HOW VULNERABLE ARE SPECIES IN GREATEST NEED OF CONSERVATION TO CLIMATE CHANGE?

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In recent years, considerably more information on the potential threat of global climate change to natural and human systems has become available, as have strategies to increase resilience, increase adaptive capacity, and mitigate the effects of climate change. As part of an update to the Illinois Wildlife Action Plan, we rated the climate change vulnerability of 162 Species in Greatest Need of Conservation based on exposure, sensitivity, and adaptive capacity. Most species were evaluated in >1 watershed, resulting in 584 assessments. By grouping species by their relative risk and sensitivity factors, the vulnerability assessment helps to identify adaptation strategies likely to benefit several species.

High proportions of mollusks and fishes were rated *Extremely Vulnerable* or *Highly Vulnerable* to climate change. Intermediate numbers of amphibians and insects, and few reptiles, birds or mammals were rated as *Extremely Vulnerable* or *Highly Vulnerable* to climate change. Vulnerable species tended to be associated with headwater streams or ephemeral wetlands, and face significant natural or anthropogenic barriers to dispersal. The large rivers of Illinois, and the concentrations of natural land cover lying along them, are staged to be important corridors for species migrations. Climate change will tend to amplify the effects of other threats (e.g., altered hydrology, water quality, invasive species), and efforts to alleviate these non-climate stressors need to be redoubled to increase resilience of aquatic life to changing conditions.

INTRODUCTION

Since the first iteration of the Illinois Wildlife Action was developed in 2005 (Illinois Department of Natural Resources 2005), considerably more information on the potential threat of global climate change to natural and human systems has become available (e.g., International Panel on Climate Change 2007). In Illinois, the most profound effects of climate change are likely to be dangerous summer heat, a longer growing season, more flooding due to increased winter and spring rainfall in events >2 inches/day, increased summer drought, and lowered water levels in Lake Michigan (Union of Concerned Scientists 2009).

Over the same period, strategies to increase resilience, increase adaptive capacity, and mitigate the effects of climate change have emerged, and continue to evolve rapidly (Game et al. 2010, Groves et al. 2010, Hansen et al. 2010, Heller and Zavaleta 2009). In 2009, the Illinois Department of Natural Resources initiated a process to incorporate climate change considerations into the Illinois Wildlife Action Plan. Among our objectives were objectives were to (1) conduct a climate vulnerability assessment of Species in Greatest Need of Conservation, and (2) identify conservation strategies that increase resilience or adaptive capacity, or mitigate the effects of climate change.

METHODS

We employed the NatureServe *Climate Change Vulnerability Index,* Version 2.01 (Young et al. 2010) to evaluate a subset of Species in Greatest Need of Conservation. This index accepts input on up to 29 factors relating to the exposure, sensitivity, and adaptive capacity of species and returns a rating of the relative vulnerability of a species in the assessment area. By grouping species by their relative risk and sensitivity factors, the index helps to identify adaptation strategies most likely to benefit several species.

We considered the 14 natural divisions of Illinois for terrestrial species, including mammals, birds, reptiles, amphibians, insects, cave-dwelling crustaceans, and a terrestrial snail. For aquatic species, we divided the state into 19 major watersheds for assessments of fishes, mussels, stream-dwelling crustaceans. Each species was eligible for evaluation in >1 geographic area. Climate change projections for all natural divisions and watersheds were obtained from Climate Wizard (Zganjar et al. 2009). For all variables, we used projections for mid-century (2040-2069), and the ensemble-average of general circulation models based on the A1B medium-emissions scenario. To assess sensitivity and adaptive capacity for each species, we utilized global and state conservation ranks, range-wide distribution (including relative position of the assessment area within the species range, e.g., northern or southern edge of range), and life history information from NatureServe *Explorer* (NatureServe 2010).

