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PREHISTORIC ANTHROPOGENIC WILDLAND BURNING BY HUNTER-GATHERER SOCIETIES IN THE TEMPERATE REGIONS: A NET SOURCE, SINK, OR NEUTRAL TO THE GLOBAL CARBON BUDGET?

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ABSTRACT

There is a need for more intensive multi-disciplinary study of prehistoric "hunter-gatherer" burning patterns in temperate regions. California is presented as a case study to demonstrate how powerful, effective, and widely employed fire was in the native repertoire for directly manipulating the wildland environment. It is highly likely that the magnitude of burning in other temperate regions as well as in California, has been underestimated by anthropologists. A methodological approach to better define the broad outlines of anthropogenic wildland burning patterns in various regions of North America, at the point of Euro-American contact, is put forth. Regional studies which revaluate the extent to which Native American tribes were an important ecological force in shaping the biotic and physical environment, will have profound implications for contemporary environmental policies to reduce the threat of global warming. It is suggested that physical, social, and biological scientists work together to examine global warming in a broader historical context to include temperate wildland burning by prehistoric peoples and explore its contribution as a net source, sink, or neutral to the global carbon budget.

I. INTRODUCTION

It is often assumed that prehistoric peoples of North America were part of eras of history virtually unaffected by human environmental meddling. A corollary which has supported this view, is the myth that much of the United States was a virgin wilderness, unaffected by Indian activities prior to Euro-American contact. Only recently, have social and biological scientists begun to question old assumptions regarding prehistoric human ecological impacts on so-called "natural" vegetation. Wilson (1992), Blackburn and Anderson (1993), and Denevan (1992) among others, have uncovered unequivocal evidence that Native Americans both conserved and transformed New World environments.

Indigenous burning was the most important prehistoric land management tool, causing cumulative and very likely permanent effects on the vegetation. Therefore, many of the pristine habitats that are now set aside as natural or wilderness areas in protected status, are already altered landscapes which have evolved with frequent human disturbance. This fact provides an impetus to ecologists and land managers to develop a much deeper understanding of former indigenous fire-based management and its effects in various plant community types. Unfortunately, the diversity and complexity of fire-based land management systems, in conjunction with the sophisticated systems of traditional knowledge upon which they are based have been little studied (Blackburn and Anderson 1993).

Altering the environment with fire to suit Indian needs in prehistoric North America, not only triggered changes in the biotic environment, but also a host of other changes in the physical environment including ecological effects on soils, water, and climate. The perception of a pristine preindustrial environment in North America, so pervasive in the biological and social sciences, has also persisted in the physical sciences. For example, current efforts to predict global climate change frequently presume that the atmospheric concentrations of gases that contribute to global warming were stable and the natural cycles were in balance in the millennia immediately prior to the Industrial Revolution (Hammond 1991:13).

Recently scientists (Kammen and Marino 1993; among others) have calculated that landclearing for agriculture, and combustion of non-fossil carbon for domestic needs, have contributed substantially to CO_2 and CH_4 emissions prior to the Industrial Revolution. When preindustrial anthropogenic carbon release is calculated, only a limited number of human activities has been considered (e.g., domestic energy use, mercantile activity, construction and wetland and dryland agricultural land management (Kammen and Marino 1993:73-74). While it is generally agreed that prehistoric burning of wood for heating and cooking released substantial amounts of CO_2 into the atmosphere by both agricultural and nonagricultural societies alike, the contributions of greenhouse gases in the atmosphere attributed to an array of additional indigenous activities in nonagricultural or "hunter-gatherer" economies has not been estimated. This includes wetland and dryland horticultural land management in the form of vegetation burning in so-called "wilderness" or natural areas to meet a wide variety of cultural needs.

2. A CASE EXAMPLE: THE INTEGRAL USE OF FIRE BY CALIFORNIA HUNTER-GATHERER SOCIETIES

The rigid and rather monolithic conceptual dichotomy traditionally drawn between the seemingly passive 'food procurement' lifestyle of 'hunter-gatherers' and the apparently more active 'food production' adaptation of 'agriculturalists' is inadequate, overly simplistic, and dangerously misleading (Blackburn and Anderson 1993). It is argued here that vegetation burning was also a widely employed, efficient, and a significant management tool for nondomesticated food production systems and other wild plant production systems utilized by so-called "hunter-gatherers" in California and utilized in other temperate regions in North America.

