Prescribed Burning on B.C. Rangelands: the State of the Art

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Abstract

This paper reviews research and experiences up to the present in the use of fire as a rangeland management tool in British Columbia. Although the climate of opinion towards burning is becoming increasingly more favourable, little specific information is yet available to allow precise use of fire for habitat modification. Some results from north-western United States are applicable but these are sometimes contradictory and, not infrequently, incomplete. A program of fire ecology research is outlined which will provide the necessary information to permit the use of fire to achieve specific range management objectives.

In the last decade or so a strong reaction has developed to Smokey Bear's dramatically forceful message that "Fire is Bad", and so fire is now becoming acceptable as a management tool (Kayll 1974). This changing attitude is, perhaps, sometimes going too far and there is a real danger that fire will be used uncritically or inappropriately without a clear, prior definition of objectives.

Burning to manage vegetation has been used all over the world for centuries: some of the very earliest explorers reported smoke over Africa 2,000 years ago (Casson 1960) and its controlled application there goes back many years (West 1965); it is a technique of long-standing in Britain (Lovat 1911); and it was a pre-historic practise in North America too (Lutz 1959). Now that controlled burning is becoming "respectable", serious scientific interest is growing and one is permitted to employ "prescribed burning", that is the use of fire of pre-set characteristics to achieve a specified change in a known plant community. This paper assesses the art of prescribed burning for British Columbia range types and suggests requirements for fire research in the Province.

Setting

Because of its climate, the southern interior of British Columbia between the Coastal Mountains and the Rockies lends itself to the managed use of fire more than does the wetter mountainous littoral. The vegetation of the interior valleys and plateaux has been well described in general eco-regional terms (Krajina 1969) and a number of more specific works are available (Spilsbury and Tisdale 1944, Tisdale 1947, Tisdale and McLean 1957, McLean and Holland 1958, van Ryswyk et al. 1966, Brayshaw 1970, McLean 1970, Lord and Green 1971, Beil 1974). Fire is accepted (Brayshaw 1970) as one of the many habitat factors.

Of the 5 major associations in the interior it is likely that fire can be used in only 3. The 5 are: in the southernmost latitudes and lowest elevations a grassland zone dominated by bluebunch wheatgrass *(Agropyron spicatum)* and big sagebrush *(Artemisia tridentata)*—a dry area with less than 30 cm of annual precipitation; immediately above the grasslands lies the slightly moister, open forest of ponderosa pine *(Pinus ponderosa)* and bunchgrasses; with increasing elevation and moisture, a Douglas fir *(Pseudotsuga menziesii)*/pinegrass *(Calamagrostis rubescens)* zone which is by far the most extensive of the three; at successively higher elevations, sub-alpine fir *(Abies lasciocarpa)*/Englemann spruce *(Picea engelmannii)* and alpine zones. This paper deals only with the 2 lower forested zones and the grasslands.

Sagebrush-Grasslands

Little published information exists regarding the history and effects of fire on British Columbia grasslands. Tisdale and McLean (1957) postulate that fire has been an historic factor in this zone and that Indians probably used fire to improve hunting conditions on the grasslands. Smith (1969) suggested that, more recently, ranchers have employed grassland burning to improve or produce range. However, the objectives of these burns and their primary and secondary effects are poorly documented.

The B.C. Fish and Wildlife Branch has been most active in using fire as a management tool in British Columbia. In cooperation with the B.C. Forest Service, they have employed cool spring burning on several grassland ranges in the Okanagan, Chilcotin, and East Kootenays (Eastman 1978) (Fig. 1). Their specific objectives have varied slightly from one region to another but, in general, these have been to increase forage production and quality, control undesirable plant species (notably big sagebrush), and to alter the botanical composition of the plant communities (Eastman 1978) for the benefit of California bighorn sheep *(Ovis canadensis californiana)* in the Okanagan and Chilcotin and elk *(Cervus canadensis)*, mule deer *(Odocoileus hemionus hemionus)*, Rocky Mountain bighorn sheep *(Ovis canadensis canadensis)*, and white-tailed deer *(O. virginianus)* in the East Kootenays.

