POTENTIAL IMPACTS OF CLIMATE CHANGE ON THE SUMMER DISTRIBUTIONS OF NEW YORK'S PASSERINE BIRDS

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Introduction

Water vapor, carbon dioxide (CO2), methane, and other trace gases in the Earth's atmosphere act much like the glass in a greenhouse, helping to retain heat by trapping and absorbing infrared radiation. This "greenhouse effect" acts to keep the Earth's surface temperature significantly warmer than it would otherwise be, allowing life, as we know it, to exist. However, since pre-industrial times, there have been significant increases in the amount of these greenhouse gases in the atmosphere. The current levels of the two primary greenhouse gases are now greater than at any time during at least the past 420,000 years and are well outside of the bounds of natural variability (IPCC 2001).

Accompanying the increases in greenhouse gases has been an increase in temperature. The annual global mean temperature is now 1.1°F (0.6°C) above that recorded at the beginning of the century. Limited data from other sources indicates that the global mean temperature for the 20th century is at least as warm as any other period since approximately 1400 AD (IPCC 1996, 2001). And, ***"There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities"*** (IPCC 2001). These activities include the burning of fossil fuels, increases in agriculture and other land use changes (such as deforestation).

Increases in greenhouse gases (past and projected), coupled with the length of time these gases remain in the atmosphere are expected to cause a continued increase in global temperatures. Models based on various scenarios for population growth, economic well being, improvements in technology, and fossil fuel use project annual average temperature increases in New York of 7-13°F (3.9-7.2°C) in winter and 7-14°F (3.9-7.8°C) in summer by 2100 (Kling et al. 2003).

"Recent regional changes in climate, particularly increases in temperature, have already affected hydrological systems and terrestrial and marine ecosystems in many parts of the world" (IPCC 2001). For example, there have been changes in growing season, earlier spring green-up and earlier arrival and breeding in some birds (Root et al. 2003). The global average sea level has risen by 4-8 inches due to a combination of thermal expansion of the oceans and melting of land ice (IPCC 2001). If these changes have been observed with only a small rise (1°F) in the global average temperature, what might happen if temperatures continue to rise? In addition to rising temperatures, many climate

models also project an overall increase in evaporation - leading to increases in precipitation (mostly in storms) but also to overall declines in soil moisture. Shifts in the timing of precipitation and snowmelt are also possible. Even after emissions are reduced, CO_2 concentrations, temperature and sea level will all continue to rise for a period ranging from decades/centuries (CO_2 stabilization, temperature rise) to millennia (sea-level rise). Thus, climate change will likely have a continuing impact on New York's birds and their habitats.

Projected habitat changes

As the climate changes so will plant and animal distributions. In general, the geographic range of North American plants and animals will tend to shift poleward and/or upwards in elevation in response to temperature changes. It is very unlikely that plant and animal species will respond in the same manner to climate change. The best available evidence from paleoclimatic studies, models and observations suggests that each plant and animal species will move independently. Thus, communities as we now know them will look different in the future. Indeed, there is evidence indicating that many ecosystems have already begun to change in response to observed climatic changes (Root et al. 2003).

Thus, there could potentially be major changes in the suitable climates of many vegetative communities in New York occurring over the next 75-100 years. Models estimate that climate suitable for maple-beech-birch forests will potentially become more suitable for oak-hickory forests (NAST 2000). Models also project the potential complete loss of species like balsam fir, red pine, northern white cedar and bigtooth aspen; potential major declines in the extent of eastern white pine, sugar maple, paper birch, and quaking aspen; and potential eventual gain or spread of species like Virginia and shortleaf pine, flowering dogwood and yellow poplar (Iverson et al. 1999).

As many tree species are long-lived and migrate slowly it could potentially take decades to centuries for species in some vegetative communities to be replaced by others (Davis and Zabinski 1992). However, as increased temperatures and drought stress plants they become more susceptible to fires and insect outbreaks. These disturbances could play a large role in the conversion of habitats from one type to another. There could very well be instances where existing plant communities are lost to disturbance but climatic conditions and migration rates limit the speed at which they are replaced. Thus, invasive species, grasslands and shrublands may transitionally replace some of these areas.