Through extensive research involving a variety of methodologies (e.g., ethnohistoric research; ethographic interviews and participant observation; study of museum artifacts; and experiments to mimic indigenous practices), substantial evidence was amassed, regarding former indigenous burning in California (Anderson 1993a; Anderson 1993b). Certain cultural use categories required enormous quantities of plant materials on a continuous and frequent basis and three of these categories, basketry, cordage, and foods, are highlighted below to demonstrate that fire was integral to the maintenance of food and fiber production systems.

Knowledge and use of the slow match and torch, recorded for many tribes in California, gave the Indians the technological capability to burn both small patches and extensive tracts of vegetation in a systematic fashion (Olmstead and Stewart 1978:229, Driver and Massey 1957:347; Barrett 1907:257; Driver 1937:70). Unlike the consequences of an unplanned lightning event, indigenous application of fire most always had cultural purposes attached. There were specific planned outcomes for fires that were set (Timbrook et al., 1982; Lewis 1973; Anderson 1993b). By understanding these outcomes, one begins to see that the former landscape compositions and patterns were not purely happenstance, or incredibly rich due solely to the "natural" bounty of California, but rather were partly attributed to the sophisticated environmental management of the various tribes.

There is increasing archeological, paleoecological, ethnographic, and ethnohistoric evidence that human manipulations were regular, constant, and long-term, causing cumulative and possibly permanent effects which would register in the plant associations, species composition and perhaps the gene pools of the species and genetic structures of the plant communities found in many parts of California (Anderson and Carpenter 1989; Anderson 1993b; Mensing 1990).

2.1 Burning for Basketry Production Systems and other Cultural Items

Over 75 percent of the plant material culture of California Indian tribes depended upon the use of epicormic branches or adventitious shoots (also known as "sprouts" or "suckers") from a diversity of native plants. Ten cultural use categories required these special types of branches: baskets; ceremonial items; clothing; cordage; games; musical instruments; snares, traps, and cages; structures; tools, and weapons.

Epicormic branches and adventitious shoots grow from specialized buds that are held in reserve until some disturbance has occurred activating them (Zimmerman and Brown 1971:30,35). In addition to lightning-set fires, flooding, or other natural disturbances, Native Americans set fires in chaparral, oak woodland, mixed conifer forests, redwood forests, and mixed evergreen forests to augment the production of this growth form to meet their cultural needs (Anderson 1986-1992). The favored plant species include both obligate sprouters and facultative sprouters that have the capacity to reproduce either by seeding or sprouting (Kauffman and Martin 1990:749).

When burning for their purposes, Native Americans set fires in ways that perpetuated species having protected, subterranean plant organs which allowed for subsequent in situ development. For example, areas harboring buckeye (Aesculus californica) were fired to stimulate shoots used for Miwok fire drills; the new dogwood shoots after human-set fires were cut (Cornus spp.) for Western Mono pidgeon decoy cages; the sprouting bases of burnt maples (Acer macrophyllum) were harvested for Miwok cordage material and Washoe baskets; the first or second year growth of gooseberry (Ribes sp.) after a fire was harvested for Foothill Yokuts arrows; the epicormic branches along the boles of burned black oaks (Quercus kelloggii) were harvested for Western Mono looped stirring sticks (Barrett and Gifford 1933; Mathewson, 1992, personal communication; Beecher, Mono, 1992, personal communication.)

Walking through an oak woodland or a mixed conifer forest that has not recently burned will yield few "usable" shoots to accommodate the indigenous industries. This is due to the strict adherence to the rule of only using young growth--first-, second-, or third-year growth for the making of baskets, cordage, weapons, clothing, musical instruments, etc. In fact, in most cases within two to three growing seasons after a disturbance such as fire, the resulting sucker growth is already unfit for manufacturing items, because it no longer contains the qualities necessary for the proper manufacture of a cultural product. Most shrub sprouts send out lateral branches within two years after a fire. Older branches are often knarly, crooked, with mottled and cracked bark, and many lateral branches. Old growth is often insect or disease damaged and has lost flexibility. Gathering tracts not periodically burned, quickly accumulate dead material, further reducing the amount and quantity of young growth (Anderson 1993b).

