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United States
Department of
Agriculture

Forest Service

Intermountain
Forest and Range
Experiment Station
Ogden, UT 84401

General Technical
Report INT-182

April 1985

Proceedings—Symposium and Workshop on Wilderness Fire

Missoula, Montana, November 15-18, 1983

FO 5614

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SD 420.6 .S98 1983
Symposium and Workshop on
Wilderness Fire (1983. :
Proceedings-Symposium and
Workshop on Wilderness Fire

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Proceedings—Symposium and Workshop on Wilderness Fire

Missoula, Montana, November 15-18, 1983

Technical Coordinators:

JAMES E. LOTAN, Program Manager, Intermountain Forest and Range Experiment Station, Missoula, Mont.

BRUCE M. KILGORE, Project Leader, Intermountain Forest and Range Experiment Station, Missoula, Mont.

WILLIAM C. FISCHER, Research Forester, Intermountain Forest and Range Experiment Station, Missoula, Mont.

ROBERT W. MUTCH, Fuels and Fire Ecology Specialist, Northern Region, Missoula, Mont.

Proceedings of a Symposium Sponsored by:

Intermountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture
National Park Service, U.S. Department of the Interior
National Wildfire Coordinating Group
Society of American Foresters
University of Montana

FOREWORD

The Wilderness Fire Symposium held November 15-18, 1983, in Missoula, Mont., can be described in one word: *exciting!* Since its very inception, people have been excited. As I write these words almost a year later, people are still excited about wilderness fire management.

Credit for the initial concept of having such a symposium belongs to William C. Fischer, Research Forester at the Intermountain Fire Sciences Laboratory in Missoula. Bill spent many long hours developing and writing the recently published "Wilderness Fire Management Planning Guide."[1] One day as we were discussing the concept of using fire in wilderness, Bill suggested that we should pause to assess wilderness fire management inasmuch as we had been practicing it for 10 years or more. I said, "Let's do it!" And so we did.

I then formed a program committee chaired by Dr. Bruce Kilgore and consisting of Robert Mutch (both Bruce and Bob were pioneers in wilderness fire), Bill Fischer, and me. This early planning took place in January 1982. Bruce became a prime mover from that moment on. None of us at that time realized either the work involved or the size of the program that would evolve. We were excited, however, and that excitement spread to the estimated 700 people in attendance. More than 600 people registered; their names and addresses are listed at the end of the proceedings.

The symposium was one of a series planned to terminate the highly productive Fire Effects and Use Research and Development Program, conducted by Forest Service Research at the Intermountain Station's Intermountain Fire Sciences Laboratory located Northwest of Missoula, Mont.

Our goal was to openly discuss how well we have managed wilderness fire and current concerns. We wanted to discuss these issues in an open forum, with attendees contributing. During my opening remarks at the symposium, I pointed out that either topic--wilderness or fire--was apt to be controversial; and when we combine them, we are doubly assured of having plenty of controversy.

That we did! The arguments are continuing to this day. Our goal was to get them out into the open and to deal with them professionally. I suspect that as the issues of allocation and classification of wilderness are resolved, we will hear more debate about management of wilderness. What we have heard so far is probably just the tip of the iceberg.

One management controversy that has already arisen is whether to use deliberate, scheduled ignitions in wilderness. William A. Worf, retired Recreation Director of the U.S. Forest Service, Northern Region, pointed out that we did not present the cons of using scheduled ignition in wilderness. I therefore invited him to present his views in a paper to be included in the proceedings. In addition, I decided to include the views of Robert C. Lucas and Bruce M. Kilgore, who reviewed Worf's paper. I suppose the process could have continued *ad infinitum*. These papers point out the complexities of wilderness fire management. I suspect that such controversy extends to many other wilderness issues.

Processing papers for this proceedings revealed a frustrating inconsistency in the terminology used to describe wilderness fires. We felt that uniform terminology would facilitate communication among the various Federal resource agencies, State and Province organizations, universities, conservation groups, industry, consultants, and research organizations. I therefore asked Bill Fischer to include his well-thought-out lexicon ("Wilderness Fire Terminology") in this proceedings, and we tried to use it throughout the proceedings even though we did not intend to press for universal adoption. Our hopes were dashed because each agency had its own terminology and good reasons for adherence to its usage. We ended up deferring to definitions used within an agency.

