INFLUENCE OF FIRE ON GREAT BASIN WILDLIFE HABITATS

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ABSTRACT: Historically, low-intensity fires ignited by lightning and American Indians significantly perturbed wildlife habitats of the Great Basin. These fires encouraged dominance by grasses and suppressed development of woody plants. Settlement by European-Americans disrupted fire regimes. Ignitions by Indians were eliminated, fine fuels were removed by livestock, and fires were suppressed. A marked decrease in fire promoted a major increase in woody plant cover. Initially, this compositional shift provided quality habitat for mule deer (*Odocoileus hemionus*) and other wildlife dependent upon shrub-dominated types. However, prolonged absence of fire fostered senescence of the shrub component. On other sites, trees displaced shrubs and herbs. Fuel buildup has increased the risk of high-intensity wildfires, which reduce the availability of key shrub species. If the goal is to maintain productive shrublands, then prescribed fire should be applied in these vegetation types. Fire applications should be designed to rejuvenate and encourage re-establishment of desirable shrubs and herbs, and also to reduce the risk of high-intensity wildfire.

Key words: bitterbrush, fire, frequency, Great Basin, habitat, juniper, pinyon, sagebrush, wildlife.

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I examined evidence of the role of fire in wildlands of the interior West, including the Great Basin, from European contact to the mid 1990's. I describe the influence of fire on vegetation based upon professional experience and synthesis of historical documents and scientific literature. My goal is to advance understanding of the role and wise use of fire in management of vegetation comprising wildlife habitats of the Great Basin.

HISTORIC OCCURRENCE OF FIRE

Observations recorded in the historical literature indicated that fire was a recurrent disturbance agent in the American West (Moore 1972, Shinn 1980, Barrett 1981, Pyne 1982, Gruell 1991). Some of these accounts described burned landscape and fires in progress in various localities of the Great Basin during the early and mid 1800's (Gruell 1985*a*, Gruell unpubl.). Although seldom noted in the historical literature, lightning was a source of ignitions for millennia. Fire occurrence was also influenced by the level of Indian activity. Indians intentionally set fire to vegetation for a variety of reasons including production of grass seed and other food plants, stimulation of willow shoots used for basket-making, immobilizing crickets and grasshoppers, driving jackrabbits (*Lepus* spp.), clearing campsites, and signaling between bands (Cooper 1961, Stewart 1963, Moore 1972, Lewis 1985, Gruell 1985*b*).

Understanding the role of fire on early western landscapes requires knowledge on how fires burned, particularly the frequency at which they occurred. In forested regions where trees are widely distributed, fire-scarred trees can provide quantitative data on fire frequency (Arno and Sneck 1977). Fire dates are determined by counting annual growth rings from the outer cambium to the point where a fire scar is in contact with healing tissue. Unfortunately, in rangeland settings typical of the Great Basin, trees that could document fire frequency are scarce. Data on fire frequency is largely restricted to localities where fire scarred ponderosa pine (*Pinus ponderosa*) or other large conifers occur. Fire scarred pinyon (*Pinus* spp.) and juniper (*Juniperus* spp.) provide a less definitive record because older trees bearing fire scars are largely restricted to sites that did not readily burn.

Historically, fires occurred at variable intervals because of differences in fuels, ignition sources, topography, and local climate (Arno 1980, Martin 1982). Semiarid landscapes where fuels were abundant, and there was a yearly coincidence of ignition and hot weather, burned on the order of 2-20 years (Baker 1925, Burkhart and Tisdale 1976, Martin 1982). Except for localized areas, lowland valleys burned infrequently because of the wide spacing of shrubs and sparsity of grasses. Consequently, most valleys were visibly dominated by sagebrush (*Artemisia* spp.) and other shrubs (Vale 1975, Billings 1994).

During the past 10 years, I have studied fire frequency in 2 widely separated regions in the Great Basin: (1) In Great Basin National Park in eastern Nevada, fire scarred pinyon and ponderosa pine suggested a pre-1900 fire frequency of <20 years on productive north slopes and basins where surface fuels were sufficient to allow fires to carry (Gruell et al. 1994); fires were infrequent (50-150 years) on southerly aspects and ridges that supported shallow soils where fuels were sparse and discontinuous. (2) As reported in my 1995 USDI Sheldon-Hart Mountain Refuge Complex Report, an isolated stand of ponderosa pine in the shrub steppe of Hart Mountain National Antelope Refuge in southern Oregon contained fire scarred trees that suggested a fire frequency of 13 years up to 1861. Other studies adjacent or within the Great Basin (Burkhart and Tisdale 1976, West 1984) suggest a similar occurrence of historical fire.

