The Effects of Climate Change on Terrestrial Birds of North America

Synthesis

David King, U.S. Forest Service, Northern Research Station Center for Research on Ecosystem Change, University of Massachusetts, Amherst, Massachusetts

Deborah M. Finch, U.S. Forest Service, Rocky Mountain Research Station, Grassland, Shrubland, and Desert Ecosystems Program; Forestry Sciences Laboratory, Albuquerque, New Mexico

Previous (2008) versions of this paper are **available here**.

Issues

A discussion of avian responses to climate change is of interest for a number of reasons. First, because birds are relatively easy to identify and measure and their responses to environmental perturbation are relatively well known, they are useful as indicators of ecological change (1). Furthermore, birds are of conservation interest in their own right. Bird populations face global conservation challenges, with 1 in 8 species facing a high risk of extinction in the near future according to a recent report (2). Finally, birds perform significant ecosystem services with consequences for human health and well-being, including pest control, sanitation, seed dispersal and pollination (3).

The gray jay is a montane and boreal specialist, and could be particularly sensitive to climate change because it caches food using frozen spit. Credit: Bill DeLuca

Climate can interact with other factors to threaten the sagebrush habitat needed several species, such as the greater sage grouse. Credit: USFWS Pacific Southwest Region.

Recent declines of montane spruce-fir indicator species on the White Mountain National Forest highlight concerns about montane bird species under climate change. Credit: Bill DeLuca.

Invasive plants like cheatgrass can negatively affect birds that are dependent on sagebrush habitat by altering fire behavior in those ecosystems. These interactions can be exacerbated by clima

-
- **Grey Jay**
- **Greater Sage Grouse**
- **Montane birds**
- **Cheatgrass & Sagebrush**

Likely Changes

Research on birds has shown that climate change affects birds both directly and indirectly. The distributions of birds are closely associated with both winter and summer temperatures, and increased temperatures due to climate change may directly affect birds by forcing them to use more energy for thermoregulation. This can disrupt their maintenance (the energy needed by organisms to maintain their basal levels of activity and condition) , reproduction, timing of breeding and migration, and reduce survival or fitness (4). Birds may respond to these costs by shifting their ranges over time to areas with more suitable thermal conditions, but habitat and other resources may be insufficient or unsuitable for their needs (5).

Generally speaking, global temperatures decrease with increased latitude and elevation, so a fundamental prediction of climate scientists is that species will shift towards the poles and upward in elevation (6; 7). Long-term changes in North American bird distributions show clear evidence of latitudinal shifts, with many species shifting their geographic distributions northwards over the past few decades (8, 9). Elevational shifts have also been reported in long-term datasets, and these shifts appear to implicate changes in precipitation as well as temperature. In the Sierra Nevada mountains, data show that the majority of species ranges have shifted upwards in elevation since the 1940s, with some bird species more closely associated with temperature shifts and others with changes in precipitation (10).

Climate-related shifts in species distribution along latitudinal and elevation gradients have important implications for conservation. If shifts in temperature take place at a more rapid rate than vegetation responses, or occur beyond the boundaries of suitable potential vegetation, then bird populations could be forced into areas of marginal habitat where they are likely to experience decreased survival and reproduction (4). With elevational shifts, the area available for species to colonize as ranges shift upwards also decreases with elevation (11). For this reason, montane species are considered to be especially vulnerable to climate change. This concern is highlighted by recent evidence of declines of montane spruce-fir indicator species on the White Mountain National Forest, including the threatened Bicknell's Thrush (Catharus bicknelli; 12). Analyses of these same data also show an upward shift of bird species from lower forest areas into montane forest, which is consistent with general observed patterns that show middle elevation species shifting upwards (13).

In contrast to expectations, DeLuca (13) also reported that the montane spruce-fir bird species that occupy the forests nearest tree line are actually shifting downwards in elevation. This might at first seem like a cause for optimism, since there is more area at lower elevations, and thus montane bird ranges would not be constricted at the lower end of an elevational gradient. A more detailed analysis however indicates that lower elevations are marginal habitats for montane birds where they experience lower pairing and nesting success, and therefore lower reproductive success. These results demonstrate some important aspects of climate change research: they contradict the prevailing paradigm that species will respond to climate change by shifting their ranges towards higher elevations, and they highlight the necessity of considering aspects of fitness as well as the distribution of organisms in relation to climate change, because shifts might not be adaptive.

