PRESERVING NATURE IN FORESTED WILDERNESS AREAS AND NATIONAL PARKS

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ABSTRACT. The natural forest ecosystems of some of our national parks and wilderness areas are endangered by subtle ecological changes, primarily because we have failed to understand the dynamic nature of these ecosystems and because protection programs frequently have excluded the very factors that produce natural plant and animal communities. Maintaining natural ecosystems requires that the elemental forces of the past, such as fire, must still prevail.

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THE INSPIRATIONAL, scientific, and educational values of our National Parks and Wilderness Areas depend heavily on our success in preserving nature. But do you know that the natural forest ecosystems of some of our most cherished areas are endangered by subtle ecological changes? This is so primarily because we have failed to consider the dynamic character of primeval ecosystems, and because "protection" programs frequently exclude the very factors that produce natural plant and animal communities.

This problem is part of our present ecological crisis, but it is a special problem, often unrecognized even by conservationists and environmentalists. We have assumed that preservation is assured by prohibiting logging, grazing, mining, agriculture, hunting, or trapping, and by protecting the forests from fire, insects, and disease. Sometimes this is so, where a climax ecosystem exists. But as modern biology and ecology reveal the life histories of plants and animals and the intricate interactions between environmental factors and plant and animal communities, we see more and more broken links in natural ecosystems.

Fire is perhaps the single most important environmental factor being altered—it was essential in the reproduction of the primeval forests of many areas, for example the lodgepole pine forests of Yellowstone National Park and the Bob Marshall Wilderness; the jack, red, and white pine forests, and the aspen-birch forests of the Boundary Waters Canoe Area; and even the giant Sequoia forests of Sequoia-Kings Canyon National Parks.

What then does the "preservation of nature" really mean for forested wilderness? I think it means we must focus on restoring the total natural environment – physical factors as well as plant and animal communities. But let me give you a more complete picture of the ecological problems, and possible new program directions.

ECOLOGICAL PROBLEMS

Natural forest communities exhibit a remarkable adjustment to local geology, soils, topography, and climate. Each plant species occurs on soils to which it is adapted, and within altitudinal and latitudinal zones that meet its temperature and moisture needs. Many forests also exhibit a layered structure, in which certain species occupy the upper canopy, while others form an understory. There is an adjustment of one plant species to another in the competition for moisture, nutrients, heat, and light.

Yet seldom does a single forest community hold permanent possession of any given site. For if we look around we see one community here, while not far away a very different one may occupy an otherwise identical situation. Perhaps in one situation the forest is an ancient and uneven-aged assemblage of Englemann spruce and subalpine fir, with scattered old lodgepole pines; next door is a dog-hair thicket of young lodgepoles—with fire-blackened snags standing in their midst. What we are witnessing is proof of a dramatic vegetation change related to a powerful natural environmental factor—fire.

Studies in forest ecology in the last 60 years have taught us much about such vegetation changes, and some of this knowledge has already become part of the lore of wilderness enthusiasts and amateur naturalists. But even professional land managers have more to learn before the full meaning of this natural drama becomes recognized in Wilderness and Park programs, because we still ignore some of the implications.

Forests are born of change, and they die through change as well. Plant and animal communities are dynamic—ever-changing, ever-growing, maturing, and dying—to be succeeded by some other community adapted to new circumstances. And yet there is a fascinating order to these changes, for similar sequences of events are repeated again and again.

The concepts of "pioneer" and "late successional" or "climax" communities are helpful in understanding vegetational history. A "pioneer" forest is composed of trees and other plants capable of occupying denuded terrain, such as recent glacial moraines and exposed bedrock, or ground laid bare by fires, windstorms, avalanches, and erosion. The trees that form pioneer stands are sun-loving and well adapted to growing in the open, but often poorly adapted to growing beneath a forest canopy.