To facilitate communication in this proceedings and to eliminate reader confusion, we shall list some of the most common terms coined by the Forest Service, National Park Service, and Bill Fischer.

We caution readers to heed the official terminology of their respective agencies, and we urge the agencies to strive for literal and consistent meanings. Perhaps over the next decade a clearly understood and uniform terminology will evolve.

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[1]Fischer, William C. Wilderness fire management planning guide. Gen. Tech. Rep. INT-171. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, 1984. 56 p.

Types of fire	Forest Service term	Park Service term	Fischer's term
Fires ignited by lightning or other natural forces (volcanoes) that are permitted to burn under prescribed conditions.	Fires with unplanned ignition	Prescribed natural fires	Fires with unscheduled ignition
Fires ignited by trained professionals under prescribed conditions.	Fires with planned ignition	Prescribed burns	Scheduled ignition
Unwanted fires started either by natural forces or people (arson or carelessness).	Wildfires	Wildfires	Wildfires

I thank Dr. Bruce Kilgore and the members of the program committee: Gerry T. Baertsch, our general manager; the many speakers and authors; and the many attendees and their supporting agencies. Bruce's energy and attention to detail were particularly important to the successful completion of the symposium and publication of the proceedings. This symposium will serve as a milestone in his future research in wilderness fire management. Bill Fischer deserves further acknowledgment for his outstanding poster session. It added immeasurably to the value of the meeting. I personally thank Gail Hallesy and Patricia Proebstel who did far more than type papers. Their assistance was invaluable.

For their sponsorship and generous support of the symposium, I thank administrators in the Washington Office of Forest Service Research and in the Intermountain Station; and also the Center for Continuing Education, University of Montana; the National Park Service; the Prescribed Fire and Fire Effects Working Team, National Wildfire Coordinating Group; and the Ecology and Fire Management Working Groups, Society of American Foresters.

With these comments I submit these proceedings to the wilderness fire management community. *It has been fun! . . . and exciting!*

JAMES E. LOTAN
Research Forester

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ECOLOGICAL EFFECTS AND MANAGEMENT IMPLICATIONS OF INDIAN FIRES

Stephen F. Arno

ABSTRACT: Current evidence suggests that Indian fires substantially augmented those set by lightning in grassland, shrubland, and certain lower-elevation forest types for a millennium before settlement by Euro-Americans. In some large areas Indian fires apparently had a marked and continuing influence on vegetation. Managers of wilderness and other natural areas should assess the probable effects of past Indian fires on their ecosystems and consider this information in developing management alternatives.

INTRODUCTION

Previous papers (Gruell; Lewis this proceedings) indicate that fires started by American Indians were common in what is now the central and western United States and adjacent portion of Canada. In this paper I present my hypotheses concerning the effects of Indian fires on major vegetation types from the Great Plains to the Pacific Coast and discuss the implications for fire management in wilderness and natural areas.

TIME SPAN OF INDIAN FIRES

Indian fires evidently had a widespread influence on vegetation in much of central and western North America until the mid-1800's (Stewart 1956; Moore 1972; Lewis 1973, 1982; Pyne 1982; Gruell 1985, this proceedings). Aboriginal ignitions augmented lightning ignitions and thus shortened the average intervals between fires in many of the grassland, shrubland, and dry forest types.

It is difficult to determine when extensive Indian burning first began and thus how long it continued, but evidence from several areas suggests that Indian fires were common for a rather long period before Euro-American settlers arrived. In western Montana, investigations of fire-scarred trees suggest that aboriginal burning extended back at least to A.D. 1500, whereas Euro-American settlement began in about 1860 (Barrett 1981; Barrett and Arno 1982).

Paper presented at the Wilderness Fire Symposium, Missoula, Mont., November 15-18, 1983.

Stephen F. Arno is Research Forester, U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Northern Forest Fire Laboratory, Missoula, Mont.

