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# Chapter 6.

# Modeling Human Impacts to the Borderlands Environment From a Fire Ecology Perspective

## Introduction

Theoretical and topical orientations in current archaeology address the interaction between past human populations and their environment. These themes reflect ecological frameworks that were incorporated into the social sciences by the 1950s, as exemplified by the influential publication, *Man's Role in Changing the Face of the Earth* (Thomas 1956). Cultural practices for actively manipulating targeted species and ultimately modifying vegetation structure have been highlighted in recent studies of foraging societies and have gained recognition as key processes in the transition from hunting and gathering to farming economies (for example, Hillman and Harris 1989; Price and Gebauer 1995; Smith 1992). From this background of such interests, archaeologists are increasingly involved in examining the relationships between prehistoric peoples and precontact vegetation on what are now public lands in the United States.

There is, of course, no unitary means of characterizing the manner and the magnitude of impact by preindustrial societies in North America or even in the Southwest. Natural vegetation dynamics over time are driven primarily by climate and secondarily by processes such as geomorphological change. However, these natural processes are more regular and subject to uniformitarian approaches than are the overlay of human interventions that affect them; no uniform reconstruction of human impact can be advanced without reference to economic orientation, population densities, or culture-specific practice. To assess human influence on a precolumbian baseline, it is necessary not only to specify a vegetation class consistent with environmental variables, but also to specify the dimensions of indigenous population, subsistence, and settlement.

## Human-Induced Fire in Historical Perspective

The conviction that wildfire has played a decisive role in the evolution and maintenance of desert and plains grasslands and open forests in the American Southwest is an important component of range management philosophy and ecological thinking. According to this view, periodic and widespread grassland blazes in the past encouraged vigorous return of annuals but inhibited the survival of woody plants. Likewise, cyclical wildfires removed woodland understory so that forests of large trees were open and sprinkled with clearings. Changes in frequencies in the wake of fire suppression and overgrazing resulted in conditions that permitted the invasion of dense young trees, brush, and shrubs by the late 1800s.

Carl Sauer (1944, 1956) and Omer Stewart (1956) are among the most influential proponents of the hypothesis that the former broad, brush-free grasslands and mature, open forests of the New World originated with repeated fires set by Native Americans as much or more than from naturally occurring conflagrations. Stewart (1956:

118) believed that the unrestricted burning of vegetation was a universal trait among "primitive" peoples. Grasslands were repeatedly subjected to fires used in Native American hunting activities (Sauer 1944: 554, 1956; Stewart 1956: 129). Conversely, fire suppression is limited to contemporary societies (Sauer 1956: 55). Sauer and Stewart correlated this perceived universality of native burning with historic environmental change to arrive at the potent force shaping premodern grassland and forest landscapes. Some current environmental historians working in the Western United States have expanded this thesis to implicate burning by Native Americans in the overall development of North American ecosystem structure (Kay 1994; Pyne 1982).

Researchers in the Borderlands study area and adjacent regions (for example, Branscomb 1958; Cooper 1960; Humphrey 1958; and more recently Bahre 1985, 1991; Dobyns 1981: 27–44; Pyne 1982, 1984) have assembled an array of ethnographic, archival, and newspaper accounts of historic fire in general and anthropogenic fire in particular. Conrad Bahre (1985: 190, 1991: 124–142), reviewing local newspaper accounts of wildfires in grasslands of southeastern Arizona during the latter portion of the 19th century, summarizes that: wildfires were much larger and more frequent than at present; the occurrence of these fires declined dramatically during the 1880s; cessation of large fires preceded the "brush invasion" of the 1890s; Native Americans often set wildfires; and suppression of fires was encouraged by Anglo settlers.

