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To Harold Biswell, who can truly be called the father of fire ecology in California.
His patience, persistence, humor, and devotion to managing wildlands and
fire in harmony with nature have been an inspiration to all of us.

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FOREWORD

James K. Agee

Fire was finally recognized as an important ecological factor in the mid-twentieth century in Rexford Daubenmire's *Plants and Environment*. Before then, it had largely been considered an allogenic factor even by ecologists such as Fredric Clements, who had done some of the first work on fire-dependent lodgepole pine in the Rocky Mountains. The volume you have in your hand is the most comprehensive work ever on a state's fire ecology, and demonstrates tremendous progress in understanding the role of fire in California wildlands. Although the destructive fires of southern California in 2003 have captured the headlines at the time of this writing, it is the less dramatic truths in this volume that will have a far more lasting effect on wildland fire in California.

Fire and people have interacted for millennia in California. Native Americans burned the landscapes of the state for a variety of purposes, including protection of their villages (the first wildland-urban interface), resources such as basket-weaving materials, the many food plants that were favored by fire, hunting game animals, and signaling and warfare. Their fires, often starting at low elevations, complemented those started from lightning, more common at high elevations. The long dry seasons typical of the Mediterranean climate ensured a prolonged fire season every year. Although fire did visit almost every landscape in California, it did so with a remarkable variety in frequency, intensity, and effects. California has always been and will continue to be a fire environment unmatched in North America.

Institutionalized fire policy in California began early in the twentieth century when the great fires of Idaho and Montana in 1910 galvanized the fledging Forest Service to promulgate a policy of total fire exclusion. A battle to retain *light burning*, as prescribed fire was called in those days, was fought both in the southern states and in California. Forest industry was leading the charge for light burning, not because of altruistic sentiments about natural forests but because they believed it would help protect the old growth forests until they were ready to be harvested.

Aided by the passage of the Federal Clarke-McNary Act in 1924 that funneled fire protection dollars to the states and by research from the Forest Service, fire exclusion was firmly entrenched in California. Yet some of the same research used to support the fire protection policy, such as that by Bevier Show and Edward Kotok in the Sierra Nevada and Emmanuel Fritz in the coast redwood belt, also showed that fire had played a very significant historical role in forest ecosystem dynamics. The fire exclusion policy remained unchallenged until the 1950s, when it came under attack by a few courageous men, such as Harold Weaver who worked for the Bureau of Indian Affairs and Harold Biswell from the University of California at Berkeley.

Dr. Biswell, more than anyone, actually bent the old fire culture in California. The idea of underburning forests to prevent more destructive wildfires was a revolutionary idea in California in the 1950s and 1960s, although fire then was routinely used in some shrublands. It is important to keep in mind that during those times, Harold was widely criticized for the same ideas, presented in the same way, for which he received so much favorable response later in his career, including his classic integration of science and interpretation, *Prescribed Burning in California Wildland Vegetation Management* (UC Press 1989). Harold was an advocate of fire prevention, but he believed that a balance between fire suppression, prevention, and use was critical. Smokey Bear just couldn't say it all in one sentence anymore. One had to be very courageous in those days, and Harold strode on, focusing on spreading his message and taking the high road in terms of his professional demeanor. The logic of that message attracted many of us, including me, to become interested in fire science as a career.

Where have we come since then, when we at least were providing lip service to the important role of fire in California wildlands? We have made some great strides in some areas, and seem to be mired in the muck elsewhere. The technology needed to conduct prescribed burns continues to improve. We now have computer models that incorporate fire behavior information with geographic information systems to predict fire spread across landscapes. It works well. We have more sophisticated fire effects models to predict the ecological outcome of fire. We can tell what size classes of the various tree species on a site are likely to die in fires with various flame lengths. Our technological fixes are not complete, but in comparison to our knowledge about other ecological disturbance factors, such as wind, insects, or fungi, fire technology is at the head of the pack.