FIRE EFFECTS ON WILDLIFE HABITATS

Prior to European-American settlement, fire influenced vegetation comprising wildlife habitats by suppressing shrubs and trees, and promoting the production of herbs (Cooper 1961, Daubenmire 1968, Vogl 1979, Arno 1985). This phenomenon was reported by early observers before the advent of scientific studies (Gruell 1985a). Perennial grass was conspicuous on productive sites within the Great Basin (Watson 1871, Simpson 1876, Russell 1884). Fire inhibited establishment of fire-sensitive shrubs and trees including pinyon, juniper, curlleaf mountain-mahogany (*Cercocarpus ledifolius*), bitterbrush (*Purshia tridenta*), and sagebrush. Frequent surface fire also suppressed fire-tolerant species that regenerate vegetatively such as oaks (*Quercus* spp.), serviceberry (*Amelanchier alnifolia*), chokecherry (*Prunus* spp.), and aspen (*Populus tremuloides*).

Relict juniper woodlands, tree-age class ratios, fire scars, and historical documents generally indicate pinyon-juniper and juniper woodlands were once open and savannah-like. Trees were largely confined to rocky ridges and low sagebrush flats where fine fuels (i.e., grasses and forbs) were too sparce to carry fire (West 1984, Miller and Wigand 1994). Relatively young age classes of pinyon and juniper (<120 years) at Great Basin National Park on mountain big sagebrush (*Artemisia tridentata vaseyana*) vegetation types (Eddleman and Jaindl 1994) indicated that historically, this potential native plant community was savanna-like with a ground cover of herbs and shrubs (Gruell et al. 1994). Post-1900 photographs in and adjacent to Great Basin National Park repeated in 1966 by me (on file at USDA Humboldt-Toiyabe National Forest, Ely Ranger District, Nevada) provide visual evidence of this condition.

In contrast to semi-arid regions, the historic fire frequency in relatively cool moist and temperate subalpine zones was 50-300 years (Loope and Gruell 1973, Romme 1979, Barrett 1982). These longer fire intervals resulted in an abundance of fire-dependent crown sprouting shrubs and a mosaic of seral and climax conifers. These fire regimes maintained landscape mosaics comprised of communities of herbs, shrubs, and trees in various successional stages of post-fire development.

CHANGE IN FIRE REGIMES

Studies of fire history in drier regions of the interior West have shown a pronounced reduction in the size and occurrence of fires by the early 1900's (Agee 1993). In Great Basin National Park, fire-scar data revealed that only 3% of the fires occurred in the 20th century (Gruell et al. 1994). This marked decline in fire occurrence appears to be related to a shift in the way humans utilized the landscape. Relocation of Indians from their ancestral territories removed a major ignition source. By the late 1800s and early 1900s, when lightning and other ignitions did occur, the possibility of extensive spreading fires was checked by the sparsity of fine fuels left after intensive livestock grazing. Evidence of intense livestock grazing is well documented for the 1870-1935 period (Griffiths 1902, Stewart 1936, 1941; Young et al. 1976). Annual reports of the Humboldt National Forest indicated that few fires occurred during the 1920s; those that did burned a minimal number of hectares. Early photographs on file at USDA Humboldt-Toiyabe National Forest, Elko, Nevada show a sparsity of fine fuels resulting from intense grazing during this era. Following development of irrigated pastures and roads, the likelihood of fire spread was further limited by disruption of fuel continuity. Establishment of federal and state fire organizations led to successful suppression of most fires by the 1940s.

CHANGES IN VEGETATION

Changes in northern and eastern Nevada vegetation since the late 1800s are recorded by my repeat photographs on file at USDA Humboldt-Toiyabe National Forest, Elko, Nevada and in (Gruell 1986, Rogers 1982). The 1966 Humboldt River Basinwide Report (pp. 78-85) and (Young et al. 1976) document thickening of sagebrush and decline of perennial grass. Elsewhere in the Great Basin, sagebrush dominated the grasslands of the Cache Valley of Northwestern Utah by the 1870s (Hull and Hull 1974). An increase in density and extent of pinyon and juniper has been widely documented (Cottam and Stewart 1940, Christensen and Johnson 1963, Tausch et al. 1981, West 1984, Eddleman 1987, Miller and Rose 1995). Expansion occurred into open meadows, grassland savannahs, sagebrush steppe, and in aspen patches (West 1984, Eddleman 1987, Miller and Wigand 1994). Succession to pinyon-juniper is evidenced by the relatively young age of trees and vegetal remnants beneath the tree canopies (Koniak and Everett 1982). In Great Basin National Park, pinyon and juniper stands were dominated by trees <120 years of age on productive mountain big sagebrush sites (Eddleman and Jandl 1994). Analysis of curlleaf mountain-mahogany and western juniper (*Juniperus occidentalis*) populations at Hart Mountain and Sheldon Refuges similarly suggested that most stands were dominated by trees that established after 1880.