## Natural Versus Cultural Magnitudes

The scale and efficacy of naturally induced fire is a question that warrants serious consideration prior to retrodiction of human effects. If natural ignitions were plentiful and cultural suppression nonexistent, why would not the balance between accumulating fuels and recurrent fires be sufficiently close to preclude first order consequences of human initiations? Under conditions approaching such a balance, why would culturally generated fires transform or maintain vegetation types rather than affect relatively minor and local adjustments of vegetation potential? Proponents of Native American burning as a primary factor in the persistence of grasslands and open forests seldom confront this fundamental issue (but see Lewis 1973 for an exemplary analysis of the interplay between aboriginal burning and natural fire regimes in California).

The thoroughness and rapidity with which naturally ignited fires consume available fuels is particularly germane in assessing prehistoric human impacts on Borderlands ecosystems. Conrad Bahre (1991: 124) summarizes the impressive occurrence of lightning in the study area and vicinity. Nearby portions of Mogollon Rim country have among the highest incidences of lightning fires in the United States. Seventy-three percent of all fires since 1959 in the Coronado National Forest have originated in this way. The Coronado Forest leads the Southwest in average acreage burned annually by lightning fires, despite a long history of fuel reduction through grazing. These high natural ignition rates bring the role of aboriginal burning into perspective as a residual mechanism in total fire ecology. Bahre (1991: 128) noted, ". . .given the high incidence of lightning-caused fires, reliably documented by modern data, the relative importance of fires set by Indians is probably moot."

Although the exact nature of the relationship between natural fire and vegetation in the past cannot be easily resolved, it is possible to ask whether Borderlands trends attributed to historic human agency had earlier parallels. For example, Thomas Van Devender (1995: 89–94) cites packrat midden evidence for increases of desert shrubs in southeastern Arizona grasslands about 4,000, 3,000, and 1,000 years ago, in the absence of livestock or fire suppression programs. Although he attributes these prehistoric increases to climate, he acknowledges the unprecedented intensity and possible irreversibility of modern activities. In any case, there is wide concurrence on the two foremost causes for a decreased scope and frequency of fire by the latter part of the 19th century: the removal of ground cover and fine fuels through overgrazing and active fire-containment efforts (for example, Bahre 1985, 1995; McPherson 1995; Pyne 1984; Van Devender 1995). Thus, it is clear that prehistoric human fire ecology should be viewed in the framework of a more vigorous natural fire regime than at present.

## Fire Ecology of the Early Archaeological Sequence

There is a substantial body of information on Native American use of fire in the southern Southwest during the historic era (see summaries in Bahre 1985; Dobyns 1981). But for the prehistoric era, unfortunately, direct evidence pertaining to the fire practices of Borderlands inhabitants is limited, and models of this behavior rely strongly on ethnographic accounts. Analogs must be judiciously selected for best fit with the demographic and economic profiles of specific groups of prehistoric peoples. No single, generalized model of human

fire ecology can adequately encompass the demographic and economic variability in archaeological sequences.

Little is known about Paleoindian hunters of the study area beyond the existence of kill and butchering sites for large, extinct game such as mammoth. Paleoindian residence and mobility strategies are not well known, nor are other aspects of subsistence practices. Packrat middens in uplands suggest that grasslands emerged from more arboreal vegetation types about 8,500 years ago (Van Devender 1995: 89), but pollen diagrams associated with still earlier Paleoindian kill sites conform to grassland patterns (Mehringer and Haynes 1965: 22; Martin 1963a,b). The use of fire drives for game is plausible but assessing their overall effect is highly speculative.

Forms and distributions of desert grassland and scrub resembling those of the present were in place by approximately 4,000 years ago (Van Devender 1995: 89). With the demise of large Pleistocene fauna, subsistence practices shifted to a focus on diversesmaller animals and, as suggested by grinding stones and other implements in artifact assemblages, varied plant resources. Although we know little about the lifestyles of the Archaic peoples who succeeded Paleoindian hunters, the few known structures from the latter centuries before agriculture imply intervals of relatively prolonged occupation in some locales (for example, O'Laughlin 1980).

