Evaluating Regional Wildlife Corridor Mapping: A Case Study of Breeding Birds in Northern New York State

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Abstract

Using data from the New York State Breeding Bird Atlas, I compared the abundance of breeding birds within a proposed wildlife corridor in northern New York State to their abundance outside of the corridor to evaluate the effectiveness of corridor mapping using coarse-scale habitat variables. As a group, the abundance of the 160 bird species in the study area was 22.4% higher inside compared to outside the corridor, five of 14 bird guilds were significantly more abundant inside the corridor ranging from 27% to 77% higher, and the group associated with mature and old-growth forests was 30% more abundant inside the corridor. Greater bird abundance inside the corridor is likely due primarily to 10% greater forest cover inside the corridor, road density (as an indicator of fragmentation) that is at least three times greater outside the corridor, and human population (as an indicator of land-use intensity) that is at least 10 times higher outside the corridor. More work is required to undertake similar comparative analyses for other species including mammals, amphibians and reptiles, and vascular plants to further evaluate the effectiveness of the current corridor design. Protected areas, easements, and more ecologically-based resource management will be required to secure this wildlife corridor.

Key words: habitat connectivity, bird atlas data, northern New York

Introduction

Scientists have been studying and debating the benefits of wildlife corridors (e.g., 1-11) and their costs (e.g., 12-20) for the better part of three decades and have yet to agree on a set of standards and principles to guide their design. Meanwhile, despite a lack of consensus about corridor science and faced with the mandate to halt and/or restore ecosystem degradation and species loss, conservation practitioners have been designing and implementing corridors at local (21-24), regional (25-29), state/multi-state (30-38), national (39-42), and continental (43-45) scales throughout the world. A primary motivation of these corridor initiatives is an acceptance of the need to act now or lose many habitats irrevocably (6). Perhaps the most basic corridor design principle that can be derived from the corridor science to date, which has established that there are both benefits and costs associated with creating corridors, is that corridors will function optimally only if the unique ecological conditions of each corridor region are understood and reflected in the design of each individual corridor (7).

Recently, coarse-scale, regional ecological features were assessed and analyzed for a corridor design proposal to maintain and restore wildlife habitat connectivity between Algonquin Park in central Ontario and Adirondack Park in northern New York State (35, 46). For the New York portion of the Algonquin to Adirondacks (A2A) Corridor (focus of this study), these features included road density, presence of major roads, human population density, land cover type (30 categories), and hydrology at 90 x 90 m cell resolution for more than 2 million cells covering the ~20 000 km^2 study area. Although the proposed Corridor is located in the portion of highest ecological integrity within the study area and represents the ecosystem types there fairly well, the ability of the Corridor to support species and communities at levels significantly higher than areas outside of the Corridor remains to be tested. Thus, the purpose of this study was to compare the abundance of breeding bird populations within the proposed Corridor to the abundance of breeding bird populations outside of the proposed Corridor area.

Materials and Methods

Study area

The proposed A2A Corridor (in New York) is ~55 km in length, with an area of ~1 045 km^2, and varies in width from ~10 km at the northwest end to ~30 km at the southeast end (Fig. 1). The Corridor location was selected primarily because of its high ecological integrity (lowest road density and human population density) relative to the other portions of the study area (35, 46). The dominant ecosystem type within the study area and the proposed A2A Corridor is maple-beech-birch forest (70% and 90%, respectively; Table 1). Of the 12 main ecosystem types in the study area, eight are well-represented (% difference <2%; Table 1) within the Corridor. However, the maple-beech-birch forest type is over-represented by ~20%; the spruce-fir, oak-hickory, and white-red-jack pine forest types are all mildly under-represented by 4%, 3.2%, and 2.4%, respectively; and non-forested terrestrial ecosystems are under-represented by ~10% (Table 1). Wetland and aquatic ecosystems are well-represented within the Corridor. In addition to providing habitat for wildlife movement including migration, the proposed Corridor also provides permanent wildlife habitat due its extensive size (see territory sizes in 47). For example, based on mean home range size for great horned owls in central New York (11.4 km^2/pair; 48), which is the largest common top avian carnivore in the study area, the Corridor area may support up to ~90 pairs of these large predators.

