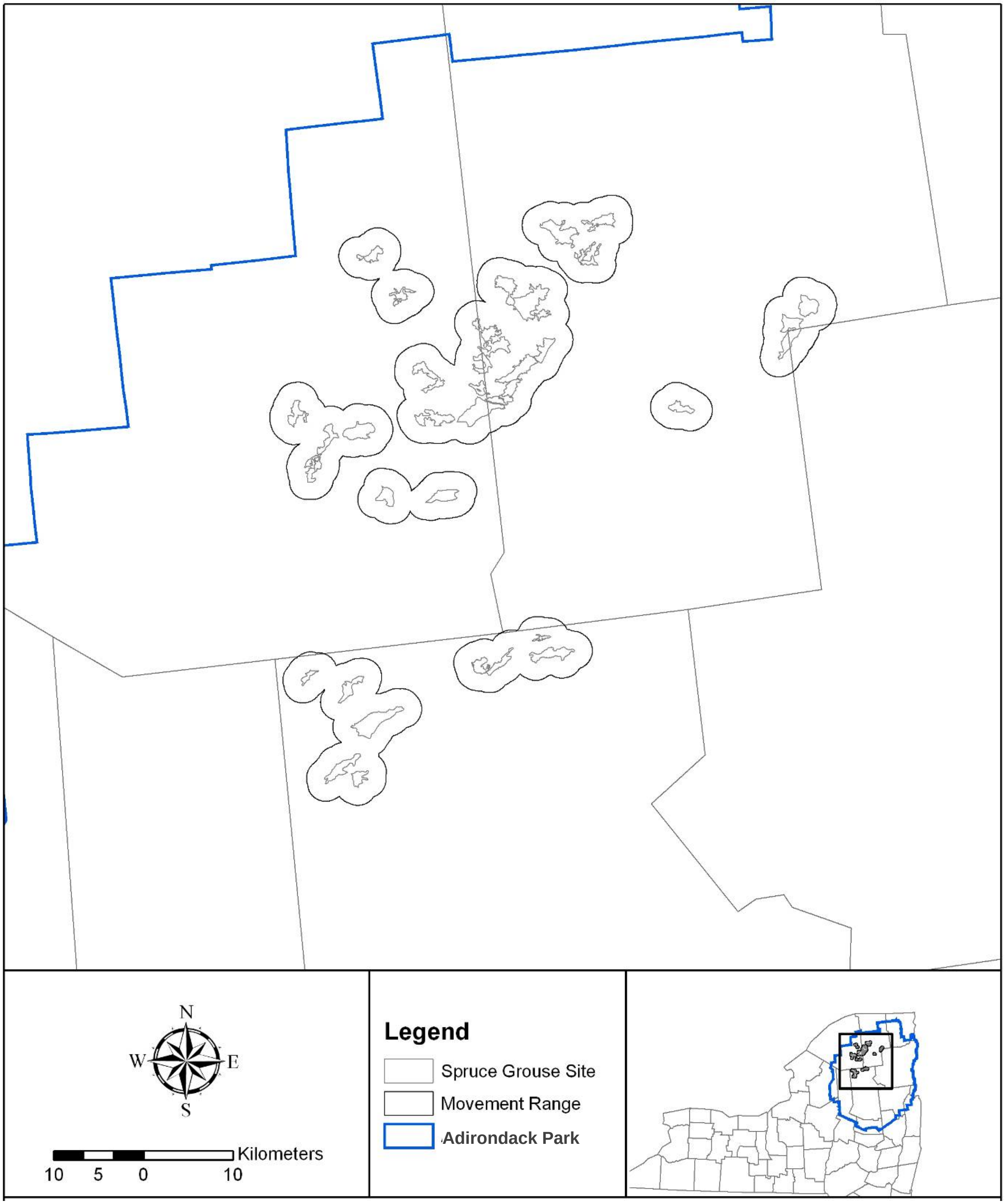

Figure 4. Spruce grouse sites occupied between 1976 and 1987 (Fritz 1977, Bouta 1991) and surveyed from 2002-2006 by Ross and Johnson (2008) in the Adirondack Park, New York. The buffer shown is the maximum dispersal distance (2 km) observed from 2002-2006 and may represent the "movement range" or area where birds may move relatively freely within and between sites.

