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Title: MAN AND THE LAND: AN ECOLOGICAL HISTORY OF FIRE AND GRAZING ON EASTERN OREGON RANGELANDS

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Ecological and historical information are combined in examining the environmental influence of fire and grazing on rangelands in eastern Oregon through time. Competitive relationships between herbaceous and woody flora in the northern Great Basin are discussed, focusing broadly on the shrub-steppe regions of Franklin and Dyrness (1973) but with special reference to the Artemisia/Agropyron association. Impacts of native and domestic grazing animals and of cultural burning are traced from the distant past into recent history.

During the Pleistocene Epoch North America supported a wide diversity of large mammals. Toward the end of the Pleistocene, many of these fauna became extinct, perhaps as a result of post-glacial climatic change, perhaps also under the influence of incoming primitive hunting cultures and their broadcast burning practices. Some question exists about the intensity of native grazing in the northern Great Basin during the last few thousand years. Actual levels of bison populations and the duration of their residence in the study area have not been determined. The

character of indigenous vegetations, however, indicates that native grazing was relatively light for an extended period primevally.

Twenty-four references to native cultural burning at the time of European contact were found in historical journals. Though the antiquity of these customs is uncertain, an analysis of Native American fire myths demonstrates the depth of native cultural perceptions of the relationship between man and fire, and supports the likelihood that fire was used primevally in the northern Great Basin as it was used by aboriginal peoples elsewhere in North America.

With the influx of European culture during the 19th century, misapprehensions about fire among whites distorted the influence of native cultural burning. Exotic flora and fauna were introduced, and ecosystems began to change. Large herds of livestock depleted native herbaceous populations. Early irresponsible burning by whites became associated with declining rangeland resources, and efforts toward total fire suppression became incorporated in developing conservation policies. Native woody flora and exotics began to invade open rangeland communities. Climatic flux during the period of European settlement in the northern Great Basin may have exacerbated the impacts of intensified grazing and elimination of burning.

Early photographs of rangelands in east-central Oregon were gathered; their dates range from 1880 to the early 1930's. Sites represented in these pictures were re-photographed in 1976. Photo-set comparisons show expansion of western juniper (Juniperus occidentalis) populations into rangeland ecosystems, demonstrating the consequences of cultural disturbances during the last 150 to 200 years.

# Man and the Land: An Ecological History of Fire and Grazing on Eastern Oregon Rangelands

by

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF ILLUSTRATIONS

# MAN AND THE LAND: AN ECOLOGICAL HISTORY OF FIRE AND GRAZING ON EASTERN OREGON RANGELANDS

## INTRODUCTION

This study was supported by the National Park Service and was conducted with reference to land management interests in the Pacific Northwest. During the recent past, natural ecosystems in this region have shifted away from their primeval condition. Environmental change can be correlated with disruptions of traditional relationships between native cultural standards and natural phenomena, resulting principally from the influx of European civilization during the past 150 years.

An important focal point for National Park Service research is the restoration of park lands, as nearly as possible, to their original pre-settlement condition--as stated in "Wildlife Management in the National Parks" (National Park Service, 1970) to "represent a vignette of primitive America." This requires the reestablishment and maintenance of environmental processes and ecosystem relationships which existed primevally. This, in turn, requires not only an understanding of the environmental complex as it acts today, but also a knowledge of the various interacting natural and cultural factors, and changes in these factors, which have moved the land and its biotic associations from their pristine to their present condition. An historical view of ecology, or an ecological treatment of history, can explore patterns of flux in natural and cultural components of ecosystems, and can provide valuable time depth in the environmental sciences.

Fire and grazing, as natural and artificial components of ecosystems, are of particular interest in the restorative management of National Park lands in the West. The present study examines the environmental force of these two factors through time--their changes, their relationships and their impacts on land. During primeval and frontier periods, these phenomena acted on land largely free of artificial

demarcations, certainly free of those now in force. Since that time, changing cultural influences on fire and grazing have caused complex shifts in ecosystems over broad areas. Therefore, the reestablishment of an image of pristine America on Park Service lands cannot ignore the ecological history of the larger regional landscape in which they lie.

## STUDY AREA

Though the orientation of the present study derives from land management interests at Lava Beds National Monument in northern California and John Day Fossil Beds National Monument in east-central Oregon, its scope compasses most of Oregon east of the Cascade Mountains and areas of Washington, Idaho, Nevada, and California adjacent to that portion of Oregon. The time span considered extends from the distant past to about the middle of this century, with then a brief look at the consequences of past events on present circumstances.

Much of Lava Beds National Monument and much of John Day Fossil Beds National Monument are vegetated by the Artemisia/Agropyron association, though its original character has been altered at both sites by cultural events during the recent past. Therefore, attention in this study centers on this plant community. However, to develop a complete account of relevant phenomena, the discussion will focus broadly on shrub-steppe habitats. Some reference to forests and woodlands occurring within the study area will also be included.

### Description of Study Area

The physiography of the northern Great Basin is characterized by steep rocky slopes, and dry breezy plains. Precipitation ranges from 127 mm. to 508 mm. annually (127 mm. to 254 mm. annually over much of the study area) occurring principally during winter and early spring. Such low levels of precipitation are critical due to their high spatial and temporal variability and to high evaporation during summer and fall

(Stoddart and Smith, 1943; Sweeney, 1968; Griffiths, 1902, 1903).

In Oregon east of the Cascade Range, shrub-steppe regions occur largely in the south and east with some extension into the north. In the north, however, native bunchgrasses originally dominated large areas, probably forming almost pure stands (Franklin and Dyrness, 1973; Stoddart and Smith, 1943). The vegetation of these regions is not homogeneous. Much diversity among individual sites results from wide variability in topography, soils, local climate and drainage characteristics. Generally, deep-rooted semi-desert shrubs constitute the dominant overstory vegetation, big sagebrush (Artemisia tridentata) being the most prominent with shadscale (Atriplex confertifolia) and and tall green rabbitbrush (Chrysothamnus vicidiflorus) of respectively lesser importance (Stoddart and Smith, 1943; Tisdale, Hironaka, and Fosberg, 1969). Three perennial grass associates generally dominate the understory: the needlegrasses (Stipa sp.), which occur on dry sites; bluebunch wheatgrass (Agropyron spicatum) which occupies intermediate sites and is usually the most extensive, and Idaho fescue (Festuca idahoensis) on moister sites. Perennial forbs occur with varying local densities. Cheatgrass (Bromus tectorum), an exotic annual, has invaded throughout the area and may dominate locally (Franklin and Dyrness, 1973; Stoddart and Smith, 1943; Tisdale, Hironaka, and Fosberg, 1969; Wright and Britton, 1976).

The geographic area occupied by the Artemisia/Agropyron association, or by successional stands derived from it, has remained virtually constant overall since the beginning of European settlement, though in many areas shrub populations have expanded at the expense of herbaceous flora (Tisdale, Hironaka, and Fosberg, 1969). Western juniper woodlands occur at intermediate elevations between grass/shrub plains below and coniferous forests above. The juniper vegetation type is very close ecologically to the Artemisia/Agropyron type and intermixes with it in some places. In recent years western juniper populations have encroached considerably into adjacent grass/shrub lands (Franklin and Dyrness, 1973; Stoddart and Smith, 1943).

Coniferous forest areas, which are centered in the Blue Mountains to the north and east and in the Cascade Range to the west, are of interest in this study insofar as they constituted the principal summer foraging grounds for domestic stock at the height of the open range era in Oregon (Stoddart and Smith, 1943).

## Ecology of the Artemisia/Agropyron Association

In sagebrush/bunchgrass vegetation, a strong competitive relationship exists between the shrub overstory and the herbaceous understory. Healthy grasses may eliminate sagebrush seedlings through competition, but if severe drought, grazing or other perturbations reduce the vigor of grasses, many shrub seedlings may become established. If so, shrub species may grow vigorously during subsequent years and achieve significant advancement over herbaceous species as a result of reduced competition with grasses for moisture. On the other hand, reduction or removal of the shrub overstory enhances the opportunity for the herbaceous understory to increase if an adequate seed source is available. Stated generally, in a healthy co-dominant stand of the Artemisia/Agropyron association, if the growth or reproductive capacity of the herbaceous species is inhibited, shrubs prosper, but if the shrub population is damaged or destroyed, herbaceous species can expand their influence.

Strong competition also exists between native perennial species and alien annuals. Cheatgrass, which grows rapidly and matures early in spring, may pre-empt bluebunch wheatgrass seedlings and eliminate them. If an established bunchgrass population is injured during its period of active growth, its competitive capacity is diminished, allowing cheatgrass populations to expand rapidly (Daubenmire, 1940, 1974).

## FIRE

The arid grass/shrub plains of the northern Great Basin reflect features characteristic of landscapes having close association with fire. Both their dry climate and their even surface configuration favor wide-

spread burning. Periodic drought and strong steady winds cause plains vegetation to become seasonally very dry and readily flammable. Thus, a single fire may range extensively over an area having a relatively uniform fuel supply. Many plant species native to dry plains environments have adapted to recurrent burning by developing resistant or resiliant characteristics. Because such plains lands are distinguished by features favoring periodic and widespread fires, and because their native vegetations are distinguished by features closely correlated with recurrent disturbance, as by burning, these areas may be characterized as fire environments (Agee, 1974; Humphrey, 1974; Sweeney, 1968).*

Fire is especially harmful to shrubs during drought years, and may destroy individuals of both sprouting and non-sprouting species (Wright, 1972; Wright and Britton, 1976). If the subsurface structures of sprouting shrubs are not seriously damaged, they may recover within ten years, but non-sprouters must depend on seed reproduction and generally do not recover as rapidly (Stoddart and Smith, 1943; Wright, 1972). In either case periodic burning usually destroys many years of shrub growth, and afterward, several years are required for the population to regain maturity (Humphrey, 1974). Frequent fires, even of low intensity, may keep shrub populations in the juvenile, non-fruiting state, because seedlings are killed more readily than larger plants thus precluding maturation and seed production (Humphrey, 1963, 1974). On the other hand, a moderate fire destroys only a single year's growth of perennial grasses, the roots and growth-active structures usually avoiding serious injury (Humphrey, 1958, 1974). Recently burned grasses, however, are highly vulnerable to damage by close grazing (Komarek, 1965). In the northern Great Basin, fires in late summer and autumn, as they occur most often naturally, favor cool season perennial grasses which are then dormant. Early spring fires are more likely to kill shrubs and to subdue

*The average frequency of natural fires on the grass/shrub plains of Lava Beds National Monument during recent history has been one fire each .86 years (Johnson and Smathers, 1974). But perhaps this fire frequency should not be applied in an assessment of the primeval environment since cultural standards during historical times have altered the constitution of grass/shrub fuels.

native perennial bunchgrasses during their primary period of growth, thus opening space for annuals, such as cheatgrass, to invade (Wright, 1972; Wright and Britton, 1976).

In burning experiments, Moomaw (1957) found shrub species to be decreasers and perennial grasses, and cheatgrass, to be little affected. He also found that the vigor of bluebunch wheatgrass declined under grazing in all habitats examined but that it improved under burning in the Artemisia/Agropyron association.

Studying revegetation following fire in Idaho, Blaisdell (1953) learned that during the first season after burning the vigor of perennial grasses and forbs was diminished, that only a few sprouting shrubs began to regenerate, and that annuals responded aggressively. During the second season after fire, the vigor of perennial grasses and forbs was high and flowering was profuse, while sprouting shrubs remained relatively inconspicuous. Total herbage production peaked during the third season after burning, but generally declined thereafter in association with an increase in shrub growth. Bluebunch wheatgrass was the least damaged of the grasses and the earliest to recover. Overall, the shrubs suffered greater damage than the grasses and forbs.

Daubenmire (1974) found that fire did not reduce the basal area of bluebunch wheatgrass and that pre-burn cover and frequency were restored by the 12th year. Harniss and Murray (1973) found that yields of grasses and forbs were higher on burned than on unburned sites in the 12th year following fire, but lower in the 30th year, whereas shrub yields were lower on burned than on unburned sites in the 12th year and about the same in the 30th years. However, as sagebrush gained a dominant position the 12th year following fire, almost all important grasses, forbs and other shrubs declined.

## GRAZING

The impact of grazing on plant distributions on grass/shrub plains depends in part on the frequency, intensity, and selectivity of cropping

and on the season of occurrence (Willard and McKell, 1973). Grazing becomes damaging to herbaceous populations (and thereby favorable to shrub populations through reduction of herbaceous competition) when cropping occurs during the critical period of spring growth or when too much photosynthetic tissue is removed (Stoddart and Smith, 1943). Both result in a loss of vigor and density among herbaceous species, which then permits shrub species to advance (Cooper, 1953). Bluebunch wheatgrass and Idaho fescue are decreasers and cheatgrass and big sagebrush are increasers under heavy grazing (Moomaw, 1957).

Cottam and Stewart (1940) have correlated invasions of meadow lands by big sagebrush and western juniper with soil drought and overgrazing. In one area removal of sagebrush by fire and subsequent protection from intensive grazing resulted in a rapid expansion of grasses. On another area, not burned but subject to controlled moderate grazing, grasses increased in a dense stand of sagebrush, though to a lesser degree than on the burned site. Grasses constituted only a trace of the total vegetation in unfenced areas, about 0.5% on land partially protected from grazing and about 2% on the adjacent burned area. The increase in grasses in the protected area corresponded almost exactly with decreases of sagebrush and on the burned area resulted from the reduction of sagebrush competition.

Daubenmire (1974) found that lightly grazed grasses declined after full protection from grazing, and Humphrey (1953) found that the number and rate of encroachment by woody species was greater on protected than on grazed sites. Thus, suitable grazing may stimulate herbaceous production; neither the absence of grazing nor optimum grazing behaviors alone are sufficient to prevent encroachment by shrubs (Cotton, 1904; Harniss and Murray, 1973; Humphrey, 1958).

## FIRE AND GRAZING INTERACTIONS

As we can see, fire and grazing are linked in the competition between woody and herbaceous species. In general these agents act

reciprocally in the flux of sagebrush and bunchgrass populations in the Artemisia/Agropyron association--fire tends to favor the perennial grasses over the shrubs and excessive grazing tends to deplete herbaceous populations allowing woody species to increase (Harniss and Murray, 1973; Tisdale, Hironaka, and Fosberg, 1969).

But the interactions between fire and grazing are much more complex than this: If a healthy stand of perennial grasses is burned, resiliant species profit, though perhaps only temporarily, from increased nitrification effects and from release of mineral nutrients to the soil (Humphrey, 1958; Stoddart and Smith, 1943). Therefore, the fresh shoots which emerge afterward generally have higher protein and mineral contents than grasses of unburned areas, thus stimulating vigorous herbaceous regeneration (Christensen and Muller, 1975; Komarek, 1965, 1967). But because this new growth is more palatable and more nutritious, burned sites tend to be particularly attractive to herbivores, and grazing activity may then become concentrated on burned areas. Grass populations may suffer severe depletion if new shoots are too promptly and too closely cropped (Komarek, 1965). This may offset the negative impact of fire on shrubs and allow them to recover more rapidly and to expand beyond their previous population levels. Drought may complicate these effects by aggravating the stress on herbaceous species and inhibiting their productivity, thus further reducing competition from grasses. The impact of burning on shrubs may also diminish if grass populations become too sparse to carry fire (Wright, 1972). If shrubs and grasses are both seriously damaged by fire and grazing, exotic, aggressive annuals may invade and dominate large areas (Tisdale, Hironaka, and Fosberg, 1969; Wright and Britton, 1976). On the other hand, moderate and timely grazing of healthy vegetation can stimulate herbaceous production and permit grasses to subordinate shrubs (Cooper, 1953; Cottam and Steward, 1940; Ellison, 1960).

During the distant past, natural grazing behaviors of native animals contributed to the variability of fires, probably leading to a patchy mosaic pattern of burned areas (Ellison, 1960; Komarek, 1965). Though

an assessment of the grazing activities of the fauna present in the study area prior to the influx of European influences can only be made indirectly, it appears that no vast herds of grazing ungulates, comparable to the bison populations of the Great Plains, have existed here for several thousand years. The nature of the native flora, which are not well adapted to cropping and trampling, supports this belief (Daubenmire, 1970; Heady, 1968). Considering our knowledge of fire and grazing, as outlined here, their relationships may have been particularly influential primevally in affecting the relative distributions of herbaceous and woody species in the shrub-steppe regions of the northern Great Basin.

## CLIMATIC HISTORY OF THE GREAT BASIN

During the Pleistocene Epoch, or for about the last one million years, the earth has been subject to profound climatic fluctuations associated with the oscillations of vast continental glaciers (Dunbar, 1965; Flint, 1967; Sauer, 1950). During this period the Great Basin was influenced by cooler, moister weather conditions than presently exist there (Strong, E., 1969). Two pluvial periods, during which environmental moisture became still greater, occurred during the Wisconsin Age, the last major ice advance during the Pleistocene. The Bonneville Pluvial occurred about 35,000 years ago; the Provo Pluvial occurred about 10,000 years ago (Wormington, 1964). Climatic conditions during these periods were marked by relatively significant increases in precipitation over former and subsequent periods, and water accumulated as pluvial lakes in basins throughout the region (Strong, E., 1969; Wormington, 1964).

Following the Provo Pluvial, the climate gradually warmed. About 5,000 years ago, a long period of progressively diminishing precipitation and increasing evaporation began. Lakes began to shrink, becoming marshes which eventually dried leaving parched desert flats (Strong, E., 1969; Wormington, 1964). Some minor climatic fluctuations have occurred, but general conditions during this recent period have not differed

greatly from those at present (Strong, E., 1969), though some debate persists over the variability of climate in the Great Basin during the last 10-20,000 years (Jennings, 1968; Strong, E., 1969).

## HISTORY OF LARGE MAMMALS IN NORTH AMERICA

By the beginning of the Pleistocene, North America was populated by a diverse fauna--the ground sloth, giant bison, mastodon, horse, tapir, camel, wolf and deer. During the Kansan Age, the second major glacial advance in the Pleistocene Epoch, interior North America was colonized by the elephant, and the bovid and cervid families, represented by the mammoth, great bison, elk, musk ox, and sheep (Sauer, 1944, 1950; Stoddart and Smith, 1943). By the middle of the Pleistocene, a great counter-migration of fauna between Asia and North America had established the most diverse assemblage of large mammals ever to occupy this continent (Sauer, 1944; Strong, E., 1969). And though only minor evolutionary changes altered these fauna prior to the time of man's arrival in North America, afterwards many forms suffered relatively rapid extinction. Man then may have been a significant agent of change in the New World (Sauer, 1944, 1950).

## FIRE AND MAN

Language, tools and possession of fire distinguished man from other primates perhaps as early as the beginning of the Pleistocene Epoch. To this day these attributes form the foundation of humanity and culture. The earliest empirical evidence of man's familiarity with fire derives from an ancient cave dwelling in southern France and dates to about 750,000 years B.P. (Poirier, 1974). But there is little question that man nurtured, transported and used fire at large long before he brought it inside the came (Sauer, 1956; Stewart, 1956).

Uninterrupted possession of fire was essential to man's existence away from the tropics. As groups moved toward more inclement regions, preservation and transportation of fire was a persistent concern, for

throughout most of man's duration he has lived without the capacity of creating it himself; independent production of fire is believed to have been a relatively recent achievement (Chard, 1975; Komarek, 1967; Stewart, 1956).

## Antiquity of Cultural Burning

Because early man was thoroughly savanna-adapted, the opening of sun-lit areas, as by fire, not only expanded man's physical habitat but also favored the proliferation of his food resources, and early inadvertent burning led to relatively sophisticated fire economies. And since man remained in the Paleolithic state for all but about 1-2% of human time (Sauer, 1956), artificial burning has probably participated in nature for a period considerably longer than that indicated by empirical evidence left to us in caves (Stewart, 1956).

Stewart (1956, 1963) believes that the impact of artificial burning surpassed that of naturally-occurring fires long ago. Archeological and ethnographic data from every continent indicate that man has intentionally and consistently burned vegetation during at least the past 500,000 years for the following reasons: 1) to facilitate hunting by improving visibility and depriving prey of cover, by gathering and driving game, and by killing insects, rodents, reptiles, and other small animals for food; 2) to manage the movements of game animals by manipulating their forage resources; 3) to improve natural pasturage for wild game or for domestic stock (The common objective here has long been to remove rank, dry vegetation to promote fresh palatable forage productions); 4) to enhance the production of favored plant and animal resources; 5) to facilitate food gathering; 6) to clear land to expedite travel or to prepare and fertilize soil for cultivation (Burning to eliminate forests and woody vegetation in favor of herbaceous and agricultural vegetation has been a consistent and widespread practice); 7) to drive away predators and pests; 8) to evict an enemy from refuge or to repel attack in warfare; 9) to signal of the approach of strangers or enemies; 10) to

protect the dwelling place from wildfire; and 11) simply as an entertaining spectacle. (Bartlett, 1956; Graham, 1956; Komarek, 1962; Sauer, 1944, 1950, 1956; Stewart, 1956, 1963).

In this light, man's aboriginal influence on the composition and distribution of biotic communities would have been significant. Deep and lasting modifications in natural ecosystems would have developed as cultural phenomena (Bartlett, 1956; Sauer, 1950; Stewart, 1963).

Dobzhansky (1962) has proposed that for perhaps the last million years "man has been adapting his environments to his genes more often than his genes to his environments." Indeed, the evolution of many plant and animal species became closely related to the development of man; the major domestic crops and livestocks of today are descended from the biota of ancient savanna-grassland ecosystems (Komarek, 1965, 1967; Sauer, 1947). This began with the activities of early hunting/gathering peoples long before the development of agriculture, herding and the broadcast burning associated with these economies. But with the domestication of plants and animals about 10,000 years ago all of the motives for man's broadcast burning outlined above were operative (Stewart, 1956).

## Cultural Burning in the New World

It is likely that the consequences of climatic stress during the late-Pleistocene, and of the environmental warming and drying which followed in the Great Basin, were accentuated by the influx of human culture. Those who first arrived in North America practiced the hunting/gathering way of life, pursuing the herds of large mammals which populated the continent. Archeological remains of these hunters demonstrate their close association with this ancient fauna. However, many species perished soon after man's arrival. Some probably perished as a result of the climatic flux which brought decreasing precipitation over the interior and intermountain plains, and increasing contrasts between winter and summer extremes (Sauer, 1944). This change was not catastrophic but slow, allowing ample opportunity for faunal migrations; indeed

most forms would have experienced an expansion of their range. So a large measure of responsibility for the extinction of many species may be attributable to the advent of man and his hunting culture, for many of the large, slow and awkward species were notable victims (Hansen, 1947; Sauer, 1944, 1950).

