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CLIMATE CHANGE-RELATED CHANGES IN MIGRATORY BIRD BEHAVIOR ALONG THE U.S. EAST COAST

1 Introduction

Migratory birds nest throughout North America, some as far north as the Arctic (U.S. Fish and Wildlife Service, 2017b). In late summer and fall, these birds migrate south for the winter. Some species winter in the southern United States, Mexico, the Caribbean, or Central America while others go as far as South America. Then, each spring they must return north to their breeding grounds. Birds migrate along four main routes or flyways: the Atlantic, Central, Mississippi, and Pacific. The Chesapeake Bay watershed lies within the Atlantic Flyway and is a winter destination for some birds. About one million swans, geese, and ducks winter on the Bay, roughly one third of all waterfowl wintering along the Atlantic Coast. Many migratory songbirds, shorebirds, and raptors rest and refuel here during their spring and fall migrations. Still others winter south and return to the Chesapeake Bay watershed each spring to breed.

Many species of migratory birds rely on the Chesapeake Bay. The Chesapeake Bay now has one of the highest concentrations of bald eagles in the United States (U.S. Fish and Wildlife Service, 2017b). In addition to the breeding population, the Bay supports winter migrants of bald eagles from as far north as Canada and summer migrants from Florida. Black rail fall migration ranges from early September to early November, with most records mid-September to mid-October. Canadian geese migrate along the Atlantic Flyway as well. From late February to early March, geese leave the Chesapeake Bay area and migrate back to their northern breeding grounds. As winter approaches, canvasbacks (species of duck) migrate to warmer climates. During migration and winter, canvasback flocks aggregate in regions such as the Chesapeake Bay. Cerulean warblers breeding area includes the Chesapeake Bay watershed, arriving from late March and breeding until mid-May. More than half of the Atlantic coast's breeding population of great blue herons nest in Chesapeake Bay, predominantly in wetlands. Although many herons migrate through the Bay region, some great blues remain in the Bay area year-round. The red knot is a master of long-distance migration, with some individuals flying more than 9,300 miles from Arctic breeding grounds in North America to wintering grounds in southern South America (U.S. Fish and Wildlife Service, 2017b). The spring migration coincides with horseshoe crab spawning. Lastly, the osprey’s nesting cycle starts in March, and ends in August to September when they migrate to Central-South America.

Over time, it has been shown that ecological processes are changing in response to climatic warming (Marra et al., 2005). Past studies of bird migration times have shown great variation in migratory responses to climate change (Miller-Rushing et al., 2008). Climate variables, migration distance, and date of migration explained portions of the variation in migratory changes over time. Birds have been documented to arrive and breed earlier in spring and this has been attributed to elevated spring temperatures (Marra et al., 2005). Short-distance migrants have been found to respond to changes in temperature, while mid-distance migrants responded particularly strongly to changes in the Southern Oscillation Index (Miller-Rushing et

al., 2008). However, another study has found that although the onset of migration may be determined endogenously, the timing of migration is flexible and can be adjusted in response to variation in weather and/or phenology along migration routes (Marra et al., 2005).

2 Hazards Threatening Migratory Birds

Habitat change

Loss and fragmentation of suitable wetland habitat poses the greatest threat to migratory species such as bald eagles and black rails (U.S. Fish and Wildlife Service, 2017b). Loss of habitat has drastically reduced the amount of suitable land available to these species. Of the many factors, responsible for declining canvasback populations, habitat degradation has had the largest impact. This habitat degradation is due to disturbances from shoreline development, as well as many other factors. Field sparrows appear to be declining in numbers, most likely due to changes in their breeding habitat as shrubby fields succeed to forest or are cleared for farms or suburban development. Loss of nesting and wetland habitat are issues of concern for great blue heron survival. Natural generation of new nesting islands, created when old islands and headlands erode, has decreased due to artificial hardening of shorelines with bulkheads. Variations in climate systems of other migratory areas affect migratory birds as well. For example, unfavorable weather conditions in northern nesting grounds can cause Canadian geese to experience poor annual production of young.