Although few quantitative data have emerged from this burning program since its inception in the mid 1970's, some general observations have been noted. Early indications suggest that favorable changes in the spring distribution of California bighorn resulted from spring burns in the Ashnola with the objective of drawing the sheep from the heavily grazed ridges. Bone (pers. comm.)[1] believes the sheep now spend more grazing time on the burned patches of the lower slope. In the Chilcotin, improvements in both forage quality and production are claimed, although the specific plant species affected are not listed. The effect on quality is reportedly short-lived however, while enhanced production may be due to decreased competition following elimination of big sagebrush. Basal sprouting of willows (*Salix* spp.), saskatoon or serviceberry *(Amelanchier alnifolia)*, and even bitterbrush *(Pursia tridentata)*, have been observed following fire (Eastman 1978).

Under the aegis of Coordinated Resource Planning, the Range Division of B.C. Forest Service has initiated a prescribed burning program but they too lack the staff to monitor the fires or their effects in any detail (Milroy, pers. comm.)[2].

Considerably more fire research has been conducted on the comparable sagebrush/bunchgrass type in the northwest United States. This has provided some information regarding the effects of fire on forage production (Pickford 1932, Blaisdell 1953, Mueggler and Blaisdell 1958, Harniss and Murray 1973, Daubenmire 1975,

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[1]Bone, J. 1979. Fish & Wildlife Br., Min. of Recreation & Conservation, Penticton.
[2]Milroy, J.E. 1979. Director, Range Division, B.C. Forest Service, Victoria.

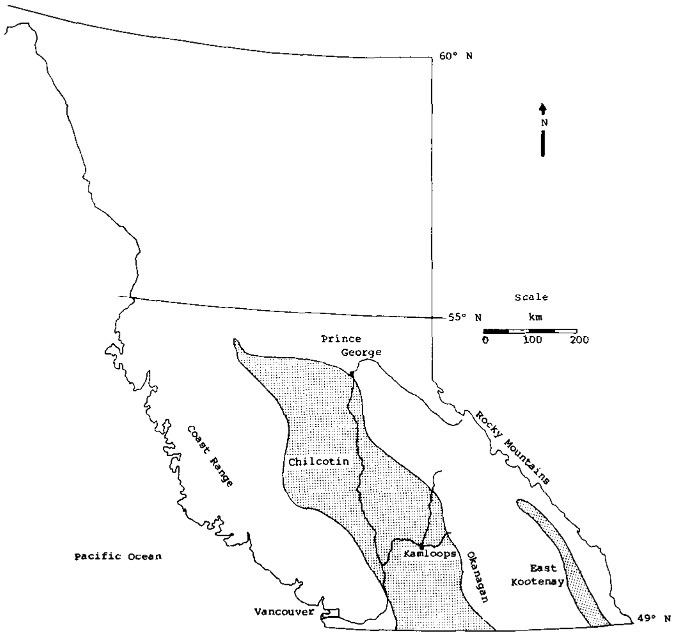

FIGURE 1

BRITISH COLUMBIA
Rangeland areas with potential for prescribed burning

Uresk et al. 1976), botanical composition (Pickford 1932, Blaisdell 1953, Harniss and Murray 1973, Daubenmire 1975, Young and Evans 1978) and directly, on several range plant species (Blaisdell 1953, Pechanec et al. 1954, Moomaw 1956, Mueggler and Blaisdell 1958, Wright and Klemmedson 1956, Young and Evans 1978) which are also common in British Columbia. Unfortunately these studies have produced few consistent results. For example, the reported effects of fire on the productivity of bluebunch wheatgrass have been variable. Uresk et al. (1976) indicated that burning increased productivity of bluebunch wheatgrass by 24% when comparing burned and unburned sites. Moomaw (1956) reported that bluebunch wheatgrass was only slightly affected by fire and postulated that the minor increases noted may have resulted from the release of competition from shrubby species. Similar results were obtained by Conrad and Poulton (1966) and they suggested that the primary effect of fire on this species was a reduction in basal area.