The desired wood properties vary depending upon the item, but include flexibility, no pathogen or insect activity, straightness, no lateral branching, special anthocyanins, no bark blemishes, long length, uniform cell structure, size and density for optimal drying, and uniform diameter. For example, according to Clara Charlie (Chukchansi-Choinumni Yokuts) burning enhances certain qualities exhibited in the new growth so prized in indigenous basketry:

"The sticks are straighter and more flexible and easier to handle. Old growth is brittle, not straight, and hard to work with."

Many other contemporary weavers stressed the importance of selecting the "right" material:

"Weavers like their sticks without any side branches. They're easier to split and with sourberry--they're easier to scrape the skin off" (Grace Tex, North Fork Mono).

"If you don't burn the basket plants you get all kinds of branching and crooked sticks. You have to split it so it has to be straight to begin with" (Ruby Cordero, Chukchansi Yokuts/Miwok).

In prehistoric times, enormous quantities of young shrub shoots were needed by each Indian village, pointing to the need for frequent burning to accommodate the plant material culture. For example, one cradleboard takes between 500 and 675 straight sticks of sourberry, Rhus trilobata, (Planas, Mono, 1991, personal communication; Turner, Mono, 1992, personal communication) which would be taken from six separate patches that had been burned prior to harvest. A burden basket requires over 1,200 straight shoots over four feet long to complete, while a twined seedbeater requires at least 188 straight shoots of buckbrush (Ceanothus cuneatus) for its construction (Turner, Mono, 1991, personal communication).

The above amounts are so tremendous given the architecture of wild plants as to make gathering "wherever one might find the right material" prohibitive. Thus, collecting basketry material was not happenstance, but was more on the level of a collective enterprise of a sizeable nature. Tremendous efficiency was needed to gather enough materials yearly to comply with the strict standards for the manufacture of many cultural items. The quantity of plant material needed for the completion of baskets provides unshakable evidence for the necessity of management by burning at the level of an industry. These facts support a burning regime that was very frequent, to keep shrubs at a young growth stage in order to obtain a continual supply of a tremendous quantity of usable shoots for the making of many kinds of baskets as well as many other items (Anderson 1993b).

2.2 Burning for Fiber Production Systems

Cordage can be defined as "the twisting together of separate fiber strands into a single, long twined string or rope" (Mathewson 1985:3). Making of string or cordage is probably the oldest fiber art in America (Adovasio 1974:100). The knowledge of how to make string was probably brought in with the migration of Indians into California. The most important cordage fiber plants used by California Indians were Indian hemp throughout California; the milkweeds used mainly in the central part of the state; iris in northwestern California, and yucca and agave in the southern deserts (Mathewson 1985).

The Sierra Miwok, Foothill Yokuts, and Western Mono, as well as many other tribes favored the use of two genera, Asclepias or the milkweeds and Apocynum or Indian hemp. These two genera contain herbaceous species with stems that are composed of excellent "bast" fibers. These bast fibers were collected, extracted, and manufactured into many items including: fishing nets, deer nets, rabbit nets, netting bags, tump lines, slings, flicker feather head bands, hair nets, feather capes, feather skirts, belts, cord belts for womens' aprons, and bow strings.

Herbaceous plants that contained desirable fiber were gathered mostly in the late fall or wintertime when the stalks had died back. Milkweed (Asclepias spp.) was gathered by the Sierra Miwok in summer, fall, or winter according to Barrett and Gifford (1933:246). Plants were gathered in the mountains, foothills, and plains, depending upon the tribe. In 1851 Robert Eccleston (Crampton 1957:101) wrote in his diary:

"They [Sierra Miwok] make a handsome twine out of a flax that grows in the mountains, & from the twine they construct fish nets, as well as scarfes a la Mexicana, &c."

Large quantities of Indian hemp were needed to make different items. Passages in journals and reports comment on the vast fields of "flax" or "hemp" in California:

"....and some very curious snares that they [Mohave Indians] make of wild hemp, of which there is much in these lands" (Coues 1900).

"It [milkweed] grows profusely along roadsides and in low, dry, or wet ground; sometimes, as in valleys, claiming large areas to the extent of from 60 to 90 per cent of the bulk of the vegetation [Mendocino County]" (Chestnut 1974:379).

