

# Preface

This is a book about fire on landscapes. We explore fire as a contagious spatial process from a number of perspectives, including fundamental theory, fire-climate interactions, interactions with other ecological processes, and ecosystem management. Along the way we visit traditional domains of landscape ecology such as scaling, pattern-process interactions, and the complex interplay of top-down and bottom-up controls on ecosystem dynamics. We devote considerable space to theoretical considerations, particularly cross-scale modeling and landscape energetics, which we believe are under-represented in the current literature on landscape ecology of fire and other disturbances. In the remainder of the book, we look at fire climatology in an explicitly spatial context, examine four case studies of fire dynamics, two topical and two geographic in focus, and discuss issues facing fire management under rapid global change.

Our geographic focus is western North America (Fig. 1). This not only reflects the expertise of the editors and authors, but also allows us to look at a single large and diverse bioregion from multiple perspectives. Moreover, fire regimes in western North America are relatively less modified by humans than many other fire-prone landscapes around the world. Western North America is endowed with expanses of uninhabited areas over which we have ample opportunity to observe fire at a variety of scales. This facilitates our examining the interactions of climate, vegetation, and fire; fire extent, severity, and spatial pattern; and fire's interactions with other disturbances such as insect outbreaks and with other ecological processes such as invasions of landscapes by non-native plants.

Fire regimes in western North America, and the western United States in particular, have evolved in a mostly temperate climate, ranging from maritime to continental, and from wet to arid. Topography is very diverse, ranging from flat to extremely rugged, with elevations from below sea level to greater than 4,000 m. Human-induced changes in the fire regime range from essentially none (subalpine and other systems with stand-replacing fire regimes) to significant (Native American burning, twentieth-century fire exclusion, human-facilitated spread of invasive non-native species). Major vegetation types include semi-arid grasslands, chaparral, semi-arid woodlands, and a wide range of conifer and mixed forests. Western North America therefore encompasses many (though not all) of the major



**Fig. 1** Locations in the western USA of study sites analyzed or referred to in individual chapters of the book. Chapter numbers are in parentheses. Map color schemes here and elsewhere in the book draw substantially upon ideas at <http://colorbrewer2.org/>, developed by C.A. Brewer, Dept. of Geography, Pennsylvania State University

fire-regime types of Earth's fire-prone ecosystems, and we believe that the more general inferences from this book will have wide applicability around the world.

Section I focuses on the concepts of ecosystem energetics, scaling, and resilience. In [Chap. 1](#), we outline a potential theoretical framework for landscape fire based on ecosystem energetics. This chapter provides a lens through which succeeding chapters may be viewed. We explore how the concepts of ecosystem energetics, top-down vs. bottom-up controls, and scaling laws might be integrated to provide both a theoretical framework that reduces the apparent complexity of landscape disturbance and a window into its underlying mechanisms.

McKenzie and Kennedy (Chap. 2) review quantitative scaling relationships in fire regimes and describe how they can be used to discern controls operating at different scales. They review the basis for scaling laws in fire-size distributions, fire frequency, and fire hazard. These authors also use scaling laws to illuminate the spatial autocorrelation structure in fire-history data, which in turn reveals the dominant drivers of historical fire occurrence and extent.

In Chap. 3, Moritz, Hessburg, and Povak focus on scaling laws that describe fire size distributions and show how the spatial domain over which these scaling laws obtain is linked to dominant scales of regulation. They further present ideas about how self-organized ecosystem dynamics play out at these characteristic “landscape scales”, possibly building or enhancing landscape resilience.

Section II attends to one of the most important drivers of landscape fire dynamics: climate. Fire climatology references spatial scales broader than the usual domain of landscape ecology and is the subject of these two chapters. Gedalof (Chap. 4) reviews fire climatology with an emphasis on broad spatial patterns of climate drivers of fire and how they interact with biome-scale vegetation across North America. He invokes the idea of top-down vs. bottom-up controls on landscape fire, introduced in Chaps. 1–3, as they apply at regional to continental scales.