To be effective in killing large numbers of large herd animals, early hunters equipped only with primitive implements would require organization and some strategic advantage over their prey. Archeological findings suggest that an essential component of early hunting techniques in North America was the strategem of fire (Sauer, 1944; Stewart, 1956). The fire drive is known to be effective against large prey and to have been a traditional tactic among hunting cultures not having the advantage of powerful weapons or horsemanship. At the time of European contact, this technique was used by Native American hunters, and it is reasonable to assume that the tradition derived from the earliest hunting cultures to reach the New World (Sauer, 1944; Wedel, 1961).

Furthermore, Native American peoples in the West not only carried fire either as a fire brand, a live ember or "slow match" but also ignited bushes and trees to preserve fire in long-burning roots to avoid the necessity of using the fire drill (Barrett, 1907; Forbes, 1839; Hough, 1926; Stewart, 1956; Strong, E., 1969). Many references attribute untended domestic fires and purposeful broadcast burning to Native Americans (Boardman, 1967; Moore, 1972; Sauer, 1956; Stewart, 1956, 1963). In the Great Plains and in the Southwest, reports dating from 1528 to 1926 attribute grassland fires to native peoples (Hough, 1926; Humphrey, 1953, 1958, 1963; Stewart, 1951, 1963). The reasons for this burning included all those mentioned earlier (Graham, 1956; Hough, 1926; Moore, 1972; Stewart, 1951, 1956).

Moore(1972) has produced an exhaustive account of historically documented uses of fire by Great Plains tribes. Separating the Great Plains into four regions, he found that without regional distinction, hunting, pasture improvement and accident were the most significant causes of

wide-ranging grass fires, though burning in warfare, signalling and horse stealing were also important. The fire drive was used notably by the Santee, Miami and by other tribes of the Upper Mississippi Valley. Moore found only one reference attributing grass fire to lightning.

Moore (1972) also investigated evidence for the season of grass burning. He found that though there was considerable variation between the four regions, fires were most often reported in the fall. Summer fires were second in frequency of reference, being most important in the northwestern and central regions. Winter fires were very infrequent or absent in all but the southern region, where almost half of those reported were winter fires.

## ARRIVAL OF MAN IN THE GREAT BASIN

Cultural remains dated at several archeological sites in the northern Great Basin indicate that man probably arrived there over 10,000 years ago. An area 60 miles north of Lower Klamath Lake was occupied continuously by aboriginal peoples from early post-Pleistocene to historic times, the minimum date of arrival being about 7,000 B. P. At Catlow Cave #1 in Harney County, Oregon, habitation began prior to about 7,600 B. P., its early occupation perhaps being contemporaneous with animals now extinct. At the Lind Coulee Site, in the central plains of the Columbia Basin in Washington, burned bison bones indicate the residence of early hunters there approximately 8,700 years ago. Sandals found at Fort Rock Cave in the Fort Rock Valley, Oregon, date to about 9,100 B. P. East of the Dalles, Oregon, continuous occupation of the Five Mile Rapids Site probably began more than 10,000 years ago (Hansen, 1947; Wormington, 1964).

### Cultural Burning in the Northern Great Basin

The Desert Archaic Culture, which followed the primitive hunting/gathering way of life, dominated the Intermountain West from man's

earliest occupancy there until the last century (Driver, 1969; Jennings, 1968; Strong, E., 1969). This culture and the artifacts it produced were intimately associated with general environmental aridity, and judging from remains left to us, the Desert Archaic way of life persisted virtually unchanged throughout its duration, indicating that the climate and the resources of its territory have been relatively stable since initial human occupation. Although archeological sites in the northern Great Basin overlook ancient lake beds, at the time of man's arrival there, pluvial lakes had probably already receded considerably due to post-Pleistocene warming and drying (Hansen, 1947). The lacustrine/riverine habit of many native peoples of the area and their relative nonspecialization on big game (as compared to native Great Plains hunters) argues against extensive use of fire in their economies. But because their food resources included the jackrabbit, mountain sheep, desert fox, antelope, deer, and bison (Barrett, 1907; Jennings, 1968), the possibility that fire was used in association with these game should not be ignored.

Rymon (1969) states that fire was used as a means of habitat control by the native peoples of Oregon, though reference is made only to the Willamette Valley and coastal areas. He attributes this burning to many of the same reasons outlined earlier.

During the present study an examination of the journals of early travelers in the Great Basin revealed 30 references to fire and burned vegetation within the study area (Bolton, 1950; Farnham, 1905; Hall, 1967; Irving, 1955; Lewis and Clark, 1959; Minto, 1900; Ogden, 1961, 1971; Palmer, 1906; Townsend, 1905; Turner, 1873; Whitehouse, 1959; See Figure 1). Twenty-four of these references attribute the cause of burning specifically to native peoples.

On September 22, 1776, Escalante and his party, traveling westward just east of Utah Lake

> saw in front of (them) and not very far away many large columns of smoke arising in the same sierra. The guide Silvestre said they must have been made by his people who were out hunting. We replied to them with other smoke signals so that if they had

> already seen us they would not take us to be enemies and thus flee or welcome us with arrows. They replied with larger smoke signals in the pass through which we must travel to the Lake, and this caused us to believe they had already seen us, because this is the most prompt and common signal used in any extraordinary occurrence by all the people of this part of America.

The following day they "saw that all around (them the native people) were sending up smoke signals one after another, thus spreading the news of our coming." Upon entering the Utah Valley where Spanish Fork is now located, the Spaniards

> found that the pasture of the meadows through which (they) were traveling had been recently burnt, and that others nearby were still burning. From this we inferred that these Indians had thought us Cumanches or some other hostile people, and since they had perhaps seen that we had horses, they had attempted to burn the pastures along our way, so that the lack of grass might force us to leave the plain more quickly. But since the plain is so large and extensive they could not do this in such a short time even though they had started fires in many places (Bolton, 1950).

It is not clear whether the fires which the Spaniards first observed were set before or after the native people learned of approaching strangers, so the exact purpose for initiating the burning remains unknown to us. Four interpretations are possible from Escalante's account: 1) If the native people were not alarmed at first, burning could have begun as customary autumn burning for pasture improvement or for some other purpose; 2) as Silvestre, the guide, suggested, the smoke first seen by the Spaniards could have issued from fires being used in hunting game, or in gathering other foods; 3) Escalante's reference to smoke signals being "the most prompt and common signal used . . . by all the people in this part of America" leaves little doubt that this practice was current among native peoples of the area; or 4) the burning of pastureland in advance of his party may have been, as Escalante suspected, a strategy of defense from suspected aggression.

By the time Lewis and Clark reached the vicinity of present Armstead, Wyoming, they had learned to anticipate broadcast burning by Native Americans, for in caching canoes there on August 23, 1805, Lewis

sank them in a pond and

> weighted them down with stone, after taking out the plugs of the gage holes in their bottoms; hoping by this means to guard against both the effects of high water, and the fire which is frequently kindled in these plains by the natives.

Two days later Lewis noted that "the northeast side of the Creek (along which they were traveling had) lately been burned by the Indians as a signal on some occasion," and then on August 31, 1805, a "warm and sultry" day, the "Prairies or open valleys (near North Fork, Montana were) on fire in Several places." It was then noted that "The Countrey is Set on fire for the purpose of Collecting the different bands, and a Band of the Flatheads to go to the Missouri where they intend passing the winter near the Buffalow" (Lewis and Clark, 1959; Whitehouse, 1959).

Apparently fire was a prominent agent in the area which is now northeastern Oregon and southeastern Washington, primevally and during European settlement there. Hall (1967) states that according to Hodgson (1913) the Blue Mountains received that name because fires frequently shrouded the area with thick smoke prior to the turn of the century; native tribes used the forests then during summer and occasionally set fires purposefully or allowed campfires to escape and burn over large areas. Burnt River, which flows east from the Blue Mountains to the Snake River, was probably given its name by Ogden in 1825. Traveling in that area again two years later, on September 21, Ogden noted that burned-over land was interfering with his progress (Ogden, 1961). And in August, 1834, Bonneville's party was troubled by smoke and fire along their entire journey from the mouth of Burnt River across the Blue Mountains to the Walla Walla River. Upon reaching the headwaters of the Powder River and crossing the Grande Ronde River, they saw that all the plains and meadows of the Grande Ronde Valley were burning. Washington Irving, a chronicler of Bonneville's adventures in the West, in relating this event, states that this "was the season of setting fires to the prairies," implying that the conflagration Bonneville witnessed resulted from the customary burning practiced by native inhabitants (Irving, 1955).

On August 16, 1834, at a place one day's journey east of Camas Prairie in Elmore County, Idaho, Townsend noted that "scarcely a blade of grass could be found (because the prairie grasses had) lately been fired by the Indians to improve the crops of next year." While traversing the Blue Mountains in the vicinity of the Grande Ronde Valley fifteen days later, less than a month after Bonneville's experience there, Townsend wrote: "the grass has been lately consumed, and many of the trees blazed by the ravaging fires of the Indians." Then two years later, on the evening of September 3, 1836, while actually watching a large fire in progress, Townsend noted that

> the Indians have fired the prairie, and the whole country for miles around is most brilliantly illuminated. Here am I sitting crosslegged on the ground, scribbling by the light of the vast conflagration with as much ease as if I had a ton of oil burning by my side, but my eyes are every moment involuntarily wandering from the page before me, to contemplate and admire the grandeur of the distant scene. The very heavens themselves appear ignited, and the fragments of ashes and burning grass-blades ascending and careering about through the glowing firmament, look like brilliant birds let loose to roam and revel amid this splendid scene. It is past midnight; every one in the camp is asleep, and I am this moment visited by half a dozen Indian fishermen, who are peering over my shoulders, and soliciting a smoke, so that I shall have to stop, and fill my calamet.

Apparently Townsend's awe at the spectacle was not shared by the local people, nor by anyone else in his camp (Townsend, 1905).

In 1900 John Minto set forth one explanation for broadcast burning by the native peoples of this region:

> The tribes on the south bank of the Snake River, and southward, used to fire the high, arid plains, where possible, and collect the crickets and grasshoppers thus killed. As late as 1844 these insects were dried and made into a kind of pemmican by pestle and mortar (Minto, 1900).

On September 18, 1839, Farnham recorded evidence of another fire along Burnt River: "Immediately around our track, the hills were clothed with dry bunchgrass. Some of them had been burnt by the Indians." Three days later he had reached the Blue Mountains and saw that "The vales . . . had been set on fire by the Indians" (Farnham, 1905).

The principal overland route into the Pacific Northwest during the early period of European entry traversed this region of the study area. This may account for the number of references to native cultural burning there, and indicates that traditional broadcast burning in areas not regularly visited by European travelers may have been more prevalent than relatively infrequent historical references would demonstrate.

Fire was also used by native tribes in present east-central Oregon. Ogden traversed this region repeatedly as agent for the Hudson's Bay Company, charged with the leadership of beaver trapping expeditions in the old Oregon Country. Several times during his travels, Ogden was troubled by fire and burned vegetation and attributed the source of these difficulties to the local inhabitants. On September 24, 1826, moving southward east of the Deschutes River about 29 miles south of Sherar's Falls, Ogden's party, "owing to the dense smoke was at a loss to proceed." Ogden noted: "The country has been but lately overrun by fire and I suppose there are Indians not far distant from us." Two days later, then about 62 miles south of Sherar's Falls, Ogden wrote: "All the Hunters off in quest of Deer we advanced but a short distance for the facility of our Hunters but I am not of opinion their success will be great as all the country appears lately to be overrun by fire." That evening his hunters returned with five antelope, reporting that the "tracks of Indians (were) numerous." Then on October 4, 1926, while in the upper Crooked River area, near present Paulina, Oregon, Ogden reported that his group

> had certainly a most providential escape last night. The Indians crossed the river (probably at Beaver Creek near the mouth of Wolf Creek) in the night and set fire to the plain within ten yards of our camp. Fortunately the watch perceived it and gave the alarm from the grass being dry and long had there not been a point of willows to arrest its progress every thing was lost our exertions would have been of no avail . . . it blowing a gale at the time. On rising this morning not an Indian to be seen they raised Camp during night. If ever Indians deserved to be punished they certainly do they were well treated and fed by us and in return they attempted to destroy us. This is Indian gratitude, and this is not the

> first instance I have experienced of their villainry for kindness shown them.

Eight months later on June 22, 1827, after ten days of illness and immobility in the hills northwest of Malheur Lake, Ogden vented much frustration through his aversion for the native people:

> Many small Streams have been discovered in the Mountains and were not long since well supplyed with Beaver but unfortunately the Natives have destroyed them all and probably by the aid of fire which is certainly a most distructive mode of exterpating them for scarcely ever one escapes particularly when the Streams are not wide, and from what I have seen in this my last years travels I will venture to assert without exageration the Natives have destroyed and principally by fire upwards of sixty thousand Beavers and of this number not a Hundred have reached any Establishment but all have been lost, nor in my opinion will any of these different streams be ever again supplied and for various reasons the Natives are too numerous their Country too poor to allow Beaver to increase of this I have had too many convincing proofs to be of a contrary opinion (Ogden, 1961).

Ogden made three other references to fires. On July 15, 1827, while at the Malheur River south of present Drewsey, Oregon, he wrote: "The Country on all sides is on fire, these are signals for the Indians to assemble as they shortly will steer their course to Buffaloe." It is unclear whether they had actually seen buffalo locally on this occasion, or whether they were gathering for customary migration to hunting grounds across the Rocky Mountains. Two years later during another beaver trapping expedition, while moving toward present Oregon north of present Winnemucca, Nevada, on June 7, 1829, Ogden reported that: Fires were seen in almost every direction in the mountains this is a convincing proof the natives are aware of our being here . . ." And on the 20th of that month, then on the northern shore of Malheur Lake at the mouth of the Silvies River he wrote: "We had rather a stormy night, thunder, lightning, and rain. This morning fair, this will diminish the heat. From the number of fires seen by us in all directions this day the natives are already aware of our arrival." It is interesting to note that though these fires were preceded by heat and lightning, Ogden confidintly assigned their cause to the local inhabitants (Ogden, 1961, 1971).

Fremont (1849) and Stansbury (1852) also refer to signal fires in the Great Basin. Fremont (1849) wrote: "Columns of smoke rose over the country at scattered intervals--signals by which the Indians, as elsewhere, communicate to each other that enemies are in the country. It is a signal of ancient and very universal application among barbarians." Stansbury (1852) reported that his party "observed from the high ground, the smokes of numerous Indian Signal fires, rising in several directions--an intimation that strangers have been discovered in the country."

Turner (1873) reported the use of fire as an implement of hostility. In 1852 Modoc warriors used fire in attacking a group of white immigrants on the eastern shore of Tule Lake, which lies just north of Lava Beds National Monument. He wrote that "suddenly the dry sage-brush was fired . . . and swarthy and painted savages poured by the score from the rocks overhead." Later, "The remains of the victims were found . . . half charred."

These references to cultural burning by native peoples of the Great Basin span a period of 124 years, all but three falling within the first half of the 19th century. However, some aboriginal customs current in the study area at the time of European contact, such as broadcast burning, may not have been truly traditional primevally, for preceding influences of European expansion reached the Intermountain West several decades prior to the actual arrival of whites. Early cultural disruptions resulted from encroachments into the northern Great Basin by more easterly tribes, and aboriginal customs from the Great Plains may have been introduced to the study area during relatively recent time.

## Cultural Disturbance in the Study Area Prior to European Intervention

Extensive movements of tribes from their traditional territories occurred in the northern Great Basin after about 1750. These movements were an indirect result of cultural influences which preceded the westward front of European expansion, principal among these influences being

the dissemination of horses. The greater mobility afforded native peoples by horses, combined with subsequent encroachments by white settlers on tribal lands east of the Rocky Mountains, exerted pressure on cultures farther west. Receding from the force of white cultural expansion, native peoples themselves encroached on the territories of more westerly tribes. Though diseases brought to the Pacific coast and into the Columbia River area by early trading vessels did not directly affect tribes east of the Cascade Mountains during this time, they did reduce native populations in the Columbia and Willamette Valleys, thereby reducing resistance to pressure from tribes to the south and east (Berreman, 1937).

These tribal movements began early and influenced areas yet unaffected directly by European culture. By about 1740, Shoshonean tribes of the northern Great Plains had horses and were conducting extensive raids against the Blackfoot and other Plains tribes. By 1751 the Blackfoot had acquired horses and firearms and were able to repel the Shoshonean peoples toward the south and west. Thus, pressure was exerted on the Snake who were driven into the interior of present eastern Oregon. The Bannock were close behind them and may have extended their movements as far as the Blue Mountains. The Sahaptin-speaking tribes of east-central Oregon probably suffered the major impact of encroachments by more easterly tribes, and were driven north and west across the Columbia River and the Cascade Range (Berreman, 1937).

The height of Snake and Bannock incursions lasted from about 1800 to about 1820. During this period these two tribes occupied all of present eastern Oregon except the lands of the Nez Perce (to the northeast), the Klamath (to the southwest) and the Paiute (to the southeast). Early in the 19th century, returning Sahaptin-speaking peoples began to displace the Snake, but the final distribution of tribes south of the Columbia River was quite different from that prior to about 1750 (Berreman, 1937).

As a result of these westward moving cultural influences, native traditions from the Great Plains, such as cultural broadcast burning,

may have been introduced to the northern Great Basin. Therefore, it cannot be determined directly whether cultural burning as observed at the time of European contact was an ancient custom among tribes in the study area or whether such practices were relatively recent introductions, originating in Great Plains traditions. On the other hand, because the native peoples of present eastern Oregon may have already been in a state of decline prior to their first contact with Europeans, and because horsemanship may have diminished the need to use fire in hunting and in warfare, if indeed such uses were traditional, it is unclear whether the influence of cultural burning in eastern Oregon was intensified shortly before the arrival of Europeans, whether it was a long-standing agent recently diminished or whether no particular change actually occurred at all in this regard. Further archeological, ethnographic, historical and ecological inquiries would be useful in assessing the actual degree to which cultural burning participated in the northern Great Basin environment primevally.

## Native American Fire Myths of the West

Native American peoples, of course, maintained no written histories to which reference can be made now in examining the heritage of their cultural traditions. However, their heritage is recorded in oral histories, or myths. By examining the oral histories of aboriginal cultures of the Great Basin, of the Pacific Northwest, and of the West at large, an indication of the true aboriginal relationship between man, land and fire in the study area may be detected.

Hough (1926) states that myths carried by very distinct cultures may derive from a common origin, each myth being an abstract interpretation of actual, yet distant, events. Unfortunately, few analytical studies of native Great Basin myths have been made, and so information concerning the foundations of Native American cultural perceptions of fire and their aboriginal relationships to broadcast burning among Pacific Northwest tribes, as seen through their fire myths, is very

scant, if not non-existent. Therefore, the following analysis of native fire myths was undertaken.

## Myth Analysis

Thirty-five Native American myths of the origin of fire from the Western sub-Arctic, Northwest coast, Plateau, Great Basin, California, and Southwest regions of Spencer and Jennings (1965) were analyzed (Ballard, 1929; Boas, 1917; Curtin, 1912; Dixon, 1910; Driver, 1969; Frazer, 1930; Goodwin, 1939; Judson, 1910; Kelly, 1938; Lowie, 1924; Mason, 1910; Opler, 1942; Reichard, 1947; Spencer and Jennings, 1965; Steward, 1936).*

Thirty-two motifs were identified; ten are of particular interest here. Myths containing each motif are listed by tribe in Appendix A; tribes within the study area are underlined. Numbers of myths containing each motif were tabulated and the percentage of the total number of myths analyzed was calculated for each motif. Where a motif was not contained explicitly in a myth, though it was carried implicitly, or where the motif, as designated for analysis and classification in this study, did not directly fit within the mythic text, the myth-tribe is listed in brackets. By examining several of the principal motifs identified in the study, we can assess the degree to which mythic perceptions corroborate the information presented above.

### Principal Motifs

1) The mythic events take place prior to the existence of human-kind; or at the time of the coming of man:

*A separate Coeur d'Alene tale was found in which the use of a fire corral is described. A large circle of fire was ignited in the grass in which a small opening was left. Animals were driven and impounded in this fire corral, to be shot more easily. On the occasion represented in the myth, a strong wind rose, causing the grass within the circle to burn suddenly, injuring one of the hunters (Reichard, 1947).

This motif pair is perhaps the most interesting with respect to the modern realization that possession and use of fire were of central significance in the evolution of man; but these motifs, as they exist in their native mythic context, are perhaps the most difficult for modern man to appreciate and fully explain in his own terms. In all of the myths analyzed, the distinction between human and animal beings is very tenuous, if it existed at all as a concrete concept in aboriginal cultures. This mythic identity coincides with the general scheme in most Native American oral traditions (Spinden, 1907). In the myths studied here the same individual or group might be identified indiscriminantly, it seems, as a specific animal or representative of an animal species, as a "man" or "woman" or as "people" or "the people."

In most cases the time setting of the myth is clearly prior to the existence of "the people" in their fully human condition. In a complementary portion of the myths, the action occurs at the time when human status was attained and is directly associated with that achievement. In all of the myths studied, the acquisition of fire is presented as a crucial event for "the people."

2) The original fire is kept by a fire-owner(s); "the people" have no fire:

3) A journey is made to acquire fire:

4) The original fire-owner(s) is deprived of fire:

All of the myths studied involve the dichotomy of possession and deprivation. The full character of the individual or group originally holding fire is generally not exposed in the context of the myth itself. However, the fire-owner(s) could be a deity, an animal, a plant, or another group of "people." Its domain could be in the upper world, in the lower world, in another geographic region, in a particular direction from the homeland, or within an indefinite proximity to the homeland. In most cases a journey of some length is involved in the acquisition of fire, often the journey being an arduous one which requires some preparation or magical "training." In nearly half of the myths analyzed, the dichotomy of possession and deprivation is explicitly reversed, the

result of the principal action being the deprivation of fire from the original fire-owner(s), little further concern being accorded it thereafter within the context of the myth.

5) Fire is obtained through a stealthy, surreptitious or pretentious visitation.