Data collection and analysis

Bird species presence data from the New York State Breeding Bird Atlas (49), based on 5 x 5 km survey blocks for the period 1980-85, were used to test the hypothesis that the abundance of breeding bird populations inside the A2A Corridor in New York is higher than the breeding bird abundance outside the Corridor. There are, however, a number of limitations of this data set that are associated with using volunteers to collect data over a large and variable study area (~20 000 km^2). Most importantly, few survey blocks resulted in a complete inventory of breeding birds due to variation in amount of time spent in each block, difficulty of access in some areas, weather, habitat type, and observer ability (49). Despite these limitations, many researchers have used breeding bird atlas data to address ecological questions at regional scales (e.g., 50-55) including reserve design (56, 57). Due to these limitations, particularly the difficulty of access within the Corridor where the presence of roads is roughly 67% lower than outside the Corridor, only data resulting from the least demanding level of bird observation were used: (1) visual species identification made during the breeding season in possible nesting habitat and (2) male song recognition or breeding calls heard during the breeding season (49).

To test the hypothesis, the bird presence data for the 54 survey blocks within the 1 045 km^2 Corridor area were compared with the presence data for the 54 randomly chosen blocks outside of the Corridor area. Since the portion of the study area north of the Corridor made up 35% of the study area outside of the Corridor, 19 of the 54 blocks or samples (35%) were randomly located there. Similarly, 35 of the 54 samples (65%) were randomly located in the study area south of the Corridor. Since each inventory block was treated as an individual sample, abundance was determined by the number of blocks each species was observed in with a maximum abundance of 54 for a species either inside or outside the Corridor. To evaluate differences in abundance within versus outside the Corridor, bird species were classified into 14 guilds based on taxonomy and function (e.g., 58) according to Sibley (59), and into a group associated with mature and old-growth (M&OG) forest based on DeGraaf et al., (47), with a minimum of six species per group. Related groups with less than six species were lumped together, e.g., the "wrens, kinglets, gnatcatchers, shrikes & vireos guild". The paired t-test was used to compare the mean abundance of the species in each group and for all species combined within the Corridor versus outside the Corridor.

Results

The mean abundance of the 160 bird species observed during the breeding season within the study area between 1980 and 1985 was 22.4% higher inside (9.3 blocks) versus outside (7.6 blocks) the Corridor ($t=4.17$; $p=.001$, Table 2). The guild with the greatest mean abundance within the Corridor included the chickadees, nuthatches & allies-tanagers, cardinals & allies (19.3 blocks) followed by the woodpeckers (18.0 blocks) (Table 2). The least abundant guilds within the Corridor were the ducks, duck-like birds & swimming birds (2.3 blocks), finches & old-world sparrows (5.4 blocks), and birds of prey and foul-like species (5.8 blocks). The ranking of most to least abundant guilds outside the Corridor was similar with the exception of the lower ranking of Icterids (11th outside vs. 4th inside) and the higher ranking of wading birds (4th outside vs. 12th inside).

Eleven bird guilds were more abundant inside the Corridor by at least 16%, however, only five of these guilds had differences that were statistically significant: (1) chickadees, nuthatches & allies-tanagers, cardinals & allies (77.1% higher, $p=.018$), (2) wrens, kinglets, gnatcatchers, shrikes & vireos (53.8% higher, $p=.019$), (3) woodpeckers (50% higher, $p=.043$), (4) others (31% higher, $p=.014$), and (5) wood warblers (27% higher, $p=.011$). In addition, the abundance of M&OG forest species was significantly higher inside the Corridor (29.5% higher, $p=.001$) compared to outside the Corridor. Three bird guilds were more abundant outside the Corridor by at least ~15%, however, none of these differences were statistically significant

(Table 2). These three guilds included the wading birds; ducks, duck-like birds & swimming birds; and birds of prey & foul-like species.

For six of the 11 guilds that were more abundant inside the Corridor, at least 50% of their species are known associates of M&OG forest including the finches & old world sparrows; thrushes; wood warblers; chickadees, nuthatches & allies-tanagers, cardinals & allies; wrens, kinglets, gnatcatchers, shrikes & vireos; and the woodpeckers (Fig. 2). For the three guilds that are more abundant outside the Corridor, only the birds of prey & foul-like species guild had a high percentage of M&OG forest associates (65%; Fig.2). Two of the three guilds that are more abundant outside the Corridor are composed of birds that are associated primarily with aquatic habitats (Table 2).