We use this technology only sparingly, and a strong case remains that we could do much more. The phrase "forest health" emerged in the late 1980s to explain why we see so many trees dead and dying across western landscapes, and high-density, multi-layered forests caused by fire exclusion are at the root of the problem. Current forest health situations at Lake Arrowhead are unprecedented, with millions of drought-killed pines helping to fuel current wildfires. Insects and disease epidemics are at historic highs, and intense wildfires are expanding like never before on western landscapes. California, as well as Oregon, New Mexico, and Colorado, have experienced their largest-ever wildfires in recorded history since the turn of the millennium. We continue to despair at the state of our western forests, but the solutions have become mired in political debates. Yet there are some radiant examples of fire use in the state: California state parks are burning in a wide variety of forest and shrub vegetation types; nature organizations such as The Nature Conservancy have been using prescribed fire in prairie restoration and oak woodland maintenance, and are coordinating the pooling of resources of large private landowners to effect landscape burns in the Sacramento Valley; and the National Park Service is continuing to move forward with prescribed fire plans in chaparral and forested portions of national park system lands in the Sierra Nevada and elsewhere. These programs are complex: They require knowledge of plant and animal response to fire, and the effects of varying the frequency of fire, its intensity and extent, the season of burning, and its interaction with other ecosystem processes.

The national forests will see expanded fire programs in the coming years, too. Professor Biswell's idea in the 1950s to use the large federal emergency firefighting fund upfront to do fuel treatment was recently championed by Secretary of the Interior Bruce Babbitt on behalf of all the federal land management agencies. It made perfect sense 40 years ago, but took almost half a century to become part of the fire culture. A portion of the fund became authorized and available in 1998 for prescribed burning on all federal lands. This will have a tremendous impact on project funding, and will result in much more prescribed fire, and reduced threat of wildfire, over millions of acres of the West. The National Fire Plan and the Western Governors' Association are providing consensus polices in the wildland-urban interface. Whether or not the president's Healthy Forests Initiative, recently enacted into law, is embraced as part of the solution depends on whether it is perceived as a real opportunity to increase forest health or simply a way to expedite logging.

The intrusion of residences into wildlands, with its attendant fire problems, was always a major concern of Biswell's, and in his book he warned of impending catastrophic fire in the Berkeley Hills. His warning was based on precedence, in that one of the most devastating urban–wildland interface fires prior to 1991 occurred in the Berkeley Hills in 1923. A fire started in the hilltop area, and blown by hot, dry autumn winds, swept down right to the edge of the University of California campus. Fire marshals were considering dynamiting entire residential blocks to save the rest of the town, when fog blew in from the Golden Gate and helped extinguish the fire. The burned area sprouted back with residences, just as the brush and eucalyptus trees sprouted back, and the residences spread further into the wildlands over the subsequent decades.

The Berkeley Hills are not unique in this regard. They are but one of innumerable communities where residences are invading wildlands, but Harold lived in the Berkeley Hills, so it was of special interest and concern to him. His late 1980s prediction of a major catastrophic fire there came true in 1991. No one was saddened more than Harold Biswell when the fire killed 25 people, destroyed more than 3,000 homes, and cost more than $1.5 billion—and it was preventable. Sadly, these property losses were exceeded in the 2003 southern California fires.

This growing fire problem in what is called the *urban-wildland interface* will continue to plague fire managers. Of all the institutional problems with fire, these are the most complex: most land is privately owned; myriad jurisdictional problems exist for zoning, building codes, fire protection; and attitudes persist that the disaster will strike somewhere else, or will never strike twice.

The volume you hold now will become the secular bible of fire ecology for Californians. But what does the future hold for new knowledge and application? Peruse the list of contributors, and it is clear that agency people are by far the majority of authors. This was also true of the Sierra Nevada Ecosystem Project, which began as a federally funded grant to the University of California, Davis, in the mid-1990s and ended with most of the papers on ecological change completed by late-added agency scientists. Academic trends over the last decade have disfavored small, technically oriented programs (i.e., fire ecology, forest management) in favor of more general and efficient programs (environmental science) that attract larger numbers of students. California's universities, while not disfavoring fire ecologists, will be hiring general ecologists in order to meet their teaching mandates. Those that can attract research funding in fire ecology may be able to carve a niche for themselves, but few universities will be advertising specifically for fire ecologists.