In a cross-cultural survey of foraging societies, Lawrence Keeley (1995) found a correlation between use of fire for landscape management, dietary reliance on seeds and nuts, intensive manipulation of wild plants, and decreasing mobility. Indeed, this combination of attributes fits those historic cultures of the Western United States for whom the most systematic and complex burning practices have been recorded, such as the Shoshone and Paiute of the Great Basin (Steward 1938; Stewart 1939) and a variety of groups in California (Bean and Saubel 1972; Lewis 1973). With longer residence in single locations, management efforts are both increasingly practicable and necessary to derive food supplies from circumscribed territories. Archaic foragers closely predating the transition to farming may well have been the premier landscape burners of Borderlands prehistory.

In the Tucson Basin and on its eastern borders, the threshold of agriculture dates back at least to 1,000 B.C. and probably centuries earlier (B. Huckell 1996; Mabry 1996; S. Fish and others 1990). Corn pollen recovered by Owen Davis (2001: 408) from the Animas Creek Cienega near the Gray Ranch Headquarters, in a level dated earlier than 3000 B.P., suggests that the appearance of farming was generally synchronous in the Borderlands. Late Archaic subsistence studies near Tucson show even the earliest cultivators possessed a full complement of aboriginal food crops, and corn remains are as common in their pithouse villages as in later agricultural settlements (L. Huckell 1996, n.d.).

## Fire Ecology of the Late Prehistoric Archaeological Sequence

Information is most complete for later prehistoric sites in the Borderlands. Data on the distribution of residential sites, including the largest occupations of all times, provide the basis for modeling cultural dimensions of fire ecology in the last centuries before Old World intrusion, from about A.D. 1250 to 1450. Because archaeologists have undertaken little systematic inventory or excavation, reconstruction of human fire ecology during this era draws upon more numerous and refined studies to the west and north in southern Arizona, particularly studies of the Hohokam. Ethnographic analogs will similarly emphasize agricultural groups in those sectors.

### *Disjuncture with Apache Practices*

It is useful to contrast the cultural contexts of the use of fire before and after Old World contacts in the Borderlands. Both proponents and discounters of aboriginal burning as a primary force invoke accounts of Apaches and similar groups from initial Spanish encounters to the late 19th century. It is improbable that these observations are valid reflections of precontact times. In addition to the tenuous cultural continuity of the Apache with prehistoric agriculturalists, their lifestyles were shaped by factors unique to historic.

Throughout the periods of Spanish, Mexican, and United States hegemony, the Apache were simultaneously in conflict and economically intertwined with these dominant societies and other Native American groups. Mobility was heightened by ongoing hostilities, capabilities for animal transport, and heavy economic involvement in raiding and trading. Although Apaches gathered plant resources and sometimes cultivated for subsistence needs, their opportunities for extended residence and intensive forms of land use often were limited. Furthermore, some Apache had more than a passing involvement with livestock. For example, Dobyns (1981: 24) cites a description of large numbers of Apache livestock along Pinal Creek by 1830. Livestock obtained in perpetual raiding also had to be temporarily sustained, even if later disposed of through trade.

Apache patterns of land use, including the application of fire, diverges from that of relatively intensive or sedentary foragers and, presumably, that of from late prehistoric agriculturalists. Mobile (and to some extent unpredictable) Apache lifestyles, in conjunction with low population size, would hold few incentives for regular, intensive, and fine-tuned manipulations of the environment. Relocation was a ready option and sometimes an urgent necessity. Not surprisingly, reports of Apache burning in historic records, though probably inflated by automatic attribution, are repeatedly linked with conflict (Bahre 1985; Dobyns 1981), and fire chronologies derived from Borderlands tree-ring studies suggest a correlation between increased frequencies and intervals of heightened warfare (Kaib and others 1996).

### *Late Prehistoric Settlement Patterns*

Borderlands settlement patterns after A.D. 1200 are characterized by adobe structures at larger residential sites, with a range from 50 to perhaps several hundred rooms. All of these are pueblo-style with contiguous rooms. Compounds, consisting of more dispersed sets of rooms surrounded by a wall, were constructed at moderate-sized sites near the western boundary of the study area; room numbers are more difficult to estimate with this type of architecture. Locations of the large settlements correspond to better situations for irrigated and floodwater farming along the larger mid-valley drainages and along mountain edges where tributaries with large upland watersheds emerge (fig. 3.5). The importance of agriculture is inferred from these hydrological settings, and corn remains have been recovered in each of four substantial excavations at these sites (Kidder and others 1949; McCluney 1965a, 1965b) and in a number of dry caves (Lambert and Ambler 1961).