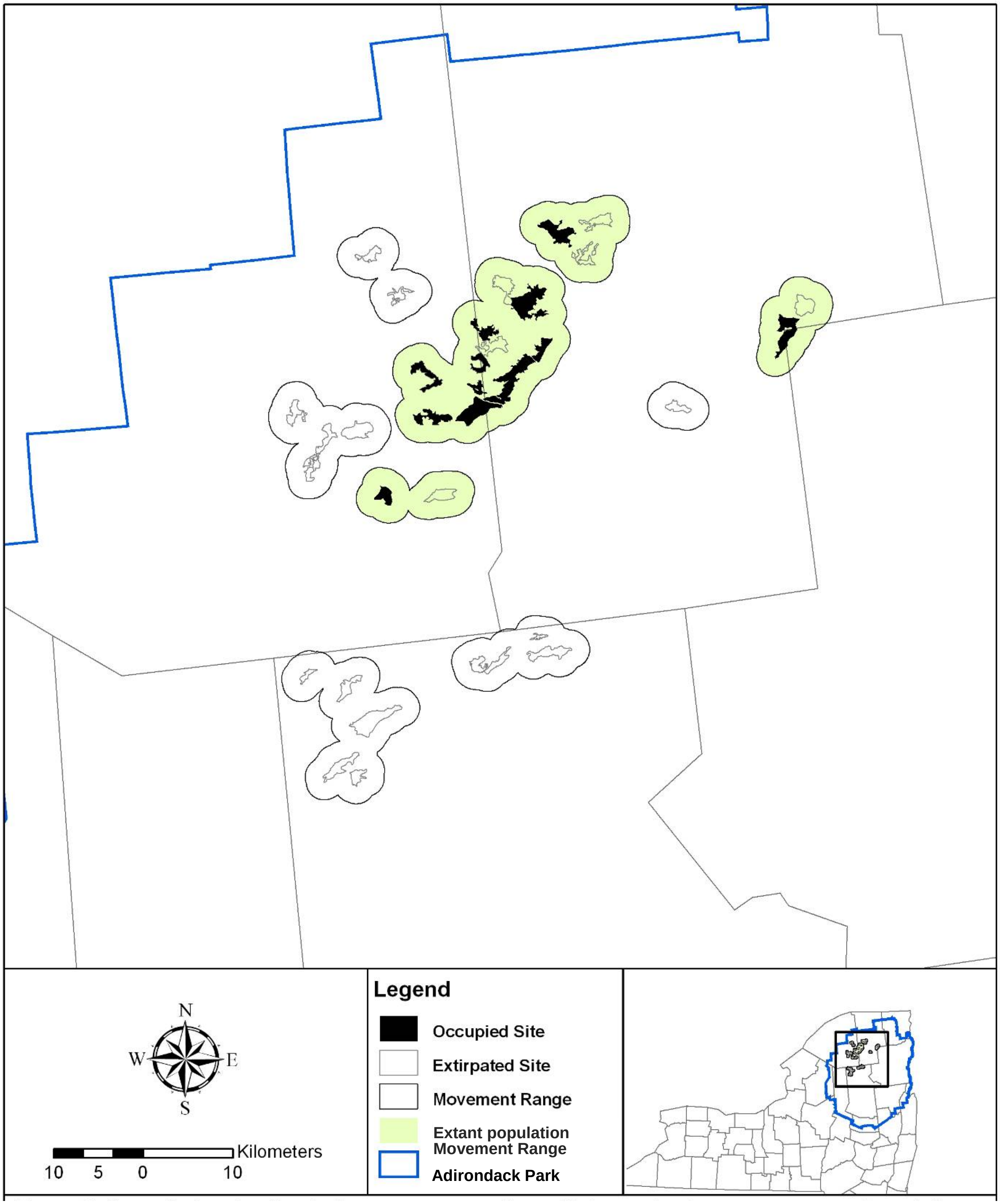

Figure 5. Occupied and extirpated spruce grouse subpopulations in New York showing the maximum dispersal distance (2 km) recorded in 2002-2006 by Ross and Johnson (2008). Sites with extirpated subpopulations depicted are those that were occupied between 1976 and 1987 (Fritz 1977, Bouta 1991). The 2 km buffer may represent the "movement range" or area where birds may move relatively freely within and between sites.

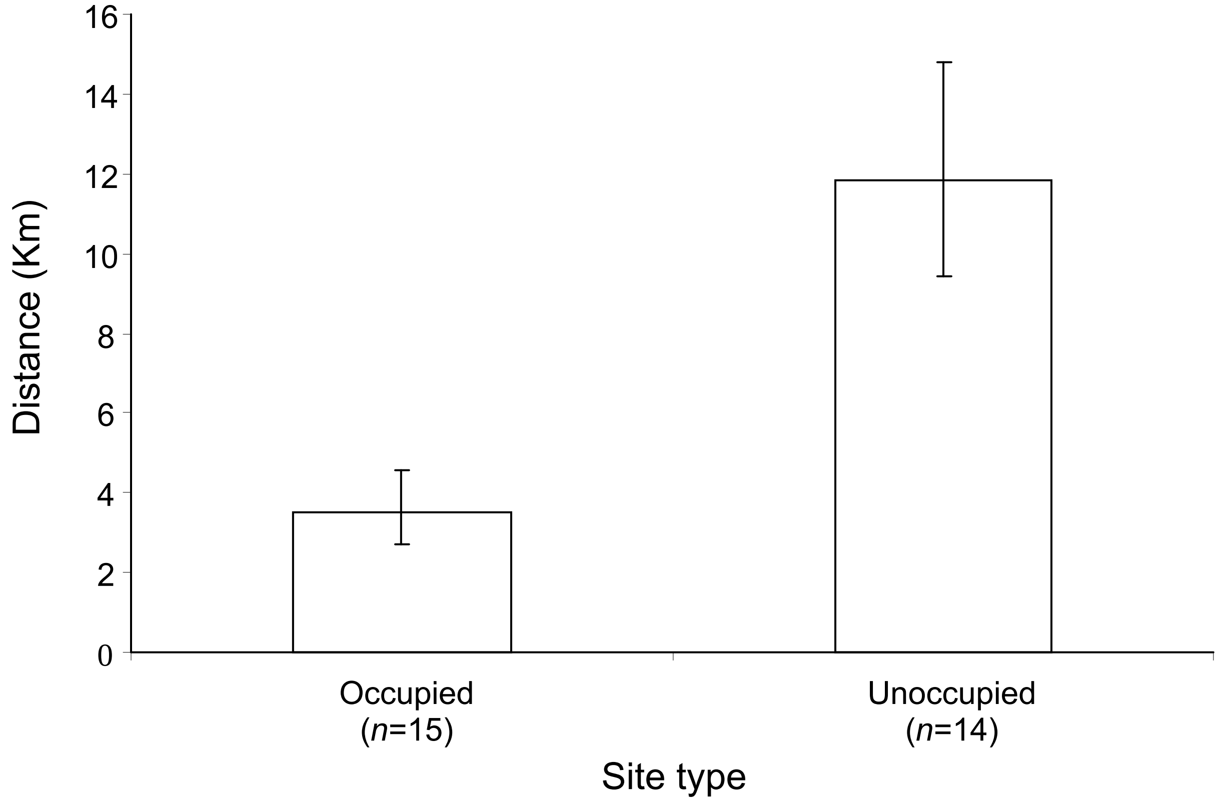

Figure 6. Mean distance between occupied and unoccupied spruce grouse sites to their nearest occupied neighboring site in New York from 2002-2006 (Ross and Johnson 2008). Error bars are 95% confidence intervals. Distances were measured between site polygon centroids.