Pioneers also possess special adaptations for reproducing on open lands, or following forest fires or other catastrophes. Some have light seeds easily transported by the wind—such as the aspens, birches, willows, and certain pines and spruces. Some are capable of sprouting from the root collar, or from underground stems or roots. The oaks, aspens, birches, many other deciduous trees, and coast redwood possess one or both of these abilities. Only under unusual circumstances does fire destroy the ability of such trees to quickly repopulate burned land.

HOW FIRE HELPS

One of the most fascinating adaptations of pioneer species to fire is the persistent closed-cone habit of lodgepole pine, jack pine, and certain other conifers. These trees are readily killed by forest fires—either crown fires or severe ground fires. But their cones are borne high in the crown, and remain attached and closed for years, storing huge quantities of viable seed.

When fires sweep through the forest, they kill the trees and scorch both crowns and cones. But temperatures inside the cones usually do not reach lethal levels, and the resins that seal the cone scales are melted. After the fire the cones open and release the seeds, which fall upon ashes and exposed soil, temporarily freed of competing plants.

These are ideal conditions for the young conifers, and most of our forests of lodgepole pine, jack pine, and black spruce originated in this manner. Next time you admire the vast forests of lodgepole pine in Yellowstone Park or the Bob Marshall Wilderness, or the jack pine and black spruce forests of the Superior-Quetico canoe country, remember, these beautiful forests are the products of past fires.

And these fires did *not* destroy the soil, nor rob the land of its fertility. In fact, in northern regions and cool mountains there is a gradual accumulation of needles, leaves, mosses, and rotting wood during the life of a forest that actually *ties up* essential plant nutrients and covers the soil with such a thick layer of humus that tiny conifer seedlings have difficulty getting established. Fires consume this organic mantle, bare the mineral-soil seedbeds, and release the accumulated mineral elements.

Thus fires can actually rejuvenate a forest by replacing an old decadent stand with a new vigorous one. This is precisely what has happened ever since the Ice Age in the lodgepole forests of the Rockies, and throughout the range of jack pine and black spruce in the Lake States and the boreal forests of Canada and Alaska.

Red (Norway) pine and white pine in the Lake States and the Northeast, and ponderosa pine, sugar pine, larch, western white pine, Douglas-fir, and giant Sequoia in the West also reproduce after fires, but by a different mechanism. Because of their thick bark and long branchless trunks, these trees are fire-resistant and can survive severe ground fires. But they lack the closed-cone habit, and shed their seed and drop their cones soon after the cones mature. Furthermore, in several species good seed years occur only at intervals of 2 to 5 years or more.

CONDITIONS FOR REGENERATION

In presettlement times ground fires often crept through forests of these species, eliminating the undergrowth of competing shade-tolerant trees and shrubs that would otherwise invade such forests. Such ground fires also retarded the accumulation of organic matter and fuels. Eventually, however, a fire hot enough to kill many of the old trees occurred, setting up conditions for regeneration. The area was partially freed of tree cover; standing snags and scattered groves or individual trees provided partial shade; mineral-soil seedbeds were available; and competition for nutrients and moisture was greatly reduced. The scattered veterans provided seed in good seed years, and the denuded area gradually seeded in to the original species. A new and nearly even-aged forest was formed, perhaps interrupted by groves of unburned or fire-scarred older trees.

Thus arose the famous pineries of the old North Woods, the great ponderosa pine, larch, Douglas-fir, and Sequoia forests of the West, and the pineries of the Old South. Fire scars or "catfaces" on old trees still tell of this history. And the ages of many of our present forests can still be related to the tree-ring records of fire scars on these veterans. Thus many of the most magnificent conifer forests in our National Parks and Wilderness Areas owe their origin and present composition to past fires.

In presettlement times, fires were caused both by lightning and by the accidental or deliberate firing of forests by the Indians. Early man, in fact, is thought to have burned the forests of North America in at least some regions for perhaps 10,000 years. But lightning was (and still is) a sufficient cause of fire in many regions; and if man failed to ignite a flammable forest, sooner or later lightning produced the same result. This can be inferred from the evolutionary adaptations to fire of many plants (for example, the closed-cone habit of jack pine and lodgepole pine), and from records of ancient charcoal in peat bogs, lake sediments, and glacial deposits.

