# Introduction

This book describes the ecology and the use of fire in wildlands vegetation management. It emphasizes (1) the role of natural fires set by lightning in prehistoric times and the importance of understanding and working in harmony with nature, (2) the environmental impacts of excluding fires from wildland environments, and (3) the why, where, when, and how of prescribed burning (also known as controlled, or control, burning) to protect and enhance the wildland resources.

In this introduction I present the rationale for prescribed burning and describe how my background led me to heed and espouse that rationale. In Chapter 1 I examine the fundamentals of fire behavior and the factors that determine how fires burn. Chapter 2 is a discussion of the natural role of fire in ecosystems before the days of European settlement—that is, fires set by lightning and by the Indians. The histories of wildfires, on the one hand, and of prescribed burning, on the other, are then presented in Chapters 3 and 4. In Chapter 5 I discuss prescriptions and techniques of prescribed burning and how to put together a fire management plan. As will be seen, burning affects many different resources, all of which are discussed in Chapter 6. The concluding chapter presents the reasons (or excuses) given for not doing more prescribed burning.

An evolving philosophy about prescribed burning begins by reflecting on fires set both by lightning and by Indians during primeval times, fires that spread freely over the landscapes and served to recycle fuels and renew the vegetation. (See Figures

Figure 1. *"The friendly flame" in the understory of ponderosa pine. The prescribed fire (also called a control burn or a broadcast burn) reduces the fuels and structures the forest to make it largely fire-resistant. The fire is moving ½ to ¾ foot per minute. The area will need a reburn in five to seven years.*

Figure 2. *A prescribed fire in southern oak woodland-savanna.*

1–3.) It was only about 100 years ago that people decided that all wildland fires were harmful and determined to suppress them as quickly as possible. This practice has allowed unnatural changes to take place in the vegetation and caused fuels to build up, making some present-day wildfires so intense that they cannot be stopped until the weather changes or they approach natural fuel breaks such as bodies of water or recently burned areas. (See Figures 4–5.) Fierce wildfires burning in large volumes of highly flammable fuels during hot, dry summer weather under windy conditions are now doing tremendous damage to property and wildland resources and are hor-

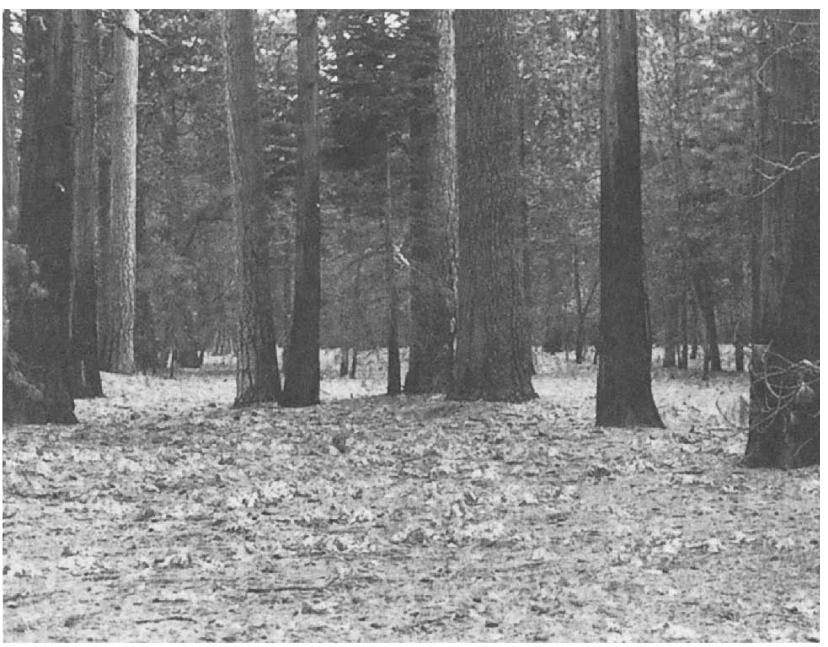

Figure 3. *A reasonable facsimile of a primitive, open, parklike mixed-conifer forest. The ponderosa and sugar pine trees show hardly any effects of recurring surface fires, while the incense-cedar with its scaly fibrous bark shows the ease with which this tree can be blackened. Some ecologists describe this forest as a fire climax, meaning that it is maintained by recurring surface fires. Others describe it as a fire subclimax, meaning that if fire is excluded, the forest develops into a different type. This picture was taken two years after a prescribed fire in Yosemite National Park.*

Figure 4. *A once-pristine, fire-climax ponderosa pine forest until fire protection without any control burns enabled white fir to invade the understory. Some people believe this invasion represents natural succession and are satisfied with what they see. But certainly it is not natural. How could it be when ground-surface lightning-caused fires, one of the principal features of nature, have been suppressed? The picture was taken in the Tahoe National Forest a few yards south of the Placer County Grove of giant sequoias.*

ribly expensive to control. And that is not all! Each year the wildfire situation worsens as suppression efforts become more sophisticated. Inevitably, some of the wildfires of the future will be more destructive of wildland resources and more dangerous to public safety and welfare than any fires of the past.