6) The original fire is stolen:

In all but one of the myths studied, fire is obtained by stealth and cunning, the one exceptional myth being a short, simplified tale involving merely an aerial flight to and from an island in the sea. In all but one of the myths, the acquisition of fire involves theft, the exception being the same one just mentioned; in another the theft is of a child who is held for a ransom of fire. The inherent implication of the guile presented in these tales is that fire was a highly valued commodity, possession of which, in this mythic distant past, was of salient importance, was not universal among man, was highly contended, and was furtively sought and protected by mutual antagonists. Hough (1926) would concur with this interpretation. He has found that the Native American myths related to the acquisition and preservation of fire far out-number those related to artificial production of it, the latter being comparatively rare.

7) Flight with fire after acquisition:

8) Flight with fire by relay:

9) Fire is scattered over the land:

Again, in all the myths studied, the thief(-ves) fled after obtaining fire, except in the one case in which fire was not stolen but simply fetched. In thirteen of the thirty-five myths, thieves fled in relay, each member of the group carrying the fire a portion of the distance away from the original fire-owner(s) and into their own homeland. This could be simply a mythic application of a traditional method of theft among these tribes. It could also recall a time prior to artificial production of fire when theft and swift, effective flight were the only means of regaining fire if it were lost. Or this motif may fathom the abyss of time, representing the distribution of domestic fire over

the globe as each succeeding generation of man pressed the frontiers of human expansion. In nearly half of the myths analyzed, fire was scattered over the landscape without regard for hardship or misfortune; indeed the stories' tenor is of fulfillment--that fire should be spread throughout the land. The single reference to caution in handling fire is attributed explicitly to a concern for preventing others from obtaining it. This lends support to the belief that through his unique acquaintanceship with fire aboriginal man in North America spread it far and wide, expanding its natural influence on vegetation.

10) Transgenesis of man:

The transgenesis of man through the acquisition of fire is explicit in two of the origin myths studied. A passage from the Northern Paiute tale follows:

> After getting fire the man from Job's Peak came and raised his four children. Before that all the wild animals, rocks, greasewood, and so on, were like persons and spoke the Indian language. After the Indians had been made, these birds and beasts got wild, while the Indians used language and killed wild animals (Lowie, 1924).

This new distinction between man and other animals is explained through the reversal of the possession/deprivation dichotomy, presented in the preceding events of the tale.

## Summary of Myth Analysis

These tribal legends of the origin of fire express the awareness that man was once like all other animals being without the use of fire. And they recognize that fire was sought with keen wit and dexterity. More than one-third of the myths studied contained the motif of flight by relay, and nearly one-half contained the motif of the scattering of fire far and wide. The correlation between these mythical perceptions and the inferences made earlier about the expanding influence of fire in the hands of man is notable.

The possession/deprivation dichotomy is significant, for this motif is contained in half of the myths studied. Man is explained by the transformation of that dichotomy. Mythic recognition of the transgenesis of man by his acquisition of fire is of interest in correlating aboriginal perceptions with the scientific explanation of human development.

Though far-reaching judgments from such mythological evidence may seem presumptuous, to suppose that these fire-origin myths are simple applications of standard theft tales to fire would do aboriginal cultures a coarse injustice. Though they do not transmit information in ways similar to those of modern science, these fire myths do provide another account of man's distant past. They may symbolize the struggle between separate hominid races, competing through guile for possession of fire and for the chance of humanity. Or they may represent an abstract recognition of the original acquisition of fire from natural conflagrations and its widespread dissemination as an artifact of man's culture. In any case, the existence of these oral traditions among native peoples of the West indicates the depth of their acquaintanceship with fire and their positive perception of its role in their lives.

## Discussion of Cultural Burning in the Study Area

From the overall body of information presented above, it seems reasonable to believe that Native Americans of the northern Great Basin used fire traditionally in many, if not all, of the same ways in which aboriginal peoples elsewhere are known to have used it. However, because the landscape of the Intermountain West is so varied, it is unlikely that fire was used with equal regularity everywhere throughout that entire region. Some areas, or some types of vegetation, may not have been burned purposely with any regularity. But, it seems likely that native peoples periodically burned particular areas where and when particular objectives could be achieved, such as: 1) in bottomlands and meadows where the production and quality of wild forage could be enhanced and the production and accessibility of plant foods could be improved; 2) in

forests where hunting and travel could be facilitated by burning away underbrush* and berry production could be enhanced; and 3) on grass/shrub plains where game could be encircled or driven, distant signals could be made and detected, advantage could be gained in battle, and shrubs could be subdued and grasses stimulated.

We cannot determine with certainty the regularity with which grass/shrub plains in the study area were burned primevally, but three factors merit consideration: 1) these plains areas are extensive; 2) they contain few resources which could be enhanced by burning; 3) aboriginally they supported relatively sparse populations of both man and his prey. These considerations would seem to argue against frequent cultural burning of any particular area, especially those remote from human habitations. This is not to say that fire was not purposely applied periodically to grass/shrub plains, but that broadcast burning of this extensive vegetation type may not have been as evenly distributed, nor as conscientiously regulated overall, as it may have been where a greater variety of resources could be manipulated to greater advantage through periodic use of fire. However, the influence of broadcast burning among the Paiute, who were nomadic people of the arid grass/shrub plains of the study area, could have been widespread, extending into remote areas.

Though arid plains contained only few resources, three of importance could be manipulated, enhanced and effectively exploited through the use of fire. These were 1) prey, whether it be large mammals or grasshoppers, 2) the habitat these prey required, and 3) wild grains. It should be recalled that the Desert Archaic Culture, which was founded on the hunting/gathering way of life, remained virtually unchanged after its inception in the Intermountain West thousands of years ago. And local emphasis on lacustrine and riverine resources among some tribes

*The Klamath of southern Oregon and the Pomo of California complained that the whites' policy of excluding fire from their forest habitats was depriving them of their traditional hunting grounds because the brush, which they formerly had burned periodically, had become so overgrown that game was scarce and effective pursuit of prey was impossible (Stewart, 1956).

did not preclude the use of resources from surrounding grass/shrub plains--resources which could be exploited through burning.

Of the references to burning found in historic journals for which specific dates could be determined, 71% were dated in late summer and autumn. Of these, 65% explicitly attributed the cause of burning to native inhabitants; actual observations of cultural fires occurred from July 14th to October 4th. For aboriginal desert economies, this was the season for gathering, preparing and storing resources for the winter. Large game could be effectively hunted by burning the vegetation surrounding them, and because their populations were relatively sparse, some degree of predictability in locating them could be gained by managing their habitat with fire. A good supply of small game, such as crickets and lizards, could also be acquired by the same means. The smoke of such fires could serve to signal for the gathering of tribal bands. And, as indicated by ecological literature, the foraging grounds of game animals could be rejuvenated, temporarily subduing shrubs and stimulating grasses, through periodic application of fire. In this way, grain crops derived from wild grasses could also be enhanced.

No reliable estimation of the frequency with which any single acre might have been burned is possible. Some portions, however, perhaps large portions, of less remote plains areas may have been purposefully burned with relatively high frequency, even annually, though it is not likely that any one area was burned during two consecutive years. Much certainly depends on the standards and techniques current among native peoples at the time. Unfortunately, the relationship between ancient cultural perceptions and prevailing environmental circumstances which may have regulated aboriginal burning remain largely a mystery to us.

What effect cultural burning had on the constitution of native grass/shrub flora is a salient issue, but consideration of this point should follow a discussion of the influence of native grazing animals on the primeval character of shrub-steppe vegetation in the study area. Still, cultural burning would have significantly altered the frequency of lightning fires by altering fuel levels and distributions, and could have dominated natural burning in influencing grass/shrub vegetation.

# NATIVE GRAZING IN THE NORTHERN GREAT BASIN

The presence, and even the absence, of large herbivores has contributed formatively to the nature of savanna-grassland vegetations all over the world (Graham, 1956). Whereas the Great Plains of North America are known to have supported vast herds of bison prior to the intervention of European hunters, the character of native grazing activities in the Intermountain West, and its role in the development of the native flora there, are less apparent. The influence of large grazing animals probably declined after the Pleistocene Epoch, as many Ice Age mammals were eliminated by post-glacial climatic changes, and also perhaps by the influx of primitive hunting cultures west of the Rocky Mountains (Daubenmire, 1970; Sauer, 1944, 1950). Therefore, it may be that during the last several thousand years grazing by large-herd ungulates was not a prominent factor in the evolution of vegetation native to the northern Great Basin (Daubenmire, 1970). But questions concerning the duration of bison residence west of the Rocky Mountains and the introduction of horses there early in the 18th century tend to complicate an analysis of native grazing activities in the study area.

## Bison

In considering the influence of native grazing activities on the indigenous flora of the northern Great Basin, the bison is of particular interest since this is the principal large herd animal whose influence in the development of native vegetation may have been of special significance, yet whose primeval presence or absence in the region remains uncertain. It is generally agreed that bison were not present in the Intermountain West in numbers comparable to those present on the Great Plains prior to European intervention. But to what degree they were present, if they were indeed not absent aboriginally, is not known.

The occurrence of bison west of the Rocky Mountains, after the extinction of ancient forms, appears to have been comparatively recent

and sporadic. Small herds ranged as far west as central Washington and Oregon (Galbraith and Anderson, 1971; Haines, 1967; Roe, 1970). Bison and evidence of bison were observed west of the continental divide at the time of European exploration in the Great Basin, though their occurrence there was then thought to have been only recent and transient (General Notes, 1930; Haines, 1967; Roe, 1970). Possibly the most westerly extent of bison in the United States during relatively recent times was indicated by remains found at the foot of Steens Mountains and at Harney Lake in eastern Oregon, though no living animals were observed at either site (Haines, 1967; Roe, 1970).

Haines (1967) believes that the range of North American bison was limited on the west by impassable geographic and environmental barriers. In his view, under unusual circumstances, resulting perhaps from climatic fluctuations, small herds of bison occasionally, but temporarily, occurred beyond the usual western limits of their range by moving westward across the Snake River near the mouth of the Boise River and northward along the Malheur River in eastern Oregon. However, he believes that they did not thrive in the northern Great Basin.

Roe (1970) believes that the westward movements of bison were effectively curtailed by predation from native tribes west of the Rocky Mountains, and Haines (1967) agrees, those herds which did reach the Columbia River drainage probably being quickly eliminated by native hunters. In fact, many tribes west of the continental divide journeyed across the Rockies to obtain bison meat and hides (Lewis and Clark, 1959; Ogden, 1961; Roe, 1970). In 1806, when Lewis and Clark crossed the Rocky Mountains at the headwaters of the Missouri, buffalo skins constituted an important trade item between tribes on either side of the continental divide (Roe, 1970). In 1820, the native peoples of the Lewis River Valley stated, though large herds were then present, that it was unusual for bison to visit their territory. Another indication that few, if any, bison occupied the Columbia Basin continuously during ancient times can be drawn from a Nez Perce folk tale which states that coyote, the culture hero of the Nez Perce, attempted to bring bison across the eastern

mountains but succeeded only in bringing them as far as the Bitterroot Range (Haines, 1967).

However, evidence concerning the presence of bison west of the continental divide and their duration there is not altogether conclusive, though it seems to indicate that bison were virtually absent from the Great Basin, or constituted at most a modest and transient influence there, for an extended period prior to the force of European expansion. Roe (1970) has concluded from his work that no uniformity or regularity can be discerned in the habits of bison, their movements being erratic and unpredictable wanderings rather than regular migrations. In this regard, he quotes Hind (1859): "If the prairies have been extensively burned in the autumn, the search for the main herds during the following spring must depend on the course the fires have taken." Cultural burning then may have produced some regularity in the movements of bison herds, and the cultural disruptions preceding American frontier expansion may have imposed a westerly trend to this regularity. In this light, observations made by European explorers could indicate either the actual reappearance of bison in the Great Basin after an absence of long duration, or the erratic movements of a few herds in a region from which they were never really absent but in which they were irregularly observed (Roe, 1970).

The following questions then arise: 1) Were relatively small, scattered bison herds indigenous, and continuous, residents of the northern Great Basin prior to the mid-18th century, native hunting pressures then expanding with the introduction of the horse to a degree which brought the bison near extinction west of the continental divide shortly before the arrival of white explorers? 2) Was the bison actually eliminated from the Great Basin by post-Pleistocene climatic changes, the intermittent wanderings of occasional herds west of the Rockies then being an ancient though erratic phenomenon which overall constituted a fairly minor and variable influence on native vegetation? 3) Or were these movements a recent response to the same or similar pressures from the east which compelled native peoples to move westward?

In examining these questions, other related issues arise: Though it is known that many tribes west of the continental divide undertook extended journeys across the Rocky Mountains to procure buffalo meat and hides, it is unclear whether these were purely hunting or purely trading excursions, nor is it clear whether this practice was of recent or ancient derivation. That is, we cannot be sure 1) whether the native people of the study area traversed this great distance by ancient tradition, in pursuit of game which had become scarce in their own territory long ago; 2) whether they had begun these journeys recently on horseback to hunt game which had recently become extirpated locally; 3) whether the travel was actually an ancient avenue of trade between peoples on either side of the continental divide; or 4) whether the journeys were undertaken to satisfy new demands acquired through recent contact with more easterly tribes. Additional paleontological and archeological data, and further study of regional ethnographies would cast welcome light on the nature and extent of bison residence in the Great Basin and on the relationship between native grazing and cultural burning in the development of natural vegetation there.

## INTRODUCTION OF HORSES

The introduction of horses among tribes of the West preceded European intervention there by several decades and may have had a bearing on grazing activities, bison populations, and the character of vegetaion in the study area before white explorers arrived.

The nomadic northern Shoshonean peoples were most prominent in leading horses into the northern Plains and into the West. Horses moved northward from New Mexico west of the continental divide, and arrived in the upper Snake River Valley perhaps as early as 1690. The Snake tribe, raiding into the northern Great Basin, was the first to bring animals to present eastern Oregon. Horses came to the Nez Perce country in the Columbia Basin by about 1720, and were well distributed in present Oregon and Washington by about 1730 (Berreman, 1937; Daubenmire, 1970; Haines, 1966; Oliphant, 1948).

However, horses did not become disbursed in south-central and south-eastern Oregon until much later. Neither Ogden nor Fremont noted horses among the native peoples of this region, though they were constantly troubled by attempted thefts of their own (Berreman, 1937). The paucity of horses in this section of Oregon may be related to the poverty of the land and its people; only a sparse human population persisted in this country and horses may have been more valuable as an immediate source of food than as economic servants (Haines, 1966). In 1826 Ogden found that the Klamath tribe of south-central Oregon had very few horses, which indicates that the Paiute, with whom they had regular contact, kept very few also (Berreman, 1937).

More horses were kept by the native peoples farther north on the Snake and Columbia Rivers and in the lower Owyhee country (Berreman, 1937; Haines, 1966). When Lewis and Clark visited their territory, the Nez Perce held "emence numbers of horses" (Lewis and Clark, 1959). Lewis remarked at the fine condition

> of their horses at this season of the year (spring of 1806) when I knew that they had wintered on the dry grass of the plains and at the same time road with greater severity than is common among ourselves. I did not see a single horse which could be deemed poor and many of them were as fat as seals (Lewis and Clark, 1959).

Nearly 29 years later Townsend recorded similar impressions. His party frequently encountered

> large bands of Indian horses. There are among them some very beautiful animals, but . . . they are generally almost as wild as deer, seldom permitting an approach to within a hundred yards or more. They generally have owners, as we observe upon many of them strange hieroglyphic looking characters, but there are no doubt some that have never known the bit, and will probably always roam the prairie uncontrolled (Townsend, 1905).

Indeed most of the horses owned by the Nez Perce did run wild over the plains much of the year. As their numbers increased, they must have had some effect on the native vegetation. Alexander Ross, after observing a tribal convocation near Walla Walla, Washington, in 1811, wrote: "The plains were literally covered with horses, of which there could not have

been less than four thousand in sight of the camp" (Ray, 1971). When large herds were assembled and held generally to a single area, their impact certainly may have been significant though localized (Haines, 1966).

But a more crucial question emerges: To what degree did these early stock alter the character of native vegetation in the study area at large, particularly on grass/shrub plains, before Europeans recorded their first observations of it? This question gains more interest when coupled with the possibility that cultural burning may have been curtailed as horsemanship influenced ancient hunting techniques.

The Nez Perce apparently kept many more horses than did other native peoples to the south, whose domain occupied the grass/shrub plains of eastern Oregon. Therefore, shrub-steppe regions in the study area may have been influenced less by early horses than would be indicated by reports from the Nez Perce territory. Unfortunately, such issues cannot be finally settled in truth from our distant vantage, though they are worthy of regard in considering subsequent events, for the introduction of horses was the precedent of impending change.

## NATIVE VEGETATION

Native vegetation in the study area as it existed prior to disturbance by cattle and sheep was variously described by early explorers. Many recorded their dismay on seeing shrub-covered plains; others reported both scarcities and abundances of grass, either with or without descriptions of associated shrubs. The variety of early accounts may be due, in part, to the great geographic and environmental variability of the region and perhaps also to the observation of various successional stages following fires, whether natural or artificial. The thought should also be kept in mind that explorers, crossing the continental divide toward the Intermountain West, usually late in summer or fall, were accustomed to the vastness and plenty of pure-grass prairies after weeks of travel in the Great Plains. The arid plains of the Great Basin

and their mixtures of grasses and shrubs may have seemed poor in comparison. Unfavorable reactions to natural shrub populations may have prejudiced their remarks. This is not to say that these accounts are invalid, but simply that they should not be accepted without discretion.

Early reports of dense shrub populations in the northern Great Basin have been used to refute notions that fire was a significant force in the primeval environment there and that grasses were once more plentiful and shrubs more sparse than at present. Shrubs are, of course, a natural component of the native vegetation, as are grasses, and their relative dominance is regulated by an intricate array of environmental factors. Aboriginally, cultural burning was one of these factors, as we have learned. The force with which purposeful burning may have influenced plant communities at any particular site would have depended on the strength with which each local ecosystem opposed that shift, as well as on the frequency and conduct with which fire was applied. Much useful information could be derived from careful and critical examination of early descriptions of vegetation coupled with current ecological studies of the sites described. Unfortunately, the scope of such an inquiry exceeded the means available for the present study.

## INTERVENTION OF EUROPEAN CULTURE

Initial introductions and breeding of European livestock along western frontiers led to the displacement of native animals by vast herds of domestic stock. This markedly changed foraging behaviors and intensities. The practice of broadcast burning was adopted by some white stockmen and settlers and applied to their own economies--that is, to protect their homes and property from wildfires and to remove dead plant material to give their livestock unobstructed access to fresh forage. However, their conduct with fire was not tempered by tradition and long experience, and much burning became promiscuous and abusive. Expanding grazing pressure on herbaceous species combined with indiscriminate uses of fire distorted primeval relationships between fire and grazing and

tended to invert their native influence on grass/shrub communities (Harniss and Murray, 1973; Humphrey, 1963; Tisdale, Hironaka and Fosberg, 1969).

Many scholars believe that prior to European settlement, fires occurred in North American plains environments with sufficient frequency and intensity to maintain a dominance of grasses over shrubs (Ellison, 1960; Griffiths, 1910; Humphrey, 1953, 1958, 1963; Komarek, 1965, 1967; Leopold, 1924; Thornber, 1910; Wooton, 1916). Griffiths (1910) and Thornber (1910) suggested that prior to European settlement in the Southwest, fire, moving through uniform and abundant herbaceous fuels, maintained desert grasslands largely free of shrubs and that livestock had since become an indirect check on fire by depleting grass fuels. Griffiths predicted that invasions of grasslands by shrubs would proceed as a result of intensive grazing and curtailment of fire. Wooton (1916) noted that this prediction was coming true and that occasional fires were the only inhibition to advancing shrub populations. Leopold (1924) held the same opinion, noting that oak and juniper invasions from higher elevations followed the cessation of fires.

Similar events have occurred elsewhere in the West. The combination of overgrazing and irresponsible burning led to a reduction in the vigor, density and competitive force of herbaceous flora. This interrupted the continuity of surface fuels; the frequency and intensity of burning declined, and the impact of fire on shrubs diminished. Evolving fire suppression capacities then virtually eliminated that inhibition on shrub populations. Woody vegetation, formerly restricted to rocky slopes and hillsides, stream banks, plateau summits and mesas, advanced in a shift toward shrub dominance at the expense of grasses (Humphrey, 1953, 1958; Stewart, 1951; Wright, 1972; Wright and Britton, 1976).*

*Overgrazing and fire suppression have ultimately magnified the potential impact of fire where shrubs and unpalatable herbaceous species have increased to form a dense and uniform fuel supply. Such is the case in many areas of the West; and the present condition of much dense and decadent vegetation now aggravates difficulties with fire and restorative land management.

As elsewhere in North America, the pastoral opportunities of the Intermountain West were promptly exploited as suitable markets for livestock became available. Though settlement in the study area closely followed the characteristic pattern of white cultural expansion elsewhere in the West, it occurred relatively late. Settlement came first to the western reaches of the Pacific Northwest and then returned eastward across the Cascade Range. Significant interventions in present eastern Oregon occurred later, the southeastern portion of the state being the most recently settled. Therefore, we are still relatively close to the early history of this region and to the events which caused environmental and floristic change there.

The enactment of the Law of Public Domain opened the way in the Pacific Northwest, as it did elsewhere, to free and unrestricted use of grazing lands. As the fur trade in the region declined, the interests of the Hudson's Bay Company shifted toward agricultural and livestock production for export from the Columbia Valley. Overland immigrants, entering the eastern Great Basin, traded cattle for horses. Not only did livestock holding at trading posts and missionary stations increase but by the 1840's cattle had also become widely distributed among native peoples east of the Cascades. By the mid-1840's immigration to the Pacific Northwest had increased and settlers had begun to colonize the Columbia Valley region (Oliphant, 1948, 1968).

The excitement of gold mining in California in the mid-19th century stimulated trade in livestock from the Pacific Northwest, and when miners rushed north to British Columbia, markets for livestock produce were expanded even further. By 1860 thousands of immigrants had brought many thousands of livestock into the Pacific Northwest. In 1861 mines were opened in eastern Oregon, Idaho and western Montana (Galbraith and Anderson, 1971; Oliphant, 1948, 1968).

During the decade of the 60's western Oregon stockmen began using eastern Oregon as a vast pastureland annex, moving large numbers of young animals east of the Cascades to mature and fatten for markets to

the north and east. By the mid-60's cattle were grazing in the John Day River Valley. In 1868 many settlers entered the Klamath Basin and settlement of the southeastern portion of Oregon began (Oliphant, 1948, 1968).

