Restoring Fire to the Ecosystems of the Boundary Waters Canoe Area, Minnesota, and to Similar Wilderness Areas

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THE REMAINING virgin forests of the Boundary Waters Canoe Area in northeastern Minnesota owe their composition and structure to periodic fires over the past 400 years. In fact, the entire biota has adapted to fire over eons of time. Because the BWCA is a unit of the National Wilderness Preservation System there is an interest in maintaining or where necessary restoring its natural ecosystems. But if this policy alternative is to be achieved, fire must be reintroduced as a key environmental factor. I am convinced that similar conclusions apply to many other Wilderness Areas and National Parks that contain relatively intact northern conifer forest ecosystems. I base these statements on my current forest history studies in the BWCA, on a large body of fire ecology literature, and on the current and still largely unpublished research of several investigators in other nature reserves.

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FIG. 1. The virgin forests of the BWCA owe their present composition and structure to periodic fires over the past 400 years.

It is not my purpose here to extensively document the historical role of fire in the BWCA ecosystem, since a full technical exposition of that history will appear elsewhere. And three recent articles have already described the biological effects of fire in such ecosystems (Heinselman 1969, 1970a, b). But let me outline the impact of recent human activities on the area, and summarize the tentative conclusions from my fire history research.

PRESENT CONDITION OF FORESTS

Today the forests of the million-acre BWCA are a patchwork of several large blocks of virgin forest, largely on the original public domain, and of second growth timber on logged-over land. This is a consequence of the early private use of some land, the gradual public acquisition of the present BWCA, and the evolution of management policies. The virgin areas cover about 40 percent of the area, or some 400,000 acres. They are true virgin forests in the sense that they have never been logged, farmed, grazed, or otherwise directly altered by man. Many stands are only 50 to 150 years old and of post-fire origin, but fire was part of this ecosystem, and thus a natural factor in the ecology of the area. These virgin areas are the largest blocks of uncut northern conifer forest remaining in the northeastern United States. As such they are clearly a significant scientific, educational, and cultural resource. A map showing the logging history and locating the remaining virgin forest blocks has been published (Heinselman 1969).

FIRE HISTORY STUDIES

The objective of my current studies is to determine the origin and ecological history of the remaining virgin forests of the BWCA and to relate their present status to the primeval situation. These things must be understood both to provide a yardstick for possible vegetation maintenance and restoration programs and to advance our knowledge of the northern forest ecosystem.

I have been successful in deciphering this history back about 370 years. This was done by: (1) Checking historical records, old maps, old government reports, and the General Land Office Survey notes; (2) obtaining the ages of several thousand overstory trees on some 900 study plots scattered across the entire virgin forest and on recent timber sales where stand remnants were present; (3) obtaining a fire chronology from old fire-scarred trees by counting annual rings from the cambium to the scars; (4) mapping forest age classes and fire boundaries throughout the area with the aid of airphotos, forest type maps, and field checks; and (5) studying the age structure and time of reproduction by species in 30 stands scattered across the area. A popular account of both the logging and fire history has been published (Heinselman 1969).

The following conclusions seem warranted, although they are still tentative until the final analyses and fire maps are completed:

(1) At least 80 to 90 percent of the virgin forests can be traced to a post-fire origin. The oldest known stand dates from about 1595 A.D., and the youngest stands of any size from the fires of 1936. Charcoal is almost universal in soil organic layers.

(2) Major fires recurred at 5- to 50-year intervals from at least 1600 A.D. to 1920. Some areas rebound at intervals as long as 200 to 300 years, others as short as 10.

(3) There may have been an increase in fire from 1800 to 1910 due to the activities of explorers, prospectors, loggers, and settlers, but this is uncertain.

(4) Since about 1920 only limited areas of virgin forest have burned, due to effective fire control.

(5) Most stands still have a nearly even-aged overstory dating back to the last fire. Some stands of red and white pine and other species contain groves or scattered trees of two or more age classes, each dating from separate fires. Some sites regenerated slowly and contain a mixture of ages.