In counting the numbers of plant stems needed to make a cultural item, the quantity required is phenomenonal. For example, according to Craig Bates (1992, personal communication) it takes about five plant stalks to make one foot of string. A forty foot deer net made by the Sierra Miwok (Barrett and Gifford 1933:178) would require 7,000 feet of string or 35,000 plant stalks. A feather cape would require 100 feet of string or 500 plants gathered.

Long straight stems with no laterals, growing in direct sun make the best material for cordage (Bates, 1992, personal communication). Cordage plants were periodically burned to decrease accumulated dead material, providing increased access for harvesting, greater sunlight to the new growth, and nutrient recycling to the soil. Plants were reputed to grow straighter and taller when burned:

"There's another plant that benefited alot by fire that my dad said. It was the Indian hemp. Because they used that for rope also and it could get really knarled up. The hemp plant would get all congested. The whole plant would burn all the way down to the roots, but then it would come up the next year straight. And then you need those straight long stems so they could crack them open and get their fiber out of there" (Franco, Wukchumni Yokuts, 1991, personal communication).

David Peri (et al 1982:121-122):recorded among the Pomo people that they burned milkweed (Asclepias sp.) and Indian hemp (Apocynum pumilum) for better production.

2.3 Burning for Food Production Systems

Leaves for greens, fruits, mushrooms, seeds, and bulbs, corms, and tubers were the "wild" edible plant parts that were managed for with fire by tribes throughout California. Westerners are taught that plant abundance and management are linked only in human-designed systems such as ornamental gardens, orchards, or fields of domesticated crops. Without repeated human intervention, the vineyard succumbs to a pathogen problem, the dense canopies of unpruned apple orchards produce fewer and fewer apples, and the untended corn field is encroached by weeds.

Traditional gathering sites were subjected to the same competitors as a modern-day orchard, agricultural monoculture, or vineyard: insects and other animal pests, diseases, and weeds. Thus, fire management was required to keep these pests in check and stimulate qualities that were culturally valued.

Plant species that harbored edible greens weren't "naturally" productive continuously over many years but required disturbance to maintain their quality and quantity each year. For example, clovers (Trifolium spp.) for greens were fired by the Wukchumni Yokuts, Western Mono, and Pomo tribes to encourage tender, young growth, stimulate seed production, increase the size of the tract, and keep clover areas clear and open (Peri et al 1982; Bethel, North Fork Mono, 1991, personal communication).

Hector Franco, Wukchumni Yokuts, remembers (1992, personal communication):

"The only plant that I know benefited tremendously from fire in the high mountain meadows was the clover. Clover patches were burned. In Squaw Valley the Indian people burned clover patches right by the Mission my dad said. There's not that much clover left now because of all the buildings the houses, they've destroyed alot of the clover--there used to be sloping meadows of clover. The clover was gathered in March, April. When it got older it got tougher and it didn't taste good. You ate it when the leaves were tender. I remember the people wouldn't uproot the whole plant. They would pinch it off. My dad said that they burned it after it produced seeds and after the seeds fell. The fire also stimulated different seeds. They burned it probably at the end of the year when they burned everything else, in the cool time, anywhere from October to November.

Shrub areas that harbored edible fruits (e.g., Arctostaphylos spp., Fragaria californica, Sambucus caerulea, Vaccinium spp.) were periodically burned by the Achumawi, Pomo, Sierra Miwok, Western Mono, and Karuk tribes to increase fruit production, open up shrub canopies for sunlight, reduce insect activity by eliminating old wood, and thin dense shrub patches (Beecher, Mono, 1992 personal communication; Avis Punkin North Fork Mono/Miwok 1991 personal communication; Stewart 1935; Garth 1953; Harrington 1932:63).

Today some individuals from different tribes remember that in the past fire was used as a management tool to maintain or increase fruit production of native shrubs such as manzanita, elderberry, chokecherry, wild strawberry, blackberry, wild grape, and gooseberry:

"Fires help the berries too. There are some kinds of plants that grow up in the mountains and they set the fires for them" (Hutchins, Mono, 1992 personal communication).

"After they'd light the fires, the strawberries would come up better" (Beecher, Mono, 1991, personal communication).

Over time any productive berry gathering site will degenerate as the density of branching per individual shrub increases, decreasing light to the fruiting structures. According to Franco, Wukchumni Yokuts (1991, personal communication):

"Some of the other berry plants that benefited from fire were elderberry and chokecherry. If you look at chokecherry bushes, they can become really congested. When fires were set in these areas the plants weren't as congested. You're able to reach in the bush and grab berries. Fires would make more berries and make the shrubs healthier."