Discussion

As a group, the 160 bird species assessed in the northern New York study area were 22.4% more abundant inside compared to outside the A2A Corridor. In addition, all five bird guilds that showed significant differences in abundance between inside and outside the Corridor were more abundant inside the Corridor ranging from 27.0% to 77.1% higher. Finally, the group of birds (66 species) known to be associated with M&OG forests was 30% more abundant inside the Corridor. Associations between many of these bird species and M&OG (or high integrity) forests in regions close to northern New York have also been documented by other studies.

Of the 14 bird guilds in this study, only the woodpeckers included 100% M&OG forest-associated species. In the forests of Poland, Mikusinski et al. (60) also found that woodpeckers are associated with high-integrity forests and that they are useful as indicators of forest bird diversity in general. In addition, associations between woodpecker species observed in the Corridor study area and high-integrity forests have also been documented elsewhere by Webb et al. (61) in northern New York (Yellow-bellied Sapsucker), Villard (62) in eastern Ontario (Hairy Woodpecker), Malcomb et al. (63) in central Ontario (Downey Woodpecker, Hairy Woodpecker, Northern Flicker, Pileated Woodpecker, and Yellow-bellied Sapsucker), and Chadwick et al. (64) in southern New England (Downey Woodpecker and Hairy Woodpecker).

Roughly 72% of the species in the CNTC and WKG guilds (see Fig. 2 for definitions) are M&OG associates in the Corridor study area. Birds in these guilds that were more abundant within the Corridor were also observed as associates of high-integrity forests in northern New York (Winter Wren; 61), eastern Ontario (Scarlet Tanager; 62), central Ontario (Golden-crowned Kinglet, Red-breasted Nuthatch, Ruby-crowned Kinglet; 63), New Hampshire (Winter Wren; 65), and southern New England (Black-capper Chickadee, Brown Creeper, and White-breasted Nuthatch; 64).

Finally, M&OG associates make up 55% of the Wood Warbler guild in this study. Species in this guild with greater abundance inside the Corridor that are also associated with high-integrity forests elsewhere include three Warbler species: Black and White Warbler in eastern Ontario (62); Blackburnian Warbler in northern New York (61), central Ontario (63), and Wisconsin (66); and Black-throated Green Warbler in northern New York (61), eastern Ontario (62), and Wisconsin (66).

Greater abundance within the Corridor of all breeding birds as a group and those associated with M&OG forests in particular is most likely due to more forest cover, older forests, and less habitat fragmentation within the Corridor. Although no direct measure of forest integrity is currently available for the Corridor area, low road and human population densities generally indicate relatively high ecological integrity (67, 58). Outside the Corridor, road density is at least three times greater (68) and human population is at least ten times higher (69). In addition, ~92% of the landscape inside the Corridor is forested – about 10% more than the study area in general.

Based on the results of numerous studies throughout North America, James and Wamer (70) concluded that areas with high tree species richness and canopy height supported the highest density of birds and that conversely, habitats with low tree species richness, low canopy height, and high density of small trees supported the lowest density and species richness of birds. In addition to the loss of forest habitat and conversion to younger forest, anthropogenic activities over the last three centuries have also resulted in the creation of more edge habitat primarily through forest fragmentation. As a result, throughout the deciduous forest biome of North America, populations of birds that utilize forest-edge and grassland habitat have increased enormously and forest interior birds have decreased significantly (71). For example, using bird atlas data for forest-interior birds from more than 4 000 roadside routes representing a gradient of forest fragmentation in New York, Pennsylvania, and Maryland, Boulinier et al. (52) found that increased forest fragmentation at regional scales results in decreased bird species richness, increased rates of local bird species turnover, and higher rates of local extinction of bird species.

In addition to the direct impact of habitat conversion on forest interior bird species, parasitism of their nests, particularly by Cowbirds – a forest-edge species that preys on eggs and nestlings, has also contributed to the decline of many forest-interior species (72). Other nest predators that have increased due to forest fragmentation and more intensive land use include small mammals such as Raccoons and Feral Cats, and egg-eating birds such as American Crows and Blue Jays (73, 74).