(6) The areas burned most frequently or intensely are large uplands distant from natural firebreaks. Jack pine, black spruce, aspen, birch, other sprout hardwoods, and fir dominate such areas.

(7) The areas burned least frequently or intensely are sites naturally less subject to fire, such as swamps, ravines, lakeshores, the lower slopes of high ridges, islands, and the east, north, northeast, or southeast sides of large lakes or streams. White pine, red pine, white spruce, and northern white-cedar are relatively more abundant on such sites.

(8) Fire was probably frequent enough to prevent succession from proceeding far toward the theoretical spruce-fir-birch climax. Most forests today are only first generation stands following fire, and this may always have been true. The lifespans of red and white pine, the spruces, and cedar (300 to 500 years) seem longer than the probable periodicity of fires on most sites. Even jack pine and aspen can persist for more than 200 years without fire, and few areas escaped longer than this.

(9) The vegetation that might develop with fire exclusion (present management practice) is in a sense unnatural *and largely unknown to science*. We do not know whether such circumstances have

FIG. 2. Even jack pine may persist more than 200 years without fire. Specimen in center foreground dates from a fire in about 1755–59.

occurred in post-glacial times, and we have no good examples of climax forest today.

COOPERATIVE PALEOBOTANICAL RESEARCH

We would like to know whether the fire regime recorded for the last 370 years is similar to that in primeval times, and whether any changes in the fire regime may have influenced the composition of the present virgin forests. Studies of the existing virgin forests cannot entirely answer these questions because these forests mostly date from after 1650 A.D.—about the time Western man's impact on the fire regime could have begun.

Fortunately, the means may now be at hand to answer these questions also. The University of Minnesota's Limnological Research Center under Dr. H. E. Wright, and the Department of Botany through Dr. E. J. Cushing are cooperating with us by studying the sediment record of certain BWCA lakes. They hope to determine the sequence of vegetation changes and the associated fire history for nearly the full post-glacial time period. This is possible because annually laminated organic lake sediments have been discovered in Lake of the Clouds—a small, deep lake far within the virgin areas. Sediment cores have been collected, and the full post-glacial record is present. There are some 9,500 annual layers of sediment (lake mud)—checked by carbon-14 dating. The sediment contains tiny bits of charred wood and plant fragments as well as the usual plant pollens and other fossils from top to bottom. By studying the fluctuations in abundance of charcoal and of various plant pollens over time, the University research team hopes to document the vegetation and fire history of the locale for 9,500 years. Eventually other lakes may also be studied. But already this project has changed the questions we are asking. The question is no longer "Was fire a natural factor before Western man came?" It is now "*How much fire was natural*, and were there changes in the vegetation and fire record associated with the buildup of early human populations, with the arrival of Western man, and with post-glacial climatic fluctuations?"

MANAGEMENT IMPLICATIONS AND ALTERNATIVES

Although the research I have described is not complete, certain implications for BWCA ecosystem management can be foreseen. The BWCA vegetation mosaic was clearly a fire dependent system in both primeval and recent times. We do not know exactly how much fire was "natural," but we do know that fire was an over-riding environmental factor. It was the great reaper that periodically eliminated or opened up old forests, making way for a new generation of trees. It was the source of most new plant successions. It generated the vegetation types upon which the moose, beaver, hare, and grouse depended—and thus also the timber wolf and other mammalian and avian carnivores. In short, the whose ecosystem was geared to periodic fire.

Thus we must begin now to consider our alternatives regarding fire as a key natural environmental factor. I can see only three general management alternatives for the Interior Zone of the BWCA, where commercial logging is excluded: (1) We can continue to suppress fire and force a totally new and uncertain sequence of successional changes in the plant and animal communities, (2) we can reintroduce fire into the ecosystem by prescribed burning or by changing wildfire control practices, or (3) we can abandon the concept of natural ecosystems and turn to mechanical vegetation manipulation using the tools of applied forestry.

