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Global Climate Change and Wildlife

Pervaze A. Sheikh
Analyst in Natural Resources and Environmental Policy
Resources, Science, and Industry Division

M. Lynne Corn, Jane A. Leggett, and Peter Folger
Specialists in Natural Resources and Environmental Policy
Resources, Science, and Industry Division

Summary

Recently projected climate changes could have widespread effects on wildlife species. These effects may include extinctions, changes in species' ranges, mismatches in their phenologies (timing of pollination, flowering, etc.), and population declines. Other species could flourish in response to projected climate change. Effects of climate change on wildlife have been reported for some species and populations in localized areas. Many studies also show that climate change acts in concert with other variables to effect changes in species. If climate change is widespread, there is uncertainty on how wildlife will adapt. Some suggest that evolution and migration will enable species to adapt, whereas others contend that adaptation will be minimal because of limited habitat and changes in climate that may occur more rapidly than adaptation can respond.

Introduction

Climate change can have major repercussions for ecological systems, as indicated by past major climate shifts. Effects of climate change are sometimes local, although some may be widespread and linked to changes in other regions through food chains, nutrient flows, and atmospheric and ocean circulation, among other things. Some populations and species could flourish as the environment changes, whereas others could decline. Some species would probably be able to adapt or adjust their ranges to stay within a hospitable habitat. Others may be affected by obstacles to migration, disruptions in food chains, or habitat alteration or loss.

Wildlife species can be affected by several climatic variables such as increasing temperatures, changes in precipitation, and extreme weather events. Some scientists predict that climate change can cause extinctions, which would lower biodiversity. Other scientists contend that many species could benefit from climate change, such as some migratory bird species which may have shorter distances to migrate for breeding and over-wintering.[1]

The impacts of regional climate change and extreme weather on wild species has been studied for several decades.[2] Paleoclimatic studies have shown that species have adjusted to climate changes at times in the past without mass extinctions.[3] Yet, it is uncertain if projected climate change widely foreseen today would mimic climate change events in the geological record, and if human-ecosystem relationships would help or hurt adaptation. In the last ten years, scientists have documented the effects of climate change on species and populations on every continent and in most taxonomic groups.[4] Some studies provide correlations between climate change and species changes, others predict changes with climate and species models, and some demonstrate mechanistic connections between species changes and climate change.[5] Many studies report that climate change acts in concert with other factors to affect species and their habitat. For this reason, and because of differences across biomes and species, it is difficult to generalize about the overall impacts of climate change on biodiversity, wildlife, and ecosystems.

In discussing the effects of climate change on wildlife, some contend that climate change may not be bad for species overall, even if some go extinct. They reason that because biodiversity is greatest in tropical zones, biodiversity may benefit by warming and greater precipitation. Further, they argue that climate change may induce species to evolve behaviors or traits that will allow them to adapt to different conditions.[6] Others counter these arguments by stating that climate change may be too rapid for species to evolve. Scientific studies show that climate change affects species in different ways, yet the message that these studies convey may be biased because studies that show no changes in species due to climate change are less likely to be published.[7] With monitoring, research, and modeling, the responses of populations, species, landscapes and ecosystems to climate change may be predicted more reliably, but the complexity of living systems and the lack of long-term data make this task difficult.

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[1] R.A. Robinson, et al. *Climate Change and Migratory Species*, British Trust for Ornithology (Norfolk, UK: 2005), 304 p.

[2] Camille Parmesan, "Ecological and Evolutionary Responses to Recent Climate Change," *Annual Review of Ecology, Evolution, and Systematics*, vol. 37 (2006): 637-669. Hereafter referred to as *Parmesan 2006.*

[3] Isabel P. Montanez, et al., "CO_2-Forced Climate and Vegetation Instability During Late Paleozoic Deglaciation," *Science*, vol. 315, no. 5808 (2007): 87-91.

[4] *Parmesan 2006.*

[5] T. Root, et al., Fingerprints of Global Warming on Wild Animals and Plants, *Nature*, vol. 421(2003): 57-60.

[6] A.C. Baker et al., Corals Adaptive Response to Climate Change, *Nature*, vol. 430 (2004): p. 741.

[7] See *Parmesan 2006* for a discussion on this issue.

Climate Change Affecting Wildlife

Climate change producing higher temperatures may affect wildlife by causing species to expand, contract, or shift their ranges, typically toward the poles or higher elevations.[8] It may alter their phenologies,[9] leading to mismatches with their food and habitat resources. It may also cause habitat loss, and allow exposure to new pathogens. These changes could have either negative or positive effects on the abilities of species to survive. The abilities of species to adapt to some degree of climate change depends, in part, upon the rate at which the change occurs. The following sections of this report provide examples of wildlife that are thought to be, in part, affected by climate change. Examples were taken from published studies with appropriate citations. The examples illustrate the types of changes that have been observed.