The number of years between major fires in any one area must have varied greatly. Our best record of this today is the tree-ring record on fire-scarred trees, and the ages of whole forests known to have originated following fires. Research in the Boundary Waters Canoe Area in Minnesota indicates that severe fires resulting in the destruction of the old forest and regeneration of a new stand usually recurred on any one site at intervals of 50 to 300 years.

But occasionally the interval was as short as 10 to 30 years, and in the West the intervals in some areas may have been longer than 300 years. The interval tends to be characteristic of particular geographic regions, and related to the typical age of post-fire forests at maturity. Light ground fires also burned through many stands at shorter intervals, but these fires usually brought in little successful tree reproduction.

"SUCCESSION"

In the absence of fires, insect outbreaks, or severe windstorms, most pioneer forests are gradually replaced by shade-tolerant species. This process is known as "succession." We once thought its ultimate product was a regional "climax" vegetation, capable of reproducing itself indefinitely on the same site, without the intervention of major disturbances such as fire or windstorms.

This view of forest succession is no longer held by most ecologists, because the actual history of forest stands is usually far more complex, and often punctuated by intermittent disturbances. Even the shade-tolerant "climax" species are replaced under some circumstances, and the environment itself may change through peat accumulation, climatic shifts, erosion, changes in animal populations, and other events. Some of the trees that are capable of growing beneath the pines and other pioneers are the maples, eastern and western hemlock, northern white-cedar and western redcedar, red, white, and Englemann spruce, and several true firs. They are characterized by an ability to grow under the conditions associated with deep shade, and to become established on thick layers of humus.

As forests grow old, trees gradually die and fall to the ground. The age at which this occurs varies greatly by species, local growing conditions, geographic region, and many chance factors. Generally however, jack pine, lodgepole pine, and aspen trees are relatively short-lived—most do not live more than 100 to 250 years. The white pines, red pine, ponderosa pine, Douglas-fir, and western larch may live 300 to 500 years or more. And the Sequoia, redwood, western hemlock, western redcedar, and some other western conifers may live 800 to several thousand years. These differences in longevity also influence stand composition.

Many forests contain mixtures of shade-tolerant trees, some of which reproduce successfully in small openings created by the death of individuals. Forests of this kind tend to develop a many-aged structure if they persist for long periods without serious disturbance by fires, insects, or windstorms. Examples are the hemlock, cedar, spruce, and true fir forests of the Cascades, Olympics, and Coast Range in the Pacific Northwest; the Englemann spruce and subalpine fir forests of the Rockies; the maple, birch, beech, and hemlock forests of the Lake States and the Northeast; and the balsam-fir, spruce, and cedar forests of the New England mountains, the Adirondacks, and the northern Lake States.

But even these more stable forests are often ravaged by windstorms or insect epidemics. The spruce budworm, for example, has recently killed most of the balsam fir and much of the white spruce over millions of acres in eastern Canada, New England, and Minnesota. Fortunately, these forests also have a mechanism for replacing themselves. Thousands of tiny balsam seedlings are usually present on the ground, and many are not killed by the budworm. Thus when the budworm has consumed an old forest, the next generation of young firs is waiting to replace it.

In the Rockies, vast areas of Englemann spruce are sometimes decimated by bark beetles. This has happened in some of our Wilderness Areas in the past few decades. But usually enough seed trees escape; and these, together with a few small seedlings not killed by the beetles, initiate a new stand. Insect-ravaged forests such as these may look desolate for a decade or more; but then the new forest appears, and life begins anew as it has for untold generations.

Fires can denude vast areas for long periods if they entirely consume forests of conifers lacking the closed-cone adaptation, or if they reburn young stands before seed-bearing age is reached. Lodgepole pine, jack pine, and black spruce begin to bear seed between 10 and 20 years of age, but many conifers begin much later—often age 50 or more. Such reburns are not too common, however; and usually scattered individuals or groves of mature trees escape.