Projected changes in bird distributions

Summer bird ranges are often assumed to be tightly linked to particular habitats. This generalization is only partially true. While certain species are usually only found in specific habitats (e.g., Kirtland's Warbler breeding in jack pines), others are more flexible in their habitat use. Species found in a particular habitat type throughout their summer range may not be found in apparently equivalent habitat north or south of their current distribution. Birds are also limited in their distributions by their physiology and food availability. The link between physiology and the winter distributions of many species is well-established (Kendeigh 1934, Root 1988a, 1988b). Research shows that physiology plays a role in limiting summer distributions as well (Dawson 1992, T. Martin, *pers. comm.*). Often, the choice of a specific habitat may actually be to provide a microclimate suitable for a species' physiology. While habitat selection, food availability, and competition may all play a role in influencing *local* distributions of a given bird species, looking at a species' overall distribution often yields different results. This study examined the association between summer bird distributions and climate and how these distributions may change with a changing climate.

Methods

To determine how the summer ranges of birds may actually change, logistic regression models were developed associating bird distributions (from Breeding Bird Survey data) with climate (both temperature and precipitation). The climate variables acting as surrogates for the many factors possibly limiting a species distribution (e.g., physiology, habitat, food availability). One way of determining how 'accurate' these models are is to compare how well the predicted species distribution map based on climate (Fig. 1B) matches a map of the actual distribution (Fig. 1A) based on similar bird data (Price *et al.* 1995). This comparison (and various statistical tests) indicated that at least a portion of the summer distributions of many North American birds could be modeled accurately based on climate alone. These models were then coupled to output from the Canadian Climate Center (CCC) based on a doubling of atmospheric CO2. This model projects what the average climatic conditions may look like sometime in the next 75 to 100 years. These combined models were then used to create maps (cf. Fig. 1C) of the projected summer distributions of many North American passerine birds. A more complete explanation of methods used to develop the models and maps has been published elsewhere (Price 1995, Price *in press*).

What the maps developed in this study show are areas projected to have the proper climate for the species, or climatic range, under conditions derived from the CCC model. While the results of the models cannot be used to look at the fine points of how a given species' distribution might change, they can provide an impression of the possible direction and potential magnitude of the change in the suitable climate for the species. These maps of projected summer climatic ranges of birds were then compared with the maps and information found in *Atlas of Breeding Birds of New York State* (Andrle and Carroll 1988) to determine how New York's avifauna might change under this climate change scenario.

Results

Species whose future climatic summer ranges might exclude New York (i.e., possibly extirpated as summer residents) – Olive-sided Flycatcher, Yellow-bellied Flycatcher, Alder Flycatcher, Willow Flycatcher, Least Flycatcher, Blueheaded Vireo, Philadelphia Vireo, Bank Swallow, Cliff Swallow, Boreal Chickadee, Red-breasted Nuthatch, Winter Wren, Golden-winged Warbler, Tennessee Warbler, Nashville Warbler, Magnolia Warbler, Cape May Warbler, Yellow-rumped Warbler, Black-throated Green Warbler, Blackburnian Warbler, Bay-breasted Warbler, Northern Waterthrush, Mourning Warbler, Hooded Warbler, Wilson's Warbler, Canada Warbler, Clay-colored Sparrow, Lincoln's Sparrow, White-throated Sparrow, Dark-eyed Junco, Rusty Blackbird, Purple Finch, Pine Siskin and Evening Grosbeak.

Species whose future climatic summer ranges in New York might contract – Warbling Vireo, Tree Swallow, Black-capped Chickadee, House Wren, Gray Catbird, Blue-winged Warbler, Northern Parula, Yellow Warbler, Chestnut-sided Warbler, Black-throated Blue Warbler, Black-and-white Warbler, American Redstart, Ovenbird, Scarlet Tanager, Vesper Sparrow, Savannah Sparrow, Song Sparrow, Swamp Sparrow, Rose-breasted Grosbeak and Bobolink.

Species whose future climatic summer ranges in New York might expand – Acadian Flycatcher, Loggerhead Shrike, White-eyed Vireo, Purple Martin, Northern Rough-winged Swallow, Tufted Titmouse, Carolina Wren, Northern Mockingbird, Yellow-throated Warbler, Pine Warbler, Prairie Warbler, Cerulean Warbler, Prothonotary Warbler, Louisiana Waterthrush, Kentucky Warbler, Yellow-breasted Chat, Grasshopper Sparrow, Northern Cardinal, Blue Grosbeak

Species whose future climatic summer ranges might eventually include New York – Scissor-tailed Flycatcher, Bell's Vireo, Carolina Chickadee, Brown-headed Nuthatch, Summer Tanager, Dickcissel and Great-tailed Grackle.

