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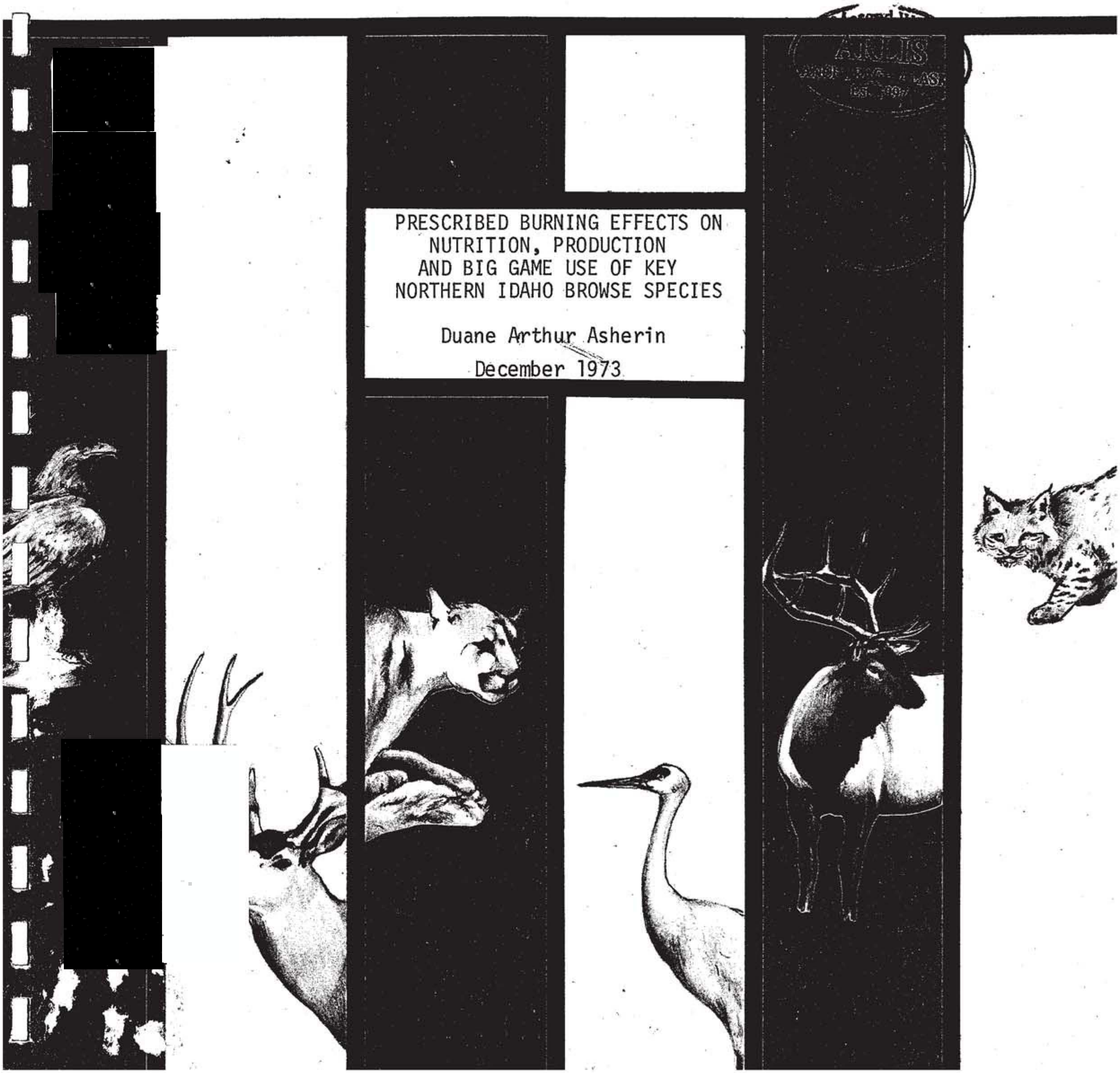

PRESCRIBED BURNING EFFECTS ON NUTRITION, PRODUCTION AND BIG GAME USE OF KEY NORTHERN IDAHO BROWSE SPECIES

Duane Arthur Asherin

December 1973

PRESCRIBED BURNING EFFECTS ON NUTRITION, PRODUCTION AND BIG GAME USE OF KEY NORTHERN IDAHO BROWSE SPECIES

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AUTHORIZATION TO PROCEED WITH FINAL DRAFT:

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Graduate work commenced at the University of Idaho in September, 1967, and requirements for the degree of Doctor of Philosophy in Wildlife Science were completed in December, 1973.

Mr. Asherin married the former Judith B. Maas on April 15, 1961. They presently enjoy four children: Lance A., Craig R., Steven P., and Deborah J.

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ABSTRACT

Prescribed burning effects on the production and nutritional quality of four northern Idaho key browse species were investigated in three spring burns (1967, 1948, and 1969) in each of two main study areas--the Lochsa and St. Joe River drainages--and in 1968 and 1969 prescribed burns on the University of Idaho's experimental forest. Big game use of burned and nonburned sites was also compared. Only dormant plant tissue was sampled for nutritional effects corresponding to the critical big game winter stress period.

Nutrient analyses of current annual growth (CAG) not longer than four inches from four key browse species--mountain maple (*Acer glabrum*), serviceberry (*Amelanchier alnifolia*), redstem ceanothus (*Ceanothus sanguineus*), and willow (*Salix* spp.)--indicate species specific responses to spring prescribed burning. Crude protein was significantly higher the first year after burning in 83.3 percent of the burned vs. nonburned comparisons for all species. This effect was absent by the end of the second year, suggesting spring burns are of low intensity. With one exception, redstem protein content was lower on burned compared to nonburned sites. Strictly maintenance forages are indicated by the protein content noted. Fat content generally was lower the first year but higher in the second and third years after burning. Willow was considerably higher in fat than any other species and redstem the lowest. Crude fiber was significantly lowered in 72.7 percent of the comparisons for all three years of burns, indicating increased overall digestibility. Crude fiber content increased, however, in mountain maple on burned sites. Ash showed no apparent trends for any browse species but was highest on controls and burns in willow. Calcium was lower in

66.6 percent of the significant comparisons through the three years of burns. Phosphorus increased in all first year comparisons but no difference was detectable after two years. The combined effect was a significant reduction in the C:P ratio over all species for the first two years. This may benefit effective reproduction of forest ungulates present. All first year moisture comparisons were significantly higher. However 87.5 percent of the significant comparisons were lower in the second and third years following burning. Preference by big game for burned sites compared to nonburned sites and for the most recent burn may be associated with the higher succulence of plant tissue on burned sites.

Available production of redstem ceanothus on Lochsa burned sites exceeded control plant production after two years, while redstem plants on Avery burned sites produced less available browse than control plants after three years due primarily to heavy summer use. Willow plants produced significantly larger amounts of available browse on all three years of burns in both study areas compared to control plants. Increased available production of such tall-growing shrubs as willow more than offsets the loss of available redstem production for the first few growing seasons following spring prescribed burning.

Pellet group and utilization counts substantiate higher summer and winter use of burned compared to nonburned sites by big game. Utilization data also show a higher preference for redstem ceanothus over the other three browse species examined. Increased use of burned sites as well as forage species preferences are questioned as being solely attributable to associated nutritive values. Nutrient data do not support the contention that big game select or prefer certain browse species over others on the basis of higher protein content. The higher carbohydrate fraction found in redstem nutrient analyses compared to the other three browse species analyzed may be responsible for the higher preference for redstem by big game.

Winter CAG availability, seedling survival, and possibly the future vigor of the shrub community were found greatly affected by the degree of summer utilization of preferred browse species by big game, snowshoe hares (*Lepus americanus*), and possibly other rodents during the first few growing seasons following burning. Burning scattered areas on a given tract of winter range appears more beneficial than one area of the same acreage. This way, the CAG available in adjacent nonburned sites may be utilized more fully. Nonburned sites may thus receive a regrowth stimulus, maintain better growth form, and animal distribution and plant utilization may be more uniform over the entire winter range.

Three potential problems associated with spring prescribed burning as opposed to fall prescribed burning are discussed. Re-examination of the effects of and the potential for more fall burning is posed. The past and present practice of intensive fire suppression on our forest ecosystems is also discussed and the probability of producing unnatural ecosystems is predicted if this practice continues.

INTRODUCTION

Wildfires in the early 1900's destroyed millions of acres of mature coniferous timber and created extensive seral brushfields which allowed remnant populations of elk (*Cervus canadensis*) and deer (primarily *Odocoileus hemionus*) to expand in northern Idaho. These brushfields have progressed to an advanced, mature stage due to subsequent natural succession and the past and present practice of total wildfire suppression. Shrub decadence, unavailability of current annual growth on tall-growing shrub species, and conifer encroachment on these ranges are indications of the need for winter range rehabilitation. Prescribed burning is a relatively recent management tool being applied to northern Idaho brushfields by the Idaho Fish and Game Department and the U.S. Forest Service to rehabilitate big game winter ranges created by early wildfires. It was first used for this purpose on an experimental basis in 1960 on the Avery Ranger District of the St. Joe National Forest (Brown 1966). Initial results indicated that both fall and spring prescribed burning were cheaper than spraying and produced more desirable results. In 1965, the Idaho Fish and Game Department and the U.S. Forest Service entered a cooperative study on the use of prescribed burning in the Clearwater National Forest.

Objectives

This project was initiated in the spring of 1968 to investigate important aspects of prescribed burning as a tool for rehabilitating big game winter ranges. Specifically, research objectives were: (1) to ascertain the effects of prescribed burning on the nutritive value of key browse species; (2) to evaluate the effects of prescribed burning on browse yield; and (3) to compare big game use of burned and nonburned areas in relation to nutrient changes. Key browse species studied included: redstem ceanothus (*Ceanothus sanguineus*), mountain maple (*Acer glabrum*), serviceberry (*Amelanchier alnifolia*) and willow (*Salix* spp.).

It was necessary to omit two additional objectives when attempts to do my own prescribed burning failed due to poor burning conditions. These objectives included: (1) to define the burning temperatures of prescribed burns in relation to subsequent reproduction of plant species and survival of existing browse species and (2) to evaluate the energy released on prescribed burns.

Justification

That big game animals are an extremely important asset to the ecosystems of the western United States, including Idaho, cannot be denied. Their immediate economic importance lies not only in the financial returns derived from the big game hunting seasons, but also in the aesthetics these animals offer the vacationing public. Each year, residents and nonresidents spend thousands of dollars on the opportunity to bag "trophy" big game animals either with firearm, bow and arrow, camera or some combination of these. According to the Outdoor Recreation Resources Review Commission (1962), Americans in year 2000 will spend about 80 percent more time hunting than they did in 1960. Big game is an essential element in the economy of the state of Idaho and by all indications will become even more so. In addition, I believe many people enjoy just knowing big game species still exist somewhere -- even though they may never be able to hunt them with a firearm or camera. Peterle (1961, 1967) found some support for the latter when preliminary results of a hunter questionnaire showed 70 percent of the people favor setting aside more wilderness areas; about half of the hunters felt it was a successful hunt even if they did not kill game; and 79 percent of the people "said that part of the pleasure of hunting results from seeing sunsets, bird nests, trees, flowers, and other wonders of nature." He concludes that "For the urbanized hunter of Ohio, wilderness is attractive even though he has little experience with it, indicating that enthusiasm can be generated for preserving wilderness tracts even among people who may never use them."

To meet these demands of a rapidly expanding population of recreation-minded Americans, fish and game departments and federal natural resource agencies are contronted with the problem of maximizing the carrying capacity of existing game ranges and creating new wildlife habitat. This problem is intensified by man's destruction of literally thousands of acres of big game range annually. He is accomplishing this in a variety of ways--urban expansion, intensified ranching and farming practices, more extensive recreational demands, more efficient and extensive road and highway systems, as well as water development projects to name only a few.

In addition to the immediate economic benefits accrued from big game animals and undoubtedly of even greater importance, is the balance these animals lend to ecosystems in which they occur. Many ecologists have suggested that the complexity of food webs is correlated with the stability of an ecosystem. More mature ecosystems are characterized by more efficient utilization of food materials, high species diversity, smaller amounts of energy for maintaining their structure or for preventing their destruction, and others (Odum 1962; Margalef 1963). Deer and elk add to the complexity or the stability of an ecosystem and thus increase its maturity or better its chance of self-preservation.

Investigations into the problems of managing North American deer and elk show that local populations are often limited by inadequate supplies of nutritious, available forage. Today, most game managers agree that big game "starvation" is a direct result of inadequate nutrition. Big game food habits studies on various ranges show that the animals consume small quantities of a great variety of forage species. But on each area they are dependent on a few species, commonly termed "key species," for their maintenance during the critical period of the year--usually late winter and early spring. The results of severe overutilization on key species include lowered calf and/or fawn production, poor vigor, disease,and malnutrition. Most big game which die of malnutrition do so with a full rumen containing browse which will not sustain them--and thus should not be attributed to starvation unless a lack of forage is clearly demonstrated.

Thus, the problem of adequate nutrition for big game is one of quality as well as quantity. It is essential that we acquire an understanding of the chemical composition and actual nutritive value of key browse species before and after a habitat manipulation program including prescribed burning. Essential also is an understanding of treatment-production effects and determination of animal preference for the newly created habitat. This is prerequisite to recognizing the limitations of game ranges that exist and the particular manipulation that will alleviate them. Most certainly, analysis of the prescribed burning program and key browse species will make an important contribution to understanding the winter nutrition of big game. In addition, it will help to fill a gap in our technical know-how of restoring depleted ranges, creating new range, and integrating game and forest management.

Previous Work

Little is known about fire behavior and its effects in the mountainous, western United States; whereas, in southeastern United States a great deal is known about prescribed burning. The Tall Timbers Research Station at Tallahassee, Florida, is primarily concerned with the ecology of fire, both basic research on the influence of fire on the environment and the application of fire in land management. In the Southwest, fire is being used on an increasing scale for the suppression of undesirables, like sagebrush in grassland management. Today we realize that fire is a useful tool if properly applied. We must re-educate the public on the beneficial uses of fire and thereby partially shed the sacred "Smokey the Bear" concept.

Throughout the West, big game densities are controlled by the nutritive levels of the available food supply on their ranges (Biswell et al. 1952, Einarsen 1946, Longhurst et al. 1952, Robinette et al. 1952, Swank 1956). An observed phenomenon among wildlife people is that following extensive forest fires elk and deer populations increase. Researchers generally agree that these increases can be attributed to an increase in the nutritional quality and quantity of available forage (Dasmann and Hines 1959, Einarsen 1946). In addition, many investigators attribute higher selection and palatability of forage species by big game on burned areas to increased nutritive values (Dietz et al. 1958, Hagan 1953, Kucera and Ehrenreich 1962, Moore and Johnson 1967, Penfound and Kelting 1950, Reynolds and Sampson 1943, Swift 1948). Higher protein content has frequently been postulated as the reason for higher selection of certain plants. However, most studies on this subject have dealt with wildfire areas until recently.

On broadcast-burned areas in northern Idaho, Mueggler (1965) found a higher percentage of potassium in the soil and a higher percentage of shrub cover compared to unburned areas. A positive correlation existed between soil potassium and shrub cover. Broadcast-burned sites also had more tall-growing shrubs than undisturbed sites and sites which had been logged but not burned.

Pengelly (1966) noted no harmful effects on soil, plant and animal resources by burning logging slash on the Coeur d'Alene National Forest in northern Idaho. He observed rapid revegetation of the slopes which prevented erosion and leaching while producing valuable wildlife habitat.

Leege (1968, 1969, 1971) has reported on a number of the significant findings of the Clearwater cooperative study being conducted by the Idaho Fish and Game Department and the U.S. Forest Service. Included among his findings are: (1) all shrub species usually sprout prolifically after both spring and fall burns, but more sprouts generally resulted after spring burning; (2) all species produced a larger number of basal sprouts than Mueggler (1966) reported for the same species when they were treated with herbicides; (3) browse palatability increased on both spring and fall burns for all species as indicated by a heavier percentage of browsed twigs and an increase in browsing diameter on burned areas; and (4) a higher protein content was found in burned plants than in controls.

In summary, prescribed burning has a place in wildlife habitat manipulation. It creates more browse in an available form which appears to be more nutritious than browse on unburned areas. However, this latter point has not been substantially defined.

STUDY AREA LOCATIONS AND DESCRIPTIONS

Three study areas were used during the course of this investigation--the Hatter Creek, Avery and Lochsa study areas (Figure 1).

Hatter Creek

This study area is located approximately six miles south of Princeton, Latah County, Idaho, within the Hatter Creek deer enclosure. A nine foot high woven wire fence surrounds this 800 acre plus tract of land located on the north slope foothills of Moscow Mountain within the University of Idaho experimental forest. The area is underlain by intrusive weathered granitic rock with some mantling by loess. No recent wildfire history characterizes the area and current grazing use is by white-tailed deer (*Odocoileus virginiana orchorourous*) and black bear (*Ursus americanus*).

Specific study site locations are: (1) Hatter Creek 1968 spring burn--SW¼SW¼ of Sec. 1, R4W, T40N, Latah County, Idaho; and (2) Hatter Creek 1968 fall burn and 1969 spring burn--SW¼SE¼ of Sec. 2, R4W, T40N, Latah County, Idaho. The area was cover-mapped by Basile (1954) using Daubenmire's (1952) classification and Hungerford's (1951) cover type classification. Thilenius (1960) updated Basile's original cover-map work. The 1968 spring prescribed burn is in the cedar-hemlock zone and more specifically in the *Thuja plicata/Pachistima myrsinites* habitat type. True aspect is 25°NNE with 50 percent slope at an elevation of 2800 feet and relief is hilly-to-mountainous. The 1968 fall burn and the 1969 spring burn are in the Douglas fir zone, and more specifically in the *Pseudotsuga menziesii/Physocarpus malvaceus* habitat type. True aspect is 65°ENE with 40 percent

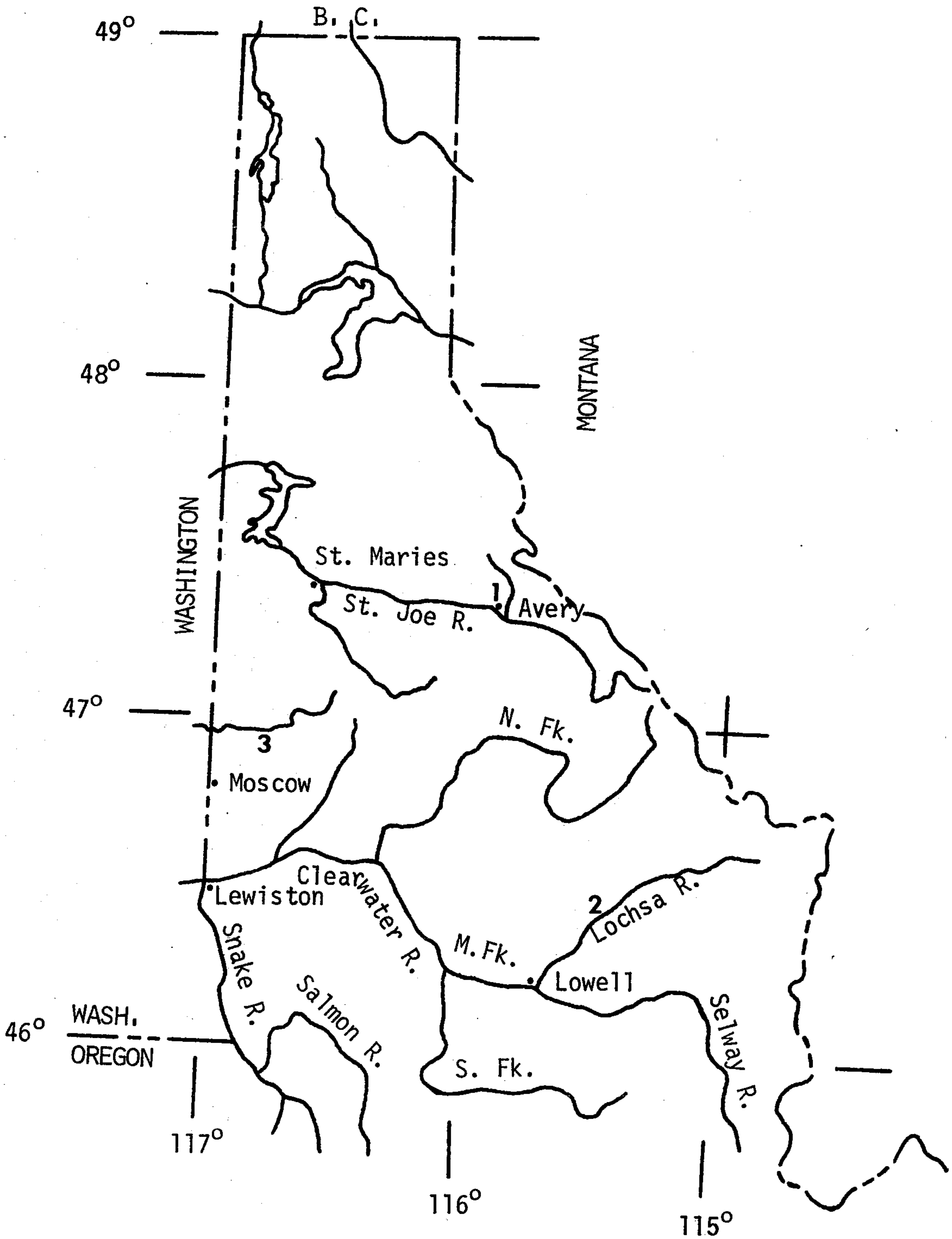

FIGURE 1. AREA MAP OF NORTHERN IDAHO SHOWING GENERAL LOCATION OF THE AVERY(1), LOCHSA(2), AND HATTER CREEK(3) STUDY AREAS.

slope at an elevation of 2900 feet and relief is again hilly-to-mountainous. All controls or nonburned study sites are located adjacent to the treated sites.