Water quality

Changes in water quality is a highly impactful hazard on multiple species of migratory birds (U.S. Fish and Wildlife Service, 2017b). Alteration of the water regime can allow common reed to invade and degrade black rail habitat. The decline of water quality in the Chesapeake Bay has greatly reduced available food for canvasbacks as well as many other species of waterfowl. Increased sedimentation from erosion has caused a dramatic decline in submerged aquatic vegetation (SAV) by reducing light penetration. Deterioration of water quality and wetland habitat are issues of concern for great blue heron survival as well. Poor water quality reduces the amount of large fish and invertebrate species available in wetland areas.

Climate change

Climate change hazards exacerbate all previously mentioned hazards to migratory birds. Rising sea levels expose coastal ecosystems to inundation, erosion, overwash, and the accretion and migration of plant communities. Additionally, since the atmosphere is warmings it has the ability to hold more water, thus increasing the chance for more intense and heavy downpours with longer dry periods in between (Irizarry-Ortiz et al., 2013). Heat waves and rising temperatures could have detrimental effects on both plants and animals within ecosystems such as the Chesapeake Bay watershed, as well as other areas that are critical for migratory bird procreation and survival.

Changes in temperature could potentially cause many issues for migratory birds. In general, it has been found that birds migrate earlier in warm years and later in colder years (Marra et al., 2005). This could mean that long-distance migratory birds would be able to respond quickly to long term warming. However, it has also been found that the timing of breeding for long-distance migrants, such as the pied flycatcher, can be mismatched with the optimal times based on breeding success (Marra et al., 2005). Therefore, mismatch may be a constraint based on inflexible arrival times of specific species.

Furthermore, the northward progression of leaf out in spring is closely linked to temperature and provide important habitat for migratory birds during spring migration (Marra et al., 2005). Leaf-out can be important both in the food it provides, as well as the protection foliage may offer to camouflage birds from predators (Marra et al., 2005). Such factors can all contribute to the rate at which migratory birds can move northward, since plants are more sensitive to changes in temperature than are birds. Temperature can have direct and indirect effects on insect development which may influence food availability to migratory birds. For example, because temperature can influence plant phenology, it can also delay or stimulate insect emergence, impacting the abundance of herbivorous insects that are prey to migrating birds (Marra et al., 2005). This in turn can have important impacts on the length of bird stopover and the rate of migration. Furthermore, delays in spring arrival by migratory birds may lead to increased competition for nest sites with species arriving earlier (Walther et al., 2002). Such mismatch of fine-tuned events may negatively impact species interactions and the persistence of ecological communities across an array of ecosystems (Walther et al., 2002).

3 Vulnerabilities of Migratory Bird Species to Climate Change

Sustained habitats

In order for bald eagle’s populations to improve, they need suitable nesting trees near open water, isolation from human activity and a stable food supply (U.S. Fish and Wildlife Service, 2017b). Like all migratory species, canvasbacks need dependable, high-quality breeding, wintering and migration habitats. The prairie wetlands of North America are vital to the survival of many species of waterfowl, including canvasbacks. Black rail adult survival is vulnerable to extreme high tide due to predation by herons and other avian predators. This is the primary source of mortality for populations of black rail in tidal marshes because the birds fleeing flooded areas are more susceptible to predation.

Cerulean warblers forage on insects and nest high in the canopy (U.S. Fish and Wildlife Service, 2017b). The forests of the Chesapeake Bay watershed provide this critical habitat, particularly in areas that were once heavily logged but have been reforested. Field sparrows appear to be declining in numbers, most likely due to changes in their breeding habitat as shrubby fields succeed to forest or are cleared for farms or suburban development. A necessity for red knots is the existence of arctic habitat for breeding. Global climate change, which may be

greatest at the latitudes where this species breeds and winters, could destroy critical fragile habitat. The location of blue heron colonies depends upon an available food supply for raising the young near nesting trees; however, the birds show a preference for stands of loblolly pine, beach, oak and large, old sycamore trees; plants species that could be impacted by changes in temperature and precipitation.