But changes in forest composition are to be expected after such fires, and the rebirth process may take several decades.

WHAT IS "VIRGIN"

The foregoing discussion suggests that the usual concept of a "virgin forest" is misleading. Many people think of such forests as only the old and venerable communities of large trees, and regard them as permanent legacies from the past, that somehow escaped the ravages of fire, insects, and disease. We also require, and rightly so, that these forests never have been logged or cleared by man. Forests resulting from logging, clearing, burning, or similar disturbances are called "second growth," and are considered inferior. But the "virgin forest" must be redefined in the light of modern ecology, because we know that many of our finest examples are really the products of presettlement fires, windstorms, insect outbreaks, and similar natural disturbances.

A better definition of a virgin forest is that it simply be the product of natural environmental factors and ecological processes, as opposed to a forest resulting from logging, land-clearing, herbiciding, planting, or similar disturbances by man. By this definition a virgin forest can be either young or old, composed of large species or small, well-stocked or nearly open, and magnificent or homely. This is a far more ecologically defensible concept, for it admits all truly natural landscapes, whether the forests originated centuries ago, or just last year following a fire or insect epidemic. We must then recognize that the "second growth" on a new burn today may become the "venerable" old forest in our great-grandchildren's time!

Many species of wildlife are adapted to early successional plant communities, while others are characteristic of mature forests. Both kinds have a place in Wilderness Areas today if they were present in the primeval ecosystems. Species characteristic of burns, open areas, shrub communities, and early successional stages include the white-tailed and mule deer, elk, ruffed grouse, sharptailed grouse, hares, foxes, coyotes, bears, beaver, and many more. Some of these animals were really more at home on the edges of disturbed areas than in the great open areas, but they nevertheless were associated with new successions. Species that seem to have been more abundant in mature conifer forests include the pine marten, certain squirrels, and several birds. Other species, such as the moose, timber wolf, cougar, and woodland caribou ranged widely between mature forests and new successional stages and are difficult to pigeonhole.

THE ELEMENTAL FORCES

The implications of natural history for wilderness and national park preservation programs are far-reaching. For if we are serious about maintaining the natural ecosystems of these areas, then clearly the elemental forces of the past must still prevail. And when we consider past and present resource "protection" policies, we see important deficiencies.

What have we been doing? Perhaps most significant, we have attempted to control forest fires for 50 years or more; in most areas we are now quite successful. Yet, by so doing we have sometimes accelerated successional changes over vast areas—causing the simultaneous aging of forests over entire landscapes, preventing the establishment of new pioneer plant and animal communities, eliminating the diversity of nature, and excluding the ecological niches of many forms of wildlife. The immediate impact is far greater in certain even-aged and short-lived pioneer forests such as jack pine, lodgepole pine, and aspen than in long-lived forests such as Douglas-fir, red pine, ponderosa pine, and Sequoia, or in shade-tolerant forests of maple-beech birch, or spruce and fir.

We have also "controlled" (mostly *eliminated*) the large carnivores, such as the timber wolf and cougar. Yet they were the only effective predators of the large herbivores—the elk, moose, and deer. Excessive herbivore populations and the consequent overbrowsing, overgrazing, starvation losses, and necessary herd-reduction programs are old stories now.

And we have also, until recently, tried to control forest insect infestations with pesticides, or by felling and burning infested trees. We sometimes "clean up" wind-damaged forests, and exotic plants have been introduced—even deliberately.

But our fire policies have the most powerful and pervasive effects. In a sense we are committing our parks and wilderness areas to a grand ecological experiment, by inadvertently trying to produce climax forests over vast areas—on a scale that may never have occurred before.