In addition to these direct effects, increased temperatures associated with climate change have the potential to cause a myriad of indirect effects.. One of the most widely reported is the de-synchronization of migrant bird reproduction with food resources. Many bird species synchronize their nesting cycle so the period of maximum food requirements of the young coincides with the maximum food availability (14). In the case of migratory birds, which comprise the majority of species and individuals in many temperate ecosystems, their departures from winter areas are related to photoperiod, whereas the availability of their largely insect food resources is affected by plant phenology. Since plant phenology is related to climate and is advancing in most regions, migratory bird species are in some cases arriving and therefore breeding too late to keep pace with the timing of their food supply (15).

Other indirect effects are mediated by changes in the types and timing of disturbance. In parts of the western U.S., climate change is manifested by drought conditions that increase the frequency and severity of wildfires. These disturbances can impact birds directly by destroying nests and altering habitats. For example, in the Great Basin the effects of drought on fire regimes is compounded by the invasion of cheatgrass (*Bromus tectorum*), an exotic species introduced from Eurasia. Cheatgrass is more flammable than native grasses, and as drought conditions increase, fire frequency and severity increases and plant species adapted for less severe fire regimes are replaced by cheatgrass, which further increases extreme fire behavior. The synergistic effects of climate, fire and invasion are blamed for loss and fragmentation of big sagebrush habitats needed by sagebrush obligates like sage thrasher (*Oreoscoptes montanus*) sage sparrow (*Amphispiza belli*), and greater sage-grouse (*Centrocercus urophasianus*), a candidate species for listing under the Endangered Species Act (16). West Nile virus models also show climate's influence in this region, predicting disease spread to more western locations and states. This could impact vulnerable birds like the greater sage-grouse, which withdraws during droughts to water sources where it can be infected by mosquitos potentially carrying the virus. Finally, studies of high elevation birds in Arizona show that lower snowpack associated with climate change allows greater access to montane areas by elk, and recent declines in several species of migratory songbirds could be the result of decreased reproductive success resulting from habitat degradation from over-browsing (17).

There have been dramatic changes in global climate before, however the current challenge to species and ecosystems from climate is not only the degree of change but the rate. Rapid changes in environmental conditions are likely to exceed the ability of many bird species to adapt via natural selection (18). This concern has led to increased interest in identifying species characteristics associated with vulnerability to climate change (19). In addition to the examples presented above showing that montane and western grassland species are negatively affected, analyses of data from the Breeding Bird Survey are underway to determine whether traits like migratory status, clutch size or geographic range affect the vulnerability of bird species to climate change, as indicated by elevational and latitudinal shifts in their distributions (20). Because responses to climate change are largely species-specific it is expected that species will recombine into novel communities, which could present additional challenges as species are exposed to predators or competitors for whom they have no evolved defenses (21).

Management Options

Strategies to mitigate the impacts of climate change on bird populations include maintaining the resilience of their habitats by reducing compound stressors that potentially interact with climate change and magnify its impact. The effect of cheatgrass on fire regimes mentioned above is an example that illustrates the potential compounding effects of invasives. Other examples include habitat fragmentation and pollution. Where necessary, habitat resilience can be increased through active management, which can maintain robust growth and reproduction of native plants to mitigate the impacts of drought, heat stress and other climate-related effects (22). Other strategies to mitigate the effects of climate change include increasing the area of protected lands to include greater representation of habitat refugia, where species are predicted to be buffered from the effects of climate change because of site characteristics. Establishing and maintaining habitat connectivity among preserves and along elevational and latitudinal gradients by establishing corridors or networks of preserves could also facilitate shifts by climate-sensitive species (23).

Projects are underway nationwide to enhance resiliency through habitat improvement of ecosystems considered susceptible to climate change. For example, the Central Appalachian Spruce Restoration Initiative is a multi-partner collaboration of individuals and organizations who share the common goal of restoring the red spruce-northern hardwood ecosystem across the high elevation landscapes of Central Appalachia. The US Forest Service is a key player in this initiative, and recent accomplishments include planting, silvicultural treatments and removal of exotic species to enhance spruce regeneration, as well as reforestation and habitat acquisition to reduce fragmentation. These efforts will help priority species within this threatened ecosystem to withstand the effects of climate change or shift their range to track suitable climate conditions. Similar practices are being embraced by National Forests in their forest plan revisions. For example, the Kaibab National Forest in Arizona implements fuels control treatments and mechanical thinnings in an attempt to reduce the risk of pest and disease outbreaks and catastrophic wildfire, all of which are expected to increase with continued climate change.