Avery

Avery is located along the St. Joe River approximately 52 miles east of St. Maries, Idaho. The St. Joe River flows northwesterly from the mountains of the Bitterroot Range, along the Idaho-Montana State line, into the southern end of Lake Coeur d'Alene. My study area here consisted of two parts, both of which lie in the Avery Ranger District of the St. Joe National Forest. One area is located in the Hammond Creek drainage--the mouth of which is about six miles upstream from Avery on the North Fork of the St. Joe River road. The Hammond Creek study site is on the north side of the drainage about one and one-half miles upstream from the mouth of Hammond Creek. A second area is located on the north face of the St. Joe River only about one airline mile northwest of Avery. Study sites here are referred to as Relay Station sites due to a cable television relay station located near them. All five study sites are within a two-mile radius of each other.

Geologically, the Avery area is characterized by mildly folded and metamorphosed Beltian sedimentary strata. Steep, narrow-bottomed canyons with relatively high, rounded ridges characterize this area. Large acreages were burned north of Avery by wildfires in 1910 and again in 1934 (Current 1971). Thus, most of this country is virtually a seral brushfield with scattered pockets of lodgepole pine (*Pinus contorta*). Current grazing use is by big game only--namely, Rocky Mountain elk (*Cervus canadensis nelsoni*), white-tailed deer, mule deer (*Odocoileus hemionus*), and black bear.

Specific locations and the physiography of study sites in the Avery study area are listed in Table 1, and an Avery weather summary is compiled in Table 2. Where a study site is split by a finger ridge, as in the Relay Station 1969 Burn, or by an intermittent stream, as in the Relay Station Control, two sets of aspect and slope data are listed. Because of the close proximity of the 1969 and 1968 Relay Station burns and because of a lack of similar control sites, only one control is used for both treatments.

All study sites are in the *Thuja plicata/Pachistima myrsinites* habitat type according to Daubenmire's (1968) classification.

Lochsa

Six study sites, all within a two-mile radius of each other, were located in the Lochsa River drainage. The Lochsa River flows west-southwest through the Lochsa Ranger District of the Clearwater National Forest in Idaho County, Idaho. It joins the Selway River at Lowell, Idaho, to form the Middle Fork of the Clearwater River. The burn sites used are part of the cooperative studies being conducted by the Idaho Fish and Game Department and the U.S. Forest Service to evaluate the use of prescribed burning as a habitat manipulation tool for increasing available browse on big game winter ranges.

Two study sites, a 1969 burn and its respective control, were located approximately thirty miles upstream from Lowell in the Lone Knob Creek drainage. A 1968 burn and control were located about two and one-half miles upstream from the mouth of Fish Creek near Pagoda Creek. A 1967 prescribed burn and its control were located on the U.S. Highway 12 face of the Lochsa River just below its junction with Bee Creek. The Bee Creek junction is

TABLE 1. PHYSIOGRAPHY AND SPECIFIC LOCATIONS OF FIVE MOUNTAINOUS STUDY SITES AT AVERY, SHOSHONE COUNTY, IDAHO.

Study Site	Location	Elevation (Feet)	Aspect (True)	Slope (Percent)
Relay Station 1969 Burn	SW¼NE¼ of Sec.9,R5E,T45N	3930	90°ESE	45
			244°W	34
Relay Station 1968 Burn	NE¼SE¼ of Sec.9,R5E,T45N	3620	104°ESE	56
Relay Station Control	SE¼SE¼ of Sec.9,R5E,T45N	3550	96°ESE	56
			186°SSW	55
Hammond Creek 1967 Burn	SE¼NW¼ of Sec.26,R5E,T46N	3620	158°SSE	55
Hammond Creek Control	SE¼NW¼ of Sec.26,R5E,T46N	3710	196°SSW	54

TABLE 2. WEATHER SUMMARY FOR THE AVERY STUDY AREA. READINGS LISTED ARE MEANS FOR THE PERIOD JANUARY, 1960, THROUGH MARCH, 1971, AT THE AVERY RANGER STATION (2492 FEET ELEVATION).

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Temperatures												
27.2	32.4	36.4	44.4	53.9	61.7	68.0	67.1	58.8	47.4	37.7	29.4	47.1
Total Precipitation												
5.94	3.42	3.26	2.78	2.34	2.50	0.80	1.57	1.91	2.87	3.60	3.56	34.48
Snow Totals												
30.4	12.6	11.0	0.7	Tr					Tr	6.8	22.1	
Maximum Snow Depth on Ground												
23.8	22.5	20.0	3.0						Tr	4.1	12.5	

about one-half mile below the Fish Creek junction. A 1969 burn in the Bee Creek drainage about one-half mile upstream from the mouth was also utilized.

Geologically, the Lochsa country is underlain by weathered, intrusive granitic rock of the Idaho Batholith. Steep, narrow-bottomed canyons with high, craglike ridges characterize the Lochsa River and many of its tributaries.

The Lochsa River drainage has an extensive wildfire history. Millions of acres of coniferous timber were destroyed by wildfires in 1910, 1919, and 1934. None of my study sites was burned in the 1910 wildfire (Norberg and Trout 1958). The Lone Knob Creek sites were burned in 1919 and 1934; the Fish Creek sites were burned in 1917, 1919 and again in 1934; and the Bee Creek sites were burned in 1934 only. These wildfires were responsible for the sudden boom in elk and deer numbers following the burns by creating vast brushfields of available browse. Present grazing use is by Rocky Mountain elk, white-tailed and mule deer, moose (*Alces americana shirasi*), and black bear.

Specific locations and the physiography of study sites in the Lochsa study area are listed in Table 3, and a Lochsa weather summary is compiled in Table 4. For comparison, I have included weather data from the Fenn Ranger Station on the lower, western end of the Lochsa River drainage. These two stations represent the extremes of weather that can be expected. However, I feel the Fenn weather data to be more characteristic for the study sites. Two aspect and slope values are listed where finger ridges are found in the study site.

All study sites are in the *Thuja plicata/Pachistima myrsinites* habitat type according to Daubenmire's (1968) classification.

TABLE 3. PHYSIOGRAPHY AND SPECIFIC LOCATIONS OF SEVEN MOUNTAINOUS STUDY SITES ON THE LOCHSA RIVER, IDAHO COUNTY, IDAHO.

Study Site	Location	Elevation (Feet)	Aspect (True)	Slope (Percent)
Lone Knob 1969 Burn	SW¼NW¼ of Sec.26,R9E,T35N	2370	232°WSW	34
			200°SW	37
Lone Knob Control	SW¼SW¼ of Sec.26,R9E,T35N	2310	220°WSW	52
			286°WNW	44
Fish Creek 1968 Burn	NE¼SE¼ of Sec.19,R9E,T35N	2740	196°SSW	52
			66°ENE	68
Fish Creek Control	SE¼SE¼ of Sec.19,R9E,T35N	2530	236°WSW	58
Bee Creek 1969 Burn	NW¼SE¼ of Sec.32,R9E,T35N	2657	142°SSE	66
Bee Creek 1967 Burn	NE¼SE¼ of Sec.32,R9E,T35N	2327	96°ESE	71
Bee Creek Control	NE¼SE¼ of Sec.32,R9E,T35N	2327	96°ESE	71

TABLE 4. WEATHER SUMMARY FOR THE LOCHSA STUDY AREA. READINGS LISTED ARE MEANS FOR THE PERIOD JANUARY, 1960, THROUGH MARCH, 1971, AT THE FENN RANGER STATION (1580 FEET ELEVATION) AND AUGUST, 1962, THROUGH MARCH, 1971, AT POWELL (3632 FEET ELEVATION).

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annu.
Fenn Temperatures												
29.4	35.6	39.6	46.8	55.0	62.8	70.7	69.4	60.0	48.1	40.0	31.3	48.8
Powell Temperatures												
23.4	28.4	27.4	39.4	48.7	57.1	64.4	62.6	54.8	43.8	33.6	24.8	42.8
Fenn Total Precipitation												
5.46	2.96	3.67	4.14	3.02	2.98	0.56	1.48	2.46	3.28	3.91	4.05	37.60
Powell Total Precipitation												
8.08	3.76	3.03	2.81	2.33	3.82	0.95	1.72	2.69	3.82	4.46	5.46	41.66
Fenn Snow Totals												
19.1	8.8	4.4	0.1	Tr						1.1	12.1	
Powell Snow Totals												
76.7	36.0	29.6	8.9	1.8				Tr	2.0	15.4	50.6	
Fenn Maximum Snow Depth on Ground												
13.5	11.6	4.6	Tr							1.1	6.1	
Powell Maximum Snow Depth on Ground												
42.1	46.9	44.9	25.0	1.5					1.1	7.4	22.4	

METHODS AND PROCEDURES

Preliminary Investigations

A pilot study was initiated at the Hatter Creek deer enclosure in a predominantly willow (*Salix* spp.) brushfield in April, 1968. Three treatments were planned for this study site: (1) spring burns, (2) fall burns, and (3) controls. The intent was to follow treatment results for the following three years. I selected twelve subplots and randomly assigned treatments on an equal basis. All subplots were permanently marked with a metal stake and properly identified with a metal tag. The four spring-burn subplots were prescribed burned on April 19 and 20, 1968. Because all three treatments were located within a one acre brushfield, the subplots were quite small and burning was attempted only around those shrubs selected for chemical analysis sampling. Fuels had to be added to the burns and thus were not characteristic of normal prescribed burning. I did not repeat this experimental design.

In addition, white-tailed deer use of sprouting browse was so intense that I needed to fence individual subplots to assure sufficient plant tissue for chemical analysis. This was the only study site in which subplots were fenced. That snowshoe hares (*Lepus americanus*) and possibly other rodents were utilizing the succulent sprouts, also, became evident when even after fencing, many of the sprouts were being readily taken. Fresh hare pellets were noted in all fenced plots. The 4-foot high woven wire fence did keep the deer out. No redstem seedling establishment was noted on fenced plots even where a good seed source was present.

The second mature, seral brushfield (about 4 acres in size) was laid out in a randomized block design. I was able to place two replications of each treatment on this Hatter Creek study site. Fire breaks 10 feet wide were bulldozed down to mineral soil on three sides of the treatment units with a road serving as a fire break at the top of the slope. All subplot stakes were selected in a systematic-random manner by first randomly locating the first subplot stake at the top of the slope and then systematically locating the remaining subplots at 40 foot intervals along a selected azimuth down the slope. All treatment units were more or less rectangular in shape--at least 40 feet wide at the top and bottom of the slope, but varying from 477 feet to 600 feet in length. An attempt to burn one fall treatment in late September, 1968, was very spotty even though weather conditions appeared good at the time. Grasses and bracken fern (*Pteridium equilinum*), the two primary flash fuels present, were only half cured. This resulted in difficult initial ignition of these flash fuels, an extremely slow rate of fire spread, and the necessity to reignite areas where the fire front burned itself out. Poor burning conditions were also responsible for a dismal failure in my attempt to document the heat energy absorbed by one-gallon water cans (Beaufait 1966) distributed systematically throughout the burn area. This would have yielded an index of energy released. Ignition devices used included back-packed diesel fuel drip-torches and hand-held propane cylinders. Because of the poor burning results and later rains, the second fall treatment was never burned. Similar results occurred in the spring burning attempts in May, 1969. Again only one plot was burned rather spottily.

Limited success in my own prescribed burning program forced me to utilize burns already completed and/or scheduled for burning. Thus, I expanded the study to the Avery and Lochsa areas where successful burns had already been completed by the U.S. Forest Service and the Idaho Fish and Game Department.

Species Composition, Frequency, and Density

Species composition, frequency of occurrence, and density data were collected during July and August, 1969, on all Avery and Lochsa study sites except the Bee Creek 1969 burn. I sampled 25 permanent points located in a restricted random manner in each stand or study site. All major aspects in each stand were included. Figure 2 depicts method of plot location.

A 1-meter square plot was used to record frequency of occurrence for all species having a portion of their canopy within the frame. Representative plants of most species were collected for later identification and verification. High floral diversity and an early growing season, especially in the Lochsa study area, precluded a collection of the total flora.

The point-quarter-center method (Cottam and Curtis 1956) was used for density estimates of woody plants at the 25 frequency points. Density refers to the number of root crowns per unit area. Using the same method, Roper (1970) had determined that 15 plots would give reliable density estimates ($P>.2$). I qualified my density sampling by placing a 0.5 meter height minimum on woody plants before including them in the sample, and I excluded white spiraea (*Spiraea betulifolia*) when preliminary sampling indicated a 60 percent frequency of occurrence for this species. In addition, white spiraea is not a known preferred big game forage species. Maximum crown

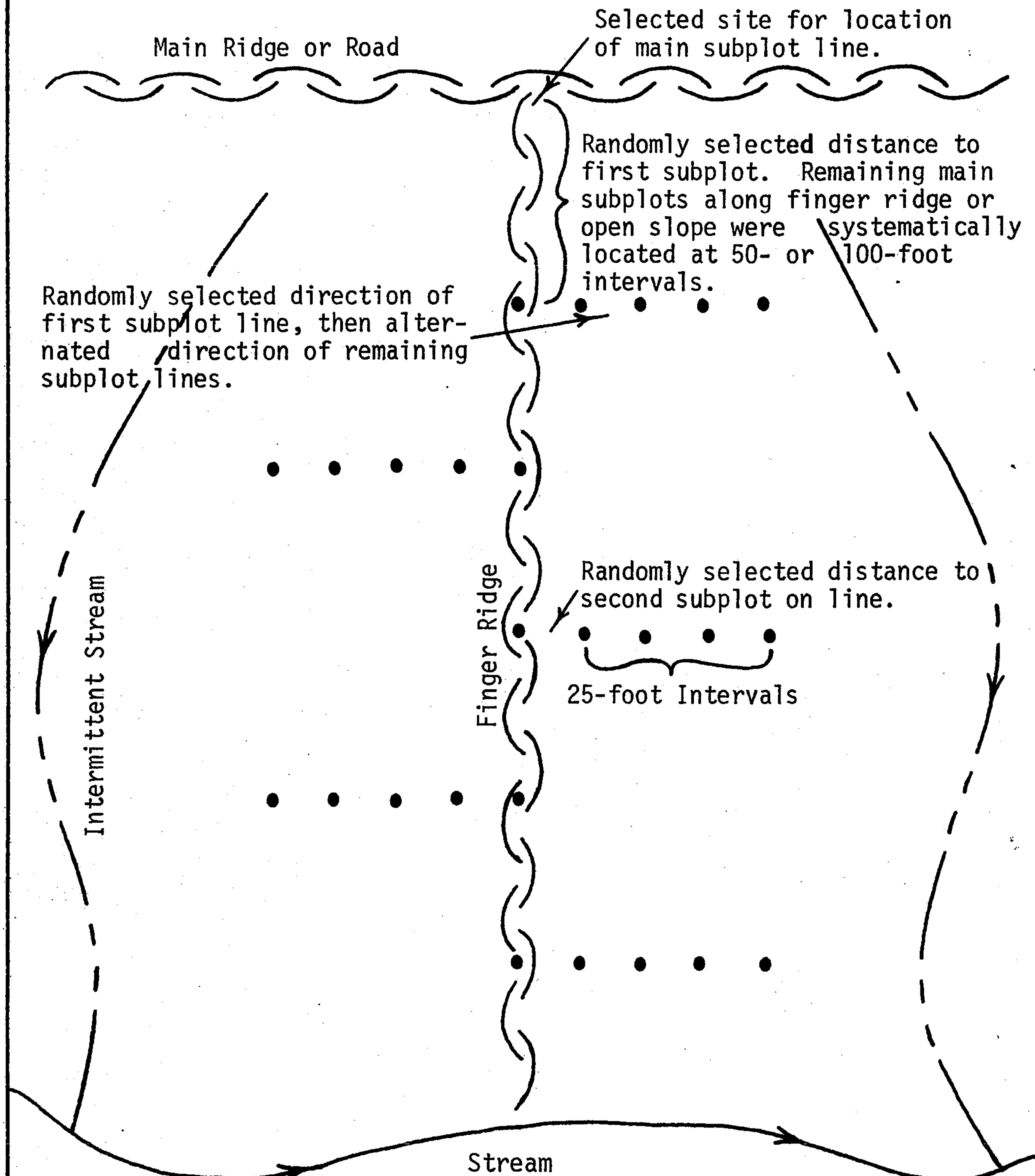

FIGURE 2. METHOD OF RESTRICTED RANDOM LOCATION OF 25 SUBPLOTS PER STUDY SITE.

height of each woody plant in the sample was also recorded.

Vegetation nomenclature follows Hitchcock et al. (1955-69).

Browse Nutrient Analyses

Key Browse Species Defined

Key browse species considered for nutritional effects include: mountain maple (*Acer glabrum*), redstem ceanothus (*Ceanothus sanguineus*), serviceberry (*Amelanchier alnifolia*), and willow (*Salix* spp). *Salix scouleriana* is the predominant willow species in northern Idaho and is the only species I identified, but other species may have been present. These species are accepted by most big game managers as important elk and deer browse species. At Hatter Creek, Thilenius (1960) considered serviceberry, redstem ceanothus and willow to be important browse forage. In the Lochsa River drainage, Leege (1969) considered willow, serviceberry and mountain maple to be three of the most valuable forage species on the basis of abundance. He felt redstem ceanothus was possibly the most important browse plant due to its low growth form.

I consider key browse species to be those plant species which big game are primarily dependent upon to supply them with their life requirements on a given range. They are preferred, available species in sufficient abundance to be an important component of the vegetation complex and are nutritionally valuable. Key species are dynamic and should serve as indicators of changes in the vegetational complex.

Clipping Procedure and Sample Preparation

Initially I anticipated collecting browse samples throughout the year to obtain a spectrum of the rise and fall in nutritive value of key browse species. This phenomenon of initial high nutritive values associated with rapid growth in the spring and decreasing as the seasons advance has been reported by a number of investigators (Biswell et al. 1952, DeWitt and Derby 1955, Dietz et al. 1958, Einarsen 1946, Hellmers 1940, Short et al. 1966, Swank 1956). In light of this documentation and because of a shortage of funds for chemical analyses, I altered this objective and limited my collection period to the critical winter stress period for big game, namely February through mid-April. This is also the dormant phenological stage for vegetation.

Browse samples were clipped with either a pocket knife or a small pruning shears from the nearest shrubs, of a given species, to the subplot stakes.

I clipped up to the terminal four inches of current annual growth (CAG) and required the presence of a terminal bud. I arbitrarily imposed these restrictions realizing that the nutritive value decreases the further away from the terminal bud the sample is taken (Aldous 1945, Bailey 1967, Blair and Epps 1961). The presence or absence of a terminal bud and lateral buds is also influential. Approximately 40 grams of fresh weight material constituted a sample, and 12-15 samples of each species were collected in each study site. By clipping on a weight basis I attempted to divide each shrub sampled into 4 horizontal sections and 2 or 3 vertical sections depending on shrub height. The sample was clipped in approximately equal portions from each of the 4 horizontal divisions in the available zone (2-8 feet high measured from the base of the root crown). Two or three shrubs of a particular species were usually used for each sample collected.

Samples were placed in number 8 paper bags, weighed on a Chatillon spring balance, allowed to air dry, oven dried for at least 24 hours at 105°C., reweighed on an electronic balance, and ground in a Braun Blender (model MX32). Thus, moisture content is based on fresh field weight compared to oven dried weight. I had very little loss of fine bud material using the Braun Blender. Considerably more fine material would have been lost using a Wiley Mill. Including this fine bud material is critical in this type of analysis due to the known concentration of nutrients here (Aldous 1945, Blair and Epps 1961, Bailey 1967).