Range Shifts. There are few studies that report the effects of climate change over an entire species' range, partly because of the difficulties of gathering data throughout its range and for a period sufficient to produce significant results.[10] Even so, range shifts have been documented in some species of birds and insects, and in some marine communities. One example is the mountain pine beetle (*Dendroctonus ponderosae*). The mountain pine beetle feeds primarily on lodgepole pine,[11] and occasionally on other species including whitebark pine (*Pinus albicaulis)*.[12] Until recent decades, the beetle has been held in check at higher elevations by its inability to complete a full life cycle during the short growing season. Research shows that, with warming, the beetles are becoming able to complete a full reproductive cycle within one year in whitebark pine habitat.[13] As a result, they can time their breeding cycle to produce huge numbers of eggs whose emerging larvae can overwhelm the defenses not only of damaged trees but also of healthy ones. The beetles' expansion correlates closely with local warming data. This beetle is reported to be moving up mountains, and also northward into Canada where it is occupying some forest stands for the first time in recorded history.

Phenological Changes. Phenological cues are critical in the life cycles of many species. When global warming alters the climate, certain phenological events generally

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[8] L. Hannah, T. E. Lovejoy, and S. H. Schneider, "Biodiversity and Climate Change in Context," in *Climate Change and Biodiversity*, T.E. Lovejoy and L. Hannah, eds. (Yale University Press, New Haven CT: 2005): 3-14.

[9] *Phenology* is "the relationship between climate and periodic natural phenomena such as the migration of birds, bud bursting, or the flowering of plants." *The Dictionary of Ecology and Environmental Science,* H. W. Hart, ed. (New York, NY: Henry Holt & Co, 1993)

[10] *Parmesan 2006.*

[11] The lodgepole pine is adapted to this beetle, and stands of this fast-growing tree can regenerate fairly quickly — for trees.

[12] The heavy seed crop of the whitebark pine supports many species, including the Clark's nutcracker which harvests and stores large caches of the seeds, and feeds on them through winter and into the breeding season. Red squirrels also collect and store the seeds. The stored caches are important fall and spring food sources for grizzlies.

[13] This discussion is adapted from Michel Nijhuis, "Global Warming's Unlikely Harbingers," *High Country News*, vol 36 (July 19, 2004): p. 1. The author cites a variety of primary sources, largely U.S. Forest Service scientists.

shift accordingly. If a phenological change in one species does not match linked changes in an interdependent species, an *ecological mismatch* can occur.[14] For example, if certain trees bloom earlier in response to warmer springs, but pollinators do not hatch earlier, disruptions (e.g., failed or inadequate pollination) may occur. Mismatches can occur between predators and prey, herbivorous insects and host plants, and pollinators and flowering plants, among others. Scientists are studying potential mismatches caused by climate change because they can disrupt the reproductive cycle of many species. In one example, variability in precipitation, linked to regional climate change, is considered as the cause of the extinction of two populations of checkerspot butterflies in California.[15] Changing levels of precipitation were found to alter the relationship between butterfly larvae and host plants. In very wet or dry years, larvae do not get the opportunity to feed on host plants before the plants die. These lost opportunities for successful reproduction cause variation in butterfly abundance, which eventually may lead to their extinction.

Population Decline Due to Habitat Loss. There are few examples of studies that directly associate wildlife population declines with climate change. Indirect links have been reported, such as population declines in species due to habitat loss exacerbated by climate change. For example, the impact of climate change on Antarctic krill (small, shrimp-like animals) has been documented. Antarctic krill are major grazers in the Southern Atlantic Ocean and are food for various species of fish targeted by commercial fisheries. Declines in sea-ice area and in the duration of sea-ice formation, linked in part to climate change in Antarctica, have been connected to declines in krill density. Variability in krill densities has implications for the Antarctic food web, which includes penguins, albatrosses, seals, and whales.[16]

Pathogens. Some pathogens could increase their ranges due to climate change, whereas others may diminish their ranges. For example, harlequin frogs are declining due to increased outbreaks of a harmful chytrid fungus. In the last 20 years, 67% of the 110 species of harlequin frogs have gone extinct.[17] A mechanistic explanation of how climate change promotes outbreaks of the chytrid fungus has been presented. Nighttime temperatures are shifting closer to the thermal optimum for chytrid growth, and daytime cloudiness prevents frogs from seeking thermal refuges.[18] These climatic shifts are promoting outbreaks of chytrid fungus in areas where harlequin frog populations reside.

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[14] Marcel Visser and Christiaan Both, "Shifts in Phenology Due to Global Climate Change: The Need for a Yardstick," *Proceedings of the Royal Society Bulletin,* vol. 272 (2005): 2561-2569.

[15] John McLaughlin, et al., "Climate Change Hastens Population Extinctions," *Proceedings of the National Academy of Sciences,* vol. 99, no. 9 (2002): 6070-6074.

[16] Angus Atkinson, et al., "Long-term decline in krill stock and increase in salps within the Southern Ocean, *Nature*," vol. 432 (2004): 100-103.