At the same time, the complex nature of resource management argues for more technically trained managers. The agencies have hired many more doctorate-level fire scientists than have the academic systems, and this demand will continue to grow. But there is a major supply and demand problem emerging: Prospects for long-term supply are meager, given the trend in academia to avoid specialist faculty who would guide these students. The typical historical solution to these types of problems has been cooperative programs partly funded by the federal government at selected universities to maintain viable teaching and research capability in a specific discipline. My prediction is that the federal agencies will develop a series of National Fire Science Centers to help meet their own demands in fire science, including fire ecology. A major caveat to this prediction is the general lack of attention to natural resources issues at the federal level. Disasters such as the 2003 fires in southern California spark a few congressional brushfires, but they usually fade as quickly as the headlines. I think Fire Science Center–like programs are likely to be initiated, but may not expand as fully as they perhaps should.

In wildlands, history does repeat itself. Fire environments of yesterday are those of today, and will be those of tomorrow. California and the West are fire environments without parallel in North America. Harold Biswell would say that our mountains will always stand majestically, and dry summers and windy spells will always be part of our western heritage. We can only intervene in the fire behavior triangle by managing the vegetation. Biswell and his contemporaries gave us the tools to manage change through controlled fire, integrating it with naturally occurring fire in wilderness and intelligent, cost-effective fire suppression. It is now time for us to recognize that fire is part of our culture, and we need to make good decisions about the use of fire, not just its control. The solutions will be complex, will vary by place, and will occur in a changing environment. This book tells us what we know now, but we have the ability to learn much more as we manage, and we will need to feed this information back into better decision making. There are many treatments we can apply, in various places with unique land-use histories, and at different scales, in stochastic environments, and perhaps permanently changing climates. Fire ecology will inform this debate, with no better place to start than this book. We hope you enjoy it, learn a lot, and finish with more questions than when you started.

PREFACE

Alterations to fire regimes have resulted in many changes to the biological communities including changes in vegetation composition and structure and vegetation type conversions or ecosystem migrations. This text details many of these changes, explains how fire has changed as an ecosystem process, and provides insights for determining the direction that the changes might take in the future. As with introductory treatments of any of the elements of natural ecosystems, we are prone to generalization, simplification, and standardization of processes and interactions that are inherently complex. In describing fire effects and regimes we are by necessity guilty of continuing that trend toward simplification. However, we hope that by communicating the concepts of the role that fire plays as a dynamic ecological process, we can communicate the importance of fire's role in defining what we know as California ecosystems.

This book is intended for use both as a text for learning and teaching the basics of fire ecology and as a reference book on fire in California ecosystems. It synthesizes and expands upon our knowledge of fire as an ecological process and facilitates a better understanding of the complex and dynamic interactions between fire and the other physical and biological components of California ecosystems. Modern western society has tended to view ecosystems within narrowly defined ranges of time and space. Focused studies of ecosystems from the standpoint of individual species within their habitats, individual stands of trees, populations, plant communities, fire events, or watersheds allow us to know specific mechanics of ecosystems but, by nature, do not help us develop a broad view of large dynamic landscapes. On the other hand, studies of broad spatial or temporal application are usually quite limited in their application to specific examples. Understanding fire in ecosystems requires us to greatly expand our spatial and temporal context to include both discrete fire events that occur on finite landscapes and complex multi-scale burning patterns and processes that are dynamic on large landscapes. We intend this text to present an integrated view of fire in California ecosystems from as wide a spectrum of temporal and spatial scales as possible.

This text is divided into three parts. Part I is an introduction to the study of fire ecology that is intended for use in teaching the basics of fire ecology. It includes overviews of fire in California, fire as a physical process, fire regimes, and interactions of fire with the biological and physical components of the environment. Part II is a treatment of the history, ecology, and management of fire by bioregions and is intended for use as a reference and for teaching fire ecology within the various bioregions within California. Part III is a treatment of fire management issues and is intended for use as a reference and for teaching fire management from a historical, policy, and issue perspective.

Obviously, a book such as this is not written without the help of many people. First, we would like to thank the many authors of all the chapters; they endured structured outlines, tight deadlines, and an authoritarian group of editors. Heath Norton drew the figures, Daniel Rankin prepared the maps, Scott Dailey formatted the tables, Gail Bakker formatted tables and chapters, and Lester Thode created the fire regime graphs. Without their help, the book would have lacked the consistency and attractiveness that add greatly to its readability. Finally, we would like to thank the Joint Fire Science Program board and Ray Quintanar of the Forest Service's Pacific Southwest Region for providing the funds and time necessary to write the book. Their support was essential.