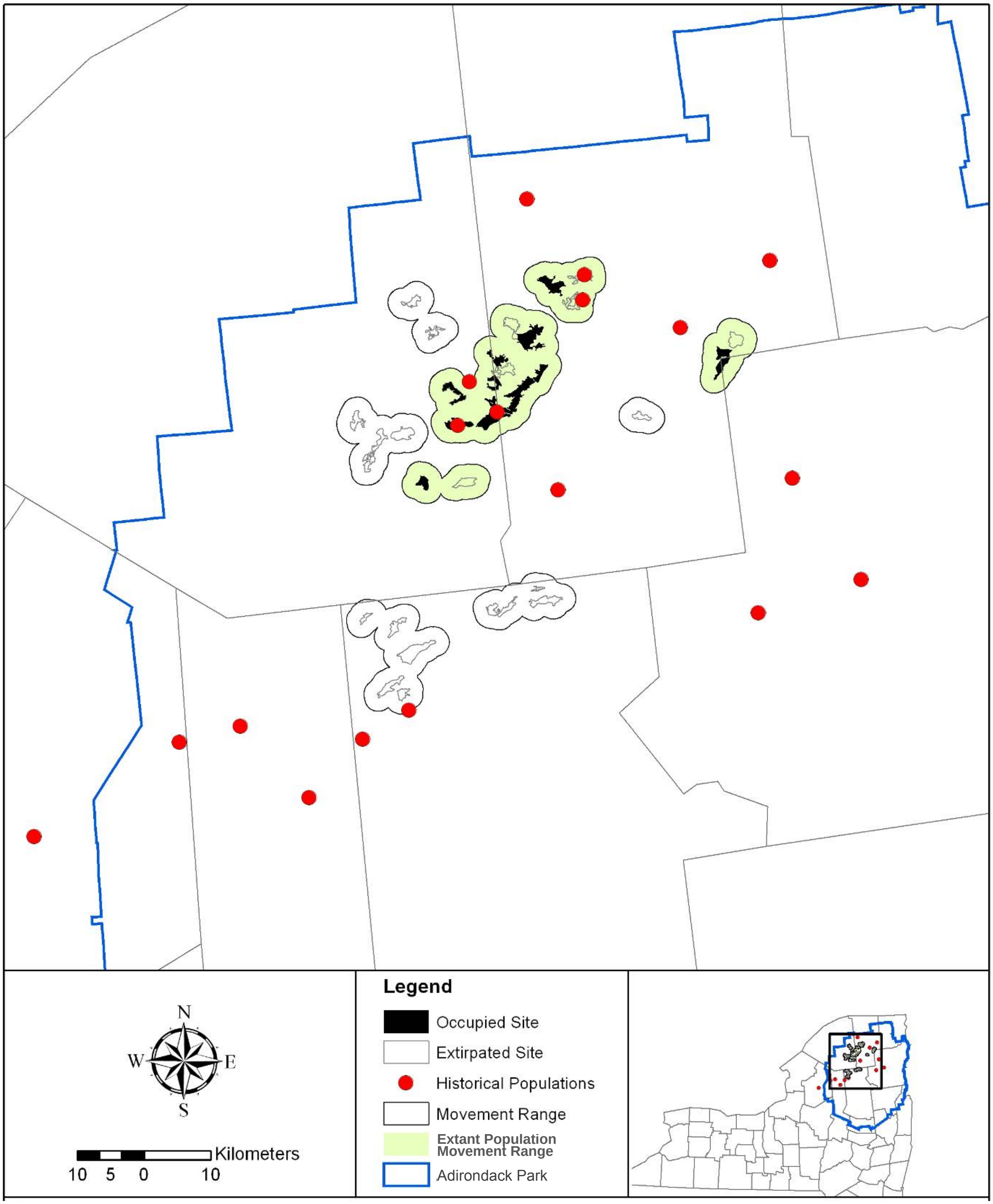

Figure 7. Occupied, extirpated and historically occupied spruce grouse sites in New York showing the maximum dispersal distance of 2 km recorded in 2002-2006 by Ross and Johnson (2008). Extirpated sites depicted are those that were occupied between 1976 and 1987 (Fritz 1977, Bouta 1991). The 2 km buffer may represent the "movement range" or area where birds may move relatively freely within and between sites.

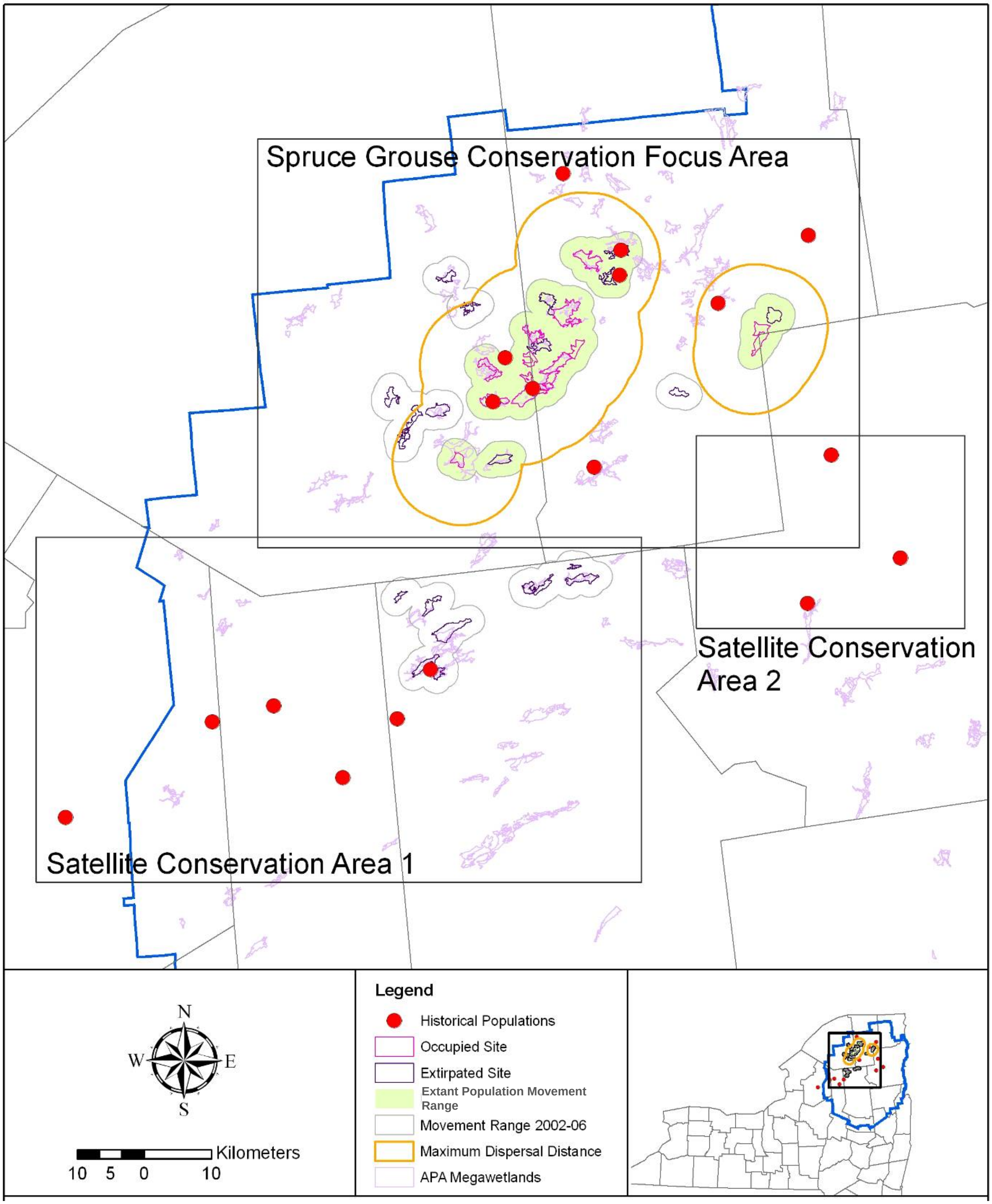

Figure 8. Three major spruce grouse conservation areas in New York with occupied, extirpated and historically occupied spruce grouse sites and maximum dispersal distance recorded in both 2002-2006 by Ross and Johnson (2008) (2 km) and in the literature (8.6 km) (Bouta 1991). Adirondack Park Agency Megawetland data delineates additional sites that may be potential spruce grouse management locations.