On the other hand, Blaisdell (1953), Daubenmire (1975), and Mueggler and Blaisdell (1958) all reported an initial reduction in productivity of bluebunch wheatgrass in the first postburn season. Reductions up to 50% were observed (Daubenmire 1975) with recovery time varying from 3 (Blaisdell 1953) to possibly 12 (Daubenmire 1975) years. Blaisdell (1953) suggested that, by the third year, productivity of bluebunch wheatgrass on burned sites was outyielding that of the unburned sites. The greatest increases were found on areas lightly burned, and he concluded that productivity varied inversely with fire intensity.

Few studies have monitored changes in botanical composition carefully following fire. In fact, of the studies reviewed, only 3 (Moomaw 1956, Wright and Klemmedson 1965, Daubenmire 1975) provided detailed descriptions of pre- and postburn floristics although 2 others (Pickford 1932, Blaisdell 1953) discussed general vegetative changes. Only slight reductions in coverage and frequency of perennial grasses were observed by Daubenmire (1975), Moomaw (1956), and Young and Evans (1978) following wildfire. Pickford (1932), however, indicated that perennial grass cover declined significantly, while forbs increased following prescribed burning. Moomaw (1956) concluded that all shrubby species studied, including sagebrush and bitterbrush, declined after fire, as did phlox *(Phlox longifolia),* balsamroot *(Balsamhoriza sagittata),* and Wyeth buckwheat *(Eriogonum heracleoides).* Yarrow *(Achillea millefolium), Lomatium macrocarpum* and *Calochortus macrocarpus* were found to increase while *Sisymbrium altissimum* and *Epilobium paniculatum* invaded.

Very little research has yet been directed towards the autecological effect of fire on rangeland plant species. Wright and Klemmedson (1965) studied the effect of 2 burn intensities (38 and 93° C) at 3 seasons of burning (June, July and August) on 4 grass species common in the sagebrush-grasslands in southern Idaho. Of these, only needle-and-thread *(Stipa comata)* and Sandberg's bluegrass *(Poa secunda)* are common in British Columbia.

Needle-and-thread declined with burning, especially in June and July, but was slightly more resistant in August. As the season progressed, however, size of plant became more important with small plants more susceptible to damage than large ones. Intensity of burning had little effect on needle-and-thread at any season of burn (Wright and Klemmedson 1965). These results are contrary to Blaisdell's (1953) earlier observations in Idaho. He indicated that needle-and-thread was positively effected by fire, producing from 11.7 kg/ha to 30.3 kg/ha more on burned than on unburned range.

Sandberg's bluegrass was not affected by fire at any intensity or season of burning (Wright and Klemmedson 1965). These results agree with those of Moomaw (1956) and Daubenmire (1975), who suggested that bluegrass tended to increase after burning and speculated that this may result from an increase in insolation reaching the plants after the larger overstory species have been burned. In general, the pattern of most perennial grasses decreasing in the first year after fire and then increasing slowly over a variable number of years appears well established (Blaisdell 1953, Mueggler and Blaisdell 1958, Harniss and Murray 1973, Daubenmire 1975).

The autecological effects of fire on other species can be inferred from changes in productivity, botanical composition, vigor and mortality. For example, consistent results have been reported on the impact of fire on Idaho fescue *(Festuca idahoensis)* and big sagebrush. Both species were adversely effected by burning and declined in all localities studied (Pickford 1932, Blaisdell 1953, Moomaw 1956, Mueggler and Blaisdell 1958, Conrad and Poulton 1966, Ralphs and Busby 1979, Nimir and Payne 1978). The extent of damage to each species depended upon the intensity of burn, and effects might persist for 12 to 15 years for Idaho fescue (Blaisdell 1953) and up to 30 years for sagebrush (Harniss and Murray 1973).

