Courtesy of the National Archives

Is Aspen Doomed?

When the landscape was torched by Native Americans and the elk were heavily hunted, aspen flourished. Now this characteristic western species is in decline.

By Charles E. Kay

Communities of aspen *(Populus tremuloides)* are deteriorating throughout the western United States *(fig. 1, p. 6)*. Comparisons of data from historical records indicate that the area occupied by aspen has declined by 60 to 90 percent or more since European settlement, and photo comparisons show dramatic changes in western landscapes (Lachowski et al. 1996).

Many aspen stands contain old-age or single-age trees and have not successfully regenerated for 80 years or longer (Mueggler 1989a, 1989b). Moreover, many western aspen stands are being replaced by shade-tolerant conifers. These changes are usually attributed to the "fact" that aspen is a seral species whose decline is due to fire suppression (Cartwright and Burns 1994). I believe, though, that this view is incorrect, and I offer a new perspective on aspen ecology in the West.

Ancient Clones

Aspen is not seral as that term is commonly used because the species does not grow from seed (e.g., Kay 1993, 1996a). Given aspen's demanding seedbed requirements, it is thought that environmental conditions have probably not been conducive to seedling growth and the establishment of new clones since shortly after the glaciers retreated 10,000 or more years ago (e.g., McDonough 1985). Aspen seedlings are more common in the northern Canadian Rockies (Peterson and Peterson 1992), and there may be "windows of opportunity" that allow seedling establishment at infrequent intervals of 200 to 400 years or even longer (Jelinski and Cheliak 1992), but successful sexual reproduction of aspen is still exceedingly rare (Mitton and Grant 1996). This means that aspen clones found in the West today have likely survived thousands of years via vegetative regeneration (Mitton and Grant 1996). Some clones in the southern Rockies are thought to be a million years old (Cartwright and Burns 1994). Thus, in a sense, western aspen represents old-growth ancient forests (Peterson et al. 1995), not seral plant communities. Aspen, in fact, may be among

Journal of Forestry 95(8). August 1997.

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Opposite: **This image was made in 1872 by Hillers of the Powell Survey on Boulder Mountain in southern Utah during spring, before the aspen was fully leafed out. The vegetation had never been grazed by livestock, since this area was not settled until later. The multiaged, regenerating aspen trees show no sign of browsing by deer or elk, which suggests that historically, wildlife numbers were low. The scattered conifers behind the lake are all Douglas-fir, and most were growing on rocky outcrops or other fire refugia. Nevertheless, many were scarred by fire.**

Above: **By 1996, 124 years later, aspen regeneration had been curtailed by grazing cattle and wildlife. In the absence of fire, spruce (*Picea* sp.) and fir (*Abies* sp.) have invaded the site. The hillside behind the lake is now covered with dense growths of regenerating conifers, which would support high-intensity, stand-replacing crown fires—something that never happened in the past.**

the longest-lived organisms on Earth (Mitton and Grant 1996).

Western aspen clones are also generally quite large. In Yellowstone, for example, randomly selected aspen stands averaged more than an acre, and larger clones are common (Kay 1990). One clone in southern Utah contains an estimated 47,000 stems, covers 106 acres, and weighs approximately 6,000 tons, making it the largest known living organism (McLean 1993). If aspen is lost to advancing forest succession or overbrowsing, there are no proven means of reestablishing those clones.

Although individual trees within a clone are relatively short-lived (usually <150 years), the long-lived aspen clones often depend on periodic disturbance, such as fire, to stimulate vegetative regeneration via root suckering and to reduce competition from conifers (Bartos et al. 1991; Shepperd and Smith 1993). Aspen will "appear" after a fire, though, only if it is already present—that is, if the clone is already established. It will not seed onto the site. Thus, aspen is really not seral; instead, the presence of aspen indicates a long history of past disturbance, primarily frequent fire. Fire-return intervals of 20 to 130 years are necessary to maintain aspen, and as fire cycles lengthen, aspen is eliminated (Noble and Slatyer 1980).

DeByle et al. (1987) reported that at current rates of burning, "it would require about 12,000 years to burn the entire aspen type in the West." So something has clearly changed, and if current trends are to continue, much of the aspen in the West will be lost. It should be noted, however, that approximately one-third of western aspen may be potentially climax: these stands lack invading conifers, and even in the absence of fire or other disturbance, they will successfully regenerate via root suckering, producing mixed-age stands (Mueggler 1988), if browsing is not excessive.