The first transcontinental railroad was completed in 1869 and opened markets through the railhead in Utah. However, much of the pastureland in western Oregon had been eliminated by an expansion of agriculture there and some rangelands east of the Cascades were becoming depleted by the early 1870's. Areas in southeastern Oregon were beginning to suffer from overstocking and the south-central portion was being settled rapidly (Galbraith and Anderson, 1971; Oliphant, 1948, 1968).

Late in the 1870's large herds of cattle were kept in present Klamath and Lake Counties. Larger herds also ranged through Grant, Baker, Harney and Malheur Counties, where the cattle kingdoms of the Pacific Northwest developed (See Figure 2). As the decade of the 80's approached the livestock industry suffered a depression as the mining boom declined. The 1880's brought some recovery as the white population east of the Cascades rapidly increased, rising from 39,100 to 73,162 during that decade (Oliphant, 1948, 1968).

Much of the land in the Columbia Basin was suitable for cultivation. As this region was settled by wheat farmers, the open range became much restricted (Cotton, 1904; Galbraith and Anderson, 1971; Oliphant, 1948, 1968). The wheat culture expanded over native bunchgrass plains of north-central and northeastern Oregon, especially in Sherman, Gilliam, Morrow, Umatilla and Union Counties and became the dominant industry there by about 1930 (Griffiths, 1902; Oliphant, 1968; Strong, D. K., 1940). It made little progress in Lake, Harney and Malheur Counties in the southeastern portion of the state. Cattlemen retreated in the face of advancing wheat cultivation as rangelands became rapidly constricted to rocky and inaccessible lands. In some areas cattle raising became a subordinate aspect of farming operations (Griffiths, 1902; Oliphant, 1948, 1968).

By 1890 the livestock industry had been virtually eliminated from the northern portion of the study area, and major consolidations of cattle raising interests took place in southeastern Oregon. Forage on remaining open rangelands became depleted as agriculturalists continued to take possession of arable lands to the north and west. Under this pressure stockmen began boldly to encroach on Indian reservations, for in the words of a federal agent at the time

> in general, they considered the difference between government-owned land which they could freely use and government-owned land which they could not use because some Indians were not yet exterminated, to be a lawyer's distinction--that is, one without a difference (Oliphant, 1968).

Severe weather in the winter of 1889-90 caused thousands of cattle to perish on the open range and a general depression set in again during the early 1890's. Many cattlemen were forced out of business and range horses were left to roam and multiply freely (Griffiths, 1903). Large bands of sheep by this time were also competing for dwindling range resources.

The rapid appropriation of land for farming and the consequent constriction of open range, without corresponding decreases in numbers of cattle, combined with rising numbers of sheep and horses, caused severe depletions of forage in many areas. As late as 1905, most areas in Harney County, Malheur County, eastern Lake County and southeastern Crook County were considered to be year-round open range, and nearly all of this region remained unrestricted public domain through the first quarter of the present century (Strong, D. K., 1940). Eventually private acquisition and control of land in this portion of Oregon caused further restriction of open rangelands, and the deterioration of remaining range resources caused another decline in the cattle raising industry (Cotton, 1904; Daubenmire, 1970; Galbraith and Anderson, 1971; Oliphant, 1968; Strong D. K., 1940). Though in the late 1870's "the gentle sloping hills (of the Steens Mountains area were) covered with bunchgrass and the wild grass of the valley (would) produce a ton and a half of hay to the acre" (Strong, D. K., 1940), the region ultimately suffered

some of the most severe overgrazing to occur in Oregon, and by 1924 the whole area was considered by stockmen to be worthless.

Sheep were relatively unimportant in Oregon until about the decade of the 1880's. Development of the sheep raising industry along the Columbia River and in the Blue Mountains roughly coincided with the rapid expansion of wheat farming in north-central Oregon, for both were stimulated by the completion of the Northern Pacific Railroad in 1883--these commodities could then be produced in quantity and shipped to distant markets (Oliphant, 1968). Extensions of both the sheep industry and the wheat culture acted together in forcing the range cattle interests into southeastern Oregon. Numbers of sheep east of the Oregon Cascades increased markedly during the 1880's, principally in Crook, Grant, Wasco, and Umatilla Counties, but expansions were made also in the southeastern and south-central regions. After the severe winter of 1889-90 and the depression of 1893, sheep numbers again increased rapidly. In 1890 there were 108,410 sheep in Lake County, 57,974 in Malheur County and 56,699 in Harney County (Oliphant, 1968). Their numbers continued to soar in eastern Oregon until 1900, when they reached their first peak. When Griffiths (1902) visited this region in 1901, 73 bands of sheep occupied the top of Steens Mountains, each band containing about 2500 animals. He calculated that this would place 450 sheep on each square mile of that range, though he noted that another estimate put the figure at 1000 animals per square mile. Cattle from the ranches at the base of the mountains were also driven up whenever possible. After returning the following year, Griffiths (1903) wrote that the greatest need in the region was for summer feed, which had been diminished by settlement of mountain meadows, development of alfalfa fields and withdrawals of forest reserves from the public domain (Daubenmire, 1970; Galbraith and Anderson, 1971; Griffiths, 1902, 1903; Oliphant, 1948, 1968; Strong, D. K., 1940).

Conflict between sheepmen and cattlemen was common, and the struggle between them for occupancy of the open range in eastern Oregon became heated (Oliphant, 1948, 1968). It was generally believed by those who

opposed them that sheep would spoil the open range by "eating out the pasturage" and "poisoning and scenting the grass," making it unfit for other stock. Cattlemen and farmers (who also owned cattle and horses) found themselves on the same side of this issue. In the 1870's attempts were made to separate the two types of stock on designated portions of still shrinking open range. But as the decade of the 80's approached, sheep raising became an important enterprise with some force in contending for a share of the open range (Oliphant, 1968). The Blue Mountain area, in northeastern Oregon, became a center of harsh conflict during the late 1880's and by the mid-90's herds and flocks were converging on summer ranges which were already inadequate for either. In 1901 a range war was imminent and by 1904 open warfare was at its height both in northeastern and southeastern Oregon (Griffiths, 1903; Oliphant, 1948, 1968). Two years later the contest subsided when the federal government began to regulate grazing on summer ranges by leasing grazing lands in its new forest reserves (Oliphant, 1968; Strong, D. K., 1940).

## HISTORICAL DEVELOPMENT OF LAND AND RESOURCE MANAGEMENT*

### Public Lands

A lack of far-sighted policies serving the future, at both the state and federal levels, marked early official perceptions of land and its resources. Public officials in Oregon historically were not conscientious in protecting and managing state lands as a public trust. In the mid-1880's the clear objective of the Oregon Board of Land Commissioners was to dispose of state lands by sale as quickly as possible. As late as 1880 the land office remained generally disorganized and vulnerable to much abuse. Though the Oregon Legislature conducted an investigation in 1878, the only change in the overall

*For a more thorough discussion of federal policies toward fire and grazing management see Dana, 1956.

philosophy toward public lands was to magnify the urgency with which they should be removed from public jurisdiction. Profligate land policies persisted until the land fraud scandals of the early 1900's; only long afterward did the notion become current that Oregon's grant lands should be held as a commonwealth resource and preserved for future generations (Robbins, 1974).

Policies at the federal level did not initially present a better example. No considerable value was ascribed to land itself and little concern was given to its administration. Land was regarded simply as a source of federal revenue through private acquisition and remittance of taxes (Stoddart and Smith, 1943). By January 1, 1903, 75% of all state grant lands in Oregon had been sold, and the federal government was moving slowly toward preservation of remaining public lands and resources under its control (Robbins, 1974).

A series of federal actions making free land available for private ownership began in the early 1840's, though stockmen did not take significant advantage of them until the 1870's when they began to secure holdings in southeastern Oregon (Stoddart and Smith, 1943; Oliphant, 1968). The quantity of land available to a single party under the provisions of these acts was generally insufficient for a viable ranching operation in the Great Basin, so the most desirable sites were taken and the surrounding rangelands, which remained in the public domain, were used for unrestricted grazing of livestock (Stoddart and Smith, 1943; Griffiths, 1903).

## Grazing

Ranching practices of stockmen differed little from place to place throughout the study area. The common policy was to set livestock out to roam freely over the open range during the entire year without further care or management. Feed and shelter were provided by only a very few cattlemen, even during severest winter stress. Most ranchers saw the livestock business of that era as a highly speculative enterprise to be

operated on the open range and directed toward high returns from minimum effort and expense. Optimistic promotions picturing Oregon as a land of easy and abundant pastoral success supported this notion (Oliphant, 1948, 1968).

Newspaper editorials consistantly lamented losses of cattle from exposure and starvation and continued to warn stockmen as late as the 1890's about the harshness of their neglect in wintering livestock untended on depleted rangelands. Ample models of more reasonable stock management were apparent, for native peoples, who were more responsible in tending their stock, lost "little of their small wealth from exposure and cold" (Oliphant, 1968). But the speculative philosophy of white cattlemen persisted and heavy winter losses continued into the 1900's. In March of 1862, local newspapermen noted that "you cannot walk out one thousand yards from the main street of Walla Walla but you encounter the festering and decaying carcasses of animals" (Oliphant, 1968). In 1875, dead cattle were so numerous along the Snake River that scavengers were hard pressed to salvage hides before they spoiled.

Before the end of the 1870's cattlemen in southeastern Oregon and southern Idaho had begun to acquire, fence and control large tracts of land, lawfully or unlawfully, to insulate themselves from agricultural encroachments on the open range and from overstocking by sheepmen and other cattlemen (Cotton, 1904; Oliphant, 1968). Fencing had become the general practice among conscientious stockmen in eastern Oregon by the 1880's. By the turn of the century much land was being fenced, section by section, to make the management of livestock and range resources more systematic--stock were set out to graze one section at a time to allow forage species a period of growth before pasturing (Griffiths, 1903; Oliphant, 1948, 1968).

Furthermore, where formerly stock had ranged freely and virtually untended throughout the year, cattlemen began to provide two to four months of feed during the winter, because settlement and cultivation of the best rangelands and overstocking and depletion of the remaining open range had made it impossible to expect increases in herds left unattended

on the open range through the entire year (Cotton, 1904; Griffiths, 1902). Since bottom lands were the only source of hay and winter grazing, they suffered from overuse, and by expanding winter feed supplies more animals could be held through severe winter weather and set out on remaining open range in the spring (Oliphant, 1968).

Both cattle and sheep were often left on high mountain pastures too long, causing damage there as well (Griffiths, 1902, 1903; Strong, D. K., 1940). Sheep bands became particularly crowded as cattlemen acquired and controlled land. Sheep, like cattle, were kept in valleys and on desert plains and were fed during the winter (Griffiths, 1902). In the spring they were moved onto low hills as soon as grasses began to grow and grazed there until lambing and shearing were finished. Afterward they were moved higher, pressing at the snow line as it retreated, to reach the best mountain pastures as early as possible. In fall they moved back to the lowlands where they grazed until winter feeding began (Cotton, 1904; Griffiths, 1903). Close grazing, crowding and trampling of sheep tended to clear the ground of vegetation even more seriously than the activities of cattle, which tended to roam about (Griffiths, 1903; Rakestraw, 1958).

However, both classes of stock became quite overcrowded on mountain pastures in the summer because these grazing lands constituted a very small portion of the total range. Animals were forced to higher elevations even earlier than usual as free grazing on intermediate pastures was restricted by private acquisitions of land. As these events proceeded more stockmen acquired more land, and soon all but high elevation rangelands, having a very short grazing season, were under private control (Cotton, 1904).

The conservation ethic began at the federal level, but it did not gain force in the study area until about the turn of the century (Robbins, 1974). By the end of the 19th century the federal government had begun to recognize the limitations of land-based resources, the abuses and misuses they were suffering and the need to start conserving what remained (Stoddart and Smith, 1943). Establishment of grazing

districts on public lands was proposed as early as 1878, but open rangelands remained free of public administration for many years (Strong, D. K., 1940).

Action toward preserving and managing land resources began with the establishment of National Parks and Forest Reserves (Agee, 1974). Yellowstone National Park was set aside in 1872 and the Forest Reserve Act was instituted in 1891 (Stoddart and Smith, 1943). But the establishment of forest reserves heightened the controversy over the disposition of state and federal lands, conservationists asserting that public ownership would permit fair and systematic management of resources for future as well as for present uses (Robbins, 1974). Even many stockmen by this time were anxious for some sort of equitable regulation of grazing on the public domain.

Systematic range management accompanied a growing interest in other resources and land uses and was first applied to summer ranges as part of the development of the national forest system (Council for Agri. Sci. & Tech., 1974; Strong, D. K., 1940). But when the Cascade Forest Reserve was established in 1893 use of mountain pastures by any livestock was initially prohibited (Langille, 1956; Robbins, 1974; Strong, D. K., 1940). Stockmen continued to use summer pastures in the Cascades in subsequent years; even Federal officials were divided on the issue and enforcement of grazing restrictions was often irresolute (Langille, 1956). Arguments between sheepmen and conservationists in Oregon became strident late in the 1890's, sheepmen claiming that their animals caused no permanent damage to forest and range resources, conservationists asserting the reverse. After conducting an investigation of disturbances caused by livestock in the Cascade Mountains, the National Academy of Science recommended that grazing be prohibited from Cascade Forest Reserves. But stockmen contended that forest reserve areas were essential to the livestock industry since they provided the only source of summer forage for eastern Oregon stock operations. Later the Department of Agriculture took the position that regulated grazing was advisable

(Rakestraw, 1958) and a policy was developed which permitted commercial grazing if it did not damage forest and range resources (Strong, D. K., 1940).

In 1900 grazing permits became necessary to regulate the time and period of use and to limit the number of animals using a given area at once (Galbraith and Anderson, 1971; Strong, D. K., 1940). In 1906 grazing fees were imposed on all classes of livestock. The Taylor Grazing Act of 1934 authorized the withdrawal of 80,000,000 acres of public domain from entry and the establishment of grazing districts under the Department of the Interior. In 1936 the area of withdrawal was extended to 142,000,000 acres, compassing virtually all public lands of value. The last large tracts of public land in Oregon were thereby withdrawn from unrestricted access for grazing, and the promotion of orderly use, conservation and improvement of public rangelands was given firm impetus (Oliphant, 1968; Strong, D. K., 1940).

## Fire

Native American peoples apparently burned vegetation in the northern Great Basin during an extensive period; ecosystems long influenced by this tradition would then have assumed an environmental balance which was maintained by the continuation of customary broadcast burning. But as the livestock industry intensified and as agricultural settlement proceeded, strong negative attitudes toward uncontrolled fires developed, and those "who set fires that swept over the ranges" were soon characterized as "careless white men and malicious Indians" (Oliphant, 1968). In late summer of 1867, fires on the plains east of the Cascades caused some anxiety. Reports referred to "prowling bands of Indians" setting fires which "entirely destroyed the stock ranges" in some areas. In 1878, more distress was voiced over prairie fires consuming grasses needed for winter livestock forage. Between 1882 and 1884, "destructive" fires occurred on the east end of the Nez Perce Reservation in northern Idaho, in the Big Bend country of eastern Washington and on the grass/

shrub plains between Boise and the Snake River (Oliphant, 1968). Some people (it is not clear whether they were native people or whites) contended that occasional burning of rangelands tended to eliminate sagebrush, but newspaper articles "explained" that fires "destroyed the bunchgrass that grows among the brush, and so heat the ground that the grass will not grow again in time for winter pasturage. It is safer and better," they asserted, "to leave the sage brush until the land is needed for cultivation, when it can be easily removed" (Oliphant, 1968). But burning continued and in November of 1889, fires "ruined" rangelands in the Warner Valley of south-central Oregon, which presumably could have supported 3,000 cattle through the winter (Oliphant, 1968). It is not clear to what degree fire may have contributed to the extraordinary stock losses suffered during the winter of 1889, nor to the losses of previous years, for these misfortunes were primarily attributed at the time to extreme cold, frozen watering places, and inaccessibility of forage due to ice-crusted snow.

In 1901, when Griffiths visited the study area, he saw six separate areas recently burned between Burns and Drewsey in east-central Oregon; two or three of these were burning as he passed (Griffiths, 1902). He also found evidence of fires in every mountain range he visited. One of these fires was set by the native people; another was set by sheepmen; and two campfires had been left unattended by campers and a round-up crew, one of which was then burning up the side of a pine tree. Like others, Griffiths at that time bitterly lamented the burning of winter forage and attributed the cause of range fires simply to criminal negligence (Griffiths, 1902). However, nine years later he regarded the curtailment of range fires in the Southwest to be the most salient factor in the spread of shrub populations into grasslands (Griffiths, 1910).

The situation on the summer ranges of eastern Oregon was similar to that on winter ranges, though on the former it was the stockmen, principally the sheepmen, who "lightburned" summer pastures in the fall to "green up" forage for the next season by stimulating fresh tender

spring growth, and to clear the land of dead and down timber that interfered with the movements of sheep bands (Agee, 1974; Griffiths, 1902; Rakestraw, 1958). Large flocks moving up close behind the melting snow the following spring quickly consumed new green shoots before they could get a fair start (See Figures 3 and 4). This severely depleted forage species and exposed the soil and the roots of other species to serious damage from trampling (Griffiths, 1902, 1903).

If early stock management practices had not been so unfortunate, Native American customs of periodic burning may have been viewed with less contempt and may have been more conscientiously adapted to white American economies. As it was, "lightburning," untimely grazing and generally intensive use of all rangelands seriously distorted the native relationship between grazing and fire and made the new combination especially detrimental. In the desire to protect natural resources from waste, an oversimplified view of fire developed, and attention was diverted from other cultural excesses, such as exploitive stock management and improper agricultural practices. A broad policy of total fire prevention and suppression evolved, directed toward completely eliminating fire as an agent in the environment. This policy was based on the notions that all fires were unnatural and thwarted human progress. Fire exclusion gained official sanction when Yellowstone National Park was established in 1872, and was implicitly incorporated in federal land management policies with the institution of Forest Reserves after 1891 and of the National Park Service in 1916 (Agee, 1974; Kilgore, 1976; Komarek, 1962).

We now recognize that the absence of fire in the environment is unnatural. By the late 1920's research had indicated that controlled, low-intensity fires could be used beneficially in some environments (Kilgore, 1976). And though there has been much resistance to the reintroduction of fire in nature, today prescribed and natural fires are being used in the restoration and maintenance of natural ecosystems in National Parks and to assist in the management of resources on other federal and state lands (Agee, 1974; Kilgore, 1976). The National

Forest Service introduced prescribed burning in the pine forests of the Southeast in 1943, and the National Park Service began similar procedures at Everglades National Park in the 1950's. By 1970 policies had been instituted to allow fire to assume a more natural role in wilderness areas, and in 1973 a federal program was approved which permits either natural or man-caused fires to burn unchecked if certain predetermined land management standards and objectives are satisfied (Kilgore, 1976). A more sensible attitude toward fire is evolving, but there is much yet to be learned before contemporary cultural burning is wholly harmonized with all other land resource necessities.

## IMPACTS OF HISTORICAL GRAZING AND BURNING AND FIRE EXCLUSION ON VEGETATION IN THE STUDY AREA

By the 1880's grazing lands in the Columbia Basin were deteriorating; by the turn of the century they were seriously depleted and bunchgrasses were disappearing (Cotton, 1904; Strong, D. K., 1940). In 1901 Griffiths observed that as a direct result of overgrazing open rangelands in eastern Oregon could supply only about one third of the forage they once provided and that private lands, though in better condition than open ranges, were being used to the limit of their capacity (Griffiths, 1902). At about this time livestock was becoming concentrated in the southeastern part of the state, and overstocking caused even more serious deterioration of rangelands there than were evident to the north (Griffiths, 1902; Strong, D. K., 1940).

By the early 1890's summer ranges in the Steens Mountains had suffered considerable damage, principally from the management of sheep, and little valuable forage remained. Summer pastures in the Cascades and the Blue Mountains fared better--overgrazing was not apparent in those areas until about the end of the 80's and by the mid-1890's only local deteriorations had been imposed (Strong, D. K., 1940). After the turn of the century the overall area of utterly depleted mountain pasturelands was increasing. The Steens Mountains area was the most

seriously affected region observed by Griffiths in 1901, which he attributed to close grazing and close herding of sheep (Griffiths, 1902). In 1902 he noted that ranges intermediate between mountain and lowland pasture were grazed twice each year and also suffered from faulty management of sheep. Griffiths further observed that, in the Blue Mountains area, forage near settlements where sheep were excluded was in better condition that it was on the open range (Griffiths, 1903).

Results of a survey issued in 1905 indicated that most stockmen in the study area believed that deterioration of grazing lands was due to encroachments by settlers, to overgrazing and to replacement of forage species by trees and brush, resulting from the exclusion of fire. Those who reported range improvements attributed this to more responsible management and use of range resources (Strong, D. K., 1940). Between 1910 and 1914 the quality of rangelands throughout Oregon as a whole declined about 5%; those which received some protection improved about 25%; and those left unregulated, principally the remaining public domain in southeastern Oregon, declined about 30% (Strong, D. K., 1940).

## Juniperus occidentalis as an Impact Index Species

Western juniper (Juniperus occidentalis) is indigenous to eastern Oregon, is relatively long-lived and durable, is closely associated with grass/shrub vegetation without being an integral part of it, and is responsive to the environmental influences of fire and grazing. Therefore, this species is especially useful in demonstrating the long term environmental consequences of the historical events discussed earlier.

Western juniper, especially small young individuals, are highly vulnerable to destruction by fire (Wright, 1972). Driscoll (1964) and Wright (1972, 1974) state that fire has been a major factor in the distribution and abundance of juniper. Wright and Britton (1976) and Wright (1972) go on to say that though drought and competition from grasses tend only to slow rather than to prevent the establishment and growth of juniper seedlings, they are both intimately associated with the influence of fire in determining the character of juniper populations.

Western juniper is not common in flat, unbroken topography typical of grass/shrub and grassland plains, though it will invade and colonize these areas. According to Wright and Britton (1976) and Wright (1972, 1974) juniper invasions are controlled by the frequency of fires. Junipers can prevail on rocky, irregular ground where they gain some protection from burning.

Wright (1974) has proposed that junipers would be eliminated from land subject to fire more than once every 15 years and that they could persist if burning were less frequent; Wright and Britton (1976) have proposed a span of 10 to 30 years.

During Griffiths' travels in the northern Great Basin in 1901, the largest juniper population seen by him occurred in the Steens Mountains, though even there individuals were scattered "at long intervals," their size ranging from 10" to 18" in diameter. He also noted that between Winnemucca, Nevada, and Burns, Oregon, ranchers were obliged to travel 30 to 50 miles to find junipers to be used as fence posts.