Environmental clues for migration

Many of the Canadian geese wintering on the Chesapeake Bay breed in northern Quebec (U.S. Fish and Wildlife Service, 2017b). On the breeding grounds, the pairs wait until the snow and ice melt before they begin nesting. The shortening of days and crisp frosts of early autumn signal the Canada geese to prepare for another journey back to the Chesapeake Bay. Change in the arrival of spring and/or when the ice begins to melt could result in early or late migrations.

Food sources

Rootstalks, tubers and stems of SAV, as well as bottom dwelling animals, such as aquatic insects and small crustaceans, are some of the canvasback's preferred foods (U.S. Fish and Wildlife Service, 2017b). Although the Bay is still important to canvasbacks, the decline of SAV has forced the ducks to winter on other coastal brackish waters where food is more abundant. Red knots survival depends upon the continued availability of billions of horseshoe crab eggs at staging areas like the Delaware coast. During the 1990’s an increase in harvesting of horseshoe crabs, may have contributed to the decline in red knots. Further reduction in these food sources due to climate change could be detrimental to species such as canvasbacks and red knots.

4 Foresight into Climate Change Scenarios

The Earth's climate has warmed by approximately 0.6 °C over the past century with two main periods of warming (Walther et al., 2002). The rate of warming during the latter period has been approximately double that of the first period. Organisms, populations and ecological communities respond to the regional changes that occur due to the increased average global temperatures. These regional changes vary largely in various areas of the globe (Fig. 1). In many regions, there is an unevenness in the warming that will contribute to ecological dynamics across systems. The freeze-free periods in most mid- and high-latitude regions are lengthening and satellite data reveal a 10% decrease in snow cover and ice extent since the late 1960s (Walther et al., 2002). Changes in precipitation have also varied largely (Fig. 1).