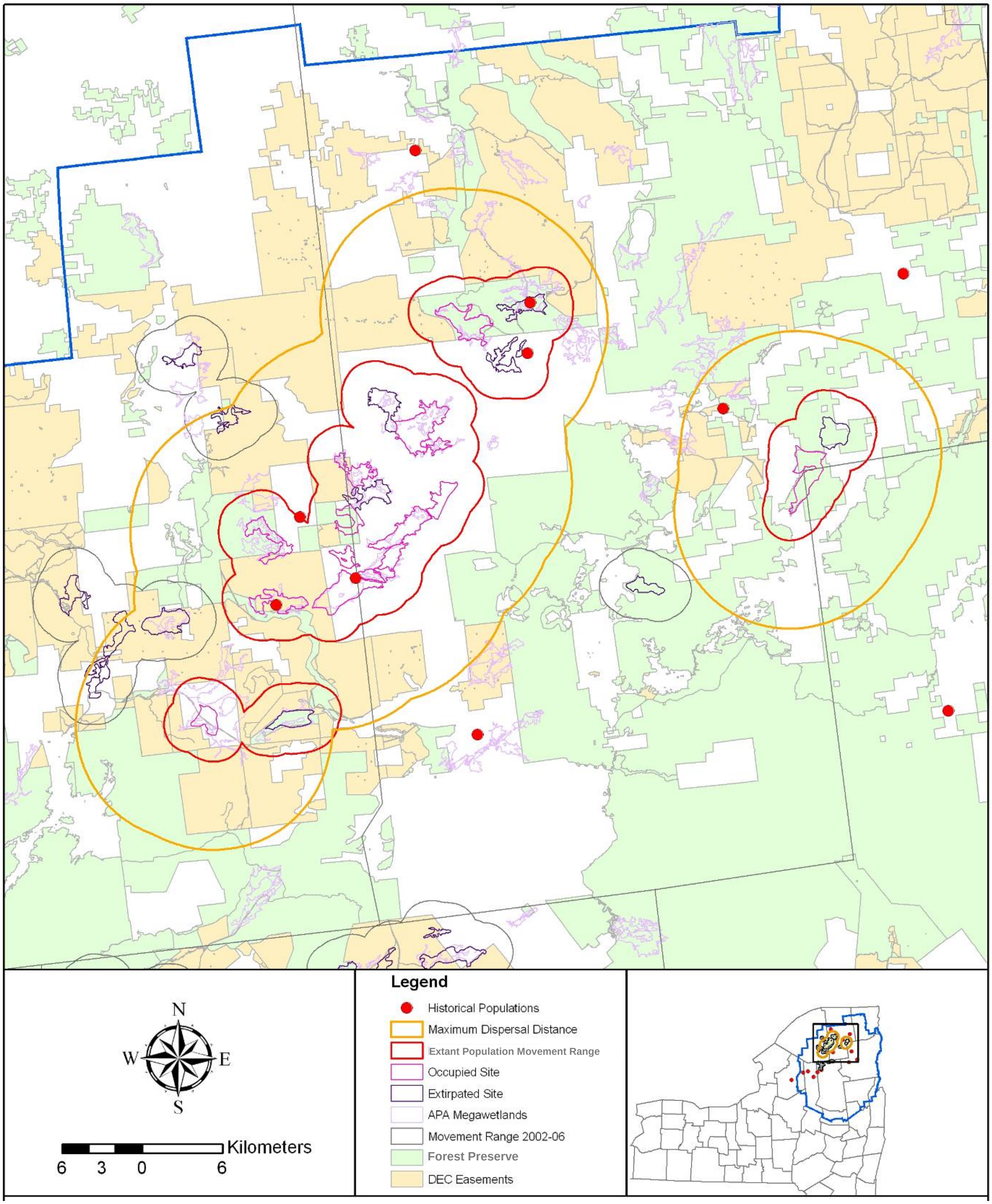

Figure 9. Spruce Grouse Conservation Focus Area in New York with occupied, extirpated and historically occupied spruce grouse sites and maximum dispersal distance recorded in both 2002-2006 (Ross and Johnson 2008) and in the literature (8.6 km) (Bouta 1991). Adirondack Park Agency Megawetland data delineates additional sites that may be potential spruce grouse management locations. Public land ownership and easements are shown.

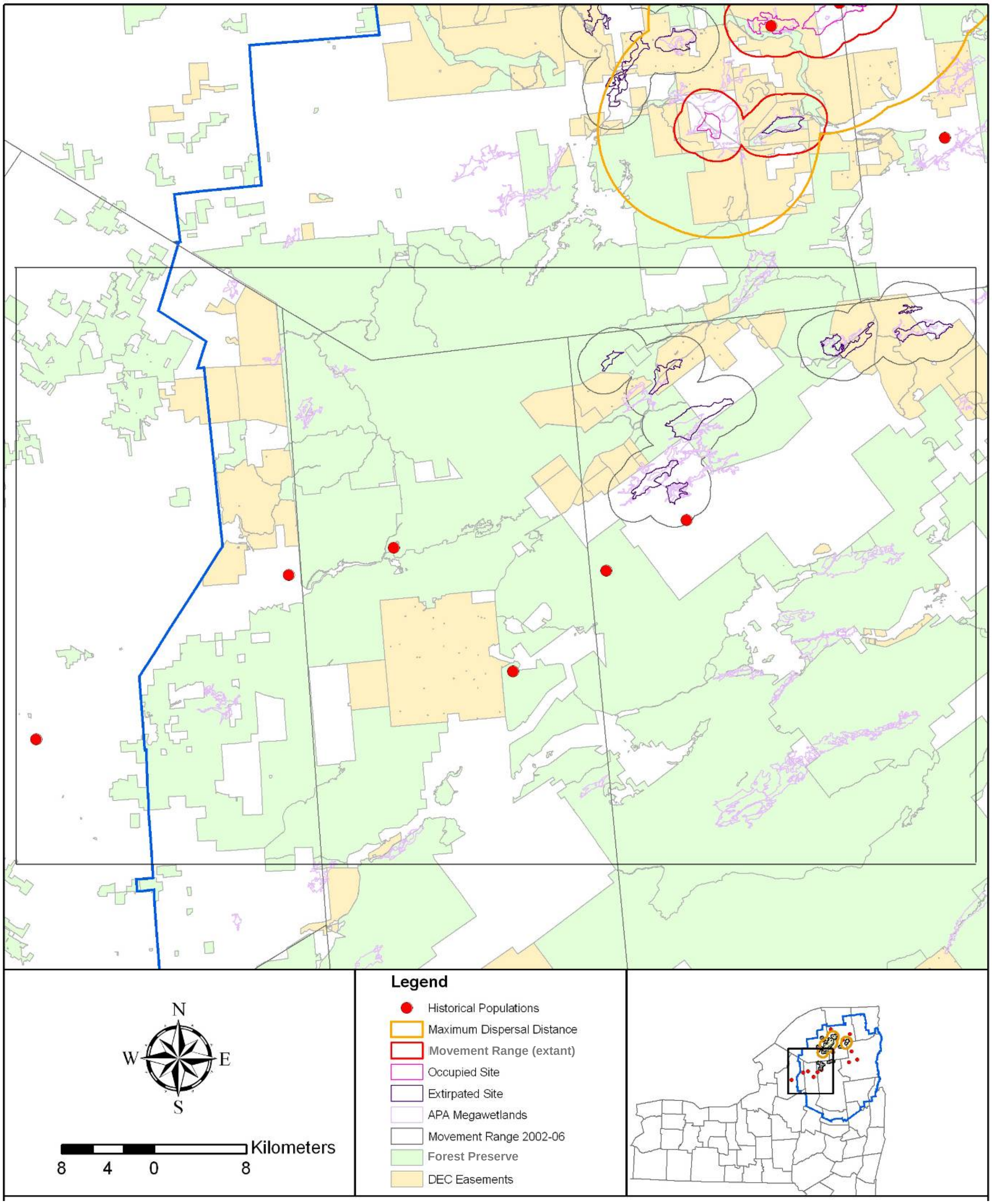

Figure 10. Spruce Grouse Satellite Conservation Area 1 with occupied, extirpated and historically occupied spruce grouse sites and maximum dispersal distance recorded in both 2002-2006 (Ross and Johnson 2008) and in the literature (8.6 km) (Bouta 1991). Adirondack Park Agency Megawetlands data delineates additional sites that may be potential spruce grouse management locations. Public land ownership and easements are shown.