Studies on cheatgrass *(Bromus tectorum)* have produced more variable results. Most have concluded that this species increases following fire (Pickford 1932, Young et al. 1976, Young and Evans 1978). Daubenmire (1975) on the other hand, showed that annual species of *Bromus,* including cheatgrass, declined after wildfire and, even after 12 years, their population levels remained suppressed. These results agreeded with Moomaw's (1956) earlier findings in eastern Washington.

Ponderosa Pine Zone

The importance of fire as an ecological factor or a management tool in the Ponderosa pine type has received little attention in B.C. Brayshaw (1970), like many others (Ahlgren and Ahlgren 1960; Cooper 1961; Biswell 1972; Weaver 1958, 1961a, 1974), suggested that fire had been prevalent, both historically and recently, in this type and it must be considered a natural part of the environment. He did not speculate on the frequency of fire but postulated that most would be surface fires favoring a grassy understory at the expense of shrubs Brayshaw (1970). Weaver (1967b) believed that fire may have occurred as frequently as every 8 years in the ponderosa pine type in Washington and that it was largely responsible for the open, parklike physiognomy there.

The B.C. Fish and Wildlife Branch has recently initiated a rotational burning program in the Okanagan for enhancement of mule deer winter habitat. The objectives of this program include reducing forest cover, and, increasing forbs, shrubs and nutritive quality of preferred foods. Although follow-up vegetational analyses are planned (Eastman 1978), no published data are yet available.

From the extensive literature on burning in the ponderosa pine-/bunchgrass type in the United States, it is apparent that few studies were aimed at forage species (Heady 1975). Predomi ntly, silvicultural objectives have been the primary research and management goals—thinning young stands, reducing understory fuel loads to prevent wildfire, and disease control. However, the potential of prescribed fire for benefiting both forestry and forage management objectives have been noted (Biswell 1972; Weaver 1951, 1958). Indeed, mechanical thinning of young stands of ponderosa pine resulted in dramatic increases in forage biomass (McConnel and Smith 1965, Thompson and Gartner 1971) and an inverse relationship between canopy closure and herbage productivity seems well accepted (Pase 1958, McConnel and Smith 1965, Thompson and Gartner 1971, Biswell 1972).

Weaver (1943, 1947, 1951, 1955, 1957, 1958, 1959, 1961a & b, 1967 a & b 1974) has contributed many publications on fire in the ponderosa pine zone in Washington, Oregon, and Arizona. He contended that bluebunch wheatgrass, rough fescue *(Festuca scabrella)*, pine grass *(Calamagrostis rubescens)* and *Stipa* spp. increased in abundance following burning in this type. Although his conclusions were based upon numerous and repeated observations and photographs, no quantitative data were collected. Unfortunately, despite the abundant literature the specific effects of fire on individual plant species, botanical composition, vigor and productivity, as well as the fire, fuel, and weather conditions which brought about these changes remain unknown.

Studies by Gaines et al. (1958), Sweeney and Biswell (1961), and Vlamis et al. (1955) have carefully documented fire, fuel, and weather conditions in addition to time and length of burn for prescribed fires in Arizona and California Ponderosa pine. Gaines et al. (1958) observed a 50% reduction in grass density in the first postburn year but the principal species studied, mountain muhly *(Mulhenbergia montana)* and squirrel tail *(Sitanion hystrix)*, are absent or infrequent in B.C. (Hubbard 1955). Sweeney and Biswell (1961) reported the effects of prescribed fire on removal of duff from the forest floor and Vlamis et al. (1955) tested pre- and postburn differences in soil nutrients. While these results are of general interest, they are of little direct value for prescribed burning in British Columbia.