Although the guild including birds of prey & foul-like species has a high percentage of M&OG forest associates (65%), its abundance as a group was higher outside the Corridor by 14.7% (but not statistically significant). Given the large home ranges of these large birds, perhaps some of them were sighted along the boundaries of the Corridor, but were recorded as a sighting in a block outside of the Corridor. Due to the low density of roads inside the Corridor resulting in more difficult observer access, this would not be an unusual bias affecting data collection. For example, the Great Horned Owl, which breeds in the study area, has a mean home range of 11.4 km^2/pair (48) and a diameter of almost 4 km for a circular home range. This diameter represents 40% of the width of the Corridor at its narrowest location.

The other two guilds that are more abundant outside the Corridor (differences also not statistically significant) are composed of birds that are associated with aquatic habitats. Representation of wetland ecosystems inside and outside the Corridor differs very little (0.39% higher inside), however, aquatic ecosystems are much more abundant and have greater representation outside the Corridor. In addition, the ~10 km of coastline along the St. Lawrence River inside the Corridor represents only 3.3% of the entire ~300 km Lake Ontario-St. Lawrence River coastline in the study area, whereas the Corridor makes up 5% of the study area.

Although the results of this study show that breeding birds in northwestern New York State are generally more abundant within the A2A Corridor area, future work is needed to undertake similar analyses for other groups of taxa such as mammals, amphibians and reptiles, and vascular plants. In addition, more detailed studies of habitat composition and integrity both inside and outside of the Corridor are needed to better explain differences in species abundance. Finally, studies alone will not secure the future of native species and ecosystems – protected areas, easements, and more ecologically-based resource management will be required to ensure a functional A2A Corridor.

References

1. Diamond, J.M., 1975. The island dilemma: Lessons of modern biogeography and the design of nature reserves. Biological Conservation 7, 129-146.
2. MacClintock, L., Whitcomb, R.F., Whitcomb, B.L., 1977. Evidence for the value of corridors and minimization of isolation in preservation of biotic diversity. American Birds 31, 6-12.
3. Noss, R.F., 1983. A regional landscape approach to maintain diversity. BioScience 33, 700-706.
4. Noss, R.F., 1987. Corridors in real landscapes: A reply to Simberloff and Cox. Conservation Biology 1, 159-164.
5. Bennett, A.F., 1990. Habitat corridors and the conservation of small mammals in a fragmented forest. Landscape Ecology 4, 109-122.
6. Reed, D.F., 1996. Corridors for wildlife. Science 271, 132.
7. Perault, D.R., Lomolino, M.V., 2000. Corridors and mammal community structure across a fragmented, old-growth forest landscape. Ecological Monographs 70, 401-422.
8. Tewksbury, J.J., Levey, D.J., Haddad, N.M., Sargent, S., Orrock, J.L., Weldon, A., Danielson, B.J., Brinkerhoff, J., Damschen, E.I., Townsend, P., 2002. Corridors affect plants, animals, and their interactions in fragmented landscapes. Proceedings of the National Academy of Sciences 99, 12923-12926.
9. Haddad, N.M., Browne, D.R., Cunningham, A., Danielson, B. J., Levey, D.J., Sargent, S., Spira, T., 2003. Corridor use by diverse taxa. Ecology 84, 609-615.
10. Levey, D.J., Bolker, B.M., Tewksbury, J.J., Sargent, S., Haddad, N.M.. 2005a. Effects of landscape corridors on seed dispersal by birds. Science 309, 146-148.
11. Levey, D.J., Bolker, B.M., Tewksbury, J.J., Sargent, S., Haddad, N.M., 2005b. Response to “Landscape corridors: Possible dangers?” Science 310, 782-783.
12. Simberloff, D.S., Cox, J., 1987. Consequences and costs of conservation reserves. Conservation Biology 1, 63-71.
13. Simberloff, D.S., Farr, J.A., Cox, J., Mehlman, D.W., 1992. Movement corridors: Conservation bargains or poor investment? Conservation Biology 6, 493-504.
14. Hess, G.R., 1994. Conservation corridors and contagious disease: A cautionary note. Conservation Biology 8, 256-262.
15. Dunn, C.P., 1996. Response to “Corridors for wildlife”. Science 271, 132-133.
16. Clinchy, M., 1997. Does immigration rescue populations from extinction? Implications regarding movement corridors and the conservation of mammals. Oikos 80, 618-622.
17. Earn, D.J.D., Levin, S.A., Rohani, P., 2000. Coherence and conservation. Science 290, 1360-1364.
18. Hannon, S.J., Schmiegelow, F.K.A., 2002. Corridors may not improve the conservation value of small reserves for most boreal birds. Ecological Applications 12, 1457-1468.
19. Orrock, J.L., Damschen, E.I.., 2005. Corridors cause differential seed predation. Ecological Applications 15, 793-798.
20. Proches, S., Wilson, J.R.U., Veltman, R., Kalwij, J.M., Richardson, D.M., Stellenbosch, S.L., 2005. Landscape corridors: Possible dangers? Science 310, 781-782.
21. Burley, J.B., 1995. International greenways: A Red River Valley case study. Landscape and Urban Planning 33, 195-210.
22. Taylor, J., Paine, C., FitzGibbon, J., 1995. From greenbelt to greenways: Four Canadian case studies. Landscape and Urban Planning 33, 47-64.
23. Bryant, M.M., *In press*. Urban landscape conservation and the role of ecological greenways at local and metropolitan scales. Landscape and Urban Planning.
24. Frischenbruder, M.T.M., Pellegrino, P., *In press*. Using greenways to reclaim nature in Brazilian cities. Landscape and Urban Planning.
25. Bueno, J.A., Tsihrintzis, V.A., Alvarez, L., 1995. South Florida greenways: A conceptual framework for the ecological reconnectivity of the region. Landscape and Urban Planning 33, 247-266.
26. Fleury, A.M., Brown, R.D., 1997. A framework for the design of wildlife conservation corridors with specific application to southwestern Ontario. Landscape and Urban Planning 37, 163-186.