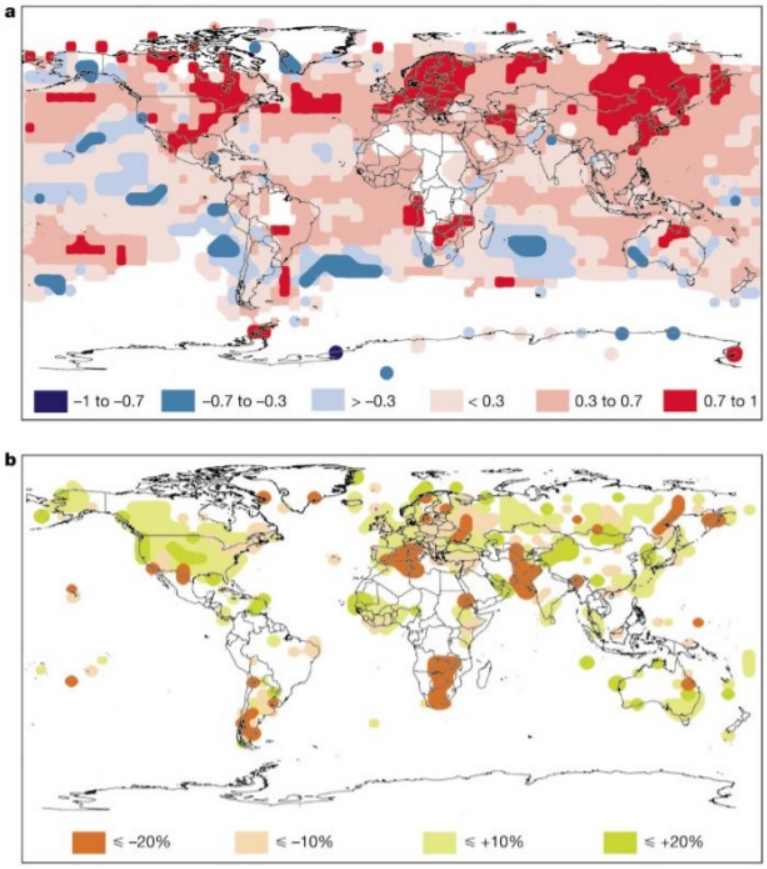

Figure 1: Spatial variability of annual trends in temperature and precipitation since 1976. (a) Temperature (°C per decade), (b) precipitation (% per decade). (Walther et al., 2002)

When considering possible future scenarios, the IPCC report has found that Global surface temperature change for the end of the 21st century is likely to exceed 1.5°C, and even 2°C, relative to 1850 to 1900 (Stocker et al., 2013). Warming will most likely vary between each year, as well as each decade, and will it not be regionally uniform (Fig. 2). Changes in the global water cycle in response to the warming over the 21st century will not be uniform either (Fig. 2) (Stocker et al., 2013). The contrast in precipitation between wet and dry regions and wet and dry seasons will increase. Extreme precipitation events over most of the mid-latitude land masses will very likely become more intense and more frequent by the end of this century, as global mean surface temperature increases (Stocker et al., 2013).

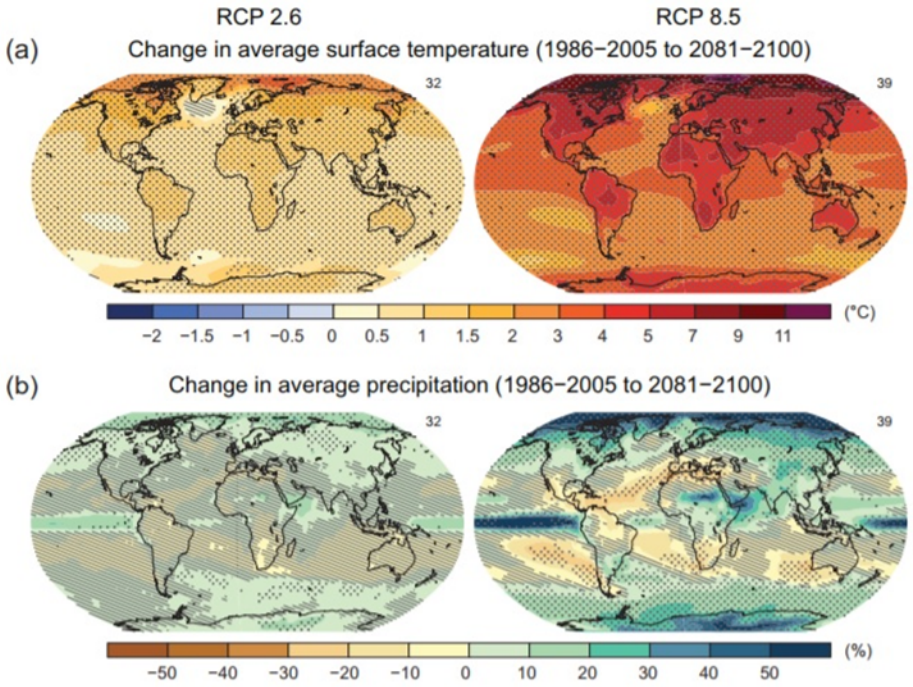

Figure 2: (a) annual mean surface temperature change, (b) average percent change in annual mean precipitation relative to 1986–2005 (Stocker et al., 2013)

The current landscape provides little flexibility for ecosystems to adjust to rapid environmental changes (Walther et al., 2002). Species in many areas today must move through a dangerous landscape that has been created by human activity. Because of the widespread loss and fragmentation of habitats, many areas which may become climatically suitable with future warming are isolated from current distributions, and beyond the dispersal capacity of many species. Consequently, species with low adaptability and/or dispersal capacity will be caught by the dilemma of climate-forced range change and low likelihood of finding distant habitats to colonize, ultimately resulting in increased extinction rates.