Some consequences of fire exclusion can be predicted in a general way. The short-lived pioneer forests such as the jack pine and aspen-birch communities will decrease and largely disappear within 100 to 150 years. The longer lived stands of red pine and white pine may persist as an overstory for 300 to 500 years, but they too may eventually almost disappear. The shade tolerant balsam fir, northern white-cedar, and spruces will greatly increase as they already have in some areas. Epidemics of the spruce budworm, such as the one now rampant, may become more frequent and periodically kill much of the balsam. There may be an accumulation of organic matter and forest fuels that could lead to a conflagration when severe fire weather occurs. In a sense, fire exclusion is a grand ecological experiment. We cannot accurately foresee the outcome, but we can guess at the trends. We have already been conducting this experiment for some 35 to 50 years!

On the other hand, even though we now understand the ecological need, we are not yet ready to reintroduce fire as a significant factor in the BWCA, either by prescribed burning or by "herding" wildfires. More research on fire behavior, fire control, prescribed burning techniques, and the ecological effects of prescribed fire will be needed.

To many of us, including myself, the third alternative—mechanized forestry—is "giving up the ball game." Mechanical or chemical tree harvest, soil preparation, seeding, planting, and weeding will all be required if a degree of control over plant successions is to be

FIG. 3. Fuel accumulations are often heavy in northern forests. This is a 90-year-old jack pine stand; the understory of fir has been largely killed by the spruce budworm.

achieved through silvicultural techniques. We know how to proceed, but do we want to in a Wilderness as unique as the BWCA? The natural ecosystem can never be adequately simulated by such means.

The Wilderness-Area fire policy dilemma is not unique to the BWCA. Similar ecological circumstances and problems, differing in detail but not in principle, exist in many cherished Wilderness Areas and National Parks (see, for example, Habeck 1970, Heinselman 1970a, b, Kilgore 1970, Weaver and Biswell 1969). Wherever fire was a key environmental factor—and this includes a great many areas—we are faced with the same decisions. We have more hard facts to go on in the BWCA than in many other areas, and fortunately we still have some time to decide. The successional changes produced by fire exclusion are slow in northern forests, and the

FIG. 4. Fire scars such as this may record the natural "fire rotation."

seed sources for most native plants will be available for decades yet. But the animal side of the ecosystem may suffer more rapidly because succession eliminates the habitats of certain species rather quickly.

PROBLEMS OF REINTRODUCING FIRE

The problem of restoring fire to northern conifer-forest ecosystems is new to applied ecology. This is so because the ecological role and character of the fires are different from those of fires in grasslands, savannas, heathlands, the southern pines, ponderosa pine, or even post-logging prescribed fires in the North. Prescribed fires in these ecosystems may burn spectacularly, and with high rates of spread, but they are basically light to medium intensity ground fires, with relatively low resistance to control.

In contrast, fires in living northern conifer forests are frequently a combination of intense ground fires and running crown fires. Often heavy litter and thick organic-matter accumulations on the ground become part of the fuel load during burning weather. In some communities fires burned only at long intervals, perhaps 50 to 400 years or more. The ecological function here was to destroy the old forest and begin successions anew. Such fires can be awesome spectacles!

I am thinking here of fires in jack pine, lodgepole pine, the white pines, spruce and fir, Douglas-fir, and the many other forest types of the Lake States, the true boreal forests, and the higher elevations of the Rockies, the Cascades, and the Sierras. Almost our only experience with such fires until very recently has been in prevention and suppression work. The "herding" or "management" of such wildfires, or their deliberate ignition for beneficial purposes, have rarely been attempted. Yet this is what may be needed to preserve the ecosystems in Wilderness Areas or National Parks containing these ecosystems.

We must also be able to protect commercial forests, communities, and property on the periphery of the wilderness. And we must be able to predict the progress of fires to ensure the safety of visitors to the area.