Douglas Fir Zone

As in the grasslands and ponderosa pine zone, the importance of fire as an ecological factor in the Douglas-fir zone has not received much attention. Tisdale and McLean (1957) suggested that fire has historically been, and still is, a common feature of this zone, and identified 3 seral communities resulting from fire for the *Pseudotsuga/ Calamagrostis* association at Kamloops. These include: the aspen *(Populus tremuloides)*/pinegrass, lodgepole pine *(Pinus contorta)*/pinegrass and the conifer/aspen/pinegrass associes. Homologues of each are present in the Okanagan (Brayshaw 1970) and East Kootenays (McLean and Holland 1958) but they are poorly represented in the Similkameen (McLean 1970, McLean et al. 1971).

Forage production has been assessed under each fire associes. Tisdale (1950) showed that as tree canopy cover increased from the open aspen to the closed Douglas-fir types, palatable forage yields declined from 720 kg/ha to 180 kg/ha. While these data suggest that fire may increase forage production in the Douglas-fir/pinegrass association, few other effects of fire have been studied in this type.

Beaton (1959a & b), comparing the physical and chemical properties of soils on burned and unburned sites at Lac le Jeune near Kamloops, found that total porosity and non-capillary porosity decreased, while percent capillary porosity increased on burned compared to unburned sites. Burning reduced infiltration rates on all sites and soil temperatures were higher on burned-over soils (Beaton 1959a). On recently burned sites, total nitrogen, percent organic matter, acidity, and the carbonic acid soluable phosphorus in the organic horizon decreased (Beaton 1959b).

Eastman (1978) summarized the history, use and objectives of burning in the Douglas-fir zone by the B.C. Fish and Wildlife Branch. The first prescribed fires, in Wells Grey Park (north-east of Kamloops) in the mid 1950's, were generally unsuccessful. During the period 1966 to 1971 spring burns were employed on 1654 ha to maintain early seral stages of forest for moose *(Alces alces)*. Although no data were presented, Eastman concluded that availability and forage production increased on all burned sites. With the objective of increasing browse availability for mule deer, prescribed burning also has been undertaken on some Douglas-fir/pinegrass ranges in southcentral British Columbia but no results from these burns are reported, yet.

McLean (1969) compared root characteristics of fire resistant and non-fire resistant herbaceous plant species common in the Douglas-fir type in British Columbia. Species with fibrous root systems or possessing stolons or rhizomes that grow above mineral soil were most susceptible to fire. Fibrous-rooted species with rhizomes that penetrate mineral soil to at least 5 cm were considered moderately resistant. Tap-rooted species with the ability to regenerate from below their crowns, and rhizomatous species that grow between 5 and 13 cm below the mineral soil were considered the most resistant to fire.

McMinn (1951) compared the floristics of burned and logged sites in the coastal Douglas-fir type at the University of British Columbia research forest. However, these results are of limited value for range management due to the vast ecological differences between the coastal and interior forests.

Slightly more research on prescribed burning in the Douglas-fir zone has been undertaken in the United States. Independent studies by Asherin (1974) and Lyon (1966) were aimed at rejuvenating browse production in seral communities of the Douglas-fir type in Idaho. Fire increased availability for wildlife and stimulated growth of maple *(Acer glabrum)*, willows and serviceberry in both studies. Other species which responded favorably to burning and that are common in British Columbia are redstem ceanothus *(Ceanothus sanguineus)* (Asherin 1974) sticky currant *(C. velutinus)*, and snowbush *(Ribes visicosissimum)* (Lyon 1966).

Asherin (1974), comparing nutrient contents of redstem ceanothus on burned and unburned sites, found that, in the first postburn year, burned plants had higher crude protein levels, lower fat and crude fibre contents, while ash remained constant. By the second year crude fibre contents were similar, fat contents reversed and crude fibre remained lower even into the third year after fire.