In view of this bleak situation, I have strongly recommended that prescribed fires, carefully planned and set under the proper conditions, be used in wildlands vegetation management. Such fires can mitigate the bad effects that would otherwise result from practices leading to intense wildfires. If natural fires set by lightning were once essential to the development and survival of many types of vegetation, and the vegetation is

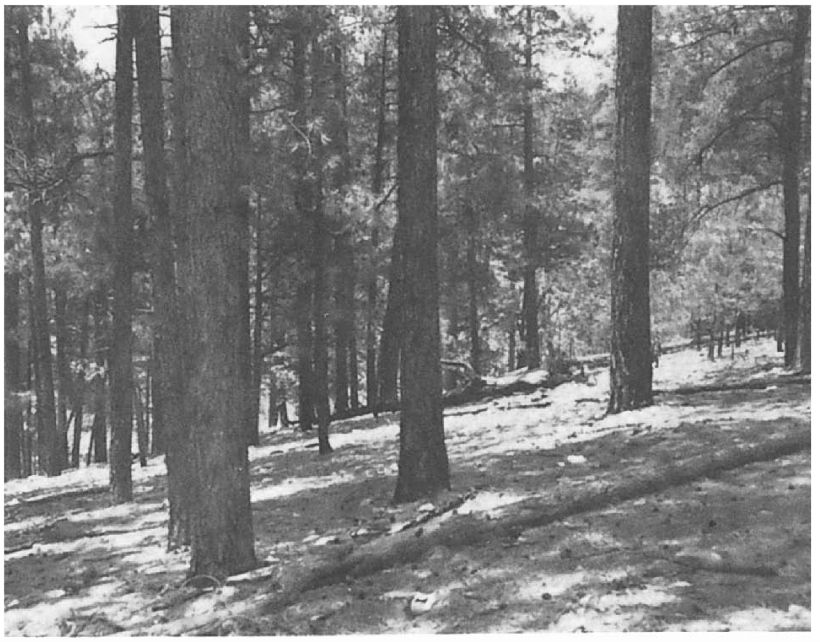

Figure 5. *A forest structure in ponderosa pine, created by prescribed burning. This structure illustrates how the forest reproduced naturally during primeval times in the presence of frequently recurring surface fires set by lightning. Reproduction is kept out of the understory while it thrives in the opening on the right, where there is barely enough surface fuel to carry fire beneath saplings (see far right background).*

still desirable to maintain, why don't we, then, purposely simulate them by setting fires on our own terms through prescribed burning? Such fires would be carefully set in selected places, at selected times, and under selected conditions of fuel moisture content, air temperature, relative humidity, wind direction and velocity, atmospheric stability, and weather predictions. And with the use of proven techniques, the flames would be managed and controlled. Thus, by prescribed burning and by working in harmony with nature, we could reduce debris and modify plant communities to make the vegetation more resistant to wildfires, thereby also helping to prevent damage and to reduce the costs of fire suppression. (See Figures 6–7.)

Figure 6. *Extreme accumulation of fuel in a mixed-conifer forest. Fuels of this type ensure that wildfires will be extremely intense, destructive, and difficult to control. Prescribed burning is an effective means of correcting this dangerous and unhealthy condition.*

Prescribed fires relate to nearly every aspect of the environment: the people, including their philosophies, politics, and laws; individual plants and plant communities; soils; wildlife; water and watersheds; diseases and insects; the atmosphere; and aesthetics. Combinations of interrelationships are nearly endless. And, of course, there are economic and sociological aspects related to every wildland management practice.