Although small residential settlements and other site types are numerous throughout the study area, occurrences are so spottily reported that their relationship to the larger sites cannot be documented in more comprehensive patterns. The presence of probable Casas Grandes-style ballcourts at four large sites in the study area and at three near its edges suggests some form of multi-site community organization similar to that in the Hohokam area (S. Fish and Fish 1994) and other parts of the Southwest (Adler 1996; P. Fish and Fish 1994). Communities in this sense are sets of closely interrelated outlying settlements that share a relatively large center with communal public architecture such as a ballcourt, platform mound, or big house. The roughly regular spacing of large Borderland sites (fig. 3.9) also resembles the spacing of centers in other community distributions (P. Fish and Fish 1994; S. Fish 1996)

## A Zonal Model of Fire Use

Just as differing economic orientations have differing implications for the use of fire as a management tool, its use can also vary among differing locations within a single orientation. We will use the zonal character of prehistoric community territory as the principal point of reference in modeling this variability. Community boundaries encompass the primary sustaining area for the entire set of interrelated member settlements. Among the neighboring Hohokam, community territories exhibit an internal zonal arrangement corresponding to varied topographic opportunities for agriculture and the procurement of wild resources (Crown 1987b; Fish and others 1992; Masse 1991).

### *Zones of Intensive Cultivation*

Communities usually include a productive core of hydrologically favored agricultural land. Such a core in the study area would consist of land irrigated from primary or large secondary drainages by small networks of canals. At the scale of Borderland watercourses, formal irrigation would intergrade with extensive floodwater systems, in which long ditches serve a series of fields (compare Doolittle 1984; Nabhan 1986; Withers 1973).

Within the radius of intensively cultivated land, uncontrolled fire would have posed a threat. Nearby village structures with highly flammable roofs contained household possessions and, more important, internal or adjacent facilities with stored food. During the growing season, crops would be threatened in fields. Throughout the year, however, fire might damage other vegetation elements of intensively farmed locales. As in Pima agriculture (Rea 1981, 1983), field edges and hedgerows may have consisted of woody plants and herbaceous species that were selectively spared in clearing and of herbaceous plants that, together, furnished gatherable resources and firewood and harbored a concentrated supply of small game. Species such as mesquite grew along outer edges of canals. A mesic flora also lined canal banks, extending riparian resources into the zone of cultivation. In adjacent northern Sonora, traditional farmers still plant "living fencerows" of cottonwood and willow to stabilize field edges on floodplains and to safely deflect nutrient-rich flood flows over fields (Sheridan and Nabhan 1978).

Uses of fire in intensively farmed zones are clearly documented for aboriginal and traditional farmers of the southern Southwest. Piled brush was sometimes burned

in the initial clearing of fields (Castetter and Bell 1942: 125) and possibly to remove weedy growth in subsequent plantings. Canal channels were similarly cleaned at times. Burning to clear water delivery systems may have been extended to the dense growth of cienegas and drainage bottoms in locations where canals and ditches headed; an additional goal might have been to enhance the productivity of nonwoody riparian resources (Nabhan and others 1983; Rea and others 1983). Such practices could account for the charcoal of riparian species recovered from Borderland cienegas in levels predating the late 19th century (Davis n.d.). In all of these cases, unrestrained fires would have been destructive to residential and agricultural environs.

Table 4.5 gives estimates for amounts of irrigated land needed to supply projected populations at seven of the better-recorded large Borderlands sites. Quantities are based on historic Piman farming for which at least 2.5 persons could be supported by 1 ha (2.5 acres) of irrigated land (Castetter and Bell 1942: 54). Although irrigable land is intermittently distributed along adjacent streams for all but one of these sites, in no case does it satisfy even half of the projected acreage. This lack of congruence suggests a major role for alternative methods of agricultural production and gathering.