Mushrooms harvested in the mixed coniferous forests of the Sierra Nevada and the blue oak (Quercus douglasii) woodlands were relished by many tribes and areas were burned to increase mushroom quality and abundance by the North Fork Mono, the Wobonuch Mono, and the Auberry Mono tribes. Species include: Morchella elata, Peziza spp., Amanita spp. and Ramaria sp. (Goode 1992; Hutchins, Mono, 1992, personal communication; Williams, North Fork Mono, 1991, personal communication; the Bowman brothers, Wobonuch Mono, 1991, personal communication).

Bulbs, corms, and tubers formed an important starch and protein source in the California Indian diet. Often these starchy underground stems were abundant enough to store over the winter. For example, Patrick Breen (Reid 1983:81) part of the Donner Party during the stranded winter wrote in his diary in 1847 on Sunday February 28:

"Solitary Indian passed by yesterday come from the lake had a heavy pack on his back gave me 5 or 6 roots resembling onions in shape taste some like a sweet potato, all full of little tough fibres."

Fires were set at Chukchansi Yokuts, Miwok, and North Fork Mono traditional gathering sites to eliminate competitive shrubs and grasses, recycle plant nutrients, increase the size and quantity of underground swollen stems, and keep areas open to maintain these "crops." Species include Perideridia spp., Sanicula spp., Brodiaea spp. and Allium spp. (Baxley 1865; McSwain North Fork Mono, 1991, personal communication; Cordero, Chukchansi Yokuts/Miwok, 1991, personal communication; Beecher, Mono, 1991, personal communication).

Elders in Sierran tribes still remember the relationship between fire and bulb abundance:

"Down near the San Joaquin River where Grandma and Grandpa live there used to be lots of wild potato with a little yellow flower called 'tena'. Grandma used to tell me they come up good where there's a burn" (Anonymous North Fork Elder, 1991, personal communication).

"Tena has yellowish flowers and smells like celery and is gathered before flowering. It comes up better after a fire. (McSwain, North Fork Mono, 1991, personal communication).

Seeds of a diversity of different plant species formed the most important protein source in the diet of many California Indian tribes. Annual or bi-annual burning of wild seed tracts was common among the Western Mono, Paiute, Mohave, Pomo, and Central Miwok tribes to recycle nutrients, keep patches open within forests and dry montane meadows, eliminate weed competition, increase seed production, and eliminate detritus of perennial grasses. Species include: Astragalus bolanderi, Lathyrus sulphureus, Pickeringia montana, Clarkia spp., Plagiobothrys spp., Salvia columbariae, Wyethia spp., and Calandrinia ciliata (Anonymous elder, North Fork Mono, 1991, personal communication; Franco, Wukchumni Yokuts, 1991, personal communication; Steward 1938:104; Kroeber 1925:736).

Hudson (1901), for example, in interviewing Central Sierra Miwok people at Groveland, noted six kinds of seeds that were cultivated with burning and sowing:

"Burnt rich spot chosen and scratched with brush harrow, hauled by squaws. Seed sown broadcast."

Another extremely important reason to burn areas after seed harvest was probably to reduce the incidence of insect pests and pathogens. Yet this rarely got recorded:

"Some ground, they [Luiseno] stated, was cleared by fire in order to later scatter seeds of desired food plants, grass seed was mentioned by the older coastal informants particularly. Regular burning, some informants commented, destroyed insect pests and parasites, such as dodder, which damaged food crops" (Shipek 1977:118).

After fire exclusion policies, Native Americans could no longer burn for seed production, but the connection between fire and better seed growth was still remembered by certain elders:

"Pink and yellow flowers that have seeds for food come up better after a burn" (Beecher, Mono, 1991, personal communication).

"There is a plant with a little yellow flower, kind of like a tarweed. My mother collected seeds from this plant and they have an almond flavor. This plant comes up better after a fire" (McCombs, Chukchansi Yokuts/Miwok, 1989, personal communication).