This book is intended to be useful to all segments of society and particularly to environmentalists and to resource practitioners involved in park and wilderness preservation, timber management, wildlife habitat improvement, range livestock grazing, watershed management, and recreation. To comprehend and fully appreciate prescribed burning, one must know that prior to European settlements, for thousands of years re-

Figure 7. *Prescribed burning in April in southern California oak woodland-savanna to reduce fire hazards and return the area to a more natural stable condition. Fire is backing down the slope at a measured rate of 5/8 foot per minute.*

curring lightning fires were a *natural* feature of the environment. Those fires were not ruinous. They maintained balance in ecosystems and ensured that the forests and other plant communities would reproduce, grow, and mature in good health and with vigor. How could this be, when no one tried to put out the fires? This question has been in the minds of many people in recent years as they read about and see on television the destructive wildfires that burn over thousands of acres of prime watershed lands, destroy precious timber, consume houses, and endanger the welfare and safety of countless people.

Wildlands fire management has three aspects: prevention, suppression, and use. They are equally important. Yet, over the years, great attention and support have been given to prevention and suppression, and rightly so, but very little to use.

Figures 8 and 9. *Before* (above) *and after* (below) *prescribed burning in ponderosa pine. Fuels on the forest floor have been reduced 57 percent, and the fire hazard is now very low.*

This is wrong. For if equal attention and support were to be given to all three aspects, fire suppression would gradually become easier and more effective, and the total costs of fire management activities would diminish.

In no way does this book advocate the lessening of efforts in wildlands fire prevention and suppression; these activities are essential. Instead, it advocates prescribed burning in wildlands vegetation management, since these fires can be highly beneficial in preserving and enhancing the vegetation and other wildland resources, as well as in reducing the wildfire hazards. (See Figures 8–9.)

This book is confined mostly to California's vegetation and conditions because that state is where I have done most of my research and study and where the wildfire problems are greatest. However, the ideas and principles involved should have wide application in other areas of the world where the vegetation is abundant and becomes excessively dry at some season of the year.

Certain features of the California environment make the wildlands extremely susceptible to fire occurrence and spread. Mild, moist winters are favorable to abundant plant growth; rainless, or nearly rainless, summers dry out the vegetation and soils; daytime temperatures in summer are usually high, and the humidity may be exceptionally low; winds are often strong; and in places the topography is rugged and steep. Dead fuels accumulate rapidly in this environment because winters are too cold and summers too dry for much bacterial activity; consequently, decay of organic matter is slow. In addition to these natural features, the great influx of people into California and the building of houses in areas of high fire hazards greatly complicate the wildfire problem. (See Figures 10–11.)

## *The Author's Background*

My research, observations, and reading have convinced me that fire is natural to wildland environments and must be used. Lightning fires have always burned over our hot and dry summertime landscapes and always will. It is up to the public to determine whether the wildland fires will be gentle and bene-

Figure 10. *A prescribed burn through an area of young ponderosa pine. The burn killed most of the incense-cedar invading the understory, reduced fire hazards, and produced a diverse forest pattern.*

ficial affairs or raging holocausts that devastate the vegetation, soils, watersheds, and wildlife, and sometimes spread so relentlessly that they kill people and destroy homes.

My early background gave me much experience in vegetation management. It was on a highly diversified farm in the Ozark foothills of Missouri that I grew up, in a family of five girls and five boys. We tended pastures and raised beef cattle, sheep, hogs, and brood mares. Two or three cows and a few chickens furnished dairy and poultry products. Field crops were corn, wheat, oats, and hay of alfalfa, red clover, and timothy. (Today, soy beans are an important crop there.) About half of the 346 acres was nearly level bottomland, and the other half, hills. As a rule, we cultivated the level grounds, and let our livestock graze the hilly portions. Two large creeks passed through the farm; one was sandy and good for swimming, and

Figure 11. *Houses located in highly flammable fuels. Such buildings are a wildfire management problem. They also add to the risk of prescribed burning in nearby areas. A large number of houses of this sort are located both immediately above and below Calaveras Big Trees State Park, where prescribed burning has been in progress. Bear clover draped with pine needles and small twigs, along with small incense-cedar and white fir "ladder fuels" in the understory of large trees, is one of our most flammable and dangerous fuel types. This area should be prescribe-burned and cleaned to reduce the fire hazard to a tolerable level.*

the other was muddy with clay and loam. In both, fishing was good. Where the creeks meandered through cornfields, muskrats were plentiful.

The forests were hardwood of oaks, hickories, black walnut, and other species typical of that area. They had the potential for high-priced logs, as well as affording homes for many raccoons, opossums, skunks, mink, red squirrels, groundhogs, cottontail rabbits, and bobwhite quail. Cardinals and other songbirds were abundant. At present, all these wildlife species,

plus deer, coyote, and wild turkey, are plentiful, except for groundhogs, which seem to be fewer, perhaps because of coyote predation.