Still another constraint will be the need to avoid mechanical scarring of the landscape with bulldozers and other heavy equipment. And large, permanent, artificial firebreaks, roads, and similar developments will usually be unacceptable.

Are these obstacles insurmountable? I think not. First, we need not burn a large percentage of the area at one time. What is needed is to slowly re-establish the natural mosaic of forest age classes and successional stages. Only a small fraction of an area would usually burn in any given fire year. There might be periods of several years with no fire, whether lightning fires or prescribed fires are relied on. If prescribed fires or "managed" wildfires are to be used, the natural "fire rotation" should be the yardstick to fire frequency and size where it can be determined. The incidence and size of past fires and the resulting pattern of forest age classes in the virgin forests can often be determined directly through studies of stand ages and fire scars. Where it can be, here is the best guide.

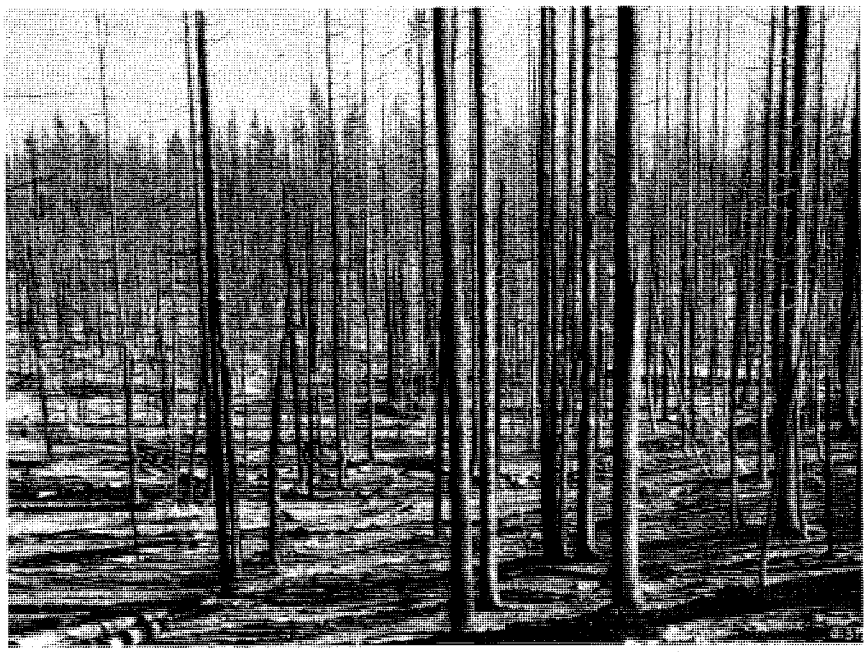

FIG. 5. The ecological function of many fires in northern conifer forests was to eliminate the old forest and begin successions anew. This is a burn in lodgepole pine. U.S. Forest Service photo.

Various landscape features can be used advantageously in either wildfire "management" or prescribed burning. Natural firebreaks such as lakes, streams, swamps, rocky fuel-deficient lands, mountaintops, and high elevation barrens and snowfields can be worked with. Areas that have functioned as natural firebreaks can often be identified by changes in the age classes or community composition of the forests adjacent to them. Certain plant communities may create firebreaks that can be utilized. And recent burns often make effective firebreaks.

Aerial equipment greatly enhances our ability to locate and suppress spot fires, and to exert control quickly at crucial points without using firelines or heavy equipment. I am thinking of such things as aerial spotters, air tankers, smokejumpers, helicopters, and re-

FIG. 6. Helicopters and other modern aerial equipment are valuable aids to wilderness fire management and should help avoid mechanical scarring of the landscape. U.S. Forest Service photo.

tardant drops. Water curtains and similar developments may also be very helpful.