Ground samples were taken to the Department of Agricultural Biochemistry and Soils, University of Idaho, Moscow, for chemical analyses. The proximate analysis system was employed, using the official methods of the Association of Official Agricultural Chemists (Horwitz 1965). In addition, calcium and phosphorus determinations were made on the ash content at an ashing temperature of 525°C.

Browse nutrient data were analyzed statistically using a least squares and maximum likelihood general purpose program. Duncan's new multiple range test ($P>.01$) was used for significance tests on adjusted means. University of Idaho Computer Services handled all statistical analyses.

All nutrient values, except moisture, were multiplied by the correction constant 1/.9673 before being analyzed statistically to place all values on a total dry weight basis. The value, 0.9673, was arrived at by calculating the mean percent moisture absorbed by randomly selected samples of all browse species following oven drying and then subtracting that percentage (3.27 percent) in its decimal form from 1.

Required sample sizes (n) were calculated on an Olivetti Underwood 101 electronic desk computer using the formula:

$$n = \frac{t_1{}^2 s^2}{d^2}$$

where t_1 is the tabulated t value for the desired probability level (95 percent) and the degrees of freedom of the initial sample, s^2 is the initial sample variance, and d is the half-width of the desired confidence interval (± 10 percent) (Stein 1945).

Browse Production Determinations

Prescribed burning effects on browse production were evaluated on the Avery and Lochsa study areas only. Redstem ceanothus and willow were the only two browse species considered. Current annual growth (CAG) collections of these two species were made during April, 1970. Selected branches were cut with a pruning shears from a number of root crowns over the entire study site, and all CAG over 3 inches long was removed. Only unbrowsed twigs were included in the sample. Twigs were then air dried, individually weighed to the nearest 0.01 gram and measured to the nearest 0.5 centimeter.

The total twig sample from each stand for each species was then stratified into length classes and tested for needed sample sizes using the same formula as in the nutrient analyses. The required number of twigs (n) for each species was satisfied for all but a few of the longest length classes where the 80 percent probability level ± 20 percent of the mean was used.

I assumed that twigs as collected in the field were representative numberwise of the shrub species population on the study site. Stand mean twig weights were then calculated as follows:

$$\text{Weighting Factor}_{(i)} = \frac{\text{No. Twigs in Length Class}_{(i)}}{\text{Total No. Twigs Collected in Stand}}$$

$$\text{Weighted Ave. Class Twig Weight}_{(i)} = \text{Weighting Factor}_{(i)} \times \text{Class Mean Twig Weight}_{(i)}$$

$$\text{Stand Mean Twig Weight} = \ _{(i)} \text{ Weighted Ave. Class Twig Weights}$$

where: i refers to length class.

I used the following equation for calculating production on a per plant basis:

$$\text{Production (grams/plant)} = \text{Mean No. Twigs Per Shrub} \times \text{Stand Mean Twig Weight}$$

Procedures for determining the mean number of twigs per shrub are discussed later.

Evaluation of Big Game Use

Relative intensity of use of burned and nonburned sites by big game was compared using pellet group counts, twig counts and personal observation. Twig counts were taken concurrent with pellet group counts. Spring counts which were taken to document winter use include the May-June, 1970 count and the April-May, 1971 count. The only actual fall count was taken in October and November, 1970, to record summer use. However, in taking the 1970 spring count I classified both browsed twigs and pellet groups to the 1969 summer use period and to the 1969-70 winter use period. Therefore, two summer use periods and two winter use periods were covered in the study. No attempt was made to estimate the number of big game animals utilizing an area on the basis of pellet group counts. They were used only as a relative intensity of use index in addition to the twig count index.

Stratified Twig Counts

Twig refers to current growth only. In reference to growth of the first growing season following burning, twig refers, in general, to sprouts. However, some lateral growth was noted even on sprouts. In addition to the relative use index, twig counts were used in production computations of both available and unavailable browse.

Spring, 1970 twig counts considered both willow and redstem ceanothus. Fall, 1970 and spring, 1971 counts considered only redstem ceanothus. Twig counts were conducted only on the Avery and Lochsa study areas.

I counted all the twigs on 25 plants of a species in each stand. The closest plant of a species to the subplot stakes was used. If a stand contained less than 25 subplots, for example, the Bee Creek Control, the closest two or three plants of a species were counted. Only twigs greater than three inches long were counted. Twigs were arbitrarily classified into three height stratifications: (1) below two feet, (2) two feet to eight feet, and (3) above eight feet. Measurements were made from the center of the root crown except where branches grew downslope for some distance from the root crown in which case measurements were made to ground level directly below the twig in question. I considered twigs below two feet and above eight feet unavailable for winter use.

I tabulated utilization on the basis of the number of twigs and/or sprouts which showed evidence of being leaf stripped and/or browsed. Formula used is:

$$\text{Mean \% Utilization} = \frac{\text{Mean No. Twigs Browsed Per Plant}}{\text{Mean No. Twigs Per Plant}}$$

Pellet Group Counts

Pellet group plots 0.01 acre in size as recommended by Robinette et al. (1958) and Julander et al. (1963) were used on all study sites. Belt transects were used on the Hatter Creek and Lochsa areas while circular plots were used at Avery. Transects were located both parallel and perpendicular to the contour of the slope. Stand subplot stakes served as end points or centers for the counts. Counts were made twice along each transect or in each circular plot, but in opposite directions to avoid missing pellet groups (Robinette et al. 1958). All pellet groups present were removed. In addition, all pellet groups present for about two feet on the uphill side of the plots were removed, as Wallmo et al. (1962) found that in steep terrain, heavy rainfall could cause a redistribution of pellet groups or cause them to be indistinguishable.

Soil Classification and Chemical Analyses

Soil descriptions of all sites in the Lochsa and Avery study areas were obtained by describing a soil pit dug in a representative location in each stand. Soil descriptions are based on the 7th approximation for classifying soils (Soil Survey Staff 1962). I also collected at least 1000 grams of soil from each horizon for further laboratory chemical analyses. Laboratory analyses included pH, carbon, nitrogen, organic matter, calcium, phosphorus, potassium and magnesium. Methods used follow Jackson (1958) with a few minor modifications.

RESULTS AND DISCUSSION

Vegetation Analysis

Frequency of occurrence, density, and species composition for woody species occurring in the Avery and Lochsa study sites are listed in Appendix I - Tables 15 and 16, respectively. The 0.5 meter height minimum arbitrarily required for woody species before inclusion in the density sample minimized chances of some medium- and nearly all low-growing shrubs from being sampled. Frequency data for these species are more accurately listed in Appendix I - Table 17. Because all overstory vegetation was included in frequency determinations, frequency of occurrence for large spreading species may be overestimated. For notes on the successional stages these species occupy, their general distribution, and the typical vegetation zones in which they occur in northern Idaho, see Roper (1970), Table 8.

The wide range of densities found for the key browse species indicates that evaluation of burning effects on production or yield would be invalid on a unit area basis. For this reason, production effects are compared later on a per plant basis.

Frequency data for woody species and for the grass and forb constituents of the stands (Appendix I - Table 17) along with observations of charred *Thuja plicata* stumps, downfalls, and standing snags substantiate that all study sites are in a common habitat type of the *Thuja plicata* - *Pachistima myrsinites* association in the *Thuja-Tsuga* zone according to Daubenmire's (1968) classification.

Browse Nutrient Relationships

Chemical analysis results from the 1969-spring collection period are presented in Table 5. Although an attempt was made to clip only dormant twigs, the 1969 Avery samples may include some bud-active twigs. Because of this possibility and because of a small sample size in the 1969 Hatter Creek collections, no inferences as to treatment effects and/or trends are made from these data.

All 1970-spring collections were obtained before dormancy broke. In addition, required sample sizes are satisfied at the 95 percent probability level within ± 10 percent of the mean. The only exceptions were the Hatter Creek East Fork 1968 burns and controls. Chemical analysis results appear in Tables 6, 7, and 8. Apparent treatment effects and nutrient trends which follow are taken from the Avery and Lochsa 1970 analyses. Table 9 lists the combined chemical analysis results for the latter two study areas to facilitate gross comparisons of burned vs. nonburned areas.

Certain precautions should be exercised in the interpretations placed on chemical analysis of forage plants for a number of reasons: (1) laboratory results may be in error (Dietz 1966); (2) statistical significance does not necessarily indicate physiological significance to the animals concerned; (3) plant parts analyzed may not be in the same proportions or kinds as taken by animals in their selective feeding habits; and (4) analyzing species singly gives only a partial reflection of the total mixture of plant species normally consumed by animals. Significance in the following discussion refers to statistical significance only ($P>.01$).

Chemical analysis of forage nutritive composition is only one

TABLE 5. NUTRITIVE COMPOSITION OF TERMINAL FOUR INCHES OF CAG FROM KEY BROWSE SPECIES ON BURNED AND NONBURNED SITES IN THE AVERY AND HATTER CREEK STUDY AREAS.[1,2]

Species, Study Site and Treatment Date	Moisture	Crude Protein	Crude Fiber	Calcium	Phosphorus	C:P Ratio
<u>AVERY</u>						
<u>Mountain Maple</u>						
Relay Station Control	61.10	8.28	33.60	0.98	0.21	4.7:1
Relay Station Burn - 1968	59.78*	8.63	35.95*	1.02	0.22	4.8:1
<u>Willow</u>						
Relay Station Control	54.32	8.52	32.32	1.30	0.20	6.6:1
Relay Station Burn - 1968	58.31	10.12*	27.90*	1.08*	0.24*	4.6:1*
<u>HATTER CREEK</u>						
<u>Mountain Maple</u>						
H. C. East Fork Control	53.57	6.61	36.56	0.88	0.17	5.2:1
H. C. East Fork Burn - 1968	58.35	6.94	39.19	0.84	0.19	4.4:1
<u>Willow</u>						
H. C. East Fork Control	52.47	7.18	32.89	0.93	0.23	4.0:1
H. C. East Fork Burn - 1968	53.86	8.72	33.62	1.16	0.21	5.8:1

1 All measurements in percent of total dry weight.
2 Samples collected in March and April, 1969.
* Different from control at .01 level.

TABLE 6. NUTRITIVE COMPOSITION OF TERMINAL FOUR INCHES OF CAG FROM KEY BROWSE SPECIES ON BURNED AND NONBURNED SITES IN THE HATTER CREEK STUDY AREA.[1,2]

Species, Study Site and Treatment Date	Moisture	Crude Protein	Fat	Crude Fiber	Ash	Nitrogen-Free Extract	Calcium	Phosphorus	C:P Ratio
Mountain Maple									
H. C. 1969 Control	53.28	9.84	4.44	26.32	3.37	56.03	1.13	0.18	6.3:1
H. C. Burn - 1969	54.28	9.96	4.28	26.96	3.12	55.68	0.98	0.19	5.2:1*
H. C. East Fork Control	49.77	9.98	--	28.38	--	--	1.14	0.19	6.1:1
H. C. East Fork Burn - 1968	53.58*	11.12*	--	30.14	--	--	0.86*	0.20	4.4:1*
Willow									
H. C. East Fork Control	53.06	8.69	--	35.07	--	--	0.75	0.14	5.2:1
H. C. East Fork Burn - 1968	50.94	9.51	--	37.26	--	--	0.66	0.16	4.1:1*

[1] All measurements in percent of total dry weight.
[2] Samples collected in March, 1970.
* Different from control at .01 level.

TABLE 7. NUTRITIVE COMPOSITION OF TERMINAL FOUR INCHES OF CAG FROM KEY BROWSE SPECIES ON BURNED AND NONBURNED SITES IN THE AVERY STUDY AREA.[1,2]

Species, Study Site and Treatment Date	Moisture	Crude Protein	Fat	Crude Fiber	Ash	Nitrogen-Free Extract	Calcium	Phosphorus	C:P Ratio
Redstem Ceanothus									
Relay Station Control	54.90	9.36	1.53	27.78	2.60	58.73	0.91	0.13	7.0:1
Relay Station Burn - 1969	63.18*	8.72*	1.35	28.47	2.49	58.97	0.85	0.15*	5.8:1*
Relay Station Burn - 1968	55.99*	8.69*	1.53	27.40	2.34	60.04	0.96	0.15*	6.4:1
Hammond Cr. Burn - 1967	56.24*	8.12*	1.73	28.21	2.59	59.35	1.01	0.13*	8.1:1
Hammond Cr. Control	57.10	9.29	1.81	28.62	2.60	57.68	1.05	0.14	7.7:1
Willow									
Relay Station Control	55.20	7.61	3.91	31.12	3.49	53.87	1.39	0.18	7.8:1
Relay Station Burn - 1969	57.63*	8.60*	2.86*	28.68*	3.13	56.73	1.00*	0.19*	5.2:1*
Relay Station Burn - 1968	53.15*	7.27	4.64*	28.65*	3.25	56.19	1.38	0.18	7.8:1
Hammond Cr. Burn - 1967	53.49*	7.74	5.54*	27.29*	3.09	56.34	1.32*	0.18	7.3:1*
Hammond Cr. Control	54.73	7.47	4.80	28.77	3.29	55.67	1.55	0.18	8.4:1
Serviceberry									
Relay Station Control	55.09	9.14	2.44	27.95	2.84	57.63	1.07	0.16	6.7:1
Relay Station Burn - 1969	54.42	10.04*	1.95	27.16	2.95	57.90	1.17*	0.16	7.2:1
Relay Station Burn - 1968	51.90*	9.28	3.33*	26.74*	2.77	57.88	0.91*	0.15	6.0:1*
Hammond Cr. Burn - 1967	53.50*	9.48	3.25	25.20*	2.79	59.28	1.08	0.15*	7.1:1*
Hammond Cr. Control	56.30	9.44	2.62	26.39	2.86	58.69	1.10	0.17	6.5:1

TABLE 7. CONTINUED.

Species, Study Site and Treatment Date	Moisture	Crude Protein	Fat	Crude Fiber	Ash	Nitrogen-Free Extract	Calcium	Phos-phorus	C:P Ratio
Mountain Maple									
Relay Station Control	55.22	8.19	3.26	34.14	3.02	51.39	0.86	0.16	5.3:1
Relay Station Burn - 1969	57.97*	8.82*	2.36*	36.12*	2.81	49.89	0.85	0.17	5.0:1
Relay Station Burn - 1968	54.26*	8.58	3.28	37.98*	2.44	47.72	0.74*	0.16	4.8:1
Hammond Cr. Burn - 1967	56.34*	8.87*	3.39	35.74*	2.45	49.55	0.62*	0.15*	4.2:1*
Hammond Cr. Control	58.49	9.29	2.97	33.86	3.29	50.59	0.93	0.18	5.0:1

[1] All measurements in percent of total dry weight.

[2] Samples collected in February and March, 1970.

* Different from control at .01 level.

TABLE 8. NUTRITIVE COMPOSITION OF TERMINAL FOUR INCHES OF CAG FROM KEY BROWSE SPECIES ON BURNED AND NONBURNED SITES IN THE LOCHSA STUDY AREA.[1,2]

Species, Study Site and Treatment Date	Moisture	Crude Protein	Fat	Crude Fiber	Ash	Nitrogen-Free Extract	Calcium	Phos-phorus	C:P Ratio
<u>Redstem Ceanothus</u>									
Lone Knob Control	53.40	8.04	1.55	28.83	2.30	59.28	1.05	0.12	9.2:1
Lone Knob Burn - 1969	55.60*	8.30*	1.55	28.60	2.83*	58.72	1.00	0.13	7.9:1*
Fish Cr. Control	53.61	8.53	1.79	29.09	2.58	58.01	0.99	0.12	8.0:1
Fish Cr. Burn - 1968	53.87	8.17*	1.81	29.17	2.35	58.50	0.94	0.13	7.4:1*
Bee Cr. Control	54.72	9.41	1.60	29.81	2.56	56.62	0.99	0.14	7.2:1
Bee Cr. Burn - 1967	54.20	9.23	1.84	28.72*	2.58	57.63	0.97	0.13	7.6:1
<u>Willow</u>									
Lone Knob Control	53.01	7.33	4.09	32.10	3.30	53.18	1.57	0.19	8.4:1
Lone Knob Burn - 1969	55.56*	8.23*	3.95	29.55*	3.26	55.01	1.20*	0.20	5.9:1*
Fish Cr. Control	52.16	7.44	4.31	33.51	3.48	51.26	1.30	0.18	7.5:1
Fish Cr. Burn - 1968	52.13	7.83*	4.83*	28.81*	3.00	55.53*	1.04*	0.17	6.0:1*
Bee Cr. Burn - 1967	52.00	7.23	3.80	31.35	3.74	53.88	1.77	0.17	10.7:1

[1] All measurements in percent of total dry weight.

[2] Samples collected in February and March, 1970.

* Different from control at .01 level.

TABLE 9. COMBINED NUTRITIVE COMPOSITION OF TERMINAL FOUR INCHES OF CAG FROM KEY BROWSE SPECIES ON BURNED AND NONBURNED SITES IN THE AVERY AND LOCHSA STUDY AREAS.[1,2]

Species and Treatment	Moisture	Crude Protein	Fat	Crude Fiber	Ash	Nitrogen-Free Extract	Calcium	Phosphorus	C:P Ratio
					AVERY				
Redstem Ceanothus									
Burned	58.47	8.51	1.54	28.03	2.47	59.45	0.94	0.14	6.8:1
Nonburned	56.00	9.32	1.67	28.20	2.60	58.20	0.98	0.13	7.3:1
Willow									
Burned	54.76	7.87	4.35	28.21	3.16	56.42	1.23	0.18	6.8:1
Nonburned	54.96	7.54	4.36	29.94	3.39	54.77	1.47	0.18	8.1:1
Serviceberry									
Burned	53.27	9.60	2.84	26.37	2.84	58.35	1.05	0.15	6.8:1
Nonburned	55.70	9.29	2.53	27.17	2.85	58.16	1.08	0.16	6.6:1
Mountain Maple									
Burned	56.19	8.76	3.01	36.61	2.57	49.05	0.74	0.16	4.7:1
Nonburned	56.86	8.74	3.12	34.00	3.16	50.99	0.90	0.17	5.2:1
					LOCHSA				
Redstem Ceanothus									
Burned	54.56	8.57	1.73	28.83	2.59	58.28	0.97	0.13	7.6:1
Nonburned	53.91	8.66	1.65	29.24	2.48	57.97	1.01	0.13	8.1:1
Willow									
Burned	53.23	7.76	4.19	29.90	3.33	54.81	1.34	0.18	7.5:1
Nonburned	52.58	7.38	4.20	32.80	3.39	52.22	1.44	0.18	8.0:1

1 All measurements in percent of total dry weight.
2 Samples collected in February and March, 1970.

indicator of forage quality. Forage nutrient content yields limited information concerning physiological values to the animals utilizing the forage. Big game animals utilizing the browse species evaluated are all forest ungulates--namely deer, elk, and moose. As ruminants, they are the near ultimate in walking fermentation vats (Picton 1970). The rumen and its associated microbial population is an ecosystem in its own right. As such, it is dynamically involved in the conversion of stored plant energy to usable animal energy. Forage digestibility is another indicator of the efficiency of this energy conversion and therefore of forage quality. Thus, digestibility determinations of the browse species I studied as well as other forage species is here recommended as a supplemental means of evaluating the qualitative physiological effects of the prescribed burning program to the big game species involved. Of several techniques available for determining forage digestibility, the in vitro methods developed by Tilly and Terry (1963) and modified by Pearson (1970) may be the most logical to use in further investigations because of the simplicity, speed, precision, and economy involved.

Crude Protein

Crude protein content was higher in 5 of 6 significant comparisons the first year after burning. This effect was not apparent in the second and third years after burning. Serviceberry contained the highest protein content, averaging 9.60 percent on burns, and willow was the lowest averaging 7.82 percent on burns (Figures 3 and 4). This relationship was also true on nonburned sites.