Both Asherin (1974) and Lyon (1966) compared the floristics on burned and unburned sites. Although Asherin provided a very detailed list of species, many of which occur in British Columbia, his results only appear in an appendix without interpretation. Many of the shrub species, including ocean spray *(Holodiscus discolor)*, mock orange *(Philadelphus lewisii)*, chokecherry *(Prunus emarginata* and *P. virginiana)*, and snowbush (*Ceanothus* spp.) occurred less frequently on burned than on unburned sites. Others, such as willows, snowberry *(Symphoricarpus albus)* and rose *(Rosa gymnocarpa)* appeared to respond to fire erratically. Herbaceous species that were found more frequently on burned sites included pinegrass, fireweed *(Epilobium angustifolium)* and *Poa compressa*, while aster *(Aster conspicuus)* occurred more frequently on unburned sites. Unfortunately, the fire, fuel, weather and topographic conditions which produced these differences were not recorded.

Lyon (1966) carefully documented weather and fuel conditions, fire intensity, time of fire, and season of burn. Of the few plant species comprising the understory flora, only pinegrass and heart-leaf arnica *(Arnica cordifolia)* grow in British Columbia. Both species declined in the first year after burning but recovered to preburn levels by the second year.

Discussion

The definition of prescribed burning in the introduction is explicit. It suggests that land managers are sufficiently familiar with fire behavior and its characteristics that predictable results can be accomplished under a variety of weather and fuel conditions. At the same time, well-defined management objectives must be set and met.

Available results on the specific effects of the fire within any of the vegetation types considered in this review have been conflicting and inconclusive. This should not be surprising, however, since it is unlikely that fire, fuel, topography and weather conditions were similar from one study to another; indeed each fire is a unique event. In addition, data collection techniques often varied thus making comparisons difficult. As a result, we lack the information necessary to conduct prescribed burns or to predict their effects for most objectives of forage, habitat and range management in British Columbia.

It seems clear then that the art of prescribed burning is not yet well developed here, indeed many of the burns presently called "prescribed" might be defined as "controlled" (Vallentine 1974) not only in this Province, but in similar vegetation types throughout the northwest United States. It is equally apparent that a well-designed research program where fire and its effects are the focus of study, is necessary if fire is to reach its potential as an effective management tool.

Research Required

Since we need so many answers on the effects of fire on vegetation in British Columbia, a research program that initially emphasizes collection of baseline data is proposed. Areas of investigation needed include: the physical conditions of fuels, weather, and topography; the effects of fire on soils and plants, and hence indirectly on animal productivity; postburn interactions between fire and grazing on vegetation; and the economics of range burning. Because more than one objective can sometimes be accomplished with a single burn (Wright 1974) and hence many hypotheses could be tested simultaneously, no priority is necessarily implied. However, those facts most important to grazing management—changes in forage quantity and quality, botanical composition, and animal distribution and productivity—might be investigated first. Advantage should be taken of operational burns to collect data which will complement and amplify research findings.

(1) *Physical Conditions.* Fire intensity, duration and behavior are strongly affected by weather conditions before and during the burn, by topography, and by fuel conditions (Ahlgren and Ahlgren 1960). Weather, topographic and fuel parameters, which can be easily measured and have high predictive value for producing fires with specific intensities and characteristics, must be identified and quantified. They include: relative humidity, temperature, wind speed, length and angle of slope and, most importantly, the moisture content, kind and amount of fuel. Development of a data bank and retrieval system would facilitate access to fire information by resource managers in the Province.

(2) *Fire Behavior and Characteristics.* An understanding of fire behavior and its characteristics under different combinations of weather, fuel conditions, and topography is prerequisite to control and safe use. It is essential that resource managers are sufficiently skilled and knowledgeable about the fire they are producing for burns to be contained within the target area. This is especially important here in British Columbia where much of the grazing land occurs within or adjacent to forested lands of high timber value. Qualitative descriptions of every fire should accompany other data collection, and techniques which provide for the safe ignition and use of fire under local conditions need development.

(3) *Effects on Soils.* There is a dearth of information on changes in the physical and chemical composition of soils under known fire conditions for any of the vegetation types used for domestic grazing in British Columbia. Knowledge of changes in soil structure, temperature, infiltration rates, percolation, water-holding capacity, moisture content and the subsequent effects on range plants still require investigation.