5 Stakeholders and Decision Making

Development has accelerated nationwide to meet increasing societal demands for food, space, and energy (U.S. Fish and Wildlife Service, Migratory Bird Program). This development can result in habitat loss, degradation, change, or fragmentation, reducing the availability of resources to meet the needs of birds. Utilities and cooperatives, federal power administrations, are involved in the potential impacts of electric utility infrastructure on birds. Bird collisions also include communication towers, power lines, wind energy, and transportation.

Local, state, and federal agencies are important stakeholders for migratory birds. The government has aided in passing important acts such as the Bald Eagle Protection Act of 1950,

the Endangered Species Act, and the Migratory Bird Treaty Act of 1918 (U.S. Fish and Wildlife Service, 2017b). Agencies within the various branches of the government include the U.S. Fish & Wildlife Service (FWS), the United States Department of Agriculture, the Transportation Sector, the Army Corps of Engineers, Water Management, and many more agencies.

Migratory Bird Joint Ventures are voluntary, cooperative, regional partnerships of private industry and private landowners working alongside federal and state agencies, non-profit organizations, tribes, academia, businesses, conservation organizations, individual citizens, and other partners. For example, the Atlantic Coast Joint Venture is concerned with the conservation of habitat for native birds in the Atlantic Flyway. Joint venture partners work together to build and sustain a healthy world for birds, other wildlife, and people. Partnership organizations such as joint ventures are an impactful stakeholder for migratory birds (Migratory Bird Joint Ventures, 2017).Conservation NGO's must be considered as well when regarding migratory birds.

Lastly, neotropical migratory birds journey each year between U.S. and Canadian breeding grounds and more southerly wintering areas in Mexico, Latin America, and the Caribbean. Therefore, multiple countries are stakeholders as well. BirdLife International is an example of an international organization dedicated to safe-guarding bird species, including migratory birds (BirdLife, 2017).

6 Options and Recommendations to Minimize Climate Change Impacts

Since climate change has such a powerful impact on bird habitats and resources, it is important to understand how and where these effects will be manifested, so that we can proactively preserve landscapes that supports healthy bird populations (U.S. Fish and Wildlife Service, 2017a). Therefore, climate change research and habitat change predictions is an extremely important option that must be implemented.

Habitat restoration can be a powerful conservation tool for maintaining healthy bird populations (U.S. Fish and Wildlife Service, 2017a). For example, the U.S. FWS works with partners to promote and assist with habitat restoration and conservation areas across the nation through grant programs, migratory bird management plans and various partnership initiatives. Precise and viable habitat restoration efforts in critical areas that will not be degraded frequently would provide habitat to migratory species.

International coordination is paramount since birds often travel outside of U.S. borders throughout the year, it is important not only to maintain quality habitat for birds inside the U.S., but also other areas around the world where birds migrate and winter.

Habitat mitigation must be allowed. Loss of important habitats cannot be totally avoided. One option is to create habitat that will benefit the affected species elsewhere, reducing the effects of the lost habitat (U.S. Fish and Wildlife Service, 2017a). Furthermore, as climate change pressures continue, allowing habitats to move due to sustained deviations in climate

norms will positively impact conservation efforts. Mapping future migratory paths under certain climate change scenarios, and then aiming to ensure reasonable habitats along these paths would be extremely advantageous, but would require changes in land use planning.

Lastly, conservation efforts must include minimizing habitat impacts. Reduction in development of critical habitats will allow migratory birds to maintain their seasonal habitats. Also, simple vegetation management measures that developers, landscapers and others can follow can take place to preserve important nesting habitat during the breeding season and restore native vegetation that many birds use and depend on (U.S. Fish and Wildlife Service, 2017a).

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