References Cited

1. Niemi, G. J.; McDonald, M. E. 2004. **Application of Ecological Indicators. Annual Review of Ecology, Evolution, and Systematics.** 35: 89-111.
2. Vié, J.-C., Hilton-Taylor, C.; Stuart, S.N. (eds.) (2009). **Wildlife in a Changing World – An Analysis of the 2008 IUCN Red List of Threatened Species.** Gland, Switzerland: IUCN. 180 pp.
3. Sekercioglu, C.H; Daily, G.C; Ehrlich, P.R. 2004. **Ecosystem consequences of bird declines. Proceedings of the National Academy of Sciences of the United States of America. 101:**18042–18047.
4. Crick, H. Q. P. 2004. **The impact of climate change on birds.** Ibis. 146:48-56.

5. Devictor, V.; Julliard, R.; Couvet, D.; Jiguet, F. 2008. **Birds are tracking climate warming, but not fast enough. Proceedings of the Royal Society B.** 275: 2743–2748.
6. Rodenhouse, N. L.; Matthews, S. N.; McFarland, K. P.; Lambert, J. D.; Iverson, L. R.; Prasad, A.; Sillett, T. S.; Holmes, R. T. 2008. **Potential effects of climate change on birds of the Northeast. Mitigation and adaptation strategies for global change** 13:517–540.
7. Matthews, S.N.; Iverson, L. R.; Prasad, A. M.; Peters, M. P. 2011. **Changes in potential habitat of 147 North American breeding bird species in response to redistribution of trees and climate following predicted climate change.** Ecography. 34: 933-945.
8. Hitch, A. T.;Leberg, P. L. 2007. **Breeding distributions of North American bird species moving north as a result of climate change. Conservation Biology**. 21:1523-1739.
9. LaSorte, F. A.; Thompson, F. R. III. 2007. **Poleward shifts in winter ranges of North American birds.** Ecology. 88:1803-1812.
10. Tingley, M. W.; Monahan, W. B.; Beissinger, S. R.; Moritz, C. 2009. **Birds track their Grinnellian niche through a century of climate change. Proceedings of the National Academy of Sciences.** 106:19637-19643.
11. Sekercioglu, C.H.; Schneider, S.H.; Fay, J.P.; Loarie, S.R. 2008. **Climate Change, Elevational Range Shifts, and Bird Extinctions.** Conservation Biology. 22: 140–150.
12. King, D. I.; Lambert, J. D.; Buonaccorsi, J. P.; Prout, L. S. 2008. **Avian population trends in the vulnerable montane forests of the Northern Appalachians, USA.** Biodiversity and Conservation. 17:2691–2700.
13. DeLuca, W.V. 2012. Ecology and conservation of the high elevation forest avian community in northeastern North America. Doctoral Dissertation, University of Massachusetts, Amherst.
14. Visser, M.E.; Holleman, L.J.M.; Gienapp, P. 2006. **Shifts in caterpillar biomass phenology due to climate change and its impact on the breeding biology of an insectivorous bird.** Oecologia. 147: 164–172.
15. Both, C.; Visser, M.E. 2001. **Adjustment to climate change is constrained by arrival date in a long-distance migrant bird.** Nature.411: 296–298.
16. Finch, D. M. 2012. **Climate change in grasslands, shrublands, and deserts of the interior American West: a review and needs assessment**. Gen. Tech. Rep. RMRS-GTR-285. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 139 p.
17. Auer, S. K.; Martin, T. E. 2013. **Climate change has indirect effects on resource use and overlap among coexisting bird species with negative consequences for their reproductive success**. Global Change Biology. 19:411-419.
18. Visser, M.E. 2008. **Keeping up with a warming world; assessing the rate of adaptation to climate change.** Proceedings of the Royal Society B. 275: 649–659.
19. Cormont, A.; Vos, C.C.; van Turnhout, C.A.M.; Foppen, R.P.B.; ter Braak, C.J.F. 2011. **Using life-history traits to explain bird population responses to increasing weather variability**. Climate Research. 49: 59–71.
20. *Auer and King, In review*
21. Lurgi, M.; López, B. C.; Montoya, J. M. 2012. **Novel communities from climate change. Philosphical Transactions of the Royal Society** B. 367:2913-2922.
22. Millar, C. I.; Stephenson, N. L.;Stephens, S. L. 2007. **Climate change and forests of the future: managing in the face of uncertainty.** Ecological Applications. 17:2145–2151.
23. Mawdsley, J.R.; O'Malley, R.; Ojima, D.S. 2009. **A review of climate□change adaptation strategies for wildlife management and biodiversity conservation**. Conservation Biology. 23: 1080-1089.

Recommended Citation

King, D.; Finch, D.M. 2013. **The Effects of Climate Change on Terrestrial Birds of North America**. (June, 2013). U.S. Department of Agriculture, Forest Service, Climate Change Resource Center.