It was on the farm that I first developed a respect for the land. We saw the need for tender care of soils. Slopes had to be managed with utmost care or the soil would wash away. I learned about the requirements of wildlife and how the habitat for each species can be improved. Every year at woodcutting time we made brush piles and left them for the cottontail rabbits, which we later hunted in the winter snow. I also learned about the importance of den trees for raccoons, squirrels, and owls. Those trees were protected. Selective cutting of trees for stove wood was a means of improving the forest stand. I discovered the beneficial effects of thinning on crop production by hand-thinning many miles of rows of listed corn. Each spring we did some burning of dry weeds and trash around the cornfields to help control plant diseases and insect pests. In managing livestock, I saw that animal numbers must be kept in line with forage and hay production. A farm boy learns an endless number of things about the environment and conservation, including crop rotation and the costs and returns of different methods of operation. One of the most valuable things I learned was the importance of hard work.

In October 1984, I visited the farm, now managed by my brother, Frederic. It is in excellent condition, with no visible soil erosion, thanks to tall fescue grass and good management.

I left the farm to attend Central College in Fayette, Missouri, where I majored in zoology. From there I went to the University of Nebraska and did graduate work in botany and plant ecology, with Dr. J. E. Weaver as my major professor. He was an excellent teacher and example, but he rarely mentioned the ecology of fire. My M.S. degree was in botany and grassland ecology; my thesis concerned the effects of clipping on the yield of tops and roots of grasses in prairie sod. I received my Ph.D. in botany and forest ecology, with a minor in animal ecology, my dissertation dealing with the effects of the environment on the root development of deciduous forest trees.

My first employment was in range research with the U.S. Forest Service (USFS) at the California Forest and Range Experiment Station, now the Pacific Southwest Forest and Range

Experiment Station, in Berkeley. I worked one summer on mountain meadows and six years on mid-Sierran foothill woodland-savanna out of the San Joaquin Experimental Range in Madera County. In 1940, I was put in charge of range research at the Forest Service Southeastern Forest Experiment Station in Asheville, North Carolina. Part of my work was in the coastal plain of Georgia, where, in 1941, I was introduced to the use of low-intensity fires in the production of timber and forage in the piney woods.

After field surveys and a study of the literature and in response to people's interests and suggestions, I decided to experiment with rotational burning and livestock grazing in forests of longleaf and slash pines and wire grass. The primary objective was to maximize timber production; the secondary purpose was to improve grazing. These aims would be achieved by using fire to reduce logging slash, reduce brush in the understory of trees, prepare seedbeds, control brown spot disease on longleaf pine, and regulate fire occurrence and grazing to favor reproduction of longleaf and slash pines.

During the early forties, very little planned burning was done in the southeastern piney woods. However, there was a growing interest in this activity. Much confusion and controversy existed because the need for fire in forest management and for expertise in burning was little understood. Emphasis had been on fire prevention and suppression. Many foresters frowned on the use of fire, finding it difficult to understand the difference between a wildfire and a prescribed fire.

Early in the planning stage of the southeastern studies, I had an eye-opening experience. I was invited to see where foresters had been burning in the piney woods—an area of 80,000 acres of Brunswick Peninsula Company lands, now Union Camp. One elderly man had been assigned the job of burning. He worked alone, making full use of forest roads, past burns, and his experiences with fire behavior under varying conditions. Patient and skilled, he managed with full control of the flames. It was an important lesson: in using fire, both patience and experience are invaluable. My observations during this one day were sufficient to convince me that prescribed fires can be used beneficially in forestland management.

In 1947, I accepted a teaching and research position in the

Department of Forestry and Conservation at the University of California, Berkeley. Very soon I found myself involved in research on the use of fire in Sierran foothill woodland-savanna to improve ranges for livestock grazing and wildlife. I spent many weekends in the foothills working with ranchers in control burning to reduce and manipulate brush. During that period I also carried on a large project of burning chaparral in Lake County for game habitat improvement and sheep grazing. In the spring of 1951, I began studies on the use of fire in ponderosa pine in the Teaford Forest in Madera County near North Fork, and started a similar project in the fall of that year at Hoberg's Resort in Lake County. These studies continued through 1964. Some of the plots at Hoberg's are still in place, and I have examined them many times since their inception.

In 1961 and 1962, thanks to a Guggenheim award, I spent two months each summer in the Mediterranean region of Europe, studying the role of fire in various vegetation types there.