Protein is an essential dietary constituent of animals required not

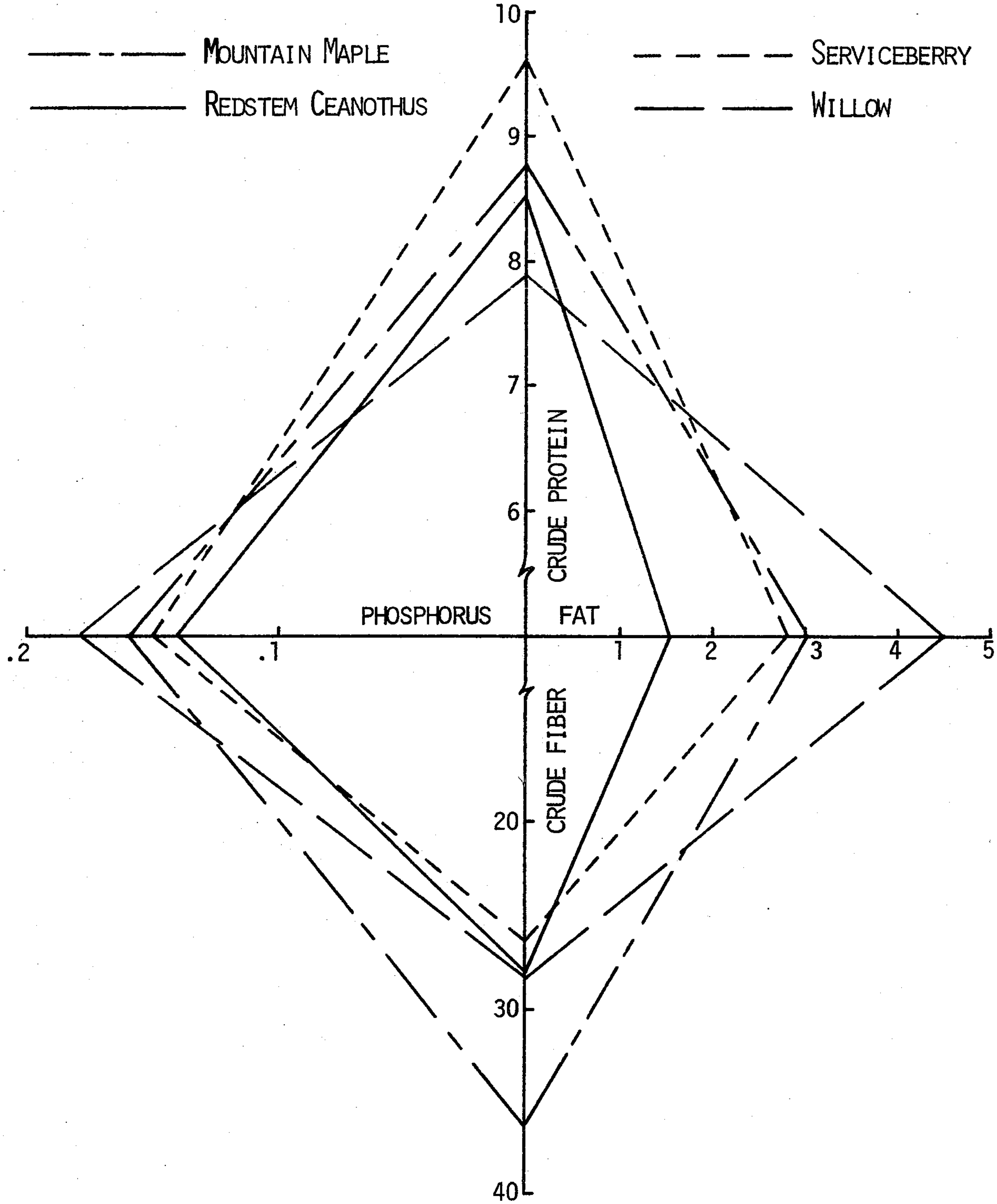

Figure 3. Relative nutritive composition of four key browse species on Avery burned sites. All measurements in percent of total dry weight.

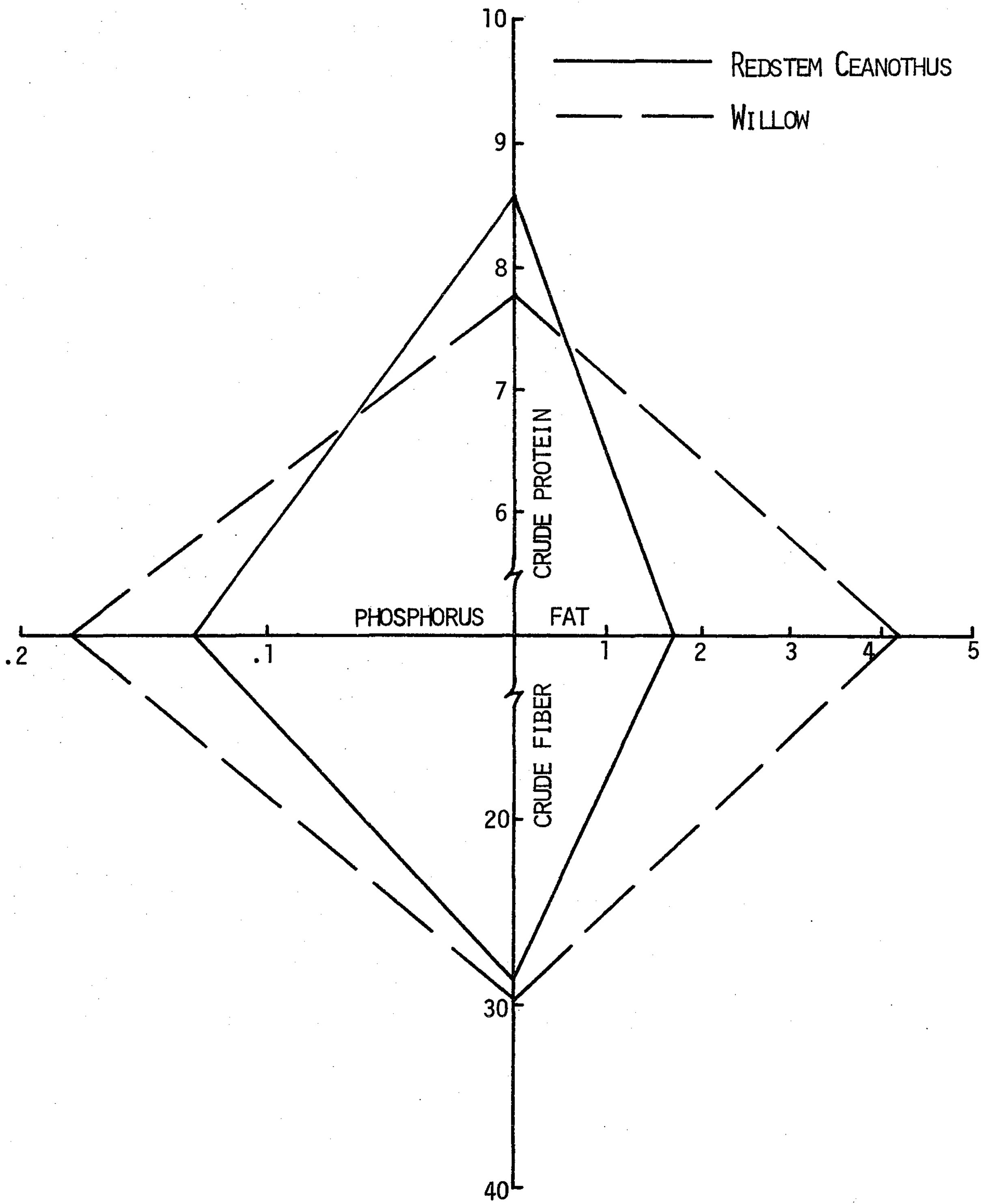

FIGURE 4. RELATIVE NUTRITIVE COMPOSITION OF TWO KEY BROWSE SPECIES ON LOCHSA BURNED SITES. ALL MEASUREMENTS IN PERCENT OF TOTAL DRY WEIGHT.

only for body maintenance, growth, reproduction, and lactation; but also for effective digestion and metabolism of carbohydrates and fats (Dietz 1965). Dietary protein levels of 13 to 16 percent are suggested for "optimum" growth and 6 to 7 percent for maintenance in big game animals (French et al. 1955, Dietz 1965). The National Research Council (NRC) (1964) recommends protein levels of approximately 7 to 11 percent for domestic sheep. If these values are applicable, then the preferred browse species which I analyzed are strictly maintenance forages during the later stages of dormancy. In addition, calf and/or fawn survival may be directly affected by these apparent low protein levels. Several investigators (Kitts et al. 1956, Murphy and Coates 1966, Verme 1962) have shown that pre- and post-natal mortality in fawns may be traced to delayed milk production and/or failure to produce milk in undernourished does. Young per female and post-natal development are also directly related to the dietary protein level.

It is interesting to note that redstem ceanothus was lower in protein content in 4 of 5 significant comparisons over the three years of burns on both study areas. It is the only species to show this trend. Leege (1971) noted the same effect in redstem when entire sprouts were analyzed. Collection methods may be responsible for this. On burned sites twigs may contain longer internodes and fewer lateral buds within the established collection length (Dills 1970).

My data do not support the contention that big game select or prefer certain browse species over others on the basis of higher protein content as has been implied by a number of workers (Bissell and Strong 1955, Dietz 1958, Knoche 1968, Swift 1948). Utilization data indicate a strong preference for redstem ceanothus, yet serviceberry protein content averaged 1.1 percent higher on burned sites during the dormant winter stage I studied.

Fat

Crude fat (ether extract) was lower in the only 2 significant comparisons and in 3 of 3 nonsignificant comparisons the first year after burning, but higher in 4 of 4 significant comparisons and 5 of 7 nonsignificant comparisons in the second and third years after burning. Willow was highest in fat, averaging 4.27 percent on burns and 4.28 percent on controls, while redstem was lowest, averaging 1.64 percent on burns and 1.66 percent on controls (Figures 3 and 4). Fat content tended to increase from the first through the third year after burning in all species examined.

Although ruminants are not dependent on fat because it can be synthesized in the rumen from carbohydrates and proteins, it does provide an efficient immediate energy source (Dietz 1965). True fats or esterified fatty acids provide about 2.25 times more energy than carbohydrates and proteins. However, less than one-half of ether extract in plants is reported to be true fat (Sullivan 1962).

Crude Fiber

Crude fiber was lower in 8 of 11 significant comparisons and 5 of 7 nonsignificant comparisons for all three years of burns over the Avery and Lochsa study areas. Mountain maple showed the highest crude fiber content on burned areas, averaging 36.61 percent, while serviceberry was lowest, averaging 26.37 percent (Figure 3). In addition, mountain maple was the only species to show a significant increase in crude fiber for all three years of burns compared to nonburned sites, whereas willow was consistently lower (P>.01) in crude fiber on burns.

Cellulose, hemicellulose, lignins, and related compounds are responsible for the relative indigestibility of crude fiber. However, ruminants are generally able to digest at least 50 percent of the crude fiber of most feeds with the constituents of mature plants less well digested than they are in young growing plants (Maynard and Loosli 1962). Short (1966) has demonstrated an inverse relationship between the dietary cellulose content and both digestible energy and digestible dry matter. Thus, burning increased the overall digestibility of the browse species studied for at least three years.

Ash

Total mineral content or ash showed no apparent trends for any browse species studied. However, 14 of 16 nonsignificant comparisons were lower over the three years of burns on both study areas. Calcium and phosphorus analyses are discussed later.

Nitrogen-Free Extract (NFE)

NFE represents that portion of a plant remaining after the dry weight percentages of ash, crude fiber, crude fat, and crude protein are substracted from 100. This fraction contains most of the more soluble carbohydrates like sugars and starch and some of the less soluble forms discussed under crude fiber.

NFE content was lower in 10 of 17 nonsignificant comparisons over the three years of burns on the Avery and Lochsa study areas. Species comparisons reveal a possible explanation for the high preference found for redstem by big game on the areas studied. The redstem carbohydrate fraction as reflected in the NFE portion was higher in 95 percent of the comparisons with the other three browse species examined. It is generally agreed that plants high in sugar content are selected by ruminants (Dietz 1970).

Calcium and Phosphorus

A significant decrease in calcium content occurred in 6 of 9 comparisons for the three years of burns. Eight of 9 nonsignificant comparisons were also lower. Calcium was significantly lower in 5 of 6 comparisons over the first two years of burns while phosphorus showed an inverse trend--3 of 3 significant comparisons were higher as were 4 of 6 nonsignificant comparisons.

The combined effect is a significant reduction in the calcium: phosphorus (C:P) ratio for the first two years after burning. This effect appears beneficial due to the high C:P ratio of shrub species on nonburned sites. The C:P ratios in browse species I studied were considerably higher than the desirable ratios suggested for domestic livestock--2:1 or 1:2--and may be affecting reproduction of big game on these winter ranges. Phosphorus metabolism may be impaired or possibly result in a phosphorus deficiency when a wide C:P ratio exists (Maynard and Loosli 1962). However, wider ratios are permissible when sufficient vitamin D is present in forage. A wide C:P ratio or a phosphorus deficiency may result in weak young, decreased lactation, failure to conceive, retarded growth, a high feed requirement, unthrifty appearance and stiffness of joints among others (Dietz 1965).

The NRC (1964) suggests a minimum of 0.16 percent phosphorus be present in forage fed pregnant ewes. If this can be applied to big game, then the redstem plants in the Avery and Lochsa study sites were deficient during late dormancy. Combining burns and controls, Avery averaged 0.14 percent phosphorus and the Lochsa sites averaged 0.13 percent phosphorus. Mountain maple and serviceberry averaged 0.16 percent phosphorus on both study areas. Willow was by far the highest in phosphorus during the dormant season averaging 0.18 percent on both study areas (Figures 3 and 4).

Phosphorus is reportedly deficient in many forage species on western game ranges during the winter season and may be an important factor in the low calf and/or fawn production on many of these ranges (Dietz 1965). Thus, those species which maintain adequate phosphorus levels should be managed for on winter ranges. Because willow shows the highest phosphorus content of the four key browse species on both burned and nonburned sites and because there may be an overall deficiency of phosphorus during the critical winter stress period, every effort should be made to maintain and/or improve the status of willow on these winter range sites. Willow also provides the highest immediate energy source of the four key browse species examined, as noted earlier.

Moisture

Moisture content increased in 5 of 5 significant comparisons the first year after burning. However, 7 of 8 significant comparisons and 3 of 4 nonsignificant comparisons were lower in the second and third years after burning. Increased plant succulence the first growing season following burning may be partially responsible for the apparent preference of burned sites shown by elk and deer.

Burn Intensity Effects

DeWitt and Derby's (1955) findings at the Patuxent Wildlife Research Refuge suggest that the duration of nutritional effects is directly related to the intensity of the burn. Browse species on wildfire sites contained higher protein content after two years compared to nonburned sites, whereas this effect was present during the first year only on low intensity prescribed burns. This suggests that the spring burns I studied are of the low intensity type and thus the reason for the rather short duration in nutritional effects. No data were available regarding burn intensities on the study sites I evaluated.

These low intensity spring burns are not characteristic of wildfire intensities. The question should be asked: Is spring prescribed burning accomplishing its main objective--that of replacing the natural fire regime in the rejuvenation of big game winter ranges? There is no doubt that it is beneficial from the standpoint of increasing browse-forage availability and temporarily increasing nutrient quality. However, could these benefits and perhaps more be gained by burning at a different time; for example, in the fall which is more characteristic of wildfires?

The Bee Creek 1967 burn and the Relay Station 1968 burn point out one possible problem of spring burning. When burning conditions are not ideal, fire consumption of standing and downed dead growth and standing live growth is minimal. In subsequent years (usually one to three) the charred standing growth topples, creating nearly impenetrable brushfields. Big game movements and travel under these circumstances are inhibited and such burns may be avoided for this reason even though available CAG of palatable browse is abundant.

CAG availability and utilization are adversely affected. Marginal, spring burning conditions foster this phenomenon. Admittedly, this is not a widespread problem, but fall burning should minimize this even further. Reburning these sites as soon as ground fuels allow would also alleviate this problem.

A second problem with spring burning is the apparent low germination rate, survival, and growth of redstem ceanothus--perhaps the most important browse species for deer and elk on northern Idaho winter ranges (Leege 1969). Of the four browse species I studied, redstem is certainly the most selected species according to observations and CAG utilization counts on both burned and nonburned sites. A fall burn on a Lochsa River winter range produced 242,000 redstem seedlings per acre the following spring; whereas, only about 60,000 redstem seedlings per acre germinated on an adjacent spring burn (Leege 1969). Although the germination rate is thus higher with fall burns, both spring and fall burns evidently produce adequate seedlings to restock an area. High mortality of redstem seedlings is characteristic, however. Hickey and Leege (1970) report a 91 percent loss of redstem seedlings on that fall burn which produced 242,000 seedlings per acre--leaving 22,220 seedlings per acre after the first growing season. Competition with herbaceous vegetation and desiccation are cited as critical seedling survival factors.

Orme's (1972) research on redstem seedling survival sheds further light on this subject. His preliminary findings indicate that desiccation due to lack of moisture is the major cause of mortality and occurs primarily in August. Some mortality also occurs as a result of animal activity (insects and rodents) and from an unidentified chlorotic condition--perhaps a mineral deficiency--during early summer. Redstem seedlings growing under no competition and 25 percent shade had much larger leaves, thicker stems, and more leaves per plant than seedlings in the other three treatments. Approximately 41 percent survival existed after the first growing season. Orme also noted these same vigor characteristics present in fall-burn seedlings. Seedling survival on transects with no competition and 100 percent shade was about 20 percent, with no competition and 0 percent shade about 10 percent, and with natural shade and competition about 4 percent.

Thus, restocking of an area with redstem may be enhanced more by fall burning compared to spring burning from the viewpoints of higher germination and survival and more vigorous plants. With fall burns most seeds would germinate the following spring and growth would be initiated concurrently with competing herbaceous vegetation (e.g., bracken fern and thimbleberry) instead of after competitors have put out extensive root systems and established themselves the previous summer.

Finally, the longevity of nutritional benefits derived from prescribed fires would be maximized through higher intensity fall burns. A direct relationship exists between burn intensity and duration of nutritional effects (DeWitt and Derby 1955, Einarson 1946). The feasibility of utilizing fall prescribed burning for winter range rejuvenation needs further investigation and evaluation. Perhaps both spring and fall burning have their places as management tools. Fall burning might be prescribed for winter range areas where a minimum erosion hazard to the base resource exists and where burn-area boundaries are not critical.

CAG Length-Weight Relationships

Polynomial regression equations showing CAG length-weight relationships for redstem ceanothus and willow on the Avery and Lochsa study areas appear in Tables 10 and 11. The equations were derived from 2671 paired measurements of 7450 twigs. Mean twig weight was used where more than one twig occurred per length class.

A curvilinear relationship was suspected from rough plotting of selected data and personal knowledge of growth characteristics. Negative Y-intercept values of first degree polynomials along with highly significant F tests for improvement in terms of sums of squares due to fitting a second degree polynomial verified a nonlinear relationship. Third degree polynomials yielded some improvement in terms of sums of squares but did not increase the multiple correlation coefficient appreciably. In addition, completely erroneous weight estimates in the lower length classes are given by third degree equations, particularly with willow. The second degree polynomial regression equation used is:

$$\text{Twig Weight} = A + B_1\,(\text{Twig Length}) + B_2\,(\text{Twig Length})^2$$

These equations should not be used for computing stand mean twig weights unless the stand mean twig length has been weighted on the basis of the number of twigs occurring in various length classes from random samples of the population.

Browse Production and Availability

Mean Maximum Canopy Height Changes

Mean maximum crown height measurements at Avery (Figure 5) show a significant decrease in shrub height and apparent increase in CAG availability following burning for three tall-growing browse species--namely mountain maple, serviceberry, and willow. Only willow exceeded the arbitrary 8-foot

TABLE 10. REGRESSION EQUATION COEFFICIENTS AND CORRELATION COEFFICIENTS (R) FOR DETERMINING TWIG WEIGHT FROM TWIG LENGTH ON CAG OF REDSTEM CEANOTHUS.

Study Area and Treatment	Sample Size	Constants				
		R	$S_{Y.X}$	A	B_1	B_2
AVERY						
Combined Analysis						
Nonburned	165	0.9745	0.4866	0.1377	0.0040	0.0013
Burned (2-3 Years Old)	201	0.9614	0.6666	-0.0656	0.0081	0.0010
Individual Analysis						
Relay Station Control	91	0.9796	0.5324	-0.0136	0.0125	0.0012
Hammond Creek Control	74	0.9691	0.2690	0.1878	-0.0089	0.0012
Hammond Creek 1967 Burn	83	0.9709	0.2612	0.2146	-0.0088	0.0013
Relay Station 1968 Burn	118	0.9541	0.8417	-0.2292	0.0121	0.0009
LOCHSA						
Combined Analysis						
Nonburned	303	0.9581	0.5303	-0.4728	0.0478	0.0006
Burned (1-3 Years Old)	410	0.9650	1.7858	0.1214	0.0132	0.0011
Individual Analysis						
Lone Knob Control	110	0.9652	0.5507	-0.3233	0.0331	0.0007
Fish Creek Control	101	0.9571	0.5157	-0.2509	0.0342	0.0008
Bee Creek Control	92	0.9757	0.3587	-0.2701	0.0283	0.0011
Bee Creek 1967 Burn	132	0.9748	0.8857	-0.4283	0.0367	0.0011
Fish Creek 1968 Burn	117	0.9770	0.7631	-0.0142	0.0075	0.0013
Lone Knob 1969 Burn	161	0.9716	2.1806	1.1266	-0.0524	0.0015

TABLE 11. REGRESSION EQUATION COEFFICIENTS AND CORRELATION COEFFICIENTS (R) FOR DETERMINING TWIG WEIGHT FROM TWIG LENGTH ON CAG OF WILLOW.