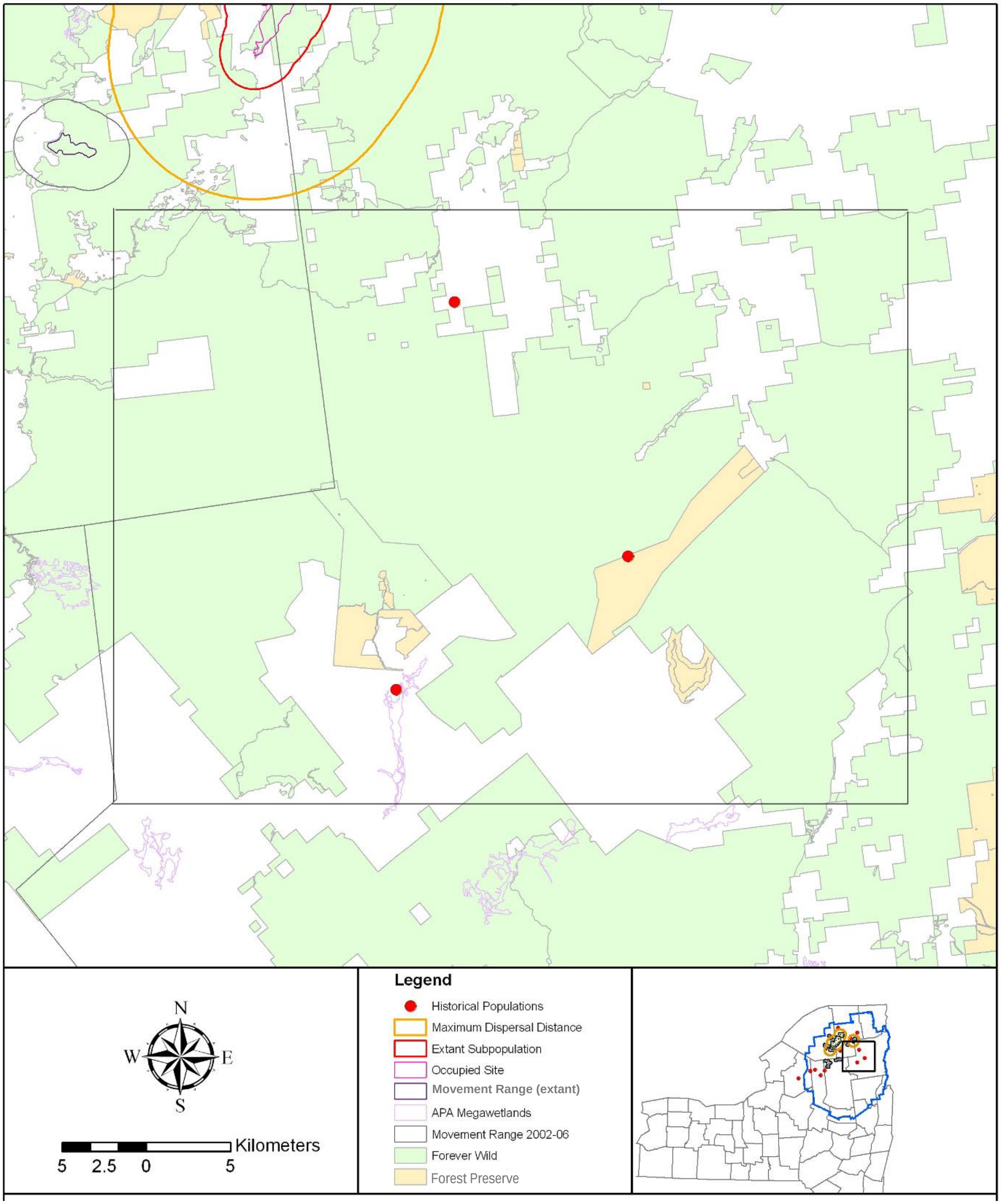

Figure 11. Spruce grouse Satellite Conservation Area 2 in New York. Adirondack Park Agency Megawetland data delineates additional sites that may be potential spruce grouse management locations. Public land ownership and are easements shown.

APPENDICES

Appendix 1. Spruce grouse sites occupied during the study periods of 1976-1977 (Fritz 1977), 1985-1987 (Bouta 1991) and 2002-2006 in the Adirondack Region of New York State with county, town, ownership and date of last spruce grouse observation*. All sites on private lands were surveyed with landowner permission.

Site	County	Town	Ownership	Date of last spruce grouse observation
Bear Brook	St. Lawrence	Piercefield	Private	2012
Beaver Pond	St. Lawrence	Clifton	Private	1987
Bear Pond [N]	Franklin	Waverly	Private	-
Benz Pond [N]	Franklin	Waverly	State	-
Black Brook	Franklin	Altamont	Private	2012
Black Pond Swamp	Franklin	Santa Clara	State	1977
Bloomingdale Bog	Franklin/ Essex	Franklin/St. Armand	State	2012
Bog Lake	Hamilton	Long Lake	Private	1980
Bog Stream I	Hamilton	Long Lake	Private	1980
Bog Stream II	Hamilton	Long Lake	Private	1980
Brandon Road	Franklin	Santa Clara	State	1987
Camp Bliss [N]	Hamilton	Long Lake	State	-
Dead Creek I	St. Lawrence	Colton/Clifton	State	1987
Dead Creek II	St. Lawrence	Piercefield	Private	1987
Elbow Brook	Franklin	Waverly	Private	2011**
Elk Lake [N]	Essex	North Hudson	Private	-
Ferd's Bog [N]	Hamilton	Long Lake/Inlet	State	-
Forestdale Road [N]	Clinton	Black Brook	State	-
Goodnow Bog [N]	Essex	Newcomb	Private	-
Grasse River Club	St. Lawrence	Colton	Private	2012
Hays Brook [N]	Franklin	Brighton	State	-
Hedgehog Club	St. Lawrence	Piercefield	Private	2012
Helldiver Pond [N]	St. Lawrence	Inlet	Private	-
High Falls Reservoir [N]	St. Lawrence	Fine	State	-
Indian Rock Club	Franklin	Santa Clara	State	2012
Joe Indian Pond	St. Lawrence	Parishville	Private	1987
Jordan River	St. Lawrence	Hopkinton	State	2006**
Kettle Pond [N]	Franklin	Hopkinton	Private	-