### Areas of Runoff Cultivation

Somewhat removed from well-watered community sectors, more marginal plantings likely were situated on ephemeral tributaries. Such secondary floodwater plots likely were interspersed among more extensive fields watered solely by the concentration of surface runoff. Impressive arrays of runoff devices are widespread in portions of southern Arizona and northern Chihuahua surrounding the Borderlands. For example, in three Hohokam communities of the Tucson Basin, simple cobble devices called rockpiles covered between 550 and 600 ha (1,359 and 1,483 acres). In the two reliably bounded examples of these large territorial units (136 and 146 $km^2$; 53 and 56 square miles), such fields constituted about 2 percent of community land (S. Fish and Fish 1994). Terraces, linear borders, and checkdams were prominent stone features of the Casas Grandes region of Chihuahua (Di Peso 1984; Whalen and Minnis 2001: 71–75), and miles of large stone grids covered the upper terraces of the Gila River near present-day Safford, Arizona (Masse 1991).

Historically, aboriginal and traditional farmers most commonly constructed runoff diversion devices of earth and brush. Preserved stone features, then, may represent a minimum indication of prehistoric use. The lack of reports of runoff features in the Borderlands may reflect the rudimentary level of inventory or a predominance of earth and brush materials.

If present, as seems likely, zones of runoff farming defined further circumscription of anthropogenic fire. Agave has been documented as a principal cultigen, and cacti have been suggested for many Hohokam runoff complexes (Fish and Nabhan 1991). Such drought-adapted plantings are strong probabilities in the arid Borderlands as well. These are perennial crops, leaving no off-season in which burning of weeds could be freely implemented. Furthermore, succulents tend to be among the least fire tolerant of desert plants (Cave and Patten 1984; McLaughlin and Bowers 1982; McPherson 1995: 137–140).

### Variable Radii of Gathering

The disturbed environs of prehistoric cultivation provided secondary resources in the form of weedy plants (Fish and Nabhan 1991). Typically, these were annuals that matured rapidly and produced edible greens and abundant seeds. Intensive gatherers burned plots to increase the production of such species, but broad applications of fire by agriculturalists would have been relegated to zones beyond residences and both intensively and extensively cultivated land. The lower needs of farmers than foragers for weedy harvests may have been largely satisfied from field margins and fallow land.

Labor expended in agriculture can be seen as a counterbalance to investments in wild plant manipulation near and beyond community boundaries. It is doubtful, for instance, that irrigation and floodwater farmers would have had sufficient time or incentive to routinely burn meadows in high elevation forests, despite potential enhancement of edible species. The most intensive manipulations of wild plants by agriculturalists might be expected near the margins of cultivation rather than at greater distances. Moreover, wild resources respond variably to fire. Grasses and other seed bearing annuals are more abundant after burning, while cacti providing fruit are damaged.

### Strategies for Hunting

Vegetation effects at the broadest scale are often linked to hunting (for example, Kay 1994; Stewart 1956). Fire was widely employed for this purpose among cultural groups of the southern Southwest and northern Mexico (Dobyns 1981: 42). Hunters lit fires to flush out their prey, to direct or contain the flight of animals, and to promote abundant, palatable fodder. Mounted hunters in postcontact times could rapidly pursue fleeing game; prehistoric hunters

**Table 6.1.** Population and land-use characteristics for selected large, late prehistoric pueblos in the Malpai Borderlands study area.

| Site No. | Site name | No. of rooms[a] | Estimated population[b] | Hectares of farmland[c] | Cords of fuelwood[d] |
|---|---|---|---|---|---|
| LA 1369 | Pendleton | 125 | 125 | 50 | 250 |
| LA 4980 | Box Canyon | 175 | 175 | 70 | 350 |
| LA 1823 | Joyce Well | 200 | 200 | 80 | 400 |
| LA31050 | Culberson | 225 | 225 | 90 | 550 |
| LA54033 | Double Adobe | 200 | 200 | 80 | 400 |
| LA54034 | Cloverdale Park | 75 | 75 | 30 | 150 |
| LA54038 | Timberlake | 200+ | 200 | 80 | 400 |