Recent investigators have observed juniper populations expanding into adjacent grass/shrub vegetations in the West as a factor either of overgrazing, of fire suppression or of both (Barney and Frischknecht, 1974; Blackburn and Tueller, 1970; Cottam and Stewart, 1940; Hall, 1967). Data obtained by Barney and Frischknecht (1974) in a study of burned areas in west-central Utah indicate that Utah juniper (Juniperus osteosperma) began to invade during the 6th to the 11th years following fire and that it began to dominate sites in the 46th to 71st years. Perennial grass cover increased markedly the first five or six years after burning and remained relatively constant during the following 40 years, but subsequently fell to its lowest levels. The decline of perennial grasses appeared to correspond to the rapid advance of junipers.

In an area studied by Cottam and Stewart (1940) herbaceous competition was seen to have prevented invasions of grassy hillsides by Utah juniper prior to European settlement in 1862. Heavy grazing by cattle and sheep occurred after 1864, and soil moisture was severely reduced by

erosion in 1884. The investigators found that juniper populations had expanded nearly 500% between 1864 and 1934, even though early settlers had removed a considerable number of trees.

In an area studied by Blackburn and Tueller (1970), Utah junipers and pinyon pines (Pinus monophylla) were advancing into black sagebrush (Artemisia nova) communities in 1923; in 1966 dense stands of pinyon and juniper dominated the area. Juniper was found to invade black sagebrush first, though it was eventually dominated by pinyon pine. Junipers were present since about 1725 on sites lately supporting "closed," "dense," and "scattered" stands; they had accelerated their advance about 1921. This was considered to be attributable, at least in part, to overgrazing and fire exclusion, which correlated well with marked invasions during the 1920's and 1930's.

## Climatic Fluctuations in the Study Area

Climate has also influenced the competitive relationship between grass and shrub flora in the study area. Cottam and Stewart (1940) have demonstrated that soil drought, as well as grazing, can be significant in the alteration of vegetation; they observed that many junipers invaded former wiregrass meadows following dessication of these areas. Atmospheric drought is comparable. Short dry periods may inhibit, or simply slow, juniper invasions into grasslands since grass populations would ordinarily not be seriously affected by short droughts alone. But long periods of drought may reduce grass competition and tend to enhance juniper invasions following drought since junipers can become established readily in wet years, especially if relieved from significant competition from grasses (Blackburn and Tueller, 1970; Wright and Britton, 1976).

Bowman (1935) has reported that during the mid-1800's Goose Lake, in south-central Oregon and northeastern California, was receding and that an immigrant road crossed a dry portion of its bed. Thereafter, the lake floor was flooded again until the 1920's when the road was

exposed once more (See Figure 5). He also reported that tree ring records indicated that periods of drought occurred from 1829 to 1852 and after about 1918 and that a marked and unusually moist period occurred between 1805 and 1829.

Keen (1937), conducting a similar tree ring analysis, discovered that a relatively stable climatic force has dominated the northern Great Basin during the past 650 years. Though no major trend toward either moister or drier conditions was indicated, marked fluctuations have occurred. Keen (1937) found, in agreement with Bowman (1935), that a period of abnormally low precipitation began in 1917 and became the most severe of the entire period studied. During 1931, the poorest year, tree growth was 68% below normal.

A chart supplied by Keen (1937) is of interest in the present inquiry (See Appendix C). Fluctuations in tree ring growth as related to precipitation during the 18th century were relatively smooth and regular, and deviations from the norm were not particularly striking. However, during the first 30 years of the 19th century several distinct peaks occurred, three representing precipitation 30% or more above the norm. Another peak of nearly this magnitude occurred in 1831, which was followed by a marked decline to about 15% below normal the following year. In 1838 a steady trend of decreasing precipitation began which reached a low point in 1849 of nearly 30% below the norm; this subnormal period ended in 1854 and was followed by a long period of erratic fluctuations. A general period of higher than normal precipitation lasted from 1854 until 1868 with a peak of nearly 40% above the norm in 1861. This was followed by generally lower than normal precipitation from 1870 until 1893 with lows of about 35%, 30%, and 30% in 1871, 1876 and 1890 respectively. Another overall increase in precipitation lasted then from 1893 until about 1917 with a peak of about 25% occurring in 1894. The severe drought of the 1920's and 1930's then began (Keen, 1937).

Correlation of these climatic fluctuations with historical events is instructive in examining the factors involved in floristic changes on grass/shrub plains in the study area. The interests of the Hudson's

Bay Company were being directed toward agricultural and livestock production in the Intermountain West during the 1820's and 1830's. This coincided with a decline from a preceding period of higher than normal precipitation. The drought which followed, lasting from 1838 until 1854, was accompanied by the first significant expansion of the livestock industry east of the Cascade Mountains; the year of most extreme moisture deficiency, 1849, corresponded precisely with the rush of mining activity in the West which gave the livestock trade its primary impetus. By 1860, climatic moisture levels had recovered, though the variation between the years preceding and following this one was extreme. Overland immigration to the Pacific Northwest by this date had introduced thousands of livestock to the northern Great Basin. During the 1860's, a decade which preceded another, though more erratic, period of below normal precipitation, large numbers of livestock were brought to eastern Oregon, which was then being used as a vast pasturing land for cattle bred in western Oregon. By 1869, the year prior to an extreme depression in climatic moisture (reaching more than 30% below normal in 1871), cattle were widely distributed over the grass/shrub lands of the Intermountain West. During the 1870's and 1880's a period of erratic climatic fluctuations and general subnormal precipitation, the cattle kingdoms east of the Cascades were at their height, large herds of livestock ranging freely year-round over the open range. By 1880, the midpoint of this period of drought, both cattle and sheep had become widespread in the study area. A rapid expansion of livestock grazing in eastern Oregon, marked by vastly increased numbers of sheep, coincided with the abatement of this drought during the 1880's. A period of generally higher than normal precipitation followed from 1893 until 1917; an extreme peak in numbers of livestock occurred about 1900. The severe drought of the 1920's and 1930's followed and was accompanied by a decline in livestock numbers in eastern Oregon until about 1925. Stock numbers reached another peak in 1930 and again declined rapidly thereafter.

Intensification of grazing in the study area during periods of drought (1838-1854, 1870-1893 and during the 1920's and 1930's) would have imposed severe stress on herbaceous species. During these times and especially during intervening periods of increased precipitation, when grazing was also intense, shrubs, freed of grass competition, could have become established and gained significant advancement over herbaceous species.

## Photo-set Comparisons

As part of the present study a number of early photographs was gathered in which range vegetation of Grant County, in east-central Oregon, was pictured. The dates of these photographs range from 1880 to the mid-1930's. Each photo-site was relocated and rephotographed during the summer of 1976. Figures 6 through 10 are examples of the photo-set comparisons which resulted. Western juniper populations have increased at all photo-sites. Very low population densities and the immaturity of individuals present on sites photographed earliest indicate that juniper invasions were then recent.

Numbers of junipers per unit area were counted in the photographs of each photo-set. The average increase in numbers of junipers per year was calculated for each of the 17 photo-sets. The peak average increase per year occurred on the site first photographed in 1912 (See Figure 11). Though no firm conclusions may be drawn from this photo sample, lower average yearly increases in juniper on sites first photographed in more recent years indicates a reduction in the rate of expansion as juniper densities increased.

On one site, photographed in 1920, in 1945, in 1956 and in 1965 (See Figure 12), a similar trend is apparent--the rate of juniper expansion has declined in recent years. Figure 13 represents this trend graphically.

# SUMMARY AND CONCLUSIONS

In summarizing the ecological history of fire and grazing in the study area, the following points should be recalled:

1) Grazing ungulates, fire and the open savanna-grassland habitat are closely associated with the development of the human species.

2) The northern Great Basin is characterized by features common to open savanna-grassland fire environments.

3) Environmental relationships between fire and grazing on grass/shrub plains of the western United States include the following interactions:

a--Periodic burning, even of low intensity, may keep shrub populations in a juvenile, non-fruiting state, while at the same time tending to stimulate herbaceous production during intervening years.

b--Grazing may seriously damage herbaceous populations when cropping occurs during the critical period of spring growth or when too much photosynthetic tissue is removed, and thereby favors shrub populations by reducing the competitive capacity of grasses.

c--Recently burned grass populations are especially vulnerable to serious depletion by close grazing.

With regard to changing natural and cultural phenomena, five periods of environmental differentiation in the study area are discernable during about the past one million years. The first was an era of fully natural, though relatively unstable, phenomena during the Pleistocene Epoch--a true wilderness. The second and fourth may be described as cultural frontier periods. The third was a time of relative environmental and cultural stability. The fifth period, in which culture is regaining a balance with the environment, is now under way.

1) Wilderness: An era of broad climatic fluctuations was associated with Pleistocene glaciation. During this period man was not present in North America and the Great Basin environment involved only purely natural phenomena. A diversified array of large herbivores influenced the constitution of the existing flora. Only naturally-occuring fires were environmentally active. However, lightning activity may have been

intensified in association with constrictions of climatic zonation in the mid-latitudes, as cold, dry air masses and warm, moist air masses were pressed more closely upon one another. The degree to which this may have affected the incidence of fire in the Great Basin would have depended on the condition of existing vegetation during that period.
2) Cultural Frontier I: The influx of man and his primitive hunting culture marked the beginning of the first cultural frontier period in the New World. Man's activities, including his use of fire, may have joined a trend toward climatic warming and drying at the close of the Pleistocene Epoch in causing the extinction of many species of large mammals. Changes in these three factors--fire, climate and native grazing--would have been influential in altering the indigenous flora.
3) Settlement I (Aboriginal): Following environmental accomodation to the above changes, diminished grazing, natural and cultural burning, and fairly consistent climatic influences probably maintained a relatively stable environment in the northern Great Basin for several thousand years prior to European intervention. Existing evidence indicates that during this period, grazing by native large-herd ungulates was not a prominent influence, though questions concerning the presence or absence of bison during this period are unresolved. Native American peoples used broadcast burning techniques for various purposes during historical times. Specific assessments of the frequency and regularity of native cultural burning are not yet possible. Nomadic groups may have burned portions of grass/shrub plains with some regularity, though this may not have resulted in frequent or regular burning of specific sites. Though the influence of European cultural expansion preceded the actual arrival of whites in the Great Basin and may have caused early changes in native cultural standards there, an analysis of the fire myths of native western tribes supports the likelihood that customary broadcast burning was an ancient and traditional component of aboriginal cultures in the study area. The introduction of horses occasioned a period of cultural instability in the study area and may also have influenced native vegetation in two ways: through grazing by the large

numbers of animals kept by native peoples, especially locally when horses were gathered and closely herded; and through a reduction in the use of fire in hunting as horsemanship increased mobility in the pursuit of game. It is unlikely that the grass/shrub plains of eastern Oregon were much affected in these ways, however, for native peoples there apparently kept few horses.

4) Cultural Frontier II (Historical): With the influx of European culture in the northern Great Basin, grazing by large herbivores was markedly intensified and quickly again constituted a prominent influence on existing flora. The period of intensive and often untimely grazing by domestic livestock, beginning in the mid-19th century and culminating at about the beginning of the present century, resulted in serious depletions of native herbaceous species. Liberal and irresponsible use of fire by whites early in this historical frontier period contributed to the damage to range resources imposed by excessive grazing. Efforts toward total fire prevention and suppression began late in the 19th century and have virtually eliminated fire as an agent in the environment. This sequence of events has occasioned an expansion of shrub populations in the study area. Photo-set comparisons examined as part of this study indicate that western juniper populations in east-central Oregon have expanded markedly since 1880. Climatic fluctuations in the study area during this historical frontier period may have exacerbated effects on vegetation of the shifting influence of fire and grazing.

Considering the four periods described above, two inversions of existing relationships between fire and grazing in the northern Great Basin may be identified with two frontier incursions of non-indigenous human culture. The first apparently increased the environmental force of fire and decreased that of native grazing; the second did the reverse.

During neither frontier period did a prevailing sense of cultural responsibility for land and natural resources exist. In the former, indigenous cultures had not yet developed or established traditional homelands; in the latter, native tribal proprietorships were disrupted by a relatively sudden transposition of authority. As aboriginal

settlement resolved from the first cultural frontier, native cultural standards developed in concert with the character of territorial habitats. Societal mores came to mitigate human conduct in accord with natural ecosystems. Though many separate settlement periods may have occurred during this extended time, punctuated by periods of cultural instability, it should be recalled that the Desert Archaic Culture remained virtually unchanged since its inception in the Great Basin, suggesting that instabilities, when they occurred, were relatively minor and locallized. During the second frontier period, free access to public lands and inordinate exploitaion of natural resources became the source of private opportunity. Soon it was apparent that this situation was neither publically nor privately progressive. Individual proprietorship of land and resources, generally in lieu of public, or cultural, responsibility, was then promoted as a preferable arrangement. 5) Settlement II (Modern): At about the turn of this century the development of modern cultural standards for natural resource conservation began. Various land management agencies have since been established at every level of government. But governmental regulation alone is insufficient. Today, and for the future, the need to culturally embrace a sense of genuine individual and public responsibility for land is crucial in resolving modern human prerogatives with natural necessities.

The National Park Service can lead this effort in three ways: 1) through the preservation of natural ecosystems; 2) through basic environmental research; 3) through public education. The National Park Service commitment to the restoration and maintenance of natural ecosystems transcends the nostalgic wish to regain a pristine environment. Knowledge derived through the study of undisturbed natural phenomena contributes fundamentally to the management of land beyond Park boundaries, where nature is subject to more rigorous cultural demands. And beyond this, a coordinated program of public education, placing man in nature through time, can promote a more intrinsic cultural perception of the natural heritage, character and capacity of the American

environment. Through these means the National Park Service can contribute uniquely to the development of modern culture toward greater accord with its foundations in nature.


Figure 1. Location map of fires and burned vegetation cited in historical journals.

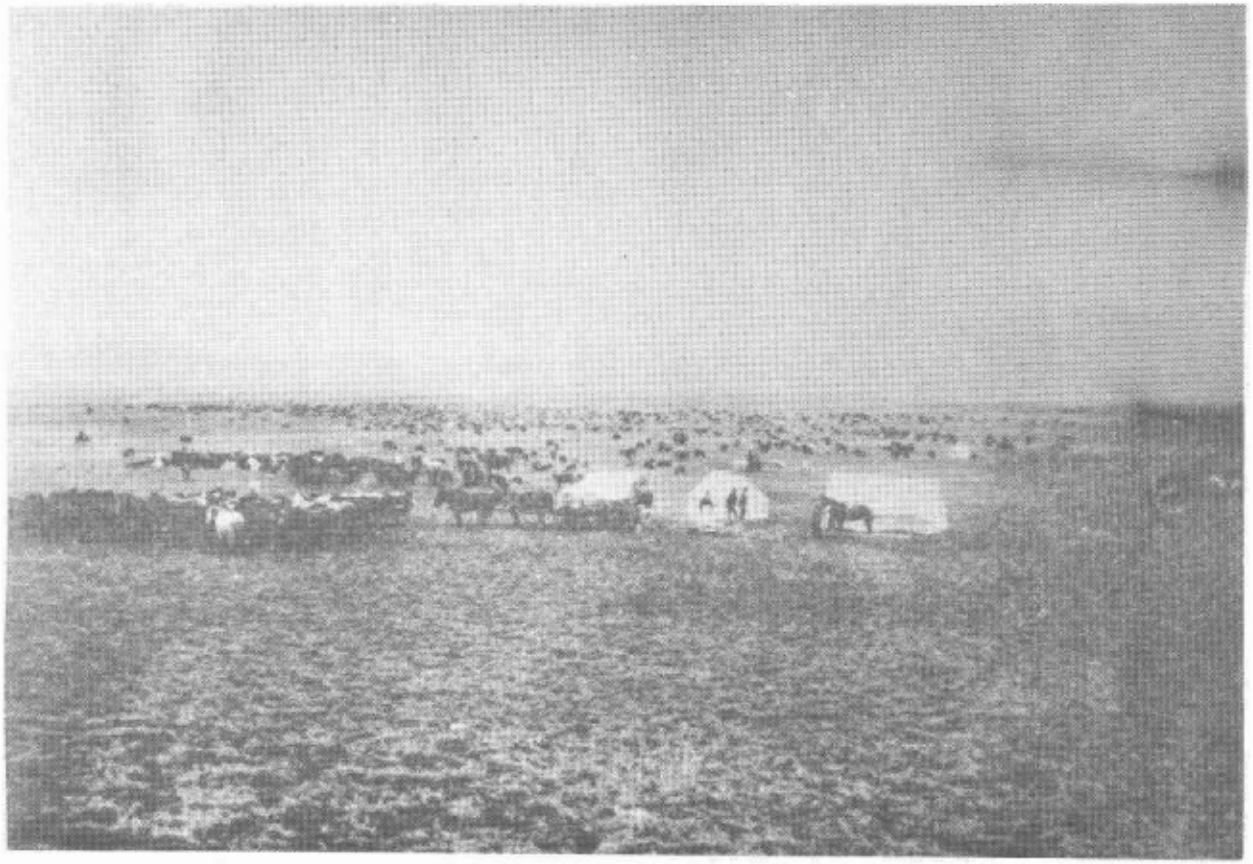


Figure 2. Early cattle round-up (2500 head) in Fox Valley, Grant County, Oregon.

Figure 3. Sheep shading in the forest on summer range, eastern Oregon.

Figure 4. Sheep on mountain pasture, eastern Oregon.

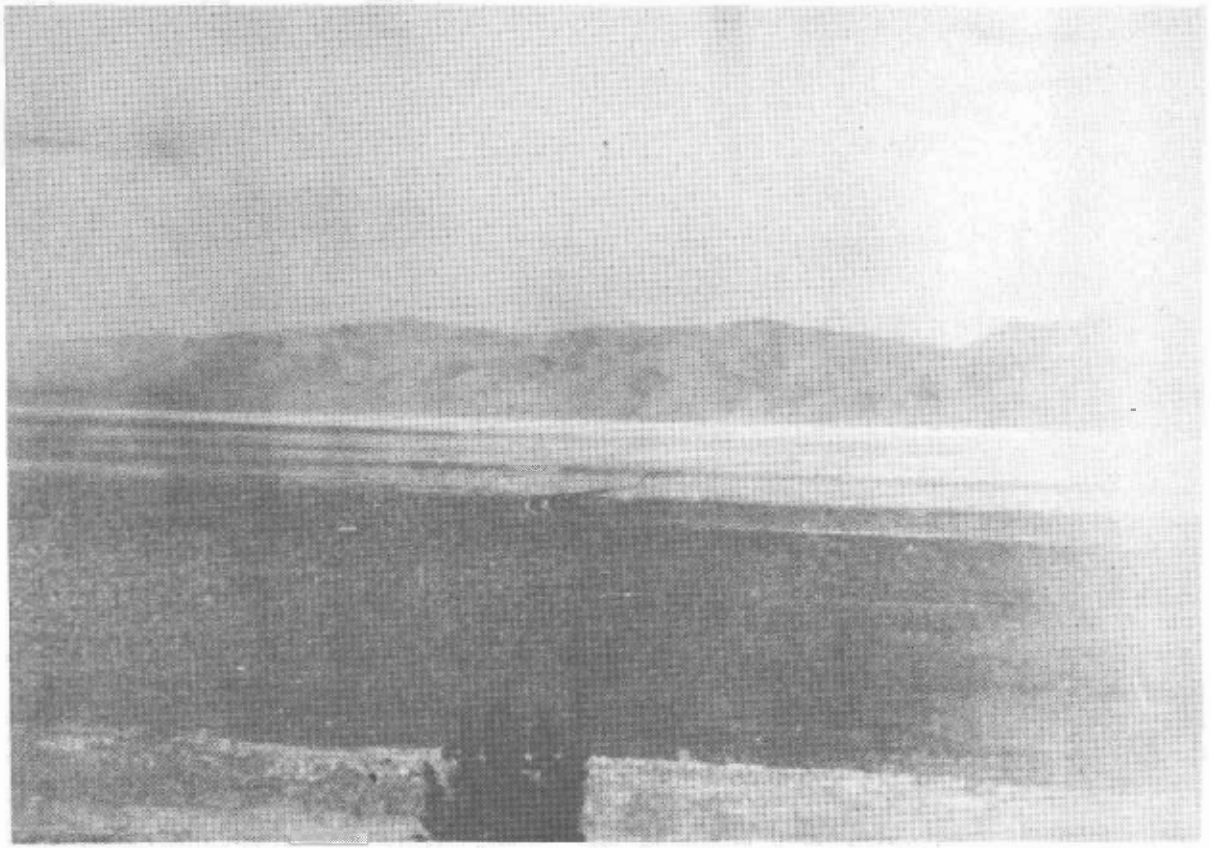
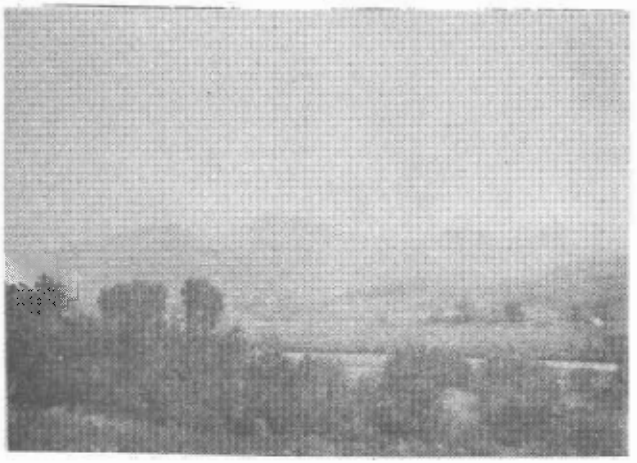


Figure 5. Immigrant road across the dry bed of Goose Lake.