The potential for erosion by wind and water often increases following fire as a result of the reduction in plant cover (Pechanec et al. 1954, Ralphs and Busby 1979). Most of the grazing land in British Columbia occurs on slopes where wind is a common feature (Tisdale 1947) and high-intensity, short-duration rain storms may occur during summer. These factors enhance the risk of wind and water erosion after ground cover has been removed. Presently, we know little about the secondary effects of fire on accelerated erosion under different topographic and climatic conditions.

Daubenmire (1968) has questioned the real significance of mineral release from litter by fire and the resulting benefits to plants. The magnitude of this mineral cycling, its effects on plant nutrition, forage quality and herbage production is of more than just academic interest and requires study since these parameters relate directly and immediately to animal management. Similarly, the direct effects of fire on soil chemistry and its secondary effects on plant growth and phenology have not been investigated under controlled conditions in the sagebrush-grasslands, ponderosa pine and Douglas-fir types in British Columbia.

(4) *Effect on Plants.* It is well accepted that individual plant species and entire plant communities may vary in their response when burned at different intensities, frequencies and seasons (Heady 1975, West 1965). It is doubtful that any single combination will meet all objectives of domestic grazing or wildlife habit modification within the 3 vegetation types considered here. However, management objectives and the appropriate combination of intensity, frequency and season of burn can be aligned only when these variations are understood.

Carefully designed experiments, with various treatment levels of fire intensity, frequency and season, are required in the sagebrush-bunchgrass, ponderosa pine and Douglas-fir zones. In addition to changes in botanical composition, the response of the most important plant species for management should be monitored and compared under different treatment combinations within each type. Vigor, vitality, mortality, productivity and nutritive content are useful plant parameters to monitor and compare under different burning regimes. As suggested earlier, it is essential that the physical characteristics of each fire treatment be documented so that duplication may be possible under management conditions. One of the authors (Strang) began a research project to investigate the role of prescribed burning in management of forested rangelands near Kamloops in 1978 but no data have yet been reported.

(5) *Effects on Animals.* Little research to date has considered the secondary effects of fire on animal performance and distribution through changes in vegetation. When availability, palatability, species composition, forage nutrient content and productivity change in response to burning, corresponding changes in diet selection and animal productivity might be expected. If enhanced animal production is the objective of management, comparisons of diet, weight gains, birth weights, natality and mortality for animals utilizing burned and unburned ranges require study under local conditions before we can assess the success of any burn.

It seems well accepted that, in general, both wild and domestic animals are attracted to recent burns (Daubenmire 1968, Vogl 1974). Although preliminary observations in the Ashnola suggest that bighorn sheep distribution has been altered by burning, there is a paucity of specific information regarding the potential of using fire to promote animal distribution in British Columbia. More precisely, information on how, when, where and how often fire may be used to maintain desired changes in animal distribution and an adequate stand of forage plants is required.

(6) *Fire-Plant-Animal Interactions.* Moomaw (1956) indicated that individual plant species in the sagebrush-grassland of Washington responded differently when treated with fire or grazing, or both in sequence. It is likely that this relationship also will hold here not only in the sagebrush-grasslands but in the ponderosa pine and Douglas-fir zones as well. This has important implications for range management since grazing is likely to follow most prescribed burns. Unfortunately, very few hypotheses have been tested on any aspect of this important interaction. Questions still outstanding include: what synecological variations within a stand may result from grazing, fire, and both in combination; how do different seasons, intensities and frequencies of burn affect these relationships; what effects do fire and grazing in sequence have on plant productivity and forage quality; and how long must grazing

be deferred after fire to permit vegetation to recover before it can safely be grazed again?

(7) *Economic Factors.* Although Mueggler and Blaisdell (1958), and more recently Ralphs and Busby (1979) presented some data on fire costs for prescribed burning on sagebrush-grassland, a detailed economic analysis has yet to be undertaken. In view of the fact that grazing must usually be deferred both before and after fire (Heady 1975), a considerable amount of forage is not available for animal use. The cost would even be higher if animal production did not improve following fire since animal products provide a major financial return. Costs are also tied to local conditions, with major components being labor and fire line construction (Ralphs and Busby 1979). Where topography is varied, as in British Columbia, these costs are likely to be higher than in localities with more gentle slopes. Economic analysis must test the financial feasibility of burning in British Columbia by weighing the costs and benefits, but the costs of not burning must also be included in the analysis.