Fire Ecology

Before European settlement, aspen burned at frequent intervals throughout the West, and it is generally assumed that those fires were started by lightning (e.g., Houston 1982). Research and experience, though, have proven that aspen is extremely difficult to burn (Brown and Simmerman 1986). "Asbestos type" and "firebreak" are terms often used to describe aspen (DeByle et al. 1987). Crown fires in conifers drop to the ground when they encounter aspen and, before autumn leaf-fall, spread only short distances into aspen stands (Fechner and Barrows 1976). DeByle et al. (1987) noted that "wild fires that had burned thou-

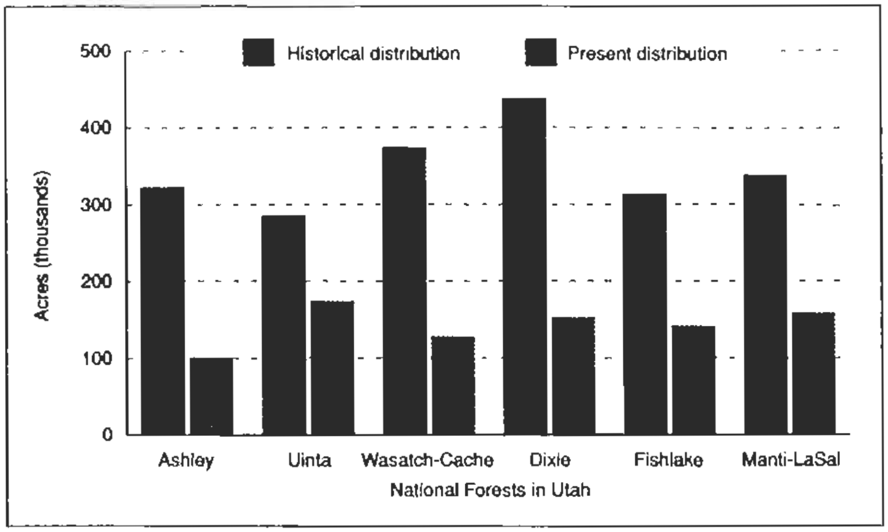

***Figure 1.* The decline of aspen on national forests in Utah. Once there was more than 2 million acres of aspen in Utah, but today there is less than 860,000 acres—a 60 percent decline. Similarly, Johnson (1994) reported that from 1962 to 1987, aspen declined 46 percent in Arizona and New Mexico. *Source:* Unpublished forest inventory data, Intermountain Research Station, USDA Forest Service, used with Forest Service permission.**

sands of acres of shrubland or conifer types during extreme burning conditions usually penetrated less than 100 feet into pure aspen stands." Lightning-fire ignition rates for aspen are also the lowest of any western forest type, and overall ignition rates are less than half that for all other cover types, including grasslands (Fechner and Barrows 1976).

Aspen readily burns only when the trees are leafless and understory plants are dry—conditions that occur in early spring and late fall (Brown and Simmerman 1986; Peterson and Peterson 1992). Before May 15 and after September 15, when aspen is normally dry enough to burn, however, there are few lightning strikes and virtually no lightning fires in the northern Rockies (Nash and Johnson 1993) *(fig. 2)*. So if aspen burned at frequent intervals in the past, as fire-frequency data and historical photographs indicate it did, then the only logical conclusion is that those fires had to have been set by Native Americans, who used fire extensively to manage plant communities, especially food plants, for human benefit (Lewis 1985; Kay 1995a, 1996b; Pyne 1995).

Ungulate Browsing

Single-age aspen stands are generally considered normal, but exclosure studies indicate that is not the case. Kay (1990), for instance, measured all 14 aspen-containing exclosures in the Yellowstone ecosystem, where elk

Why Aspen Once Thrived

Many aspen clones need fire to regenerate, but if elk and deer browse all the new shoots, the clone will die. For aspen to have survived in the past, therefore, browsing by ungulates must have been light. But then what kept populations of elk and deer in check?

Predation by carnivores could have limited ungulate populations, but wolves *(Canis lupus)*, bears (*Ursus* sp.), and mountain lions *(Felis concolor)* are less efficient predators than were Native Americans (Kay 1994, 1995a, 1996b, 1997). Unlike carnivores, which tend to kill the young, the old, the unfit, and males, Native Americans killed a predominance of prime-age females—a preference that runs counter to any modern-day conservation strategy.