Palynological studies in a ponderosa pine/Douglas-fir (*Pinus ponderosa/Pseudotsuga menziesii*) forest near Lewiston in northern Idaho suggest that frequent Indian fires may have begun about a millennium ago (Smith 1981). Similarly, investigations of sediments in two western Montana bogs show a large increase in wind-deposited charcoal beginning between 1,000 and 2,000 years ago (Mehringer and others 1977; Hemphill 1983). Indian fires may have been responsible for this charcoal deposition because no related major change in climate was evident. Anthropologists queried by Kilgore and Taylor (1979) felt that Indian burning may have occurred for roughly a thousand years in the ponderosa pine-mixed conifer forest of the California Sierra Nevada. Fritz (1931) found that a history of frequent fires extended back at least 1,100 years in an area of the California redwood (*Sequoia sempervirens*) forest. Indians were implicated as a major ignition source (Thompson 1916; Lewis 1973; Veirs 1982) because lightning fires are uncommon in that area.

ECOLOGICAL EFFECTS

I will present my hypotheses about the effects of Indian fires by major vegetation zones (Küchler 1964).

Grasslands and Sagebrush

Prior to Euroamerican settlement, native grasslands covered most of the Great Plains from northern Texas to southern Canada. Grasslands also dominated extensive areas of Washington and Oregon's Columbia River Basin, California's Central Valley, and smaller areas of the West's drier intermountain valleys. In general, frequent light fires help perennial grasses to maintain dominance because they regenerate readily from buds near the soil surface. Less frequent burning allows fire-tolerant, resprouting shrubs and trees to develop; these include chokecherry (*Prunus virginiana*), serviceberry (*Amelanchier*), and aspen (*Populus tremuloides*). Long intervals between fires favor development of nonsprouting shrubs, such as big sagebrush (*Artemisia tridentata*), and most coniferous trees.

Evidently Indians set many fires inadvertently and for several purposes in the grasslands. Indian

fires may have equaled or exceeded lightning fires in numbers (Moore 1977; Gruell 1985), and the short intervals between all fires favored expansion of grasslands into the adjacent shrub or tree "habitat types" (potential climax without fire) (Gruell 1983). Shrub and tree communities have now developed in some former grasslands as a result of fire suppression and grazing. In northern California (Lewis 1973), western Oregon (Habeck 1961; Thilenius 1968; Johannessen and others 1971), and northern Alberta (Lewis 1980) seral grasslands were maintained by deliberate burning in environments that through vegetal succession would have developed into forest.

Sagebrush (*Artemisia* spp.)-grass communities cover a large part of the semiarid Intermountain West, from the east slope of California's Sierra Nevada to southeastern Wyoming. On the more productive sites--those that are relatively moist and have well-developed soils--sagebrush dominance often appears to have resulted from past grazing and fire suppression (Gruell 1984). Grassland may have dominated these areas until the late 1800's. By that time, however, heavy domestic grazing had reduced grass vigor, giving sagebrush the competitive advantage; heavy grazing also removed fine fuels and thus prevented fires from spreading. In contrast, before the introduction of livestock, fire was relatively frequent. Fires probably occurred every two or three decades (Houston 1973; Arno and Gruell 1983, 1984) in all but the rockiest and poorest sites with inherently sparse vegetation. Many of these fires were apparently ignited by Indians, and fire's effect was to favor grass relative to most kinds of sagebrush and bitterbrush (*Purshia tridentata*), mountain-mahogany (*Cercocarpus spp.*), and most other shrubs. Dry and stony sites that supported only sparse vegetation and fuels probably burned less often, and shrub dominance was thus maintained. Today, succession on some sagebrush-grass sites has advanced to dominance by juniper, interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*), or other conifers. This seems to be the result of fire suppression and domestic grazing (Burkhardt and Tisdale 1976; Dealy and others 1977; Young and Evans 1981; Arno and Gruell 1983).

Pinyon-Juniper

Pinyon and juniper woodland communities occupy many of the mountain slopes and high plateaus from central Oregon to western Texas. This vegetation type commonly replaces sagebrush-grass under somewhat more moist or cool conditions. Pinyon and juniper also represent the potential climax, in the absence of fire, on some sagebrush-grass sites (Wright and others 1979). This woodland type sometimes occurs in a mosaic pattern with sagebrush-grass, occupying the stoniest soils, where fires spread poorly and competition from grasses and shrubs is minimal.