RESULTS

We assessed the climate change vulnerability of 162 Species in Greatest Need of Conservation. Because many species were assessed for >1 natural division or watershed, 584 assessments were completed. High proportions of mollusks and fishes were rated *Extremely Vulnerable* or *Highly Vulnerable* to climate change (Fig. 1). In general, species associated with headwater streams, cooler water temperatures, and clearer water were more vulnerable to climate change than species occurring in large rivers or lakes, or tolerant of warm-water and turbid conditions (Fig. 2).

Intermediate numbers of insects and amphibians were rated as *Extremely Vulnerable* or *Highly Vulnerable* to climate change. Few birds and mammals were rated as *Extremely Vulnerable* or *Highly Vulnerable* to climate change. However, we evaluated climate change vulnerability only for conditions within Illinois, and long-distance migratory species (e.g., many birds and bats) likely face additional, complex vulnerabilities along their migratory routes.

The extent of human-caused fragmentation or barriers to dispersal and species rarity contributed to somewhat more vulnerable ratings, whereas relative range position (north edge, southern edge, center of range) did not have a discernable effect on climate change vulnerability ratings.

DISCUSSION

Climate change poses several specific challenges to the natural, agricultural and human systems of Illinois. The Union of Concerned Scientists (2009) outlined a number of changes likely to affect Illinois by the middle and end of the 21st century, including dangerous summer heat, more flooding and drought, lower water levels in lakes and reservoirs, and a growing season up to 6 weeks longer. All of these changes will favor species that can quickly adapt to changes in local conditions. “Climate winners” will likely have the characteristics of short generation times, high fecundity and rapid dispersal. By contrast, species with long generation times, low fecundity and low dispersal will be most challenged by climate change, and these challenges will be amplified by habitat fragmentation/isolation and small population size/lack of genetic diversity.

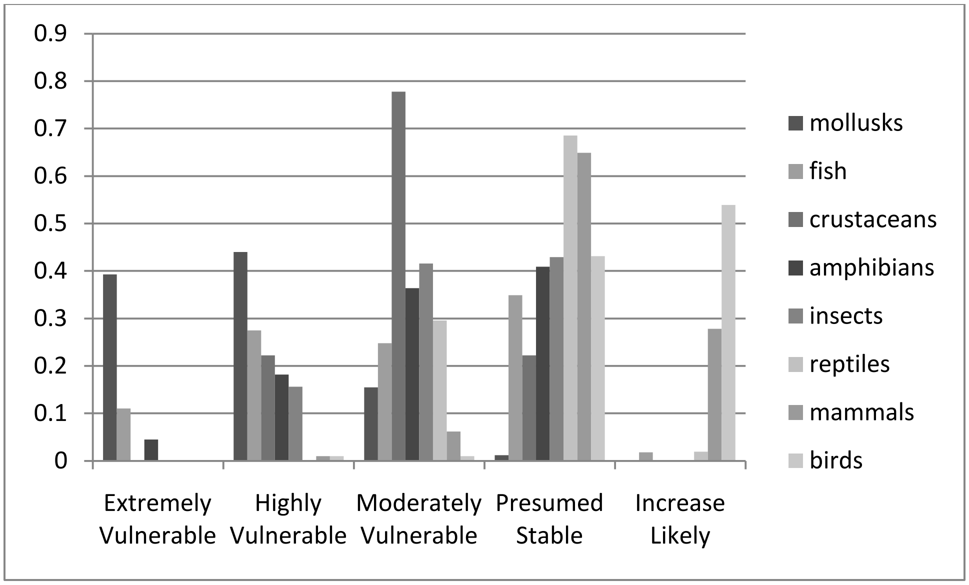

Fig. 1. Proportions of Species in Greatest Need of Conservation within seven major taxonomic groups assigned different climate change vulnerability ratings.