The increase in shrubs and trees in the 20th century has been attributed to changes in climate, grazing, and fire regimes. Miller and Rose (1995) report that the initiation of the increase in western juniper encroachment during the late 1800s coincides with optimal climatic conditions for berry production and establishment, reduced fire-return intervals, and heavy livestock grazing. They concluded that the accelerated increase in juniper expansion since 1960 may have been due to the continued absence of fire, abundant woody plant cover, and the large increase in western juniper seed production. Some investigators have attributed the buildup of pinyon, juniper, and sagebrush to unrestricted livestock grazing between the late 1800s and 1940 (Arnold et al. 1964, Blackburn and Tueller 1970). Livestock may have encouraged juniper expansion through their dissemination of juniper seed and their preferential grazing of herbs that directly compete with juniper seedlings (Cottam and Stewart 1940, Branson 1985).

Increase in woody vegetation has been primarily attributed to reduction of fine fuels by livestock grazing and exclusion of fire (Burkhart and Tisdale 1976, Gruell 1986, Kauffman 1989, Miller and Rose 1995). The exclusion of fire over extensive areas favored establishment and survival of fire-sensitive plants, including sagebrush, bitterbrush, and curlleaf mountain-mahogany. Repeat photographs on file at USDA Humboldt-Toiyabe National Forest, Elko, Nevada show that sagebrush and other woody plants increased significantly on productive sites. Hazeltine et al. (1961) reported that establishment of bitterbrush stands in Elko County, Nevada after 1890 resulted from livestock reductions following the severe winter of 1889-90. Establishment of bitterbrush seedlings would have also been favorably influenced by removal of fine fuels by livestock.

Curlleaf mountain-mahogany, a weak sprouter, has increased greatly on productive sites in the Northern Rockies and Great Basin (Gruell et al. 1985). Presently, most mountain-mahogany stands are composed of trees <130 years-old growing on deep soils where fine fuels were removed by livestock and fire was excluded (Scheldt 1969, Dealy 1975, Gruell et al. 1985) Apparently, the invasion of western juniper on the Owyhee Plateau was primarily associated with decrease in the incidence of fires after 1870 (Burkhart and Tisdale 1976). At Mountain Meadows in south-central Utah, Cottam and Stewart (1940) recorded a 500% increase in juniper (*Juniperus osteosperma*) between 1862 and 1934. They concluded that this dramatic increase was best explained by the elimination of grass competition by livestock. Subsequent studies conducted in juniper and pinyon-juniper woodlands (Burkhart and Tisdale 1976, Young and Evans 1981, Miller and Wigand 1994) suggested fire exclusion was the primary factor that allowed for the increase in juniper.

TRENDS IN WILDLIFE HABITATS

Wildlife populations are strongly influenced by the composition and structure of plant communities. Some wildlife species prefer early stages of succession where herbaceous plants predominate; other species have a preference for advanced stages dominated by woody plants. Considering food preference and historic populations, the herb-dominated fire-climax was optimal habitat for bighorn sheep (*Ovis canadenis*), pronghorn (*Antilocapra americana*), whitetail jackrabbits (*Lepus townsendi*) and sharp-tailed grouse (*Pedioecetes phasianellus*). Mule deer in semi-arid regions were not benefitted by fire, since fire suppressed development of shrubs and trees needed for cover and food (Gruell 1986). Fire inhibited development of sagebrush, pinyon, and juniper vegetation preferred by blacktail jackrabbits (*Lepus califoricus*), sage grouse (*Centrocercus urophasianus*), and certain neotropical migrant birds. By stimulating the growth of herbacious plants and inhibiting sagebrush encroachment, fire may have enhanced meadows utilized by brooding sage grouse.