The consequences of this program are not only unintended, but in most cases unknown, for ecologists can find few examples of such circumstances within comparable ecosystems. This is simply not the way it was in primeval nature. We clearly have this situation in the Boundary Waters Canoe Area, where my own research is relevant, and also in Yellowstone National Park, Sequoia-Kings Canyon National Parks, and probably many other areas. (I mention these examples because the ecological background has recently appeared in conservation journals. See recent issues of *National Parks Magazine* and *Naturalist*, for example.)

A SOUND POLICY

If past policies are not resulting in the preservation of nature, then what *is* an ecologically sound policy? First, we must have clear, specific, and biologically attainable objectives for each area. Policy statements should spell out the philosophy of ecosystem management, and the biological nature of the ecosystem to be maintained or restored.

Philosophically, the focus should be on restoring the primeval *environment*. What we are interested in is preserving the total *system*—the ever-shifting mosaic of plant and animal communities. We cannot freeze nature into a static mold. What we must do is simply offset the disturbances caused by modern man.

Our concept of the ecosystem to be preserved or restored should be based on detailed studies of vegetational and faunal history, and on an inventory of present plant and animal communities. Fortunately, forests write their own history in tree rings. And many forests in our Parks and Wilderness Areas still date from the primeval period.

Sophisticated methods for reconstructing the primeval scene are available where such tree-ring records can be obtained. By using ring counts on old fire-scarred trees, it is possible to determine the fire history for hundreds of years. And by obtaining the ages of forest stands over whole watersheds, it is possible to correlate the age structure of present forests with this fire record.

Written records or old photographs and drawings can also help, especially the early U.S. Land Office survey records, explorers' diaries, old newspapers, and similar sources. Preserved pollens, larger plant remains, and charcoal in lake sediments or peat bogs have recorded plant communities over much longer periods. They can be used to connect information about the recent past with the situation hundreds or even thousands of years ago. Indian and early-man archaeological sites are an important source of faunal records. And carbon-14 dating now makes it possible to place firm dates on many organic sediments, fossils, and archaeological finds.

Decisions must be made on ecosystem objectives when this assessment of the primeval ecosystem is complete, and when an inventory of present communities is available. The historical research and the inventory will allow judgments about the degree to which present ecosystems have changed from the primeval. The objectives should spell out the vegetational, faunal, and environmental characteristics to be achieved.

But they are *not* to be viewed as static prescriptions for each landscape unit. They should simply detail such things as the vegetation types and successional stages to be encouraged, the approximate proportions of the area that might be occupied by each type and stage at any one time, the native fauna to be encouraged, and the significant natural environmental factors that may require attention.

GENERAL STRATEGY

The proportion of the area to be occupied by various successional stages is a key decision. If possible, it should be based on virgin-forest age classes or other solid evidence of the frequency of new successions.

Once ecosystem objectives have been set, a strategy to achieve these goals is needed. Unfortunately, strategies are not yet available for many ecosystems, and in such cases the initial focus must be on relevant ecological research and technique development.

But the basic general strategy is clear. It will simply be to replace missing vegetation types or faunal elements, and to see that important natural environmental factors are present at approximately their natural frequencies. When these requirements are met, we accept as natural the changes in plant and animal communities that may occur in both place and time. We are not really trying to manage nature or control succession. We must not insist on a given vegetation type or animal community for each site.

Fortunately, in the United States, many Park and Wilderness ecosystems are still close enough to the primeval that drastic changes in flora and fauna will not be needed over much of the area. It is mainly the proportion of successional stages that will require corrective action. In contrast, in much of Europe, the Middle East, and the Far East, virtually all primeval ecosystems have been destroyed for so long that the concept of the "natural" ecosystem is hardly relevant.