Conclusion

Due to the variable nature of fire (Heady 1975), its use as a management technique is unlikely ever to be refined to the point where specific effects can be predicted. On the other hand, understanding fire and its consequences is fundamental to good management and without this understanding, the hope of achieving particular goals with prescirbed burning is dubious at best. Indeeded, indiscriminate burning, without adequate knowledge, may be tantamount to the range manager jumping from the proverbial frying pan into the fire!

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POSITION ANNOUNCEMENT

The Department of Animal and Range Sciences, South Dakota State University, Brookings, South Dakota, announces the opening for a position as **Superintendent, Antelope Range Field Station, Buffalo, South Dakota.**

The responsibilities of the position will be ongoing management of the animal and range research projects at the 7866-acre field station under the direction of two or more research scientists. Duties include feeding, breeding and care of research animals consistent with experimental procedures outlined in projects approved for the station. This is a working as well as supervisory position with typically one full time assistant and seasonal part-time help. The superintendent acts as spokesman for the Animal and Range Sciences Department and South Dakota State University in matters relating to local public relations and community service, individual and group requests for information from local station research or research conducted elsewhere and local needs, problems or concerns that may warrant university involvement either on or off station. Current projects involve a beef cattle breeding project and a sheep production project.

Qualifications: The individual must have a B.S. degree in Animal Science (MS. preferred). Training in artificial insemination and experience in range livestock production and management are preferred. Applicants should have both desire and ability to work harmoniously with students, staff and ranchers and have an appreciation for research and research methods. The salary will be commensurate with training and experience.

Applications will be accepted until March 15, 1983, with employment beginning as soon as possible thereafter. Those received after that date will be considered if a qualified and acceptable candidate has not applied earlier. Applications should include a resume and university transcripts. In addition, the applicant should request that a minimum of three persons submit letters of recommendation to: *Dr. John R. Romans, Head, Department of Animal and Range Sciences, South Dakota State University, Box 2170, Brookings, South Dakota, 57007-0392. Telephone (605)688-5165.* South Dakota State University is an Affirmative Action/Equal Opportunity Employer (Female/Male).

The Department of Animal and Range Sciences, South Dakota State University, Brookings, South Dakota, announces the opening for a position as **Assistant in Range Science.**

The responsibilities of the position will be hiring and supervision of summer employees; developing research plans with project leader; planning and scheduling field sampling; selection of research cooperators and establishing field studies with assistance from project leader; maintenance and care of field and laboratory equipment; careful and sometimes detailed measurements of attributes of vegetation, soil and grazing animals; data organization, compilation and computation; and assisting with preparation of written progress reports, annual reports and other publications. Preparation of oral presentations for producer groups, federal and state agency technical and management personnel or other audiences may be periodically required. Frequent travel in western South Dakota, especially in summer, can be expected with occasional overnight stays. University transportation is available.

Qualifications: The individual must have a B.S. or M.S. degree in Range Science or related fields. Preference will be given for education, training and experience in range management, range science or closely related disciplines. Experience in data processing is desirable. The position should be considered as providing valuable experience for individuals contemplating further graduate study. The salary will be commensurate with training and experience.

Applications will be accepted until March 15, 1983, or until a suitable applicant has been selected. Applications should include a personal data sheet and university transcripts. In addition, the applicant should request that a minimum of three persons submit letters of recommendation to: *Dr. Robert Gartner, West River Agricultural Research and Extension Center, 801 San Francisco Street, Rapid City, South Dakota, 57701. Telephone (605)394-2236.* South Dakota State University is an Affirmative Action/Equal Opportunity Employer (Female/Male).