27. Hunter, R.D., Fisher, R.N., Crooks, K.R., 2003. Landscape-level connectivity in coastal southern California, USA, as assessed through carnivore habitat suitability. Natural Areas Journal 23, 302-313.
28. Rottle, N.D., *In press*. Factors in the landscape-based greenway: A Mountain to Sound case study. Landscape and Urban Planning.
29. Toccolini, A., Fumagalli, N., Senes, G., *In press*. Greenways planning in Italy: The Lambro River Valley Greenways System. Landscape and Urban Planning.
30. Dawson, K.J., 1995. A comprehensive conservation strategy for Georgia's greenways. Landscape and Urban Planning 33, 27-43.
31. Forman, D., Dugelby, B., Humphrey, J., Howard, B., Holdsworth, A., 2000. The elements of a wildlands network conservation plan: An example from the Sky Islands. Wild Earth 10, 17-30.
32. Hoctor, T.S., Carr, M.H., Zwick, P.D., 2000. Identifying a linked reserve system using a regional landscape approach: The Florida ecological network. Conservation Biology 14, 984-1000.
33. Long, R., MacKay, P., 2000. Maine wildlands network: A science-informed conservation vision for Maine. Wild Earth 10, 66-74.
34. Noss, R.F., 1999/2000. A reserve design for the Klamath-Siskiyou Ecoregion. Wild Earth 9, 71-76.
35. Quinby, P., Trombulak, S., Lee, T., MacKay, P., Long, R., Lane, J., Henry, M., 2000. Opportunities for wildlife habitat connectivity between Algonquin Provincial Park and the Adirondack Park. Wild Earth 10, 75-80.
36. Beazley, K., Smandych, L., Snaith, T., MacKinnon, F., Austen-Smith, Jr., P.A., Duinker, P., 2005. Biodiversity considerations in conservation system planning: Map-based approach for Nova Scotia, Canada. Ecological Applications 15, 2192-2208.
37. Ryan, R.L., Fabos, J.G., Allan, J.J., *In press*. Understanding opportunities and challenges for collaborative greenway planning in New England. Landscape and Urban Planning.
38. Weber, T., Sloan, A., Wolf, J., *In press*. Maryland's Green Infrastructure Assessment: Development of a comprehensive approach to land conservation. Landscape and Urban Planning.
39. List, R., Manzano-Fischer, P., 2002. Conserving wildlands in Mexico. Wild Earth 12, 46-55.
40. Tan, K.W., *In press*. A greenway network for Singapore. Landscape and Urban Planning.
41. Turner, T., *In press*. Greenway planning in Britain: Recent work and future plans. Landscape and Urban Planning.
42. Yu, K., Li, D., Li, N., *In press*. The evolution of greenways in China. Landscape and Urban
43. Mann, C.C., Plummer, M.L., 1993. The high cost of biodiversity. Science 260, 1868-1871.
44. Soule, M.E., Terborgh, J., 1999. Conserving nature at regional and continental scales – a scientific program for North America. BioScience 49, 809-817.
45. Raimer, F., Ford, T., 2005. Yellowstone to Yukon (Y2Y) – one of the largest international wildlife corridors. Gaia-Ecological Perspectives in Science and Society 14, 182-185.
46. Quinby, P., Trombulak, S., Lee, T., Lane, J., Henry, M., Long, R., 1999. Opportunities for Wildlife Habitat Connectivity between Algonquin Park, Ontario and the Adirondack Park, New York. Unpublished report, the Wildlands Project, Richmond, Vermont.
47. DeGraaf, R.M., Yamasaki, M., Leak, W.B., Lanier, J.W., 1992. New England Wildlife: Management of Forested Habitats. United States Department of Agriculture, Forest Service, General Technical Report NE-144.
48. Hagar, D.C., 1957. The nesting populations of red-tailed hawks and horned owls in central New York State. Wilson Bulletin 69, 263-272.
49. Andrle, R.F., Carroll, J.R., 1988. The Atlas of Breeding Birds in New York State. Cornell University Press, Ithaca, NY.
50. Turner, J.R., Lennon, J.J., Lawrenson, J.A., 1988. British bird species distributions and the energy theory. Nature 335, 539-541.
51. Venier, L.A., McKenney, D.W., Wang, Y., McKee, J., 1999. Models of large-scale breeding-bird distribution as a function of macro-climate in Ontario, Canada. Journal of Biogeography 26, 315-328.
52. Boulinier, T., Nichols, J.D., Hines, J.E., Sauer, J.R., Flather, C.H., Pollock, K.H., 2001. Forest fragmentation and bird community dynamics: Inference at regional scales. Ecology 82, 1159-1169.
53. Titeux, N., Dufrene, M., Jacob, J., Paquay, M., Defourny, P., 2004. Multivariate analysis of a fine-scale breeding bird atlas using a geographical information system and partial canonical correspondence analysis: Environmental and spatial effects. Journal of Biogeography 31, 1841-1856.
54. Shephard, J.M., Catterall, C.P., Hughes, J.M., 2005. Long-term variation in the distribution of the white-bellied sea eagle (*Haliaeetus leucogaster*) across Australia. Australian Ecology 30, 131-145.
55. Virkkala, R., Luoto, M., Heikkinen, R.K., Leikola, N., 2005. Distribution patterns of boreal marshland birds: Modelling the relationships to land cover and climate. Journal of Biogeography 32, 1957-1970.