Kildare Club Bog [N]	St. Lawrence	Piercefield	Private	2010
Kildare Pond	St. Lawrence	Hopkinton	Private	1987
Kildare Road	St. Lawrence	Altamont	Private	2012
Lake Lila	Hamilton	Long Lake	State	1980
Long Pond*	Franklin	Waverly	Private	2011*
Lows Lake [N]	Hamilton	Long Lake	State	-
Madawaska Club	St. Lawrence	Santa Clara	State	1987
Massawepie [N]	St. Lawrence	Piercefield	Private	-
McDonald Pond	Franklin	Waverly	Private	1987
Meachum Lake [N]	Franklin	Brighton	State	-
Mountain Pond [N]	Franklin	Brighton	Private	-
Oregon Plains Road [N]	Franklin	Franklin	State	-
Osgood Creek [N]	Franklin	Brighton	State	-
Potter Pond Outlet [N]	Franklin	Altamont	Private	2004 (*radio tagged bird from Rock Pond visited area*)
Rock Pond*	Franklin	Hopkinton	State	2012
Round Lake [N]	Hamilton	Long Lake	State	-
Sevey Bog	St. Lawrence	Colton	Private	1987
Salisbury Marsh [N]	St. Lawrence	Hopkinton/ Piercefield	Private	-
Shingle Shanty Brook	Hamilton	Long Lake	Private	-
South Meadow [N]	Essex	North Elba	State	-
Spring Pond Bog	Franklin	Altamont	Private	2012
St. Regis River [N]	Franklin	Santa Clara	State	-
Thirtyfive Pond [N]	Franklin	Hopkinton	Private	-
Titusville State Forest [N]	Franklin	Malone	State	-
Ton-Da-Lay	Franklin	Altamont	Private	2012
Willis Brook Bog	Franklin	Altamont	Private	2012
Windfall Brook	St. Lawrence	Colton	Private	1987
Wolf Pond	Franklin	Waverly	Private	1987

[N] Site first surveyed from 2002-2006.
* Indicates individuals or their sign.
** Site was last visited on that date.

Appendix 2(A). Distances of occupied sites to the two nearest occupied sites from the study period of 2002-2006. All sites analyzed were also occupied during the periods of 1976-1977 (Fritz 1977) or 1985-1987 (Bouta 1991) unless otherwise indicated. Distances were measured between site polygon centroids and means shown are geometric means.

Site	Nearest Occupied Site (km)	2nd Nearest Occupied Site (km)
Bear Brook	1.8	2.3
Black Brook[a]	1.1	1.4
Bloomingdale Bog	27.2	27.6
Elbow Brook	1.9	1.9
Grasse River Club	10.6	14.5
Hedgehog Club	5.0	5.5
Indian Rock Club	9.3	13.3
Jordan River	5.5	6.2
Kildare Club Bog*	2.2	2.3
Kildare Road	1.4	1.8
Long Pond	5.3	5.5
Rock Pond	1.9	2.6
Spring Pond Bog	1.3	2.3
Ton-Da-Lay	5.2	5.7
Willis Brook Bog	1.1	1.3
Mean	5.4	6.2

* Site new as of the 2002-2006 study period.

[a] Site included in the occupied site group for this analysis because it was occupied briefly when a radio-tagged female with a brood entered the site for one radio tracking event and returned to her site of origin by the next tracking event.

Appendix 2(B). Distances of unoccupied sites to the two nearest occupied sites from the period of 2002-2006. All sites analyzed were previously occupied during the periods of 1976-1977 (Fritz 1977) or 1985-1987 (Bouta 1991) unless otherwise indicated. Distances were measured between site polygon centroids and means shown are geometric means.

Site	Nearest Occupied Site (km)	2nd Nearest Occupied Site (km)
Black Pond Swamp	15.2	19.2
Bog Lake	22.0	32.0
Bog Stream I	22.7	28.5
Dead Creek II	6.4	8.9
Joe Indian Pond	14.3	18.3
Kildare Pond	8.8	10.9
Lake Lila	25.5	35.3
Lows Lake*	22.2	32.7
McDonald Pond	1.7	1.9
Oregon Plains Road*	3.5	27.6
Round Lake*	22.0	28.4
Sevey Bog	8.0	8.6
Shingle Shanty	31.8	41.9
Windfall Brook	9.1	12.5
Mean	15.2	21.9

* Sites new as of the 2002-2006 study period.

Appendix 3(A). Photos of both occupied (a) and extirpated (b) spruce grouse sites in the Adirondack Park, New York. Note the difference in shrub cover between the two sites types.

(a)

(b)

Appendix 3(B). Photos of both occupied (a) and extirpated (b) spruce grouse sites in the Adirondack Park, New York. Note the difference in shrub cover between the two sites types.

(a)

(b)

Appendix 4. Spruce grouse habitat management guidelines proposed for Vermont taken directly from Alexander and Chipman 1993. These guidelines were developed with input from Robert Chambers, Chris Fichtel, Steve Parren, Ed Quinn and Daniel Keppie.

These guidelines were written to be applied to existing spruce grouse range in Vermont. These guidelines should also be applied to Vermont habitats which become the site of any future spruce grouse reintroduction. To be considered as a possible reintroduction site, the area or "patch size" of suitable habitat should be at least 100 ha (250 acres) (Fritz 1979). The overriding consideration in spruce grouse habitat management is the maintenance of nearly continuous tree cover interspersed with openings.

The following guidelines are recommended:

1. Manage habitat in 50 ha (124 acres) units, to accommodate the upper range of home range size for females with broods.

2. Even-age or all-age management systems may be used, however, 37% to 50% of all trees within the habitat management unit (HMU) should be in age classes between 20-50 years at all times.

3. Whether the management is described as even-age or all-age, the area of regeneration in each HMU is calculated using the following formula:

   $$\frac{\textit{CUTTING INTERVAL}}{\textit{ROTATION AGE}} = \text{AMOUNT OF AREA REGENERATED}$$

   Example: In a stand with a 60 year rotation, and a treatment scheduled every 15 years, 15/60 = 0.25 (25%) of the HMU should be regenerated during each treatment (Adapted from Reay et al. 1990).

4. Rotation age should range from 60 years for predominately fir stands to 80 years for predominately spruce stands. Cutting intervals should be 10-15 years, resulting in the creation of 4-8 age classes.

5. Softwood regeneration is a critical goal. Clearcut only when softwood regeneration is adequate. Otherwise, employ shelterwood techniques to obtain necessary softwood generation. Spruce regeneration is preferred over fir.

6. Silvicultural treatment should occur during snow-free periods if scarification is necessary to establish softwood regeneration. However,

cutting should not occur during spruce grouse courtship and breeding seasons (mid-April to mid-July).

7. If even-age management is employed, regeneration cuts should be no larger than 12.5 ha (31 acres), as larger cuts would result in the inability to provide equal distribution of at least 4 age classes over time within the HMU. Smaller regeneration cuts of 0.4-1 ha (1-2.5 acres) are preferred as they allow for more thorough utilization of openings by hens with broods.