In retrospect, widespread increases in mule deer populations coincided with increases in the abundance of palatable shrubs (Leopold 1950; Julander and Low 1976; Longhurst et al. 1952, 1981; Gruell 1986). Conversion of ranges from herb dominance to shrub dominance improved forage availability and nutritional quality, particularly during stress periods when all but the taller forage species were snow covered (Harper 1968). Although this vegetation trend favored mule deer, it was detrimental to pronghorn and bighorn sheep which preferred landscapes dominated by herbaceous plants (Wakelyn 1987, O'Gara and Yoakum 1992). Increases in woody vegetation seemly resulted in displacement of whitetail jackrabbits by blacktail jackrabbits in localities formerly dominated by grasses. Post-1900 increases in sagebrush cover, particularly around meadow margins, may have favored sage grouse. The increase in pinyon and juniper apparently improved habitat for nongame birds dependent on trees. Although some wildlife habitats in the Great Basin are in early to mid stages of succession, most are successionally advanced and dominated by woody vegetation. These changes are unfavorable for mule deer, where heavy encroachment of trees has displaced herbs and palatable shrubs. Quality of deer habitat has also declined on sites devoid of trees where the shrub component is dense and senescent, seedlings are few, and repeated insect defoliation and browsing have taken their toll (Gruell 1986). Reduced availability of herbs continues to limit wildlife species such as pronghorn and bighorn sheep which rely on herbs for production (O'Gara and Yoakum 1992, Wakelyn 1987).

FUEL BUILDUP

A long-term buildup of woody vegetation and proliferation of cheatgrass (*Bromus tectorum*), combined with drought, has resulted in wildfires of high severity (Whisenant 1990, Peters and Bunting 1994). Since the 1960's, unprecedented crown fires have occurred in pinyon and juniper previously considered fire resistent.

Evidence of this trend is contained in USDA Forest Service Intermountain Region annual fire reports inclusive of the Great Basin. During the 48 year period from 1930 to 1978 there were only 2 years (in the 1930s) when 40,000 hectares or more burned. Since 1979 the region experienced 8 years in which that much acreage or more burned. These severe wildfires are largely a result of extreme fuel buildup (Davison 1996). Successful fire suppression allows vegetation to age and fuels to increase. Inevitably, this results in uncontrollable wildfires that burn until they consume available fuels or are extinguished by precipitation.

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

As discussed in the 1995 USDA/USDI Federal Wildland Fire Policy and Program Review, increased funding and sophisticated fire suppression organizations are not the solution to high intensity wildfires. A growing number of researchers and fire-suppression personnel are convinced that emphasis on fuels reduction is the most logical management alternative (Arno and Brown 1991, Babbit 1995). This can be accomplished by following existing fire management directives and utilizing proven techniques. At the present time virtually all wildfires are aggressively suppressed. This costly practice often results in suppression of fires that have potential for reducing fuels and rejuvenating wildlife habitat. Fire suppression organizations have the alternative of choosing "confine" or "contain" suppression strategies for purposes of conserving funds. Use of these strategies has the potential to result in breaking up hazardous fuel continuity and rejuvenating wildlife habitat. Use of prescribed fire can increase production of herbaceous plants and shrubs in sagebrush-grass and pinyon-juniper stands (Young 1983). Cutting trees followed by prescribed fire is a viable alternative in areas where there is a demand for wood fiber. Use of moderate-intensity fire prescriptions in sagebrush-grass, aspen, and mountain shrub plant communities would result in nutrient increases, increased palatability, and increased forage availability. Fire promotes regeneration of crown-sprouting shrubs, and it bares mineral soil allowing regeneration of herbs and shrub seedlings including bitterbrush, mountain-mahogany and willow. Fire is of particular importance for regenerating aspen suckers, as well as *Ceanothus* species, which are dependent on heat to break seed dormancy.

Wildfire will continue to burn winter ranges of game animals despite major suppression efforts. A program of seeding strips of perennial grass following fire on key winter ranges dominated by cheatgrass shows promise of breaking up fuel continuity and inhibiting the reoccurrence of high intensity wildfire (Davison 1996). The benefit of livestock grazing for reducing fine fuels should be kept in mind. In moderation, livestock grazing is an important element in reducing the vulnerability of wildlife habitats to high intensity-wildfire (Davison 1996).

Maintaining productive wildlife habitats in the Great Basin will be dependent on purposeful disturbance to achieve desired conditions, not protection from disturbance. The objective in managing perturbations should be to achieve a mosaic of different seral stages on the landscape, rather than continuing the usual approach of trying to exclude fire. Fire exclusion will allow vegetation to reach advanced successional stages that are susceptible to severe wildfires; these wildfires may have significant adverse effects.

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