56. Donald, P.F., Fuller, R.J., 1998. Ornithological atlas data: A review of uses and limitations. Bird Study 45, 129-145.
57. Gaston, K.J., Rodrigues, A.S.L., 2003. Reserve selection in regions with poor biological data. Conservation Biology 17, 188-195.
58. Bishop, J.A., Meyers, W. L., 2004. Associations between avian functional guild response and regional landscape properties for conservation planning. Ecological Indicators 5, 33-48.
59. Sibley, D.A., 2003. The Sibley Field Guide to Birds of Eastern North America. Alfred A. Knopf, New York, NY, 431 pp.
60. Mikusinski, G., Gromadzki, M., Chylarecki, P., 2001. Woodpeckers as indicators of forest bird diversity. Conservation Biology 15, 208-217.
61. Webb, W.L., Behrend, D.F., Saisorn, B., 1977. Effect of logging on songbird populations in a northern hardwood forest. Wildlife Monographs 55.
62. Villard, M., Trzcinski, M.K., Merriam, G., 1999. Fragmentation effects on forest birds: Relative influence of woodland cover and configuration on landscape occupancy. Conservation Biology 13, 774-783.
63. Malcolm, J.R., Campbell, B.D., Kuttner, B.G., Sugar, A., 2004. Potential indicators of the impacts of forest management on wildlife habitat in northeastern Ontario: A multivariate application of wildlife habitat suitability matrices. Forestry Chronicle 80, 91-106.
64. Chadwick, N.L., Progulske, D.R., Finn, J.T., 1986. Effects of fuel-wood cutting on birds in southern New England. Journal of Wildlife Management 50, 398-405.
65. Holmes, R.T., Sherry, T.W., 1988. Assessing population trends of New Hampshire forest birds – local vs. regional patterns. Auk 105, 756-768.
66. Schulte, L.A., Pidgeon, A.M., Maladenoff, D.J., 2005. One hundred fifty years of change in forest bird breeding habitat: estimates of species distributions. Conservation Biology 19, 1944-1956.
67. Trombulak, S.C., Frissell, C.A., 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14, 18-30.
68. DeLorme Mapping Company, 1988. New York State Atlas & Gazetteer. Freeport, Maine.
69. U. S. Census Bureau, 2005. www.census.gov. Washington, D.C.
70. James, F.C., Wamer, N.O., 1982. Relationships between temperate forest bird communities and vegetation structure. Ecology 63, 159-171.
71. Brewer, R., Swander, L., 1977. Life history factors affecting the intrinsic rate of natural increase of birds of the deciduous forest biome. Wilson Bulletin 89, 211-232.
72. Robinson, S.K., Thompson III, F.R., Donovan, T.M., Whitehead, D.R., Faaborg, J., 1995. Regional forest fragmentation and the nesting success of migratory birds. Science 267, 1987-1990.
73. Askins, R.A., 1995. Hostile landscapes and the decline of migratory songbirds. Science 267, 1956-1957.
74. Hansen, A.J., Rotella, J.J., 2002. Biophysical factors, land use, and species viability in and around nature reserves. Conservation Biology 16, 1112-1122.