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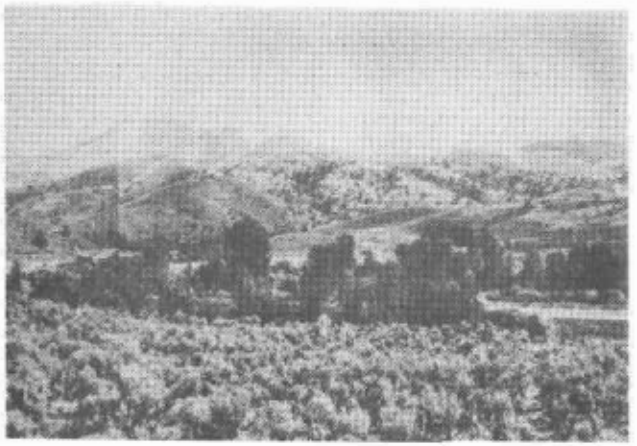

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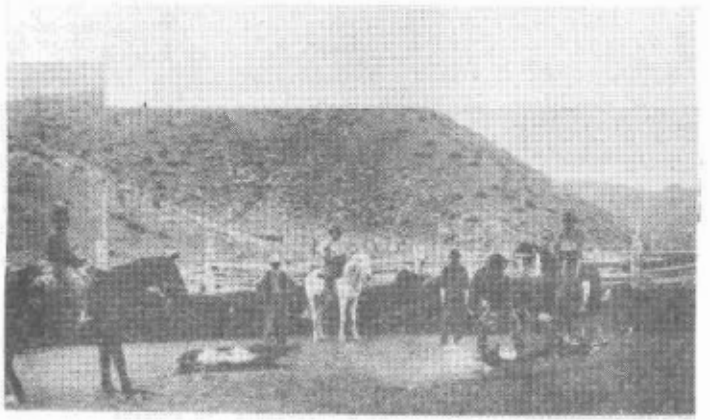
Figure 6. A. 1892. B. 1976.



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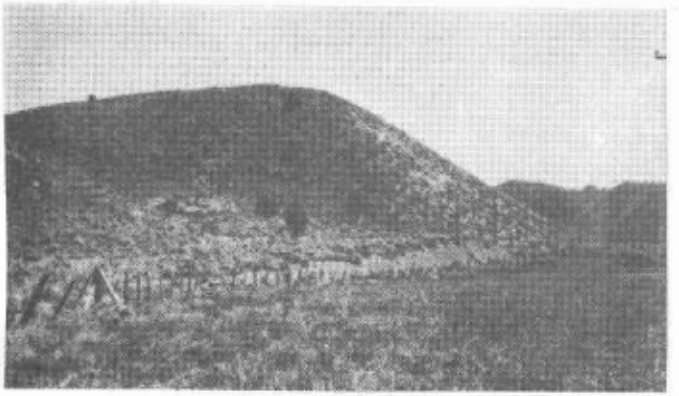

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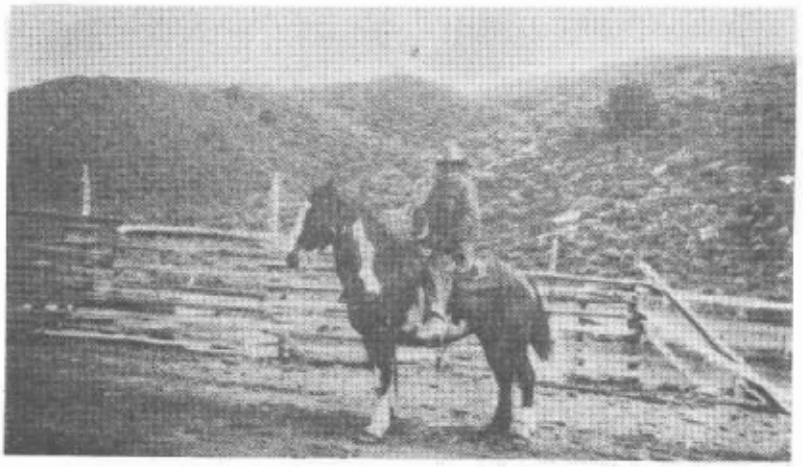
Figure 7. A. 1900. B. 1976.



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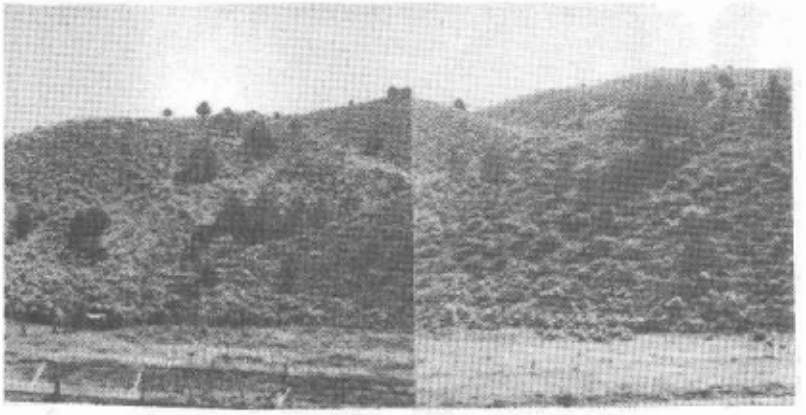

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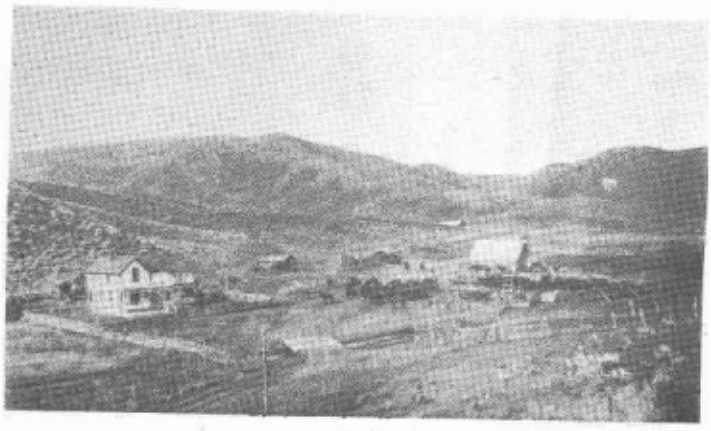
Figure 8. A. Early 1930's. B. 1976.



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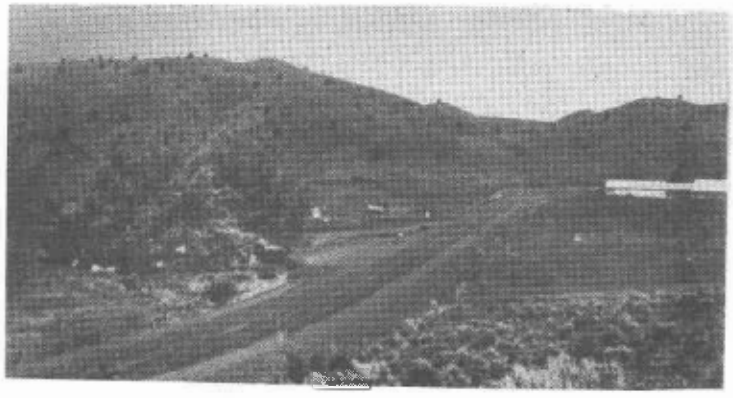

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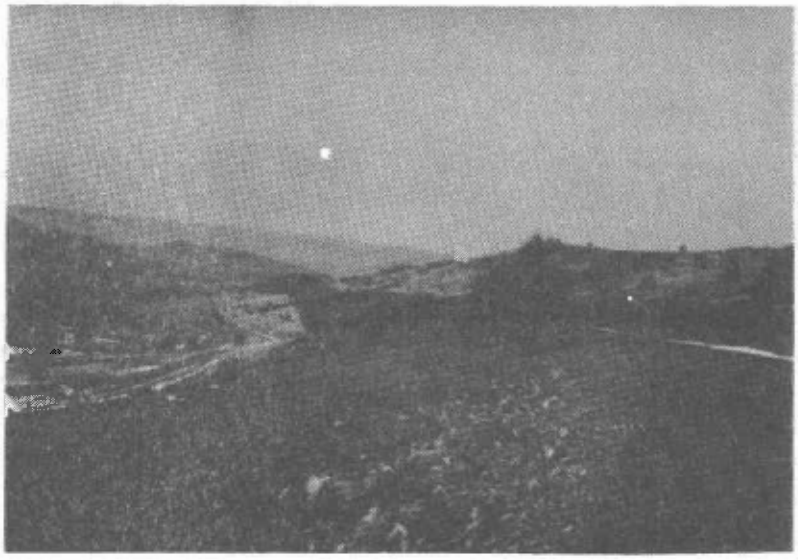
Figure 9. A. 1900. B. 1976.



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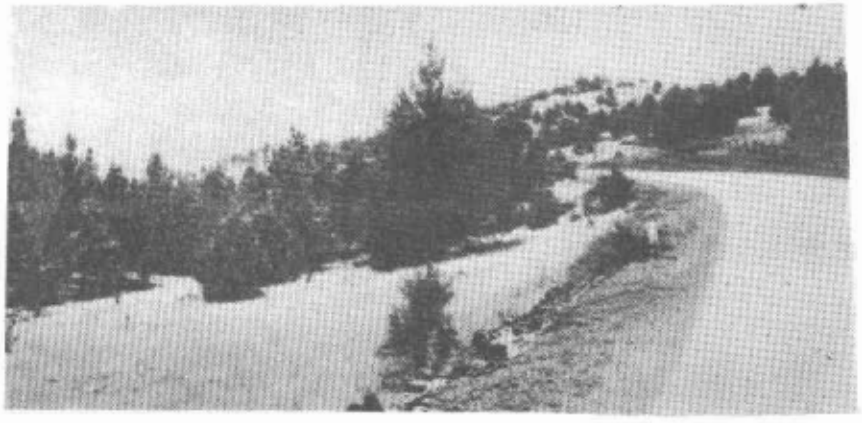


(B)

Figure 10. A. An overgrazed livestock driveway on the left reduced to bare soil by the early 1930's. Range vegetation on the right. B. Heavy juniper invasion of the driveway on the left and of the rangeland on the right. Ponderosa pine advances at extreme left.

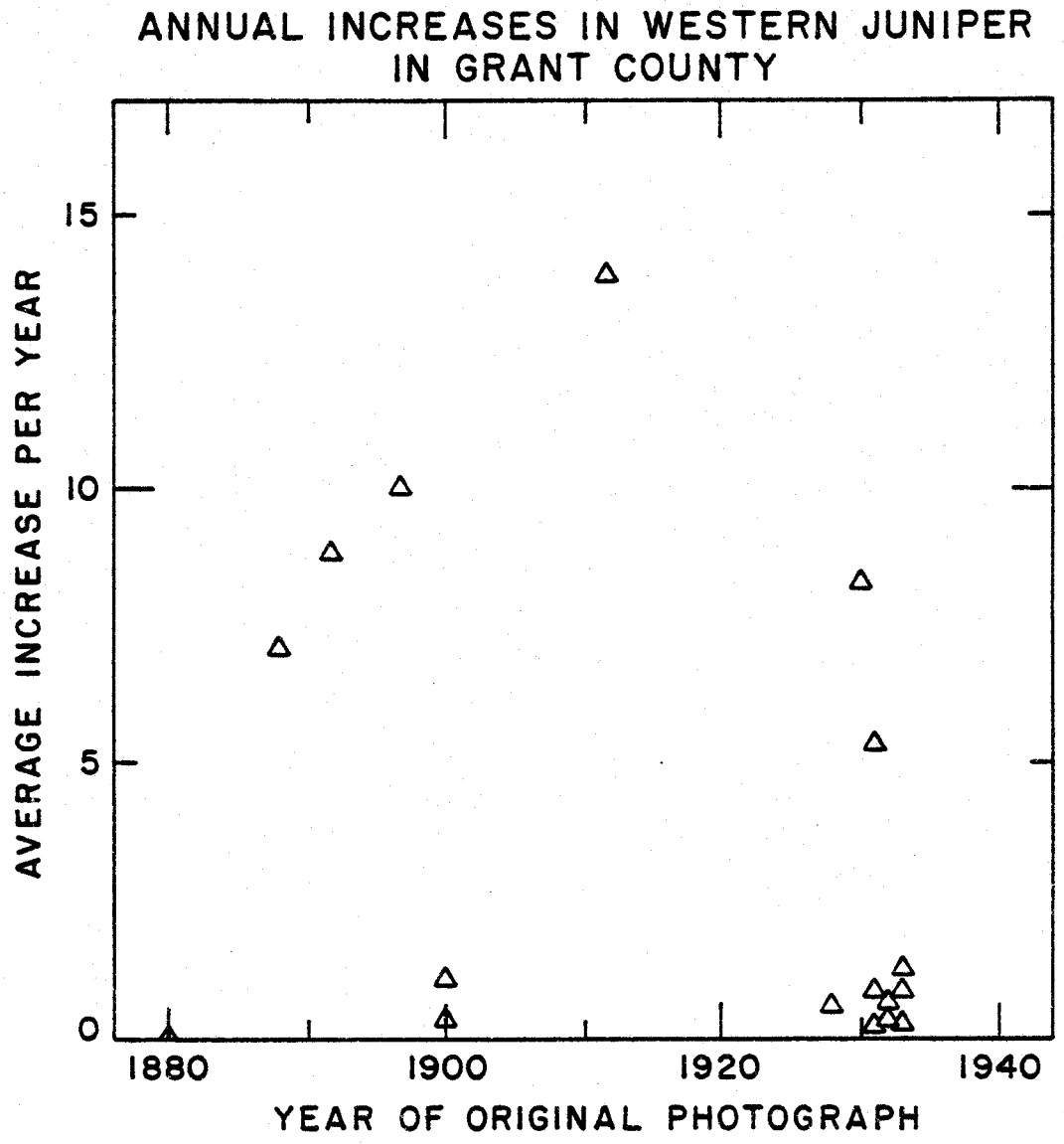
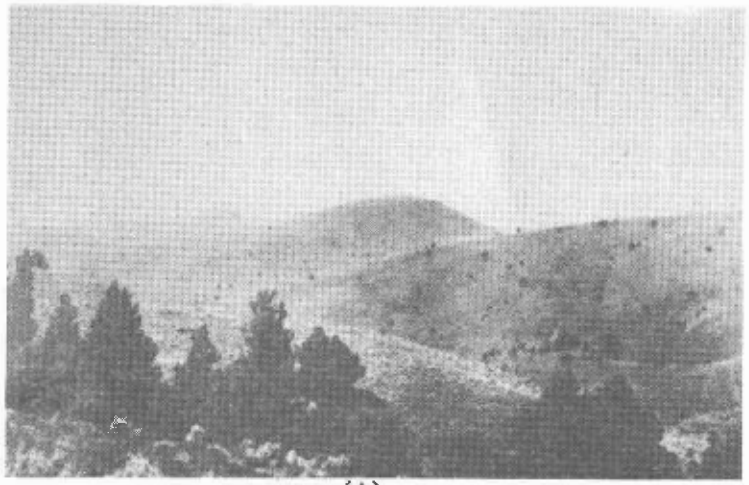



Figure 11. Average increase in numbers of Juniperus occidentalis per year in 17 photo-set comparisons.



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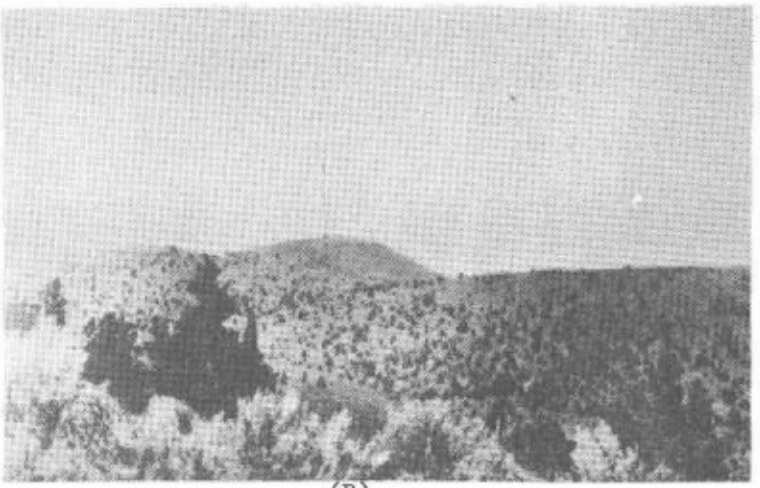

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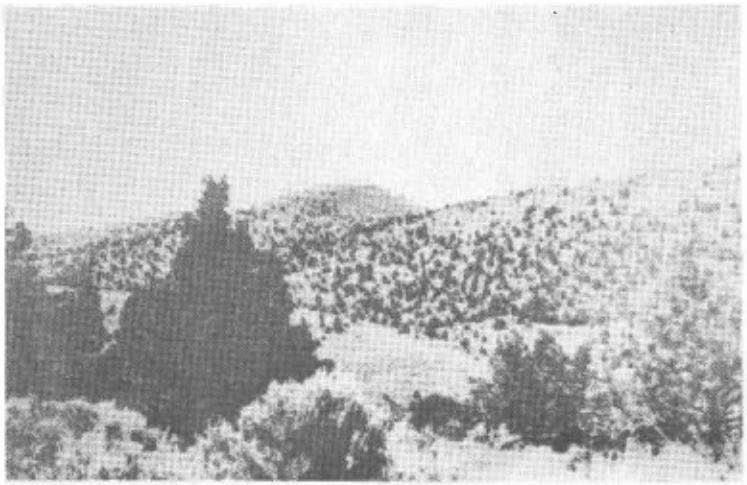

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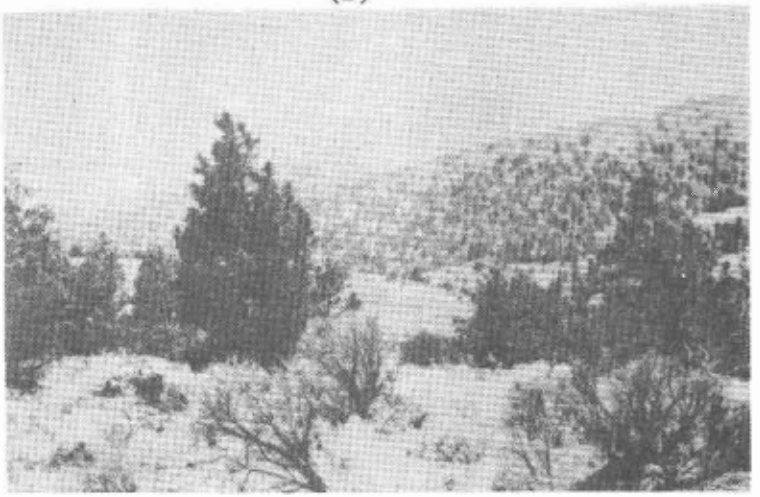


(D)

Figure 12. A. 1920. B. 1945. C. 1956. D. 1965.

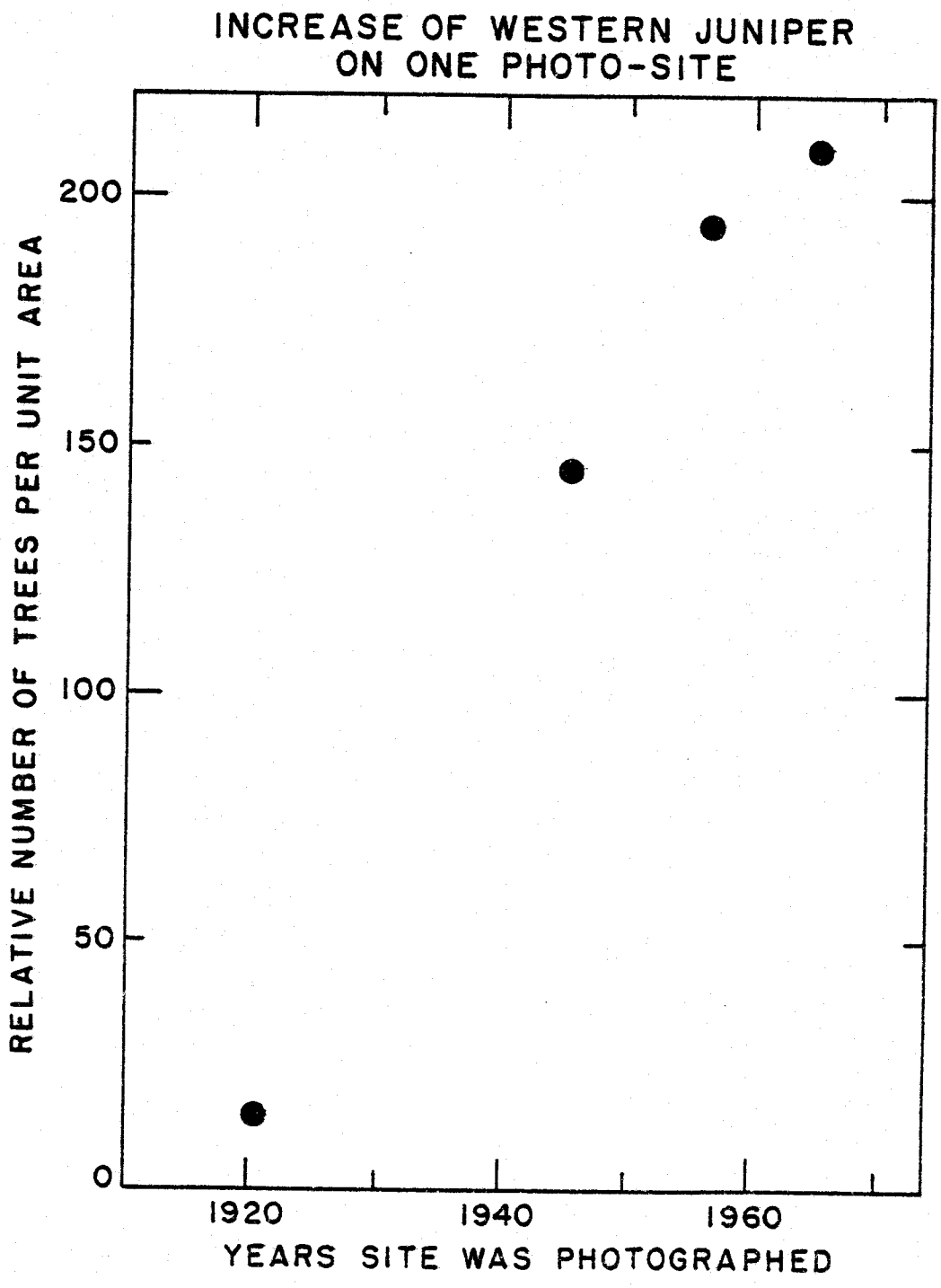



Figure 13. Increase in numbers of Juniperus occidentalis on one site from 1920 to 1965.

# BIBLIOGRAPHY

Agee, James K. 1974. Fire management in the National Parks. Western Wildlands 1(3):27-33.

Ballard, Arthur C. 1929. Mythology of southern Puget Sound. Univ. Wash. Publ. Anthr. 3(2):31-150.

Barney, M. A., and N. C. Frischknecht. 1974. Vegetation changes following fire in the pinyon-juniper type of west-central Utah. Range Mgmt 27(2):91-96.