   Employing true all-age stand management (periodic single-tree or group selection cuts from all diameter classes) across an entire HMU may not provide optimal spruce grouse habitat. While continuous forest cover with adequate vertical stratification should be provided by all-age management, sparse canopy brood openings will be lacking. To prevent this habitat deficiency, at least 20% of each HMU should receive even-age regeneration treatments (defined as an area at least 0.4 ha [one acre] in size with a residual basal area ≤ $6.8m^2/ha$ [30 sq. ft./acre] following the final regeneration cut).

8. Hardwood composition should be kept below 10% of the composition of the HMU. Tree species to encourage during management activities include black, red, and white spruce, balsam fir, and larch.

9. Larch should be maintained at 1-20% of stand composition where it occurs.

10. Pre-commercial thinnings are acceptable only up to age 30.

Reay, R.S., Blodgett, D.W., Burns, B.S., Weber. S.J., and T. Frey. 1990. Management guidelines for deer wintering areas in Vermont. Vermont Fish and Game Department and Vermont Department of Forest, Parks and Recreation. Waterbury, VT. 35pp.

Appendix 5. Summary of and Responses to Public Comments on the Draft Spruce Grouse Recovery Plan, June 2012

The New York State Department of Environmental Conservation (DEC) received comments from approximately 32 individuals and organizations on the draft "Recovery Plan for New York State Populations of the Spruce Grouse" during the 30-day public comment period (1 March – 31 March 2012). Availability of the draft plan was announced via a DEC press release, the DEC website, and the Environmental Notice Bulletin. All comments received were either addressed in the revised final plan or are responded to below.

Many comments offered little specific feedback to the draft plan's content and were instead commending DEC for focusing efforts to conserve the spruce grouse. Conversely, some comments were focused on criticizing DEC for advancing a plan for spruce grouse when there are other species with which to be concerned. We reviewed the content of each comment and organized it into finite set of issues that required response. During this process, individual comments were not counted as "votes" for or against specific proposals in the draft plan, but they were instead taken as insights into areas that required further clarification, justification or modification in the final plan. To the extent practicable, we responded to relevant concerns identified by any number of individuals. We thank all who took the time to personally review the draft plan and provide specific feedback. Based on these comments, we have made a number of both substantive and minor revisions to the plan as discussed below.

1. General support of plan from public standpoint

***Comment*:**
General comments in support of the plan were related to increased public enjoyment of the species through increased birding and hunting opportunities, and educating hunters on spruce grouse identification. Individuals raised questions about whether they can help by raising individuals to be released in the state to whether their lands can serve as release sites, or whether state lands outside of the Adirondacks can serve as release sites. There were also comments about what effects of deer browse may be.

***Response*:**
Optimistically, while reintroductions could potentially aid in the species' recovery and allow for increased hunting opportunities in the future, the spruce grouse may never achieve a high enough population level in the state to realistically allow for a sustainable harvest. As the recovery program is assessed as successful in the future, the potential for a hunting season can also be assessed. Until then, it will be necessary to maintain signage on spruce grouse identification and educate hunters that spruce grouse may be present in spruce grouse areas that are open to hunting. Raising individuals from eggs and releasing them into New York subpopulations may be effective if there were bird eggs to find and use, but nests are growing increasingly rare. For example, in ten years only six nests have been located in the state. While spruce grouse do quite well in captivity and can be raised and released, the DEC feels

that it is easier, more cost-effective and more likely to be successful to reintroduce birds from other locations. Adult birds relocated from other areas would likely be more experienced and may have lower mortality rates as well.

With regard to releasing individuals on private and state-owned lands outside of the Adirondacks. We are grateful that there are so many individuals who want to be involved in conservation of this endangered species. However, it is important that habitat management and reintroductions of individuals on lands be considered carefully as success of these efforts will be based on conducting relevant management in relevant locations. While spruce grouse habitat management would be much easier outside of the Adirondack Park, there are no occupied subpopulations near the Park boundaries, and there is very little habitat outside of the Park. The viability of the spruce grouse's population depends on having other populations nearby to which individuals could emigrate. If the DEC and the public expended a lot of effort to manage habitats and release birds outside of focus areas, the efforts would likely not be successful.

Deer browse can impact forest regeneration. However, there is not much evidence of deer browse in these thick spruce wetlands where spruce grouse occur. What has been observed is browse to red maple seedlings do not create preferred spruce grouse habitat. We may elect to erect some deer exclosures in our habitat management plots to determine how much deer browse could be affecting lowland boreal vegetation.

2. Spruce grouse conservation process

***Comment*:**
Comments were related to funding, new management on conservation easements and Open Space Institute focus areas, tax credits for management and relaxing restrictions on tree cutting on state lands within the Adirondacks. Specifically, enact conservation measures in an inexpensive way working with outside organizations by (1) developing a frugal and sustainable budget to save the Spruce Grouse from extirpation, (2) partnering with a private organization, which could help with funding and implementation, and (3) instead of funding the budget in its entirety, the DEC could provide a matching grant for half of the budget if the other half could be raised from private sources. Using private sources of funding and fund raising on websites could be used for conservation work. In addition, a conservation easement was identified in St. Lawrence County that may be used to manage for spruce grouse habitat. There was a question as to whether the Open Space Institute (OSI) is currently working on any lands that possess spruce grouse today was raised. Finally, (1) whether it is possible to create tax credits for private landowners who agree to implement, under NYSDEC oversight, habitat management efforts that will create suitable spruce grouse habitat and protection of core breeding populations in the long term and (2) whether it is possible or reasonable to create exceptions to tree cutting restrictions within the Adirondack Forest Preserve on public land in order to create and maintain habitat for spruce grouse.

Additional comments ranged from mandating The Nature Conservancy (TNC) to manage habitat for spruce grouse on their lands to waiting for results of Vermont's conservation efforts before doing similar work in New York. Other comments were that preference be given to management options such as reintroductions over habitat management because reintroductions would be less expensive.

Response:

A frugal budget has been developed for the first several conservation priorities identified in the draft plan and has been submitted for potential funding by the US Fish and Wildlife Service. In addition, private organizations and landowners have been involved to date with ongoing spruce grouse conservation efforts and the DEC hopes to partner with additional private entities to further spruce grouse conservation efforts. However, rules governing DEC funding would not allow DEC to fund raise with a specific private organization because it could be interpreted as unfair to other private organizations.

DEC will investigate and assess the possibility and potential benefits of managing habitat for spruce grouse on the conservation easement noted in St. Lawrence County. Additionally, it does not appear that OSI is working on acquiring conservation easements on any lands within spruce grouse focus areas.

There is currently a Forest Tax Law that allows landowners to receive a tax reduction for lands in which timber will be harvested in accordance with an approved sustainable forest management plan. There may be ways to take advantage of this type of credit system and also benefit the spruce grouse in New York. In addition, the relaxation of forest cutting restrictions on state lands within the Adirondack Park is not under the jurisdiction of the DEC.