[a]Number of rooms is based on National Register Nomination forms for the Animas District.
[b]Estimated population is derived from William Longacre's (1970) room-to-person ratio.
[c]Hectares of irrigated land are estimated using Castetter and Bell's (1942:54) ratio of persons to farmland among the Gila River Pima.
[d]Estimates of cords of fuelwood are those of Spoerl and Ravesloot (1994). Estimates for Animas inhabitants were reduced by 25 percent because of milder climate.

on foot had more compelling motivation to carefully position fires to constrain the path of flight. Practices designed to control both fire and animals are illustrated by the description cited by Dobyns (1981: 43) of Yaqui setting a fire in a circle when there was no wind so that it burned toward the center. Hunters waited at the perimeter for game escaping outward. Despite such means for exerting control, fire drives among the Pima were carried out in areas more distant from villages and fields than other forms of communal hunting (Rea 1979: 114–115).

Burning at a landscape scale, such as throughout grasslands on Borderlands valley floors, is conceivable as a strategy to improve the carrying capacity for herbivores (compare Dobyns 1981: 39). In light of the already high incidence of natural fires to consume built-up fuels, such programmatic burning would have required persistent effort, and would have threatened the predominantly lower valley villages and fields. Detailed ethnographic accounts of burning for forage improvement, however, often describe small-scale, areally specific goals and events. Restricted burning, such as near a water source or in a forest clearing, offers the distinct advantage of attracting and concentrating game in a precise, predictable location.

### *Radii of Fuel Demands*

During prolonged occupation of large sites, residents continually needed domestic fuel. Cleared land and culturally modified vegetation in the vicinity of settlements lengthened radii of firewood supply. Lower elevation woodlands of adjacent mountains must have been important sources. Fred Plog (1992) estimated 2.7 cords of firewood per capita annually for prehistoric populations of the Mogollon Rim. Adjusted downward to two cords for the somewhat milder Borderlands climate, areas of sustainable yield in low-density Emory oak woodland (Touchon 1988) range from 17 to 60 $km^2$ (6.5 to 23 square miles) for projected village populations in table 6.1. Repetitive harvesting of deadwood may have affected natural fire frequencies in areas of heavy fuel gathering, and it seems probable that intentional burning would have been avoided to conserve the nearest supplies.

## Fire Ecology of Anthropogenic Landscapes

Multiple lines of evidence suggest that the applications and motivations for fire use were culturally and spatially complex for late prehistoric Borderlands agriculturalists. The productive potential of small-scale irrigation and intensive floodwater techniques is modest when compared to more hydrologically favored locales in other parts of the southern Southwest. In addition to runoff cultivation of marginal land, manipulations of vegetation to increase the returns of hunting and gathering are likely to have included the same uses of fire. It seems doubtful, however, that comprehensive burning was instituted at a landscape scale, for reasons advanced in the foregoing discussion.

The greatest variety of resources can be obtained from heterogeneous rather than homogenous landscapes, with patches of mature vegetation and other areas in multiple stages of fire succession. Mobile populations could attain resource variety by periodically moving from place to place, an option not equally viable for committed farmers. Particularly for agriculturalists, a vegetation mosaic would have been as valuable for gathering plants as for

hunting, to ensure a variety of wildlife and predictable localization of game.

High incidences of lightning in the Borderlands guaranteed access to resources encouraged by fire succession. Cultural practices could accelerate vegetation response by introducing fire in seasons of natural ignition and by increasing periodicities to the extent that fuel buildups allowed (Lewis 1973; McPherson 1995). Nevertheless, fires of controlled extent were the route to achieving vegetation mosaics more diversified and resource-rich than natural zones.