Barrett, S. A. 1907. The material culture of the Klamath Lake and Modoc Indians of northeastern California and southern Oregon. Univ. Calif. Publ. Amer. Archeol. and Ethnol. 5(4):239-293.

Bartlett, H. H. 1956. Fire, primitive agriculture, and grazing in the tropics. In: Internat'l Symp. on Man's Role in Changing the Face of the Earth. Ed. by W. L. Thomas. Univ. of Chicago Press, Chicago. pp. 692-720.

Berreman, Joel V. 1937. Tribal distributions in Oregon. Mem. Amer. Anthr. Assoc. No. 47.

Blackburn, W. H., and P. T. Tueller. 1970. Pinyon and juniper invasion in black sagebrush communities in east-central Nevada. Ecol. 51(5):841-848.

Blaisdell, J. P. 1953. Ecological effects of planned burning of sagebrush-grass range on the upper Snake River plains. USDA Tech. Bull. 1075.

Boardman, Walter S. 1967. Wildfire and natural area preservation. Proc. 6th Ann. Tall timbers Fire Ecol. Conf., Tall Timbers Res. Sta. Tallahassee, Fla., pp. 135-142.

Boas, Franz. 1917. Folk-tales of Salishan and Sahaptin tribes. Amer. Folklore Soc. Vol. 11.

Bolton, Herbert E. 1950. Pageant in the wilderness. Utah State Hist. Quart. 18(1-4).

Bowman, Isaiah. 1935. Our expanding and contracting "desert." Geog. Review 25(1):43-61.

Chard, C. S. 1975. Man in Prehistory. McGraw-Hill Book Co. New York.

Christensen, N. L., and C. H. Muller. 1975. Efforts of fire on factors controlling plant growth in Adenostoma chaparral. Ecol. Monog. 45(1):29-55.

Cooper, H. W. 1953. Amounts of big sagebrush in plant communities near Tensleep, Wyoming, as affected by grazing treatment. Ecol. 34(1): 186-189.

Cottam, W. P., and G. Stewart. 1940. Plant succession as a result of grazing and of meadow desiccation by erosion since settlement in 1862. J. For. 38(8):613-626.

Cotton, J. S. 1904. A report on the range condition of central Washington. Wash. State Agri. Exp. Sta. Bull. 60.

Council for Agricultural Science and Technology. 1974. Livestock grazing on Federal lands in the 11 western states. J. Range Mgmt 27(3):174-181.

Curtin, Jeremiah. 1912. Myths of the Modocs. Little, Brown & Co. Boston.

Dana, Samuel T. 1956. Forest and range policy: its development in the U. S. McGraw-Hill Book Co., New York.

Daubenmire, Rexford F. 1940. Plant succession due to overgrazing in the Agropyron bunchgrass prairie of southeastern Washington. Ecol. 21(1):55-64.

Daubenmire, Rexford F. 1970. Steppe vegetation of Washington. Wash. Agri. Exp. Sta. Tech. Bull. 62.

Daubenmire, Rexford F. 1974. Plant succession on abandoned fields, and fire influences, in a steppe area in southeastern Washington. Northwest Science 48(3).

Dixon, Roland B. 1910. Shasta Myths. J. Amer. Folklore 23(87):8-37 and 23(89):364-370.

Dobzhansky, T. G. 1962. Mankind Evolving. Yale Univ. Press, New York.

Driscoll, Richard S. 1964. A relect area in the central Oregon juniper zone. Ecol. 45(2):345-353.

Driver, H. E. 1969. Indians of North America. Univ. of Chicago Press, Chicago.

Dunbar, Carl O. 1965. Historical Geology. John Wiley & Sons, New York.

Ellison, Lincoln. 1960. Influence of grazing on plant succession of rangelands. Bot. Review 26(1):1-78.

Fahnestock, George R. 1973. Use of fire in managing forest vegetation. Trans. ASAE 16(3):410-419.

Farnham, Thomas J. 1905. Travels in the Great Western Prairies, the Anahuac and Rocky Mountains, and in the Oregon Country. In: Early Western Travels, ed. by R. G. Thwaites. Arthur H. Clark Co., Cleveland.

Flint, Richard F. 1967. Glacial and Pleistocene Geology. John Wiley & Sons, New York.

Forbes, Alexander. 1839. California: a History of Upper and Lower California. Smith, Elder & Co., London.

Franchere, Gabriel. 1904. Narrative of a Voyage to the Northwest Coast of America in the Years 1811, 1812, 1813, and 1814 or the First American Settlement on the Pacific. In: Early Western Travels, ed. by R. G. Thwaites. Arthur H. Clark Co., Cleveland.

Franklin, J. F., and C. T. Dyrness. 1973. Natural Vegetation of Oregon and Washington. USDA For. Serv. Gen. Tech. Rep. PNW-8.

Frazer, J. G. 1930. Myths of the Origin of Fire. MacMillan & Co., New York.

Fremont, J. C. 1849. The Exploring Expedition to the Rocky Mountains, Oregon and California. G. H. Derby and Co., Buffalo.

Galbraith, W. A., and E. W. Anderson. 1971. Grazing history of the Northwest. J. Range Mgmt 24(1):6-12.

General Notes. 1930. Another record of the buffalo in Oregon. J. Mammalogy 11(3):320-321.

Goodwin, Grenville. 1939. Tales of White Mountain Apache. Mem. Amer. Folklore Soc. Vol. 33.

Graham, Edward H. 1956. The re-creative power of plant communities. In: Internat'l Symp. on Man's Role in Changing the Face of the Earth, ed. by W. L. Thomas. Univ. of Chicago Press, Chicago. pp. 677-691.

Griffiths, David. 1902. Forage conditions on the northern border of the Great Basin. USDA Bureau of Plant Industry Bull. No. 15.

Griffiths, David. 1903. Forage conditions and problems in eastern Washington, eastern Oregon, northeastern California and northwestern Nevada. USDA Bureau of Plant Industry Bull. No. 38.

Griffiths, David. 1910. A protected stock range in Arizona. USDA Bureau of Plant Industry Bull. No. 177.

Haines, Francis. 1938. Where did the Plains Indians get their horses? Amer. Anthr. 40(1):112-117.

Haines, Francis. 1966. Horses for western Indians. Amer. West 3(2): 4-15, 92.

Haines, Francis. 1967. Western limits of the buffalo range. Amer. West 4(4):4-12, 66-67.

Hall, Fredrick C. 1967. Vegetation-soil relations as a basis for resource management in the Ochoco National Forest of central Oregon. Doctoral thesis. Oregon State Univ., Corvallis.

Hansen, Henry P. 1947. Postglacial forest succession, climate and chronology in the Pacific Northwest. Trans. Amer. Phil. Soc. 37(1):1-130.

Harniss, R. C., and R. B. Murray. 1973. Thirty years of vegetal change following burning of sagebrush-grass range. J. Range Mgmt 26(5): 322-325.

Heady, Harold F. 1968. Grassland response to changing animal species. J. Soil and Water Conserv. 23(5):173-176.

Hind, Henry Y. 1859. Report on the Assiniboine and Saskatchewan Exploring Expedition of 1858. Published by authority of the Legislative Assembly, Toronto.

Hodgson, A. H. 1913. A history of the Ochoco National Forest. Unpublished material filed in the Ochoco National Forest Office. Prineville, Ore.

Hough, Walter. 1926. Fire as an agent in human culture. U. S. Nat'l Museum Bull. 139.

Humphrey, R. R. 1953. The desert grassland, past and present. J. Range Mgmt 6(3):159-164.

Humphrey, R. R. 1958. The desert grassland: a history of vegetational change and an analysis of causes. Bot. Review 24(4):193-252.

Humphrey, R. R. 1963. The role of fire in the desert and desert grassland areas of Arizona. Proc. 2nd Ann. Tall Timbers Fire Ecol. Conf., Tall Timbers Res. Sta. Tallahassee, Fla. pp. 45-61.

Humphrey, R. R. 1974. Deserts and desert grasslands of North America. In: Fire and Ecosystems, ed. by T. T. Kozlowski and C. E. Ahlgren. Academic Press, New York.

Irving, Washington. 1955. Adventures of Captain Bonneville. Binfords and Mort, Portland, Ore.

Jennings, Jesse D. 1968. Prehistory of North America. McGraw-Hill Book Co., New York.

Johnson, A. H., and G. A. Smathers. 1974. Fire history and ecology of Lava Beds National Monument. Proc. 15th Ann. Tall Timbers Fire Ecol. Cong., Tall Timbers Res. Sta., Tallahassee, Fla. pp. 103-115.

Judson, Katherine. 1910. Myths and legends of the Pacific Northwest. McClurg & Co., Chicago.

Keen, F. P. 1937. Climatic cycles in eastern Oregon as indicated by tree rings. Monthly Weather Review 65(5):175-188.

Kelly, Isabel T. 1938. Northern Paiute Tales. J. Amer. Folklore 51 (202):363-438.

Kilgore, B. M. 1976. From fire control to fire management: an ecological basis for policies. Trans. 41st N. Amer. Wildlife and Natural Res. Conf. Wildlife Mgmt Inst., Washington, D.C.

Komarek, E. V. 1962. Fire ecology. Proc. 1st Ann. Tall Timbers Fire Ecol. Conf., Tall Timbers Res. Sta., Tallahassee, Fla. pp. 95-107.

Komarek, E. V. 1965. Fire ecology--grasslands and man. Proc. 4th Ann. Tall Timbers Fire Ecol. Conf., Tall Timbers Res. Sta., Tallahassee, Fla. pp. 169-220.

Komarek, E. V. 1967. Fire--and the ecology of man. Proc. 6th Ann. Tall Timbers Fire Ecol. Conf., Tall Timbers Res. Sta., Tallahassee, Fla. pp. 143-170.

Langille, H. D. 1956. Mostly division "R" days: reminiscences of the stormy, pioneering days of the forest reserves. Ore. Hist. Quart. 57(4):301-313.

Leopold, A. S. 1924. Grass, brush, timber, and fire in southern Arizona. J. For. 22(6):1-10.

Lewis, M., and W. Clark. 1959. Original Journals of Lewis and Clark, ed. by R. G. Thwaites. Antiquarian Press, New York.

Lowie, Robert H. 1924. Shoshonean tales. J. Amer. Folklore 37(143): 1-242.

Mason, J. Alden. 1910. Myths of the Uintah Utes. J. Amer. Folklore 23(89):299-363.

Minto, John. 1900. The number and condition of the native race in Oregon when first seen by white men. Ore. Hist. Quart. 1(3): 296-315.

Moomaw, James C. 1957. Some effects of grazing and fire on vegetation in the Columbia Basin Region, Washington. Doctoral thesis. State College of Washington.

Moore, Conrad T. 1972. Man and fire in the central North American grasslands, 1535-1890. Doctoral thesis. Univ. of Calif., L. A.

National Park Service. 1970. Wildlife management in the National Parks. In: Administrative Policies for Natural Areas of the National Park System. USGPO, Wash., D. C.

National Park Service. 1975. Environmental Assessment for the Proposed Restoration of the Presettlement Vegetation Lava Beds National Monument, California. Manuscript on file at Lava Beds N. M.

Ogden, Peter S. 1961. Ogden's Snake Country Journal: 1826-1827, ed. by K. G. Davies. Hudson's Bay Record Soc., London.

Ogden, Peter S. 1971. Ogden's Snake Country Journal: 1827-1829, ed. by G. Williams. Hudson's Bay Record Soc., London.

Oliphant, J. Orin. 1948. History of livestock industry in the Pacific Northwest. Ore. Hist. Quart. 49(1):3-29.

Oliphant, J. Orin. 1968. On the Cattle Range of the Oregon Country. Univ. of Wash. Press, Seattle.

Opler, Morris E. 1942. Myths and tales of the Chiricahua Apache Indians. Mem. Amer. Folklore Soc. Vol. 37.

Palmer, Joel. 1906. Journal of Travels over the Rocky Mountains to the Mouth of the Columbia River; Made during the Years 1845 and 1846. In: Early Western Travels, ed. by R. G. Thwaites. Arthur H. Clark Co., Cleveland.

Poirier, F. E. 1974. In Search of Ourselves. Burgess Publ. Co., Minneapolis.

Rakestraw, Lawrence. 1958. Sheep grazing in the Cascade Range: John Minto vs. John Muir. Pac. Hist. Review 27(4):371-382.

Ray, V. F. 1971. Lewis and Clark and the Nez Perce Indians. Potomac Corral, The Westerners, Washington, D. C.

Reichard, Gladys A. 1947. An analysis of Coeur d'Alene Indian Myths. Mem. Amer. Folklore Soc. Vol. 41.

Robbins, William. 1974. Land: its use and abuse in Oregon, 1848-1910. In: Man and His Activities as They Relate to Environmental Quality in Oregon. Oregon State Univ., Corvallis.

Roe, Frank G. 1970. The North American Buffalo: A Critical Study of the Species in its Wild State. Univ. of Toronto Press, Toronto.

Rymon, L. M. 1969. A critical analysis of wildlife conservation in Oregon. Doctoral thesis. Oregon State Univ., Corvallis.

Sauer, C. O. 1944. A geographical sketch of early man in America. Geog. Review 34(4):529-573.

Sauer, C. O. 1947. Early relations of man to plants. Geog. Review 37(1):1-25.

Sauer, C. O. 1950. Grassland climax, fire and man. J. Range Mgmt 3(1):16-21.

Sauer, C. O. 1956. The agency of man on the earth. In: Internat'l Symp. on Man's Role in Changing the Face of the Earth, ed. by W. L. Thomas. Univ. of Chicago Press, Chicago.

Spencer, R. F., and J. D. Jennings. 1965. The Native Americans. Harper and Row, New York.

Spinden, H. L. 1907. The Nez Perce Indians. Mem. Amer. Anthr. Assoc. 3(3):165-274.

Stansbury, H. 1852. An Expedition to the Valley of the Great Salt Lake of Utah. Sampson Low, Son and Co., London.

Steward, Julian H. 1936. Myths of the Owens Valley Paiute. Univ. Calif. Publ. Archeol. and Ethnol. 34(5):355-440.

Stewart, Omer C. 1951. Burning and natural vegetation in the United States. Geog. Review 41(2):317-320.

Stewart, Omer C. 1956. Fire as the first great force employed by man. In: Internat'l Symp. on Man's Role in Changing the Face of the Earth, ed. by W. L. Thomas. Univ. of Chicago Press, Chicago.

Stewart, Omer C. 1963. Barriers to understanding the influence of use of fire by aborigines on vegetation. Proc. 2nd Ann. Tall Timbers Fire Ecol. Conf., Tall Timbers Res. Sta., Tallahassee, Fla. pp. 117-126.

Stoddart, L. A., and A. D. Smith. 1943. Range Management. McGraw-Hill Book Co., New York.

Strong, Dexter K. 1940. Beef cattle industry in Oregon 1890-1938. Ore. Hist. Quart. 41(1):251-287.

Strong, Emory. 1969. Stone Age in the Great Basin. Binford & Mort, Portland.

Sweeney, James R. 1968. Ecology of some "fire type" vegetation in northern California. Proc. 7th Ann. Tall Timbers Fire Ecol. Conf., Tall Timbers Res. Sta., Tallahassee, Fla. pp. 111-125.

Thornber, J. J. 1910. Grazing ranges of Arizona. Ariz. Agri. Exp. Sta. Bull. 65. pp. 245-360.

Tisdale, E. W., M. Hironaka and M. A. Fosberg. 1969. The sagebrush region of Idaho. Univ. Idaho Agri. Exp. Sta. Bull. 512.

Townsend, John K. 1905. Narrative of Journey Across the Rocky Mountains to the Columbia River and a Visit to the Sandwich Islands, Chili, and with a Scientific Appendix. In: Early Western Travels, ed. by R. G. Thwaites. Arthur H. Clark Co., Cleveland.

Turner, W. M. 1873. Scraps of Modoc History. Overland 11(21):21-25.

United States Census. 1860-1969.

United States Census of Agriculture. 1925-1969.

Wedel, Waldo R. 1961. Prehistoric Man on the Great Plains. Univ. of Oklahoma Press, Norman.

Whitehouse, Joseph. 1959. The Original Journal of Private Joseph Whitehouse. In: Original Journals of Lewis and Clark, ed. by R. G. Thwaites. Antiquarian Press, New York.

Willard, E. E., and C. M. McKell. 1973. Total herbage production and harvest yield as related to simulated grazing systems. Utah State Univ. Agri. Exp. Sta. Res. Report 10.

Wooton, E. O. 1916. Carrying capacity of grazing ranges in southern Arizona. USDA Bull. 367.

Wormington, H. M. 1964. Ancient Man in North America. Denver Museum of Natural History, Denver.

Wright, Henry A. 1972. Shrub Response to fire. USDA Gen. Tech. Rep. INT-1, Intermountain For. & Range Exp. Sta. Ogden, Utah.

Wright, Henry A. 1974. Range burning. J. of Range Mgmt 27(1):5-11.

Wright, Henry A., and C. M. Britton. 1976. Effects of fire on vegetation in western rangeland communities. Taken from "The Role of Prescribed Burning in Western Range and Woodland Ecosystems--Symposium Proceedings no. 3, Utah State Agri. Exp. Sta., Logan, Utah. (Unpublished)

# APPENDICES

# APPENDIX A

The mythic events take place prior to the existence of human-kind: 71.4%

(Achomawi)
Modoc
Nez Perce
Northern Paiute
Southern Paiute
(Shasta)
(Sia)
Uintah Ute
(Nishinam)
(Maidu)
Nootka
(Thompson-2)
(Lillooet-1)
(Okanaken)
Sanpoil
(Chilcotin)
(Kaska)
Tlingit-2
(Southern Ute)
(Owens Valley Paiute-1)
Chiricahua Apache
Puyallup
(White Mountain Apache)
(Lillooet-2)
(Owens Valley Paiute-2)

The mythic events take place at the time of the coming of man: 20%

Navaho
Jicarilla Apache
(Karok)
Awikenoq
Tsimshian
Thompson-1
Haida

The original fire is kept by a fire-owner(s); "the people" have no fire: 100%

(Achomawi)
Modoc
Nez Perce
Northern Paiute
Southern Paiute
Shasta
Sia
Navaho
Uintah Ute
Jicarilla Apache
Karok
Nishinam
Maidu
Nootka
Kwakiutl
Awikenoq
Tsimshian
Thompson-1
Thompson-2
Lillooet-1
Lillooet-2
Okanaken
Sanpoil
Chilcotin
Kaska
Babine
Haida
(Tlingit-1)
Tlingit-2
Southern Ute
Owens Valley Paiute-1
Owens Valley Paiute-2
Chiricahua Apache
Puyallup
White Mountain Apache

A journey is made to acquire fire: 82.8%

Achomawi
Modoc
Northern Paiute
Southern Paiute
(Shasta)
Sia
Jicarilla Apache
Uintah Ute
Karok
Nishinam
Maidu
(Nootka)
(Kwakiutl)
Awikenoq
Tsimshian
Thompson-1
Thompson-2
Lillooet-1
Lillooet-2
Okanaken
Sanpoil
(Chilcotin)
Tlingit-1
Tlingit-2
Southern Ute
Owens Valley Paiute-1
Owens Valley Paiute-2
Chiricahua Apache
Puyallup

The original fire-owner(s) is deprived of fire: 48.6%

(Achomawi)
Modoc
Northern Paiute
Southern Paiute
(Nez Perce)
Shasta
Uintah Ute
(Maidu)
(Thompson-1)
(Thompson-2)
(Lillooet-1)
Chilcotin
Kaska
(Southern Ute)
Owens Valley Paiute-1
Owens Valley Paiute-2
(Puyallup)

Fire is obtained through a stealthy, surreptitious or pretentious visitation: 97.1%

Achomawi
Modoc
Nez Perce
Northern Paiute
Southern Paiute
Shasta
Sia
Navaho
Jicarilla Apache
Thompson-1
Thompson-2
Lillooet-1
Lillooet-2
Okanaken
Sanpoil
Chilcotin
Kaska
Babine

Uintah Ute
Karok
(Nishinam)
Maidu
Nootka
Kawkiutl
Awikenoq
Tsimshian
Haida
Tlingit-2
Southern Ute
Owens Valley Paiute-1
Owens Valley Paiute-2
Chiricahua Apache
Puyallup
White Mountain Apache

The original fire is stolen: 94.3%

Achomawi
Modoc
Nez Perce
Northern Paiute
Southern Paiute
Shasta
Sia
Navaho
Jicarilla Apache
Uintah Ute
Karok
Nishinam
Maidu
Nootka
Kwakiutl
Awikenoq
Tsimshian
Thompson-1
Thompson-2
Lillooet-1
Okanaken
Sanpoil
Chilcotin
(Kaska)
Babine
Haida
Tlingit-2
Southern Ute
(Owens Valley Paiute-1)
Owens Valley Paiute-2
Chiricahua Apache
Puyallup
White Mountain Apache

Flight with fire after acquisition: 97.1%

Achomawi
Modoc
Nez Perce
Northern Paiute
Southern Paiute
Shasta
Sia
Navaho
Jicarilla Apache
Uintah Ute
Karok
Nishinam
Maidu
Nootka
Kwakiutl
Awikenoq
Tsimshian
Thompson-1
Thompson-2
Lillooet-1
(Lillooet-2)
Okanaken
Sanpoil
Chilcotin
Kaska
Babine
Haida
Tlingit-2
Southern Ute
Owens Valley Paiute-1
Owens Valley Paiute-2
Chiricahua Apache
(Puyallup)
White Mountain Apache

Flight with fire by relay: 37.1%

Modoc
Southern Paiute
Shasta
Navaho
Jicarilla Apache
Karok
Thompson-2
Kaska
Southern Ute
Owens Valley Paiute-1

Uintah Ute
Owens Valley Paiute-2
White Mountain Apache

Fire is scattered over the land: 45.7%

(Nez Perce)
(Southern Paiute)
Shasta
Jicarilla Apache
Nishinam
(Nootka)
Kwakiutl
Awikenoq
Thompson-1
Thompson-2
Chilcotin
Haida
(Tlingit-1)
Chiricahua Apache
(Puyallup)
White Mountain Apache

Transgenesis of man: 11.4%

Northern Paiute
Southern Paiute
(Southern Ute)
(Puyallup)

