

## PART 2

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# Climate and Land Use Change

The two major ways that humans influence wildland ecosystems are (1) by changing climate through greenhouse gases and (2) by changing habitats through conversion to different land cover types and through land uses that vary in intensity. In the context of vulnerability assessment, these factors are considered elements of exposure that elicit responses from ecological systems. Climate and land use each influence ecosystems in unique ways. They also interact, often in ways that make effective management even more challenging.

This section of the book uses historic data and computer forecasts to summarize past and projected climate across the two study areas for the period 1900–2100. Climate can be represented in many ways. Chapters 4, 5, and 6 frame climate in terms that are most relevant to ecosystems and the species they support. In addition to annual averages of temperature and precipitation, seasonal averages and variability are presented as are extreme warm or cold events. These data are summarized across landscape conservation cooperatives for broad context but, importantly, are also analyzed at finer scales within the ecosystems centered on national parks and on habitat types within those ecosystems. These finer scales are most relevant to management, with the goal of telling the stories of climate change that are compelling to the stewards of these lands. Summaries are produced

over the past century to show the estimated degree of climate change in recent decades. Similarly, projections for the future are offered to allow us to visualize the range of plausible future conditions in the coming decades.

Although predicting the future might be called a fool's errand, using the best scientific methods to project plausible future conditions is an essential tool to motivate both managers and the public to anticipate the future, as well as providing credible information to express scenarios of possible future conditions. These projections differ for a variety of reasons, and this section of the book attempts to communicate the uncertainty of anticipated future conditions to facilitate management decisions that are robust in the face of this uncertainty. Although a two-hundred-year period is very long by human scales, it is quite short in terms of ecological and evolutionary scales. Thus, chapters 4 and 5 summarize climate change and major vegetation response since the last glacial period around fourteen thousand years ago. A sobering conclusion is that the projected change by 2100—just eighty-five years from now—is equal to or greater than that which occurred over the past fourteen centuries.

Concern about land use intensification has been at the forefront of conservation biology for several decades. The authors of this book's chapters have done extensive primary analyses of land use patterns and change at local to national levels. Rather than emphasize the primary analyses, we largely cite previous work on land use change in this book. Chapter 6 integrates land use classes and intensities into an index of human development. More specifically, the inverse of human development is used as an index of landscape integrity, with high values indicating lower exposure to intense land use. The chapter summarizes patterns of landscape integrity and climate change across the Great Northern Landscape Conservation Cooperative as elements of exposure in analyses of vulnerability of landforms to global change. In this regard, chapter 6 offers a coarse-filter approach to evaluating vulnerability, which nicely segues to chapters in part 3 that examine the specific ecological consequences of these changes.