Study Area and Treatment	Sample Size	Constants				
		R	$s_{Y.X}$	A	B_1	B_2
<u>AVERY</u>						
<u>Combined Analysis</u>						
Nonburned	206	0.9713	1.1753	0.7200	-0.0331	0.0011
Burned (1-3 Years Old)	573	0.9691	3.5691	1.4831	-0.0678	0.0013
<u>Individual Analysis</u>						
Relay Station Control	122	0.9721	1.4036	0.9219	-0.0449	0.0012
Hammond Creek Control	84	0.9650	0.6408	0.0138	0.0084	0.0007
Hammond Creek 1967 Burn	158	0.9776	1.0588	0.6841	-0.0373	0.0012
Relay Station 1968 Burn	190	0.9688	2.3930	1.8271	-0.0932	0.0016
Relay Station 1969 Burn	225	0.9708	4.8169	2.9207	-0.1127	0.0015
<u>LOCHSA</u>						
<u>Combined Analysis</u>						
Nonburned	216	0.9675	1.1888	-0.0692	0.0041	0.0008
Burned (1-3 Years Old)	597	0.9724	3.8284	1.7379	-0.0658	0.0012
<u>Individual Analysis</u>						
Lone Knob Control	103	0.9715	1.1114	0.1722	-0.0070	0.0009
Fish Creek Control	113	0.9680	1.1980	-0.2284	0.0108	0.0008
Bee Creek 1967 Burn	132	0.9823	0.4184	0.1958	-0.0033	0.0009
Fish Creek 1968 Burn	196	0.9740	1.3745	0.9505	-0.0481	0.0012
Lone Knob 1969 Burn	269	0.9702	5.2428	2.7940	-0.1146	0.0013

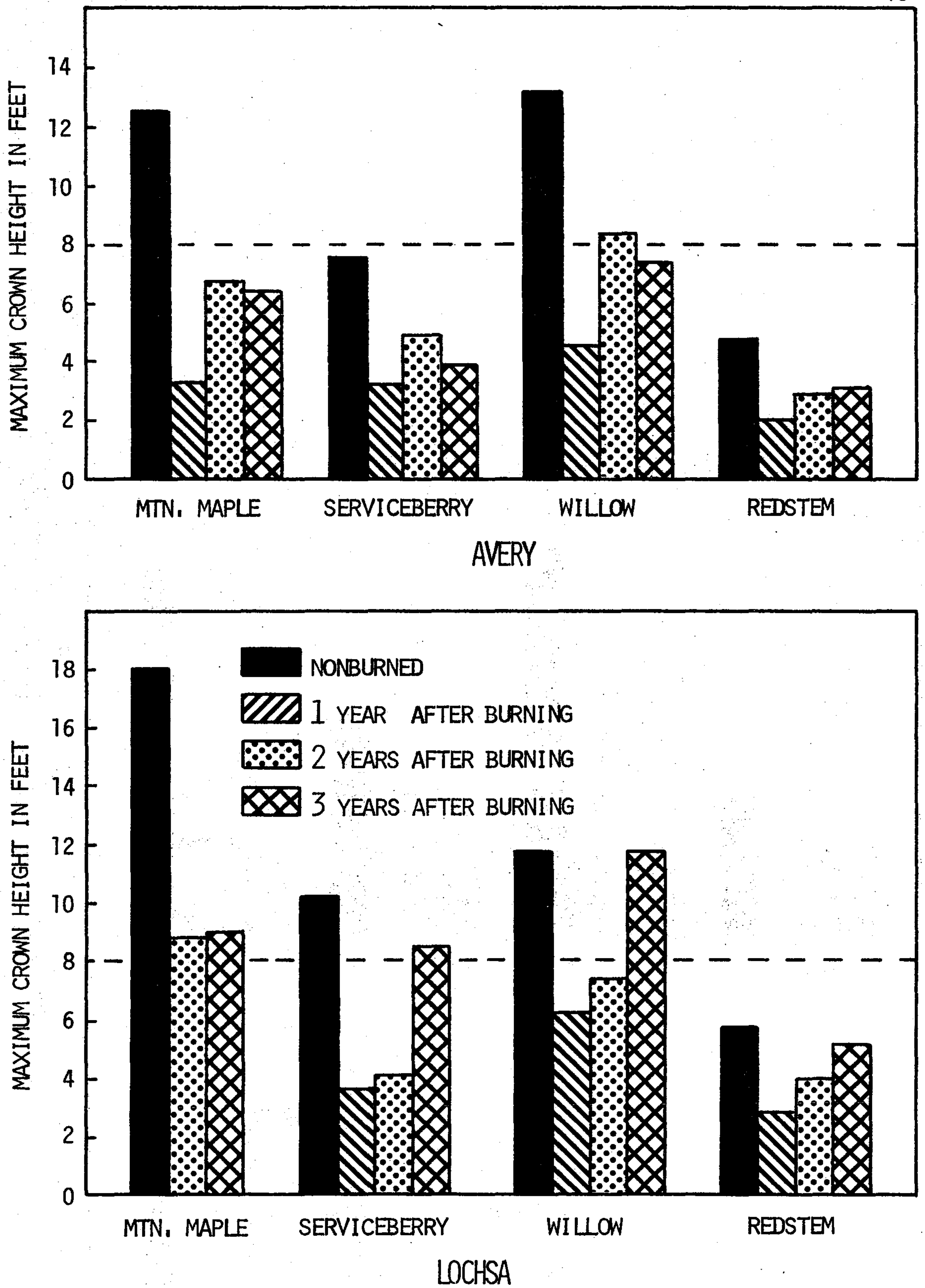

FIGURE 5. MEAN MAXIMUM CROWN HEIGHT CHANGES AND APPARENT BROWSE AVAILABILITY IN FOUR KEY BROWSE SPECIES.

unavailability height after two years. However, willow sprouts 9.8 feet high were measured on burns after only one growing season. Heavy summer use of CAG on the three-year-old burn at Avery was responsible for the decrease in maximum height three years after treatment.

Plants in the Lochsa area (Figure 5) show a similar response the first two years, but by the end of the third year following prescribed burning all three tall-growing browse species had exceeded the 8-foot height and willow sprouts 9.6 feet high were recorded after only one growing season. Mountain maple was absent in the one-year-old Lochsa burn. The potential for tall-growing shrubs to grow quickly out of reach of big game animals is evident in the burned vs. nonburned comparisons.

Because mean maximum crown heights are represented for the plants measured, these figures are not indicative of the majority of CAG in the canopy. The shortcomings of using crown height measurements as the sole index of CAG availability, particularly under winter conditions, will be apparent from the twig count data presented below.

Height-Stratified Twig Counts

Twig counts for production, availability and utilization did not take into account unavailability due to twigs growing in the old decadent growth and/or downfalls. This factor, undoubtedly would have lowered available production in control or nonburned sites more so than on burned sites. In addition, production estimates would have been more accurate if sprouts and twigs or lateral growth had been classified separately--particularly after the first growing season following burning--but both were combined in determinations.

Height-stratified twig counts on redstem ceanothus in the Avery study area (Figure 6) show that the winter availability of CAG increased from 4.2 percent the first year after burning, to 32.9 percent the second year, to 50.0 percent the third year compared to 90.6 percent on controls for the same period. Lochsa burns showed increasing winter availability also, but to a greater degree (Figure 6). After one year 39.1 percent of the CAG was available, 73.1 percent after two years, and 93.2 percent after three years. This is comparable to the 90.7 available on control plants.

Availability of CAG on willow plants in burns was increased considerably over control plants (Figure 7). Avery willow plants averaged only 28.3 percent of the CAG available on controls while first year burns averaged 68.3 percent, second year burns averaged 87.8 percent, and third year burns averaged 91.7 percent. Lochsa burned sites showed 86.2 percent of the CAG available after one year, 89.4 percent after two years and 56.5 percent after three years compared to a control mean of 43.7 percent for the same period.

These CAG availability values are considerably lower than the values indicated in Figure 5 from mean maximum crown height measurements. Although the height-stratified twig count data itself can be criticized on the basis of the arbitrary heights used for availability inclusion, it is more realistic than mean maximum crown heights.

First year sprouts of redstem were particularly susceptible to snow bending. I frequently found long sprouts on first year burns and whole branches of redstem on two, three and four year old burns bent nearly parallel to the ground during spring twig and pellet group counts. This phenomenon was not noticed to any degree on older redstem plants in the control sites nor

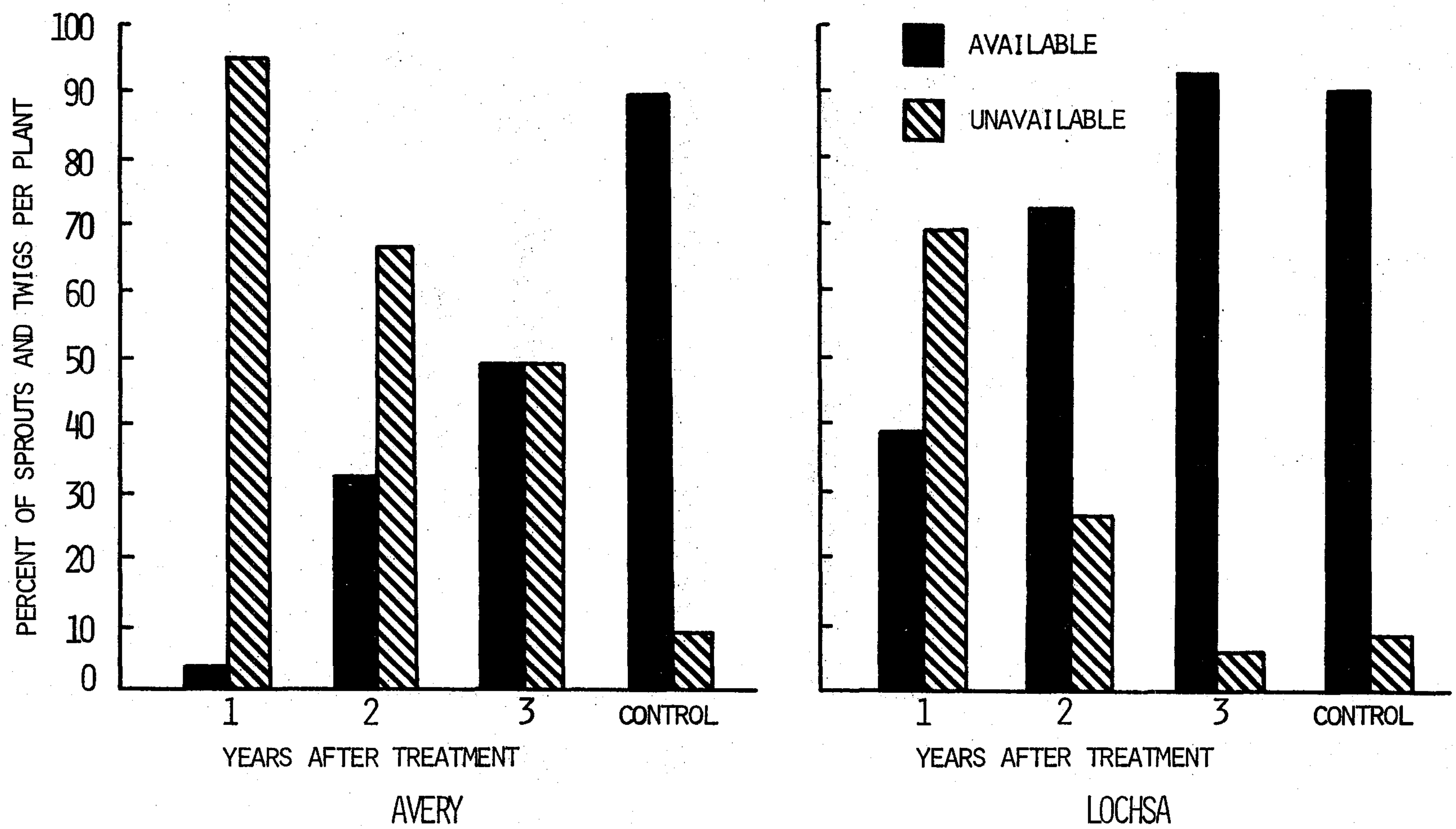

FIGURE 6. PERCENT AVAILABILITY OF CURRENT ANNUAL GROWTH OF REDSTEM CEANOTHUS (CEANOTHUS SANGUINEUS) ON THE AVERY AND LOCHSA STUDY AREAS.

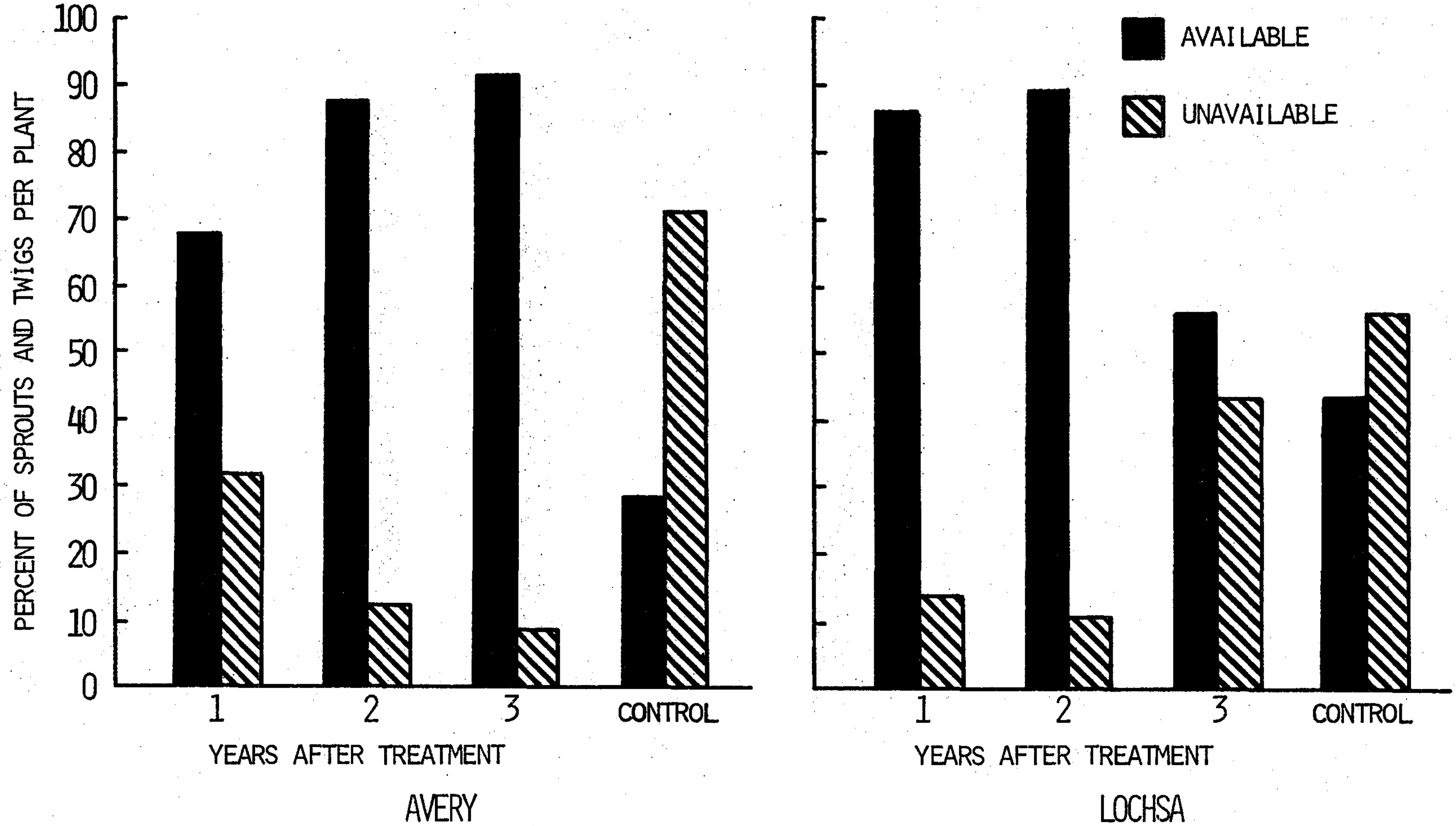

FIGURE 7. PERCENT AVAILABILITY OF CURRENT ANNUAL GROWTH OF WILLOW (SALIX SPP.) ONTHE AVERY AND LOCHSA STUDY AREAS.

was snow bending an appreciable factor affecting CAG availability of the tall-growing species. Hungerford (1964) feels that snow density is the most important factor affecting browse availability above snow pack. He also found redstem subject to greater snow bending than willow, serviceberry and western red cedar. Cedar availability was also affected measurably. The greatest effect on browse availability occurred when snow pack built on early, wet, frozen snow.

Production Effects

Due to unequal densities of key browse species on study sites, prescribed burning effects on production or yield are here compared on a per plant basis. Table 12 summarizes twig count data taken in the spring of 1970 and lists mean number of twigs per plant, mean twig weights and the resultant total production estimate based on the latter two statistics. Total production here refers to that present for winter utilization. Control plant production is the average CAG production for all controls during the 1969 growing season. First and third year production available for winter use on the Avery burn sites was decidedly lowered by heavy summer use. Intensive summer use of redstem in the Relay Station 1969 burn at Avery precluded obtaining adequate CAG growth for a mean twig weight determination. Therefore, the Lochsa value for the first year after burning was used.

Available redstem production on a per plant basis in the Avery study area did not attain control levels after three years (Figure 8). While control plants averaged 50.8 grams of available CAG, the burns averaged 1.8 grams the first year, 31.3 grams the second year, and 6.4 grams the third year.

TABLE 12. MEAN TWIG WEIGHT, MEAN NUMBER OF TWIGS AND MEAN TOTAL PRODUCTION PER PLANT FOR REDSTEM CEANOTHUS AND WILLOW ON THE AVERY AND LOCHSA STUDY SITES.

	YEARS AFTER TREATMENT							
	1ST		2ND		3RD		CONTROL	
SPECIES AND STUDY SITE	AVERY	LOCHSA	AVERY	LOCHSA	AVERY	LOCHSA	AVERY	LOCHSA
REDSTEM CEANOTHUS								
MEAN NO. TWIGS PER PLANT	6.32	8.08	30.40	21.76	15.96	40.96	46.22	46.49
MEAN TWIG WEIGHT (GRAMS)	6.61*	6.61	2.58	3.24	1.06	1.85	1.14	1.17
MEAN TOTAL PRODUCTION PER PLANT (GRAMS)	41.78	53.41	78.43	70.50	16.92	75.78	56.22	53.81
WILLOW								
MEAN NO. TWIGS PER PLANT	43.60	25.28	125.88	94.56	113.24	156.48	163.80	136.04
MEAN TWIG WEIGHT (GRAMS)	10.48	13.92	4.16	4.04	2.17	0.96	2.06	1.33
MEAN TOTAL PRODUCTION PER PLANT (GRAMS)	456.93	351.90	523.66	382.02	245.73	150.22	340.37	180.82

* USED LOCHSA VALUE (SEE TEXT PAGE 53)

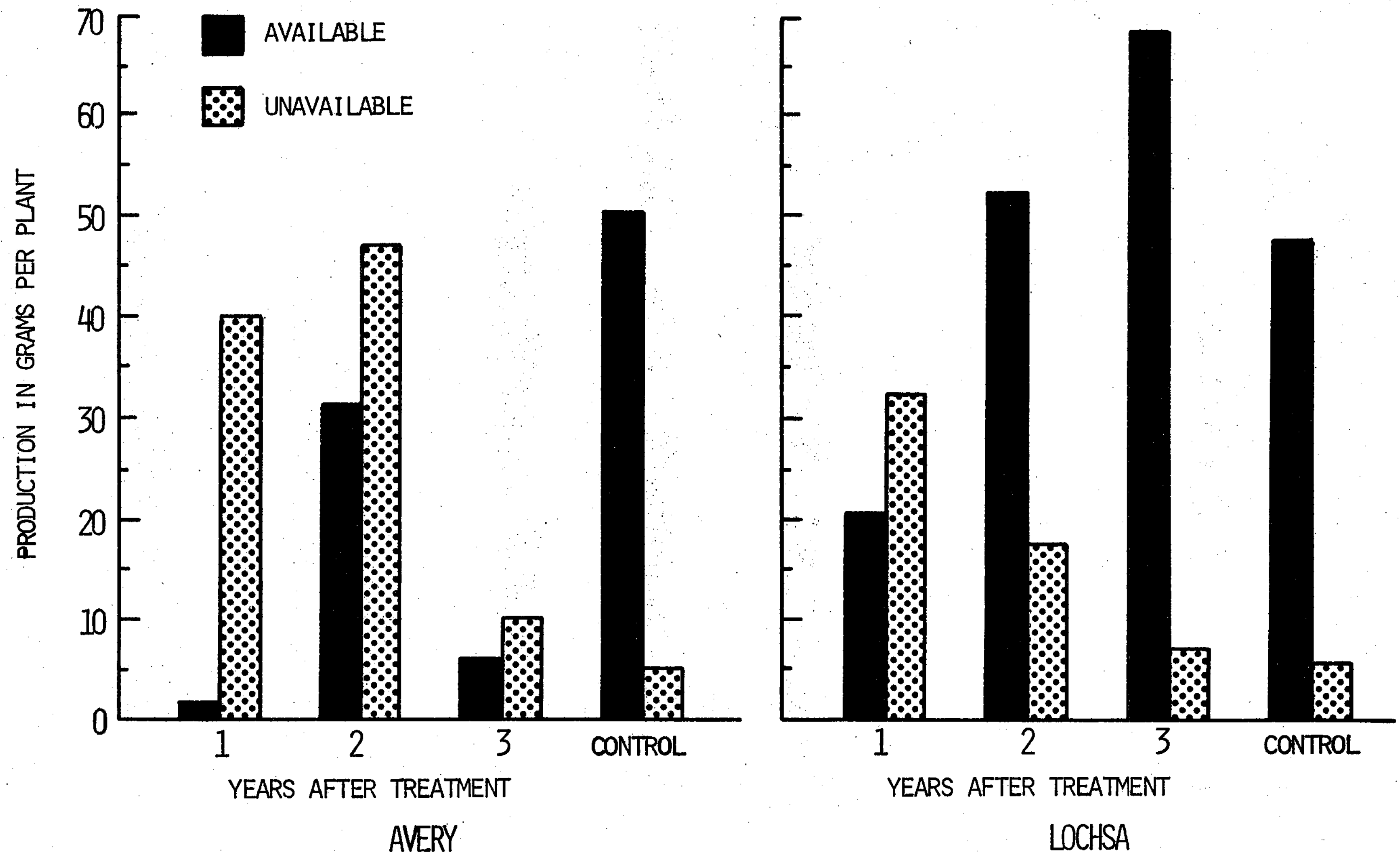

FIGURE 8. PRODUCTION COMPARISONS BY AVAILABILITY ZONES FOR REDSTEM CEANOTHUS (CEANOTHUS SANGUINEUS) ON THE AVERY AND LOCHSA STUDY AREAS.