[17] J. Alan Pounds, et al., "Widespread Amphibian Extinctions from Epidemic Disease Driven by Global Warming," *Nature,* vol. 439 (2006): 161-167.

[18] Andrew Blaustein and Andy Dobson, "A Message from the Frogs," *Nature* vol. 439 (2006): 143-144.

Wildlife Adaptation to Climate Change

Species and populations have demonstrated that they can adapt in a variety of ways to some degree of climate change. For example, they can shift their ranges, change their phenologies, and with sufficient time, may adapt to climate change through evolution. Paleoclimate evidence indicates that some ecosystems restructured during some past climate changes without records of mass extinctions.[19] Assessing the ability of species to adapt to climate change is difficult because other stressors that may drive adaptation could be present, such as habitat loss due to factors other than climate change, competition from other species, and invasive species. Further signs of adaptation, such as range expansions or shifts in phenology, may initially be viewed as positive responses by a species to climate changes, but have negative consequences if these shifts do not correspond to other ecosystem properties or other necessary conditions needed for that species' survival. For example, if the natural response to climate change for a species would be to expand northward, the consequences might be severe if intervening developed areas replace suitable habitat or block access to it.

The rate of climate change reported in this century is generally seen as being uncharacteristically rapid and many scientists have questions concerning how or whether species will adapt. Climate change models based on global average temperature changes are less precise about local climate changes that could be important for many species. This uncertainty has led some to propose artificial methods of adaptation such as *assisted migration*, which is the collection and transport of species from unsuitable to suitable habitat. This technique has been used with mixed results with endangered species and many question its viability and cost. Other suggestions to assist adaptation of wildlife include building corridors between protected areas to give species paths to migrate and shift their ranges.

Policy Implications

Climate change has the potential to adversely affect species. Some contend that effects from recently projected climate change will warrant mitigation of effects to wildlife and that planning for mitigation is prudent now. Others assert that the effects of climate change on species may not need intervention and that many species may be able to adapt successfully. Addressing this issue may require answering several questions that are still being discussed. For example, will the rate of any climate change be slow enough to allow species to adapt? What are local changes in climate that would affect specific populations and ecosystems? How could human development and management of natural resources interact with the natural adaptation process of species under climate change? And, is the extinction of species due to climate change a concern or a natural process?

If the effects of climate change on wildlife are widespread and occur rapidly, there are resulting legislative implications. Several wildlife laws and management plans that have been developed with an understanding of the life history, distribution, and habitat needs of species may merit assessment to see if they function as desired under projected

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[19] T.E. Lovejoy and L. Hannah, "Global Greenhouse Gas Levels and the Future of Biodiversity," in *Climate Change and Biodiversity*, T.E. Lovejoy and L. Hannah eds. (Yale University Press, New Haven CT: 2005): 387-395.

climate change. For example, under the Endangered Species Act (ESA), critical habitat designation, habitat conservation plans, and biological opinions for several species might have to be re-done if data change. This could overwhelm scientific resources and the resources of the pertinent agencies to review new data. For aquatic species, changes in their habitat requirements could require water flows and water supply to be altered in river management plans. This possibility is tempered by some who contend that changes to species may be gradual enough that wildlife laws that address potential changes may be sufficient. In the case of ESA, there are provisions that require the revision of recovery plans or conservation plans if new scientific data are presented.

The control, eradication, and prevention of invasive and pest species are generally addressed on a species-by-species basis in management plans. If rapid climate change affects pest or exotic species, scientific knowledge may not keep pace. Further, changes in species ranges may make it difficult to determine if species are exotic or native species with new ranges. Separating exotic species from adapting species may be relevant for national park and refuge managers. Managers might be faced with challenging management objectives: whether to preserve and protect current wildlife species and facilitate the adaptation of new species into protected areas.[20]

The effects of climate change on wildlife are being viewed by some as an issue within the larger context of potential changes to ecosystems. Ecological factors that affect wildlife, including water flows and availability, soils, and nutrients, can be addressed in an ecosystem context. Consequently, large-scale ecosystem restoration initiatives might have to incorporate changes in their restoration plans to address the potential effects of climate change. Restoration plan horizons generally range from 20 to 50 years over which local climate may change substantially. For example, the restoration of the Everglades ecosystem is expected to take 30 years under the Comprehensive Everglades Restoration Plan. This plan could need to be revised if recently predicted sea level rise occurs and causes changes in water flow in the Everglades.[21]

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[20] D. Scott, "Integrating Climate Change into Canada's National Park System," in *Climate Change and Biodiversity*, T.E. Lovejoy and L. Hannah eds. (Yale University Press, New Haven CT: 2005): 342-345.

[21] Some restoration plans include adaptive management, which incorporates information from new or unforeseen circumstances into a project to assure that the goals of the project are achieved efficiently. It is unclear if adaptive management will allow for large-scale changes in plans that may happen under climate change.