LIVESTOCK INVENTORY FOR WASHINGTON, OREGON, EASTERN OREGON AND WESTERN OREGON FROM 1850 THROUGH 1969

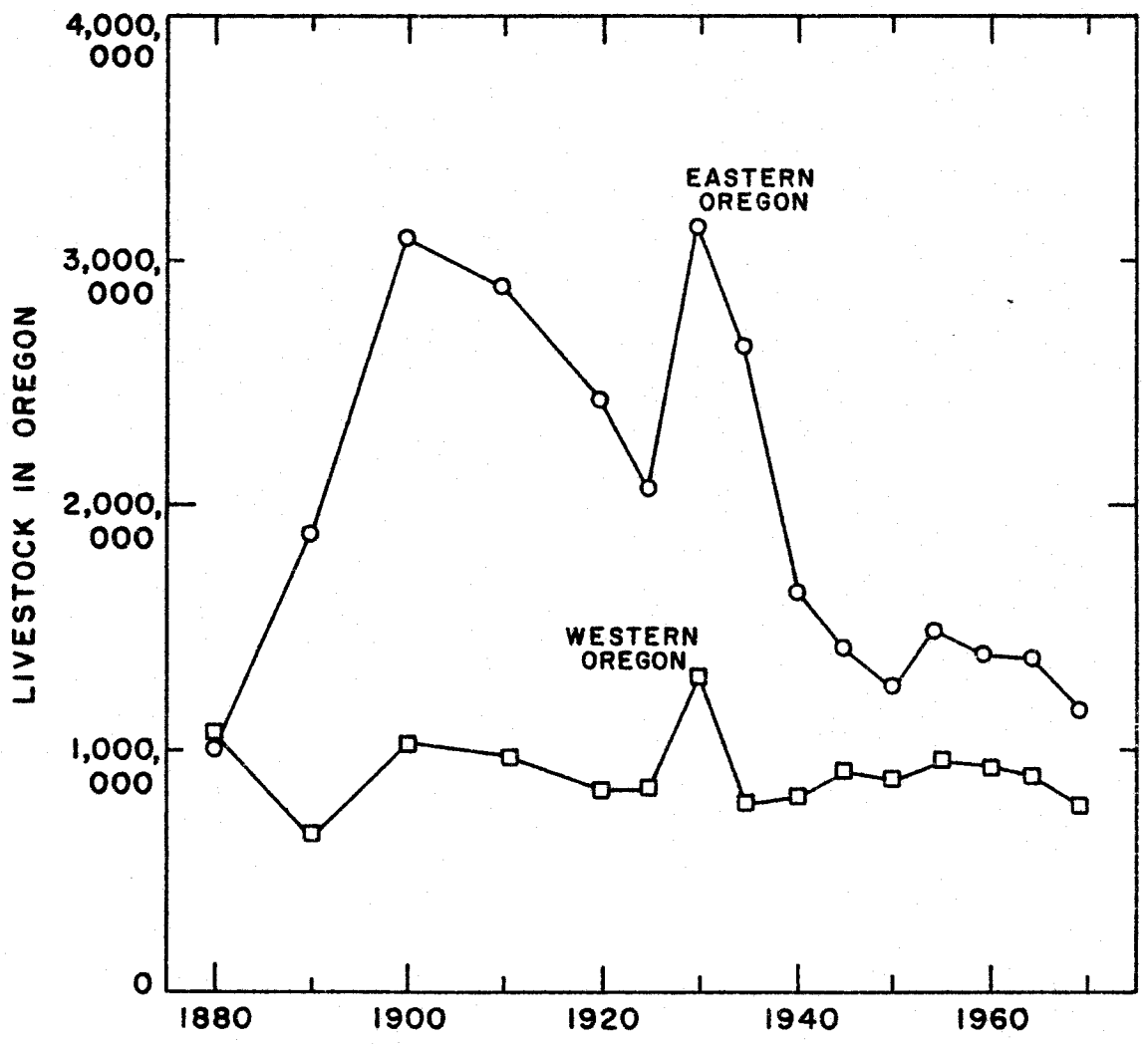
| Year | Region | Horses | Mules Asses Burros | Goats | Sheep | All Cattle | | | All Livestock | Sheep and Cattle [Other Than Milk Cows] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Milk Cows | Other Cattle | Total | | |
| 1850 | Washington | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| | Oregon | 8,046 | 420 | n.a. | 15,382 | 9,427 | 32,302 | 41,729 | 65,577 | 47,684 |
| | E. Oregon | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| | W. Oregon | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| 1860 | Washington | 4,772 | 159 | n.a. | 10,157 | 9,660 | 18,799 | 28,459 | 43,547 | 28,956 |
| | Oregon | 36,772 | 980 | n.a. | 86,052 | 53,170 | 100,961 | 154,131 | 277,935 | 187,013 |
| | E. Oregon | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| | W. Oregon | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| 1870 | Washington | 11,138 | 943 | n.a. | 44,063 | 16,938 | 30,316 | 47,254 | 103,398 | 74,379 |
| | Oregon | 51,702 | 2,581 | n.a. | 318,123 | 48,325 | 71,872 | 120,197 | 492,603 | 389,995 |
| | E. Oregon | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| | W. Oregon | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| 1880 | Washington | 45,848 | 626 | n.a. | 388,883 | 27,622 | 170,562 | 198,184 | 633,541 | 559,445 |
| | Oregon | 124,107 | 2,804 | n.a. | 1,368,162 | 59,549 | 538,466 | 598,015 | 2,093,088 | 1,906,628 |
| | E. Oregon | 72,403 | 1,178 | n.a. | 656,662 | 14,566 | 277,618 | 292,184 | 1,022,428 | 934,280 |
| | W. Oregon | 51,704 | 1,626 | n.a. | 711,500 | 44,983 | 260,848 | 305,831 | 1,070,630 | 972,348 |
| 1890 | Washington | 153,770 | 1,345 | n.a. | 265,267 | 70,721 | 184,413 | 255,134 | 675,516 | 449,680 |
| | Oregon | 224,962 | 4,946 | n.a. | 1,760,312 | 114,156 | 406,492 | 520,648 | 2,530,868 | 2,186,804 |
| | E. Oregon | 159,541 | 3,612 | n.a. | 1,431,577 | 40,629 | 250,952 | 291,581 | 1,886,311 | 1,682,529 |
| | W. Oregon | 65,421 | 1,334 | n.a. | 348,735 | 73,527 | 155,540 | 229,067 | 644,557 | 504,275 |
| 1900 | Washington | 243,985 | 2,850 | 2,876 | 929,875 | 107,232 | 287,691 | 394,923 | 737,609 | 1,217,566 |
| | Oregon | 287,932 | 7,751 | 109,661 | 3,040,291 | 122,447 | 577,856 | 700,303 | 4,145,938 | 3,618,147 |
| | E. Oregon | 206,398 | 6,091 | 7,658 | 2,531,805 | 36,028 | 324,565 | 360,593 | 3,112,545 | 2,856,370 |
| | W. Oregon | 81,534 | 1,660 | 102,003 | 508,486 | 86,419 | 323,709 | 339,710 | 1,033,393 | 761,777 |
| 1910 | Washington | 280,572 | 12,358 | 8,621 | 475,555 | 186,233 | 215,887 | 402,120 | 1,179,226 | 691,442 |
| | Oregon | 271,708 | 10,475 | 185,411 | 2,699,135 | 172,550 | 552,705 | 725,255 | 3,891,984 | 3,251,840 |
| | E. Oregon | n.a. | n.a. | n.a. | 2,249,279 | n.a. | 345,440 | n.a. | 2,899,528 | 2,594,719 |
| | W. Oregon | n.a. | n.a. | n.a. | 449,856 | n.a. | 207,265 | n.a. | 992,456 | 657,121 |
| 1920 | Washington | 296,381 | 23,490 | 6,830 | 623,779 | 238,270 | 334,374 | 572,644 | 1,523,124 | 958,153 |
| | Oregon | 271,559 | 15,112 | 133,685 | 2,002,378 | 180,462 | 670,646 | 851,108 | 3,273,842 | 2,673,024 |
| | E. Oregon | 181,896 | 13,053 | 4,779 | 1,710,801 | 65,418 | 479,087 | 544,505 | 2,443,034 | 2,189,888 |
| | W. Oregon | 89,663 | 2,059 | 128,906 | 291,577 | 115,044 | 191,559 | 306,603 | 830,808 | 483,136 |

LIVESTOCK INVENTORY (Cont.)

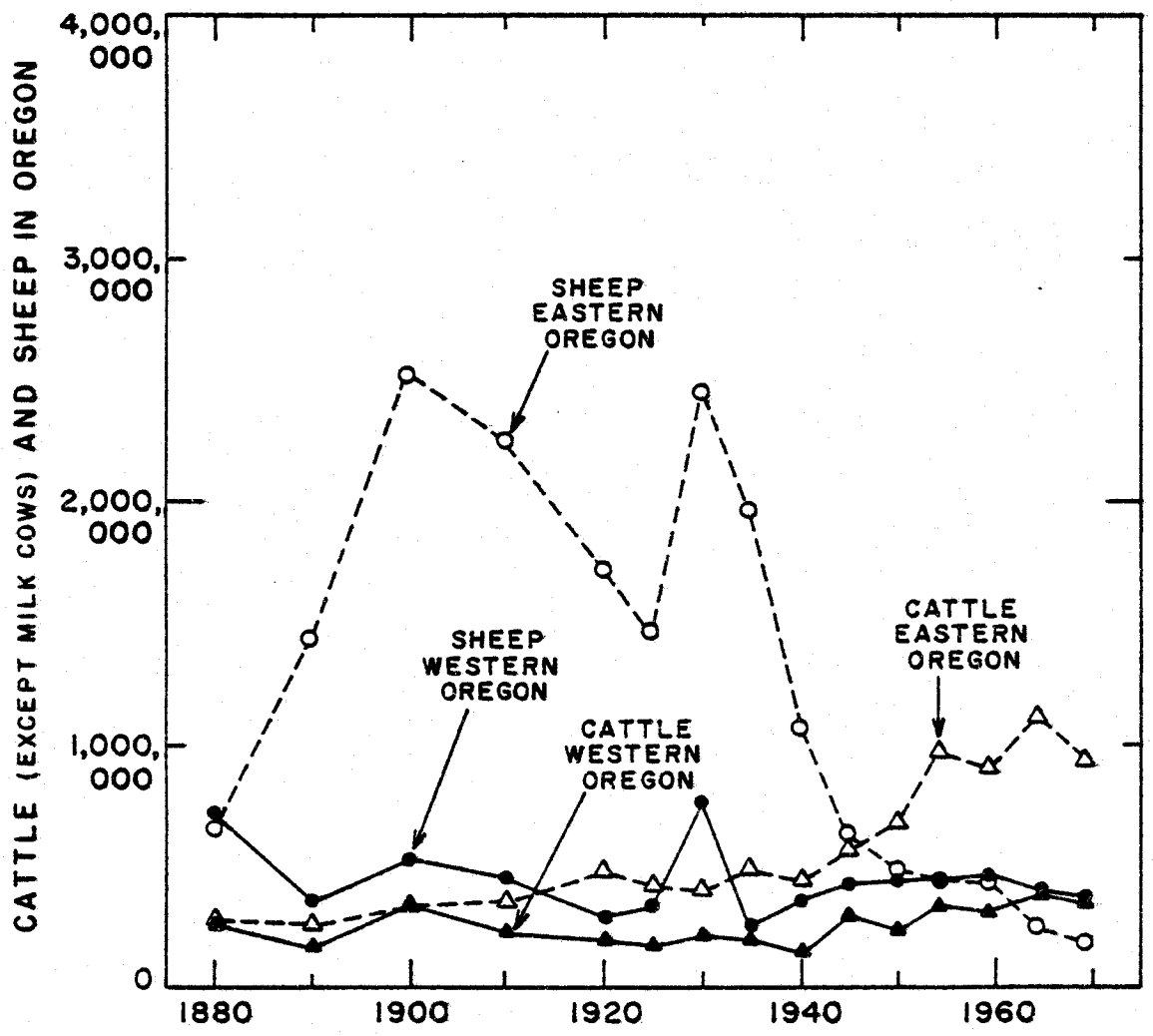
| Year | Region | Horses | Mules Asses Burros | Goats | Sheep | All Cattle | | | All Livestock | Sheep and Cattle Other Than Milk Cows |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Milk Cows | Other Cattle | Total | | |
| 1925 | Washington | 242,099 | 26,417 | 5,586 | 515,798 | 266,216 | 315,498 | 581,714 | 848,614 | 831,296 |
| | Oregon | 223,848 | 19,062 | 121,193 | 1,775,093 | 205,057 | 579,402 | 784,459 | 2,923,655 | 2,354,495 |
| | E. Oregon | 147,943 | 16,914 | 1,220 | 1,454,360 | 56,668 | 408,369 | 465,037 | 2,085,474 | 1,862,729 |
| | W. Oregon | 75,905 | 2,148 | 119,973 | 320,733 | 148,389 | 171,033 | 319,422 | 838,181 | 491,766 |
| 1930 | Washington | 182,503 | 22,483 | 11,401 | 1,142,603 | 243,869 | 380,868 | 624,737 | 1,983,727 | 1,523,471 |
| | Oregon | 178,875 | 13,974 | 138,349 | 3,319,271 | 206,404 | 598,716 | 805,120 | 4,455,589 | 3,917,987 |
| | E. Oregon | 118,734 | 11,108 | 2,309 | 2,561,373 | 60,702 | 396,874 | 457,576 | 3,151,100 | 2,958,247 |
| | W. Oregon | 60,141 | 2,866 | 136,040 | 757,898 | 145,702 | 201,842 | 347,544 | 1,304,489 | 959,740 |
| 1935 | Washington | 172,155 | 20,347 | n.a. | 747,901 | 311,509 | 429,303 | 740,812 | 1,681,215 | 1,177,204 |
| | Oregon | 161,279 | 9,792 | 124,031 | 2,209,898 | 250,573 | 677,404 | 927,977 | 3,432,977 | 2,887,302 |
| | E. Oregon | 102,487 | 6,987 | 2,232 | 1,962,126 | n.a. | 480,957 | 579,505 | 2,653,337 | 2,443,083 |
| | W. Oregon | 58,792 | 2,805 | 121,799 | 247,772 | n.a. | 186,447 | 348,472 | 779,640 | 444,219 |
| 1940 | Washington | 129,570 | 5,332 | 12,719 | 487,256 | 330,173 | 368,295 | 698,468 | 1,333,345 | 847,551 |
| | Oregon | 135,800 | 4,399 | 102,087 | 1,422,969 | 256,795 | 542,254 | 799,049 | 2,464,304 | 1,965,223 |
| | E. Oregon | 84,717 | 2,309 | 1,837 | 1,076,901 | 72,919 | 417,813 | 490,732 | 1,656,496 | 1,494,714 |
| | W. Oregon | 51,083 | 2,090 | 100,250 | 346,068 | 183,876 | 124,441 | 308,317 | 807,808 | 470,509 |
| 1945 | Washington | 99,219 | 2,629 | 13,136 | 446,749 | 315,586 | 594,269 | 909,855 | 1,471,588 | 1,041,017 |
| | Oregon | 108,267 | 3,495 | 76,443 | 1,032,040 | 240,446 | 860,575 | 1,101,021 | 2,321,266 | 1,892,615 |
| | E. Oregon | 70,734 | 2,448 | 1,503 | 616,377 | n.a. | 567,980 | 723,185 | 1,414,247 | 1,184,357 |
| | W. Oregon | 37,533 | 1,047 | 74,940 | 415,663 | n.a. | 292,595 | 377,836 | 907,019 | 708,258 |
| 1950 | Washington | 61,698 | 1,857 | n.a. | 368,334 | 254,302 | 623,898 | 878,200 | 1,310,089 | 992,232 |
| | Oregon | 72,013 | 2,527 | 47,922 | 913,435 | 203,817 | 895,307 | 1,099,124 | 2,135,021 | 1,808,742 |
| | E. Oregon | 47,395 | 1,528 | 1,124 | 485,158 | 49,915 | 673,991 | 723,906 | 1,259,111 | 1,159,149 |
| | W. Oregon | 24,618 | 999 | 46,799 | 428,277 | 153,902 | 221,316 | 375,218 | 875,910 | 649,593 |
| 1954 | Washington | 39,800 | | n.a. | 251,853 | 246,928 | 878,976 | 1,125,904 | 1,417,557 | 1,130,829 |
| | Oregon | 49,682 | | 39,843 | 860,650 | 196,589 | 1,293,566 | 1,490,155 | 2,440,330 | 2,154,216 |
| | E. Oregon | 34,247 | | 797 | 434,569 | 49,235 | 973,643 | 1,022,878 | 1,492,491 | 1,408,212 |
| | W. Oregon | 15,435 | | 39,046 | 426,081 | 147,354 | 319,923 | 467,277 | 947,839 | 746,004 |
| 1959 | Washington | 37,517 | | n.a. | 313,055 | 217,467 | 931,934 | 1,149,901 | 1,500,473 | 1,244,989 |
| | Oregon | 44,402 | | 27,867 | 886,525 | 152,226 | 1,201,979 | 1,354,205 | 2,312,999 | 2,088,504 |
| | E. Oregon | 28,849 | | 557 | 424,784 | 35,644 | 900,025 | 935,669 | 1,389,859 | 1,324,809 |
| | W. Oregon | 15,553 | | 27,310 | 461,741 | 116,582 | 301,954 | 418,536 | 923,140 | 763,695 |

LIVESTOCK INVENTORY (Cont.)

| Year | Region | Horses | Mules Asses Burros | Goats | Sheep | All Cattle | | | All Livestock | Sheep and Cattle [Other Than Milk Cows] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Milk Cows | Other Cattle | Total | | |
| 1964 | Washington | n.a. | | n.a. | 211,032 | 192,252 | 1,183,333 | 1,375,585 | 1,586,617 | 1,394,365 |
| | Oregon | n.a. | | 20,992 | 625,886 | 126,325 | 1,493,750 | 1,620,075 | 2,266,953 | 2,119,636 |
| | E. Oregon | n.a. | | 420 | 233,081 | 28,164 | 1,106,193 | 1,134,357 | 1,367,858 | 1,339,274 |
| | W. Oregon | n.a. | | 20,572 | 392,805 | 98,161 | 387,557 | 485,718 | 899,095 | 780,362 |
| 1969 | Washington | n.a. | | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| | Oregon | 42,267 | | n.a. | 533,856 | 86,638 | 1,266,143 | 1,352,781 | 1,928,904 | 1,799,999 |
| | E. Oregon | 22,824 | | n.a. | 179,927 | 18,733 | 943,088 | 961,821 | 1,164,572 | 1,123,015 |
| | W. Oregon | 19,443 | | n.a. | 353,929 | 67,905 | 323,055 | 390,960 | 764,332 | 676,984 |

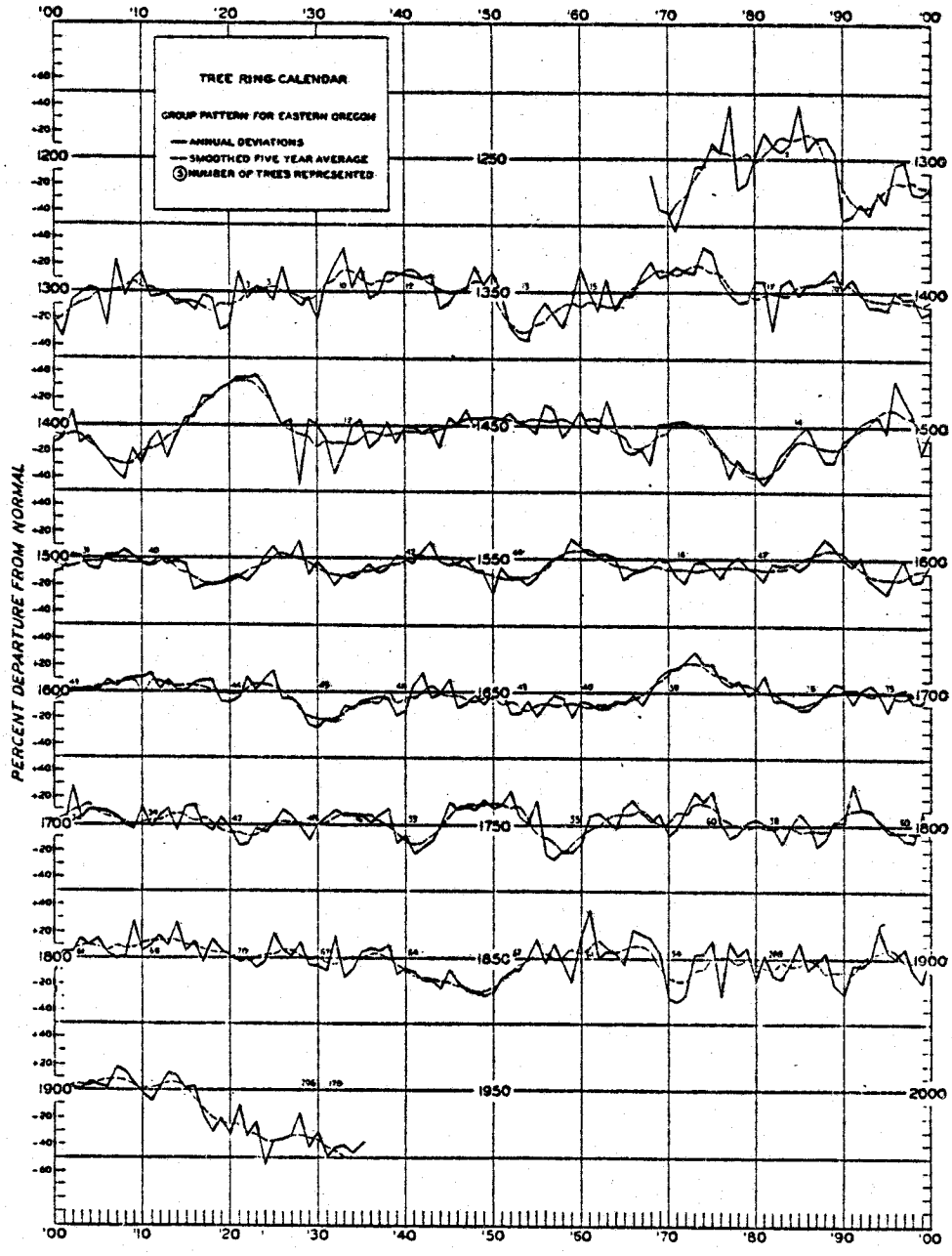



Numbers of livestock in Oregon east and west of the Cascade Range from 1880 to 1969.




Numbers of cattle (except milk cows) and of sheep in Oregon east and west of the Cascade Range from 1880 to 1969.

# APPENDIX C




Tree ring calendar from Keen, 1937