

**Key Message 1**

Kodiak National Wildlife Refuge, Alaska

**Impacts on Species and Populations**

Climate change continues to impact species and populations in significant and observable ways. Terrestrial, freshwater, and marine organisms are responding to climate change by altering individual characteristics, the timing of biological events, and their geographic ranges. Local and global extinctions may occur when climate change outpaces the capacity of species to adapt.

**Key Message 2****Impacts on Ecosystems**

Climate change is altering ecosystem productivity, exacerbating the spread of invasive species, and changing how species interact with each other and with their environment. These changes are reconfiguring ecosystems in unprecedented ways.

**Key Message 3****Ecosystem Services at Risk**

The resources and services that people depend on for their livelihoods, sustenance, protection, and well-being are jeopardized by the impacts of climate change on ecosystems. Fundamental changes in agricultural and fisheries production, the supply of clean water, protection from extreme events, and culturally valuable resources are occurring.

## Key Message 4

### Challenges for Natural Resource Management

Traditional natural resource management strategies are increasingly challenged by the impacts of climate change. Adaptation strategies that are flexible, consider interacting impacts of climate and other stressors, and are coordinated across landscape scales are progressing from theory to application. Significant challenges remain to comprehensively incorporate climate adaptation planning into mainstream natural resource management, as well as to evaluate the effectiveness of implemented actions.

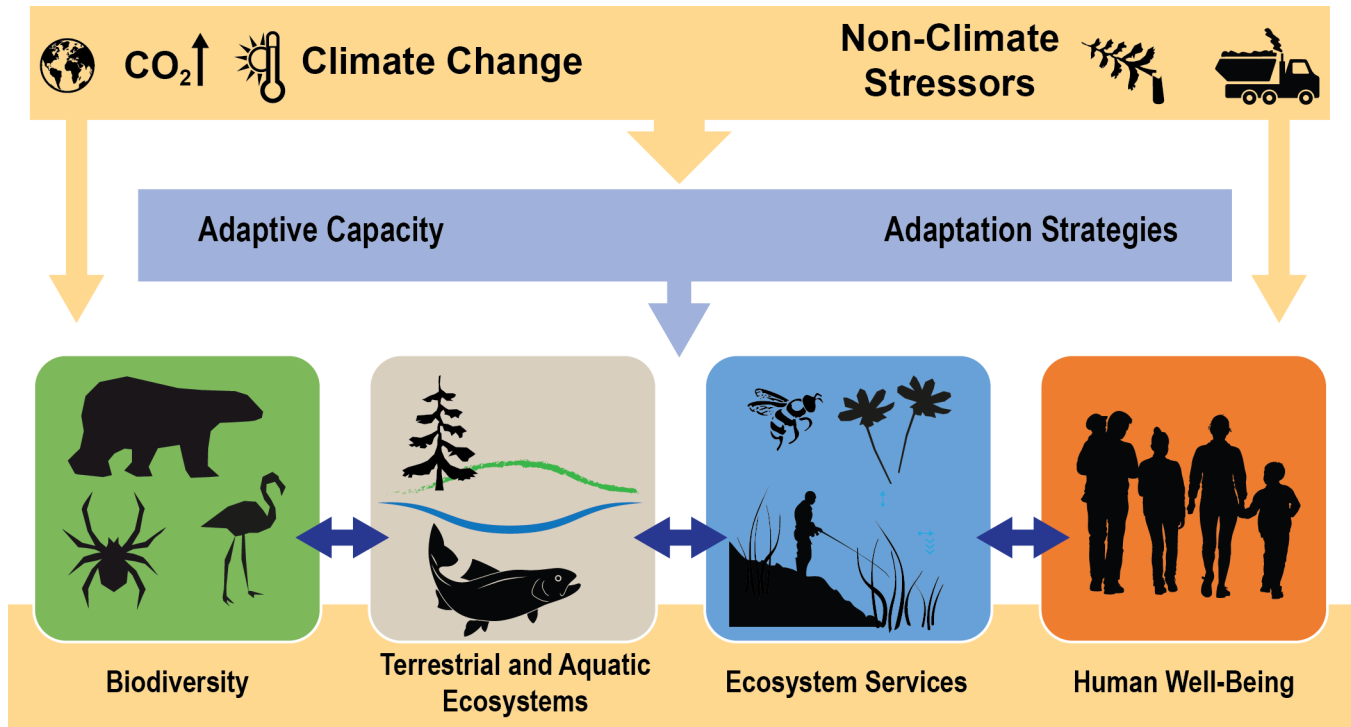
## Executive Summary

Biodiversity—the variety of life on Earth—provides vital services that support and improve human health and well-being. Ecosystems, which are composed of living things that interact with the physical environment, provide numerous essential benefits to people. These benefits, termed ecosystem services, encompass four primary functions: provisioning materials, such as food and fiber; regulating critical parts of the environment, such as water quality and erosion control; providing cultural services, such as recreational opportunities and aesthetic value; and providing supporting services, such as nutrient cycling.<sup>1</sup> Climate change poses many threats and potential disruptions to ecosystems and biodiversity, as well as to the ecosystem services on which people depend.

Building on the findings of the Third National Climate Assessment (NCA3),<sup>2</sup> this chapter provides additional evidence that climate change is significantly impacting ecosystems and biodiversity in the United States. Mounting evidence also demonstrates that climate change is increasingly compromising the ecosystem services that sustain human communities,

economies, and well-being. Both human and natural systems respond to change, but their ability to respond and thrive under new conditions is determined by their adaptive capacity, which may be inadequate to keep pace with rapid change. Our understanding of climate change impacts and the responses of biodiversity and ecosystems has improved since NCA3. The expected consequences of climate change will vary by region, species, and ecosystem type. Management responses are evolving as new tools and approaches are developed and implemented; however, they may not be able to overcome the negative impacts of climate change. Although efforts have been made since NCA3 to incorporate climate adaptation strategies into natural resource management, significant work remains to comprehensively implement climate-informed planning. This chapter presents additional evidence for climate change impacts to biodiversity, ecosystems, and ecosystem services, reflecting increased confidence in the findings reported in NCA3. The chapter also illustrates the complex and interrelated nature of climate change impacts to biodiversity, ecosystems, and the services they provide.

## Climate Change, Ecosystems, and Ecosystem Services



Climate and non-climate stressors interact synergistically on biological diversity, ecosystems, and the services they provide for human well-being. The impact of these stressors can be reduced through the ability of organisms to adapt to changes in their environment, as well as through adaptive management of the resources upon which humans depend. Biodiversity, ecosystems, ecosystem services, and human well-being are interconnected: biodiversity underpins ecosystems, which in turn provide ecosystem services; these services contribute to human well-being. Ecosystem structure and function can also influence the biodiversity in a given area. The use of ecosystem services by humans, and therefore the well-being humans derive from these services, can have feedback effects on ecosystem services, ecosystems, and biodiversity. *From Figure 7.1 (Sources: NOAA, USGS, and DOI).*