2.4 Indigenous Burning, Patch Dynamics, and Maintenance of Biological Diversity

With the landmark 1963 Leopold Report, scientists recognized that habitats are not fixed or stable entities that can be set aside and preserved behind a fence, like a cliff dwelling or a petrified tree. Biotic communities change through natural stages of succession. Earlier successional stages, such as certain hardwood forests and oak savannas, must be actively manipulated to maintain wildlife habitat.

It is now known, for example, that Yosemite Valley in Yosemite National Park is an anthropogenic landscape, composed of black oak-ponderosa pine savanna which was essentially dependent upon ongoing human intervention in the form of burning by the Southern Sierra Miwok people for centuries. Another example is in the Florida Everglades, whereby controlled burning is now used experimentally to maintain the open glades and piney woods with their diverse animal and plant life, a technique first practiced in this location by the Seminole Indians. Management of nature preserves and wildland areas today will have to involve continued human intervention. Land managers need to fully understand vegetation dynamics including the role of indigenous disturbances.

When evaluating the lists of plant species most useful to California Indian tribes, the majority are highly shade intolerant and qualify as early- to mid-successional plant species. Gaps or grassy openings were created, maintained, or enlarged within many different plant communities creating many "patches" of plants in varying successional states. For example, basketry patches of deergrass (Muhlenbergia rigens) were maintained within mixed conifer forests and chaparral areas; edible plant patches of native grasses (e.g., Elymus spp., Festuca californica, Danthonia californica, Bromus spp.) were burned for within coastal scrub and oak woodlands and edible patches of bulbs, corms, and tubers (Perideridia spp., Sanicula spp.) were set afire in the dry montane meadows, open understories of coniferous forests and openings in chaparral (Anderson 1993c). The result was that plant diversity was maximized. That these early stages are the most useful in terms of indigenous needs has been pointed out by previous studies (Lewis 1973; Reynolds 1959).

Vegetation dominated by oak woodlands, mixed evergreen forests, and mixed conifer forests were often managed for maximum vertical structural complexity to encourage a variety of plant species in the understory. The forests were frequently burned to represent plants with a tree and herbaceous physiognomy. Thus, woodlands and forests often exhibited widely spaced trees, giving better light interception and ultimately leading to an increase in species diversity on an area basis.

Some studies have shown that treefalls caused by natural disturbances such as windthrow, which cause gaps in the forest structure, often are not large enough to encourage a wide variety of shade intolerant plants because the surrounding canopy still cuts light availability and the surrounding root systems still influence nutrient availability (Denslow et al 1990:165). Yet studies of the coniferous forests of the Pacific Northwest have shown that plant species richness after fire or clear-cutting reaches its maximum values within a few years and then dwindles as the forest canopy closes, 30 to 40 years later (Spies and Franklin 1989:544).

Ecologists hypothesize that plant communities subjected to intermediate levels of disturbance size, frequency, and intensity exhibit high levels of species diversity and high productivity (Connell 1978). The emerging subfield of "patch dynamics" in the discipline of plant ecology recognizes the key role that disturbances such as windstorms, lightning fires, lava flows, and modern human interventions make in directing the successional patterns and evolution of plant populations (Pickett and White 1985; Mooney and Godron 1983). It is proposed that the Indian role in creating these "patches" in the landscape was considerable and in the absence of former indigenous burning these patches are now undergoing successional changes in an accelerated fashion.

3. A PROPOSED APPROACH TO RECONSTRUCT FORMER INDIGENOUS WILDLAND BURNING PRACTICES IN TEMPERATE REGIONS

Through the assemblage, integration, and interpretation of information from various disciplines, researchers can identify types and areal extent of key biotic and physical resources that were likely to be significantly influenced by former indigenous burning practices at the point of Euro-American contact or early historic times. In some cases, it is possible to reconstruct details of the cultural objectives for burning and important fire variables (e.g., frequency, season, areal extent). This information can then be utilized in developing modeling approaches to investigate the probable environmental impacts from those practices.

A methodological approach is proposed here utilizing ethnographic research, ethnohistoric research, museum study, and ecological field experiments to define the broad outlines of former indigenous burning practices. This approach purposely includes techniques followed by social scientists, historians, and biological scientists in order to view the research question in the widest spatial-temporal frame, recognizing the interrelatedness of cultural and biological factors in studying former Native American burning practices.