Table 1. Ecosystem Types in the Proposed A2A Corridor in New York Compared with the Greater Study Area (numbers in parentheses for each column total to 100 as do the numbers in each column that are not in parentheses; adapted from 46)

Ecosystem Types	**Greater Study Area**		**A2A Corridor**		**Difference (%)**
	area (km^2)	**%**	**area (km^2)**	**%**	
Terrestrial Ecosystem Types	18,357	(92.41)	969	(92.73)	0.32
Maple-Beech-Birch Forest	13,876	69.85	940	89.95	20.10
Non-Forested Ecosystems	2,116	10.65	6	0.57	-10.08
Oak-Hickory Forest	848	4.27	11	1.05	-3.22
Spruce-Fir Forest	805	4.05	1	0.10	-3.96
White-Red-Jack Pine Forest	693	3.49	11	1.05	-2.44
Elm-Ash-Cottonwood Forest	19	0.10	0	0.00	-0.10
Wetland Ecosystem Types	987	(4.97)	56	(5.36)	0.39
Forested Wetlands	917	4.62	52	4.98	0.36
Non-Forested Wetlands	70	0.35	4	0.38	0.03
Aquatic Ecosystem Types	521	(2.62)	20	(1.91)	-1.01
Reservoirs	307	1.55	1	0.10	-1.45
Lakes	198	1.00	19	1.82	0.82
Bays and Estuaries	10	0.05	0	0.00	-0.05
Streams, Rivers and Canals	6	0.03	0	0.00	-0.03
Grand Total	19,865	100.00	1,045	100.00	

Table 2. Mean Abundance (Number of Blocks) for each Bird Guild within the Algonquin to Adirondack Wildlife Corridor in New York State Compared to outside of the Corridor (bold = p<.05)

Bird Species Category (n=number of species)	**Inside Corridor (mean no. of blocks/rank)**	**Outside Corridor (mean no. of blocks/rank)**	**% Difference (Inside relative to Outside)**	**t-statistic & probability level**
chickadees, nuthatches & allies; tanagers, cardinals & allies (n=7)	**19.3 (1)**	**10.9 (3)**	**77.1**	**3.22; p=.018**
woodpeckers (n=6)	**18.0 (2)**	**12.0 (1)**	**50.0**	**2.70; p=.043**
others (n=17)	**14.8 (3)**	**11.3 (2)**	**31.0**	**2.76; p=.014**
Icterids (n=7)	11.6 (4)	7.1 (11)	63.4	1.90; p=.106
mature & old-growth forest species (n=66)	**11.4 (5)**	**8.8 (6)**	**29.5**	**3.60; p=.001**
tryant flycatchers (n=9)	11.4 (6)	8.9 (5)	28.1	1.43; p=.191
thrushes (n=6)	10.0 (7)	7.8 (8)	28.2	0.95; p=.387
Emberizine sparrows & allies (n=14)	10.0 (8)	8.6 (7)	16.3	1.20; p=.251
wood warblers (n=20)	**9.4 (9)**	**7.4 (10)**	**27.0**	**2.85; p=.011**
all species (n=160)	**9.3 (10)**	**7.6 (9)**	**22.4**	**4.17; p=.001**
wrens, kinglets, gnatcatchers, shrikes & vireos (n=11)	**8.0 (11)**	**5.2 (13)**	**53.8**	**2.80; p=.019**
wading birds (n=12)	7.7 (12)	10.9 (4)	-29.8	-1.90; p=.085
swallows (n=6)	6.8 (13)	4.7 (14)	44.7	1.17; p=.295
birds of prey & foul-like spp. (n=20)	5.8 (14)	6.8 (12)	-14.7	-1.17; p=.257
finches & old-world sparrows (n=7)	5.4 (15)	4.1 (15)	31.7	0.66; p=.531
ducks, duck-like birds & swimming birds (n=18)	2.3 (16)	2.7 (16)	-14.8	-0.61; p=.550