Pinyons and junipers can survive light surface fires but are killed by wind-driven crown fires. Indian fires no doubt often spread into pinyon-juniper woodlands and also kept the trees from invading the adjacent sagebrush-grass communities. Little is known about presettlement fire frequencies in pinyon and juniper woodlands. It appears, however, that before the introduction of domestic livestock in the mid-1800's, fires may have occurred at 15- to 90-year intervals, maintaining open or patchy stands in areas where woodlands have since become very dense (Young and Evans 1981; Rogers 1982; Gruell 1984). Tree densities have increased in many areas and undergrowth is so sparse (as a result of shading as well as past grazing) that surface fuels do not support fire. Thus, these stands now can burn only under extreme conditions--hot dry weather and strong winds. This woodland type receives large numbers of lightning ignitions, and Indian use and travel through it was substantial, probably resulting in many fires in the past.

Chaparral And Oakbrush

These dense, tall shrub communities cover hot, dry mountain slopes in California, Arizona, New Mexico, Colorado, and Utah. This vegetation type occurs upslope from the grasslands and other lowland types that were often burned by Indian fires. Lightning ignitions are also common in chaparral and oakbrush. The California chaparral evidently experienced frequent stand-replacing fires (5- to 40-year intervals), and these maintained mosaics of plant communities that differed in composition, structure, and age (Minnich 1983). The Rocky Mountain oakbrush (*Quercus gambelii*) resprouts vigorously after fire, and it evidently burned every few decades in presettlement times.

Indian fires undoubtedly spread into these types (Lewis 1973; Aschmann 1977; Gruell 1985). Fire suppression has now permitted large areas of old, decadent chaparral and oakbrush to develop.

Interior Montane Forests

Ponderosa pine and interior Douglas-fir make up the driest forest zones in most of western North America, from southern British Columbia to South Dakota and western Texas. Frequent surface fires--at average intervals of 5 to 25 years in most areas (Martin 1982)--were characteristic where ponderosa pine was abundant. Interior Douglas-fir forests lacking ponderosa pine occur at moderately high elevations, often adjacent to sagebrush-grass valleys in the Rocky Mountains; fire intervals in these cooler, dry forests average between 25 and 60 years (Houston 1973; Arno and Gruell 1983, 1984).

Evidence cited in Cooper (1960), Lewis (1973), Kilgore and Taylor (1979), Barrett (1981), and Gruell (1985; this proceedings) suggests that Indian fires were common; their frequencies probably equaled or exceeded those of lightning fires in some of these forests. Frequent surface fires kept stands open and parklike, and numerous 19th century travelers remarked that it was easy

to ride horseback through them without a trail. Selective logging and fire suppression since about 1900 have favored development of dense stands in which more shade-tolerant species--Douglas-fir and true firs (*Abies* spp.)--are replacing ponderosa pine. In many of these stands, accumulations of living or dead fuels probably exceed the maximums achieved before 1900 (Davis and others 1980; Gruell and others 1982). Insect and disease damage also seems to be heightened by the dense, decadent stand conditions (Mitchell and Martin 1980; Arno and Brown 1983).

As a result of fire suppression, and perhaps grazing disturbance, interior Douglas-fir has expanded into the adjacent mountain grasslands (Parminter 1978; Arno and Gruell 1983, 1984; Gruell 1983). In some areas ponderosa pine has also expanded into grasslands (Pregulske and Sowell 1974), but Douglas-fir invasion seems more widespread, probably because past fires were much more damaging to small Douglas-fir than to the fire-resistant pine.

Interior Subalpine Forests

High-elevation forests in the Rocky Mountains, the Sierra Nevada, and the inland slope of the Cascades generally are dominated by lodgepole pine (*Pinus contorta*), subalpine fir (*Abies lasiocarpa*) or red fir (*Abies magnifica*), and in many areas Engelmann spruce (*Picea engelmannii*). Most of these "cool" forests produce sufficient tree and undergrowth biomass to have burned at intervals averaging between 50 and 300 years. Some sites, however, have such low productivity and sparse fuels that they rarely support a spreading fire (Arno 1980; Martin 1982). Some productive sites, such as spruce basins, support adequate fuels but rarely burn because moist and cool conditions are so prevalent.