Native Americans tended to view wildlife as their spiritual kin, and success in the hunt was obtained by following prescribed rituals and atonement after the kill (e.g., Feit 1987). A scarcity of animals or failure in the hunt was viewed not as a biological or ecological phenomenon, but rather as a spiritual consequence of social events or circumstances. If a Native American could not find any game, it was not because his people had overharvested the resource but because he had done something to displease his gods. Religious respect for animals does not equal conservation (Kay 1994, 1995a, 1996b, 1997).

Instead, native hunters were essentially opportunistic and tended to take high-ranking ungulates regardless of the size of the prey populations (Kay 1994, 1995a, 1996b, 1997). Native Americans had no concept of maximum sustained yield and did not manage ungulate populations to produce the greatest offtake. In addition, human predation and predation by carnivores are additive and worked in concert to reduce ungulate numbers (Kay and White 1995). Competition from carnivores tended to negate any possible conservation practices. Because Native Americans could prey-switch to small animals, vegetal foods, and fish, they could take their preferred ungulate prey to low levels or extinction without compromising their own survival. In fact, once Native Americans killed off most ungulates, human populations actually rose.

There are, however, exceptions to aboriginal overkill (Kay 1994, 1995a, 1996b, 1997). According to predator-prey theory, prey populations will increase if they have a refugium where they are safe from predation. Ungulates that could escape aboriginal hunters in time or space should have been more abundant. Moreover, refugia do not have to be com-

(Cervus elaphus) are the dominant herbivore, and found that aspen stands protected from ungulates had all successfully regenerated, without disturbance, and developed multiage structures, while grazed stands had not. Where native ungulates and domestic livestock have been excluded, aspen invariably produces multiaged stems (Gysel 1960; Mueggler and Bartos 1977; Olmsted 1979; Kay and White 1995), even where aspen is heavily invaded by conifers (Kay 1996a, unpubl. data on an isolated research natural area that has never been grazed by wildlife or livestock and has not burned in several hundred years). That is to say, stands dominated by old-age or single-age trees are an artifact of excessive browsing and not a biological attribute of aspen.

Even when burned by wildfire or prescribed fire, aspen clones across the West often fail to regenerate because of excessive browsing (Walker 1993). This is especially true in national parks and wildlife areas (Bartos and Mueggler 1981; Kay 1990; Bartos et al.

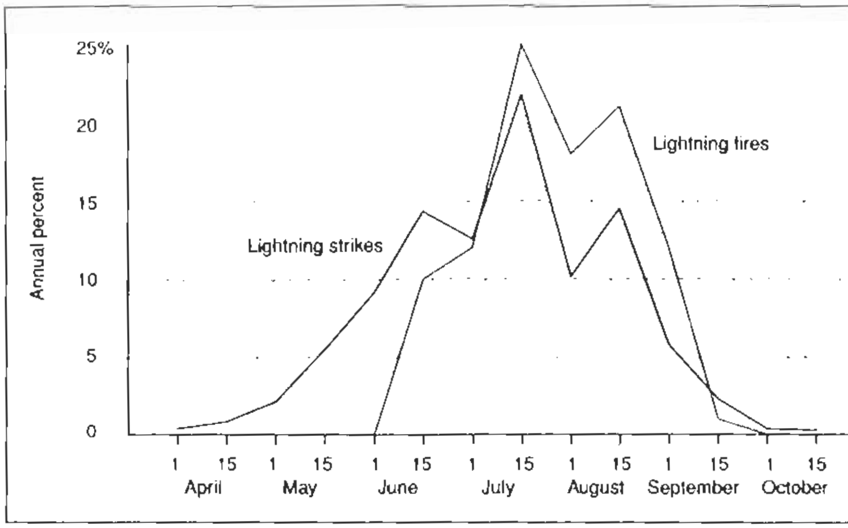

Figure 2. **Frequency distribution of lightning strikes and lightning-caused fires in the Centennial Mountains along the Montana-Idaho border. In early spring and late fall, when aspen is normally dry enough to burn, there are few lightning strikes throughout western North America. During the 29 years (1965–93) for which data are available, there were no lightning fires before June 15 and only one lightning fire after September 15. Although there are few lightning fires capable of burning aspen, historical photographs indicate that aspen in the Centennials burned frequently during the 1800s, which suggests that those fires were most likely set by Native Americans, as this area was not settled by Europeans until 1876. This pattern is common throughout western North America. *SOURCES:* Bureau of Land Management, and Targhee National Forest.**

plete to be effective: partial refugia will also suffice. This explains why there were larger numbers of ungulates on the Great Plains and in the Arctic. By undertaking long-distance migrations, bison and caribou were able to outdistance many of their human and carnivorous predators (Kay 1994, 1995a, 1996b). Ungulates were also able to survive in buffer zones between tribes at war. Lewis and Clark (1893), for instance, noted, "With regard to game in general, we observe that the greatest quantities of wild animals are usually found in the country lying between nations at war."