Discussion

These lists are not all-inclusive, since results obtained from models of some species were not adequate to assess how their climatic ranges might change. Nor do the lists include those species whose climatic ranges in New York may undergo little change. Finally, these lists are based on output from a single commonly used climate model - different climate models may yield different results. In addition, the geographic scale of these models, like those of the underlying climate change model, is relatively coarse. As such, the models are unable to take into account localized topographic changes and the possible existence of suitable microclimates (e.g., along rivers or on north-facing mountain slopes). Even so, both the climate and bird models are able to differentiate the Adirondacks from the surrounding area. Therefore, some of the species whose *climatic* ranges are projected as shifting out of New York may be able to persist in small areas that may retain suitable microclimates such as deep canyons on the north slope of the Adirondacks.

How quickly distributional changes might occur is unknown - the rate of change will largely depend on whether limits to a given species' distribution are more closely linked with physiology (via climate), vegetation, or some other factor. The rate of change will also likely be tied to the rate of change of the climate itself. If the climate changes relatively slowly, then species may be able to adapt to the new climate. However, many changes could occur (and are occurring) relatively quickly. One pilot study found that the average latitude of occurrence of some species of Neotropical migrants has already shifted significantly farther north in the last 20 years, by an average distance of almost 60 miles (100 km) (Price and Root 2001; Price, unpublished data). Other studies have found that many other species are arriving and breeding earlier, not only in the US but also in Europe and elsewhere (Root *et al.* 2003).

Conclusion

Projected future rapid climate change is of major concern, especially when viewed in concert with other population stresses (e.g., habitat conversion, pollution, invasive species). Research and conservation attention needs to be focused not only on each stressor by itself, but also on the synergies of multiple stressors acting together. These synergistic stresses are likely to prove to be the greatest challenge to wildlife conservation in the 21st Century. Because anticipation of changes improves the capacity to manage, it is important to understand as much as possible about the responses of animals to a changing climate.

In summary, a high probability exists that even a small amount of climate change could lead to changes in bird distributions within the state. Some of these changes could occur (and may be occurring) relatively quickly. While these changes may have some ecological and, possibly, economic effects, the magnitude of these effects is unknown. Ultimately, the greatest impact on wildlife and vegetation may not come from climate change itself, but rather from the rate of change. Given enough time, many species would likely be able to adapt to climatic shifts, as they have done in the past. However, the current projected rate of warming is thought to be greater than has occurred at any time in the last 10,000 years (IPCC 1996). This rate of change could ultimately lead to many changes in New York's avifauna.

Birders can help the scientist look for and document changes in bird ranges and populations. Besides participating in regular events like the Breeding Bird Survey or Christmas Bird Count, information is also needed on nesting, arrival and departure. If you, or your club, has 10 or more years of data please contact me at the address listed above.

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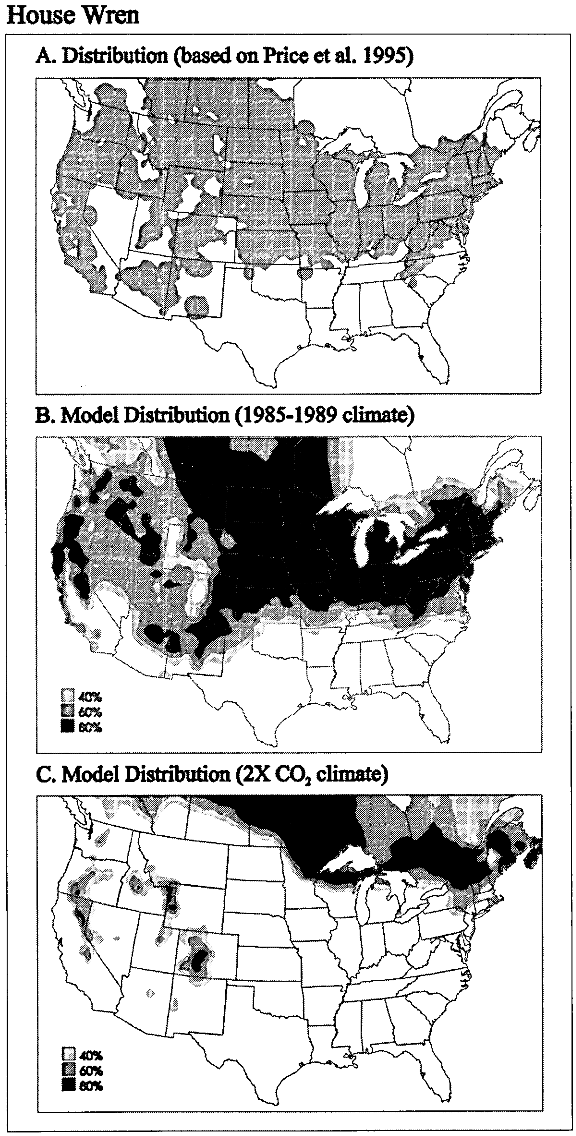
Figure 1. A. Map depicting the distribution of House Wren as detected by the Breeding Bird Survey. This map is based on one found in Price et al. (1995). B. Map depicting a model of the distribution of House Wren based solely upon the climate of 1985-1989. The scale represents the probability of the species' occurrence with shaded areas depicting the distribution of the species (i.e., areas with suitable climate). C. Map depicting the possible distribution of House Wren under the doubled CO2 climate conditions projected by the CCC. The scale represents the probability of the species' occurrence - shaded areas depicting the distribution of the species (areas with suitable climate for the species).