Lightning frequently occurs in these subalpine forests, and short warm-dry periods are also characteristic during most summers. Indians occasionally traveled through these habitats, and sometimes lit fires for route clearing or other purposes. In areas where subalpine forests occur directly above the major valleys, Indian fires no doubt spread upslope into them. Overall, however, it appears that lightning was the prevalent cause of fires in these forests simply because of their remoteness.

Maritime Forests

Forests of western hemlock (*Tsuga heterophylla*), western redcedar (*Thuja plicata*), and Sitka spruce (*Picea sitchensis*) occupy an extremely moist and temperate climatic zone along the Pacific Coast from northern California to southern Alaska. Coastal Douglas-fir (*P. menziesii* var. *menziesii*) is a prominent associate in these maritime forests south of Alaska, and redwood occupies the southern end of this strip, in California. Moist "inland-maritime" forests of western hemlock and western redcedar mixed with inland conifers occupy the western slope of the Rockies in southern British Columbia and northern Idaho and vicinity. Although annual precipitation is relatively high (>35 inches; [90 cm]) in all areas of these maritime forests, a summer drought becomes increasingly common southward from Canada.

Moderate-to-severe wildfires occurred at long intervals (averaging between 60 and 350 years) in most of these forests from southern British Columbia to northern California. In the coastal areas these fires resulted in establishment of seral, coastal Douglas-fir whereas in the inland-maritime zone fires favored establishment of western white pine (*Pinus monticola*), western larch (*Larix occidentalis*), lodgepole pine (*Pinus contorta* var. *latifolia*), and other seral species. Lightning is infrequent in the coastal forests but is common in the inland-maritime zone; however, moist fuels limit fire frequency in both regions. Indian ignitions no doubt occasionally caused spreading fires in coastal and inland-maritime forests, but their past importance is unknown. In certain localities Indian fires were common, as in the northern California redwood country (Lewis 1973; Veirs 1982; Rice this proceedings).

MANAGEMENT IMPLICATIONS

Managers of wilderness, national parks, and other natural areas might benefit from knowing the past role of Indian fires in each vegetation type. Such baseline information is necessary to understand cause and effect; it should aid a manager in predicting vegetative development under different fire regimes. If the manager's goal is to develop or maintain a certain vegetative type or complex, then information on frequency and effects of past fires can be used to develop management alternatives.

Information on Indian use of fire in a specific area can be obtained by (1) searching the technical literature (in anthropology, history, vegetation ecology, and palynology); (2) investigating historical accounts (Gruell 1984, 1985); (3) interviewing anthropologists; (4) investigating fire scar chronologies from areas of past Indian use; or (5) conducting palynological and sediment studies (Smith 1983).

Presumably managers will set specific goals for each vegetation type. Definition of such goals will be essential for determining where managers might want to mimic or simulate the effect of Indian fires. Kilgore (this proceedings) pointed out that the term "natural fire" may or may not include Indian fires, depending upon the management direction. For example, the management goal might be to maintain "the biotic associations . . . as nearly as possible in the the condition that prevailed when the area was first visited by white man," as was recommended for United States national parks by the Leopold Committee (1963). In this case, any substantial role played by aboriginal fires might need to be simulated through the use of prescribed fire.

On the other hand, the Wilderness Act of 1964 (Public Law 88-577) defines wilderness as an area managed to preserve "natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable." Does "man's work" in this case include that of aboriginal man? If so, this passage suggests that if an area's vegetation had been substantially altered by Indian burning when it was first observed by Euroamericans, that condition would not be "natural" nor qualify for wilderness. Thus, the ponderosa pine-mixed conifer and giant sequoia (*Sequoiadendron giganteum*) forests of the Sierra Nevada might not qualify for wilderness because they reflect a history of aboriginal burning and probably would have had less pine and sequoia without aboriginal burning. The language of the Wilderness Act however, does not definitely indicate whether Indian burning is to be considered natural.

Regarding vegetation management in the U. S. Department of Agriculture, Forest Service's Research Natural Area system, the following statement appears (Forest Service Manual 4063.38, March 1979):

> The Station Director, with the approval of the Forest Supervisor, may authorize management practices, except within wildernesses, necessary to preserve the vegetation for which the research natural areas was [sic] created. These practices may include grazing, control of excessive animal populations, or prescribed burning. Only tried and reliable techniques will be used, and then only where the vegetative type would otherwise be lost without management. The criterion here is that the management practice must provide a closer approximation of the vegetation and the processes governing the vegetation than would be possible without management.