In 1893, aspen on Yellowstone National Park's northern range showed no signs of ungulate browsing, but elk have since eliminated the aspen. Pieced together with other information, such evidence indicates that ungulate populations were lower than they are today.

Photo by F. Jay Haynes, Haynes Foundation Collection, Montana Historical Society

Native Americans, though, had no immunological resistance to European diseases, such as smallpox, and epidemics usually reduced aboriginal numbers 50 to 90 percent at each passing. Moreover, aboriginal populations may have declined by approximately 90 percent before the first European chroniclers arrived in the West around 1800 because of diseases transmitted between native peoples in advance of actual white contact (Dobyns 1983; Ramenofsky 1987; Campbell 1990). Pre-Columbian aboriginal numbers for North America have therefore been revised upward to as many as 100 million or more (Stannard 1992). Clearly, North America was not a wilderness waiting to be discovered but a home to millions of people (Denevan 1992; Gomez-Pompa and Kaus 1992).

I therefore suggest that prior to European influences, predation by Native Americans kept elk and other ungulates at low densities throughout the Intermountain West, and that in turn permitted aspen to flourish, especially in areas burned by native peoples. (A fuller treatment of my aboriginal overkill hypothesis appears in Kay 1994, 1995a, 1996b, 1997.)

***Right:* In 1910, shortly after the Frazier Dam in Idaho's Centennial Mountains was constructed, short-statured regenerating aspens were common and conifers were largely absent, reflecting a history of frequent but low-intensity burns.**
***Below:* By 1994, with fire suppression and fire exclusion, aspen had declined precipitously and been invaded by conifers, mainly Douglas-fir *(Pseudotsuga menziesii)*. In fact, the camera point had to be moved about 100 yards forward because the original point was covered by conifers. Forest inventory maps show that 36 percent of this drainage was aspen in 1914, but by 1994 that figure had fallen to 4 percent, a decline of 89 percent. The dam failed during the 1920s and willows have reclaimed much of the former reservoir.**

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***Right:* The area outside the Riddle Swale exclosure in southern Utah, which was constructed in 1963, is grazed by cattle in summer and mule deer during winter. Their combined herbivory has prevented aspen regeneration. The invading conifers are juniper (*Juniper* sp.).**
***Below:* Inside, protected from grazing for 25 years, aspen has regenerated without disturbance, creating a multi-aged stand. Protected aspen stands throughout the West show the same response.**

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1991; Kay et al. 1994; Romme et al. 1995). In Arizona, for instance, the Forest Service had to fence treated aspen stands to keep elk from consuming all the new suckers, and when the fencing was removed after several years, elk still killed the new aspen trees by breaking stems and browsing (Shepperd and Fairweather 1994). In fact, burning plus repeated browsing only hastens the elimination of aspen clones (Kay 1990; Kay and White 1995; Kay and Wagner 1996).

Since it is often assumed that large numbers of elk and other ungulates inhabited the West before game populations were reduced by European settlers, this raises the question of how aspen was able to survive for the last 10,000± years.