The NYSDEC is charged with conserving the spruce grouse in New York State. NYSDEC is not in a position to recommend that other agencies or NGOs provide funding for spruce grouse conservation. The NYSDEC will begin discussions with private landowners to manage habitat for spruce grouse conservation, but ultimately the private landowners are in charge of their lands. Much of TNC lands near the species' central distribution contain spruce grouse and habitat in useful age distributions to promote spruce grouse persistence. In many cases, these are the areas that remain occupied by the species.

Vermont is currently evaluating results of spruce grouse reintroduction in the state. If the DEC waits for Vermont's results before taking action, it will become more costly to manage for the species and more unlikely that management for the species will be successful in the state.

By law, managing habitat for spruce grouse will need to be conducted on private lands in the Adirondack Park. The compensation from selling the timber on managed lands would benefit the landowner rather than cost the landowner money. Therefore, habitat management would be the least expensive management option compared to spruce grouse reintroductions.

However, according to models, both are necessary actions needed to maintain a viable population of the spruce grouse in New York State over the next 100 years.

3. Climate change

***Comment*:**
The potential impact of climate change needs to be addressed in developing the plan.

***Response*:**
While climate change is a factor that could significantly impact spruce grouse habitat, there is considerable uncertainty in the degree to which climate change will influence the spruce grouse or it habitats in the short-term. However, it can be assumed that climate change will negatively affect spruce grouse and other boreal species' habitat, as black spruce is susceptible to increasing temperatures. The recovery plan does touch on the effects of climate change on boreal forests and boreal fauna in the literature review section. However, the plan is written with the idea of completing a review and rewrite in 2022 to determine which recovery criteria will be met at that time. Since tamarack, spruce and fir needles make up a considerable component of the species' diet, unless those tree species die out due to increasing temperatures, there is likely no significant danger of extirpation of those species over the following 10 years. Valid points were raised on whether efforts should concentrate on species that are sensitive to climate change. The effects of climate change are not certain, but it is likely that we can make efforts to conserve spruce grouse intelligently, efficiently and effectively for many years to promote persistence of our regional biodiversity and allow others to enjoy the species into the future.

4. Modeling

***Comment*:**
Modeling the population viability over 100 years it too long and biases the results toward having to expend more effort than necessary to conserve the species. Increasing habitat quality to reduce mortality is also not justified anywhere in the plan.

***Response*:**
Modeling the population via PVA over 100 years is fairly standard in recovery plans. Some sources indicate that 100 years may not even be long enough. Because we questioned the quality of some specific information about New York habitat and population parameters, our model assumptions were more liberal. For example, we assumed that (1) spruce grouse habitat has higher carrying capacities than likely present, (2) spruce grouse do not suffer from inbreeding depression, and (3) individuals do not experience reduced mortality with dispersal. Therefore, we believe

that the results represent an adequate tradeoff with our model assumptions. In addition, our sensitivity analysis showed that the only parameters to which the model was sensitive were changes in mortality rates and the standard deviation of mortality rates. The notion that mortality rates vary with varying habitat quality is supported in the literature for many species of mammals, reptiles and birds, hence varying mortality rates may be a surrogate for varying habitat quality via habitat management. Text was added to the plan to support this idea.

5. Genetics

***Comment*:**
Genetics data do not support that releasing spruce grouse from outside populations may introduce deleterious alleles into the population that may lead to range-wide extirpation in the state. This possibility is exceedingly remote.

Response:
The initial text regarding the possibility for a spruce grouse range-wide extirpation from reintroducing birds from other areas was overstated. Text was changed to state that reintroductions may lead to releasing individuals with genotypes that are poorly adapted to the Adirondack environment, leading to increased mortality rates.

6. Miscellaneous

Comment:
Are coyotes are causing the reduction in spruce grouse numbers?

Response:
Coyotes may depredate spruce grouse on occasion, especially their nests, but the primary cause of death of a spruce grouse is mortality by avian predators such as hawks and owls.

Comment:
Spruce grouse are observed by commenters in many locations outside of the Adirondack Park. In addition, there are undoubtedly pockets of spruce grouse in unknown areas and efforts should be made to locate these pockets before the plan is implemented.

Response:
There is only one historical record of spruce grouse outside of the Adirondack Park and this location is in Lewis County pre-1974. Commenters have confused identification with the similar looking ruffed grouse.
Detection probabilities of spruce grouse are approximately 55% based on results of analyses. A considerable amount of time and effort was spent looking for spruce

grouse in historically occupied and new areas. For example, over 55 sites in the Adirondacks were surveyed for spruce grouse and only 15 sites were found to contain the species. It is very unlikely that significant portion of the population was missed. If subpopulations were missed, they are very likely small and highly isolated population sinks and do not contribute significantly to the species state-wide population structure and function. Adequate information on distribution has been collected to implement the present recovery plan.

Comment:

Comments were related to why the DEC is concerned with managing for spruce grouse when there are other species to conserve. In addition, there were questions as to which sources funding have been used for the present and past work.

Response:

The DEC's mission is "To conserve, improve and protect New York's natural resources and environment and to prevent, abate and control water, land and air pollution, in order to enhance the health, safety and welfare of the people of the state and their overall economic and social well-being." As the agency that is concerned with conserving the state's natural heritage (e.g., its species), the DEC is mandated by the New York State Endangered Species Law to conserve endangered and threatened species. The mandate includes writing and implementing recovery and management plans. The DEC is focusing on spruce grouse at this time because there is currently sufficient information about the species' population to allow for effective conservation. The DEC does not preferentially conserve one species over another. Funding for this recovery plan and related work was provided by the USFWS through a State Wildlife Grant Program. Information regarding this program and how it is funded can be found at: http://www.dec.ny.gov/animals/7179.html and http://wsfrprograms.fws.gov/subpages/grantprograms/swg/swg.htm.

Comment:

Elsewhere in their vast range, spruce grouse are much more general in their use of habitats. Do the authors really have adequate justification for thinking that they are much more selective in the Adirondacks?

Response:

Spruce grouse are selective in their habitats in New York and in other areas of their vast range. In New York, habitat selection may be more evident as the population is small and remaining individuals are preferentially located in high quality sites. Deciphering habitat selection in areas with large or dense populations is more problematic, due to the high quality sites being at carrying capacity, thereby resulting in some individuals being forced into marginal quality habitats. In those populations, other metrics such as mortality rates and population density can be used to infer habitat quality.

Summary of changes to the plan based on public comments:

- Dates in the recovery plan were changed with newer information reflecting more recent surveys (2012).

- Modeling was revisited to test whether habitat management could be applied through changing values of carrying capacity, which is a more direct link than changing values of mortality rates. However, the model was not at all sensitive to alterations in carrying capacity, but it was sensitive to changes in mortality. The notion that mortality rates vary with varying habitat quality is supported in the literature for many species of mammals, reptiles and birds, hence varying mortality rates may be a surrogate for varying habitat quality via habitat management. Explanations and citations were added to the plan to support this idea.

- Text was changed in the genetics section to state that reintroductions may lead to releasing individuals with genotypes that are poorly adapted to the Adirondack environment, leading to increased mortality rates.