3.1 Ethnographic Research

Euro-American contact has led to the loss of native knowledge rather than to its advance (Kidwell 1985). But despite their turbulent history and subsequent acculturation, handfuls of native people in different regions of the United States are an amazing repository of information about present and former traditional plant uses and burning practices and in some cases elders may still be practicing plant management in wilderness areas. Entree into Native American communities may be difficult, due to a hostile, rocky past of Indian-non-Indian relations, but once rapport is established, valuable information about former land management practices can be obtained. Questions should be designed in a nontechnical manner, yet carefully constructed to elicit detailed reponses useful to biological and physical scientists.

Most ethnographic studies of Native Americans tend to focus on plants once they had been removed from their biological context, emphasizing the cultural product rather than the source and dynamics of production. It is essential that ethnographers report the connections made between the qualities of a plant used for a particular purpose and how these features are selected for or "nurtured" in the plants growing in wildland environments. A further step, in those cases where some management information has been recorded, is to continually relate use to management. For instant, how does management ensure continued plant abundance/availability for use? How is the plant harvested and/or managed to encourage the qualities considered desirable for specific uses? (Anderson 1993c).

3.2 Ethnohistoric Research

The history of nonliterate peoples fundamentally involves incorporation of a diverse variety of information sources. One of these sources, ethnohistory, is essential in the attempted reconstruction of precontact and early historic indigenous plant uses and fire management. Ethnographers, explorers, and early settlers wrote detailed accounts of North American Indian life and plant material culture. Much of this ethnobotanical information is housed at museums, libraries, and government facilities in forms not readily accessible to ecologists and land managers (e.g., obscure journals; unpublished manuscripts; and on notecards).

This information should be mined and milled by scholars trained in ecology, botany, and anthropology, for a more thorough understanding of former vegetration burning practices and effects, requiring historical investigations more intensive than yet undertaken. Appropriate information from the numerous unpublished manuscripts, journal articles, diaries, rare books, etc., housed at the above facilities, should be collected into a single compendium organized in a manner easily accessible for analysis by archaeologists, anthropologists, ecologists, and resource managers.

In my work with California Indian tribes, many ethnohistoric reports and early diaries hint of horticultural management when they label branches suitable for basketry, fish weirs, arrows, headdresses, structures, etc. as "withes", "sprouts", "young growth", or "suckers", thus indirectly suggesting new growth was required:

Hudson (n.d.), for example, reported that the Indians at Weldon used cottonwood sprouts for warp and weft in their twined baskets. Other statements are similar:

"The Concow squaws gather the young flexible shoots [Ceanothus integerrimus] for the circular withes of baskets, and also collect considerable quantities of the seed for pinole" (Chesnut 1974:368).

"The basket [Hupa] is stiffened by withes placed around on the outside covered by the material used in twining the basket. A split withe is also placed inside under the rim for the same purpose" (Goddard 1903:26).

3.3 Museum Study of the Cultural Products

Visits should be made to major museums to study the variety of plant material cultural items made by the tribe of interest to the particular researcher. This requires working closely with the staffs of the museums and the Indian elders or non-Indians who understand the intricacies of product manufacture and in some cases still make replicates of many of these traditional items. A subset of cultural items which require large amounts of plant material could then be selected for in-depth study. The number of plant parts and individual plants needed to complete each of the items selected should be tallied and then compared with the availability of that plant part/plant in an unmanaged plant community from which it came.

From discussions with elders, estimates of numbers of plants needed for the making of the individual item from both wild and managed populations should be made and compared. One could then calculate the number of managed plant parts and plants needed to accommodate plant material cultural needs annually for an average-sized prehistoric village. This figure would give ecologists and anthropologists a much better grasp of the quantities of plant material needed from wildlands, the fire management practices necessary to achieve sustained-yields, and the strict cultural parameters necessary for the raw plant material to be suitable for use.

3.4 Experimentation

Indigenous burning practices and resulting impacts on vegetation cannot be reliably assessed solely through the interpretation of ethnohistoric literature and ethnographic research. Vegetation productivity and dynamics resulting from or related to Indian cultural practices must be measured by experiments simulating methods of specific Indian groups. Ecological field experiments, therefore, can provide new data to test hypotheses regarding the possible effects on plant species and plant communities of past and present indigenous fire-based management. Specifically designed experiments also may substantiate historical and ethnographic reports regarding the claimed effects of certain different burning regimes on specific vegetation types.