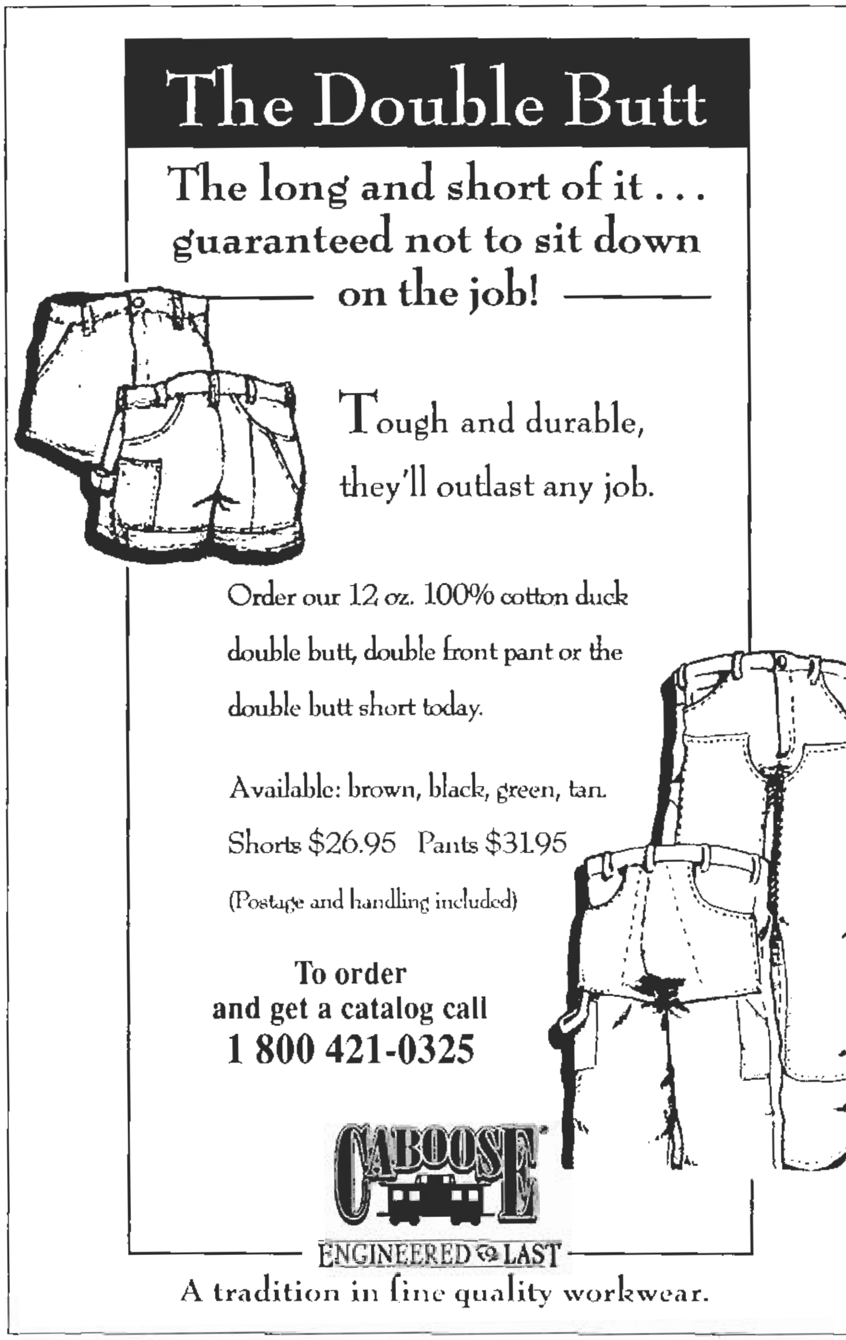
First, historical photographs show that aspen was virtually unbrowsed during the 1800s, unlike conditions today (Kay and Wagner 1994).

Second, historical journals indicate that from about 1800 to 1870, elk and other ungulates were rare. Between 1835 and 1876, for instance, explorers spent 765 days in the Yellowstone ecosystem on foot or horseback yet reported seeing elk only once every 18 days; today there are nearly 100,000 elk in that ecosystem (Kay 1990, 1995b). Similarly, between 1792 and 1872, 26 expeditions spent 369 days traveling through the Canadian Rockies yet reported seeing elk only 12 times, or once every 31 party-days (Kay and White 1995). Elk were also rarely seen in Utah, Arizona, New Mexico, or Colorado (Rawley 1985; Davis 1986; Allen 1996; Truett 1996).

Third, archaeological data indicate that elk and other ungulates were rare in pre-Columbian times as well (Kay 1990, 1994; Kay et al. 1994; Kay and White 1995; Allen 1996; Truett 1996). Of some 60,000 ungulate bones unearthed in more than 400 archaeological sites throughout the Rockies, elk accounted for only 3 percent (Kay 1990; Kay et al. 1994). Even where elk are numerous today, their bones are rarely recovered from archaeological sites (Kay 1990; Allen 1996; Truett 1996).

Apparently, then, there are more elk

in the Rocky Mountains today than at any time in the last 10,000 years.