If, for example, Indian fires helped maintain seral stands of ponderosa pine or giant sequoia, prescribed fire could be used to simulate the aboriginal fires.

Thus current management directions are variable and nebulous regarding whether "natural fire" includes those set by aboriginals. Once this issue is resolved for each type of natural area, managers can determine whether to use scheduled ignitions as a a substitute for Indian fires.

The use of prescribed fire in wilderness and natural areas is also of concern to managers of nearby nonwilderness. For instance, use of prescribed fire in wilderness might, if successful, help reduce the threat of wildfires or keep buildups of insects or diseases from spreading into adjacent nonwilderness forests.

REFERENCES

Arno, S. F. Forest fire history in the Northern Rockies. J. For. 78: 460-465; 1980.

Arno, S. F.; Brown J. Prescribed fire as a tool for multiple-use management of ponderosa pine-fir forests. Problem analysis. Review draft. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1983. 37 p.

Arno, S. F.; Gruell, G. Fire history at the forest-grassland ecotone in southwestern Montana. J. Range Manage. 36: 332-336; 1983.

Arno, S. F.; Gruell, G. A century of Douglas-fir encroachment into mountain grasslands on the Deerlodge National Forest. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1984; [in preparation].

Aschmann, H. Aboriginal use of fire. In: Environmental consequences of fire and fuel management in Mediterranean ecosystems: Proceedings of the symposium. Gen. Tech. Rep. WO-03. Washington, DC: U.S. Department of Agriculture, Forest Service; 1977: 132-141.

Barrett, S. W. Relationship of Indian-caused fires to the ecology of western Montana forests. Missoula, MT: University of Montana; 1981. 198 p. Master's thesis.

Barrett, S. W.; Arno, S. Indian fires as an ecological influence in the Northern Rockies. J. For. 80: 647-651; 1982.

Burkhardt, J. W.; Tisdale, E. Causes of juniper invasion in southwestern Idaho. Ecology. 57: 472-484; 1976.

Cooper, C. F.; Changes in vegetation, structure, and growth of Southwestern pine forests since white settlement. Ecological Monographs. 30: 129-164; 1960.

Davis, K. M.; Clayton, B.; Fischer, W. Fire ecology of Lolo National Forest habitat types. Gen. Tech. Rep. INT-79. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1980. 77 p.

Healy, J. E.; Geist, J.; Driscoll, R. Communities of western juniper in the intermountain northwest. In: Proceedings: Western juniper ecology and management workshop. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1977: 11-30.

Fritz, E. The role of fire in the redwood region. J. For. 29: 939-950; 1931.

Gruell, G. E. Fire on the early western landscape: an annotated list of recorded wildland fires in pre-settlement times. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Northern Forest Fire Laboratory; 1985; Northwest Science. [In press.]

Gruell, G. E. Post-1900 mule deer increases in the Interior West: influences of fire and other factors. Gen. Techn. Rep. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1984; [in preparation].

Gruell, G. E. Fire and vegetative trends in the Northern Rockies: interpretations from 1871-1982 photographs. Gen. Tech. Rep. INT-158. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1983. 117 p.

Gruell, G. E.; Schmidt, W.; Arno, S.; Reich, W. Seventy years of vegetative change in a managed ponderosa pine forest in western Montana--implications for resource management. Gen. Tech. Rep. 130. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1982. 42 p.

Habeck, J. R. The original vegetation of the mid-Willamette Valley, Oregon. Northwest Science. 35: 65-77; 1961.

Hemphill, M. L. Fire, vegetation, and people--charcoal and pollen analyses of Sheep Mountain Bog, Montana: the last 2800 years. Pullman, WA: Washington, State University; 1983. 70 p. Master's thesis.

Houston, D. B. Wildfires in northern Yellowstone National Park. Ecology. 54: 1111-1117; 1973.

Johannessen, C. L.; Davenport, W. A.; Miller, A.; McWilliams, S. The vegetation of the Willamette Valley. Annals of the Assn. of Am. Geogr. 61: 286-302; 1971.