Philosophical considerations dictate that prescribed fire should not be used unless natural lightning fires simply cannot be dealt with safely. In some western wilderness and park areas working with lightning fires is clearly a possibilty. Witness the "let them burn" policy in parts of Sequoia-Kings Canyon National Parks (Kilgore 1970). I am not prepared to exclude this possibility in the BWCA, but more information and experience with various kinds of natural firebreaks would be necessary for a technical evaluation. Visitor-caused fires are unacceptable, both because their frequency and location are likely to be unnatural, and for obvious policy reasons.

Prescribed fire has many safety advantages. Because the place, time, weather, and ignition pattern are all chosen in advance, the control plans, forces, and equipment can be matched to the need and readied before the fire occurs. If fires cannot be controlled under these conditions, surely there is even less likelihood that wildfires can be suppressed. And we *are* successfully handling most wildfires today.

Another objection to fire that must be met is its possible contribution to air pollution and to the nutrient enrichment of streams and lakes. The facts are not all in on these questions. For example, we still need more data on the qualitative and quantitative contributions of forest fire smoke to the amosphere. But the data already in suggest that such smoke is a minor source of dangerous chemical pollutants compared to auto exhaust, industrial emissions, and power generation (Darley *et al.* 1966, Fritschen, *et al.* 1970). Few good data are available on the nutrient input to lakes and streams following natural forest fires—and we need such data to progress beyond speculation. But for both problems one can argue that fire *was* part of the *natural* ecosystem and of the *natural* atmospheric cycle for millenia. In this sense neither smoke nor nutrient inputs from a natural fire regime can be properly called *pollution*. The remoteness of the areas concerned, the infrequency of burns, the small contributions of "pollutants," and the positive benefits to be derived all argue that ecosystem maintenance burns in wilderness can and should be tolerated.

Still another problem that must be faced is the need for public understanding and support for ecosystem maintenance burns. A near-universal belief that *all fires are bad* is one of the unfortunate legacies from the past half-century of fire prevention campaigns. These attitudes come both from a failure to tell the public about the true ecological roles of fire, and from ecologically inaccurate campaign slogans and posters. The time for change has come. In this "Age of Ecology" the public deserves and can understand the unvarnished facts about fire—both good and bad. When the public understands, I am convinced they will support the reintroduction of fire in wilderness and parks. A start has been made in getting the message to the public, but much more will be needed (see, for example, Olson 1969, Weaver and Biswell 1969, Johnston 1970, Kilgore 1970, Ternes 1970, Heinselman 1969, 1970a, b).

IS IT WORTH DOING?

One cannot consider the natural role of fire and the problems of providing for this role in Wilderness Areas without asking whether the benefits merit the effort. I think they do. If we succeed, and keep a remnant of the earth's natural ecosystems, the lives of our children and of unborn generations will be enriched. The full diversity and complexity of primeval nature will still be there for their study and wonder. The scientific, educational, and inspirational values will certainly be great, even if dollar values cannot be assigned. What price can we put on the opportunity to watch a jack pine forest spring up on a recent burn? What is it worth to know that a pack of timber wolves still stalks the moose on that burn? Will our grandchildren value these things? And may they value, too, the opportunity to answer questions about nature that did not occur to our generation? These and like questions require value judgments—but they *are* the crucial questions.

If we exclude fire from these ecosystems, one of the most powerful environmental factors that shaped them will be gone. Major and unpredictable changes in both plant and animal communities will ensue. Indeed, such changes are already occurring in some areas! Eventually we may recognize a need to create the same kinds of effects that fire produced. And if we reject fire, these effects must then be produced by mechanical or chemical means. At best the result will be a poor substitute for the natural ecosystem. The values mentioned above will be lost or seriously eroded.

Yes, we must move thoughtfully and carefully in dealing with the fire regimes of our Wilderness Areas and National Parks. There must be time for adequate study and discussion of the consequences of various approaches. But move we must! For our opportunity to maintain or restore these ecosystems will not last indefinitely.

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