ACTIONS NEEDED

What specific kinds of actions are needed to implement this general strategy? I can suggest several, and some of these are already endorsed by the National Park Service, the Forest Service, and other agencies that manage nature reserves:

1. Re-introduce missing members of the animal communities wherever possible. This includes both herbivores and carnivores.
2. Restore native vegetation where it has been badly disrupted by past logging, grazing, agriculture, etc. (Soil preparation, seeding or planting, and mechanical vegetation control may be necessary where changes have been major.)
3. Avoid the introduction of exotic plants, animals, and fish. Eradicate exotics already present where feasible.
4. Allow native insect and plant diseases to reap their toll. Cease the application of all pesticides, herbicides, and similar chemical controls.
5. Do not clean up blowdowns, or insect- and disease-killed forest stands.
6. Assure a natural fire regime where fire was a significant environmental factor in the primeval ecosystem, by prescribed-controlled burning if necessary.

Only natural environmental factors should be employed, to the maximum extent feasible. Artificial seeding and planting, soil preparation, and mechanical vegetation control are justified only to offset major disturbances by modern man. Where seeding or planting are used, only local seed sources should be used.

Fire policies and programs need discussion, because fire is such a powerful environmental factor, and because it is one of the few major natural factors over which we exert control. Today, we are greatly reducing the area burned in many nature reserves where fire was once the single most important factor in generating new successions. In such ecosystems we really have at least six fire policy options, and a decision cannot be avoided. These options are:

1. Attempt fire exclusion, and accept the slow but pervasive changes in plant and animal communities that inevitably follow.
2. Allow "safe" lightning-caused fires to burn; allow also for some other wildfires that cannot be controlled, but extinguish the rest. If this results in less than the natural fire frequency and burned area, so be it.
3. Allow "safe" lightning fires to burn, allow for some other wildfires that cannot be controlled, but prescribe enough additional controlled fires to assure the natural fire regime.

4. Suppress all wildfires to the extent feasible, and duplicate the natural fire regime with prescribed-controlled fires.
5. Allow all wildfires to burn unchecked unless life or property are directly threatened, and hope that a natural fire regime will result.
6. Abandon the ideal of natural ecosystems, and turn to full-scale vegetation and environmental manipulation by mechanical and chemical means, seeding, planting, etc. Attempt to produce a desired vegetation with the tools of applied forestry.

THE OPTIONS

For most areas I favor either option three or four, depending on the particular fire control, human safety, and property-safety considerations of the area. Either would provide approximately the natural fire regime, and avoid the risk of letting wildfires get out of hand before control is attempted.

The second option, allowing for "safe" lightning fires and some escapes, but not using prescribed fires, may also be acceptable where it would yield close to the natural fire regime. In isolated mountain areas this may be a valid policy if there is little possibility of fires escaping to lands outside the wilderness or park.

The last option, mechanized forestry, seems to me to be inconsistent with the basic philosophy and objectives of our National Parks and Wilderness Areas. It is, however, urged as the only realistic and practical choice by some foresters and by many of the forest industries, who point out that a commercial harvest of timber could be obtained as a byproduct. Timber cutting is now practiced in parts of the Boundary Waters Canoe Area, in Algonquin and Quetico Provincial Parks in Ontario, and in several other large Parks in Canada and other countries. But in none of the cases with which I am familiar is there a serious attempt to duplicate primeval vegetation conditions after cutting. Unfortunately, this option, without commercial incentives, will have to be resorted to in some auto campgrounds and other high-use sites.

I reject the fifth option, allowing all wildfires to burn, both because it endangers life and property, and because with recreational use the location and frequency of fires would be unnatural. We cannot endanger human lives either inside or outside wilderness areas, and we cannot risk damage to commercial forests or to structures outside.

It is clear also that I do not favor the first option—attempted fire exclusion. This *is* the present practice in many areas, but as pointed out before, the ecological consequences are great and uncertain.

A further problem, which we may already be facing in many areas, concerns the accumulation of forest fuels with fire exclusion. In cool coniferous forests there is a gradual accumulation of litter and humus on the forest floor. And in severe drought this organic matter can become a major fuel. Also, as forests mature, the total standing volume of flammable material increases, and often there is more dry dead wood in old stands.