Literature Cited

Andrle, R. F., and J. R. Carroll, eds. 1988. Atlas of Breeding Birds in New York State. Cornell University Press, Ithaca, NY.

Davis, M.B. and C. Zabinski. 1992. Changes in geographical range resulting from greenhouse warming: effects on biodiversity in forests. Pp. 297-308 in R. L. Peters and T. E. Lovejoy. Global Warming and Biological Diversity. Yale University Press, New Haven, CT.

Dawson, W. R. 1992. Physiological responses of animals to higher temperatures. Pp. 158-170 in R. L. Peters and T. E. Lovejoy. Global Warming and Biological Diversity. Yale University Press, New Haven, CT.

[IPCC] Intergovernmental Panel on Climate Change. 1996. Summary for Policymakers. Pp. 3-7 in J.T. Houghton, L.G. Meira Filho, B.A. Callander, N. Harris, A Kattenberg and K. Maskell, eds. Climate Change 1995: The Science of Climate Change. Cambridge University Press, Cambridge, England.

IPCC. 2001. Climate Change 2001: Synthesis report. R.T. Watson (editor). Cambridge University Press, Cambridge, England.

Iverson, L. R., A. M. Prasad, B. J. Hale and E. K. Sutherland. 1999. Atlas of Current and Potential Future Distributions of Common Trees of the Eastern United States. General Technical Report NE-265. U.S.D.A. Forest Service, Northeastern Research Station, Delaware, OH.

Kendeigh, S. C. 1934. The role of environment in the life of birds. Ecological Monographs 4: 297-417.

Kling, G. W., K. Hayhoe, L. B. Johnson, J. J. Magnuson, S. Polasky, S. K. Robinson, B. J. Shuter, M. M. Wander, D. J. Wuebbles, D. R. Zak, R. L. Lindroth, S. C. Moser, and M. L. Wilson. 2003. Confronting Climate Change in the Great Lakes Region: Impacts on Our Communities and Ecosystems. Union of Concerned Scientists, Cambridge, MA and Ecological Society of America, Washington, DC.

[NAST] National Assessment Synthesis Team. 2000. Climate Change Impacts on the United States: The potential consequences of climate variability and change. Cambridge University Press, Cambridge, UK.

Price, J. T. In press. Potential Impacts of Climate Change on the Summer Distributions of Some North American Grassland Birds. U.S.G.S. Technical Report.

Price, J. T. 1995. Potential Impacts of Global Climate Change on the Summer Distributions of Some North American Grassland Birds. Ph.D. Dissertation, Wayne State University, Detroit, MI.

Price, J. T. and T. L. Root. 2001. Climate change and Neotropical migrants. Transactions of the 66th North American Wildlife and Natural Resources Conference pp. 371-379.

Price, J., S. Droege and A. Price. 1995. The Summer Atlas of North American Birds. Academic Press, San Diego, CA.

Root, T. L. 1988a. Environmental factors associated with avian distributional boundaries. Journal of Biogeography 15: 489-505.

Root, T. L. 1988b. Energetic constraints on avian distributions and abundances. Ecology 69: 330-339.

Root, T. L., J. T. Price, K. R. Hall, S. H. Schneider, C. Rosenzweig and J. A. Pounds. 2003. Fingerprints of global warming on animals and plants. Nature 421: 57-60.