Unavailable production corresponded to 40.0 grams per plant the first year, 47.1 grams the second year and 10.5 grams the third year while controls averaged 5.4 grams per plant unavailable. Redstem plants on Lochsa burned sites (Figure 8) exceeded control plants in available production by the end of the second year. Burned one-year-old plants produced 20.9 grams of available CAG, two-year-old plants produced 52.6 grams and three-year-old plants produced 68.5 grams compared to 47.9 grams on control plants. Unavailable production of redstem plants in Lochsa burns correspondingly declined from 32.5 grams to 17.9 grams to 7.2 grams the first through the third years after burning, respectively, while control plants averaged 5.9 grams per plant unavailable for the same period.

Willow production exceeded controls on all three years of burns in both study areas (Figure 9). First year burns at Avery produced 311.9 grams of available CAG, per plant, 460.0 grams the second year and 224.6 grams the third year compared to only 87.5 grams per plant on controls. Correspondingly, unavailable production declined from 145.0 to 63.6 to 21.2 grams per plant the first, second and third years after burning, respectively, while controls averaged 252.9 grams of unavailable browse. Willow production in Lochsa burns was considerably higher in available CAG the first two years, 303.4 grams per plant the first year and 341.5 grams per plant the second year, but only slightly higher than controls the third year--84.8 grams compared to 79.5 grams. Unavailable production was 48.5, 40.5 and 65.4 grams per plant the first, second, and third years after burning, respectively, while control plants averaged 101.3 grams of unavailable production.

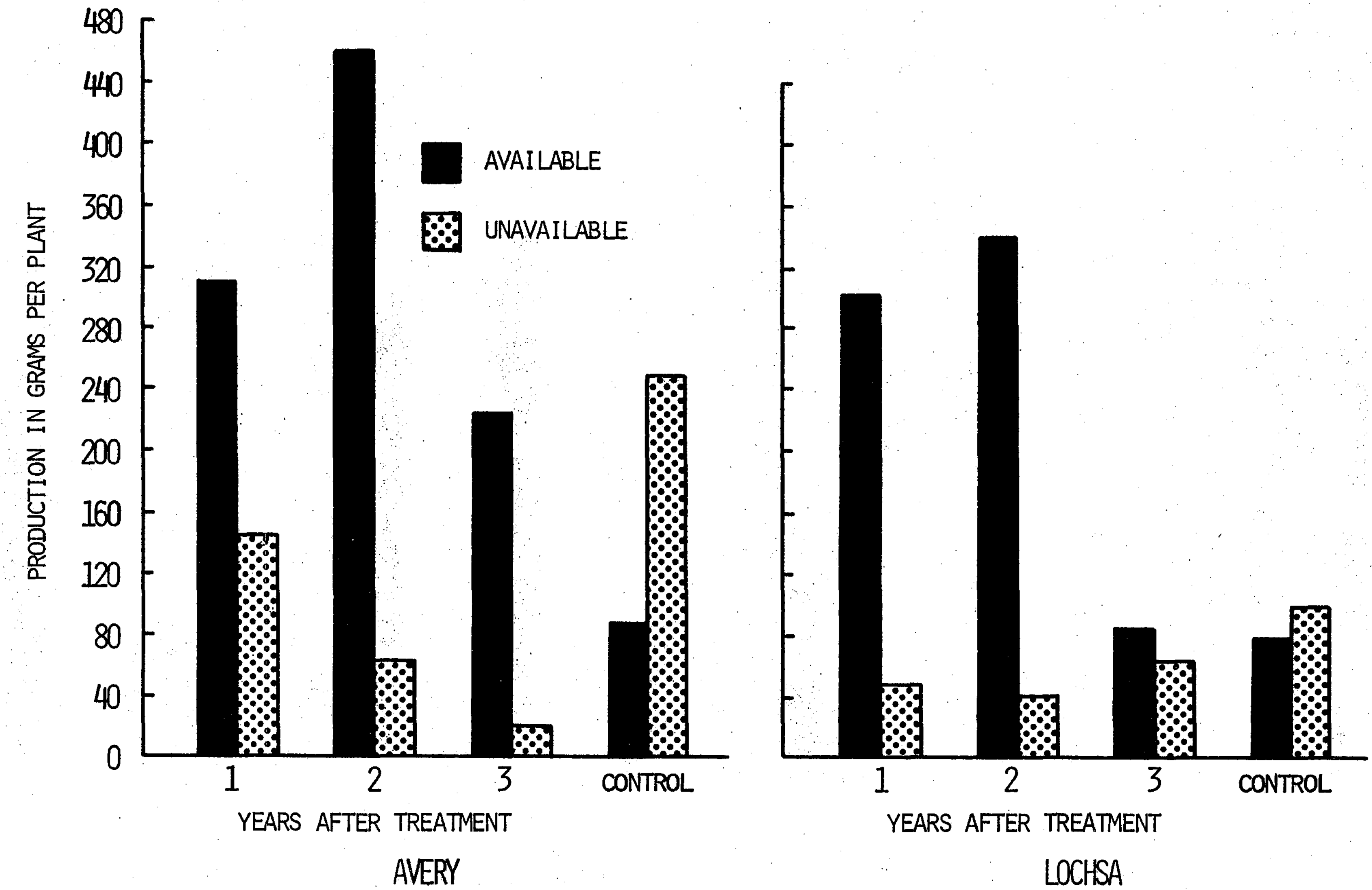

FIGURE 9. PRODUCTION COMPARISONS BY AVAILABILITY ZONES FOR WILLOW (<u>SALIX</u> SPP.) ON THE AVERY AND LOCHSA STUDY AREAS.

Relative Use of Burned Vs. Nonburned Sites

Browse Utilization Effects

It was apparent from pilot studies at Hatter Creek that big game preferred browsing the new growth on burned sites over the CAG of adjacent nonburned sites. In addition, plant species such as thimbleberry (*Rubus parviflorus*), ninebark (*Physocarpus malvaceus*), oceanspray (*Holodiscus discolor*), syringa (*Philadelphus lewisii*) and bracken fern which are normally not preferred forage species in northern Idaho were being readily taken on burned sites--particularly the first growing season. Leege (1969) also noted this.

This preference for burned areas compared to nonburned areas is demonstrated in the CAG utilization counts on redstem and willow in the Avery and Lochsa study sites (Table 13). Summer utilization during the first growing season on redstem was 62.8 percent on the 1969 Avery burn and 54.6 percent on the 1969 Lochsa burn while controls averaged only 0.4 percent and 7.9 percent, respectively.

In comparison, summer utilization on willow during the first growing season was 43.1 percent on the 1969 Avery burn and 22.2 percent on the 1969 Lochsa burn while controls showed no appreciable use. A definite summer preference for redstem is apparent. Redstem was the only browse species in my study sites which received any measurable summer use after the first growing season, with cascara (*Rhamnus purshiana*) being a possible exception.

Winter utilization measurements are based on twig counts in the available zone only. Again higher browse palatability is apparent on the burned sites compared to the nonburned sites except on the 1968 and 1969 Avery

TABLE 13. BROWSE UTILIZATION IN SUMMER AND WINTER ON THE AVERY AND LOCHSA STUDY AREAS.[1]

Species and Treatment	Mean Percent of Twigs Browsed			
	Summer		Winter	
	1969	1970	1969-70	1970-71
Redstem Ceanothus				
Avery - Relay Station 1969 Burn	62.8	27.7	18.2	28.0
Relay Station 1968 Burn	0.5	13.4	29.0	25.5
Hammond Creek 1967 Burn	46.3	24.2	87.2	73.9
Hammond Creek Control	14.6	14.8	60.8	70.7
Relay Station Control	0.4	11.6	33.3	36.4
Lochsa - Lone Knob 1969 Burn	54.6	26.5	68.0	68.5
Fish Creek 1968 Burn	10.2	0.4	59.6	83.9
Bee Creek 1967 Burn	0.0	0.1	14.3	33.3
Bee Creek 1969 Burn	--	1.4	62.6	--
Bee Creek Control	0.5	0.0	3.3	13.1
Fish Creek Control	0.8	0.7	34.0	31.3
Lone Knob Control	7.9	15.0	39.5	37.2
Willow				
Avery - Relay Station 1969 Burn	43.1	--	17.2	--
Relay Station 1968 Burn	2.4	--	8.8	--
Hammond Creek 1967 Burn	7.2	--	63.7	--
Hammond Creek Control	0.1	--	50.3	--
Relay Station Control	0.8	--	0.3	--
Lochsa - Lone Knob 1969 Burn	22.2	--	69.8	--
Fish Creek 1968 Burn	4.3	--	49.4	--
Bee Creek 1967 Burn	0.0	--	2.2	--
Fish Creek Control	0.0	--	23.3	--
Lone Knob Control	0.0	--	16.9	--

[1] Sample size is 25 plants per treatment.

burns where their respective control received slightly higher use on redstem during both the 1969-70 and 1970-71 winters. I feel this is largely a result of winter availability of redstem coupled with number of years since burning. For instance, the 1969 Avery burn which received only 18.2 percent utilization on redstem during its first winter after burning had only 0.07 sprouts and/or twigs available per plant while its respective control had 54.4 twigs available per plant. The 1968 Avery burn had only 12.12 sprouts and/or twigs available per redstem plant at the same time.

Combined relative use comparisons of redstem ceanothus and willow based on percent of twigs browsed (utilization) for burned vs. nonburned study sites appear in Figures 10, 11 and 12. These graphs illustrate that the higher preference for burned areas is not a temporary effect, as was found in Texas (Lay 1967), but rather that it is still present in most cases after three years.

Leege's (1969) work on the Lochsa River drainage not only supports the latter point but demonstrates it in another way. He found significant increases in the browsing diameter of woody species on burned areas. Willow and mountain maple had significantly larger browsing diameters after the second winter following burning.

The Avery twig utilization results (Table 13), especially on the 1969 Relay Station burn and on the 1967 Hammond Creek burn during the summer of 1969, point out the problem of (1) burning too small an area and (2) burning too few areas on a given tract of range. My Hatter Creek pilot burns also clearly indicate this. When the root reserves of plants like redstem are not replenished during regrowth the first growing season following burning, their vigor is seriously lowered and they may never attain their potential vigor.

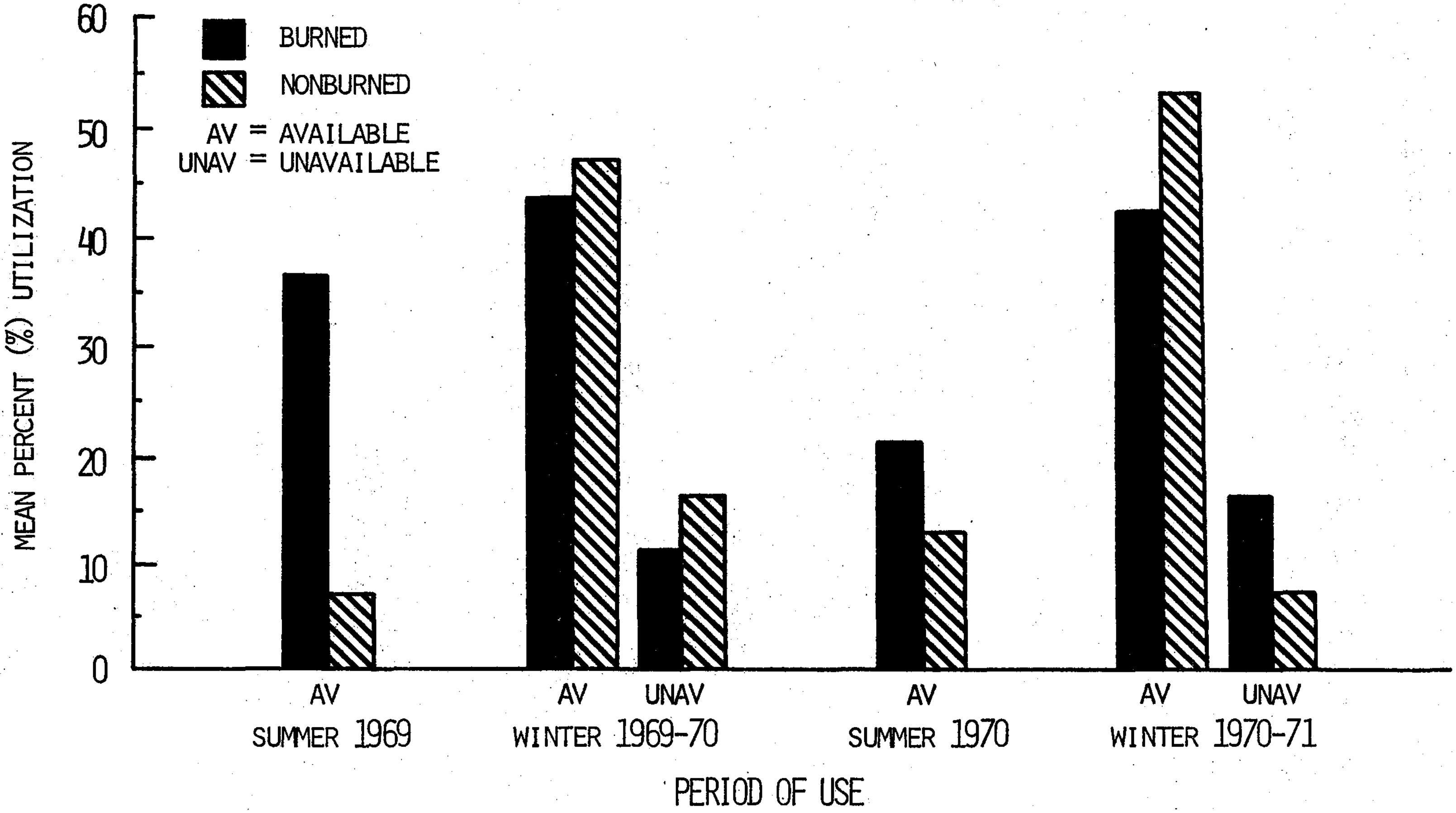

FIGURE 10. COMPARISON OF RELATIVE WINTER AND SUMMER USE ON REDSTEM CEANOTHUS (CEANOTHUS SANGUINEUS) BY BIG GAME ON BURNED AND NONBURNED SITES IN THE AVERY STUDY AREA, BASED ON PERCENT UTILIZATION.

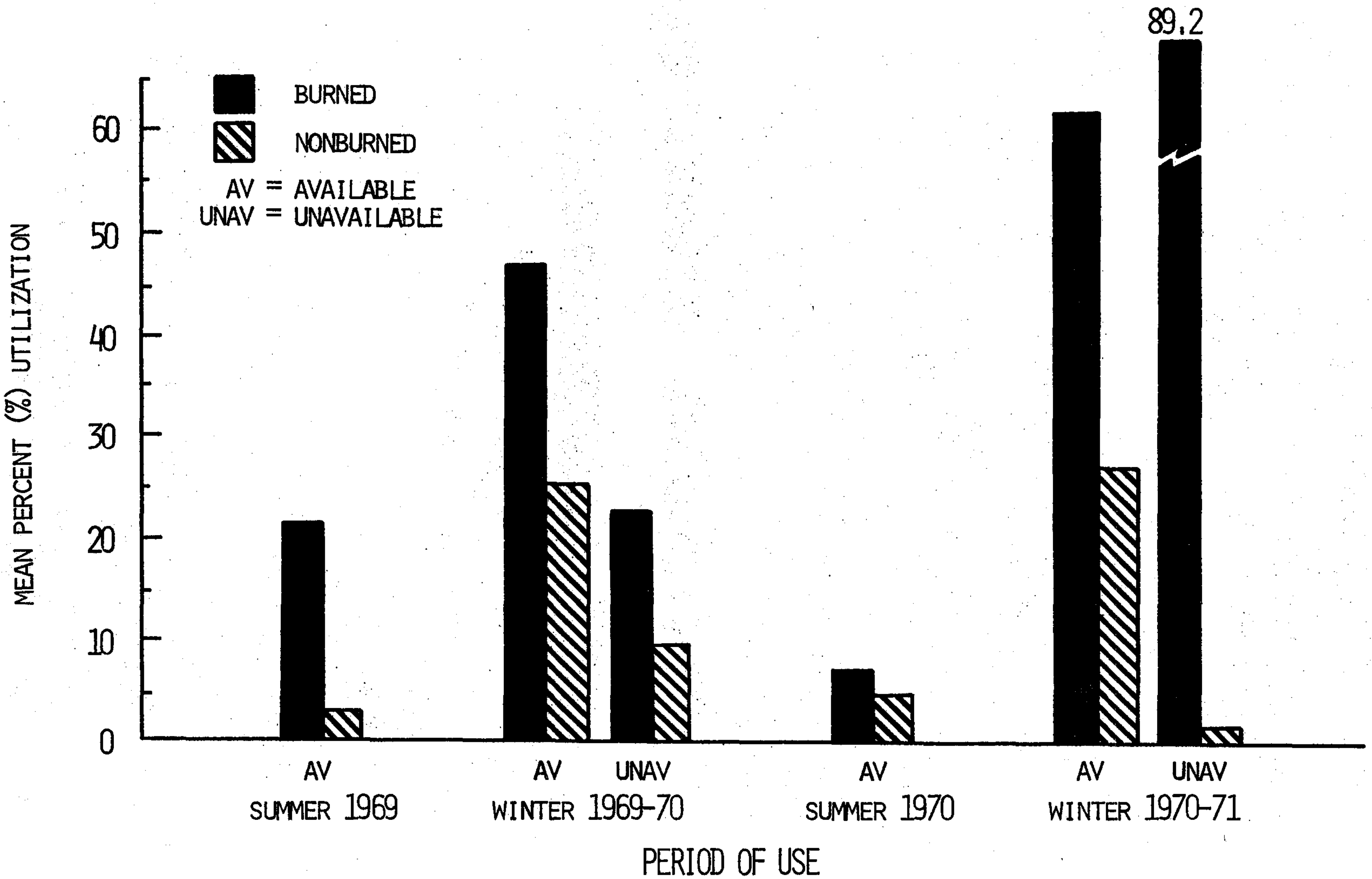

FIGURE 11. COMPARISON OF RELATIVE WINTER AND SUMMER USE ON REDSTEM CEANOTHUS (CEANOTHUS SANGUINEUS) BY BIG GAME ON BURNED AND NONBURNED SITES IN THE LOCHSA STUDY AREA, BASED ON PERCENT UTILIZATION.