Some forests certainly reached these stages under primeval conditions, and I do not mean to imply that old forests are unnatural. But if we attempt fire exclusion in an ecosystem consisting of maturing even-aged forests, we may force a totally unnatural preponderance of old stands upon the landscape. If a wildfire does then escape during severe fire weather, the potential for a real conflagration is present. Its ecological consequences may be most unfortunate, to say nothing of safety problems.

RESEARCH NEEDED

But it must be emphasized that in most areas we are not yet ready to introduce prescribed fires of the kinds required ecologically, or on the scale needed to duplicate the natural regime. Much experimentation will be needed to achieve technical expertise in firing and control methods, in gaging weather and fuel factors, and in understanding the fire prescriptions necessary to achieve the ecological effects of the natural wildfire regime. The size of areas to be burned, the frequency of burning, and the burning techniques are all matters of choice that require research. There is no need, and indeed it may be impossible, to burn every year. One might allow major burns only once every 10 to 20 years. This will depend on the natural fire frequency as well as on burning weather.

There has already been much research in prescribed burning, and many applications are being made. But for ecosystem applications in the virgin wilderness, we are talking about the introduction of severe ground fires or even running crown fires in mature forests. These fires must in some cases be severe enough to kill most or all of the trees within the burn. Of course, only a very small percentage of the park or wilderness would be burned at any one time. The aim would be to slowly re-establish the primeval distribution of forest age classes and vegetation stages. We have little relevant experience with prescribed burning to achieve this.

Research to develop the needed expertise in both prescribed burning and fire ecology is now under way adjacent to the Boundary Waters Canoe Area and in Sequoia-Kings Canyon National Parks. These studies are new, and much more work is needed. Meanwhile, as we await the development and acceptance of prescribed burning, ecologists and managers can proceed with inventories of present plant and animal communities, and with historical research to document the primeval ecosystems. Fortunately, we do have some time yet, because most successional changes in vegetation are slow.

And meanwhile the public must continue to exercise great care with fire in our Parks and Wilderness Areas. Smokey Bear has perhaps oversold his message—he should be telling us that *some* fires can help the forest and create new homes for wildlife. But we must leave prescribed burning to the experts, and prevent all man-caused wildfires.

Air and water pollution and soil erosion are being suggested as obstacles to the use of fire in ecosystem preservation programs. Fire opponents suggest that intolerable smoke would result, and that there would be excessive inputs of soil nutrients and sediment into lakes and streams.

SMOKE NOT SMOG

Let me give a few reasons why I think these fears are unfounded. First, studies show that forest fire smoke is chemically different from urban or industrial smogs. Smogs contain large amounts of sulfur and nitrogen oxides, carbon monoxide, ozone, and peroxyacetyl nitrate (PAN). Forest-fire smoke contains far less of these injurious compounds. It is composed mainly of carbon dioxide, water vapor, smaller amounts of carbon monoxide, small quantities of olefins and ethylene, and particulate matter. It does add some pollutants, but it simply does not pose the same threats to human health or vegetation.

Furthermore, urban and industrial smogs are emitted continuously, and in the areas of our densest populations. But fires in Wilderness would occur only on a few suitable burning days, and then only in years when burning was feasible and needed, and in remote wildlands. The most serious urban smogs occur where the local atmospheric circulation permits accumulation of toxic gases. Fires in wilderness would contribute to these local problems only where a Wilderness occurs within the same "airshed". This is not common.

Most of the mineral elements released in the burning of forests are not lost through runoff. They are simply recycled back into the plant and animal ecosystem. If this were not so, fires would have depleted the forests of North America long ago. The truth is that many northern conifer forests owe their vigor to this periodic recycling of nutrients—it is part of nature, and it has occurred countless times in the past.

Although some past studies have provided data on this question, we are just now really getting the facts. The available studies suggest that there are some nutrient releases to streams following fires, but these releases may be no larger than those accompanying commercial timber harvests. Furthermore, fires in nature do not remove large volumes of nutrient-containing wood, bark, and foliage from the ecosystem as does commercial tree harvesting. And fires in nature or prescribed fires generally would occur on any one watershed only at long intervals.