Management Implications

Aspen is an excellent indicator of ecological integrity (e.g., Woodley et al. 1993) because its condition provides information on long-term ecosystem states and processes. And as Aldo Leopold noted some 40 years ago, "if we are serious about restoring ecosystem health and ecological integrity, then we must know what the land was like to begin with" (Covington and Moore 1994).

The very presence of aspen, for instance, indicates that aboriginal burning was once widespread. Determining how fires started is critical because "fires set by hunter-garherers differ from [lightning] fires in terms of seasonality, frequency, intensity, and ignition patterns" (Lewis 1985). Most aboriginal fires were set in the spring, between snowmelt and vegetation greenup, or late in the fall when burning conditions were not severe (Turner 1991; Gottesfeld 1994). Unlike lightning fires, which tend to be infrequent, high-intensity infernos, native burning produced a higher frequency of lower-intensity fires. Aboriginal burning and lightning fires thus created different vegetation mosaics and, in many instances, entirely different plant communities (Kay 1995a). Moreover, aboriginal burning reduced the number of high-intensity, lightning-generated fires. Once aboriginal fires opened up the vegetation, then subsequent lightning fires behaved like those set by Native Americans (Kay 1995a).

Aspen also indicates that Intermountain ecosystems developed with relatively low levels of ungulate herbivory. This, in turn, suggests that today's land managers will have to control grazing if western aspen communities are to survive. Populations of elk and deer *(Odocoileus hemionus* and *O. virginianus)* on many western ranges today exceed the range of historical variability (Diamond 1992; Truett 1996). Aspen in the past was perpetuated and probably enhanced by aboriginal land management, so the only way to maintain or restore western aspen communities is through active managememr.

This also applies to other western forests and rangelands, since there is no evidence that Native Americans ever managed aspen communities specifically. Instead, aspen was managed as one part of a larger landscape. As a result, the Americas as first seen by Europeans had been shaped by native peoples for at least 12,000 years. Unless the importance of aboriginal land management is recognized and modern management practices changed accordingly, our ecosystems will continue to lose biological diversity and ecological integrity (Kay 1995a, 1996b). Although managing nature may seem an oxymoron, at least to some (e.g., McNamee 1987; Budiansky 1995), federal and state agencies must manage aspen to ensure its survival at anything approaching historical levels (Diamond 1992)—or functioning aspen communities will become a thing of the past.

Maintaining and restoring aspen are important because those communities have exceedingly high biodiversity, second only to riparian areas on western ranges, and because aspen covers millions of acres across the West (DeByle and Winokur 1985). Bird communities, for instance, vary with the size, age, and grazing history of aspen clones (Johns 1993; Westworth and Telfer 1993; Stelfox 1995). Beaver, a keystone species in the West, also depends on healthy aspen communities (Naiman et al. 1988). In addition to forest products, aspen communities produce forage for both wildlife and domestic livestock and can withstand moderate levels of grazing. Moreover, during the autumn, aspen provides an "outstanding visual resource" (Cartwright and Burns 1994), with economic benefits to local human communities. The decline of aspen, then, has ramifications far beyond the loss of a single species, and the condition and trend of aspen communities should be a major consideration as we attempt to revive our ailing western forest ecosystems.

It must be remembered, though, that doing nothing *is* management—a decision that has wide-ranging consequences (Wagner et al. 1995). Following the status quo in the West means, among other things,

- excessive browsing and continued suppression of fires will continue to adversely affect aspen;
- aspen will continue to decline and will eventually be eliminated from large areas;
- biodiversity will decline as aspen is replaced by conifers and other vegetation types; and
- forest fuels will accumulate, setting the stage for high-intensity crown fires that could not only threaten human life but also most likely create burn patterns not previously seen in the West.

Creating wilderness areas and parks and then allowing nature to take its course, often called hands-off or natural-regulation management, will only consign aspen to extinction. JOF

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JOURNAL OF

FORESTRY

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Editor	Rebecca N. Staebler
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http://www.safnet.org

The *JOURNAL OF FORESTRY* (ISSN 0022-1201) is published monthly by the Society of American Foresters, 5400 Grosvenor Lane, Bethesda, MD 20814-2198. ©1997 by the Society of American Foresters. Periodicals postage paid at Bethesda, MD, and at additional mailing offices. Printed in the USA.