Studies that record the specifics of indigenous burning practices, augmented by experiments to assess the impact of such practices on the plant species involved will provide resource managers valuable data for making accurate, informed management decisions. In fact, some of these techniques may provide important guidelines to improve management of wild vegetation by public land managers.

The descriptive and interpretive evidence of these systems, provided thus far by ethnobiologists form a logical basis for the development of hypotheses to objectively assess the interrelations and impacts of indigenous cultural practices on plant resource productivity and vegetation dynamics and diversity. To date, examples of quantitative, objective assessments of indigenous impacts on resources is indeed scanty.

Ecological field experiments should be designed to measure the effects of simulated indigenous horticultural practices on specified features or characteristics of individual plants, populations, or plant communities. They require quantitative data which are subjected to appropriate analyses to test stated hypotheses and/or answer relevant questions. Because of the complexity of the ecological processes concerned, this approach would require long-term experiments carefully designed and constrained to discern patterns and levels of effects with reasonable confidence. Perhaps the very effort to conceive and design such experiments would provide greater understanding and insight than presently exhibited (Anderson 1993b).

4. INDIGENOUS WILDLAND BURNING: IMPLICATIONS FOR CONTEMPORARY ENVIRONMENTAL POLICY

It's quite possible that through the qualitative and quantitative research proposed above, more accurate estimates of human subsistence and sustainable resource requirements in precontact North America can be calculated. Such estimates would then make it possible to develop more accurate models of the kinds of fire management systems that would have had to exist in the past to meet those requirements (Blackburn and Anderson 1993).

The recognition that prehistoric peoples in North America may have significantly altered vegetation and climate with burning practices, may in turn, have implications for the dictation of policies which combat serious environmental problems such as global warming and the loss of biodiversity in the world's wildlands. For example, the National Research Council (1990) and the Committee on Science, Engineering, and Public Policy (1992) recommend developing management strategies to sustain productivity of forests as well as to protect their inherent biological diversity as an "adaptation" tactic to global warming. In the book, Planet Under Stress, J. Stan Rowe argues that ecological sustainability should be humanity's goal to combat global warming and that humans must redefine their place within nature (Mungall and McLaren 1990).

There is major concern over the loss of species and habitats in the world's wildlands. Biodiversity is looked at as an "insurance policy" because diversity of ecosystems and species would probably represent a full range of responsiveness to temperature changes from global warming. Thus, "protection of biodiversity" appears on international agendas as an adaptation strategy to global warming--and calls for action include establishing and managing areas encompassing full ranges of habitats (Peters and Lovejoy 1992; Committee on Science, Engineering, and Public Policy 1992).

Biodiversity has been defined as:

"The aggregate of species assemblages (communities), individual species, and genetic variation within species and the processes by which these components interact within and among themselves" (Cooperrider 1991:41).

This meaning includes ecosystem form and function, allowing for and maintaining those evolutionary and ecological processes, which drive that diversity. Indigenous people have been a contributor to the dynamics of ecosystem development. Similarly to fires and floods, the cultivation techniques and harvesting strategies of indigenous peoples are types of disturbances, which contribute to changes in structure and function of the vegetation. Yet, loss of animal and plant diversity in the world's wildlands is equated with habitat loss, fragmentation, and the degradation of biological resources from modern land uses (Miller et al. 1989; Hudson 1991). Seldom are the root causes equated with the absence of former indigenous burning practices.

There is a relationship between indigenous wild plant management and the science of conservation biology that has yet to be full appreciated or explored (Harper 1982; Jordan et al 1987). In some cases, traditional indigenous fire-based management systems can serve as analogs in experimenting with different approaches to conservation and management of biodiversity in wilderness areas (Posey et al. 1984). The topic of anthropogenic burning for vegetation management in temperate regions, may present an interesting dilemma, because it may simultaneously contribute to enhancing biological diversity at the plant population and habitat levels of biological organization <u>and</u> contribute to environmental degradation through increased greenhouse gas emissions.

In conclusion, humans have been intervening natural processes and they have left their indelible imprint on so-called "natural" temperate ecosystems for millennia. There is a growing awareness that different indigenous land management systems caused profound, widespread, and long-term ecological consequences. Thus, studies of traditional peoples are taking on new ecological significance, of interest to scientists in diverse disciplines.

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