Figure 1. Four-County Study Area and Proposed A2A Corridor in New York State

Figure 1.

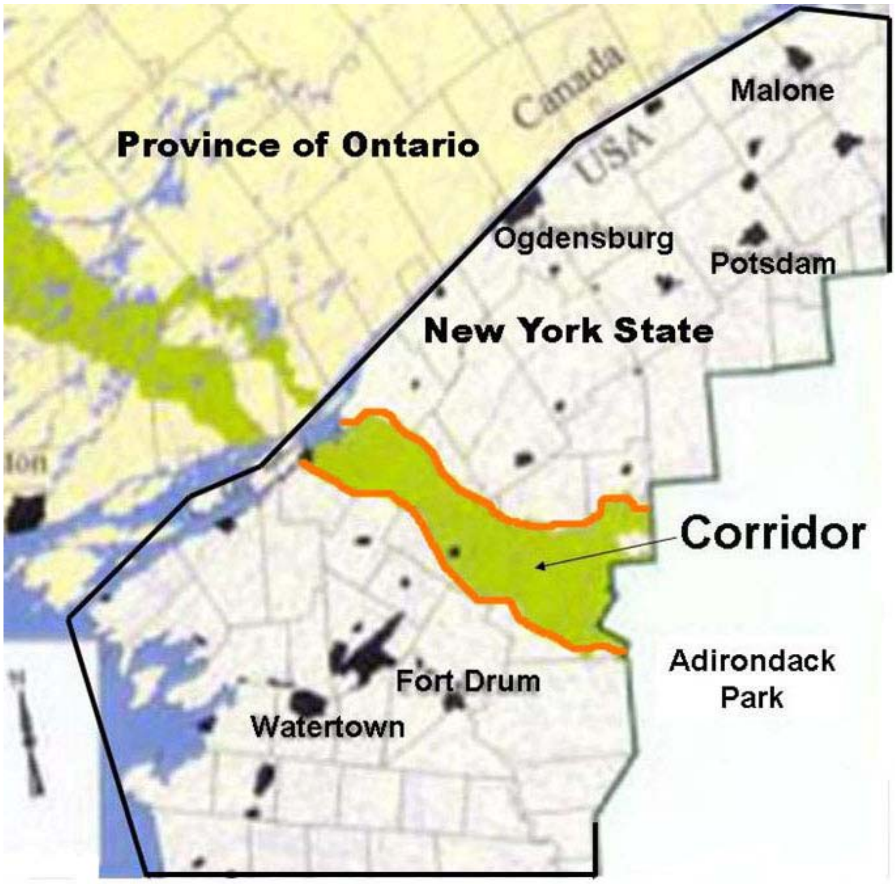

Figure 2. Percentage of Bird Species Associated with Mature and Old-Growth Forests within 14 Bird Guilds in the New York Portion of the A2A Corridor Area (WP-woodpeckers; WKG-wrens, kinglets, gnatcatchers, shrikes & vireos; CNTC-chickadees, nuthatches, tanagers, cardinals, & allies; WW-wood warblers; T-thrushes; FS-finches & old-world sparrows; O-others; TF-tryant flycatchers; S-swallows; I-Icterids; ES-Emberizine sparrows & allies; BPF-birds of prey & foul-like spp.; D&S-ducks, duck-like birds & swimming birds; WB-wading birds; * = p<.05 – see Table 2)