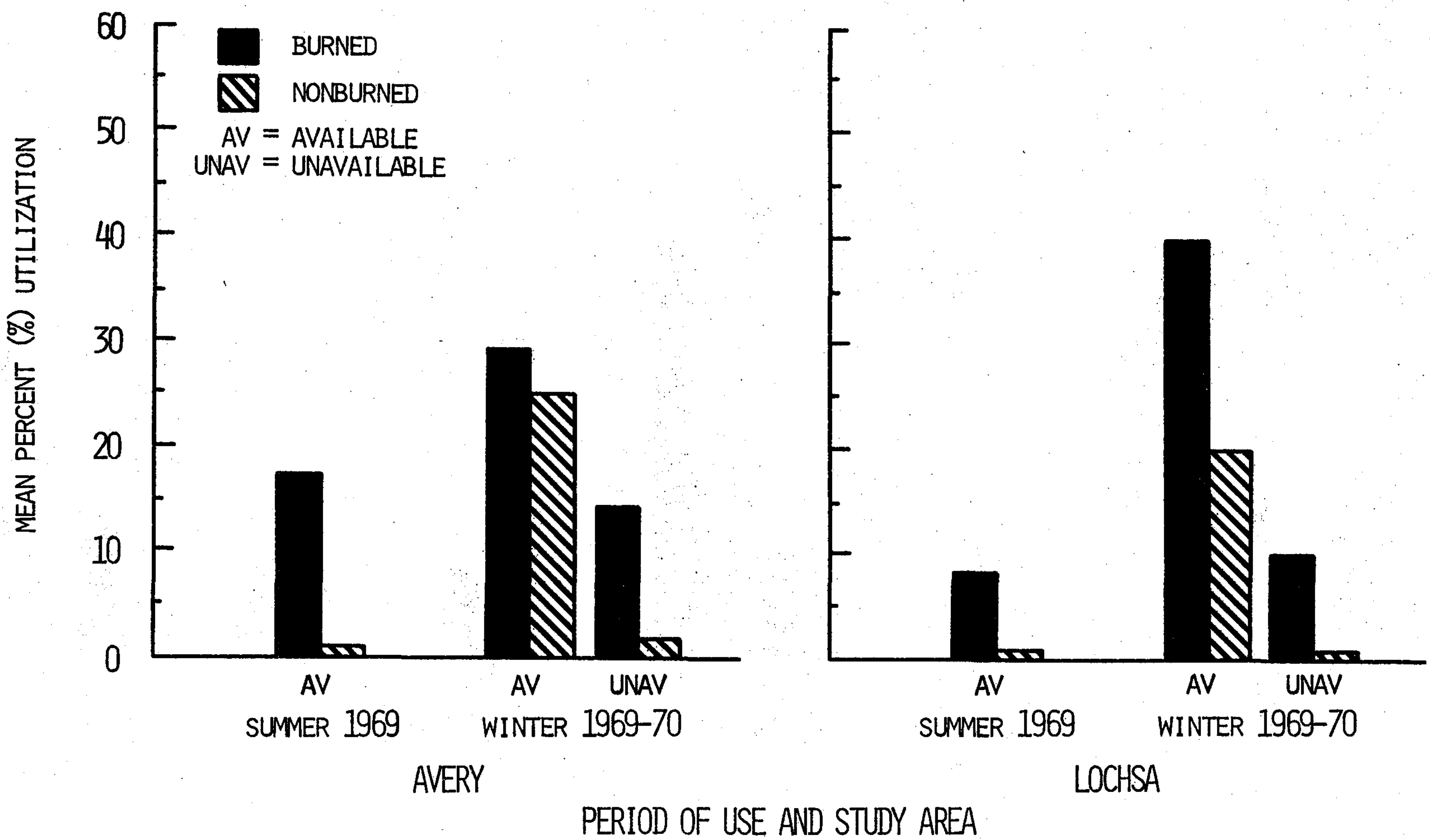

FIGURE 12. COMPARISON OF RELATIVE WINTER AND SUMMER USE ON WILLOW (SALIX SPP.) BY BIG GAME ON BURNED AND NONBURNED SITES IN THE AVERY AND LOCHSA STUDY AREAS, BASED ON PERCENT UTILIZATION.

Winter CAG availability is also lowered decidedly. In addition, repeated heavy utilization, as occurred on a number of redstem plants in the 1967 Hammond Creek burn, may result in death of the plant.

Another advantage of burning scattered areas on a tract of range is that with heavier summer use in the burned areas, big game animals may utilize more fully the CAG available in the nonburned adjacent areas during the winter period. Thus the nonburned areas may receive a regrowth stimulus, maintain better growth form and animal distribution and use may be more uniform over the entire winter range.

Pellet Group Counts

To better evaluate and document the apparent preference for recently burned areas by big game, pellet group counts were made in conjunction with twig counts. This index was used realizing the inherent drawbacks to the pellet group technique (Neff 1968). The study sites are nearly homogeneous seral brushfield types and should therefore be comparable using pellet group counts as a relative use index.

At the Hatter Creek deer enclosure a 1968 fall burn and a 1969 spring burn were sampled in October, 1969, to compare relative summer use. On the fall burn, 438 white-tailed deer pellet groups per acre were counted compared to 100 per acre on an adjacent nonburned site (a 438 percent increase). The spring burn yielded 346 pellet groups per acre compared to only 65 pellet groups per acre on a nearby nonburned site (a 532 percent increase). Although these plots were not cleared and more pellet groups may have been missed in nonburned sites, these counts show a strong preference by white-tailed deer for the burned sites.

Pellet group counts taken on specific study sites in the Avery and Lochsa study areas are summarized in Table 14. Even though only 0.08 and 0.07 acres were sampled in the 1969 Bee Creek burn and in the Bee Creek Control, respectively, they were sampled just as intensively as the 1967 Bee Creek burn on a unit area basis. Few deer were observed in or near any of the Avery or Lochsa study areas and little evidence of their presence was found (Table 14).

Combined pellet group counts indicate increases in elk use on burned sites of up to 62 percent (winter 1969-70) and 77 percent (summer 1970) on the Avery study area and up to 51 percent (summer 1970) and 382 percent (winter 1970-71) on the Lochsa study area when compared to adjacent non-burned sites (Figure 13). These counts also indicate relatively heavy summer use on these winter ranges.

Using the number of pellet groups counted on an area as an index of relative use by big game, the data indicate a higher summer and winter use preference for the burned sites compared to the nonburned sites. In addition, where burns of different years are adjacent to each other as in the Relay Station sites of the Avery study area and the Bee Creek sites of the Lochsa study area, a preference is shown for the most recent burn. Snow conditions during the 1970-71 winter may have been the reason for fewer pellet groups counted in the Relay Station burns than in the control. The Relay Station control is slightly lower in elevation than the two burn sites. In addition, the number of available redstem twigs was considerably lower in the control as noted earlier.

The pellet group data also point out that burned as well as nonburned

TABLE 14. COMPARISON OF RELATIVE WINTER AND SUMMER USE BY BIG GAME ON SPECIFIC BURNED AND UNBURNED SITES IN THE AVERY AND LOCHSA STUDY AREAS.

Treatment	Acres Sampled	Deer Pellet Groups Per Acre			Elk Pellet Groups Per Acre		
		Winter 1969-70	Summer 1970	Winter 1970-71	Winter 1969-70	Summer 1970	Winter 1970-71
AVERY							
Relay Station 1969 Burn	0.20	0	7	35	60	185	45
Relay Station 1968 Burn	0.20	0	2	35	50	75	35
Relay Station Control	0.20	10	0	10	35	30	150
Hammond Creek 1967 Burn	0.20	0	2	0	340	230	345
Hammond Creek Control	0.20	10	0	0	225	155	105
LOCHSA							
Lone Knob 1969 Burn	0.20[1]	25	50	0	170	250	400
Lone Knob Control	0.20[1]	19	45	0	172	150	105
Fish Creek 1968 Burn	0.20	0	0	0	90	105	530
Fish Creek Control	0.20	0	4	5	75	50	40
Bee Creek 1969 Burn	0.08	25	8	0	62	88	212
Bee Creek 1967 Burn	0.17	0	2	6	6	18	65
Bee Creek Control	0.07	14	0	0	0	29	43

[1] Winter 1969-70 counts included 0.36 acres.

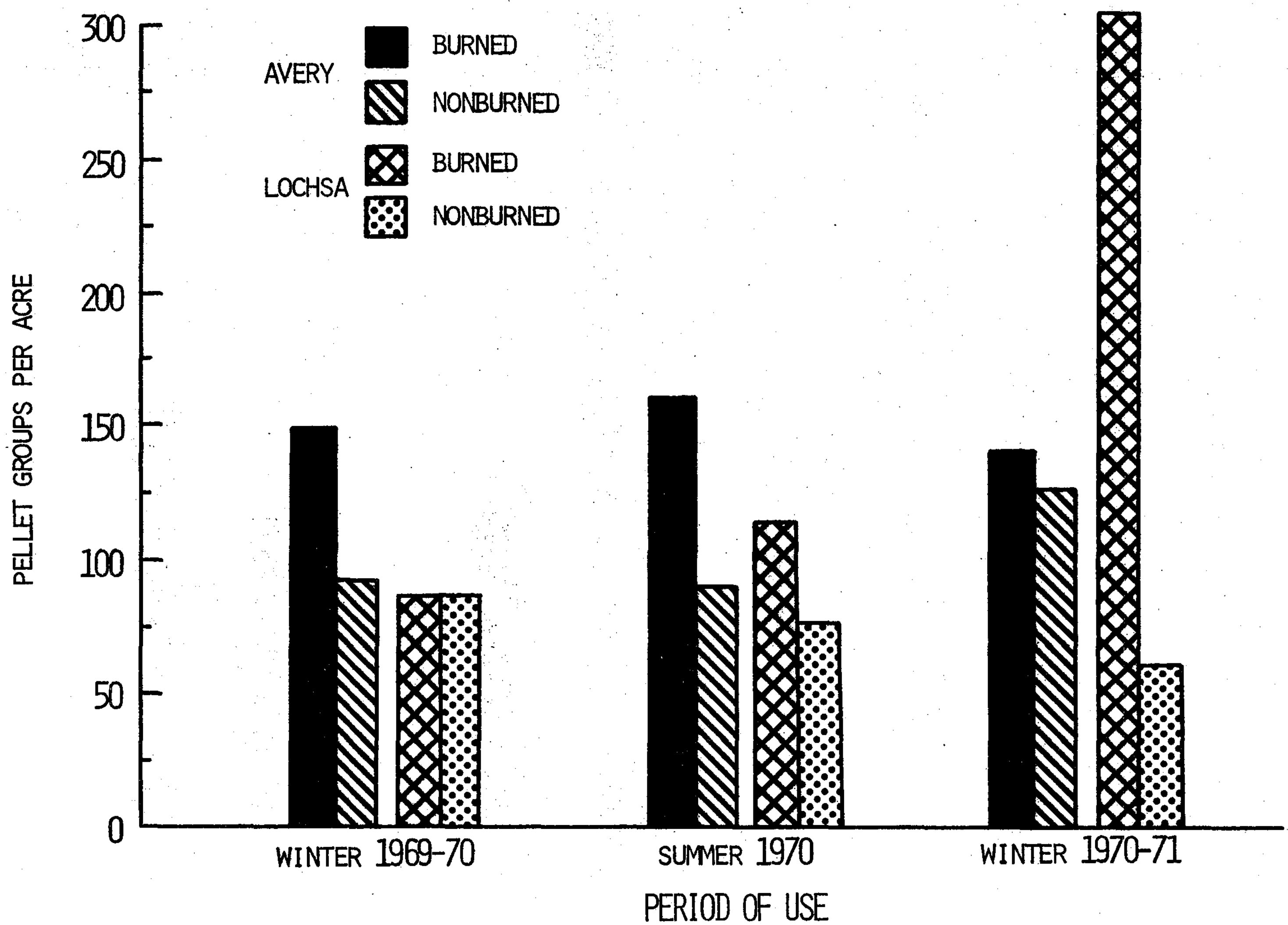

FIGURE 13. COMPARISON OF RELATIVE WINTER AND SUMMER USE BY ELK (CERVUS CANADENSIS) ON BURNED AND NONBURNED SITES IN THE AVERY AND LOCHSA STUDY AREAS, BASED ON PELLET GROUP COUNTS.

sites in the same general area (Lochsa and/or Avery study areas) cannot be compared directly because there are different big game populations utilizing these sites.

Burning Effects on the Soil

While no measurements were made on soil movement or loss, I observed no noticeable amounts of soil erosion on any of the study sites. Some soil slips were observed near the Avery and Lochsa study areas--an indication of soil instability. Hooker (1972) also found a minimum erosion hazard associated with spring burns on his study sites in the Lochsa River region. His data indicate past and present periods of active soil movement, primarily colluvial movement, which may be related to the removal of climax vegetation by early wildfires.

Although slight increases in runoff, erosion, and plant nutrient losses occurred in a study of clearcut and broadcast burned areas of western Montana, Debyle and Packer (1972) felt this increase was not detrimental to water quality and represented a small fraction of the nutrients available for plant growth on their sites. They state three reasons for this: (1) the natural resistance of soils in northern Idaho and western Montana to erosion, (2) the fact that extremely high-intensity summer storms are the exception in this region, and (3) the rapid vegetation recovery rate. Prescribed burned sites are generally imperceptible, except to the trained eye, by the end of the first growing season due to this rapid regrowth of vegetation.

Fire and the Natural Environment

Most northern Idaho big game winter ranges are presently in an advanced, mature, seral stage of succession. Medium- and tall-growing shrub species have literally grown out of the reach of foraging big game animals since the early 1900 wildfires. Shrub decadence is another important factor presently affecting CAG availability and production. Spring prescribed burning can be and is being used by the Idaho Fish and Game Department and the U.S. Forest Service to rejuvenate these winter ranges. More fall burning may enhance these rejuvenation efforts. If sufficient acreages can be burned on critical winter range areas, this overall increase in the nutrition, availability, and production of key browse species should help alleviate malnutrition losses of big game animals and perhaps increase effective reproduction and calf and/or fawn survival on these ranges.

To accomplish the burning of adequate acreages we will have to modify the public's sacred image of "Smokey the Bear" and such slogans as "Keep Idaho Green" through recognition of fire as part of the natural environment. An integral part of natural resource management is the responsibility to maintain the viability of ecosystems. That fire has played a natural and key role in the evolution of biological balances in the Intermountain West is evident from the conspicuous vegetational mosiacs present and the dependence of the animal components on various successional stages of the vegetation. An example is the adaptation of forest ungulates like deer, elk, and moose to early, seral successional stages of forest vegetation. The past and present practice of intensive fire exclusion on our forest ecosystems is in a sense producing unnatural ecosystems (Heinselman 1970). Only recently is fire being recognized as part of the natural environment--not as an unnatural disturbance--and that many ecosystems have evolved in response to it. Total fire suppression is an unnatural form of vegetation manipulation. Habeck (1972:114) states "At lower elevations, below 5,000 feet, the decades of fire protection have led to a loss of community life-form diversity on the whole," referring to the Selway-Bitterroot Wilderness in central Idaho. In effect, we are attempting to produce climax plant communities in areas where they probably seldom existed naturally.

Recent studies by the National Park Service and the U.S. Forest Service recognize fire-dependent ecosystems (Mutch 1970, Prasil 1971). Questions being examined include: (1) how often did fires occur?, (2) what were specific effects of fires?, and (3) what plant and animal communities owe their existence to fire? It appears that wildfires will be permitted to burn in the near future in such places as national parks, wilderness areas, and nature reserves--providing human life, private property, and public developments are not endangered (Prasil 1971). In other areas, for example national forests, responsible and well-planned prescribed burning programs can and should play a large role in duplicating the natural fire regime.

CONCLUSIONS

Nutrient analyses of dormant CAG from four key browse species indicate species specific responses to spring prescribed burning on northern Idaho winter ranges. Redstem ceanothus showed significant reduction in crude protein content on burned compared to nonburned sites while mountain maple consistently showed significant increases in crude fiber on burned sites. Willow maintained the highest fat and phosphorus percentages. Serviceberry was highest in crude protein and mountain maple contained the highest amount of crude fiber.

Overall, there was a temporary increase in browse quality on burned compared to nonburned sites as determined by chemical analysis. Significant increases in moisture and crude protein content were apparent at the end of the first year following burning. However, this effect was absent in the second and third years after burning. Correspondingly, an overall decrease in crude fiber content lasted at least three years. This indicates that the overall digestibility of the browse species studied, except mountain maple, was increased. While calcium showed a significant decrease for at least three growing seasons following burning, phosphorus showed a significant increase for the first two growing seasons. The combined effect, a significant reduction in the C:P ratio, lasted two years after burning. Although redstem ceanothus was the only browse species studied found deficient in phosphorus, phosphorus is reportedly deficient in many forage species on western ranges. This reduction in the rather wide C:P ratio found on nonburned sites is believed beneficial to reproduction in big game in light of the effects of a wide C:P ratio or a phosphorus deficiency on ruminants.

If crude protein content can be used as a yardstick of forage quality, then the key browse species I analyzed are strictly maintenance forages during the later stages of plant dormancy. This corresponds to the critical winter stress period in the annual life cycle of big game.

Mean maximum crown height measurements of such tall-growing shrubs as mountain maple, serviceberry, and willow point out the potential for some CAG to exceed the reach of big game by the end of the second and third growing seasons following burning though a few willow sprouts reached nearly 10 feet in height the first growing season. Heavy summer and winter use by big game on such tall-growing shrubs as occurred on the 1967 Hammond Creek burn, can effectively delay this and yet maintain apparently healthy plants.

The use of mean maximum crown height measurements as an index of CAG availability is misleading, especially winter availability. While maximum crown height measurements of Avery willow plants indicated near 100 percent CAG availability for the first three growing seasons following burning,the height-stratified twig counts showed only 68.3 percent availability the first year after burning, 87.8 percent the second year, and 91.7 percent the third year. Control plants averaged only 28.3 percent of the CAG available. Lochsa counts showed a similar response except that on the three-year-old burn nearly 44.0 percent was already above the arbitrary 8-foot maximum height for inclusion in the availability zone. The 2-foot minimum height assigned for average snow depths is largely responsible for lowering the CAG availability estimates of the twig counts compared to the maximum crown height measurements. However questionable the zone of availability is, it is certainly more realistic than crown height measurements. Low-growing shrubs such as redstem ceanothus showed an even greater discrepancy in the two estimates. Whereas mean maximum crown height measurements of burned and nonburned sites indicated 100 percent CAG availability, the redstem twig counts at Avery showed that only 4.2 percent was available the first year after burning, 32.9 percent the second year, and 50.0 percent the third year compared to 90.6 percent on controls. Lochsa redstem plants had from 39.1 percent to 73.1 percent to 93.2 percent of the CAG available from the first through the third year after burning, respectively, compared to 90.7 percent available on control plants. CAG availability of redstem was particularly affected by snow bending, especially on the burned areas. The greatest effect occurred when the snow pack built on early, wet, frozen snow.

Total production of burned redstem plants exceeded control plants by the end of the second growing season in both study areas. Burned plants at Avery never attained the available production of control plants while Lochsa redstem plants on burned sites exceeded control plants in available production by the end of the second growing season. Available willow production on all three years of burns in both study areas far exceeded control plant production. It appears that the loss of available redstem production for the first few growing seasons following spring prescribed burning is more than offset by the increased available production of such tall-growing shrubs as willow, mountain maple, and serviceberry.

Relative use comparisons using pellet group and percent utilization indices substantiate higher winter (1969-70, 1970-71) and summer (1969, 1970) use on burned compared to nonburned sites by big game. Pellet group counts at Hatter Creek indicated white-tailed deer use increased up to 532 percent. Correspondingly, elk use of burned sites was up 62 percent (winter 1969-70) and 77 percent (summer 1970) at Avery, and 382 percent (winter 1970-71) and 51 percent (summer 1970) on Lochsa burned sites compared to adjacent nonburned areas. An overall increase in utilization of redstem ceanothus and willow on burned sites indicates a more than temporary increase in browse palatability. Except for the Avery Relay Station burn sites, the percentage of redstem and willow twigs browsed was higher on burned sites compared to nonburned sites through the third year following burning. The lower utilization of redstem noted on the one- and two-year-old Avery burns compared to a nearby nonburned site is felt largely a result of winter availability. The 1969 Avery burn had only 0.07 sprouts and/or twigs available per plant while the 1968 Avery burn had 12.12 sprouts and/or twigs available per plant. At the same time the control site had 54.4 twigs available per redstem plant.

