PART 3

Ecological Consequences and Vulnerabilities

Climate and human land use have ebbed and flowed for millennia and have been agents of natural selection to which many organisms have adapted. The key question under the current rapid rate of change is what degree of *exposure* to these changes elicits strong negative responses in ecosystem processes and biodiversity. This section of the book examines past and potential future ecological responses to these exposures to identify the organisms and ecosystems that are most vulnerable to global change and that are, therefore, high priorities for management action.

As introduced in part 1, an approach for assessing vulnerability has emerged from the Intergovernmental Panel on Climate Change. With climate and land use as elements of exposure, *sensitivity* denotes the tolerance of an organism or ecosystem process to the change in exposure. Exposure and sensitivity are combined to gauge *potential impact*. The impact of a change in climate, however, may be mediated by an organism or system's *adaptive capacity*, which refers to coping mechanisms that an organism may be able to employ, or the ability of natural systems to persist in the face of change. *Vulnerability*, then, is a function of the potential impact of the climate or land use change on an organism or process and its adaptive capacity. The methods of assessing each of the elements of vulnerability differ in level of refinement, with adaptive capacity being the most embryonic. Each of the chapters in this section quantifies exposure, sensitivity, and potential

impact. Only chapter 11 (and chapter 6 in part 2) includes consideration of adaptive capacity using quantitative methods.

Because ecological systems are complex and include many organisms and processes, a major challenge to assessing vulnerability is identifying which organisms and processes (i.e., conservation targets) can be realistically analyzed. We chose to analyze a range of ecological response variables that span from "coarse" to "fine" filter. Individual species are often of highest interest to resource managers and the public. These species-specific analyses are called fine-filter conservation approaches. However, limited knowledge or practical limitations typically reduces the number of species that can be considered to a dozen or less. Consequently, analyses are often done on coarser levels of biodiversity, such as communities, biomes, or even landforms (e.g., valley bottoms of mountain plateaus). These coarse-filter elements of biodiversity are sometimes of interest in their own right (e.g., valley bottoms with good soils and high agriculture potential) or because they support many species that are of high interest.

This part considers ecological processes, such as runoff and primary productivity (chap. 7); vegetation at the species, community, and biome levels (chaps. 8–11), and coldwater fish species (chap. 12). Although our core team of scientists focused on terrestrial ecosystems, our management partners were also quite interested in considering aquatic systems. Consequently, we invited fisheries experts from both the Rocky Mountains and the Appalachians to synthesize their previous work on climate and land use vulnerability of coldwater fish. The chapter on fish (chap. 12) is a good transition into the final part of the book on management because the chapter concludes with management case studies of fish in Yellowstone and Great Smoky Mountains national parks.

An important finding from this part of the book is that species and ecosystems vary dramatically in their response to climate and land use changes. Although some species are highly vulnerable, others may benefit under the projected changes. This result highlights again the need for rigorous assessment of vulnerability at multiple spatial scales, including the finer scales within which management is typically executed.