Subscription rates are $60 for individuals in the US and Canada ($90 in foreign countries) and $110 for institutions in the US ($140 in foreign countries). A single issue is $7. Subscription price to members is included in annual dues.

POSTMASTER: Send address changes to A. Ziadi, *JOURNAL OF FORESTRY*, 5400 Grosvenor Lane, Bethesda, MD 20814-2198; e-mail: ziadia@safnet.org.

Letters

Aboriginal Arguments

I am an archaeologist, not a biologist, but there appears to be a fatal flaw in the logic of the article "Is Aspen Doomed?" by Charles E. Kay (May 1997 *JOURNAL*). Unless he is talking about a short-term and recent florescence of aspen, there are problems with his numbers.

Here in the Pacific Northwest the evidence for systematic burning by Indians starts about 3,500 years ago. The initial burning was minor. The amount burned increased over time and reached its climax just as Euro-American disease decimated Indian populations, as might be expected.

In the Willamette Valley, late-period burning opened up the landscape to about the 900-foot level. It reduced climax vegetation tied up in cellulose, increased the habitat for camas and tarweed, and encouraged the growth of oak. In the mountains, burning was used to expand berry areas as well as the ranges of other valuable food, fiber, and medicinal plants. *Extensive* burning occurs late in the archaeological and pollen profile records, essentially in the last 1,000 years.

If anything, the mixed grassland and oak forest mosaic increased valued habitat for deer and elk in the valley. There was a pioneer saying: "If you have to leave your porch to kill an elk or deer, you're working too hard." Human predation on large mammals does have an effect, but again, population density studies suggest that the greater human populations appear fairly late in the archaeological record, and that only minor environmental degradation has occurred in the last 3,000 to 2,000 years as the result of fires that were fairly restricted in scope and intensity.

Unless Kay is talking about a very late short-term jump in aspen, the data and numbers just do not work out. I find it hard to visualize a plant that loses its natural ability to reproduce in so short a span when there is no human activity involving the plant itself. I am certain that humans did not go out and control the reproductive populations of

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aspen, as happened with the plants that became domesticates, and it seems peculiar for a plant to give up its reproductive abilities in such a short period under reactive circumstances.

Leland Gilsen
Salem, Oregon

Charles E. Kay replies:

Unfortunately, the first people to reach North and South America arrived during a period of climatic adjustment. It is my contention that many of the vegetation changes seen at that time were actually due to aboriginal influences, not climatic fluctuations per se. In Australia, where aboriginal people arrived well before the end of the Pleistocene, they produced major vegetation changes that are clearly separate from climatic variation (see T.F. Flannery, *The Future Eaters*, 1994).

The same, of course, is true throughout Oceania, where initial aboriginal colonization occurred at various times during the last 10,000 years. There, massive vegetation changes and animal extinctions are correlated with human arrival, not climatic change. Even at relatively low population densities, aboriginal people had significant impacts on the vegetation, primarily by burning. In a book currently in preparation, Tom Bonnicksen of Texas A&M University concludes that 90 percent or more of the "pristine" forests in North American were, in reality, aboriginal in origin.

Moreover, the archaeological record in North America suggests that even 10,000 years ago, native hunting was already limiting the numbers and distribution of most ungulates. In his recent book *Buffalo Nation*, Valerius Geist concludes that native hunting was *the* factor that drove bison evolution and ecology ca. 12,000 BP to 1850 AD. Then too there is the question of what killed off the Pleistocene megafauna in North America and elsewhere. Again, native hunting is a more logical conclusion than climatic change. In fact, Wilhelm Schule has produced a fascinating series of papers in which he argues that aboriginal overkill actually caused the major climatic changes during the Pleistocene (e.g., *Journal of Biogeography* 20: 399–411).

Because of long-standing prejudices, science is just beginning to address the question of how native people really interacted with their environment. And as I indicated in my original paper, the answer has major implications for ecosystem and forest management.

The editors welcome letters referring to ideas or facts presented in the JOURNAL OF FORESTRY. *Priority will be given to letters no longer than 250 words that refer to material published within the past six months. All letters are subject to editing.*

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A female black bear has selected a hollow chestnut oak in Great Smoky Mountains National Park for her winter den. Although much is known about bear habitat use at the stand level, the application of multivariate statistical models using digital databases can now also examine wildlife-habitat relationships on a landscape scale.

Our mission is to advance forest science, technology, practice, education, and a conservation ethic to benefit society.