EROSION RARE

The popular notion is that massive soil erosion usually follows forest fires. But personal observations over many years in many regions have convinced me that this rarely occurs in natural forests. (A dramatic exception is the chaparral type in Southern California.) On very steep terrain it may occasionally happen for short periods, but even there prompt revegetation of the burns usually stops soil movement within a year or two. On steep slopes, the combination of clearcutting, careless road construction during logging, and slash-burning after logging may cause serious erosion. (And this is poor forestry, too!) But this should not be equated with the effect of fires in the virgin wilderness. Again, if disastrous erosion had followed most fires in nature, the virgin wilderness of North America would not have contained the beautiful conifer forests still present in many fire-dependent ecosystems.

One may also ask whether fires in Parks and Wilderness Areas would not deplete atmospheric oxygen. But this argument is invalid, too. A tree will consume just as much oxygen when it dies and decays from causes such as wind breakage, diseases, or insects, as when it is consumed by fire. The *rates* of oxygen consumption are much different, but the *amounts* are identical. Since all trees are mortal, it really matters little to the earth's oxygen balance whether trees die gradually in an aging forest, or suddenly in a fire that covers a limited region. The new forest on the burned area will again be producing a large net output of oxygen within a few seasons, while the old climax forest may not produce any more than it consumes.

But regardless of these arguments, one thing is clear. Fire *was* part of the natural environment in many of our most cherished nature reserves. If we are to truly preserve natural ecosystems, we must allow fire to be part of the system. And if such natural events in the past produced acceptable conditions, we can expect them to continue to do so in the future.

Today there are still areas of *de facto* wilderness outside designated Wilderness Areas, National Parks, and other nature reserves, especially in the West and Alaska. The ecosystems of some of these areas are still fairly intact. But as our population rises and pressures on the land increase, the designated reserves may become virtually the only lands where relatively complete ecosystems can be maintained.

LOOK TO EARTH

Let me also stress that our major nature reserves must be kept large enough to defend as viable ecosystems. They must be large enough so that reintroduction of fire is feasible, and also so the impacts from commercial forests, cultivated lands, and industrial areas will not impair them. The home ranges of significant animals and birds must be protected adequately—especially the rare or endangered species with large home ranges, such as the timber wolf, cougar, grizzly, caribou, and bald eagle. We have no firm guidelines for minimum ecosystem size. I suspect the answers will vary for each area and each problem. But obviously, where the area is too small to protect from serious external impacts, we are in trouble. Recent problems with water levels and the jetport near the Everglades National Park are cases in point.

I am sure that several of the suggestions in this article will provoke deep questioning in many minds. You will ask if somehow there aren't simpler ways to preserve nature, or to manage our National Parks and Wilderness Areas. I sympathize with you, because I have undergone the same soul-searching myself. And you may ask, is the preservation of nature really that important? It sounds like a big job; it will take more research, more time, more money, and more people trained in ecology. Can we afford to devote so much time and energy to this problem?

My answer is *YES, we must!* We are not talking about preserving a few Parks and Wilderness Areas to be used as giant playgrounds. We are talking about keeping our perspective on human life in relation to the earth's ecosystems. And we may even be talking about the survival of mankind! For if we are ever to understand the living ecosystems of the earth—the only life in our solar system as far as we know—then we must keep some remnants of this natural system before us. And for a long time yet!

Have *we*, in our wisdom, already learned all that our *children* will ever want to know about the structure, functioning, and evolution of the natural world? Is it possible that they may yet need some of the genetic diversity of the plant and animal life that is increasingly confined to our remotest lands and nature reserves?

The answers to these questions are clear enough to most of us by now. We part with these last remnants of the natural world at our peril. And the choice is simply a matter of priorities. If we can afford billions to recover a few bits of sterile dust and barren rock from the moon, perhaps we can also afford a realistic and ecologically sound program to preserve a few examples of the life systems of *PLANET EARTH!*

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