In 1965, I began studies of prescribed burning in giant sequoia and mixed conifers at Whitaker's Forest in Tulare County. This project was carried on until 1973, when I became professor emeritus at the university. For two years after formal retirement, I taught a course in fire ecology on the Davis campus of the university, and for eight years I taught university extension courses: forest fire ecology, chaparral fire ecology, giant sequoia fire ecology, and fire ecology basics. Popular and well attended, these were field courses requiring two full days (usually a Saturday and Sunday). When conditions were right, a demonstration burn added greatly to the quality of these sessions. The extension courses and field days together did much to promote better understanding of the important role of fire in wildlands vegetation management. Along the way I did some burning and instruction work in ponderosa pine forests in southern Colorado and in South Dakota.

From fall 1975 through 1982, I served as special consultant in fire ecology to the California Department of Parks and Recreation. In November 1975, prescribed burning was started in Calaveras Big Trees State Park, and spring 1978 in Cuyamaca Rancho State Park in San Diego County, as well as in Big Basin Redwoods State Park, a short distance south of San Francisco.

Since that time, prescribed burning has been used in several other state parks having different vegetation types and plant communities.

This background gives me confidence in suggesting that prescribed fires can be extremely useful in the management of wildland ecosystems. Since fire is related to nearly every aspect of the environment, there is no end to what one can learn about its fascinating role as a constructive, rather than as a destructive, force.

## *Vegetation*

Listed here are the California plant communities, identified by key species and vegetation understories, in which I have used fires. (Scientific names are given in the index.)

*Ponderosa pine forests* Ponderosa pine and California black oak, with an understory of shrubs such as manzanitas, bear clover, and grasses.

*Mixed-conifer forests* Ponderosa pine, incense-cedar, sugar pine, white fir, Douglas-fir, and California black oak, with an understory of shrubs such as ceanothus and manzanita species, tanbark oak, dwarf tanbark, and chinquapin.

*Giant sequoia forests* Giant sequoia, white fir, and sugar pine, with an understory of hazel bush, dogwood, ceanothous species, California wild rose, and lupines.

*Redwood forests* Redwood, Douglas-fir, tanbark oak, and madrone, with an understory of California huckleberry, ferns, and wood-sorrel.

*Knobcone pine forests* Knobcone pine, with an understory of manzanita and ceanothus species and perhaps chamise. (See Figure 12.)

*Torrey pine forests* Torrey pine, with an understory of forbs and shrubs.

*Monterey pine forests* Monterey pine, with an understory of briars, poison oak, and grasses.

*Foothill woodland-savanna* Blue oak, interior live oak, and digger pine, with an understory of ceanothus and manzanita species and a ground cover of annual grasses and forbs.

Figure 12. *A typical knobcone pine forest. The mature trees are small, the bark is relatively thin, and understory debris is abundant. The natural ecology of this forest is for fire to burn the entire forest stand and regenerate a new crop of seedlings. Since the cones are tightly closed (serotinous) and shed their seeds only after fire, prescribed burning should be done only in late fall, not in spring; otherwise most of the seeds will be destroyed by rodents and birds during the summer and not enough of them will remain to regenerate the forest. This is probably the case with all pines that produce serotinous cones.*

*Southern oak woodland-savanna* Coast live oak, California black oak, Coulter pine, and canyon oak, with an understory of manzanita, ceanothus, and herbaceous vegetation.

*Climax chaparral* Chamise, scrub oak, ceanothus and manzanita species, and western mountain-mahogany, with hardly any ground cover beneath the shrubs.

*Forest chaparral* Possibly manzanita or ceanothus, perhaps with bear clover in the understory.

*Southern coastal sage scrub* California sagebrush, white sage, and Wild buckwheat, with annual grasses intermixed.

*Northern coastal scrub* Coyote bush, monkey flower, California blackberry, and woody lupines, with grasses and forbs intermixed.

*Coastal prairie* Creeping wild rye, California oat grass, and velvet grass, with several annual grasses and forbs intermixed.

*Eucalyptus* Eucalyptus, with an understory of annual grasses.

As far as I can determine, all these plant communities are fire-dependent; that is, in each case the dominant species and the structure of the community manifest an adaptation to some condition of fire frequency and intensity. Plant communities are discussed further in Chapter 5 (see page 126).

## *Literature on Prescribed Burning*

Because this book is based primarily on my own research and field experiences in prescribed burning, plus an analysis of the literature over many years, I have not documented the text (and deluged the reader) with reference after reference. Rather, I have listed a few supplemental readings at the end of the text.

For those who wish to delve further into the literature on fire and prescribed burning, I recommend several publications, including several readily accessible books (see suggested readings for the Introduction, page 235).