I do not believe that increased use of burned sites compared to nonburned sites, selection of forage species, and/or selection of plant parts by foraging big game animals is solely attributable to associated nutritive values although studies have shown that deer and elk prefer plants which are especially nutritious. Protein is considered to be the most important dietary nutrient component (Dietz 1972). In addition, it is often implied that big game select or prefer certain forage species over others on the basis of higher protein content. My data do not support this contention. Utilization data show a strong preference by big game for redstem ceanothus, yet serviceberry protein content averaged 1.1 percent higher for the dormant winter stage I studied. Redstem, with one exception--the one-year-old Lochsa burn--was also consistently lower in crude protein on burned sites compared to nonburned sites and yet a high selection or preference for redstem, as well as other species, on burned sites was evident. In addition, I noted that plant species of normally low selection value are readily utilized in burns, especially during the first growing season. Leege (1969) also noted this in similar burns. Longhurst and coworkers (1968) further show that analyses of unpalatable species indicate they are frequently equally as high in the same nutrients as more palatable species. Their observations of deer both in the field and under penned conditions has shown that olfaction is the primary sense used in the initial selection of forage. Apparently, if they like the smell, they taste the plant; and if they like the taste, they proceed to feed upon it. However, once familiar with a particular plant species, the deer learned to recognize it by sight and fed upon it without first smelling and tasting it. Other investigations (Longhurst et al. 1968, Nagy et al. 1964, 1968) have shown that certain volatile or essential oils of plants are inhibitory on rumen microorganisms and may be correlated with forage palatability and selection. I would agree with Longhurst and his coworkers (1968:188) when they conclude, "It is doubtful, however, that deer through olfaction are able to detect the presence of nutrients or digestive inhibitors in plants directly and may be depending on other associated indicators." The higher preference by big game found for redstem compared to the other three browse species examined may be related to the higher carbohydrate fraction found in redstem nutrient analyses as reflected in the NFE portion. Plants high in sugar content, one of the more soluble carbohydrates in the NFE portion, are generally selected by ruminants.

Heavy summer utilization of preferred browse species by big game, snowshoe hares, and possibly other rodents during the first few growing seasons following burning lowers availability, seedling survival, and possibly the future vigor of the shrub community. This is clearly indicated in the 1967 and 1969 Avery burns and in the Hatter Creek pilot study burns. Redstem is the species most affected. Although I noticed no actual mortality in this study, Hickey and Leege (1970) found some redstem mortality where big game had browsed heavily on first-year sprouts. The low numbers of sprouts and/or twigs per redstem plant recorded in the 1967 and 1969 Avery burns and the decidedly low vigor observed was a direct result of continuously heavy summer and winter browsing. Burning scattered areas on a given tract of winter range appears more beneficial than one area of the same acreage. In this way, big game may utilize more fully the CAG available in adjacent nonburned sites. Thus, the nonburned sites may receive a regrowth stimulus, maintain better growth form, and animal distribution and plant utilization may be more uniform over the entire winter range.

Reburning areas in a rotation system to reestablish young, seral, successional stages of winter range vegetation is going to depend largely on (1) the accumulation of ground fuels (primarily bracken fern in northern Idaho), (2) shrub utilization intensity (summer use being more important than previously acknowledged), and (3) species composition of the stand. Where the ratio of tall-growing shrub species far outnumbers the medium- and low-growing species, the burning sequence would be shorter. Therefore, this phase of any prescribed burning program must remain flexible.

Re-educating the public on the ecological soundness of the role which fire has played in the maintenance of natural ecosystems in much of the United States is a real problem facing today's land managers. Public understanding and support for ecologically sound use of fire in natural resource management will only be gained by presenting unbiased facts. The findings of this research should help serve this need.

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APPENDIX I

FREQUENCY OF OCCURRENCE, DENSITY, AND SPECIES COMPOSITION OF PLANT SPECIES ENCOUNTERED ON NORTHERN IDAHO SERAL BRUSHFIELDS

TABLE 15. PERCENT FREQUENCY OF OCCURRENCE, DENSITY (INDIVIDUALS PER ACRE), AND PERCENT SPECIES COMPOSITION OF WOODY PLANTS ON THE AVERY STUDY AREA IN THE SUMMER OF 1969. DATA WERE COLLECTED USING THE POINT-QUARTER-CENTER-METHOD (COTTAM AND CURTIS 1956).

Study Site	1969 Relay Station Burn			1968 Relay Station Burn			Relay Station* Control			1967 Hammond Creek Burn			Hammond Creek Control		
Species	Species Composition	Density	Frequency	Species Composition	Density	Frequency	Species Composition	Density	Frequency	Species Composition	Density	Frequency	Species Composition	Density	Frequency
<u>Trees</u>															
Pinus contorta							1	40	4				1	40	-
Populus tremuloides													3	121	4
<u>Tall Shrubs</u>															
Acer glabrum	7	109	4	9	227	12	2	77	16	2	28	-	2	81	-
Amelanchier alnifolia	14	219	16	5	125	24	4	158	44	8	117	12	10	405	36
Holodiscus discolor				1	24	8	3	117	16						
Philadelphus lewisii										1	16	4			
Prunus emarginata	3	65	12	10	251	8	9	352	28	1	16	-	4	162	8
Salix spp.	48	749	44	38	951	68	15	583	48	17	251	36	19	773	80
<u>Medium Shrubs</u>															
Ceanothus sanguineus	15	235	44	31	777	44	41	1599	84	34	502	32	16	652	48
Ceanothus velutinus	10	159	4							36	503	44	14	570	48
Lonicera utahensis													2	81	-
Physocarpus malvaceus	3	65	12	6	150	8	6	235	16						
Rosa gymnocarpa							2	77	48				1	40	24
Rosa nutkana							1	40	4						
Symphoricarpos albus							11	429	68	1	16	24	5	202	24
Vaccinium membranaceum							5	194	40				8	324	36
<u>Low Shrubs</u>															
Pachistima myrsinites													15	611	64

* Control for both the 1968 and 1969 Relay Station Burns.

TABLE 16. PERCENT FREQUENCY OF OCCURRENCE, DENSITY (INDIVIDUALS PER ACRE), AND PERCENT SPECIES COMPOSITION OF WOODY PLANTS ON THE LOCHSA STUDY AREA IN THE SUMMER OF 1969. DATA WERE COLLECTED USING THE POINT-QUARTER-CENTER-METHOD (COTTAM AND CURTIS 1956).

Study Site	1969 Lone Knob Burn			Lone Knob Control			1968 Fish Creek Burn			Fish Creek Control			1967 Bee Creek Burn			Bee Creek Control		
Species	Species Composition	Density	Frequency	Species Composition	Density	Frequency	Species Composition	Density	Frequency	Species Composition	Density	Frequency	Species Composition	Density	Frequency	Species Composition	Density	Frequency
<u>Trees</u>																		
Abies grandis				1	53	-				2	45	-						
Betula papyrifera	3	65	12	11	591	36				1	20	4	6	170	12			
Pseudotsuga menziesii				3	162	16												
<u>Tall Shrubs</u>																		
Acer glabrum							1	24	4	1	20	4	4	113	8	2	65	8
Amelanchier alnifolia	3	65	-	2	109	40	5	125	24	1	20	24	2	57	4	8	267	32
Cornus stolonifera	1	20	4															
Holodiscus discolor	10	219	56	1	53	12	4	101	32	7	158	20	1	28	4	3	101	44
Philadelphus lewisii	1	20	-										8	227	12	8	267	20
Prunus emarginata	21	4573	36	6	324	24	32	793	40	38	846	48	18	506	32	27	894	56
Prunus virginiana													3	85	8	7	231	16
Rhamnus purshiana				1	53	-							4	113	12	2	65	16
Salix spp.	19	413	40	6	324	20	26	643	56	29	647	60	5	142	20			
<u>Medium Shrubs</u>																		
Ceanothus sanguineus	42	9105	48	69	3699	22	32	793	48	21	469	40	31	874	64	32	1060	68
Physocarpus malvaceus													18	506	36	11	364	24

TABLE 17. LIST OF PLANT SPECIES ENCOUNTERED IN NORTHERN IDAHO SERAL BRUSHFIELDS AND THEIR FREQUENCY OF OCCURRENCE ON SPECIFIC WINTER RANGE STUDY SITES. DATA COLLECTED DURING JULY AND AUGUST, 1969, USING 1 METER-SQUARE PLOTS.

	Frequency of Occurrence										
	Avery					Lochsa					
Species List	1969 Burn	1968 Burn	68-69 Control	1967 Burn	1967 Control	1969 Burn	1969 Control	1968 Burn	1968 Control	1967 Burn	1967 Control
						Percent					
Trees											
Abies grandis			4								
Betula papyrifera						12	36		4	12	8
Pinus contorta			4	4							
Populus tremuloides					4						
Pseudotsuga menziesii						16					12
Tall Shrubs											
Acer glabrum	4	12	16					4	4	8	8
Amelanchier alnifolia	16	24	44	12	36		40	24	24	4	32
Cornus stolonifera						4					
Holodiscus discolor		8	16			56	12	32	20	4	44
Philadelphus lewisii				4			4	16		12	20
Prunus emarginata	12	8	28		8	36	24	40	48	32	56
Prunus virginiana										8	16
Rhamnus purshiana						12				12	16
Salix spp.	44	68	48	36	80	40	20	56	60	20	
Sorbus scopulina			4								
Medium Shrubs											
Ceanothus sanguineus	44	44	84	32	48	48	22	48	40	64	68
Ceanothus velutinus	4			44	48						
Clematis columbiana											4
Lonicera ciliosa									4		
Lonicera utahensis			4								
Physocarpus malvaceus	12	8	16							36	24
Rosa gymnocarpa	40	32	48	20	24	24	4	20	16	28	40
Rosa nutkana			4								

TABLE 17. CONTINUED.

Species List	Avery 1969 Burn	Avery 1968 Burn	Avery 68-69 Control	Avery 1967 Burn	Avery 1967 Control	Lochsa 1969 Burn	Lochsa 1969 Control	Lochsa 1968 Burn	Lochsa 1968 Control	Lochsa 1967 Burn	Lochsa 1967 Control
	Frequency of Occurrence										
Medium Shrubs											
Rubus parviflorus	36	88	60	56	84	56	96	84	84	68	24
Spiraea betulifolia	96	84	60	68	64	40	20	48	72	44	32
Symphoricarpos albus	8	40	68	24	24	32	36	48	32	84	40
Vaccinium membranaceum	56	32	40	8	36			4	48	4	
Low Shrubs											
Berberis repens	16	12	16	60	36			16			4
Pachistima myrsinites	16	32	56	24	64			4	4		
Forbs											
Achillea millifolium				24		32	12	12		16	44
Adenocaulon bicolor							4				
Anaphalis margaritacea		4		12		12	40		4	12	12
Anemone piperi	80	92	48	48	48	40	64	64	72	72	20
Apocynum androsaemifolium			4	24				4		4	20
Arenaria macrophylla	48	48	84	72	76	52	68	72	68	80	64
Arnica spp.						4		12	4		
Asarum caudatum						4					
Aster conspicuus	36	56	84	28	60	4	8	8	64	44	16
Castilleja spp.	8										
Cerastium spp.						36	4		12		
Cirsium vulgare	4	28				28		20		20	
Clintonia uniflora	4	4	8	4	16		8		4		8
Collomia spp.						8					
Coptis occidentalis	16	16	16	4	24		4	8	24		
Cornus canadensis						12	4		20		
Disporum hookeri			12					36	32	40	12

TABLE 17. CONTINUED.

Species List	Avery 1969 Burn	Avery 1968 Burn	Avery 68-69 Control	Avery 1967 Burn	Avery 1967 Control	Lochsa 1969 Burn	Lochsa 1969 Control	Lochsa 1968 Burn	Lochsa 1968 Control	Lochsa 1967 Burn	Lochsa 1967 Control
	Frequency of Occurrence										
Forbs											
Epilobium angustifolium	48	44	36	8	40	16	4	20	4	4	4
Erigeron spp.								4			
Fragaria vesca		20	12	20	16	68	60	20	4	36	64
Galium aparine						20	4				
Galium triflorum			16			16	56	20	40		24
Geranium spp.	4					20		4			
Heuchera cylindrica											8
Hieracium albertinum								16			
Hieracium albiflorum	12	4	16	8	32		52	16	20		
Hypericum perforatum						68	52	48	16	44	92
Lactuca ludoviciana						16	36			24	
Lathyrus nevadensis	48	12	8			48	60	20		24	
Madia glomerata						8					
Mitella stauropetala		4	4		4				4		
Penstemon spp.		12	8	8		40		12	12	24	48
Phacelia hastata	8		16	40	8	8				8	24
Potentilla spp.						8			4		
Prunella vulgaris						12	8		4		
Pteridium aquilinum	80	72	60	100	64	88	92	24	24	100	56
Rumex acetosella						32	4	4		40	40
Smilacina stellata	4	40	40		32	8	44	36	68	8	32
Solidago canadensis				24	4		32	24	4		
Stellaria media						8					
Streptopus amplexifolius	8	4									
Taraxacum officinale			4			16	16	4			
Thalictrum occidentale	8	12	16								
Thermopsis montana								88	80		
Tragopogon dubius						12					

TABLE 17. CONTINUED.

	Frequency of Occurrence										
	Avery					Lochsa					
Species List	1969 Burn	1968 Burn	68-69 Control	1967 Burn	1967 Control	1969 Burn	1969 Control	1968 Burn	1968 Control	1967 Burn	1967 Control
Forbs											
Trillium ovatum								12			
Verbascum thapsus	4					20		24		8	
Viola spp.	4	44	40	52	8	40	4	20	24	4	4
Xerophyllum tenax	12	4							8		4
Grasses & Grasslikes											
Agropyron spicatum								12			
Agrostis scabra						16	4	4			
Arrenatherum elatius							4				
Bromus spp.						36			4	4	24
Calamagrostis rubescens		76	80	84	48		12	12	8	44	28
Carex geyeri			8	12		20	12	44	40	48	28
Elymus glaucus					4		60	28	20	12	8
Festuca occidentalis						24	8	20	16	8	24
Koeleria cristata								4			
Luzula campestris								4	4		
Panicum occidentale								12			
Phleum pratense						32	32	4			
Poa compressa	68						28	8		8	4
Poa pratensis								8			

APPENDIX II

SOIL ANALYSIS

APPENDIX II

SOIL ANALYSIS

All of the soil pits which were examined classify closest to spodosols of the Jughandle series which is a Typic Cryorthods coarse-loamy, mixed soil transitional to a Typic Cryochrepts. Because only one soil pit was examined per study site and because I found only minor differences between sites, I will present a composite soil profile description for both the Avery and Lochsa study areas.

<u>Avery</u> <u>Profile</u> <u>Description</u>:

01 2-0 inches. Undecomposed and slightly decomposed twigs, leaves and bracken fern fronds. 0 to 3 inches thick.

02 1-0 inches. Partially and well-decomposed twigs, leaves and wood; clear, wavy boundary. 0-1 1/2 inches thick.

A1 0-2 inches. Very dark brown (10YR 2.5/2) when moist; gravelly coarse sandy loam; weak, very fine, granular; weakly coherent, very friable, nonsticky, slightly plastic when wet, nonplastic when moist; abundant fine-to-coarse roots; clear, wavy boundary. Exposed shaly sedimentary strata. 0-3 inches thick.

B2*ir* 2-16 inches. Brown (10 YR 4/3.5) when moist; gravelly coarse sandy loam; weak, very fine, granular; weakly coherent, very friable, slightly sticky, slightly plastic when wet and moist; very abundant fine-to-coarse roots; gradual, irregular boundary. 4-22 inches thick.

C1 16-34+ inches. Brown (7.5 YR 5/4) when moist; stony loamy course sand; weak, fine, granular; weakly coherent, very friable, sticky, plastic when wet, slightly plastic when moist, few micro-to-fine roots. Shaly sedimentary strata.

Lochsa Profile Description:

O1 2-0 inches. Undecomposed and slightly decomposed twigs, leaves and bracken fern fronds. 0-2 inches thick.

O2 1-0 inches. Partially and well-decomposed twigs, leaves and wood; abrupt, wavy boundary. 0-1 inch thick.

A1 0-3 inches. Very dark brown (10YR 2.5/1.6) when moist; gravelly coarse sandy loam; weak, very fine, granular; weakly coherent, very friable, nonsticky, nonplastic wet and moist; abundant micro-to-fine roots; clear, wavy boundary. 0-4 inches thick.

B21*ir* 3-12 inches. Dark yellowish brown (10YR 4/3.1) when moist; gravelly coarse sandy loam; weak, very fine, granular; weakly coherent, very friable, slightly sticky, slightly plastic wet and moist; abundant very fine-to-medium and few large roots; clear, wavy boundary. 1-11 inches thick.

B22*ir* 12-19 inches. Brown (10YR 4.8/3.2) when moist; texture, structure, consistence and roots similar to B21*ir*; gradual, irregular boundary. 1-8 inches thick.

C1 19-44+ inches. Brown to yellowish brown (10YR 5.5/3.5) when moist; gravelly loamy coarse sand; texture and structure similar to B22*ir*; few very fine-to-large roots. Residuum from hornblende-biotite quartz dioritic orthogneiss parent material (Roper 1970).

Soil Chemistry

Soil chemistry of the horizons from a single soil pit dug in a representative location in each study site on the Avery and Lochsa study areas are listed in Tables 18 and 19, respectively. No statistical comparisons of burned vs. nonburned sites were applied due to the small sample size and because no pre-treatment samples were collected. Data are presented only for future reference and because little or no information of this type is available on either the Avery or Lochsa study areas. Hooker (1972) documented additional effects of burning on soils in a similar Lochsa study site.

TABLE 18. SOIL CHEMISTRY OF THE AVERY STUDY SITES. SAMPLES COLLECTED IN OCTOBER, 1970.

STUDY SITE	HORIZON	pH	% O M	% N	% P	% CA	% MG	% K
RELAY STATION 1969 BURN	A1	6.0	11.40	0.38	0.021	0.19	0.042	0.059
	B21*ir*	5.9	--	0.24	0.007	0.12	0.022	0.046
	B22*ir*	5.7	--	0.11	TR	0.04	0.004	0.025
	C1	5.6	--	--	--	--	--	--
RELAY STATION 1968 BURN	A1	6.1	14.29	0.50	0.022	0.24	0.047	0.051
	B2*ir*	5.6	--	0.14	0.019	0.06	0.006	0.036
	C1	5.9	--	--	--	--	--	--
RELAY STATION CONTROL	A1	5.8	15.36	0.53	0.009	0.24	0.048	0.070
	B2*ir*	5.6	--	0.09	0.012	0.06	0.003	0.020
	C1	6.2	--	--	--	--	--	--
HAMMOND CREEK 1967 BURN	A1	6.3	9.68	0.34	0.020	0.18	0.028	0.069
	B2*ir*	5.9	--	0.17	0.010	0.06	0.011	0.043
	C1	5.9	--	--	--	--	--	--
HAMMOND CREEK CONTROL	A1	5.4	9.86	0.36	0.019	0.12	0.012	0.049
	B2*ir*	5.5	--	0.16	TR	0.03	0.002	0.009
	C1	5.4	--	--	--	--	--	--

TABLE 19. SOIL CHEMISTRY OF THE LOCHSA STUDY SITES. SAMPLES COLLECTED IN SEPTEMBER, 1970

Study Site	Horizon	pH	% O M	% N	% P	% Ca	% Mg	% K
Lone Knob 1969 Burn	A1	6.0	9.96	0.35	0.023	0.18	0.038	0.042
	B2*ir*	5.4	--	0.04	Tr	0.06	0.004	0.028
	C1	4.9	--	--	--	--	--	--
Lone Knob Control	A1	5.8	7.92	0.28	0.029	0.12	0.020	0.049
	B21*ir*	5.8	--	0.08	Tr	0.06	0.004	0.028
	B22*ir*	5.8	--	0.05	Tr	0.05	0.003	0.024
	C1	6.4	--	--	--	--	--	--
Fish Creek 1968 Burn	B21*ir*	6.2	5.47	0.21	0.005	0.11	0.011	0.041
	B22*ir*	5.6	--	0.07	Tr	0.04	0.002	0.029
	C1	5.9	--	--	--	--	--	--
Fish Creek Control	A1	6.0	8.45	0.34	0.012	0.12	0.020	0.059
	B2*ir*	5.4	--	0.10	Tr	0.05	0.002	0.030
	C1	5.8	--	--	--	--	--	--
Bee Creek 1967 Burn	A1	6.2	4.80	0.19	0.057	0.13	0.016	0.035
	B21*ir*	6.0	--	0.06	0.015	0.06	0.003	0.022
	B22*ir*	5.9	--	0.04	0.007	0.05	0.002	0.016
	C1	6.9	--	--	--	--	--	--
Bee Creek Control	A1	5.8	3.82	0.15	0.025	0.10	0.011	0.031
	B21*ir*	5.8	--	0.08	0.015	0.08	0.006	0.025
	B22*ir*	5.6	--	0.03	0.004	0.05	0.003	0.015
	C1	6.5	--	--	--	--	--	--