In Chap. 5, Littell and Gwozdz develop statistical fire-climate models at a finer spatial scale in the Pacific Northwest, USA. They introduce the idea of seasonal water-balance deficit as an overarching control of fire extent at regional scales and present ideas for scaling climate-fire models down to landscapes while maintaining the water-balance mechanism as a control.

Section III focuses on the ecological consequences of landscape fire dynamics. In Chap. 6, Smithwick reviews the interactions of fire with the biogeochemistry of ecosystems, using the well studied Greater Yellowstone Ecosystem as an example of the lessons learned about biogeochemical resilience. Whereas most fire-effects research looks at species, populations, and communities, Smithwick discusses the relatively unexplored idea that ecosystem functions such as decomposition and nutrient cycling are important contributors to resilience in the face of disturbance.

Swetnam, Falk, Hessl, and Farris (Chap. 7) provide an overview of methods for reconstructing historical fire perimeters from fire-scar records (which are essentially point data) as a tool for understanding the landscape spatial patterns of unmanaged fire. They review methods of interpolation, comparing both accuracy and assumptions implicit in a variety of methods. They then give a prospectus of the application of spatial reconstruction to both contemporary and future fire management.

In Chap. 8, Keeley, Franklin, and D’Antonio use the large and biologically rich state of California, USA, as a geographic template for examining the interplay of fire, climate, invasive species, and human populations. California’s forests, shrublands, and grasslands, along with other Mediterranean ecosystems, are some of the world’s most diverse with respect to species composition, landforms, and land use. Ecosystem dynamics in this region are analogously complex and provide a challenging arena for understand landscape fire dynamics in the face of extensive invasion by persistent non-native species.

Cushman, Wasserman, and McGarigal (Chap. 9) examine potential consequences of landscape fire dynamics for wildlife habitat in a Rocky Mountain landscape in northern Idaho, USA. They report a simulation experiment on the relative effects of climate change vs. management alternatives on habitat for two wildlife species with contrasting life-history traits. Their work poses the very relevant question of whether even fairly aggressive management can be effective given expected future changes in climate.

Our focus on the relatively uninhabited lands of western North America in no way obviates the need to consider the human dimension of the landscape ecology of fire in a contemporary context. Section IV provides two perspectives on fire management in the future. In [Chap. 10](#), Peterson, Halofsky, and Johnson discuss fire management opportunities on landscapes that are moderately to intensively managed. They present both a technical overview of fire and fuels management, with implications for ecosystem function in future climate, and a review of adaptation strategies from a consensus of land managers.

By contrast, Miller, Abatzoglou, Syphard, and Brown (Chap. 11) look at fire management in areas protected as wilderness across the western United States. Acknowledging that fire regimes and their management do not exist in isolation from exogeneous forces of change, they explore how the future context of wilderness fire management might change with two future trends: increasing temperatures leading to more episodes of extreme fire weather, and increasing housing densities leading to greater risk and greater incidence of human-caused fires in wilderness areas. Using two contrasting examples, they discuss how the challenge to meet fire-management objectives could intensify in many wilderness areas.

A single book cannot cover the entire field of landscape fire ecology. Consequently, we have eschewed coverage of some topics that might be central to a broad survey of the field but have been well covered in other recent publications. For example, we do not review landscape fire simulation models or remote sensing of fire characteristics. Similarly, we do not provide surveys of the use of landscape metrics in the description of fire pattern and dynamics, or of spatial considerations in sampling designs in fire ecology. Instead, we focus on new and emerging ideas about the landscape ecology of fire that are not well covered in the existing literature. We hope that the chapters in this book stretch familiar concepts, touch upon new ideas and directions, and present a range of perspectives for the study of landscape fire ecology. We encourage the reader to use this volume as a complement to existing published work.

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