Kilgore, B. M.; Taylor, D. Fire history of a sequoia-mixed conifer forest. Ecology. 60: 129-142; 1979.

Küchler, A. W. Potential natural vegetation of the conterminous United States. Am. Geogr. Soc. Spec. Publ. 36; 1964; [map and manual].

Leopold, A. S.; Cain, S.; Cottam, C.; Gabrielson, I.; Kimball, T. The Leopold Report says national parks should be . . . "A vignette of primitive America." Sierra Club Bull. 48(3): 4-11; 1963.

Lewis, H. T. Patterns of Indian burning in California: ecology and ethnohistory. Anthropol. Pap. 1. Ramona, CA: Ballena Press; 1973. 101 p.

Lewis, H. T. Indian fires of spring. Natural History 89: 76-83; 1980.

Lewis, H. T. Fire technology and resource management in aboriginal North America and Australia. In: Williams, Nancy M.; Hunn, Eugene S., eds. Resource managers: North American and Australian hunter-gathers: Proceedings of AAAS selected symposium 67. Boulder, CO: Westview Press, Inc.; 1982: 45-67.

Martin, R. E. Fire history and its role in succession. In: Proceedings, symposium on forest succession and stand development research in the Northwest. Corvallis, OR: Oregon State University; 1982: 92-99.

Mehringer, P. J.; Arno, S.; Peterson, K. Postglacial history of Lost Trail Pass Bog, Bitterroot Mountains, Montana. Arctic and Alpine Res. 9: 345-368; 1977.

Minnich, R. A. Fire mosaics in southern California and northern Baja California. Science. 219: 1287-1294; 1983.

Mitchell, R. G.; Martin, R. Fire and insects in western pine culture in the Pacific Northwest. In: Proceedings, 6th conference on fire and forest meteorology. Washington, DC: Society of American Foresters; 1980: 182-190.

Moore, G. T. Man and fire in the central North American grassland 1535-1890: a documentary historical geography. Los Angeles, CA: University of California; 1972. 155 p. Dissertation.

Norton, H. H. The association between anthropogenic prairies and important food plants in western Washington. Northwest Anthropological Res. Notes 13: 175-200; 1979.

Parminter, J. V. Forest encroachment upon grassland range in the Chilcotin Region of British Columbia. Vancouver, BC: University of British Columbia; 1978. 121 p. Master of Forestry Essay Report.

Progulske, D. R.; Sowell, R. Yellow ore, yellow hair, yellow-pine--A photographic study of a century of forest ecology. Agric. Exp. Stn. Bull. 616. Brookings, SD: South Dakota State University; 1974. 169 p.

Pyne, S. J. Fire in America--a cultural history of wildland and rural fires. Princeton, NJ: Princeton University Press; 1982. 654 p.

Rogers, G. F. Then and now--a photographic history of vegetation change in the central Great Basin desert. Salt Lake City, UT: University of Utah Press; 1982. 152 p.

Smith, C. S. A 4300 year history of vegetation, climate, and fire from Blue Lake, Nez Perce County, Idaho. Pullman, WA: Washington State University; 1983. 86 p. Master's thesis.

Stewart, O. C. Fire as the first great force employed by man. In: Thomas, W. L., ed. Changing the face of the Earth. Chicago: University of Chicago Press; 1956: 115-133.

Thilenius, J. F. The *Quercus garryana* forests of Willamette Valley, Oregon. Ecology. 49: 1123-1133; 1968.

Thompson, L. To the American Indian. Eureka, CA: Cummins Print Shop; 1916. 214 p.

Veirs, S. D., Jr. Coast redwood forest: stand dynamics, successional status, and the role of fire. In: Means, J, ed. Proceedings, Forest succession and stand development research in the Northwest. Corvallis, OR: Oregon State University; 1982: 119-141.

Wright, H. A.; Neuenschwander, L.; Britton, C. The role and use of fire in sagebrush-grass and pinyon-juniper plant communities--a state-of-the-art review. Gen. Tech. Rep. INT-58. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1979. 48 p.

Young, J. A.; Evans, R. Demography and fire history of a western juniper stand. J. Range Manage. 34: 501-506; 1981.