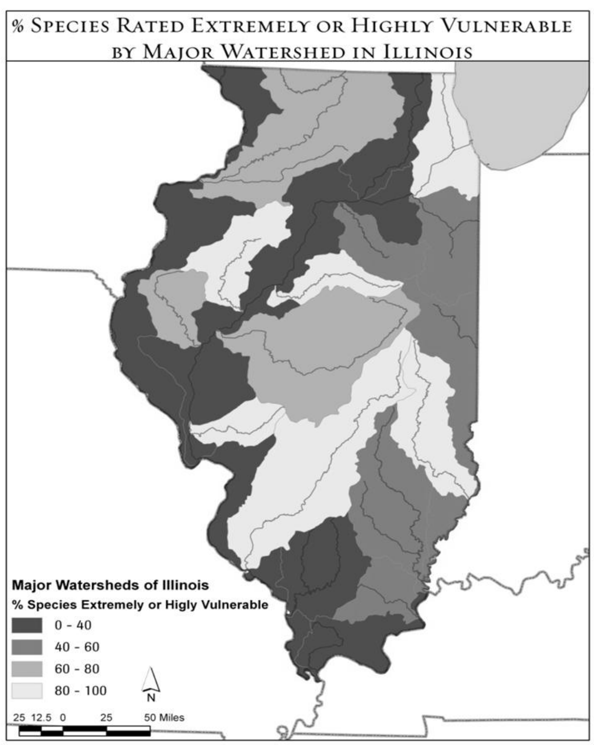

Fig. 2. Percent of Species in Greatest Need of Conservation rated *Extremely*- or *Highly-Vulnerable* to climate change by major watershed in Illinois.

These changes could lead to a variety of challenges for lakes, streams, and fisheries. A net increase and more episodic precipitation, coupled with the potential for greater groundwater withdrawal, give a mixed picture of what may happen to water levels in ponds and reservoirs. Heavy rainfall events may degrade water quality by introducing heavy sediment, untreated sewage, and pollutant loads into lakes, ponds, and reservoirs (Union of Concerned Scientists 2009). Increasing water temperature will lengthen the stratified period in deeper lakes and favor algal blooms, resulting in more areas of low dissolved oxygen (International Panel on Climate Change 2002).

With more precipitation during the non-growing season in heavy precipitation events, streams are likely to become more "flashy" (rapid rising and falling of water levels), flooding will be more frequent and severe, and stream banks will come less stable. With less precipitation during the growing season and higher air temperatures, periods of low flow, high water temperature and low dissolved oxygen will affect aquatic species. If groundwater contributions decline as a result of withdrawal for municipal water supplies or irrigation, the effects will be further amplified. Smaller headwater streams are likely to experience greater change and more variability than large rivers. Invasive species, altered hydrology, and loss of vegetation are common threats to terrestrial and aquatic systems, but sedimentation, pollutants, and excess nutrients have much more profound effects on aquatic communities (Brönmark and Hansson 2002).

A few key patterns are apparent among the natural divisions and watersheds of Illinois, in the context of climate change vulnerabilities and opportunities. The large rivers of Illinois, and the natural divisions lying along them, are staged to be important corridors for species migrations. As such, minimizing additional barriers in these regions has high importance. Navigation locks on the large rivers probably are partial barriers to some species, and rivers and larger streams are laterally isolated from side channels, backwaters and floodplains by levees in many areas.

Baseline data on water flows, withdrawal and discharge, and models of flows necessary to sustain aquatic communities are needed to anticipate changes and manage lakes and streams as climate change alters precipitation patterns and increases human demand for water (including municipal, agricultural and industrial uses). Water quality standards to protect aquatic life should be re-evaluated in the context of anticipated conditions. Increased temperature, lower dissolved oxygen, and lower pH may interact in complex ways to change the toxicity of various pollutants.

Because of the scope, potential severity, and uncertainty surrounding global climate change, it may be tempting to ignore the threat until clarity emerges on actions or outcomes. Most climate scientists agree that there is sufficient carbon dioxide in the atmosphere that some climate change over the next century or longer is assured, thus adaptation is essential. In reality, coping with climate change is not fundamentally different from traditional conservation, where decisions must be made and actions taken with incomplete information, and adaptive management is especially important for refining actions as knowledge improves and circumstances change.

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